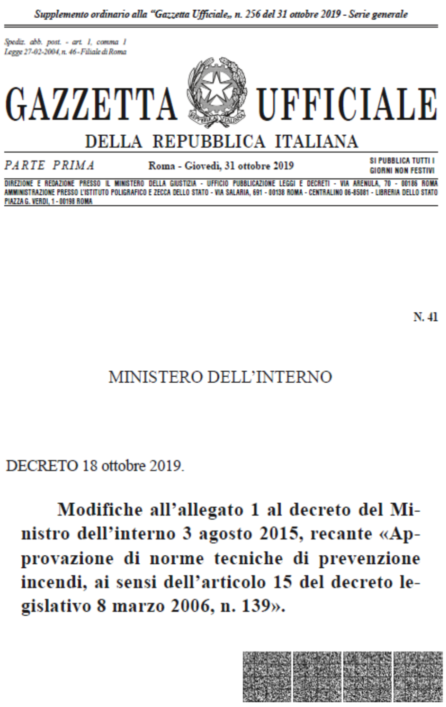

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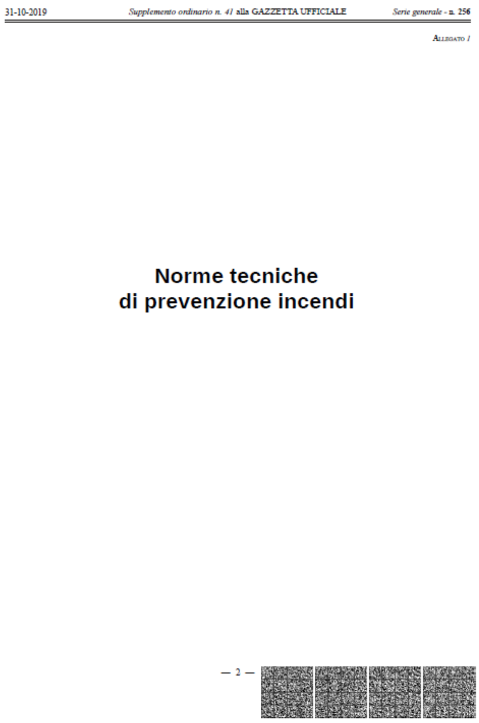
MINISTERO DELL'INTERNO

DECRETO 18 ottobre 2019.

Modifiche all'allegato 1 al decreto del Ministro dell'interno 3 agosto 2015, recante «Approvazione di norme tecniche di prevenzione incendi, ai sensi dell'articolo 15 del decreto legislativo 8 marzo 2006, n. 139».



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ALLEGATO 1

Norme tecniche
di prevenzione incendi

— 2 —

Annex 1

Technical fire prevention standards

Traduzione curata da Fabio Alaimo PONZIANI

This document is the english version of the Ministerial Decree 3 August 2015 as emended by the Ministerial Decree 18 October 2019. In case of any official interpretation of the legal provisions contained in the technical annex of the Ministerial Decrees, it ought to be used the Italian version published in the Italian Official Journal (Gazzetta Ufficiale della Repubblica Italiana).

Document structure

Section G General information

Chapter G.1 Terms, definitions and graphic symbols

G.1.1 Preface

1. The purpose of this chapter is to set out the general definitions concerning specific fire prevention expressions so that the content of this document may be applied uniformly.
2. The design solutions that meet the performance standards required by these definitions are described in the pertinent chapters of this document.
3. Other specific definitions may have been added in individual vertical technical regulations, to further detail additional specific elements or data.

G.1.2 References

1. For definitions not covered in this chapter, refer to the UNI CEI EN ISO 13943 standard, '*Fire Safety - Vocabulary*', and in general, the UNI, EN and ISO reference standards.

G.1.3 Fire prevention

1. Fire prevention: a function primarily in the public's interest aimed at achieving, pursuant to uniform criteria in Italy, the objectives of the protection and safety of human life, persons, property and the environment through the promotion, study, preparation and experimentation of fire prevention and safety standards, measures, provisions, procedures and actions aimed at avoiding the outbreak of fire and the events in any way connected to it or to limit its consequences.
2. Economic assets (or assets): tangible or intangible means of meeting the needs of human beings and having a positive value.
3. Fire prevention technical regulation (or technical regulation): mandatory legislation on fire prevention.
4. Horizontal technical regulation (HTR): fire prevention technical regulation applicable to all activities.

   Note For the purposes of this document, all the chapters in the *General information, Fire prevention strategy and Methods* sections are considered to be horizontal technical regulations.

5. Vertical technical regulation (VTR): fire prevention technical regulation applicable to a specific activity or its realms, with specific indications, complementary to or replacing those provided for in the horizontal technical regulation.
6. Risk profile: expeditious indicator of the severity of the risk of fire associated with the normal operation of any activity.
7. Reference risk profile: the worst case *risk profile* for the compartments served by the *fire prevention measure* under consideration.
8. Fire prevention strategy: a combination of *fire prevention measures* aimed at achieving *fire safety objectives*.
9. Fire prevention measure: a uniform category of prevention, protection and management tools used to reduce fire risk.

   Note e.g. fire resistance, reaction to fire, compartmentation, evacuation, …

10. Active protection: a set of fire prevention measures designed to reduce the consequences of a fire, which require human action or the activation of a system.
11. Passive protection: a set of fire prevention measures designed to reduce the consequences of a fire, not included in the definition of active protection and not of a managerial nature.
12. Performance level (performance requirement): an objective specification of the performance required by an activity to carry out *fire prevention measures*.
13. Deemed-to-satisfy solution (deemed to satisfy provision): a design solution for immediate application to specified cases, guaranteeing the achievement of the related performance level.

    Note Deemed-to-satisfy solutions are prescriptive design solutions not requiring further technical assessments (e.g. 'The safety distance is 5 m').

14. Alternative solution: a design solution alternative to deemed-to-satisfy solutions. The designer must demonstrate the achievement of the combined performance level using one of the permitted *fire safety design methods*.

    Note Alternative solutions are performance based design solutions that require further technical assessment (e.g. 'The separation distance must be calculated by setting the maximum radiation from the fire to the target at 12.6 kW/m^2').

15. Solution in derogation: design solution for which the activation of a derogation procedure is required as provided for by current legislation. The designer must demonstrate the achievement of the fire safety objectives using one of the permitted *fire safety design methods*.
16. Fire safety design method: design method specified in Chapter G.2 of this document.
17. Fire prevention product: the material, component, device, apparatus, or element whose fire safety performance is characterised, in relation to the assessment of risk connected to its use.
18. Expert judgement: analysis based on the general principles of fire prevention and on the knowledge of the expert designer in the field of fire safety.

G.1.4 Voluntary regulation

Note For definitions of *technical specification*, *standard*, *European standardisation product*, *draft standard* and *harmonised technical specification*, please refer to Regulation (EU) No 1025/2012 of the European Parliament and of the Council of 25th October 2012. For definitions of *European assessment*, *European technical assessment document* and *harmonised technical specification*, reference is made to Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9th March 2011. For definitions of *Technical Specification* (TS) and *Technical Report* (TR), refer to CEN documents.

Note As specified in Section G.1.25, the application of the voluntary regulation mentioned in this document is not *mandatory*.

1. Standard (or technical standard): a technical specification, adopted by a recognised standards body, for repeated or continuous application, not requiring mandatory compliance and which belongs to one of the following categories:

   a. international standard: a standard adopted by an international standards body;

   Note The following are examples of international standard bodies: ISO (International Organisation for Standardisation), IEC (International Electrotechnical Commission) and ITU (International Telecommunications Union).

   b. European standard: a standard adopted by a European standards body;

   Note The following are examples of European standard bodies: CEN (European Committee for Standardisation), Cenelec (European Committee for Electrotechnical Standardisation), ETSI (European Telecommunications Standards Institute).

   c. harmonised standard: a European standard adopted on the basis of a request by the EU Commission for the purpose of the application of Union legislation on harmonisation;

   Note *Harmonised standards* and, more generally, *harmonised technical specifications* usually refer to the determination of the performance of products with a view to their marketing in the European Economic Area (EEA).

   d. national standard: a standard adopted by a national standards body.

   Note Standards organisations may be equally qualified as *standardisation* or *normalisation bodies* or *entities*. The following are examples of national standards bodies: DIN and DKE (Germany), AFNOR (France), UNI and CEI (Italy), NEN and NEC (Netherlands), BSI (United Kingdom), …

2. European standardisation product: any other technical specification, other than European standards, adopted by a European standardisation organisation for repeated or continuous application, not requiring mandatory compliance.

   The following are examples of European standardisation products:

   a. Technical specification (TS): a technical document of a regulatory nature whose development may be required when various alternatives, not sufficient to reach an agreement or a European standard or because of the need for different experimental specifications or due to technological evolution, must necessarily coexist with a view to future harmonisation;

   b. Technical report (TR): a technical information document providing information on the technical content of the standardisation work in progress. This is generally prepared when it is considered urgent or necessary to provide detailed technical information to national standards bodies.

   Note Technical specifications should be adopted by national standards bodies, while technical reports may not be adopted at the national level.

3. Draft standard: this document contains the text of technical specifications on a specific issue, prepared for the purposes of adoption pursuant to the pertinent regulatory procedure, which is the result of preparatory work and which is distributed for the purposes of public examination or comment.

4. Harmonised technical specifications: harmonised standards and European Assessment Documents (EADs).

5. Internationally recognised standard: a standard adopted by an internationally recognised body.

Note All non-European standards bodies referred to in this document and those traditionally recognised in the fire safety sector (industry) are internationally recognised bodies. For example: NFPA, ANSI/UL, ASTM, API, FM, FPA, NIST, SFPE, TNO, VDS, Energy Institute, IGEM, VTT, BRANZ, …

G.1.5 Activities

1. Activities: a set of organised actions carried out in a defined place, which may present a fire or explosion hazard.
2. Subject activity: *activities* subject to fire prevention inspections by the National Fire Service.

Note Subject activities are recognised in Annex I to Presidential Decree No 151 of 1st August 2011.

3. Activity with design assessment: *subject activity* whose fire prevention design is *assessed*, also in derogation, by the National Fire Service.

Note This definition includes both the activities subject to category B or C of Annex III of the Ministerial Decree of 7th August 2012, for which the assessment of the fire prevention design is envisaged, and the activities subject to category A of the same Annex, in the event that the fire prevention design is subject to assessment in derogation pursuant to the procedures provided for by current legislation.

4. Activity without design assessment: *subject activity* whose fire prevention design is *not assessed*, not even in derogation, by the National Fire Service.

Note The definition includes activities subject to category A of Annex III of the Ministerial Decree of 7th August 2012, not included in the definition referred to in paragraph 3.

5. Existing activity: activity already operational on the date of entry into force of the reference technical regulation.
6. Outdoor activity: an activity or portion of an activity, including its evacuation routes, carried out in a defined area and mainly in *an open-air space*, which allows smoke and heat from the fire to escape directly into the atmosphere.

Note For example, activities carried out on terraces, which have evacuation routes within the construction works, are not considered to be *outdoor activities*.

G.1.6 Parties involved

1. Activity manager: the party that bears responsibility for fire prevention obligations for the activity.
2. Designer: a certified fire prevention and safety technician or professional, assigned to fire prevention design by the activity manager for that same activity or specific areas of it, in accordance with the powers conferred by the regulatory provisions.
3. Certified technician: a certified technician registered in a professional registry who works in a specific field.

4. Fire safety professional: a certified technician registered in a professional registry at the Ministry of the Interior as set out in Article 16 of Legislative Decree No 139 of 8th March 2006.
5. Occupant: a person present for any reason within the activity, also considered in light of their interaction with the environment in the event of physical, mental or sensory disabilities.
6. Rescuer: an appropriately trained and protected member of a fire-fighting squad.

G.1.7 Geometry

1. Floor: net floor area.
2. Compartment reference floor: *floor* of the external location toward which the *evacuation of the occupants* of the compartment will primarily take place and from which *the rescuers will gain access*. If there is no such floor with these characteristics, then the floor where *rescuers access the area* with the best operational fire safety characteristics shall be considered (Chapter S.9). Each compartment shall have a single reference floor determined, which will generally correspond with the public or private access roadway. Determination of the compartment reference floor shall be noted in the design.

   Note Examples may be found in the illustration G.1-3.

3. Floor height: height difference between the *floor* and its relevant *compartment reference floor*.

   Note The floor height may be positive, negative or zero. Examples may be found in the illustration G.1-3..

4. Fire prevention height: maximum *floors height* of the activity. Floors that are occupied only occasionally and for brief periods, such as equipment floors and rooms, are excluded.

   Note Examples may be found in the illustration G.1-3.

5. Compartment height: the difference between the level of the compartment floor and its reference floor. In the case of a multi-floor compartment, the greatest height difference shall be assumed as the *absolute value*. (e.g. for the *highest* compartment floor above ground, or for the *lowest* compartment floor below ground level).

   Note The compartment height may be positive, negative or zero. Examples may be found in the illustration G.1-3.

6. Above-ground compartment or floor: compartment or floor with a positive height.
7. Underground compartment or floor: compartment or floor with a negative height.
8. Setting: a defined portion of the activity with the characteristic or quality described in the specific measure.

   Note The setting may refer to all or part of the activity. For example: floor, compartment, construction works, specific risk area, outdoor area, roof shed area, etc.

9. Gross floor area in a setting: a plan view floor area within the internal perimeter of the walls delimiting the setting.

Note If the setting has multiple floors or lofts, the gross floor area shall include all floors.

10. Usable floor area in a setting: a portion of the floor area in a setting for the purposes of the required function.

Note For example, that referred to as the *available floor area of ventilation openings* is the floor area of the opening measured less any obstructions (e.g. frame, grate, fins, etc.).

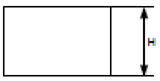
11. Mean height of a room (h_m): the weighted mean of the heights h_i of a room with the plan view projection of the portion of floor area A_i of the floor area at the height h_i:

$$h_m = \frac{\sum_i h_i \cdot A_i}{\sum_i A_i}$$

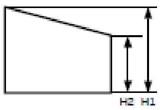
Note Examples may be found in the illustration G.1-1.

12. External safety distance: the minimum distance measured in the plan view between the perimeter of each hazardous element of an activity and the next external elements at the boundaries of the activity, which are to be maintained:
    a. the borders of buildable areas,
    b. the perimeter of the nearest building,
    c. the perimeters of any other public or private works.
13. Internal safety distance: the minimum distance measured in the plan view between the perimeters of the various hazardous elements of an activity.
14. Safety distance: the minimum distance measured in the plan view between the perimeter of each hazardous element of an activity and the boundaries of the area on which the activity is built.
15. Separation distance: the internal safety distance or external safety distance or safety distance, depending on the case.
16. Area of influence of an element: the area whose borders are obtained through the *offset* on a reference floor of the borders of the element at a distance referred to as *radius of influence* r_{offset}.

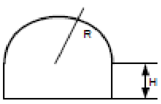
Note Examples may be found in the illustration.



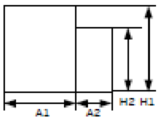
$$h_m = H$$



$$h_m = \frac{H_1 + H_2}{2}$$



$$h_m = H + \frac{\pi R}{4}$$



$$h_m = \frac{H_1 \cdot A_1 + H_2 \cdot A_2}{A_1 + A_2}$$

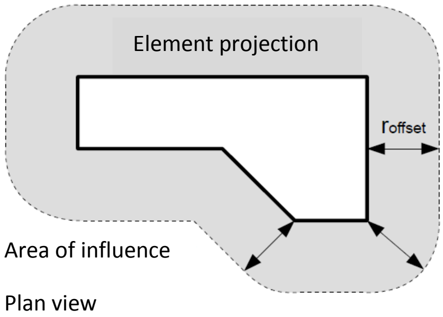


Image 1: Examples of the mean height determination, cross-section

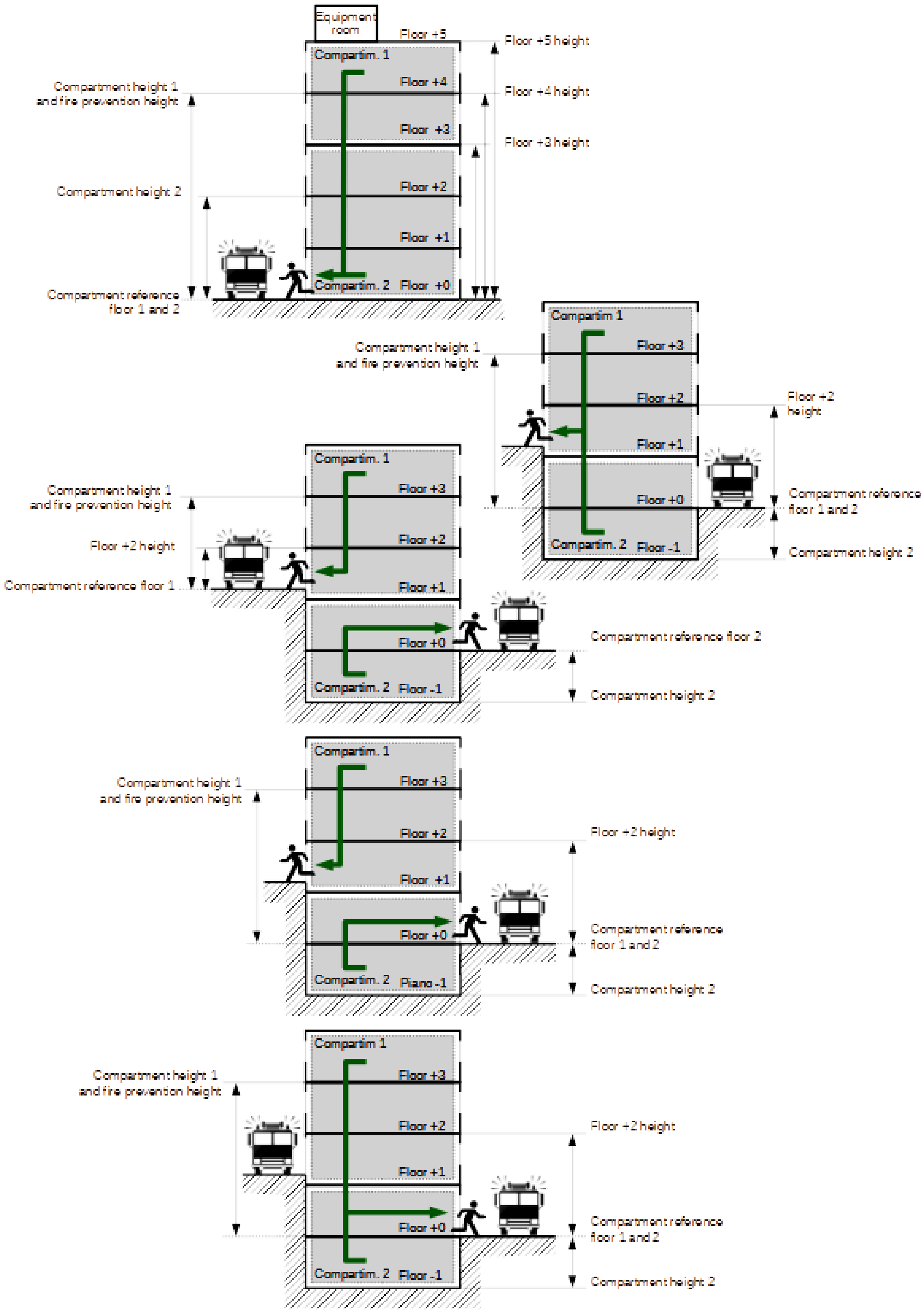


Image: Examples of the determination of the fire prevention height, floor and compartment height, cross-section

G.1.8 Compartmentation (Compartmentalisation)

1. Open-air space: an area outdoors from the construction works with no upper delimitation.
2. Open outdoor space: a space having the characteristics to *temporarily* counteract the spread of fire between any construction works or structures that delimit it.
3. Fire compartment (or compartment): a part of a construction set up to respond to safety requirements in case of fire; it is delimited by construction products or elements suitable to ensure fire resistance for a given time interval. In the event that no compartmentalisation is provided for, the compartment shall be considered the entire building structure.
4. Filter: a fire compartment in which the probability of fire ignition and development is considered negligible, in particular due to the absence of fire ignition points and to the low specific fire load q_f admitted.
5. Protected type (or protected): a qualification of an activity space making up a fire compartment.

Note Examples of the application of the definition: a protected stairway, protected room, protected space, protected route, etc.

Note If not referring to an activity space, the term shall assume other meanings, for example, protected rescuer, protected material, protected load-bearing element, opening protected from obstruction, protected position etc.

6. Smoke-proof type (or smoke-proof): a term indicating the ability of a compartment to limit the entry of smoke generated by fire that develops in a communicating compartment.

Note Examples of the application of the definition: a smoke-proof stairway, smoke-proof space, smoke-proof route, etc.

7. External type (or external): the qualification of a portion of the activity external to the construction works, with the characteristics to temporarily counteract the propagation of fire coming from the construction works.

Note Examples of the application of the definition: an external stairway, external route, etc.

8. Fire gap: a detachment space, appropriately sized for aeration, ventilation or disposal of combustion products, delimited above by open outdoor space and longitudinally delimited by perimeter walls (with or without openings) belonging to the structure served and by embankments or walls from other structures, having equal fire resistance.

G.1.9 Evacuation (Means of egress)

1. Evacuation system: a set of life-saving measures that allow *occupants* to reach a *safe area* or remain safe, independently or with assistance, before the fire leads to *incapacitating* conditions in the areas of activity where they are located.

Note Occupants become *incapacitated* when they become unable to proceed to a safe place due to the effects of the fire (Chapter M.3).

Note The evacuation system consists of *safe areas*, *evacuation routes*, *exits*, *doors*, *emergency lighting*, *signs*, etc.

2. Safe area: a place where the risk of fire for the occupants stationed there or passing through it is *permanently* negligible; this risk relates to a fire in the activity.

3. Temporary safe area: a place where the risk of fire for the occupants stationed there or passing through it is *temporarily* negligible; this risk relates to a fire in specified areas of the activity other than the area in question.
4. Refuge area: *temporary safe area* where occupants may wait for *assistance* to complete their evacuation to a safe area.
5. Crowding: maximum number of possible occupants.
6. Crowd density: the maximum number of assumed occupants per unit of gross floor area for the reference *setting* (persons/m^2).
7. Evacuation route (or emergency route): an unobstructed route of the exit system that allows occupants to reach a safe place from where they are.
8. Horizontal evacuation route: a portion of the evacuation route at a constant height or with a slope ≤ 5 %.

   Note For example: corridors, doors, exits, etc.

9. Vertical evacuation route: a portion of the evacuation route enabling occupants to exit on varying levels with a slope > 5 %.

   Note For example: stairways, ramps, etc.

10. Evacuation stairway: a stairway belonging to the evacuation system.
11. Evacuation ramp: a ramp, also a roadway, belonging to the evacuation system.
12. Evacuation pathway: a part of an evacuation route that leads from the exit of the rooms dedicated to the activity, to the final exit.

    Note The evacuation pathway does not include the rooms dedicated to the activity and consists of corridors, stairways, ramps, halls, walkways, paths, etc.

13. Floor exit: a passage through the evacuation system that leads into a vertical evacuation route from a horizontal evacuation route.
14. Fire exit (or emergency exit): an opening in the reference floor evacuation system, which leads outside to a safe area.
15. Dead-end corridor (or *cul-de-sac*): a portion of the evacuation route from which evacuation can only occur in one direction.

16. Dead-end corridor length: the distance that each occupant must travel along an evacuation route from the point at which they find themselves, to reach:

    a. a point where evacuation in more than one direction becomes possible,

    b. or a *safe area*.

    The dead-end corridor length is assessed with the straight-line method without considering furnishings.

Note Fire along the *dead-end corridor* can prevent occupants from escaping. Since it is not possible to establish the compartment where the fire started in advance, the *dead-end corridor* is independent of any compartments that may be crossed.

17. Evacuation route length: the distance each occupant must travel along an evacuation route from the point at which they find themselves to reach a *temporary safe area* or a *safe area*.

    The evacuation route length is assessed with the straight-line method without considering furnishings.

Note For example, the *evacuation route length* is used to limit the time it takes for occupants to leave any activity compartment where the fire started.

18. Evacuation route unit width (or unit width): quantitative index of the potential of an evacuation route in relation to the activity's R_{life} risk profile. This is normally (conventionally) expressed by the width in millimetres required for a single occupant to evacuate (mm/person).

19. Simultaneous evacuation: evacuation procedure that foresees the contemporaneous movement of the occupants to a *safe area*.

Note Activation of the evacuation procedure immediately follows the detection of the fire or it is deferred until after the occupants have verified the actual ignition of a fire.

20. Evacuation in stages (phased evacuation): an evacuation procedure for a building organised with several fire compartments, where evacuation of the occupants to a *safe area* comes about after evacuation of the compartment where the fire started. This is implemented using active, passive and management *fire protection measures*.

21. Progressive horizontal evacuation: an evacuation procedure that provides for the movement of the occupants from the compartment of initial ignition to an adjacent compartment capable of containing and protecting them until the fire has been extinguished or until a subsequent evacuation to a *safe area* has been completed.

22. In place protection: an evacuation procedure that provides for the protection of the occupants in the same compartment where the fire started.
23. Crowd management: a discipline that deals with systematic planning and supervision of crowd assembly and orderly movement.
24. Crowd crush: an uncontrolled crowd pressure that causes squashing of occupants and danger of asphyxiation.

G.1.10 Fire safety management

1. Fire safety management (FSM): a measure aimed at the management of an activity under safe conditions, both during operations and in an emergency, through the adoption of an organisational structure that provides for roles, tasks, responsibilities and procedures.
2. Safety signs: signs which, in relation to a specific object, activity or situation, provide a safety indication or requirement and which use, as appropriate, wording, colour, light or a sound signal, verbal communication or a hand signal.

G.1.11 Construction works and products

1. Construction works: civil and industrial buildings and works.
2. Construction product: any manufactured product or kit put on the market to be permanently incorporated in construction works or in their parts and whose performance bears on the performance of those construction works with respect to their basic requirements.
3. Intended use: the intended use of a construction product as defined in the applicable harmonised technical specifications.
4. Construction element: a part or element of construction works, comprising one or more construction products.
5. Kit: a construction product put on the market by an individual manufacturer as a combination of at least two separate components, which must be assembled to be installed in the construction works.
6. Essential characteristics: the characteristics of the construction product that refer directly to the basic requirements of the construction works as defined in the CPR.
7. Construction product performance: the product's performance in relation to its pertinent essential characteristics, expressed in terms of level, class or by description.
8. Field of direct application of test results: the scope, provided for by the specific test method and included in the classification report, of the use limitations and possible modifications that might be made to the sample that passed the test, such that no further assessments, calculations or approvals for assignment of the result are required.
9. Field of extended application of test results: the scope, not included among that provided for by the field of direct application of test results, defined by specific extension standards.
10. Test laboratory: a laboratory, notified to the EU Commission, that performs tests on products with specific requirements, for the purpose of awarding CE marks, as concerns the CPR; DCPST (Direzione Centrale per la Prevenzione e la Sicurezza Tecnica) [Central Direction for Technical Safety and Prevention] laboratories and the Italian laboratories authorised pursuant to the Ministry of the Interior Decree of 26th March 1985; laboratories in one of the European Union Member States or signatories of the Agreement on the European Economic Area (EEA) or Turkey, whose independence and expertise have been recognised as provided for by the EN ISO/CEI 17025 standard or equivalent guarantee recognised in one of the same States.
11. Key element: the stability of this element is the foundation of the stability of the remaining structural aggregate. Collapse of a key element will cause what is considered disproportionate structural damage.
12. Robustness: the capability of a structure to resist exceptional actions (e.g. explosion, etc.) without incurring disproportionate damage with respect to the cause.

G.1.12 Fire resistance

1. Fire resistance: one of the *fire protection measures* to be pursued to guarantee an appropriate level of safety for construction works in fire conditions. This concerns the load-bearing capability in case of fire, of a structure, a part of a structure or a structural element, as well as the capacity for compartmentalisation in case of fire for the structural separation elements (e.g. walls, ceilings, etc.) and non-structural elements (e.g. doors, partitions, etc.).
2. Load-bearing capability in case of fire: the capability of a structure, a part of a structure or a structural element, to maintain sufficient mechanical resistance during a fire, also considering other acting actions.
3. Compartmentalisation capability in case of fire: the ability of a constructional element to retain, under the action of fire, sufficient thermal insulation and a sufficient seal against smokes and hot combustion gases, as well as all other performance levels as required.
4. Fire load: the potential net heat of the totality of the combustible materials contained in a space, adjusted on the basis of the indicative parameters of the participation in the combustion of the individual materials. Restricted to the timber structural elements, it is possible to consider the contribution by taking into account the fact that these must also ensure consequent fire resistance. This contribution shall be determined using consolidated interpretation criteria for the phenomena. Fire load is expressed in MJ. Conventionally, 1 MJ is assumed to be equal to 0.057 kg of timber or equivalent.
5. Specific fire load: the fire load referred to the gross floor area unit. This is expressed in MJ/m^2.
6. Specific design fire load: the specific fire load corrected based on the fire risk indicator parameters of the fire compartment and the factors concerning the *fire prevention measures* present. This makes up the reference levels for the assessment of fire resistance of construction works.
7. Fire resistance class: the time interval expressed in minutes, defined based on the specific design fire load, during which the fire compartment ensures resistance to fire. It refers to a nominal fire curve.
8. Conventional design fire: a fire defined through a temperature–time fire curve that represents the variation, over time, of the mean temperature of the combustion gas in the vicinity of the surface of the structural element. The design temperature–time fire curve can be:
   a. nominal: a curve adopted for the classification of construction works and for fire resistance checks of the conventional type;
   b. natural: a curve determined on the basis of models of fire and on the physical parameters that define the state variables within the fire compartment.
9. Localised fire: an outbreak of fire involving a limited area of the fire compartment, with the development of heat concentrated in proximity of the structural elements placed above the outbreak or immediately adjacent.
10. Technical file (for fire resistance): document prepared by the manufacturer in case of variations of the classified construction product or element, not provided for by the direct field of application of the test result.

11. Non-load-bearing construction elements: structural elements, which, in the combination of exceptional loads for fire prevention structural tests, just as in the NTC, are subject only to their own weight and the thermal action caused by exposure to fire. Those elements that combine to define the structural analysis method (e.g. fixed-joint frame vertical braces) are excluded.
12. Main structural elements: structural elements whose collapse due to fire would compromise at least one of the following capabilities:
    a. load-bearing capacity of other structural elements in the structure during a fire;
    b. effectiveness of compartmentalisation of structural elements;
    c. operation of active fire protection systems;
    d. safe evacuation of the occupants;
    e. safety of the rescuers.
13. Secondary structural elements: all *non-main* structural elements.

G.1.13 Reaction to fire

1. Reaction to fire: one of the *fire protection measures* to be pursued to guarantee an appropriate level of safety in fire conditions and in particular during the initial propagation of the fire (*pre-flashover*). This expresses the behaviour of a material that, with its decomposition, participates in a fire to which it has been subjected under specific conditions.
2. Fire reaction class: the level of participation of a material (or product) in a fire to which it has been subjected. The class is assigned subsequent to normalised tests used to assess specific parameters or characteristics, which are combined to determine the level of participation in the fire.
3. Material: the component or components, variably associated, which may participate in the combustion, depending on their chemical nature and on the actual conditions of their installation/application for final use.
4. Non-combustible material: material that does not participate or that contributes in an insignificant manner to the fire, regardless of its final use conditions.
5. Insulation material: a product marketed as such, identifiable by its trade name.
6. Insulating component: in insulation materials, this is the element, or the set of elements, which have the specific function of insulating.
7. *End-use condition*: the actual application or implementation of a product or material, in relation to all aspects that influence the behaviour of said product under different fire conditions. This includes features such as orientation, position in relation to other adjacent products (type of substrate, formation of a cavity with a substrate, etc.) and the attachment method (glued, mechanically attached or merely in contact).

G.1.14 Active protection

1. Active fire protection installation or system: a fire detection and fire alarm system, extinguisher systems or fire control systems or fire inhibition systems, whether automatic or manual, and smoke and heat control systems.
2. Fire detection and alarm system (FDAS): A system capable of, as quickly as possible, detecting fire and triggering an alarm in order to activate technical firefighting measures (automatic fire control or extinguishing systems, compartmentalisation, smoke and heat exhaust, etc.) and procedural firefighting measures (emergency and evacuation plans and procedures) designed and programmed in relation to the fire detected and the area where the initial fire begins and develops with respect to the entire activity being monitored. Such a system may include voice transmission systems for emergency alarms.
3. Fire control or extinguishing or inhibition system (automatic or manual): a firefighting system capable of delivering an extinguishing agent based on appropriate configurations or of inhibiting the fire.
4. Smoke and heat evacuation system: (SHES): an installation or system intended to ensure the controlled evacuation of smoke and hot gases in case of fire.
5. Forced horizontal ventilation system (FHVS): a system or installation designed to ensure, in the event of fire, the controlled mechanical disposal of smoke and hot gases.
6. Hydrant systems (HS): a manually operated fire-extinguishing system designed to counteract the effects of fire and capable of delivering water from appropriate dispensing devices.
7. HS dispensing device (or dispenser): a firefighting device permanently connected to a fixed set of pipes, used to deliver water, such as above-ground, underground and wall hydrants and standpipes.
8. Fire department pumper truck delivery connection: a device made up of at least one shut-off valve and one non-return valve, equipped with one or more unified fittings for flexible fire hoses. This provides auxiliary water supply for the firefighting system.
9. Fire extinguisher (or extinguisher): an apparatus containing a fire-extinguishing agent which, due to internal pressure, may be sprayed onto a fire.
10. Fire extinguishing capacity of an extinguisher (or extinguishing capacity): an alphanumeric symbol indicating the capacity of a fire extinguisher to extinguish standard fires under conditions set out by test standards, which characterise their conventional firefighting performance.
11. Emergency vocal alarm system (EVAS): a system primarily designed for the vocal dissemination of information to safeguard human life during an emergency.
12. System specifications: a summary of the technical data that describes active protection system performance, its size characteristics (e.g. specific capacities, operational pressures, extinguishing agent supply characteristics, detailed system layout, etc.) and the specifications of the components to be used for its manufacture (e.g. pipes, hoses, dispensers, sensors, extinguishing agent reserves, evacuation openings, flow openings, etc.). The specifications include references to the design standards to be applied, the classification of the hazard level as required, a block diagram and the operational diagrams of the system to be

implemented, as well as the certification of suitability in relation to the fire hazard present in the activity.

Note Generally, the standards adopted by the national standards body contain the minimum indications of the contents of the documentation for the preliminary phase and the final design phase of an active protection system; the minimum contents of the system specifications may be the same as those required by the technical standard applied in the preliminary design phase.

13. Substantial change to the system: a conversion of the original type of active fire protection system or extension of its size to more than 50 % of the original, unless otherwise defined by specific regulations or standards.

14. Original system type: the nature of the active fire protection system or extinguishing agent used.

15. Typical system size:

    a. for the hydrant system, the provisions of the standard adopted by the National Standards Board apply;

    Note The non-exhaustive list of standards adopted by the national standards body can be found in Section S.6.12..

    b. for fire detection and fire alarm systems, this refers to the number of automatic detectors or manual alarm points;

    c. for extinguishing or control systems, this refers to the number of dispensers;

    d. for special extinguishing systems (gas, foam, powder, …), this refers to the quantity of the extinguishing agent;

    e. for smoke and heat control systems, this refers to the total available evacuation area for natural evacuation systems and the extracted volumetric flow rate for forced evacuation systems.

16. Industry standard: the stage of development reached, at a given moment in time, by the technical capabilities of products, processes or services, based on proven scientific, technological or experimental results. Subject to compliance with the applicable legislative and regulatory provisions, a presumption of ‘industry standard’ is recognised, in practice, in the standards adopted by national, European or international standardisation bodies.

17. System design: a set of documents indicated by the standard used as reference for the design of a new active fire protection system or a substantial modification of an existing system. The design must include, in the absence of specific indications of the standard, at least the diagrams and planimetric drawings of the system, as well as a technical report including the design calculations, where applicable, and the description of the system, with particular attention to the type and characteristics of the materials and components to be used and the performance to be achieved.
18. System maintenance manual: documentation, written in Italian, which includes the necessary instructions for the correct management of the active fire protection system and for the efficient maintenance of its components. The manual must be prepared by the system installation company, also utilising the data supplied by the manufacturers of the installed components, and delivered to the user.
19. System or installation with higher availability: a system or installation with a higher level of *availability* than the minimum required by the reference standards of the system or installation.

Note The definition of *availability* is provided in the UNI EN 13306 standard. The procedures for designing and implementing systems or installations with higher availability are described in Chapter G.2.

G.1.15 Firefighting operations

1. Dry standpipe: firefighting device used by the fire service, consisting of a rigid metal pipe running vertically through the buildings, normally within each of the vertical evacuation routes.
2. Access floor for rescuers: the floor of the external area from which rescuers access the construction works. The determination of access floors for rescuers shall be noted in the design.
3. Access route to floors for rescuers: a route leading from the access floor for rescuers to one or more entrances on each floor of the construction works of the activity. The selected entrances must allow for the rescuers to reach all areas of the activity.

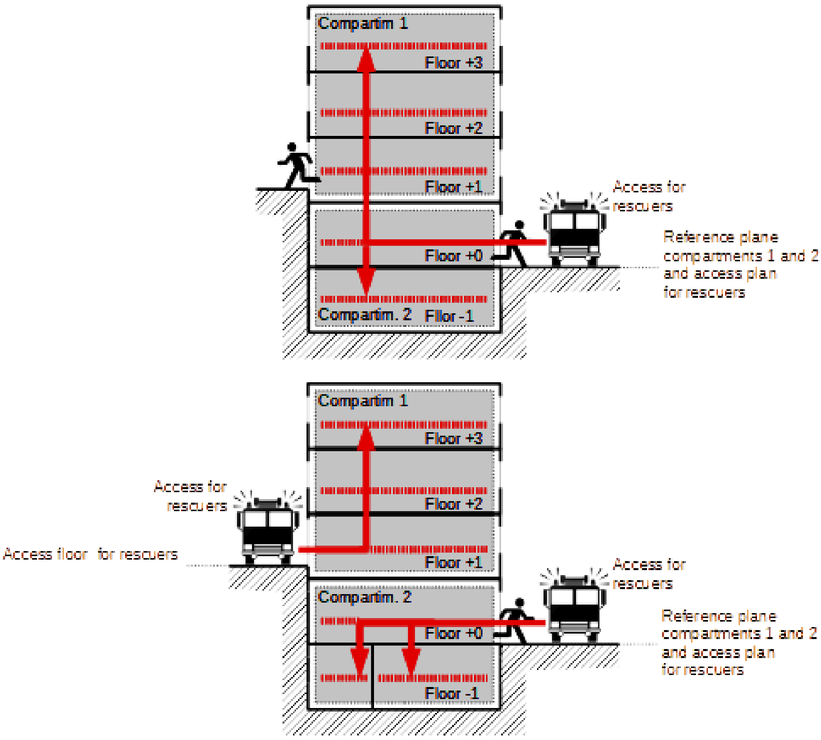


Illustration G.1-4: Access routes to floors for rescuers (solid lines), the floor entrances allow rescuers to reach all the rooms (dotted lines)

G.1.16 Specific risk areas

1. Specific risk area: a setting of the activity characterised by a fire risk that is substantially different from that typical of the activity.

Note The identification of specific risk areas shall be made by the designer based on the criteria in Chapter V.1 or shall be set out in the vertical technical regulations.

G.1.17 Hazardous substances and mixtures

1. Hazardous substance or mixture: a substance or mixture classified as hazardous pursuant to Regulation (EC) No 1272/2008 on classification, labelling and packaging (CLP) of substances and mixtures.

G.1.18 Explosive atmosphere

1. Explosion: a rapid oxidation or decomposition reaction that produces an increase in temperature, pressure or both simultaneously.
2. Explosive atmosphere: a mixture of inflammable substances, whether gas, vapour, mist, or dust with air, under atmospheric conditions, which once ignited propagates the combustion of the remainder of the mixture not yet burnt.
3. Limit of oxygen concentration (LOC), also known as *Minimum Oxygen Concentration* (MOC): represents the oxygen concentration limit in an explosive atmosphere under which combustion will not occur, regardless of the concentration of the combustible substance.
4. Vent: a non-structural portion of a construction works or structural system with the function of limiting overpressure to limit structural damage.
5. Venting: is the strategy of reducing damage from explosion by using vents.
6. Normal operation: this is the status in which equipment, protection systems and components are operating within each of their respective design parameters.

   Note Minimal emissions of flammable material may be part of a normal operation. For example, the release of substances from seals based on the humectant action of the fluid being pumped is considered minimal emissions. Malfunctions that require repair or stopping (e.g. breakage of the fittings in a pump, gaskets or flanges or the leak of substances caused by accidents) are not considered normal operation.

7. Malfunction (disfunction): the state in which equipment, protective systems or components do not perform their intended function.

   Note A malfunction may occur due to several reasons, for example: the change of a feature or a dimension of material or a piece being processed, the breakage of one or more basic elements in equipment, protection systems or components, due to external effects (e.g. impact, vibrations, electromagnetic fields), due to a design error or an imperfection (e.g. software errors), due to a disturbance in the power supply or other utilities; due to operator error (especially for manually operated machines).

8. Expected malfunction: a malfunction (breakdown or disturbances) of equipment that are normal occurrences.
9. Rare malfunction: a type of malfunction that is known to occur, but only rarely.

Note For example, two expected and independent malfunctions, which separately would not create any ignition hazard but in combination would create an ignition hazard are considered a single rare malfunction.

G.1.19 Electrical power supplies

1. Emergency power supply: a safety power supply or reserve power supply.
2. Safety power supply: an electrical system designed to ensure the power supply of consuming equipment or parts of the electrical system required for the safety of persons.

Note The safety power supply is necessary to power systems that are significant for the management of fire safety and emergencies, such as emergency lighting, fire pumping units, smoke extraction systems, electrical systems for restoring compartments, systems for detecting dangerous substances or mixtures, firefighting lifts, etc.

Note Safety systems and systems equipped with safety power supplies are normally powered by an ordinary power source which, in the event of unavailability or in emergency situations, is automatically replaced by the safety power source.

3. Reserve power supply: an electrical system designed to ensure the power supply of consuming equipment or parts of the system for reasons other than the safety of persons.

G.1.20 Lifts

1. Firefighting lift: is a lift installed mainly for passenger use but provided with additional protection, controls and signals making it able to be used directly under the control of the fire service in case of fire.
2. Note For example, the firefighting lift may be used also in case of fire for the assisted evacuation of occupants with reduced or impaired mobility capacities.
3. Rescue lift: a lift that may be used in case of fire, installed only for transport of firefighting equipment and, as required, for the emergency evacuation of occupants.
4. Protected atrium: a compartment protected from the fire that provides protected access to the firefighting lifts from the building's use area.

G.1.21 Fire safety engineering

1. Fire safety engineering, FSE: application of engineering standards, rules and expert judgments based on scientific assessment of the phenomenon of combustion, the effects of fire and human behaviour, aimed at the protection of human life, property and the environment, the quantification of fire risk and its relevant effects and the analytical assessment of the best fire prevention measures required to limit the consequences of fire, within pre-established limits, based on the indications in Chapter M.1.
2. Fire scenario: a complete and unique description of the development of the fire as concerns three fundamental aspects: fire, activity and occupants.
3. Design fire scenario: a specific fire scenario in relation to which the application of fire safety engineering methods is conducted.
4. ASET (*available safe escape time*): a time interval calculated between the ignition and the moment when environmental conditions in the place of activity become such as to render the occupants *incapable* of evacuating to or reaching a safe area.
5. RSET (*required safe escape time*): a time interval calculated between the ignition and the moment when the occupants in the structure reach a safe place.
6. PTAT (*pre-travel activity time*): the time used by the occupants for activities undertaken prior to movement toward evacuation.

G.1.22 Tolerances

1. Tolerance: the difference in absolute value between the measurements made on site and the corresponding design measurements.

Note e.g. space design width 120 cm, space as built 122 cm, tolerance 2 cm. *Tolerance* should not be confused with the *precision* of the instrument used for measurements. By definition, tolerance cannot yet be used at the design stage.

2. Permissible tolerance: the value of the permissible tolerance established by a technical standard or regulation, or in the absence, of the designer.

3. Permissible tolerance values: except for specific indications from standards, technical specifications or regulations, the permissible tolerances for different types of measurements, for application of this document, can be found in Table G.1-1

Measured values		Permissible tolerance
Length [1], [2]	≤ 2.40 m	±5 %
	for the portion longer than 2.40 m	±2 %
Floor areas, volumes, lighting, time, mass, temperature, capacity [1]		±5 %
Pressure [1]		±5 %
[1] The values are those defined in the international measurement system. [2] The values of the permissible tolerance also apply to linear measurements that contribute to the determination of the slope of ramps.		

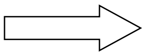
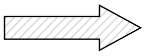
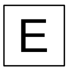
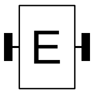
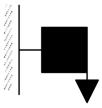
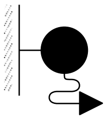
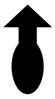
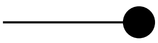
Table 1: Permissible tolerances for measured values

G.1.23 Graphic symbols

1. In the preparation of technical documents, the designer uses the graphic symbols of the UNI EN ISO 7010 standard, or those contained in Tables G.1-2 and G.1-3. These symbols may be supplemented by more detailed indications, useful for the definition of specific firefighting aspects.

Note For example: the working dimensions of doors, the presence of electromechanical restraints, k coefficients of the dispensers, type of door opening devices, type of fire detectors, sensor activation temperatures, types of automatic activation dispensers, etc.

2. If necessary, other symbols may be used for elements that are considered significant for fire safety. These symbols must be clearly defined in a key included in the technical documents.

Type	Symbol	Description
Construction elements and relative openings		Fire-resistant door. For these doors, the protrusion indicates the direction of opening [1].
Distancing		Separation distance [2]
Evacuation routes		Portion of the evacuation route going upwards
		Portion of the horizontal evacuation route
		Portion of the evacuation route going downwards
Extinguishers		Portable extinguishers [3]
		Wheeled fire extinguishers [3]
Firefighting plumbing system		Standpipe Hose reel
		Wall hydrant
		Below-ground hydrants [4]
		Above-ground column hydrants [4]
		Pumper truck delivery connection [5]

[1] The fire resistance class shall be indicated next to the graphic symbol (e.g. EI 120-S_a)
[2] Using colours, specify whether the safety distance is also external or internal
[3] Next to the graphic symbol, the extinguisher's class must also be indicated.
[4] Next to the graphic symbol, the diameter and number of outlet connections must also be indicated.
[5] Next to the graphic symbol, the number of inlet connections must also be indicated.

Table 2: Graphic symbols

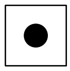
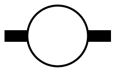
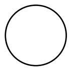
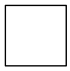
Type	Symbol	Description
Signal system		Alarm button
		Fire detector (or detector) [1]
Fixed extinguishing systems		Automatic extinguisher system dispenser [2]
		Manual extinguisher system dispenser [2]
[1] The symbol for the type of detector must be found inside of the circle [2] The symbol for the extinguishing agent must be found inside of the circle and the square (to be referred to in the key)		

Table 3: Graphic symbols

G.1.24 Codes

1. The following codes have been adopted in the document.
2. ASET: *Available safe egress time*.
3. ATEX: Explosive atmosphere.
4. EC: European Community.
5. CPD: Construction products directive. Council Directive 89/106/EEC of 21 December 1988.
6. CFD: Computational fluid dynamics.
7. CPR: Construction products regulation. Directive (EU) 305/2011 of the European Parliament and of the Council of 9 March 2011.
8. DCPST: Central Directorate (Direction) for Prevention and Technical Safety of the Italian National Fire, Rescue and Civil Defence Service of the Ministry of the Interior.
9. RAD: Risk assessment document pursuant to Legislative Decree No 81 of 9th April 2008, *Consolidated act on health and safety in the workplace*.
10. IRAD (DUVRI): Interference risks assessment document pursuant to Legislative Decree No 81 of 9 April 2008, *Consolidated act on health and safety in the workplace*.
11. EAD: European assessment document.
12. ESFR: *Early suppression fast response*, sprinkler system with the ability to suppress fire.
13. EVAS (EVAC): Emergency vocal alarm system.
14. FED: Fractional effective dose.
15. FEC: Fractional effective concentration.
16. FSE: Fire safety engineering.
17. LNG: Liquefied natural gas.
18. LPG: Liquefied petroleum gas.
19. FSM: Fire safety management.
20. FDAS: Fire detection and alarm system.
21. LEL: Lower explosive limit.
22. LOC: Limit oxygen concentration.
23. MIE: Minimum ignition energy.
24. MOC: Minimum oxygen concentration.
25. NAD: National application document for Eurocodes represented for Italy by the Decree of the Ministry of Infrastructure of 31 July 2012.
26. NFPA: National fire protection association.

27. NTC: Decree of the Minister for Infrastructure and Transport of 17 January 2018, *Construction technical standards*.
28. PTAT: Pre-travel activity time.
29. RHR (or HRR): Rate of heat released (or Heat released rate). Function expressing the temporal performance of the thermal potential released by the fire.
30. HS/HN (RI): Hydrant system/Hydrant Network.
31. RSET: Required safe egress time.
32. VTR: Vertical technical regulation.
33. HTR: Horizontal technical regulation.
34. EEA: European Economic Area.
35. SHES: Smoke and heat extraction system.
36. FSHES: Forced smoke and heat extraction system.
37. NSHES: Natural smoke and heat extraction system.
38. SPK: Sprinkler system.
39. FHVS: Forced horizontal ventilation system.
40. TAB: Technical assessment body.
41. TS: *Technical specification*.
42. TR: *Technical report*.
43. EU: European Union.
44. UEL: Upper explosive limit.

G.1.25 Language

1. The following language is used in this document.
2. With the modal verb '*must*' and the modal use of '*shall*' with other verbs (e.g. '*the height shall be...*') the mandatory requirements to be applied in the context examined are described.
3. With the conditional modal verb '*should*' and the adverbs '*generally*' and '*normally*' non-mandatory indications enabling designers to choose different technical procedures from that indicated in the context examined are described; these different procedures must be analysed and described in the design documentation.
4. With the modal verb '*may*' or '*can*' (e.g. '*may/can be installed*') appropriate assessments or additional technical procedures that are considered effective in the context examined are being suggested, also for the purpose of the assessment of equivalent safety measures.
5. The conjunction '*and*' is used to connect two conditions that must be contemporaneously valid (equivalent to the logical operator *AND*).
6. The conjunction '*or*' is used to connect two conditions that may be either contemporaneously or alternatively valid (equivalent to the logical operator *OR*).
7. In cases where one condition must necessarily exclude the others (e.g. '*or the one or the other*', equivalent to the logical operator *XOR*), this shall be explicitly signalled in the text.
8. The noun '*example*' or its abbreviation '*e.g.*' is used to indicate one or more possibilities for the mere purpose of indicating practical applications of a rule or principle. The examples are therefore to be considered as indicative, non-exhaustive cases, provided merely as an illustration and are not prescriptive.
9. The application of the voluntary regulations referred to in this document (e.g. ISO, EN, UNI, etc.) confers presumption of conformity, but remains *voluntary* and is not *mandatory*, unless it is made mandatory by other regulatory provisions.
10. The notes in this document are explicative or complementary in the contest examined.

G.1.26 Analytic index

1. The page numbers of this chapter containing the definitions of the individual items are provided below.

Chapter G.2 Fire safety design

G.2.1 Objectives and general principles (of the document)

1. This document sets out fire safety design methods aimed at achieving the *primary objectives* for fire prevention.
2. The design solutions provided for by the fire safety design methods in this document align the Italian legislative perspective with recognised international fire prevention standards.
3. The general layout of this document is based on the following principles:
   a. *general information*: the same fire safety design methods described may be applied to *all* activities;
   b. *simplicity*: where there are different possibilities to achieve the same result, the simpler more easily achievable and more comprehensible solution, making maintenance also easier, shall be given priority;
   c. *modularity*: the complexity of the issue is broken down into easily accessible modules, which guide the design engineer toward the creation of appropriate design solutions for specific activities;
   d. *flexibility*: for each fire safety performance required by an activity, there will always be many proposed design solutions that are *prescriptive* or *performance based/orientated*. Furthermore, recognised methods shall be defined so that designers can independently conceive and demonstrate the validity of specific alternative design solutions in compliance with fire safety objectives;
   e. *standardisation and integration*: the fire safety and prevention language complies with international standards. The provisions deriving from pre-existing Italian fire safety and prevention documents have also been integrated;
   f. *inclusion*: various disabilities (e.g. motor, sensory, cognitive, etc.), temporary or permanent, of the persons who frequent the activities (occupants) shall be considered an integral part of the fire safety design;
   g. *empirically based content*: this document is based on research, assessment and systematic use of the results from national and international scientific research in the field of fire safety;
   h. *updatable*: this document has been drafted in a format that is easily updated so that it can keep up with the continuous advances in technology and knowledge.

G.2.2 Field of application

1. This document shall apply to the design, realisation and management of fire safety for the activities set out in this decree.
2. This document is applicable to *new* and *existing* activities.

G.2.3 Fundamental assumptions

1. The technical contents of this document are based on the following *fundamental assumptions*:
   a. Under ordinary conditions, a fire in an activity will start at just one point of ignition.
   b. The fire risk in a given activity cannot be *reduced to zero*.

      The *fire safety* prevention, protection and management measures provided for in this document have therefore been selected to minimise the risk of fire, in terms of probability and consequences, within limits *considered* acceptable.

Note It is therefore assumed that in activities designed, implemented and managed according to the fire safety instructions and methods in this document, the residual fire risk is considered acceptable.

G.2.4 Document structure

1. This document consists of four sections, which together cover the issue of fire safety:
   a. General information section G: contains the fundamental principles of fire safety design applicable to all activities without distinction;
   b. Fire prevention strategy section S: provides (contains) the fire safety prevention, protection and management measures applicable to all activities, in order to create the *fire prevention strategy*, to reduce (mitigate) the risk of fire;
   c. *Vertical technical regulations* section V: contains the vertical technical regulations, which supplement, integrate or replace the measures in the previous section S for specific technical applications or certain types of activities.
   d. Methods section M: provides (contains) the description of the *quantitative* design methodology aimed at the resolution of specific technical problems in the defined activity.

G.2.5 Objectives of fire safety design

1. Designing the fire safety of an activity means identifying the technical and management solutions aimed at achieving the *primary objectives* of fire prevention, which are:
   a. safety of human life,
   b. protection of people,
   c. protection of property and the environment.
2. The primary objectives of fire prevention are considered to be achieved if the activities have been designed, implemented and managed in such a way as to:
   a. minimise the causes of fire and explosion;
   b. guarantee the stability of the load-bearing structures for a set period of time;
   c. limit the production and propagation of fire within activities;
   d. limit the spread of fire to adjacent activities;

e. limit the effects of an explosion;
f. ensure that the occupants can leave the activity safely or that they be rescued in another manner;
g. ensure that the firefighter/rescue squads are able to work under safe conditions;
h. protect historically or artistically significant buildings;
i. ensure business continuity in strategic works;
j. prevent environmental damage and limit any compromise of the environment in case of fire.

Note As specified in Chapter G3 of which buildings are to be considered *historically or artistically significant* and which works are to be considered *strategic* is left to specific regulatory acts or at the express request of the activity manager.

G.2.6 General methodology

Note This general methodology is applied to all activities, even if relevant *vertical technical regulations* are available (Section V).

1. The design of fire safety for activities is an iterative process, consisting of the following steps:
   a. *scope of the design*: the activity and its operation are described qualitatively and quantitatively in order to clarify the scope of the design;

   Note For example, the description of the activity may include: location and context, purpose, constraints, organisational structure and responsibilities, type and quantity of occupants, production processes, construction works, facilities, type and quantity of materials stored or used, etc.

   b. *safety objectives*: the safety objectives of the design provided for in Section G.2.5, applicable to the activity, shall be specified;

   Note For example, there is no need to protect buildings that are not *historically or artistically significant*, or to ensure business continuity for works that are not considered *strategic*.

   c. *risk assessment*: the fire risk assessment referred to in Section G.2.6.1 shall be carried out;
   d. *risk profiles*: risk profiles shall be determined and assigned, as provided for in Section G.2.6.2;
   e. *fire prevention strategy*: risk mitigation is carried out through preventive, protective and management measures that remove hazards, reduce risks or protect against their consequences:
      i. defining the overall *fire prevention strategy*, in accordance with Section G.2.6.3.,
      ii. attributing *performance levels* for all fire prevention measures as provided for in Section G.2.6.4;
      iii. identifying the *design solutions* that guarantee the achievement of the assigned performance levels, in accordance with Section G.2.6.5;
   f. if the *result* of the design is not considered compatible with the *purpose* defined in point a), the designer shall iterate the steps referred to in point e) of this methodology.

2. Where available, the designer shall apply the contents of the relevant *vertical technical regulations* to the activity concerned, as indicated in the following sections.

Note The general methodology is outlined in illustration .

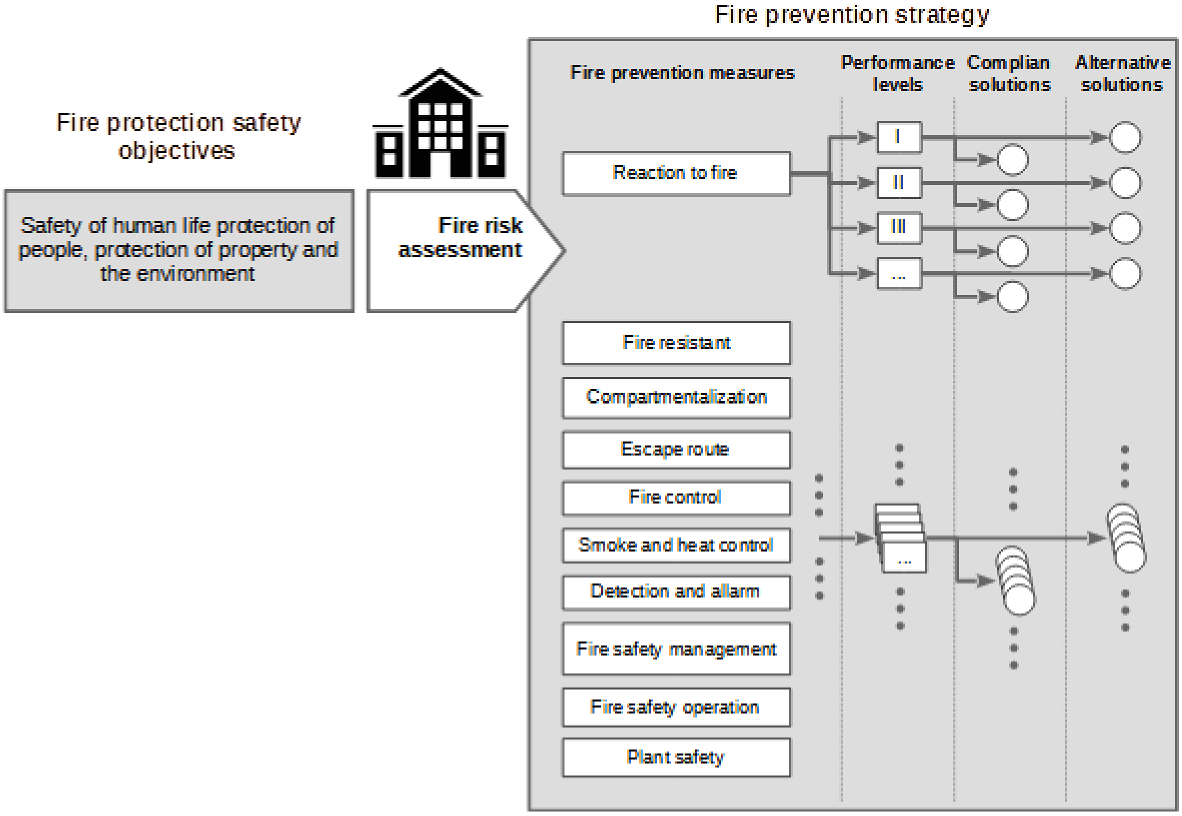


Image 2: Schematic of the general methodology

G.2.6.1 *Fire risk assessment for the activity*

1. The designer shall use an industry standard method for assessing fire risk, depending on the complexity of the activity being handled.

Note The fire risk assessment represents an analysis of the specific activity, aimed at identifying the *most severe but credible* fire scenarios and the corresponding consequences for occupants, property and the environment. This analysis allows the designer to implement and, if necessary, integrate the design solutions provided in this document.

2. In any case, the fire risk assessment shall cover at least the following topics:

   a. identification of fire hazards;

Note For example, the following are assessed: ignition sources, combustible or flammable materials, fire loads, ignition-fuel interaction, any significant quantities of mixtures or hazardous substances, processes that may lead to fires or explosions, possible formation of explosive atmospheres, …

   b. description of the context and environment in which the hazards may be found;

Note Examples include: accessibility and viability conditions, company layout, distances, separations, isolation, building characteristics, type of construction, geometrical complexity, volume, surface areas, height, underground levels, plan-volumetric articulation, compartmentalisation, ventilation and surface areas available for the extraction of smoke and heat, etc.

   c. determination of the quantity and type of occupants exposed to the risk of fire;

   d. identification of property exposed to the risk of fire;

   e. qualitative or quantitative assessment of the consequences of the fire on occupants, property and the environment;

   f. identification of preventive measures which can remove or reduce the hazards which give rise to significant risks.

3. Where relevant *vertical technical regulations* are available, the assessment of fire risk by the designer shall be limited to the peculiar aspects of the specific activity concerned.

4. In areas of activity where *inflammable substances* are present in the form of combustible gases, vapours, mists or dusts, the fire risk assessment shall also include the risk assessment for *explosive atmospheres* (Chapter V.2).

G.2.6.2 *Assignment of risk profiles*

1. After assessing the fire risk for the activity, the designer shall assign the following three types of *risk profiles*:

   R_{life}, *risk profile* concerning *human life* safety;

   R_{prop}, *risk profile* concerning the protection of *property*;

   R_{env}, *risk profile* concerning the protection of the *environment* from the effects of fire.

Note Risk profiles are *expeditious* and *synthetic indicators* of the type of risk present in the areas of activity and are not substitutes for the detailed assessment of fire risk conducted by the designer pursuant to the indications in Section G.2.6.1.

2. Chapter G.3 provides the designer with:

   a. the methodology for quantitatively *determining* R_{life} and R_{prop} risk profiles,

   b. criteria for *assessing* the R_{env} risk profile.

G.2.6.3 Fire prevention risk mitigation strategy

1. The designer mitigates the risk of fire by application of an appropriate *fire prevention strategy* consisting of fire prevention, protection and management measures.
2. In this document, the *fire prevention*, protection and management measures referred to in paragraph 1 are uniformly grouped in the chapters included in the fire prevention strategy section.
3. For each *fire prevention measure* there are different *levels of performance*, graduated according to the increasing complexity of the expected performance and identified by Roman numerals (e.g. I, II, III, etc.)
4. The designer shall apply all *fire prevention measures* to the activity, establishing for each, the relevant *performance levels* in relation to the *safety objectives* to be achieved and the *risk assessment* of the activity.

G.2.6.4 *Assignment of performance levels to fire prevention measures*

1. Once the fire *risk assessment* for the activity has been carried out and the R_{life}, R_{prop} and R_{env} risk profiles are established in the relevant areas (Chapter G.3), the designer shall assign the relevant *performance levels* to the fire prevention measures.
2. Each chapter of the fire prevention strategy section provides the designer with the assignment criteria for the *performance levels* for *fire prevention measures*.
3. Where available, a number of the *performance levels* to be assigned by the designer to the activity in relation to its characteristics (e.g. number of occupants, floor level, quantity of dangerous substances and mixtures, etc.) may be defined in the relevant *vertical technical regulations*.
4. For each *fire prevention measure*, the designer may assign different *performance levels* than those proposed in this document.

   If the assigned levels are lower than those proposed, the designer shall be required to demonstrate that the fire safety objectives have been achieved by using one of the *fire safety design methods* provided for in Section G.2.7.

   To enable the assessment of this demonstration by the National Fire Service, it is only permitted to attribute different performance levels from those proposed in *activities with design assessment*.

Note The definition of *activity with design assessment* can be found in Chapter G.1 and includes, in addition to activities with *ordinary* assessment, also those with the possibility of assessment *in derogation*.

G.2.6.5 *Identification of design solutions*

1. For each *performance level* of each fire prevention measure there are different *design solutions*. Application of one of the *design solutions* shall guarantee the achievement of the required *performance level*.
2. Three types of *design solutions* have been defined:
   a. *deemed-to-satisfy solutions*;
   b. *alternative solutions;*
   c. *solutions in derogation.*

Note The definitions of *compliant*, *alternative* and solutions in *derogation* can be found in Chapter G.1.

3. Where available, any *design solution* that complements or replaces those detailed in the fire prevention strategy section, or simple additional requirements for the specific type of activity, may be described in the relevant *vertical technical regulations*.
4. The designer may always choose the most suitable design solution for the type of activity.

G.2.6.5.1 Application of deemed-to-satisfy solutions

1. The designer using *deemed-to-satisfy solutions* is not required to provide further technical assessments to demonstrate the achievement of the related *performance level*.

2. *Deemed-to-satisfy solutions* are only those proposed in the relevant parts of the *fire prevention strategy* section and the *vertical technical regulations*.

G.2.6.5.2 Application of alternative solutions

1. The designer may make use of the *alternative solutions* proposed in the relevant parts of the *fire prevention strategy* section and the *vertical technical regulations*, or may propose specific *alternative solutions* using the methods set out in the following point.
2. The designer using *alternative solutions* shall demonstrate the achievement of the related *performance level* by using one of the *fire safety design methods* allowed for each fire prevention measure under Section G.2.7.
3. To enable the assessment of this demonstration by the National Fire Service, it is only permitted to use alternative solutions from those proposed in *activities with design assessments*.

Note The definition of *activity with design assessment* can be found in Chapter G.1 and includes, in addition to activities with *ordinary* assessment, also those with the possibility of assessment *in derogation*.

G.2.6.5.3 Application of solutions in derogation

1. If neither *deemed-to-satisfy*nor *alternative* solutions can be effectively applied, the designer may use the derogation procedure as provided for by the laws in force.
2. Designers who choose *solutions in derogation* must demonstrate the achievement of the pertinent fire prevention objectives as set out in Section G.2.5 using one of the *fire safety design methods* referred to in Section G.2.8
3. All of the provisions of this document, including those defined in the *vertical technical regulations*, may become subject to a derogation procedure.

G.2.7 Fire safety design methods

1. Table 4 lists the fire safety design methods that may be used by the *designer* for:
   a. *verification of alternative solutions* to demonstrate the achievement of the connected *performance level* (Section G.2.6.5.2);
   b. *verification of the performance level* attributed to the *fire prevention measures* in order to demonstrate the achievement of the connected fire safety objectives (Section G.2.6.4).

Methods	Description and application limits
Application of standards or technical documents	The *designer* shall apply standards or technical documents issued by internationally recognised bodies in the fire safety industry. This application, without prejudice to the obligations connected with the use of products subject to Community harmonisation legislation and national regulations, must be implemented in its entirety, using solutions, configurations and components referred to in the standards or technical documents used, specifically highlighting their suitability for each configuration considered, in relation to the risk profiles of the activity.
Design solutions that involve the use of innovative products or technologies	The use of *innovative* products or technologies arising from technological development, is allowed in all cases where suitability for use can be certified by the *fire safety professional*, during verification and analysis on the basis of an assessment of the risk associated with the use of the same products or technologies, supported by relevant test certificates referring to: ● national standards or test specifications; ● international standards or test specifications; ● test specifications adopted by laboratories approved for that purpose.
Fire safety engineering	The *fire safety professional* shall apply fire safety engineering methods pursuant to the procedures, assumptions and limits indicated in this document, in particular in Chapters M1, M2 and M3 or in accordance with nationally or internationally recognised scientific and technical principles.
Experimental testing	The *fire safety professional* shall carry out experimental testing in full scale or in a scale that is appropriately representative, aimed at truly reproducing and analysing the phenomena (e.g. chemical–physical and thermodynamic, occupant evacuation, etc.) that characterise the issue being assessed and which have an influence on fire prevention objectives. The experimental testing shall be conducted pursuant to protocols standardised or shared by the Central Directorate for Prevention and Technical Safety of the National Fire Service. The tests shall be performed in the presence of authorised representatives of the National Fire Service upon request of the activity manager. The testing shall be appropriately documented. Specifically, the test reports shall provide detailed definitions of the test hypotheses and the limits of use of the results. These test reports, including any videos or other data monitored during the test, shall be made available to the National Fire Service.

Table 4: Fire safety design methods

G.2.8 Additional fire safety design methods

1. For the verification of *solutions in derogation* (Section G.2.6.5.3), in order to demonstrate the achievement of the pertinent fire prevention objectives as set out in Section G.2.5, the *fire safety professional* may use the fire safety design methods set out in Table 4 and the additional methods set out in Table 5.

Methods	Description and application limits
Analysis and design according to expert judgment	Analysis according to expert judgment is based on general fire prevention principles and on the breadth of knowledge and experience of the *fire safety professional*, an expert in fire safety.

Table 5: Additional fire safety design methods

G.2.9 Fire prevention design assessment

1. So that the National Fire Service can assess the design pursuant to the procedures provided for by current legislation, the designer shall ensure the following through the design documentation:

   a. *appropriateness* of the fire safety objectives pursued, the basic assumptions, the input data, the methods, the models, the standards selected and applied in support of the fire safety design;

   Note For example: appropriate application of deemed-to-satisfy solutions, etc.

   b. the *correspondence* of fire prevention measures with the safety objectives pursued in accordance with the indications in this document;

   Note For example: provision of an appropriate evacuation route system that meets the life safety objective, etc.

   c. the *correctness* of the application of the methods, models and regulatory instruments.

   Note For example: absence of gross errors in calculation, correspondence of the numeric results in the calculations with the actual fire prevention measures, etc.

2. The designer shall assume *full liability* for the *fire risk assessment* in the design documentation for the activity.

G.2.10 General guidelines for the design of fire safety systems

G.2.10.1 Common requirements

Note Definitions of *system design*, *system specifications*, *system maintenance manual*, *substantial change* and definitions for the voluntary regulation can be found in Chapter G1.

1. For the installation and substantial modification of systems, a *system design* must be drawn up in accordance with the industry standard and on the basis of the requirements identified in the *system specifications*.
2. If the *system design* is drawn up in accordance with a *European standard* or a *national standard*, it must be signed by a *certified technician*.
3. Without prejudice to the obligations relating to the use of products falling within the scope of *harmonised technical specifications*, where the *design of the installation* is drawn up in accordance with *international standards* or *internationally recognised standards*, the *TS* or the *TR*, it must be signed by a *fire safety professional*.
4. The system design must be signed by a *fire safety professional* even in the event of design solutions involving the use of *innovative products or technologies* as referred to in Section G.2.7.
5. The standards or technical documents referred to in paragraph 3 must be applied in their entirety, specifically highlighting the suitability of their implementation, including the use of components required for the proper functioning of the system.
6. The parameters used for the design of the systems are identified by the subjects responsible for the assessment of the fire risk and design. The managers for the activities in which the systems are installed are obliged to maintain the conditions that have been assessed for the identification of the aforementioned design parameters.

Note Changes in working conditions (e.g. different types of stored goods, increased stacking height, introduction of fire-hazardous processes, etc.) could degrade the protection performance of the system, therefore, if the working conditions of the protected area change, it is necessary to check whether the system is still effective for the required protection.

7. For the purposes of assessing an activity's fire safety design, as required by current legislation, systems must be documented by the *system specifications* to be installed or substantially modified. The system specifications must be signed by a *certified technician* in the case referred to in paragraph 2 or by a *fire safety professional* in the case referred to in paragraph 3.
8. Upon completion of the installation of the system, the activity manager must be provided with, in addition to that already indicated by the regulations in force, the as-built designs, the final documentation described in the standard used for the design and installation of the system, as well as the related system maintenance manual.
9. The systems must be designed, implemented, operated and maintained following industry standards in accordance with the regulations in force.

G.2.10.2 *Systems or installations with higher availability*

Note The definition of *higher availability systems or installations* can be found in Chapter G.1. Definitions of *availability, reliability, maintainability, maintenance support performance, degraded state, down state, failure* and *mean failure rate* are provided in UNI EN 13306.

1. *Higher availability* for systems or installations may be achieved through:

   a. greater *reliability*,

Note For example, by using components with lower failure rates, redundancy of power supply sources, extinguishers, critical components, introducing measures to reduce human error, specific protection measures against the effects of fire, etc.

   b. greater *maintainability* and *maintenance support performance*.

Note For example, by reducing fault recovery times, scheduling maintenance for sectors of the system, periodic checks and testing, etc.

Note The NFPA 25 standards provide a useful reference for inspection, testing and maintenance of active protection systems.

2. In order to maintain the level of safety required for the activity, for systems or installations with higher availability, the management of *degraded states* or of the *down states* of the system must be anticipated.

Note For example, by limiting the severity of degraded states, compensatory management measures, operating conditions or limitations, etc.

3. If higher availability is not required in this document, no specific assessment is required for systems or installations constructed in accordance with the industry standard.

G.2.11 References

1. Each chapter of this document contains references to technical standards and scientific publications from which methods, thresholds and parameters have been drawn.

2. A number of bibliographic references used for the drafting of this document are indicated below:

   a. BS 9999 *'Code of practice for fire safety in the design, management and use of buildings'*, British Standards Institution (BSI) http://www.bsigroup.com/

   b. NFPA 101 *'Life Safety Code'*, National Fire Protection Association http://www.nfpa.org

   c. International Fire Code 2009, International Code Council http://www.iccsafe.org/

3. With regard to risk assessment, the following references are provided:

   a. ISO 16732-1 '*Fire safety engineering – Fire risk assessment – Part 1: General*'

   b. ASTM E1776 '*Standard Guide for the Development of Fire-Risk-Assessment Standards*'

Chapter G.3 Assignment of risk profiles for activities

G.3.1 Definition of risk profiles

1. In order to better assess (synthetically describe) the fire risk for an activity, the following types of *risk profiles* are set out:

   R_{life}: risk profile concerning *human life safety*;

   R_{prop}: risk profile concerning the protection of *property*;

   R_{env}: risk profile concerning the protection of the environment.

2. The R_{life} risk profile shall be assigned to *each compartment* and, where necessary, for each *open-air space* of the activity, as referred to in Section G.3.2.

   Note For example, the assignment of the R_{life} risk profile in open-air spaces is required for the design of the evacuation for *outdoor activities*.

3. The risk profile R_{prop} shall be assigned to the *entire activity* or to *settings (areas)* of it, as indicated in Section G.3.3.

4. The risk profile R_{env} shall be assigned to the *entire activity* or to *settings (areas)* of it, as indicated in Section G.3.4..

G.3.2 The R_{life} risk profile

G.3.2.1 Assignment

1. The R_{life} risk profile is assigned in relation to the following factors:

   δ_{occ}: *prevailing* characteristics of the occupants;

   Note 'Prevailing' refers to the characteristics of the occupants which, due to their number and type, are more representative of the activity carried out in the setting under consideration under any operating condition. For example, an office in which there is only a small occasional and short-term presence of members of the public, may be classified as δ_{occ} = A.

   δ_{α}: *prevailing* rate of the growth of fire characteristic, referring to the time t_{α} in seconds, used by the thermal potential to reach 1000 kW.

   Note 'Prevailing' refers to the characteristic representative of the fire risk under all operational conditions. For example, the presence in civil activities of limited quantities of flammable cleaning products properly stored is not considered significant and therefore not prevailing.

   Tables 6 and 7 are to guide the designer in the selection of the δ_{occ} and δ_{α} factors.

2. The designer may also select the t_{α} value by using one of the following options:

   a. data published by authoritative and shared sources,

   b. direct determination of the RHR (*rate of heat release*) curve relative to the fuels actually present and in the configuration in which they can be found, according to the indications of Chapter M.2 or through measurements at the *testing laboratory*, according to consolidated experimental protocols.

   Note Definitions of *RHR* and *test laboratory* are provided in Chapter G.1. As way of example, the standards of the ISO 9705 series, the ISO 24473 standard and the ISO 16405 standard are useful references for the experimental determination of the RHR curve, …

3. The value of δ_{α}, assessed in the absence of fire control systems, may be reduced by one level if the activity has been served by performance level V fire control measures (Chapter S.6.).

4. The R_{life} value is determined as a combination of δ_{occ} and δ_{α}, as shown in Table 8..

G.3.2.2 The R_{life} risk profile for certain types of occupancy

1. Table 9 provides a non-exhaustive indication of the R_{life} risk profile for the most common types of *occupancy*. If the designer chooses values different from those proposed, the reasons for the choices must then be indicated in the design documentation.

2. Where not provided for in this document, for compartments with R_{life} included in Ci1, Ci2, Ci3, performance levels and design solutions for Cii1, Cii2, Cii3, respectively, may be taken as reference, taking into account the occupants' greater familiarity with the activity and the specific fire risk.

Prevailing characteristics of the occupants δ_{occ}		Examples
A	Occupants are awake and familiar with the building	Offices with no public access, school, private garage, private sports centres, manufacturing activities in general, warehouses, industrial sheds
B	Occupants are awake and not familiar with the building	Stores, public parking garage, activity for exhibitions and public shows, convention centre, offices open to the public, bars, restaurants, medical offices, clinics, sports centres
C	Occupants may be asleep: [1]	
Ci	• in individual activity of long duration	Dwelling
Cii	• in managed activity of long duration	Dormitory, residence, student housing, residence for self-sufficient people
Ciii	• in managed activity of short duration	Hotel, alpine retreat
D	Occupants receive medical care	Hospital room, intensive care, operating rooms, residence for dependent persons and persons with health care
E	Occupants in transit	Train and metro stations, airports
[1] When C is used in this document, those directions are valid for Ci, Cii, Ciii		

Table 6: Prevailing characteristics of the occupants

δ_α	t_α [1]	Criteria
1	600 s slow	Areas of activity with a specific fire load $q_f \leq 200$ MJ/m^2, or where there is a predominance of materials or other fuels that contribute negligibly to fire.
2	300 s medium	Areas of activity where there is a predominance of materials or other fuels that contribute moderately to the fire.
3	150 s fast (rapid)	Settings (Areas) with significant amounts of stacked plastics, synthetic textiles, electric and electronic appliances, combustible materials not classified for reaction to fire (Chapter S.1). Settings (Areas) where significant quantities of combustible materials are stacked vertically with $3.0 \text{ m} < h \leq 5.0$ m [2]. HHS3 classified storage or HHP1 classified activities, in accordance with UNI EN 12845. Settings (Areas) with technological or process systems that use significant amounts of combustible materials. Settings (Areas) with the simultaneous presence of combustible materials and processes that may lead to fires.
4	75 s ultra-fast (ultra-rapid)	Settings (Areas) where significant quantities of combustible materials are stacked vertically with $h >$ 5.0 m [2]. HHS4 classified storage or HHP2, HHP3 or HHP4 classified activities, in accordance with UNI EN 12845. Settings (Areas) where significant quantities of substances or mixtures that may lead to fires, or cellular plastics/expanded plastics or combustible foams not classified for reaction to fire, are present or are being processed.
Unless otherwise assessed by the designer (e.g. literature information, direct measurements, etc.), at least the quantities of materials in compartments with specific fire loads of $q_f \leq 200$ MJ/m^2 are considered *not significant* for the purposes of this classification. [1] Prevailing characteristics of the speed of the growth of the fire. [2] With stacking height of h.		

Table 7: Prevailing characteristics of the speed of the propagation of the fire

Prevailing characteristics of the occupants δ_{occ}		Prevailing characteristics of the rate of the growth of the fire δ_α			
		1 slow	**2 medium**	**3 fast (rapid)**	**4 ultra-fast (ultra-rapid)**
A	Occupants are awake and familiar with the building	A1	A2	A3	A4
B	Occupants are awake and not familiar with the building	B1	B2	B3	Prohibited [1]
C	Occupants may be asleep: [2]	C1	C2	C3	Prohibited [1]
Ci	• in individual activity of long duration	Ci1	Ci2	Ci3	Prohibited [1]
Cii	• in managed activity of long duration	Cii1	Cii2	Cii3	Prohibited [1]
Ciii	• in managed activity of short duration	Ciii1	Ciii2	Ciii3	Prohibited [1]
D	Occupants receive medical care	D1	D2	Prohibited [1]	Prohibited
E	Occupants in transit	E1	E2	E3	Prohibited [1]

[1] To reach a permitted value, δ_α may be reduced by one level as specified in paragraph 3 of Section G.3.2.1.
[2] When in the text, C1 is used, the relative indication shall be valid for Ci1, Cii1 and Ciii1. If C2 is used, the indication shall be valid for Ci2, Cii2 and Ciii2. If C3 is used, the indication shall be valid for Ci3, Cii3 and Ciii3.

Table 8: Assignment of R_{life}

Occupancy types	R_{life}
School gymnasium	A1
Private garage	A2
Office not open to the public, lunchroom (canteen room), classroom, corporate conference room, file room, library, private sports centre	A2-A3
Commercial store not open to the public (e.g. wholesalers, etc.)	A2-A4
School laboratory, server room	A3
Manufacturing activity, light industry, process systems, research laboratory, warehouse, mechanics workshop	A1-A4
Stores of hazardous substances and mixtures	A4
Art galleries, waiting rooms, restaurants, medical offices, clinics	B1-B2
Public parking garage	B2
Offices open to the public, public sports centre, conference rooms open to the public, discotheques, museums, theatres, cinemas, detainment centres, library reading areas, exhibition activities, car showrooms	B2-B3
Commercial store open to the public (e.g. retailers, etc.)	B2-B4 [1]
Dwelling	Ci2-Ci3
Dormitory, residence, student housing, residence for self-sufficient people	Cii2-Cii3
Hotel room	Ciii2-Ciii3
Hospital room, intensive care, operating rooms, residence for dependent persons and persons with health care	D2
Train and metro stations, airports	E2

[1] To reach a permitted value among those indicated in Table 8, δ_α may be reduced by one level as specified in paragraph 3 of Section G.3.2.1

Table 9: R_{life} risk profile for certain types of occupancy

G.3.3 Risk profile R_{prop}

1. The assignment of the R_{prop} risk profile is performed according to the strategic nature of the entire activity or of the *settings* (areas) that constitute the activity, and of any historic, cultural, architectonic or artistic value it or its contents may have.
2. With regard to the application of this document:
    a. an activity or setting (area) is considered restricted in its use because of art or history if it or its contents are considered such by law;
    b. an activity or setting (area) is considered strategic if considered such by law or in consideration of public rescue and civil defence planning or upon indication of the activity manager.

Note At the request of the activity manager, in addition to the regulatory requirements, the designer may increase the value of the R_{prop} risk profile in order to ensure fire safety objectives are achieved, such as *business continuity* after a fire.

3. Table 10 guides the designer in the assignment of the R_{prop} risk profile.

		Restricted activity or area	
		No	**Yes**
Strategic activity or area	**No**	$R_{prop} = 1$	$R_{prop} = 2$
	Yes	$R_{prop} = 3$	$R_{prop} = 4$

Table 10: Assignment of R_{prop}

G.3.4 The R_{env} risk profile

1. The designer assesses the R_{env} risk profile in the event of fire, distinguishing the settings (areas) of activity in which this risk profile is *significant*, from those where it is *not significant*.

2. The assessment of the R_{env} risk profile shall take into account the location of the activity, including the presence of sensitive receptors in outdoor areas, the type and quantities of combustible materials present and combustion products developed by them in the event of fire, and the fire prevention and protection measures adopted.

Note The presence of materials stored in activities falling within the scope of Legislative Decree No 152 of 3rd April 2006, '*Environmental standards*' may give rise to significant R_{env}.

Note Chapter V.1 indicates possible measures to mitigate the risk of environmental damage caused by fire.

Note In plants for which Legislative Decree No 105 of 26th June 2015, *Implementing Directive 2012/18/EU on the control of major-accident hazards involving dangerous substances*, applies, the environmental risk is mitigated by the measures adopted as part of the authorisation procedures provided for in the aforementioned decree.

3. Unless otherwise indicated in this document or determined as a result of a specific risk assessment, the R_{env} risk profile is considered *not significant*:

   a. in settings (areas) protected by automatic total fire-extinguishing systems or installations (Chapter S.6) with *higher availability*;

   b. in civil activities (e.g. healthcare, scholastic and hospitality facilities, etc.).

4. The rescue operations conducted by the National Fire Service are excluded from the assessment referred to in paragraph 1.

G.3.5 References

1. The following references are provided:

   a. ISO/TR 16738,

   b. BS 9999 '*Section 2 – Risk profiles and assessing risk*'.

Section S Fire prevention strategy

Chapter S.1 Reaction to fire

S.1.1 Preface

1. Reaction to fire is a passive protection fire prevention measure that expresses its main effects in the fire's initial phase, with the objective of limiting the ignition of materials and the spread of the fire. This refers to the behaviour of materials exposed to fire in the actual *end-use conditions*, with particular regard to the level of involvement in the fire that these undergo under standardised test conditions.
2. These requirements are applied to settings (areas) of activity where it is intended to limit the participation of materials in the combustion and to reduce the spread of fire.

S.1.2 Performance levels

1. Table 11 provides the performance levels attributable to the *settings* (*areas)* of activity for this fire prevention measure.

Performance level	Description
I	The contribution of materials to the fire is not assessed
II	The contribution of materials to the fire is significant
III	The contribution of materials to the fire is moderate
IV	The contribution of materials to the fire is almost negligible
Contribution to the fire refers to the energy released by the materials that influence the growth and development of the fire in the pre- and post- flashover conditions pursuant to EN 13501-1.	

Table 11: Performance levels

S.1.3 Assignment criteria for performance levels

1. Tables 12 and 13 provide the *generally accepted* criteria for the assignment of individual performance levels.

Performance level	Assignment criteria
I	Evacuation routes [1] not included in the other assignment criteria.
II	Evacuation routes [1] of the compartments with R_{life} risk profile in B1.
III	Evacuation routes [1] of the compartments with R_{life} risk profile in B2, B3, Cii1, Cii2, Cii3, Ciii1, Ciii2, Ciii3, E1, E2, E3.
IV	Evacuation routes [1] of the compartments with R_{life} risk profile in D1, D2.
[1] Limited to vertical evacuation routes, evacuation pathways (corridors, halls, filters, etc.) and refuge areas.	

Table 12: Assignment criteria for performance levels of an activity's evacuation routes

Performance level	Assignment criteria
I	Rooms not included in the other assignment criteria.
II	Rooms in compartments with R_{life} risk profile in B2, B3, Cii1, Cii2, Cii3, Ciii1, Ciii2, Ciii3, E1, E2 and E3.
III	Rooms in compartments with R_{life} risk profile in D1, D2.
IV	Upon specific request by the customer, as provided for by design technical specifications, required by the competent authorities for structures intended for activities of particular importance.

Table 13: Assignment criteria for performance levels of an activity's other rooms

S.1.4 Design solutions

1. The following are the deemed-to-satisfy solutions, for each performance level, for the GM0, GM1, GM2, GM3, GM4 *groups of materials* defined in Section S.1.5. .
2. The materials specified in Section S.1.6 are excluded from reaction to fire requirement assessments.
3. Regardless of the deemed-to-satisfy solutions adopted for cladding, it is in any event permitted that 5 % of the gross internal floor area, in the evacuation routes or the activity's rooms (e.g. sum of the gross internal surface area of the ceiling, walls, floor and openings of the room), may be made up of materials installed on walls or floors included in the GM4 *group of materials*.

S.1.4.1 Deemed-to-satisfy solutions for performance level II

1. The use of materials from the GM3 group is considered to be a deemed-to-satisfy solution.

S.1.4.2 Deemed-to-satisfy solutions for performance level III

1. The use of materials from the GM2 group is considered to be a deemed-to-satisfy solution.

S.1.4.3 Deemed-to-satisfy solutions for performance level IV

1. The use of materials from the GM1 group is considered to be a deemed-to-satisfy solution.

S.1.4.4 Alternative solutions

1. *Alternative solutions* are permitted for all performance levels.
2. In order to demonstrate the achievement of *performance levels*, the designer shall use one of the methods set out in Section G.2.7.
3. Table 14 provides several *generally accepted* procedures for designing alternative solutions. The designer may, however, use procedures other than those listed.

Object of the solution	Design procedure
Participation of materials in the fire (§ S.1.1)	It shall be demonstrated that the occupants' lives are in any event safeguarded (Chapter M.3) and, if applicable, property is protected, by providing for ad hoc design fire scenarios in settings (areas) where materials with the required minimum reaction to fire requirements are not installed.

Table 14: Design procedures for alternative solutions

S.1.5 Classification of materials into groups

1. The reaction to fire classes indicated in this section refer to:
   a. *Italian* reaction to fire classes as set out in Ministerial Decree of 26th June 1984. The Italian classes indicated with the abbreviation [Ita] are the minimum provided for by each level of performance;
   b. *European* fire reaction classes assigned only to construction products, with reference to Ministerial Decree of 10th March 2005. The European classes indicated with [EU], set out in main classes and additional classes (s, d, a), are the minimum provided for by each level. Reaction to fire classes having cardinal numbers less than those indicated in the table or by a previous letter of the alphabet are permitted (e.g. if the C-s2,d1 class is permitted, then the classes B-s2,d1 C-s1,d1 C-s2,d0 ... shall also be permitted).
2. The GM0 *materials group* shall be made up of all of the Italian reaction to fire class 0 materials or the European reaction to fire class A1. These materials are also referred to as *non-combustible materials*.
3. Tables 15,16,17 and 18 GM3 show the reaction to fire classes for the materials in the GM1, GM2 and GM3 *materials groups*.
4. The GM4 *materials group* shall be made up of all the materials not included in the GM0, GM1, GM2 and GM3 *materials groups*.

Materials description	GM1		GM2		GM3	
	Ita	EU	Ita	EU	Ita	EU
Upholstered furniture (armchairs, sofas, sofa-beds, mattresses, box springs, pillows, toppers, cushions, upholstered chairs)	1 IM	[na]	1 IM	[na]	2 IM	[na]
Bedding (blankets, bedspreads, mattress covers)	1		1		2	
Furniture attached and not attached to structural elements (non-upholstered seats and benches)						
Awnings for tensile structures, air-dome structures and portable tunnels						
Theatre curtains, drapes and awnings						
Stage materials, fixed and moveable stage settings (scenery, awnings, drapes and similar)						
[na] Not applicable						

Table 15: Classification into groups for furnishing, stage settings, roof tents

<table>
<tr><th rowspan="2">Materials description</th><th colspan="2">GM1</th><th colspan="2">GM2</th><th colspan="2">GM3</th></tr>
<tr><th>Ita</th><th>EU</th><th>Ita</th><th>EU</th><th>Ita</th><th>EU</th></tr>
<tr><td>Ceiling cladding [1]</td><td rowspan="3">0</td><td rowspan="3">A2-s1,d0</td><td rowspan="5">1</td><td rowspan="5">B-s2,d0</td><td rowspan="5">2</td><td rowspan="5">C-s2,d0</td></tr>
<tr><td>False ceilings, roofing materials [2], roofing panels [2], roofing sheets [2]</td></tr>
<tr><td>Raised flooring
(hidden surface)</td></tr>
<tr><td>Wall cladding [1]</td><td rowspan="2">1</td><td rowspan="2">B-s1,d0</td></tr>
<tr><td>Internal partitions, walls, suspended walls</td></tr>
<tr><td>Floor cladding [1]</td><td rowspan="2">1</td><td rowspan="2">B_{fl}-s1</td><td rowspan="2">1</td><td rowspan="2">C_{fl}-s1</td><td rowspan="2">2</td><td rowspan="2">C_{fl}-s2</td></tr>
<tr><td>Raised flooring
(accessible surface)</td></tr>
<tr><td colspan="7">[1] When treated with fireproof paint products, the latter must have the corresponding classification indicated and be suitable for the foreseen application.
[2] This refers to all materials used in the entire package making up the roofing, not only the exposed materials that make up the final outer layer.</td></tr>
</table>

Table 16: Classification into groups of materials for cladding and finishing

<table>
<tr><th rowspan="2">Materials description</th><th colspan="2">GM1</th><th colspan="2">GM2</th><th colspan="2">GM3</th></tr>
<tr><th>Ita</th><th>EU</th><th>Ita</th><th>EU</th><th>Ita</th><th>EU</th></tr>
<tr><td>Protective insulation [1]</td><td rowspan="2">2</td><td>C-s2,d0</td><td rowspan="2">3</td><td>D-s2,d2</td><td rowspan="2">4</td><td>E</td></tr>
<tr><td>Linear protective insulation [1], [3]</td><td>C_L-s2,d0</td><td>D_L-s2,d2</td><td>E_L</td></tr>
<tr><td>Exposed insulation [2], [4]</td><td rowspan="2">0,
0-1</td><td>A2-s1,d0</td><td rowspan="2">1,
0-1</td><td>B-s2,d0</td><td rowspan="2">1,
1-1</td><td>B-s3,d0</td></tr>
<tr><td>Linear exposed insulation [2], [3], [4]</td><td>$A2_L$-s1,d0</td><td>B_L-s3,d0</td><td>B_L-s3,d0</td></tr>
<tr><td colspan="7">[1] Protected with non-metallic materials in the GM0 group or products in the K 10 fire resistance class and the minimal B-s1, d0 reaction to fire class.
[2] Not protected as indicated in note [1] in this table
[3] Classification refers to products with a linear form intended for temperature insulation of pipelines with an overall maximum diameter of 300 mm
[4] Any double Italian classification (external component that covers the insulating component on all faces exposed to the flames – an insulating component in itself) referring to exposed insulation materials made as a product with several layers of which at least one of these being insulation; the latter not exposed directly to the flames</td></tr>
</table>

Table 17: Classification into groups of materials for insulation

Materials description	**GM1**		**GM2**		**GM3**	
	Ita	**EU**	**Ita**	**EU**	**Ita**	**EU**
Ventilation and heating ducts	0	A2-s1,d0	1	B-s2,d0	1	B-s3,d0
Pre-insulated ventilation and heating ducts [1]	0-1	B-s2,d0	0-1	B-s2,d0	1-1	B-s3,d0
Fittings and joints for ventilation and heating ducts (L ≤ 1.5 m)	1	B-s1,d0	1	B-s2,d0	2	C-s3,d0
Conduits channels for energy, control and communications cables [2]	0	[na]	1	[na]	1	[na]
Energy, control and communications cables [2][3]	[na]	$B2_{ca}$-s1,d0,a1	[na]	C_{ca}-s1,d0,a2	[na]	E_{ca}

[na] Not applicable.

[1] Possible double Italian classification referring to *pre-insulated conduit* with insulating component not exposed directly to the flames; the first class refers to the external component that covers the insulating component on all faces, the second to the insulating component not directly exposed to the flames. The single European class B-s2.d0 is permitted only if the insulating component is not directly exposed to the flames due to the presence of a layer of material of class A0 or A1-s1,d0 that covers it on all faces, including the longitudinal and transversal breakpoints of the conduit.

[2] Reaction to fire performance required only when the conduit, electrical cables or signal cables are not encased in non-combustible materials.

[3] The additional dripping classification *d0* may be downgraded to *d1* if the *end use condition* of the cables is such as to physically prevent dripping (e.g. flooring, unperforated conduit laying, unperforated false ceiling laying, etc.).

Table 18: Classification into groups of materials for installations

S.1.6 Exclusion of the reaction to fire requirements verification

1. Unless otherwise indicated or determined through a specific risk assessment, verification of the reaction to fire requirements of the following materials is not required:
   a. stored materials or those to be processed for production (e.g. goods in storage, on sale, or on display, etc.);
   b. *load-bearing structural elements* for which the *resistance to fire* requirement checks have already been requested;
   c. protected materials with a separation of fire resistance class of at least K 30 or EI 30.
2. For any *cladding* and *other materials* applied to the structural elements as set out in paragraph 1(b), verification of the reaction to fire requirements are, in any event, mandatory based on the pertinent reaction to fire levels.

S.1.7 Complementary aspects

1. The verification of the minimum requirements for reaction to fire of construction materials is to be performed in compliance with Ministerial Decree of 10th March 2005; for other materials it is to be performed in compliance with Ministerial Decree of 26th June 1984.
2. On facades (facings), cladding materials must be used that limit the probability of fire and its subsequent propagation due to the possibility of fire of external or internal origin with flames and hot smoke that come out of spaces, openings, cavities or seams.

   Note Reference should be made to the circulars DCPST No 5643 of 31st March 2010 and DCPST No 5043 of 15th April 2013 containing technical guidance on '*Fire safety requirements for facades (facings) on civil buildings*'.
3. It should be noted that there is also the possibility of providing for reactions to the fire performance of other materials (e.g. doors, skylights, photovoltaic panels, etc.) wherever the risk assessment indicates a need (e.g. evacuation route corridors where there is a significant number of doorways, cable ducts or channelling with a significant presence of electric cables, evacuation routes with a significant presence of skylights, combustible roofing underneath photovoltaic panels, etc.).

S.1.8 References

1. The following references are provided:
   a. European Commission, Directorate-General for Enterprise and Industry, *'Construction – Harmonised European Standards'*, documentation from http://ec.europa.eu/enterprise/sectors/construction/declaration-of-performance
   b. Decree of the Ministry of the Interior of 10th March 2005, *Reaction to fire classes of construction products to be used in buildings to which the fire safety requirement applies*;
   c. Decree of the Ministry of the Interior of 26th June 1984, *Reaction to fire classification and type approval of materials for fire prevention purposes*;
   d. '*Fire safety products* section of the website: http://www.vigilfuoco.it

Chapter S.2 Fire resistance

S.2.1 Preface

1. The purpose of fire resistance is that of guaranteeing the *load-bearing capacity of structures* in fire conditions and the *compartmentalisation capacity* for a minimum time necessary to meet *fire safety and prevention objectives*.
2. Chapter S.3 on *compartmentalisation* measures is complementary to this chapter.

S.2.2 Performance levels

1. Table 19 below shows the performance levels attributable to *construction works* for this fire prevention measure.

Performance level	Description
I	Absence of external consequences due to structural collapse
II	Maintenance of the fire resistance requirements for a period sufficient for the evacuation of occupants to a safe area outside of the building.
III	Maintenance of the fire resistance requirements for a period of time equal (congruent) to the duration of the fire.
IV	Fire resistance requirements such that they ensure, at the end of the fire, there is limited damage to the structures themselves.
V	Fire resistance requirements such that they ensure, at the end of the fire, maintenance of the full operational functionality of the structure.

Table 19: Performance levels

S.2.3 Assignment criteria for performance levels

1. Table 20 provides the *generally accepted* criteria for the assignment of individual performance levels.

Performance level	Assignment criteria
I	Construction works, including any adjacent service works and technical installations for utilities, wherein *all* of the following conditions have been met: ● compartmentalisation with respect to other construction works that may be adjacent and structurally separated from them and such that any structural collapse does not cause damage to other construction works or outside of the border of the area on which the activity is located; ● used for activities relating to a single *activity manager* and with a R_{prop} risk profile equal to 1; ● not used for an activity requiring the presence of occupants, except for occasional staff for brief periods of time.
II	Construction works or portions of construction works, including any adjacent service works and technical installations for utilities, where *all* of the following conditions have been met: ● compartmentalisation with respect to any adjacent construction works; ● structurally separated from other construction works and such that any structural collapse does not cause damage to them or outside of the border of the area on which the activity is located; or, in the absence of structural separation, such that any failure of a portion does not cause damage to the rest of the construction works or outside of the border of the area on which the activity is located; ● used for activities relating to a single *activity manager* and with the following risk profiles: ○ R_{life} included in A1, A2, A3 and A4; ○ R_{prop} equal to 1; ● crowding density ≤ 0.2 persons/m^2; ● not generally intended for occupants with disabilities; ● all floors located at a height between -5 m and 12 m.
III	Construction works not included in the other assignment criteria.
IV, V	Upon specific request by the customer, as provided for by the design technical specifications, required by the competent authorities for construction works intended for activities of particular importance.

Table 20: Assignment criteria for performance levels

Note The definition of the *activity manager* is provided in Chapter G.1

S.2.4 Design solutions

S.2.4.1 Deemed-to-satisfy solutions for performance level I

1. There must be a free open-air *separation distance*, not less than the maximum height of the building, to other construction works and to the border of the area on which the activity is located.
2. The spread of fire to other construction works or outside the border of the area on which the activity is located shall be limited by adopting the solutions set out in Section S.3.4.1..
3. No minimum load-bearing capacity performance is required from the construction works under fire conditions, or internal compartmentalisation.

S.2.4.2 Deemed-to-satisfy solutions for performance level II

1. There must be a free open-air *separation distance* as provided for in performance level I.
2. Fire resistance performance levels of the structures must be verified based on conventional design fires as provided for in Section S.2.5..
3. The *minimum fire resistance class* must be at least 30 or less, if permitted by performance level III for the specific $q_{f,d}$ design fire load of the compartment in question.

S.2.4.3 Deemed-to-satisfy solutions for performance level III

1. Fire resistance performance levels of the structures must be verified based on conventional design fires as provided for in Section S.2.5.
2. The *minimum fire resistance class* shall be drawn for each compartment as concerns the specific $q_{f,d}$ as indicated in Table 21.

Specific design fire load	Minimum fire resistance class
$q_{f,d}$ ≤ 200 MJ/m^2	No requirement
$q_{f,d}$ ≤ 300 MJ/m^2	15
$q_{f,d}$ ≤ 450 MJ/m^2	30
$q_{f,d}$ ≤ 600 MJ/m^2	45
$q_{f,d}$ ≤ 900 MJ/m^2	60
$q_{f,d}$ ≤ 1 200 MJ/m^2	90
$q_{f,d}$ ≤ 1 800 MJ/m^2	120
$q_{f,d}$ ≤ 2 400 MJ/m^2	180
$q_{f,d}$ > 2 400 MJ/m^2	240

Table 21: Minimum fire resistance class

S.2.4.4 Deemed-to-satisfy solutions for performance level IV

1. To verify load-bearing capability in case of fire, the deemed-to-satisfy solutions valid for performance level III as set out in Section S.4.3 shall apply. The indications in Sections S.8.2 and S.2.8.3 may not be used.
2. To control damage to compartmentalisation elements, whether horizontal or vertical, except for the closures to openings (e.g. doors, shutters, passive barriers, etc.), belonging to both the compartment of initial ignition as well as to others, there must be verification of the following deformability limits under the conditions of thermal and mechanical load as provided for by performance level III deemed-to-satisfy solutions:
   - $\delta_{v,max}/L = 1/100$ ratio between the *maximum deflection* $\delta_{v,max}$ and the *span* L of the vertically load-bearing elements such as beams and orthotropic (bidirectional) flooring;
   - $\delta_{v,max}/L = 1/100$ ratio between the *maximum deflection* $\delta_{v,max}$ and the *minimum span* L of the plate elements;
   - $\delta_{h,max}/h = 1/100$ ratio between the *maximum inter-floor displacement* $\delta_{h,max}$ and the *inter-floor height* h.
3. Joints between compartmentalisation elements, if present, must be capable of favouring the movements provided for in fire conditions. To this end, it is possible to use linear joints, tested pursuant to the EN 1366-4 standard, characterised by an appropriate *percentage of movement* (M %).
4. For the purposes of compartmentalisation capacity, the closure elements of the communication spaces between compartments must be smoke proof (EI S_{200}) and the walls must have additional *mechanical resistance* (M), for a specific class, as in performance level III.

S.2.4.5 Deemed-to-satisfy solutions for performance level V

1. For the purposes of checking the load-bearing capability in case of fire, deformability (for structural damage) and compartmentalisation, valid prescriptions for performance level IV shall apply.
2. Deemed-to-satisfy solutions for the verification of installations considered significant for the functionality of the construction shall not be provided.
3. In order to check for damage to all structural elements, the deformability limits imposed by the NTC for checks at the serviceability limit states shall be verified. These checks shall be carried out under the conditions of thermal and mechanical load as provided for by performance level III deemed-to-satisfy solutions.

S.2.4.6 Alternative solutions for performance level I

1. *Alternative solutions* containing the following are permitted:
   a. compartmentalisation with respect to other constructions;
   b. absence of damage to other structures or outside of the borders of the area on which the activity is located, due to structural collapse.
2. To verify the compartmentalisation with respect to other structures, deemed-to-satisfyor alternative solutions indicated for performance level II of the

compartmentalisation fire prevention measure (Chapter S.3) are considered suitable;

3. To verify the absence of damage to other structures, solutions aimed at demonstrating that the structural collapse mechanism under fire conditions do not cause damage to other structures must be adopted. These checks must be conducted based on the design fire scenarios and the relevant conventional design fires, represented by natural fire curves, pursuant to Section S.2.6.
4. In order to demonstrate the achievement of the related *performance level*, the designer shall use one of the methods referred to in Section G.2.7.
5. Table 22 provides several *generally accepted* procedures for designing alternative solutions. The designer may, however, use procedures other than those listed.

Object of the solution	Design procedure
Checking for damage to other structures	It shall be *analytically* demonstrated that the collapse mechanism of the construction works is *implosive* by using, for example, one or more of the following technical measures to *guide* the collapse procedure: • adoption of fire resistance hierarchy criteria (e.g. assignment of over-resistance to fire at the perimeter structures of the construction works compared to internal ones, etc.); • spatial distribution of fire loads to internal areas; • adoption of convenient structural forms (e.g. with inward inclination, etc.); • adoption of *key elements* in an appropriate position; • use of automatic fire control systems with *higher availability*; • pyramidal stacking of stored combustible materials; • adoption of constraints that facilitate implosive collapse.

Table 22: Design procedures for alternative solutions, performance level I

S.2.4.7 Alternative solutions for performance level II

1. *Alternative solutions* containing the following are permitted:
   a. compartmentalisation with respect to other constructions;
   b. absence of damage to other structures or outside of the borders of the area on which the activity is located, due to structural collapse;
   c. maintenance of the load-bearing capability under fire conditions for a period of time sufficient for the evacuation of the occupants to a safe area outside of the structure. The load-bearing capacity must in any case be such as to guarantee a safety margin $t_{marg} \geq 100\ \% \cdot RSET$ and in any case ≥ 15 minutes (Section M.3.2.2.).
2. To verify compartmentalisation and the absence of damage in case of structural collapse, the alternative solutions provided for fire resistance performance level I shall be used.
3. To verify that the load-bearing capacity is maintained under fire conditions, alternative solutions shall be obtained by verifying the fire resistance performance levels of the structures based on the design fire scenarios and the relevant conventional design fires, represented by natural fire curves, pursuant to Section S.2.6.
4. In order to demonstrate the achievement of the related *performance level*, the designer shall use one of the methods referred to in Section G.2.7.

S.2.4.8 Alternative solutions for performance level III

1. *Alternative solutions* are permitted.
2. Alternative solutions for performance level III shall be obtained by verifying the fire resistance performance levels of the structures based on the design fire scenarios and the relevant conventional design fires, represented by natural fire curves, pursuant to Section S.2.6.
3. In order to verify the *compartmentalisation capacity*, alternative solutions are possible within the activity.
4. In order to demonstrate the achievement of the related *performance level*, the designer shall use one of the methods referred to in Section G.2.7..
5. Table 23 provides several *generally accepted* procedures for designing alternative solutions. The designer may, however, use procedures other than those listed.

Object of the solution	Design procedure
Verification of the compartmentalisation capacity within the activity	The designer shall assess the use of fire control systems with *higher availability* to demonstrate internal compartmentalisation capacity (e.g. smoke and heat control systems, etc.)

Table 23: Design procedures for alternative solutions, performance level III

S.2.4.9 Alternative solutions for performance levels IV and V

1. *Alternative solutions* are permitted.
2. Alternative solutions for performance levels IV and V, shall be obtained by verifying the damage and function parameters provided for by the designer and by the principal, in addition to the checks set out in Section S.4.8. Solutions shall, in any event, be researched in compliance with the NTC.
3. In order to demonstrate the achievement of the *performance level*, the designer shall use one of the methods referred to in Section G.2.7.

S.2.5 Verification of fire resistance performance with conventional design fires

1. Fire resistance performance of structures must be verified based on *conventional design fires* represented by nominal fire curves whose analytical expressions are provided in Section S.2.7.
2. Design criteria of fire-resistant structural elements are found in Section S.2.8.
3. Temperature trends in the elements must be assessed by *exposition time intervals* equal to the *minimum fire resistance class* provided for each performance level.
4. The procedure for the calculation of the $q_{f,d}$ *specific fire design load* used for the definition of the fire resistance class is provided in Section S.2.9.
5. In cases where the specific design fire load is determined with reference to its actual area of pertinence, in general, higher classes are obtained with respect to those referring to the entire compartment. The elements involved in the non-uniform distribution of the fire load are identified in relation to their proximity with the same.
6. Nominal fire curves must be applied to one compartment of the building at a time, except in the case of multi-floor buildings where the horizontal separation

elements with fire resistance appropriate to the fire load of the area below, shall enable the fire load of the individual floors to be considered separately.

Note For example, in the case of a multi-floor compartment with open stairways, with floors that provide adequate compartmentalisation capacity, it is permissible to consider the fire load acting separately on the individual floors, since a significant delay in the spread of fire from the floor of origin to those immediately above can be expected. An example of a calculation is provided in Table 27..

7. In the case of compartments with common compartmentalisation elements, the class of these elements shall be consistent with that of the compartment of origin of the fire.
8. In general, the fire resistance class of horizontal separation elements must be consistent with that of the compartment below.
9. The specific design fire load values and the characteristics of the fire compartments adopted in the design create an operational restriction for the activity that may be undertaken inside the structure.

S.2.6 Verification of fire resistance performance with natural fire curves

1. Temperature levels in the elements are assessed in reference to a natural fire curve, considering the duration of the fire scenario indicated in Chapter M.2.
2. The process of identification of fire scenarios must comply with that indicated in Chapter M.2.
3. Natural fire curves may be determined by:
   a. experimental fire models,
   b. simplified numerical fire models from the Eurocode UNI EN 1991-1-2,
   c. advanced numerical fire models.
4. Natural fire curves must be determined for the specific fire compartment, with reference to methods of recognised reliability such as those set out in paragraph 3 and with reference, when necessary, to the $q_{f,d}$ specific design fire load referred to in Section S.2.9 making the δ_{ni} coefficients equal to 1 relative to the *fire prevention measures* that are to be modelled pursuant to the criteria set out in Chapter M.2.

Note For example, for experimental, localised fire models of UNI EN 1991-1-2 and advanced numerical computational fluid dynamics, q_f is used. For the internal or external parametric curves of UNI EN 1991-1-2, $q_{f,d}$ is used. For zone models, $q_{f,d}$ shall be used, the δ_{ni} coefficients being equal to 1 (Table 26) relative to the modelled fire prevention measures.

5. The fire load values and the characteristics of the fire compartments create an operational restriction for the activity that may be undertaken inside the structure.
6. Design criteria of fire-resistant structural elements are found in Section S.2.8..

S.2.7 Nominal fire curves

1. To define deemed-to-satisfy solutions for fire resistance, the fire resistance classes are normally referred to conventional fires represented by the following standard nominal curve:

   $$\theta_g = 20 + 345 \log_{10}(8\,t + 1) \qquad (1)$$

   where:

θ_g	mean temperature of combustion gases	[°C]
t	time	[minutes]

2. In case of fire with significant quantities of hydrocarbons or other substances with equivalent thermal release rates, and exclusively for the determination of the structure's load-bearing capacity, the standard nominal fire curve must be replaced by the following nominal hydrocarbon curve:

   $$\theta_g = 1080\,(1 - 0.325 \cdot e^{-0.167t} - 0.675 \cdot e^{-2.5t}) + 20 \qquad (2)$$

   where:

θ_g	mean temperature of combustion gases	[°C]
t	time	[minutes]

3. In the event of fires developing within a compartment but involving structures situated outside of that compartment, for the latter, the standard nominal fire curve can be replaced with the following external nominal curve:

   $$\theta_g = 660\,(1 - 0.687 \cdot e^{-0.32t} - 0.313 \cdot e^{-3.8t}) + 20 \qquad (3)$$

   where:

θ_g	mean temperature of combustion gases	[°C]
t	time	[minutes]

S.2.8 Structural design criteria in case of fire

S.2.8.1 General requirements

1. The capacity of the structural system in case of fire is determined based on the load-bearing capacity of individual structural elements, of portions of the structure or of the entire construction system, including the load and restriction conditions, taking into account the possible presence of protective materials.
2. Deformation and expansion imposed or impeded due to changes in temperature by effect of the exposure to fire produce indirect stresses, forces and moments in individual structural elements, which must be taken into consideration, except in the following cases:
   a. it is recognisable, in advance, that these are negligible or favourable;
   b. the fire safety requirements are assessed in reference to a nominal fire curve as referred to in Section S.2.7.

   As a consequence, deemed-to-satisfy solutions may be adopted with reference to the load-bearing capacity of individual structural elements, while alternative solutions must be studied with reference to the load-bearing capacity of portions of the structure or of the entire structural system, unless it is verified in advance that, for the particular structure in question, the effect of deformations and expansions due to temperature changes is negligible.
3. The combination of loads for exceptional actions provided for in the applicable NTC shall be taken into account in the design and fire safety checks.

S.2.8.2 Secondary structural elements

1. For the purpose of verifying the fire resistance requirements of the *secondary structural elements*, the designer shall verify that the collapse of these elements by effect of the fire shall not compromise the:
   a. load-bearing capacity of other structural elements in the structure under fire conditions;
   b. effectiveness of compartmentalisation structural elements;
   c. operation of active fire protection systems;
   d. safe evacuation of the occupants;
   e. safety of the rescuers.
2. For the purpose of verifying the requirements of points 1.d. and 1 it is sufficient to verify that the load-bearing capacity of the secondary structural elements is guaranteed for a period of time such that all of the occupants of the activity reach or remain in a safe area. This verification shall be guaranteed by adopting the solutions provided by performance level II.

S.2.8.3 *Vulnerable structures under fire conditions*

1. For the purpose of verifying fire resistance requirements, *vulnerable structures under fire conditions* refer to those structures, usually of a light construction, which by their nature are particularly susceptible to the action of fire. The vulnerability of these structures may be linked to their reduced hyperstaticity or robustness, to the slenderness of the structural elements, to the impossibility or the anti-economy (extravagance) of the application of protection systems, or the total reliance on a sensitive membrane regime resistance to strong increases in temperature.

Note Typical examples of vulnerable structures under fire conditions are: tensile structures, air-dome structures, cabled structures, membranes with double or simple curvature, geodesic coverings, aluminium alloy structures, temporary layouts using pipes and joints, portable tunnels, etc.

2. Given the reduced fire resistance of the structures referred to in paragraph 1, these are considered preferably suitable only for structures requiring performance levels I or II.

3. The possibility of using structures as set out in paragraph1 for performance levels above II is not excluded.

Note According to Table 21, for $q_{f,d} \leq 200$ MJ/m^2, no minimum fire resistance requirements are required for the structures.

4. In case of structures manufactured in series, valid fire resistance assessments for typed or prototype structures are permitted. The *fire safety professional* shall ensure that the fire resistance requirements for structures under construction are certified by specifically verifying compliance with the assumptions made on which fire resistance tests conducted on prototypes are based.

S.2.9 Procedure for the calculation of the specific design fire load

1. The value of the specific design fire load $q_{f,d}$ is determined using this equation:

$$q_{f,d} = \delta_{q1} \cdot \delta_{q2} \cdot \delta_n \cdot q_f \quad (4)$$

where:

$q_{f,d}$ specific design fire load [MJ/m²]

δ_{q1} factor that takes into account the fire risk in relation to the size of the compartment and whose values are defined in Table 24.

δ_{q2} is the factor that takes into account the fire risk in relation to the type of activity undertaken in the compartment and whose values are defined in Table 25.

$\delta_n = \prod_i \delta_{ni}$ is the factor that takes into account the different *fire prevention measures* in the compartment and whose values are defined in Table 25

q_f is the nominal value of the specific fire load to be determined using the formula: [MJ/m²]

$$q_f = \frac{\sum_{i=1}^{n} g_i \cdot H_i \cdot m_i \cdot \psi_i}{A} \quad (5)$$

where:

g_i mass of the i-th combustible material [kg]

H_i lower calorific power of the i-th combustible material; the H_i values of the combustible materials may be determined through experimentation in compliance with the UNI EN ISO 1716 standard, drawn from Table E3 in the UNI EN 1991-1-2 standard, or may be borrowed from the technical literature [MJ/kg]

m_i factor of participation in the combustion of the i-th combustible material equal to 0.80 for timber and other cellulose materials and 1.00 for all other combustible materials

ψ_i factor of limitation of the participation in the combustion of the i-th combustible material equal to:

0 for those materials contained in containers specifically designed to resist fire for a period of time congruent with the fire resistance class and in any case at least the minimum class EI 15 (e.g. fire-resistant cabinets for inflammable liquids, etc.);

0.85 for those materials contained in non-combustible containers, which maintain their integrity when exposed to fire and not specifically designed to resist fire (e.g. metal drums, containers or cabinets, etc.);

1 in all other cases (e.g. glass jars, spray cans, etc.);

A *gross compartment floor area* or, in the case of localised fires, the effective *gross floor area* of the fire load distribution. [m²]

Note An example of a calculation is provided in Table 27.

Gross floor area of the compartment [m²]	δ_{q1}	Gross floor area of the compartment [m²]	δ_{q1}
A < 500	1.00	2 500 ≤ A < 5 000	1.60
500 ≤ A < 1 000	1.20	5 000 ≤ A < 10 000	1.80
1 000 ≤ A < 2 500	1.40	A ≥ 10 000	2.00

Table 24: Parameters for the definition of the δ_{q1} factor

Risk classes	Description	δ_{q2}
I	Areas which present a low fire risk in terms of probability of ignition, speed of flames spreading and the possibility of emergency services controlling the fire	0.80
II	Areas which present a moderate fire risk in terms of probability of ignition, speed of flames spreading and the possibility of emergency services controlling the fire	1.00
III	Areas which present a high fire risk in terms of probability of ignition, speed of flames spreading and the possibility of emergency services controlling the fire	1.20

Table 25: Parameters for the definition of the δ_{q2} factor

Minimum fire prevention measure		δ_{ni}	
Performance level III fire control (Chapter S.6.)	hydrant system with internal protection	δ_{n1}	0.90
	hydrant system with internal and external protection	δ_{n2}	0.80
Performance level IV fire control (Chapter S.6.)	automatic water or foam system and hydrant system with internal protection	δ_{n3}	0.54
	other automatic system and hydrant system with internal protection	δ_{n4}	0.72
	automatic water or foam system and hydrant system with internal and external protection	δ_{n5}	0.48
	other automatic system and hydrant system with internal and external protection	δ_{n6}	0.64
Performance level II fire safety management [1] (Chapter S.5))		δ_{n7}	0.90
Performance level III smoke and heat control (Chapter S.8)		δ_{n8}	0.90
Performance level III detection and alarms (Chapter S.7)		δ_{n9}	0.85
Performance level IV fire prevention operation (Chapter S.9).		δ_{n10}	0.81
[1] Firefighting personnel must ensure their continuous presence 24/7.			

Table 26: Parameters for the definition of δ_{ni} factors

2. Where an alternative to formula 6, q_f can be determined through statistical analysis of the fire load for the specific activity, reference shall be made to values with a probability of exceedance of < 20 %. Additional useful considerations for achieving this purpose may be found in Section S.2.9.1..
3. In case there are timber load-bearing structures in the compartment, the procedure set out in Section S.9.2.below must be followed
4. Without prejudice to the provisions of paragraph 6 of Section S.2.5, the reference space generally coincides with the fire compartment being considered and the specific fire load therefore refers to the *gross floor area* of the compartment floor, assuming a sufficiently uniform distribution of the fire load.
5. In the case of marked and clearly identified *uneven* fire load distribution, the q_f *specific fire load* value shall also refer to its actual distribution.

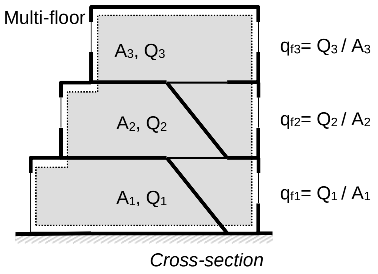
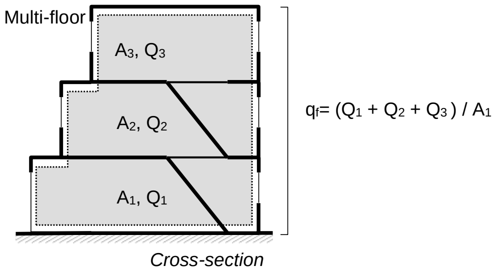
	In the case of a *multi-floor* compartment in the scenario referred to in paragraph 6 of Section s.2.5., specific fire loads are calculated for each floor, although the compartment is unique.
	In the case of a *multi-floor* compartment that does not fall within the scenario referred to in paragraph 6 of Section S.2.5, the *gross floor area of the compartment floor* A for the calculation of q_f is equal to the area of the plan view projection of the compartment. In this example: A = A_1

Table 27: Examples of specific q_f fire load calculations for multi-floor compartments

S.2.9.1 *Additional instructions on statistical determination of the fire load*

1. To calculate the fractile value of 80 % of the fire load starting from figures drawn from the technical literature, to be considered as average values, it is necessary to multiply the average value by an amplification coefficient, according to the following criteria:

   a. in activities with very limited variability as concerns furnishings or goods in storage, such as for example, dwellings, hotels, hospitals, offices and schools, a coefficient multiplier between 1.20 and 1.50 may be chosen;

   b. in activities with greater variability as concerns furnishings or goods in storage, such as for example, shopping centres, department stores and industrial sites, a coefficient multiplier between 1.20 and 1.75 may be chosen.

   Within these intervals, the appropriate coefficient value may be identified based on the calculations made for each individual case.

2. In Table 28 of Annex E of the UNI EN 1991-1-2 standard, there is a list of fire load densities for different intended uses, both as an average value and an 80 % fractile.

Activities	Average value [MJ/m²]	80 % fractile (MJ/m²]
Dwellings	780	948
Hospitals (room)	230	280
Hotels (room)	310	377
Libraries	1 500	1 824
Offices	420	511
Schools	285	347
Shopping centres	600	730
Theatres (cinema)	300	365
Transport (public area)	100	122

Table 28: Fire load densities from UNI EN 1991-1-2

S.2.9.2 *Procedure for the calculation of the fire load contribution of timber structures*

1. The contribution of timber structural elements may be determined using this procedure:

   a. the class of the compartment is determined initially disregarding the presence of any timber structural elements; this class, only as concerns the determination as set out in point b below, cannot, in any event, be less than 15 minutes;

   b. the thickness of the carbonisation of the timber structural elements corresponding to the class determined in the point above is calculated, adopting as reference values the carbonisation speed values set out in the UNI EN 1995-1-2 standard, '*Standard design of timber structures – Parts 1 and 2*: *General rules – Structural design for fire prevention*', an excerpt of which can be found in Table 29..

      In case of timber structural elements with protective fire-resistant cladding, the calculation of the carbonisation thickness may be made taking into account the specific indications in the UNI EN 1995-1-2 standard.

   c. The compartment class is finally determined, also taking into account the specific fire load concerning the relevant timber structural elements, corresponding to the thickness referred to in point b, participating in the combustion.

2. For types of timbers not specifically listed in the table below, adjustments may be made by analogy while using the more conservative values, in any event, in view of the fire safety purposes involved.

Wood species	Wood types	Speed [mm/min]
Soft wood (coniferous and beech)	Glued laminated timber with characteristic density ≥ 290 kg/m^3	0.70
	Solid timber with characteristic density ≥ 290 kg/m^3	0.80
Hardwood (broad-leaved)	Solid hardwood or glued laminate with characteristic density ≥ 290 kg/m^3	0.70
	Solid hardwood or glued laminate with characteristic density ≥ 450 kg/m^3	0.55

Table 29: Carbonisation speed of timber

S.2.10 Classification of the fire resistance of construction products and elements and structures

1. Construction products and elements are classified based on their fire resistance characteristics, according to the symbols and the classes indicated in the tables in this chapter, in compliance with the EU Commission Decisions 2000/367/EC of 3 May 2000, 2003/629/EC of 27 August 2003 and 2011/232/EU of 11th April 2011. This document adds references to additional standards to the contents of the aforementioned decisions.

2. The fire resistance performances of construction products and elements may be determined based on the results of:

   a. tests,

   b. calculations,

   c. comparison with tables.

3. Procedures for the classification of construction products and elements based on the results of fire resistance and smoke leakage tests are described in Section S.2.13.

4. Procedures for the classification of construction products and elements based on the results of calculations are described in Section S.2.13.

5. Procedures for the classification of construction products and elements based on the comparison with tables are described in Section S.2.15.

S.2.11 Symbols

1. Table 30 contains the list of symbols used for fire resistance performance of construction or structural elements. For a detailed description, see the pertinent classification standard in the EN 13501 series and the standards referred to in Section S.2.12.

Symbol	Performance	Description
R	Load-bearing capacity	Capacity of a structural element to bear present loads for a certain period of time under normalised fire conditions
E	Seal	Capacity of a structural element or structure to stop the passage of smoke and hot gases for a certain period of time under normalised fire conditions
I	Insulation	Capacity of a structural element or structure to stop the passage of heat for a certain period of time under normalised fire conditions. Depending on more or less severe limits to the transfer of heat, this requirement is specialised in I1 or I2. Lack of subscript indication means that the requisite is I2.
W	Radiation	Capacity of a structural element or structure to limit thermal radiation from an unexposed surface for a certain period of time under normalised fire conditions.
M	Mechanical action	Capacity of a structural element or structure to resist the impact of other elements without losing its required fire resistance.
C	Automatic closing device	Capacity to close an opening by a structural element under normalised fire and mechanical stress conditions.
S	Smoke proof	Capacity of a closing element to limit or reduce the passage of cold gases or smoke under normalised test conditions. The requirement is specialised in: • S_a: if the seal to the passage of gases or smoke is ensured at ambient temperature; • S_m (or S200): if the seal to the passage of gases or smoke is ensured at both ambient temperature and at 200 °C.
P or PH	Continuity of power or signalling capacity	Functional capacity of a live cable under normalised fire conditions
G	Resistance to the ignition of soot	Capacity of a smoke passage duct to resist the ignition of soot under normalised fire conditions, guaranteeing the seal for the passage of hot gases and thermal insulation.
K	Capacity of fire protection	Capacity of wall or ceiling cladding to protect the construction materials, elements or structures on which they are installed from carbonisation, from ignition or other type of damage for a certain period of time under normalised fire conditions.
D	Duration of stability at a constant temperature	Capacity of smoke barriers to maintain their fire resistance requirements under normalised fire conditions.
DH	Duration of stability along the standard time–temperature curve	
F	Function of motorised heat and smoke exhaust	Capacity of motorised (F) or natural (B) heat and smoke exhaust to maintain operational requirements under normalised fire conditions.
B	Function of natural heat and smoke exhaust	

Table 30: Symbols

S.2.12 Classes

1. The standards in the tables set out in this chapter are indicated generically with their EN classification without reference to their current status (prEN, ENV, EN).
2. The REI-M classification of a product for a given interval of time automatically corresponds to the REI, RE, R classification for the same period, regardless of the presence of this value in the pertinent table.
3. The EI-M classification of a product for a given interval of time automatically corresponds to the EI and E classification for the same period, regardless of the presence of this value in the pertinent table.
4. The I requirement of a product for a given interval of time automatically corresponds to the W requirement for the same period, regardless of the presence of this value in the pertinent table.
5. For the purposes of fire resistance, construction elements and products not bearing a CE mark may be classified with any discrete class between 15 and 360 minutes (15, 20, 30, 45, 60, 90 120, 180, 240, 360). In case of a CE mark requirement subsequent to the classification, the classes not permitted cannot be used.
6. The fire resistance classification of a product for a given period of time can be extended to all lower classes.

Note For example, if a structural element is classified as REI 60-M, it also includes classes REI 45-M, REI 20-M and REI 15-M.

S.2.12.1 Load-bearing elements with no fire compartment function

This applies to	Walls, floors, roofs, beams, columns, balconies, stairways, walkways									
Standards	EN 13501-2; EN 1365-1,2,3,4,5,6; EN 1992-1.2; EN 1993-1.3; EN 1994-1.2; EN 1995-1.2; EN 1996-1.2; EN 1999-1.2									
Classification:										
R	15	20	30	45	60	90	120	180	240	360

Table 31: Walls, floors, roofs, beams, columns, balconies, stairways, walkways

S.2.12.2 Load-bearing elements with fire compartment function

This applies to	Walls									
Standards	EN 13501-2; EN 1365-1; EN 1992-1.2; EN 1993-1.3; EN 1994-1.2; EN 1995-1.2; EN 1996-1.2; EN 1999-1.2									
Classification:										
RE		20	30		60	90	120	180	240	360
REI	15	20	30	45	60	90	120	180	240	360
REI-M			30		60	90	120	180	240	360
REW		20	30		60	90	120	180	240	360

Table 32: Walls

This applies to	Floors and roofs									
Standards	EN 13501-2; EN 1365-2; EN 1992-1.2; EN 1993-1.3; EN 1994-1.2; EN 1995-1.2; EN 1996-1.2; EN 1999-1.2									
Classification:										
R			30							
RE		20	30		60	90	120	180	240	360
REI	15	20	30	45	60	90	120	180	240	360

Table 33: Floors and roofs

S.2.12.3 Products and systems for the protection of parts or load-bearing elements in structures

This applies to	False ceilings lacking intrinsic fire resistance (protective membrane)
Standards	EN 13501-2; EN 13381-1
Classification: expressed in the same terms provided for protected load-bearing elements	
Annotations	The symbol 'sn' shall be added to the classification if the product complies with the requisites provided for ‘semi-natural’ fires.

Table 34: False ceilings lacking intrinsic fire resistance (protective membrane)

This applies to	Cladding, panels, plastering, paints and fire protective screens
Standards	EN 13501-2; EN 13381-2,3,4,5,6,7,8
Classification: expressed in the same terms provided for protected load-bearing elements	

Table 35: Cladding, panels, plastering, paints and fire protective screens

S.2.12.4 Non-load-bearing parts or elements in construction works and pertinent products

This applies to	Partition walls (including those with non-insulated parts and internal flame trap barriers)									
Standards	EN 13501-2; EN 1364-1 [1]; EN 1992-1.2; EN 1993-1.3; EN 1994-1.2; EN 1995-1.2; EN 1996-1.2; EN 1999-1.2									
Classification:										
E		20	30		60	90	120			
EI	15	20	30	45	60	90	120	180	240	
EI-M			30		60	90	120	180	240	
EW		20	30		60	90	120			
[1] For internal flame trap barriers this standard was added to by EOTA TR 031										

Table 36: Partition walls (including those with non-insulated parts and internal flame trap barriers)

This applies to	False ceilings with intrinsic fire resistance									
Standards	EN 13501-2; EN 1364-2									
Classification:										
EI	15		30	45	60	90	120	180	240	
Annotations	The classification is completed by '(a→b)', '(b←a)', or '(a↔b)', to indicate if the element was tested and complies with the requirements for fire coming from above, below or both directions.									

Table 37: False ceilings with intrinsic fire resistance

This applies to	*Curtain walls* and external walls (including windowed areas)									
Standards	EN 13501-2; EN 1364-3,4,5,6; EN 1992-1.2; EN 1993-1.3; EN 1994-1.2; EN 1995-1.2; EN 1996-1.2; EN 1999-1.2									
Classification:										
E	15		30		60	90	120			
EI	15		30		60	90	120			
EI-W		20	30		60					
Annotations	The classification is completed by '(i→o)', '(o→i)', or '(i↔o)', to indicate if the element was tested and complies with the requirements for fire coming from inside, outside or both directions. Where provided for, 'mechanical stability' indicates that any collapse of the parts is not likely to cause damage to the occupants in the time period indicated for the E or EI classification.									

Table 38: Curtain walls and external walls (including windowed areas)

This applies to	Raised flooring									
Standards	EN 13501-2; EN 1366-6									
Classification:										
R	15		30							
RE			30							
REI			30							
Annotations	The classification is completed by the addition of the suffix 'f' to indicate the resistance to a fully developed fire or 'r' to indicate only exposure to a constant reduced temperature.									

Table 39: Raised flooring

This applies to	Systems for sealing through holes and linear joints									
Standards	EN 13501-2; EN 1366-3.4									
Classification:										
E	15		30	45	60	90	120	180	240	
EI	15	20	30	45	60	90	120	180	240	

Table 40: Systems for sealing through holes and linear joints

This applies to	Fire-resistant doors and closures (including windowed areas and accessories) and their closure systems									
Standards	EN 13501-2; EN 1634-1									
Classification:										
E	15	20	30	45	60	90	120	180	240	
EI	15	20	30	45	60	90	120	180	240	
EW		20	30		60					
Annotations	The I classification is completed by the addition of the suffixes '1' or '2' to indicate which insulation definition shall be used. The addition of the symbol 'C' indicates that the product also meets the 'automatic closure' criterion ('pass/fail' test) [1].									
[1] The 'C' classification may be completed with numbers from 0 to 5 depending on the use category. Details of the products referred to must be included in their technical specifications.										

Table 41: Fire-resistant doors and closures (including windowed areas and accessories) and their closure systems

This applies to	Smoke-proof doors
Standards	EN 13501-2; EN 1634-3
Classification: S200 or S_a depending on the test conditions	
Annotations	The addition of the symbol 'C' indicates that the product also meets the 'automatic closure' criterion ('pass/fail' test) [1]
[1] The 'C' classification may be completed with numbers from 0 to 5 depending on the use category. Details of the products referred to must be included in their technical specifications.	

Table 42: Smoke-proof doors

This applies to	Closures to passages intended for conveyor belts and rail transport systems									
Standards	EN 13501-2; EN 1366-7									
Classification:										
E	15		30	45	60	90	120	180	240	
EI	15	20	30	45	60	90	120	180	240	
EW		20	30		60					
Annotations	The I classification is completed by the addition of the suffixes '1' or '2' to indicate which insulation definition shall be used. A classification 1 shall be generated in the event that a test exemplar is a pipe or duct configuration without assessment of the closure for the conveyor belt. The addition of the symbol 'C' [1] indicates that the product also meets the 'automatic closure' criterion ('pass/fail' test).									
[1] The 'C' classification may be completed with numbers from 0 to 5 depending on the use category. Details of the products referred to must be included in their technical specifications.										

Table 43: Closures to passages intended for conveyor belts and rail transport systems

This applies to	Cable ducts and utilities channelling									
Standards	EN 13501-2; EN 1366-5									
Classification:										
E	15	20	30	45	60	90	120	180	240	
EI	15	20	30	45	60	90	120	180	240	
Annotations	The classification is completed by '(i→o)', '(o→i)', or '(i↔o)', to indicate if the element was tested and complies with the requirements for fire coming from inside, outside or both directions. In addition, the symbols 'v_e' or 'h_o' indicate suitability for vertical or horizontal use.									

Table 44: Cable ducts and utilities channelling

This applies to	Stacks, chimneys
Standards	EN 13501-2; EN 13216
Classification: G + distance (mm) (e.g. G 50)	
Annotations	Distance not required for built-in products

Table 45: Stacks, chimneys

This applies to	Cladding for walls and ceilings								
Standards	EN 13501-2; EN 14135								
Classification:									
K_1	10								
K_2	10		30		60				
Annotations	The suffixes '1' and '2' indicate which substrates, fire behaviour criteria and extension rules are to be used in this classification.								

Table 46: Cladding for walls and ceilings

S.2.12.5 Products intended for ventilation systems, excluding smoke- and heat-extraction systems

This applies to	Ventilation ducts								
Standards	EN 13501-3; EN 1366-1								
Classification:									
EI	15	20	30	45	60	90	120	180	240
E			30		60				
Annotations	The classification is completed by '(i→o)', '(o→i)', or '(i↔o)', to indicate if the element was tested and complies with the requirements for fire coming from inside, outside or both directions. In addition, the symbols 'v_e' or 'h_o' indicate suitability for vertical or horizontal use. The addition of the symbol 'S' indicates that the product complies with an additional restriction on leaks.								

Table 47: Ventilation ducts

This applies to	Fire shutters								
Standards	EN 13501-3; EN 1366-2								
Classification:									
EI	15	20	30	45	60	90	120	180	240
E			30		60	90	120		
Annotations	The classification is completed by '(i→o)', '(o→i)', or '(i↔o)', to indicate if the element was tested and complies with the requirements for fire coming from inside, outside or both directions. In addition, the symbols 'v_e' or 'h_o' indicate suitability for vertical or horizontal use. The addition of the symbol 'S' indicates that the product complies with an additional restriction on leaks.								

Table 48: Fire shutters

S.2.12.6 Products intended for use in technical installations

This applies to	Fibre-optic cables and accessories; Ducts and fire-protection systems for electric cables								
Standards	EN 13501-3; EN 1366-11 [1]								
Classification:									
P	15		30		60	90	120		
[1] Reference not referred to in the European decisions provided in Section S.2.10..									

Table 49: Fibre-optic cables and accessories; Ducts and fire-protection systems for electric cables

This applies to	Cables and electric cable systems or for signal transmission with a reduced diameter									
Standards	EN 13501-3; EN 50200 [1]; EN 50577 [2]									
Classification:										
PH	15		30		60	90	120			
P	15		30		60	90	120			
[1] For a cable diameter of < 20 mm with a conductor of < 2.5 mm^2. [2] Reference not referred to in the European decisions provided in Section S.2.10..										

Table 50: Cables and electric cable systems or for signal transmission with a reduced diameter

S.2.12.7 Products for use in smoke and heat control systems

This applies to	Smoke-extraction ducts for a single compartment									
Standards	EN 13501-4; EN 1363-1,2,3; EN 1366-9; EN 12101-7									
Classification:										
E300			30		60	90	120			
E600			30		60	90	120			
Annotations	The classification is completed by the suffix 'single' to indicate the suitability for use in a single compartment. In addition, the symbols 'V_e' or 'h_o' indicate suitability for vertical or horizontal use. 'S' indicates a leak rate of less than 5 $m^3/h/m^2$ (all ducts without an 'S' classification must have a leak rate of < 10 $m^3/h/m^2$). '500', '1 000', '1 500' indicate the suitability for use up to these pressure levels, measured under ambient conditions.									

Table 51: Smoke-extraction ducts for a single compartment

This applies to	Fire-resistant smoke-extraction ducts for multiple compartments									
Standards	EN 13501-4; EN 1363-1,2,3; EN 1366-8; EN 12101-7									
Classification:										
EI			30		60	90	120			
Annotations	The classification is completed by the suffix 'multiple' to indicate the suitability for use in multiple compartments. In addition, the symbols 'V_e' or 'h_o' indicate suitability for vertical or horizontal use. 'S' indicates a leak rate < 5 $m^3/h/m^2$ (all ducts without an 'S' classification must have a leak rate of < 10 $m^3/h/m^2$). '500', '1 000', '1 500' indicate the suitability for use up to these pressure levels, measured under ambient conditions.									

Table 52: Fire-resistant smoke-extraction ducts for multiple compartments

This applies to	Smoke control shutters for a single compartment									
Standards	EN 13501-4; EN 1363-1,3; EN 1366-9,10; EN 12101-8									
Classification:										
E300			30		60	90	120			
E600			30		60	90	120			
Annotations	The classification is completed by the suffix 'single' to indicate the suitability for use in a single compartment. 'HOT 400/30' (High Operational Temperature) indicates that the shutter may open and close for a period of 30 minutes at a temperature less than 400 °C (to be used only with the classification E_{600}). 'V_{ed}', 'V_{ew}' 'V_{edw}' or 'h_{ed}', 'h_{ow}' 'h_{odw}' indicate that the product may be used with a vertical and/or horizontal orientation that may be assembled on a duct, a wall or both. 'S' indicates a leak rate of < 200 m^3/h/m^2. All shutters lacking the 'S' classification must bear a leak rate of < 360 m^3/h/m^2. All shutters with losses of less than 200 m^3/h/m^2 shall adopt this value, all valves with losses between 200 m^3/h/m^2 and 360 m^3/h/m^2 shall adopt the value 360 m^3/h/m^2. Leak rates shall be measured at ambient temperature and at elevated temperatures. '500', '1 000', '1 500' indicate the suitability for use up to these pressure levels, measured under ambient conditions. 'AA' or 'MA' indicate either automatic activation or manual activation. '(i→o)', '(o→i)', or '(i↔o)', indicate that the product meets the performance criteria from inside, outside or from both directions respectively. 'C_{300}', '$C_{10\,000}$' 'C_{mod}' indicate that the shutter may be used only in smoke control systems, in combined environmental or smoke control systems or that these are modular shutters to be used in combined environmental and smoke control systems, respectively.									

Table 53: Smoke control shutters for a single compartment

This applies to	Smoke control shutters for multiple compartments									
Standards	EN 13501-4; EN 1363-1,2,3; EN 1366-2,8,10; EN 12101-8									
Classification:										
EI			30		60	90	120			
E			30		60	90	120			
Annotations	The classification is completed by the suffix 'multiple' to indicate the suitability for use in multiple compartments. Other annotations are identical to those concerning shutters for smoke control systems in a single compartment.									

Table 54: Smoke control shutters for multiple compartments

This applies to	Smoke barriers									
Standards	EN 13501-4; EN 1363-1,2; EN 12101-1									
Classification: D										
D600			30		60	90	120			A
DH			30		60	90	120			A
Annotations	'A' may be any time period longer than 120 minutes.									

Table 55: Smoke barriers

This applies to	Motorised smoke and heat exhaust (fans), connection fittings									
Standards	EN 13501-4; EN 1363-1, EN 12101-3; ISO 834-1									
Classification: F										
F200							120			
F300					60					
F400						90	120			
F600					60					
F842			30							

Table 56: Motorised smoke and heat exhaust (fans), connection fittings

This applies to	Natural heat and smoke extractors									
Standards	EN 13501-4; EN 1363-1; EN 12101-2									
Classification: B										
B300							120			
B600					60					
B400						90	120			
F_{θ}					60					
Annotations	θ indicates the exposure conditions (temperature).									

Table 57: Natural heat and smoke extractors

S.2.13 Procedures for classification based on test results

1. Fire resistance tests have the objective of assessing the behaviour of construction products and elements under specific conditions when exposed to fire and through compliance with measurable performance criteria.
2. Fire exposure conditions, performance criteria and the classification procedures to be used in the tests as set out in paragraph 1 are indicated in parts 2, 3 and 4 of EN 13501.
3. The specifications for experimental ovens, test equipment, measurement and acquisition instruments, procedures for sampling, preservation, conditioning, ageing, installation and testing and the methods for drafting the test reports are indicated in the EN or ENV standards, in their versions in force on the date of the testing, referred to in parts 2, 3 and 4 of the EN 13501 standard.
4. In the event that one of the parts of the EN 13501 standard, or one of the EN or ENV standards referred to therein are still not subject of a UNI publication, testing shall be performed and the classification shall be issued pursuant to the following procedures:
    a. the provided EN or ENV standards shall apply, if available;
    b. the provided (prEN or prENV) European standard design shall apply, if available and if deemed sufficient by the test laboratory if the foregoing possibility in the point above is absent.
5. The classification report is the document, drafted in compliance with the EN 13501 standard by the test laboratory, which certifies, based on one or more test reports, the class of the construction product or element being tested. In the case of products tested based on the EN 13381 series standard, the classification report shall be replaced by the assessment report.
6. The test report shall be issued for construction products or elements completely defined and referenced collectively and in their component parts. These definitions and references, listed in the test report by the laboratory, must be provided by the test principal and verified by the laboratory.
7. Test reports shall be drafted in compliance with the specific section provided for by the EN 1363-1, 2 standards and by the information required by the specific test standard for each construction product or element. In particular, the test applicant shall provide the laboratory with at least:
    a. the detailed description of the sample including drawings and identifying lists of its components including their trade names and manufacturers;
    b. sample(s) intended for testing and those required for identification of the components;
    c. any other samples or components that the applicant may consider necessary for the experimental verification of the stated performance, at the discretion of the test laboratory.
8. In the event of variations in the construction products or elements classified, not provided for by the direct field of application of the test result, the manufacturer shall make available a technical file on that product containing at least the following documentation:
    a. detailed graphic designs of the modified product;

b. technical report, aimed at demonstrating that the fire resistance class has been maintained, based on tests, calculations and other experimental and/or technical evaluations, also resulting from improvements made to the components and the product, entirely in compliance with the instructions and restrictions contained in the specific EN or prEN standards on extended applications of the test results as applicable (EXAP);

c. any other approvals earned in one of the EU Member States or signatories of the Agreement on the European Economic Area (EEA) or Turkey;

d. positive technical opinion on the completeness and correctness of the assumptions supporting the assessments made for the extension of the test result by a test laboratory; to complete the technical file, the classification report issued based on the EXAP standard shall be considered the test laboratory's technical opinion.

9. The manufacturer shall preserve the foregoing technical file making it available to any professional needing it for certification, by citing its identifying details. The technical file shall also be made available to the DCPST as required for inspection.

S.2.14 Procedures for classification based on calculation results

1. The methods used for calculating fire resistance have the objective of enabling the design of fire-resistant load-bearing construction elements, whether separating or non-separating, also taking into consideration their connections and mutual interactions with other elements, under specific conditions of exposure to fire and through compliance with performance criteria and the adoption of construction particulars.

2. The conditions of exposure to fire shall be defined by specific regulations based on design fire scenarios as prescribed therein or those expected. In the same regulations those load combinations to be considered agents shall be defined together with the action of the fire and the safety coefficients on materials and models.

3. The calculation methods to be used for the purposes of this document are contained in the Eurocodes indicated below, including their annexes containing the parameters defined on a national level (NDP_s):

   a. EN 1991-1-2 '*Actions on structures – Part 1-2: General Actions – Actions on structures exposed to fire*';

   b. EN 1992-1-2 '*Design of concrete structures – Part 1-2: General rules – Structural fire design*';

   c. EN 1993-1-2 '*Design of steel structures – Part 1-2: General rules – Structural fire design*';

   d. EN 1994-1-2 '*Design of composite steel and concrete structures Part 1-2: General rules – Structural fire design*';

   e. EN 1995-1-2 '*2 Design of timber structures – Part 1-2: General rules – Structural fire design*';

   f. EN 1996-1-2 '*Design of masonry structures – Part 1-2: General rules – Structural fire design*';

   g. EN 1999-1-2 '*Design of aluminium structures – Part 1-2: General rules – Structural fire design*';

4. The calculation methods in paragraph 3 may require the determination, upon a change in temperature, of the thermophysical parameters of protection systems that may be present on load-bearing construction elements. In these cases, the levels of these parameters shall only be determined exclusively with the tests indicated in Section S.2.13. Numeric processing of the levels of these parameters, that go beyond the scope of the tests indicated in Section S.2.13 or of the standards cited in paragraph 3 shall not be considered valid for the fire resistance tests of the load-bearing construction elements.

S.2.15 Procedures for classification based on comparisons with tables

1. The following tables propose conditions sufficient for the classification of fire-resistant construction elements. These conditions are not mandatory if fire resistance performance is determined using the other methods referred to in Sections S.2.13 and S.2.14.. The levels contained in the tables are the results of experimental campaigns and numeric processing; they refer to the most used types of structures and materials. These levels, even though conservative, do not permit extrapolations or interpolations of their values or changes in their use conditions.

2. The use of the tables is strictly limited to the classification of construction elements for which fire resistance is requested as compared to the standard time–temperature curve referred to in Section S.2.7 paragraph 1 and to the other mechanical actions foreseen in case of fire.

3. Experimental or analytic tables other than those below are not included among those provided for in SectionS.2.7 paragraph 1, letter c..

4. The presence of elements of systems with chased linear development such as cables, pipelines, tubing and channels in general, may limit, in an unpredictable manner, the fire resistance of the masonry. For this reason, the use of tables for the classification of masonry is recommended under the following conditions:

   a. In the presence of elements of chased linear systems with a maximum mounting depth between 1/5 and 1/3 of the required thickness of non-load-bearing walls, the thickness of the wall corresponding to the class higher than that required must be adopted with caution. This provision does not apply to non-load-bearing masonry of class 240.

   b. In the presence of elements of chased linear systems with a maximum mounting depth less than 1/10 of the required thickness of load-bearing walls, the thickness of the wall corresponding to the class higher than that required must be adopted with caution. This provision does not apply to load-bearing masonry of class 240.

S.2.15.1 Non-load-bearing block masonry

1. Table 58 shows the minimum values expressed in millimetres of the thickness s of brick block masonry (excluding plaster) exposed on one side, sufficient to guarantee the EI or EI-M requirements for the classes indicated, with the following limitations:

    a. height of the wall between the two floors or distance between two stiffening elements with equivalent restriction function of the floors ≤ 4 m;

    b. for EI requirements, presence of 10 mm of plaster on both faces or 20 mm only on the face exposed to fire;

    c. for EI-M requirements, presence of 10 mm of plaster on both faces.

Class	Block with void > 55 %		Block with void ≤ 55 %	
	Normal plaster	Fireproof protective plaster	Normal plaster	Fireproof protective plaster
EI 30	s = 120	80	100	80
EI 60	s = 150	100	120	80
EI 90	s = 180	120	150	100
EI 120	s = 200	150	180	120
EI 180	s = 250	180	200	150
EI 240	s = 300	200	250	180
EI 120-M	s = 200	200	200	-
EI 180-M	s = 250	200	200	-
EI 240-M	s = 300	200	250	-
Normal plaster: sand and cement-type plaster, sand, cement and lime, sand lime and gypsum and similar, characterised by a density between 1 000 and 1 400 kg/m^3 Fireproof protective plaster: Gypsum plaster, expanded vermiculite or clay and cement or gypsum plaster, perlite, and gypsum and similar, characterised by a density between 600 and 1 000 kg/m^3				

Table 58: Non-load-bearing brick block masonry (E, I, M Requirements)

2. Table 59 shows the minimum widths (mm) of brick block masonry (excluding plaster) exposed on one side, sufficient to guarantee the EI or EI-M requirements for the classes indicated, with the following limitations:

    a. height of the wall between the two floors or distance between two stiffening elements with equivalent restriction function of the floors ≤ 4 m;

    b. for EI requirements, exposed or with 10 mm of plaster on both faces or 20 mm only on the face exposed to fire.

    c. for EI-M requirements, presence of 10 mm of plaster on both faces.

Class	Block with single void	Block with multi-voids or solid	Block with single or multi-voids or solid	
			Normal plaster	Fireproof protective plaster
EI 30	s = 120	100 [1]	100 [1]	80 [1]
EI 60	s = 150	120 [1]	120 [1]	100 [1]
EI 90	s = 180	150	150	120 [1]
EI 120	s = 240	180	200	150
EI 180	s = 280	240	250	180
EI 240	s = 340	300	300	200
EI 120-M	s = 240	240	200	200
EI 180-M	s = 280	240	250	200
EI 240-M	s = 340	300	300	200
[1] Only solid blocks (void < 15 %)				

Table 59: Non-load-bearing normal concrete block masonry (E, I, M Requirements)

3. Table 60 shows the minimum width values s (mm) of light (net density not greater than 1 700 kg/m^3) or autoclaved aerated concrete block masonry exposed on one side, sufficient to guarantee the EI requirements for the classes indicated, with the following limitation:
   a. height of the wall between the two floors or distance between two stiffening elements with equivalent restriction function of the floors ≤ 4 m.

Class	Block with single void	Block with multiple voids or solid and autoclaved aerated concrete
30	s = 100	80 [1]
60	s = 120	80 [1]
90	s = 150	100 [1]
120	s = 200	150
180	s = 240	200
240	s = 300	240
[1] Only solid blocks (void < 15 %)		

Table 60: Non-load-bearing in light or autoclaved aerated concrete block masonry (E, I, Requirements)

4. Table 61 shows the minimum widths values s (mm) of dressed stone block masonry exposed on one side, sufficient to guarantee the EI or EI-M requirements for the classes indicated, with the following limitations:
   a. height of the wall between the two floors or distance between two stiffening elements with equivalent restriction function of the floors ≤ 4 m.
   b. for EI-M requirements, presence of 10 mm of plaster on both faces.

Class	Solid dressed stone block
EI 30	s = 150
EI 60	s = 150
EI 90-M	s = 250
EI 120-M	s = 250
EI 180-M	s = 360
EI 240-M	s = 360

Table 61: Non-load-bearing normal dressed stone block masonry (E, I, M Requirements)

S.2.15.2 Load-bearing block masonry

1. Table 62 shows the minimum widths values s (mm) of block masonry (excluding plaster) exposed on one side, sufficient to guarantee the REI or REI-M requirements for the classes indicated, with the following limitations:
   a. h/s ratio ≤ 20;
   b. for REI requirements:
      i. h ≤ 8 m (where h is the height of the wall between the two floors or between two stiffening elements with equivalent restriction function of the floors);
   c. for REI-M requirements:
      i. h ≤ 4 m (where h is the height of the wall between the two floors or between two stiffening elements with equivalent restriction function of the floors);
      ii. presence of 10 mm of plaster on both faces.

Material	Block type	REI 30	REI 60	REI 90	REI 120	REI 180	REI 240	REI 90-M	REI 120-M	REI 180-M	REI 240-M
Brick [1]	Solid (void ≤ 15 %)	120	150	170	200	240	300	200	200	240	300
Brick [1]	Semi-solid and with void (15 % < void ≤ 55 %)	170	170	200	240	280	330	240	240	280	330
Concrete	Solid, semi-solid and with void (void ≤ 55 %)	170	170	170	200	240	300	200	200	240	300
Light concrete [2]	Solid, semi-solid and with void (void ≤ 55 %)	170	170	170	200	240	300	240	240	240	300
Autoclaved aerated concrete	Solid	170	170	170	200	240	300	240	240	240	300
Dressed stone	Solid (void ≤ 15 %)	170	170	250	280	360	400	250	280	360	400
[1] Presence of 10 mm of plaster on both faces or 20 mm only on the face exposed to the fire. Values in the table refer to normal and lightened concrete block elements. [2] Net density ≤ 1 700 kg/m^3.											

Table 62: Load-bearing block masonry (R, E, I, M Requirements)

S.2.15.3 Solid slabs and lightened floors

1. Table 63 shows the minimum values of the total thickness H (mm) of slabs and floors, of the distance a, from the centre of the longitudinal reinforcement to the exposed surface sufficient to ensure the R requirement for the classes indicated.
2. To ensure the required seal and insulation, the floors as set out in Table 63 shall have a layer of solid, non-combustible insulation material with heat conduction no greater than that of the concrete, of which at least one part is made up of reinforced concrete. Table 64 the minimum values of the thickness h (mm) of the layer of insulation material and of the part d of the reinforced concrete, sufficient to ensure the EI requirements for the classes indicated.
3. The thicknesses h and d of the previous paragraph 2 are sufficient to guarantee the EI requirements also for types of floors other than those shown in Table 63.

Note If a layer of combustible material is placed between them (e.g. a layer of material for energy containment or soundproofing, etc.) the thickness of the latter does not contribute to determining the thickness h.

Class	30		60		90		120		180		240	
	H	a	H	a	H	a	H	a	H	a	H	a
Solid slabs with one or two-way reinforcement	80	10	120	20	120	30	160	40	200	55	240	65
Composite slabs with steel plate and concrete fill [1]	80	10	120	20	120	30	160	40	200	55	240	65
Floors with beams and lightening [2]	160	15	200	30	240	35	240	45	300	60	300	75
Floors with plates and lightening [3]	160	15	200	30	240	35	240	45	300	60	300	75

Values of a shall not be less than the minimum standards for works in reinforced concrete and pre-stressed reinforced concrete. In case of pre-stressed reinforcement, increase the values of a by 15 mm. With plaster coating the values of H and a shall be taken into account as follows:

- 10 mm of normal plaster (definition in Table 58) equal to 10 mm of concrete;
- 10 mm of fire-resistant plaster (definition in Table 58) equal to 20 mm of concrete.

For concrete coating thicker than 50 mm, additional distributed reinforcement shall be provided for to ensure stability of the coating.

[1] In case of a corrugated plate, H represents the average thickness of the slab. The value of a does not include the thickness of the plate. The plate acts only as formwork.

[2] There must always be a layer of normal plaster not less than 20 mm thick or a layer of insulating plaster not less than 10 mm thick.

[3] In case of lightening with polystyrene or similar materials, provide for appropriate vents for the overpressure.

Table 63: Floors (R Requirement)

Class	30		60		90		120		180		240	
	h	d	h	d	h	d	h	d	h	d	h	d
All types in Table 63	60	40	60	40	100	50	100	50	150	60	150	60
With plastering, the values of h and d may be taken into account as indicated in Table 63. In any event, it must never be < 40 mm. In the presence of upper layers of non-combustible finishing materials (e.g. screed, bedding mortar, flooring, etc.) these may be considered in the values of h.												

Table 64: Floors (E, I Requirements)

Beams, pillars and walls in normal and pre-stressed reinforced concrete

1. Table 65 shows the minimum values (mm) of the width b of the section, of the distance a from the centre of the longitudinal reinforcement to the exposed surface and of the core width b_w of the beams with a wider lower section, sufficient to ensure the R requirement for the classes of beams indicated. With beams with a variable width cross-section, b is the width corresponding to the mid-line of the longitudinal reinforcement set.

Class	Possible combinations of b and a				b_w
30	b = 80; a = 25	b = 120; a = 20	b = 160; a = 15	b = 200; a = 15	80
60	b = 120; a = 40	b = 160; a = 35	b = 200; a = 30	b = 300; a = 25	100
90	b = 150; a = 55	b = 200; a = 45	b = 300; a = 40	b = 400; a = 35	100
120	b = 200; a = 65	b = 240; a = 60	b = 300; a = 55	b = 500; a = 50	120
180	b = 240; a = 80	b = 300; a = 70	b = 400; a = 65	b = 600; a = 60	140
240	b = 280; a = 90	b = 350; a = 80	b = 500; a = 75	b = 700; a = 70	160
Values of a shall not be less than the minimum standards for works in reinforced concrete and pre-stressed reinforced concrete. In case of pre-stressed reinforcement, increase the values of a by 15 mm. With plastering, the values of b and a may be taken into account as indicated in Table 63. For concrete coating thicker than 50 mm, additional distributed reinforcement shall be provided for to ensure stability of the coating.					

Table 65: Beams in reinforced concrete (R Requirement)

2. Table 66 shows the minimum values (mm) of the smaller side b of pillars with a rectangular cross-section or the diameter of circular pillars and the distance a from the centre of the longitudinal reinforcement to the exposed surface sufficient to ensure the R requirement for the classes of beams indicated of pillars exposed on one or more sides in compliance with both of the following restrictions:
   a. actual length of the pillar (from node to node) ≤ 6 m (for intermediate-floor pillars) or ≤ 4.5 m (for top-floor pillars or for single-storey buildings));
   b. overall reinforced area $A_S \leq 0.04\ A_C$ of the pillar cross-section.

Class	Exposed on several sides		Exposed on one side
30	B = 200; a = 30	B = 300; a = 25	B = 160; a = 25
60	B = 250; a = 45	B = 350; a = 40	B = 160; a = 25
90	B = 350; a = 50	B = 450; a = 40	B = 160; a = 25
120	B = 350; a = 60	B = 450; a = 50	B = 180; a = 35
180	B = 450; a = 70	-	B = 230; a = 55
240	-	-	B = 300; a = 70
Values of a shall not be less than the minimum standards for works in reinforced concrete and pre-stressed reinforced concrete. In case of pre-stressed reinforcement, increase the values of a by 15 mm. When there is plaster, the values of a may be taken into account as indicated in Table 63. For concrete coating thicker than 50 mm, additional distributed reinforcement shall be provided for to ensure stability of the coating.			

Table 66: Pillars in reinforced concrete (R Requirement)

3. Table 67 shows the minimum values (mm) of the thickness s and of the distance a from the centre of the longitudinal reinforcement to the exposed surface sufficient to ensure the REI or REI-M requirement for the classes of indicated load-bearing walls exposed on one or two sides in compliance with the following restrictions: actual height of the wall (from node to node) ≤ 6 m (for intermediate-floor walls) or ≤ 4.5 m (for top-floor walls or for single-storey buildings).

Class	Exposed on one side	Exposed on two sides
REI 30	s = 120; a = 10	s = 120; a = 10
REI 60	s = 130; a = 10	s = 140; a = 10
REI 90-M	s = 140; a = 25	s = 170; a = 25
REI 120-M	s = 160; a = 35	s = 220; a = 35
REI 180-M	s = 210; a = 50	s = 270; a = 55
REI 240-M	s = 270; a = 60	s = 350; a = 60
Values of a shall not be less than the minimum standards for works in reinforced concrete and pre-stressed reinforced concrete. In case of pre-stressed reinforcement, increase the values of a by 15 mm. When there is plaster, the values of a may be taken into account as indicated in Table 63 For concrete coating thicker than 50 mm, additional distributed reinforcement shall be provided for to ensure stability of the coating.		

Table 67: Load-bearing walls in reinforced concrete (R, E, I, M Requirements)

4. Table 68 shows the minimum values (mm) of the thickness s sufficient to ensure the EI or EI-M requirement for the classes of indicated non-load-bearing walls exposed on one side in compliance with both of the following restrictions:
   a. actual height of the wall (from node to node) ≤ 6 m (for intermediate-floor walls) or ≤ 4.5 m (for top-floor walls or for single-storey buildings);
   b. ratio between free buckling height and lower thickness of < 40.

Class	Exposed on one side
EI 30	s = 60
EI 60	s = 80
EI 90	s = 100
EI 120-M	s = 120
EI 180-M	s = 150
EI 240-M	s = 175

Table 68: Non-load-bearing walls in reinforced concrete (E, I, M Requirements)

S.2.16 References

1. The following references are provided:
   a. The European Commission's Directorate-General for Enterprise and Industry, Joint Research Centre, *'Construction – Harmonised European Standards'*, documentation from http://eurocodes.jrc.ec.europa.eu

European Commission, Directorate-General for Enterprise and Industry, *'Construction – Harmonised European Standards'*, documentation from http://ec.europa.eu/enterprise/sectors/construction/declaration-of-performance

Chapter S.3 Compartmentalisation

S.3.1 Preface

1. The purpose of *compartmentalisation* is to limit the spread of the fire and its effects:
   a. to other premises managed by other *premises managers* or of different *types;*
   b. within the same premises.
2. Compartmentalisation is achieved through the use of:
   a. fire compartments, located within the same building;
   b. separation distances between buildings or other combustible targets, including those located in open-air spaces.

S.3.2 Performance levels

1. Table 69 lists the performance levels attributable of *buildings* for this fire protection measure.

Performance level	Description
I	No requirement
II	The following are contrasted (suppressed) for a period corresponding to the duration of the fire: ● the spread of the fire to other premises; ● the spread of the fire within the same premises.
III	The following are contrasted (suppressed) for a period corresponding to the duration of the fire: ● the spread of the fire to other premises; ● the spread of the fire and cold smoke within the same premises.

Table 69: Performance levels

S.3.3 Assignment criteria for performance levels

1. Table 69 lists the *generally accepted* criteria required for the individual performance levels.

Performance level	Required criteria
I	Not allowed in the activities subject to fire regulations
II	Premises not covered by the other required criteria
III	In relation to the results of the risk assessment within settings (areas) of the same premises and in neighbouring areas (e.g. densely occupied premises, premises with a complex geometry or high specific fire load q_f, the presence of significant quantities of hazardous substances or mixtures, the presence of hazardous works presenting a fire risk, etc.). This may apply in particular in the case of compartments with an R_{life} risk profile that falls within D1, D2, Cii2, Cii3, Ciii2, Ciii3, in order to protect occupants who are sleeping or receiving medical treatment.

Table 70: Required criteria for the performance levels

S.3.4 Design solutions

S.3.4.1 Deemed-to-satisfy solutions for performance level II

1. In order to limit the spread of fire *to other premises,* at least one of the following deemed-to-satisfy solutions must be employed:
    a. placing the different premises in separate fire compartments, as described in paragraphs S.3.5 and S.3.6, with the characteristics described in paragraph S.3.7.
    b. applying separation distances to open-air spaces between the different premises, as described in paragraph S.3.8.
2. In order to limit the spread of fire *within the same premises,* at least one of the following deemed-to-satisfy solutions must be employed:
    a. subdividing the space within the building that contains the premises into fire compartments, as described in paragraphs S.3.5 and S.3.6, with the characteristics described in paragraph S.3.7.
    b. applying separation distances to open-air spaces between settings (areas) of the same premises, as described in paragraph S.3.8..
3. The *location* of the different premises within the same building must be established according to the criteria listed in paragraph S.3.9..
4. *Access* between the different premises located in the same building is allowed, provided it complies with the limitations and methods described in paragraph S.3.10..

S.3.4.2 Deemed-to-satisfy solutions for performance level III

1. The deemed-to-satisfy solutions for performance level II apply, with the use of smokeproof elements (S_a) to create fire compartments.

S.3.4.3 Alternative solutions

1. *Alternative solutions* are allowed for all performance levels.
2. To demonstrate that the *performance level* has been achieved, the designer must employ one of the methods outlined in paragraph G.2.7.
3. Table 71ists several *generally accepted* methods for designing alternative solutions. The designer may nevertheless employ methods other than those listed.

Object of the solution	Design method
Characteristics of the uncovered space (§ S.3.5.1.), of the compartment, of the filter (§ S.3.5.4), of the location (§ S.3.9)	Demonstrate, including with analytical models, that the fire and its effects cannot spread in the configuration in question.
Smokeproof compartment (§ S.3.5.3), smokeproof filter (§ S.3.5.5), multi-storey compartmentalisation (§ S.3.6.2) accesses (§ S.3.10.)	Demonstrate that the lives of the occupants are protected (chapter M.3) and, if applicable, that goods are protected.
Separation distance (§ S.3.8) and its calculation (§ S.3.11)	Demonstrate that the spread of the fire and its effects are limited. The same analytical method as in paragraph S.3.11.3. can be applied, for example, by employing the appropriate $E_{threshold}$ value for the target actually exposed to the fire, the view factor F_{2-1} and the radiating surface corresponding to the actual geometric configuration, the emissive power E_1 referring to natural fires. Numerical simulation models for the fire, its effluents and radiation can also be employed.

Table 71: Design methods for alternative solutions

S.3.5 General description

S.3.5.1 Uncovered space

Note The *uncovered space* limits the spread of the fire and its effects. The uncovered space is not a fire compartment.

1. The *uncovered space* is an open-air or grille-top-covered space, which can be bordered on all sides, and has:
    a. a gross minimum free surface area, expressed in m^2, of no less than the area calculated by multiplying the height in metres of the lowest bordering wall by 3;
    b. a distance between the vertical structures bordering the uncovered space of ≥ 3.50 m.
2. If the uncovered space is top-covered with a grille, the ratio between the *usable surface area* and the total *gross surface area* of the grille must be ≥ 75 %.
3. If the walls bordering the open-air or grille-covered space have overhanging structures or recesses, said space is deemed to be *uncovered* if the conditions of point 1 are met and if the ratio between the overhang (or recess) and the height at which it is set is ≤ 1/2.
4. The gross minimum free surface area of the *uncovered space* must be the net of overhanging surfaces.
5. The minimum distance of 3.50 m must be calculated between the closest walls in the case of recesses, between the wall and the outer edge of the protrusion in the case of overhangs, and between the outer edges of protrusions facing one another.

S.3.5.2 Compartment

Note The purpose of the *compartment* is to limit the passage of the fire within the building, restricting the effects to contained spaces for a pre-established period.

1. The general characteristics of the *fire compartment* are defined in chapter G.1.

S.3.5.3 Smokeproof compartment

Note Fire effluents from communicating compartments are blocked from entering the *smokeproof compartment*.

1. To be considered *smokeproof* in the event that a fire breaks out in a communicating compartment, the *fire compartment* must be constructed with one of the following additional fire prevention measures in relation to the communicating compartments from which the entry of smoke is to be prevented:
    a. the compartment has a *differential pressure system* designed, installed and managed in accordance with standard UNI EN 12101-6;
    b. the communicating compartments from which the entry of smoke is to be prevented are equipped with smoke and heat evacuation systems that trap the smoke above the communicating doorways (chapter S.8);
    c. the compartment is equipped with smoke and heat evacuation systems, and the communicating compartments from which the entry of smoke is to be prevented are equipped with smoke and heat evacuation systems (chapter S.8);

d. the compartment is separated from the communicating compartments from which the entry of smoke is to be prevented by an *uncovered space*;

e. the compartment is separated from the communicating compartments from which the entry of smoke is to be prevented by a *smokeproof filter* (paragraph S.3.5.5);

f. the compartment is separated from the communicating compartments from which the entry of smoke is to be prevented by other *smokeproof compartments*.

Note Table 73 lists several applications. Examples of smokeproof compartments are: smokeproof stairs, smokeproof lift shaft, etc.

S.3.5.4 *Filter*

Note The outbreak of a fire within the *filter* is deemed to be unlikely and the entry of fire effluents from communicating compartments is limited. The following are generally permitted within the filter: reception areas, caretaking offices, waiting rooms, limited electrical appliances, technological systems and auxiliary facilities for the functioning of the premises, etc.

1. The *filter* is a *fire compartment* equipped with all of the following additional characteristics:

   a. a fire rating of ≥ 30 minutes;

   b. two or more fire doors rated at least E 30 S_a;

   c. a specific fire load $q_f \leq 50$ MJ/m^2;

   d. no hazardous substances or mixtures contained or handled within it;

   e. no hazardous works with a fire risk performed within it.

S.3.5.5 *Smokeproof filter*

Note By definition, the *smokeproof filter* is a *filter* (paragraph S.3.5.4) that also meets the requirements of a *smokeproof fire compartment* (paragraph S.3.5.3). Therefore, the outbreak of a fire within the *smokeproof filter* is deemed to be unlikely and the entry of fire effluents from communicating compartments is prevented. The traditional methods outlined in clause 1 are also accepted, because they are deemed to allow the rapid exhaust of any effluents that may enter the smokeproof filter.

1. In the case of single-storey buildings with a small gross surface area, the *smokeproof filter* may be constructed as a *filter* (paragraph S.3.5.4.) equipped with one of the following additional characteristics:

   a. pressurised to at least 30 Pa in emergency conditions by a special protected system and managed in accordance with best practices;

   Note Standard UNI EN 12101-6 outlines a generally accepted method for protecting the pressurisation system of the smokeproof filter.

   b. equipped with a shaft to vent smoke and an outside air intake that are *adequately designed* and with a cross-section of ≥ 0.10 m^2;

   c. ventilated directly from the outside with openings with an overall usable surface area of ≥ 1 m^2. Such openings must be permanently open or equipped with closures that will automatically open in the event of a fire. The use of ducts is not permitted.

2. The use of E 30 fire doors is permitted for the *smokeproof filter*.

S.3.5.6 *Vulnerable external barriers of the compartment*

1. The adoption of certain types of external barriers (e.g. continuous façades, ventilated façades, cladding, etc.) must in no way harm the effectiveness of the compartmentalisation of the storey or any other horizontal or vertical compartmentalisation within the building.

Note Helpful references are the DCPST circular n°5643 of 31st March 2010 and DCPST circular n°5043 of 15th April 2013 providing technical guidance on ‘*Fire safety requirements of façades in civil buildings*’.

S.3.5.7 *Signage*

1. The fire doors must be labelled on both sides with UNI EN ISO 7010-F007 signs, bearing the message *’Fire door keep closed’* or *’Automatic fire door’* if equipped with an *electromagnetic holder* (Table 72).

<table>
<tr>
<td>

F007
Fire door</td>
<td>

F007
Fire door with holder</td>
</tr>
</table>

Table 72: Examples of UNI EN ISO 7010-F007 signs

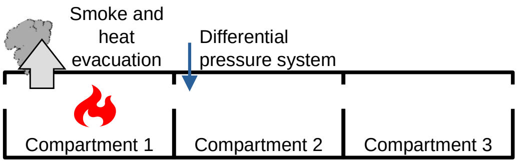
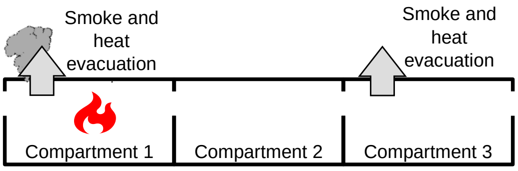
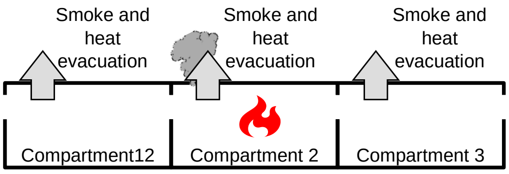
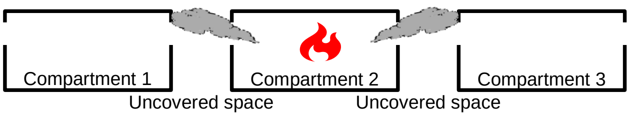
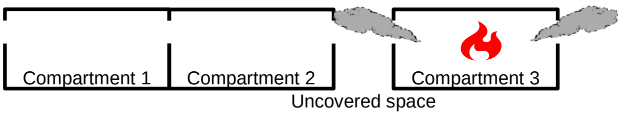
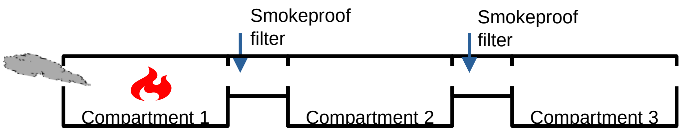
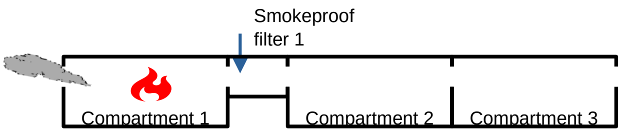
<table>
<tr><td>
</td><td>Compartment 2 is smokeproof from compartments 1 and 3.
Compartments 1 and 3 are not smokeproof from compartment 2.
Compartment 1 is smokeproof from compartment 3 and vice versa.</td></tr>
<tr><td>
</td><td>Compartment 2 is smokeproof from compartments 1 and 3.
Compartments 1 and 3 are smokeproof from compartment 2.
Compartment 1 is smokeproof from compartment 3 and vice versa.</td></tr>
<tr><td>
</td><td>All compartments are smokeproof from the other compartments.</td></tr>
<tr><td>
</td><td>All compartments are smokeproof from the other compartments.</td></tr>
<tr><td>
</td><td>Compartments 1 and 2 are smokeproof from compartment 3 and vice versa.
Compartment 1 is not smokeproof from compartment 2 and vice versa.</td></tr>
<tr><td>
</td><td>All compartments are smokeproof from the other compartments.</td></tr>
<tr><td>
</td><td>Compartments 2 and 3 are smokeproof from compartment 1 and vice versa.
Compartment 2 is not smokeproof from compartment 3 and vice versa.</td></tr>
</table>

Table 73: Examples of smokeproof compartments: plan views and descriptions

S.3.6 Design of fire compartments

S.3.6.1 General rules

1. The following must be in separate compartments:
   a. *each storey*, whether underground or above ground, in multi-storey premises;
   b. areas of the premises with a *different* risk profile;
   c. *other premises* housed in the same building.
2. The presence of *multi-storey compartments* is permitted under the conditions indicated in paragraph S.3.6.2.
3. The gross surface area of the compartments must not exceed the maximum values stipulated in Table 74.

R_{life}	Elevation of the compartment								
	< -15 m	**< -10 m**	**< -5 m**	**< -1 m**	**≤ 12 m**	**≤ 24 m**	**≤ 32 m**	**≤ 54 m**	**> 54 m**
A1	2 000	4 000	8 000	16 000	[1]	32 000	16 000	8 000	4 000
A2	1 000	2 000	4 000	8 000	64 000	16 000	8 000	4 000	2 000
A3	[na]	1 000	2 000	4 000	32 000	4 000	2 000	1 000	[na]
A4	[na]	[na]	[na]	[na]	16 000	[na]	[na]	[na]	[na]
B1	[na]	2 000	8 000	16 000	64 000	16 000	8 000	4 000	2 000
B2	[na]	1 000	4 000	8 000	32 000	8 000	4 000	2 000	1 000
B3	[na]	[na]	1 000	2 000	16 000	4 000	2 000	1 000	[na]
Cii1, Ciii1	[na]	[na]	[na]	2 000	16 000	8 000	8 000	8 000	4 000
Cii2, Ciii2	[na]	[na]	[na]	1 000	8 000	4 000	4 000	2 000	2 000
Cii3, Ciii3	[na]	[na]	[na]	[na]	4 000	2 000	2 000	1 000	1 000
D1	[na]	[na]	[na]	1 000	2 000	2 000	1 000	1 000	1 000
D2	[na]	[na]	[na]	1 000	2 000	1 000	1 000	1 000	[na]
E1	2 000	4 000	8 000	16 000	[1]	32 000	16 000	8 000	4 000
E2	1 000	2 000	4 000	8 000	[1]	16 000	8 000	4 000	2 000
E3	[na]	[na]	2 000	4 000	16 000	4 000	2 000	[na]	[na]

The maximum gross surface area is reduced by 50 % for compartments with a significant R_{env}.
[na] Not allowed
[1] Unlimited

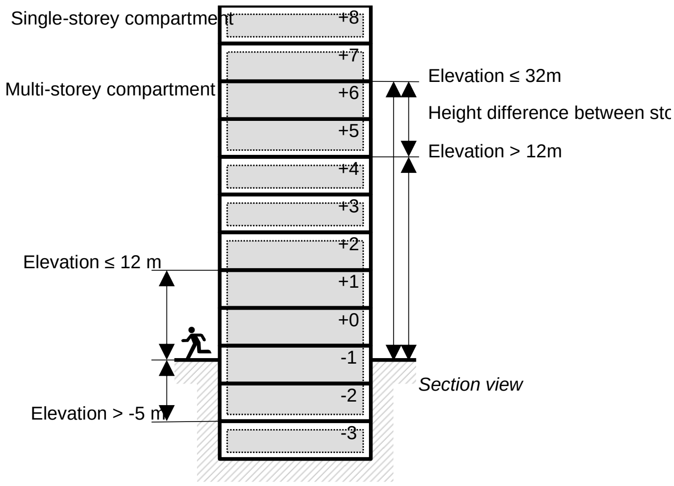
Table 74: Maximum gross surface area of compartments in m^2

S.3.6.2 *Multi-storey compartments*

1. The presence of *multi-storey compartments* is permitted under the conditions of Table 75, based on the R_{life} risk profile of the compartments and the geometric characteristics of the building.
2. The maximum gross surface area of the compartment must anyway comply with Table 74 and the requirements of the other fire protection measures (e.g. evacuation, chapter S.4)

R_{life}	Multi-storey compartments	Additional fire protection provisions
A1, A2, A3, B1, B2, B3, E1, E2, Cii1, Cii2, Ciii1, Ciii2	Storeys with an elevation of > -1 m and ≤ 6 m can be included in one or more multi-storey compartments	None
A1, A2	Storeys with an elevation of > -5 m and ≤ 12 m can be included in one or more multi-storey compartments (example in Table 76)	None
A3, B1, B2, Cii1, Cii2, Ciii1, Ciii2		[1], [2]
B3		[3]
A1, A2	Storeys with an elevation of > 12 m and ≤ 32 m can be included in one or more multi-storey compartments, with a maximum height difference between the sto)reys of ≤ 7 m (example in Table 76)	[3]
B1, B2		[3], [4]
[1] Performance level III detectors and alarms (chapter S.7))		
[2] If q_f < 600 MJ/m², performance level III fire control otherwise IV (chapter S.6).		
[3] Performance level IV detectors and alarms (chapter S.7)		
[4] Performance level IV fire control (chapter S.6).		

Table 75: Conditions for constructing multi-storey compartments



Storeys 5, 6 and 7 can be included in a multi-storey compartment, because they have an elevation of between 12 m and 32 m. in addition, the height difference between the storeys included in the multi-storey compartment does not exceed 7 m and the required additional fire protection measures have been implemented.

Storeys -2 to 2 can be included in a multi-storey compartment, because they have an elevation of between -5 m and 12 m and have the required additional fire protection measures.

For the other storeys, single-storey compartments are to be used.

Table 76: Examples of multi-storey compartments

S.3.7 Construction of fire compartments

S.3.7.1 Determining fire resistance ratings

1. The minimum fire resistance rating of each compartment is determined according to the provisions of chapter S.2.

   In the event that the specific fire load $q_{f,d}$ of the design does not specify a minimum fire resistance rating, the compartment is not required, unless a minimum fire resistance rating is otherwise expressly prescribed.

   Note For example, for the *filter* or for the *protected escape stairs* a minimum fire resistance rating 30 is prescribed.

2. In the case of adjacent compartments under the responsibility of different *premises managers*, the fire-separating elements of such compartments must have fire resistance characteristics of at least EI 60.

   Note The aim is to protect the premises from *neighbouring third parties* through the use of fire-separating elements with a required minimum level of fire resistance.

S.3.7.2 Selection of the performance of the elements

1. The performance of the compartmentalisation elements is selected according to the criteria outlined in Table 77.
2. All fire doors between compartments must have the same fire resistance rating and be equipped with a *self-closing device* (e.g. doors) or be kept permanently closed (e.g. doors to plant rooms).
3. All fire doors between compartments and escape routes within the same premises should meet at least criteria E (integrity) and S_a (smoke leakage). The insulation (I) and radiation (W) criteria are not normally required.
4. The fire doors installed along the occupants' main circulation routes should preferably be equipped with *electromagnetic holders* controlled by a fire detection and alarm system (FDAS/IRAI).

Symbol	Performance	Criterion
R	Load-bearing capacity	For load-bearing products and construction elements
E	Integrity	Containment of hot smoke, hot gases and flames
I	Insulation	Limiting the possibility of the fire spreading through contact between combustible material and the face of the compartmentalisation element not exposed to the fire.
W	Radiation	Limiting the possibility of the fire spreading to combustible material through radiation from the face of the compartmentalisation element not exposed to the fire.
M	Mechanical action	Limiting the possibility of the loss of compartmentalisation through the effect of accidental mechanical actions.
S	Smoke leakage	Containment of cold smoke and gases

Table 77: Choice criteria for the main performances of compartmentalisation elements

S.3.7.3 *Continuity of compartments*

1. The horizontal and vertical boundaries of the compartments must form a continuous and uniform barrier against the spread of the effects of the fire, for example in the case of:
    a. *junctions* between the compartmentalisation elements,
    b. penetrations of technological or process equipment, with the use of fire-stopping sealing systems when the effects of the fire can affect the integrity and shape of the equipment (e.g. PVC pipes with collars, firestop pillows in cable ducts, etc.) or with the use of non-combustible insulation on a section of pipe beyond the separation element when the effects of the fire can lead to the heating of the equipment only (e.g. metal pipe, on the side of the compartmentalisation element not exposed to the fire, covered with adequate insulating materials);
    c. air ducts, by installing fire-stopping shutters or by employing fire-resistant ducts for penetrations of the compartments;
    d. exhaust or smoke extraction shafts by employing fire-resistant ducts for penetrations of the compartments;
    e. continuous façades;
    f. lifts or other vertical shafts (e.g. plant ducts, etc.).

S.3.8 Separation distance to limit the spread of the fire

1. The application of the *separation distance* d in an open-air space between settings (areas) of the same premises or in relation to other premises limits the spread of fire.
2. In order to define a *deemed-to-satisfy solution* for this fire protection measure, the designer must use the *tabular method* indicated in paragraph S.3.11.2 or the *analytical method* indicated in paragraph S.3.11.3, applying a value of 12.6 kW/m^2 for the threshold $E_{threshold}$ of the thermal radiation produced by the *source* fire in question that reaches the *target*.

    This threshold is deemed to be sufficiently conservative to limit the ignition of any type of material, since it represents the conventional limit within which *wood* does not ignite in stationary air.
3. The designer is required to verify at least the following types of *source* and *target*:
    a. buildings,
    b. combustible material stores, including those located in an *open-air space*.
4. When the fire load q_f in the premises' compartments or combustible material stores is < 600 MJ/m^2, the application of an *uncovered space* between source and target is also deemed to be a *deemed-to-satisfy solution*.

S.3.9 Location

1. The coexistence of multiple premises within the same building is *generally* permitted, including when they are the responsibility of different *managers* or are of different types.

S.3.10 Access between premises

1. Where a *functional* need is demonstrated, access between the various premises located within the same building is *generally* permitted, including when the premises belong to different *managers*.

Note If the access between premises is also used as escape route, the provisions of paragraph S.4.5.13 should be taken into account.

2. In the case of access between premises belonging to different *managers*, compartments with a D1 or D2 R_{life} risk profile must anyway be *smokeproof* from the other premises.

S.3.11 Methods for determining the separation distance

S.3.11.1 General

1. This paragraph illustrates the methods for determining the *separation distance* d in an open-air space between the *source* and *target*, which limits the thermal radiation, produced by the *source* fire in question that reaches the *target*, to the predetermined $E_{threshold}$ threshold.
2. *Radiating elements* are the openings and surfaces of the face of the source through which the radiant energy flux of the fire is emitted to the outside (e.g. windows, French windows, combustible façade claddings, metal panelling, glass surfaces, openings in general, etc.).
3. The *radiating plane* is one of the conventional surfaces of the source. The designer identifies, for each building, one or more radiating planes from which the separation distances are determined.
4. To determine each radiating plane, vertical tangent planes that do not intersect the building itself are drawn across the building's boundaries, as shown in the illustration.. When doing so, incombustible overhanging elements can be omitted (e.g. open overhangs, balconies, eaves, etc.). Any recesses in the façade can be considered at the level of the façade itself.

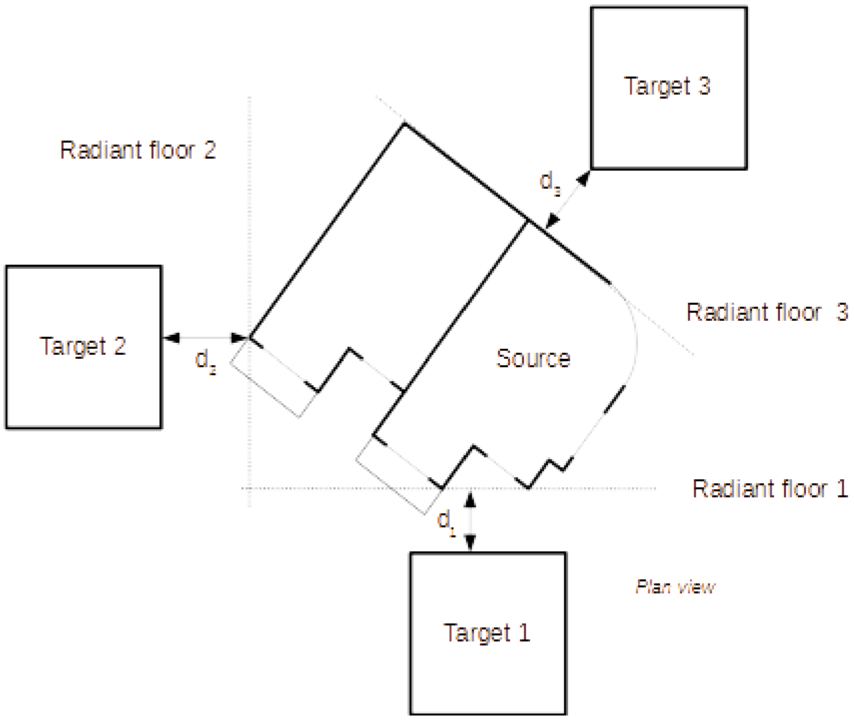


Image 3: Determining the radiating plane, plan view of the buildings

5. As shown in the illustration, the following are projected orthogonally from the source on the radiating plane:
   a. the geometry of the radiating elements;
   b. the compartmentalisation boundaries (e.g. fire floors and walls, etc.).

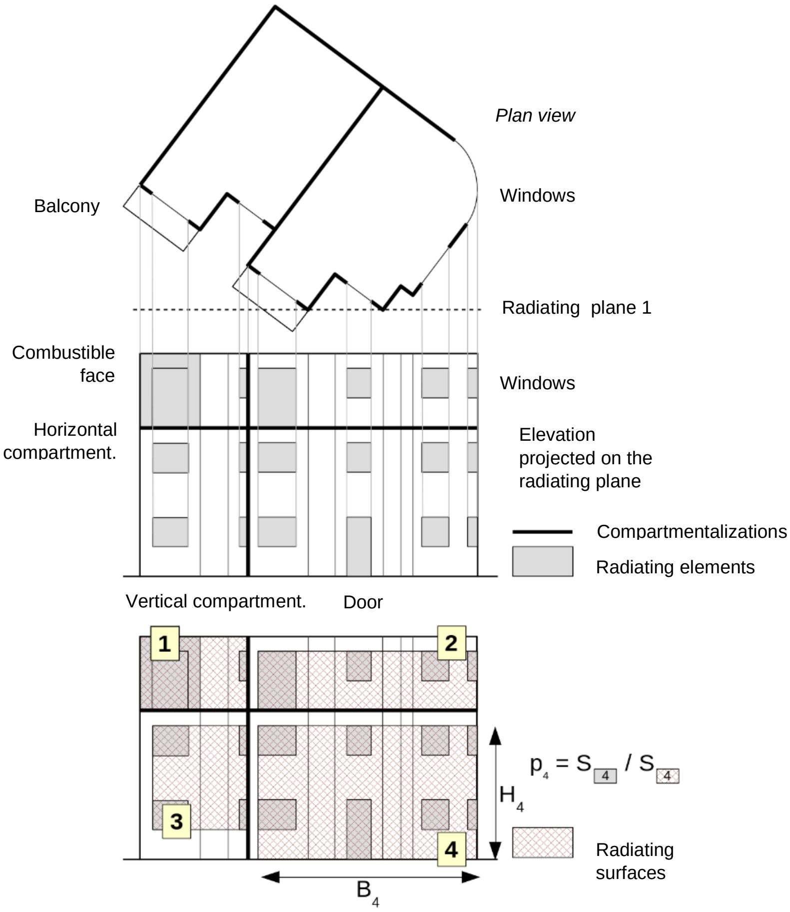


Image 4: Determining the radiating surfaces, plan and front view

6. *A radiating surface* refers to each portion of the *radiating plane* used for the simplified calculation of the thermal radiation from the source to the target. For each radiating plane, one or more radiating surfaces are identified by the designer.

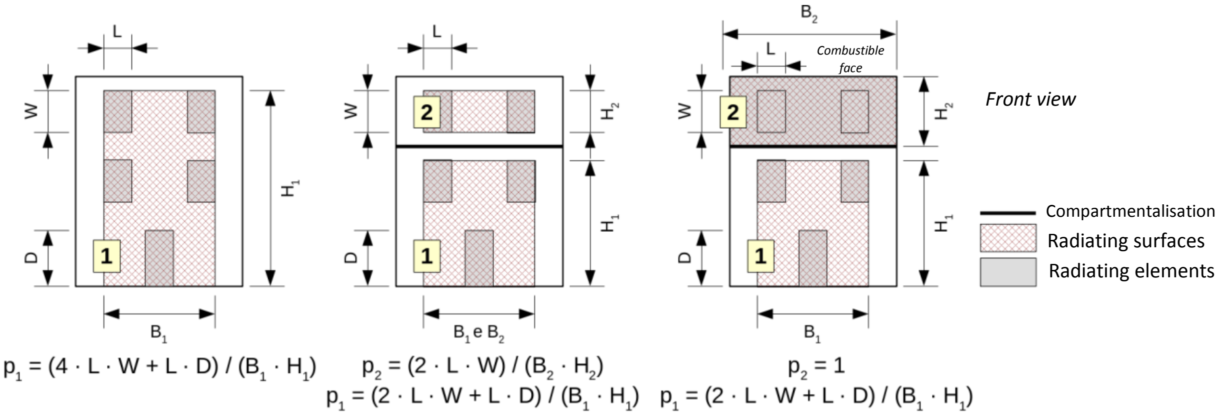


Image 5: Example of the percentage of openings of the i_{th} radiating surface, front view.

7. To determine the radiating surfaces, on each portion of the radiating plane marked by the projections of the compartmentalisation boundaries, the projections of the previously defined radiating elements are enclosed by rectangles with a base B_i and height H_i, as shown in illustrations and. These enclosing rectangles represent the *radiating surfaces* relating to the *radiating plane* in question.
8. For each *radiating surface* the *unprotected percentage* p_i is calculated, as shown in illustration, whose value cannot in any case be < 0.2:

   $$p_i = S_{rad,i} / S_{pr,i} \qquad 6$$

   where:

   p_i unprotected percentage;

   $S_{rad,i}$ total surface area of the projections of the *radiating elements* included in the ith *radiating surface;*

   $S_{pr,i}$ total surface area of the ith radiating surface.
9. When the source does not have side walls (e.g. awning, open-air combustible material store, etc.) the unprotected percentage p_i is assumed to be 1.

S.3.11.2 *Tabular method for determining the separation distance*

1. This *tabular method* determines the separation distance that limits the thermal radiation produced by the *source* fire in question and reaching the *target* to an $E_{threshold}$ value of 12.6 kW/m^2.
2. The designer determines the *radiating elements*, the *radiating plane* of reference for the distance in question, and the relative *radiating surfaces* as described in paragraph S.3.11.1.
3. For the ith radiating surface, the separation distance d_i is calculated as follows:

   $$d_i = \alpha_i\, p_i + \beta_i \qquad 7$$

   where:

   d_i separation distance [m]

   p_i unprotected percentage of the ith radiating surface

α_i, β_i coefficients extracted from Tables 78 or 79 in relation to the specific fire load q_f in the portion of the building behind the ith radiating surface and to the dimensions of the radiating surface B_i and H_i.

4. When the compartment behind the ith radiating surface is equipped with performance level IV fire protection measures (chapter S.6), the relative separation distance d_i can be halved.

5. For the tabular method, the *separation distance* d in an open-air space between the source and target is assumed to be equal to the highest value of the d_i distances obtained for all of the *radiating surfaces* relating to the *radiating plane* in question.

S.3.11.3 *Analytical method for determining the separation distance*

1. This *analytical method* determines the separation distance that limits the thermal radiation produced by the *source* fire in question and reaching the *target* to any $E_{threshold}$ value.

2. The designer determines the *radiating elements*, the *radiating plane* of reference for the distance in question, and the relative *radiating surfaces* as described in paragraph S.3.11.1.

3. The distance d_i measured between the ith radiating surface and the target guarantees sufficient *separation* if the following is confirmed:

$$F_{2\text{-}1} \cdot E_1 \cdot \varepsilon_f < E_{threshold} \qquad 8$$

where:

$F_{2\text{-}1}$ view factor

E_1 emissive power produced by the *conventional fire* [kW/m²]

ε_f flame emissivity

$E_{threshold}$ radiation threshold of the fire on the target [kW/m²]

4. The *view factor* $F_{2\text{-}1}$ for the rectangular radiating surface and target positioned on the axis of symmetry perpendicular to the surface is calculated as follows:

$$F_{2-1} = 2/\pi \left(\frac{X}{\sqrt{1+X^2}} \arctan \frac{Y}{\sqrt{1+X^2}} + \frac{Y}{\sqrt{1+Y^2}} \arctan \frac{X}{\sqrt{1+Y^2}} \right) \qquad 9$$

Assuming that the *radiating elements* are distributed vertically in the centre of the radiating surface, it is calculated as follows:

$$X = \frac{B_i \cdot p_i}{2 d_i}, \quad Y = \frac{H_i}{2 d_i} \qquad 10$$

where:

B_i width of the ith radiating surface [m]

H_i height of the ith radiating surface [m]

p_i unprotected percentage of the ith radiating surface

d_i distance between the ith radiating surface and the target [m]

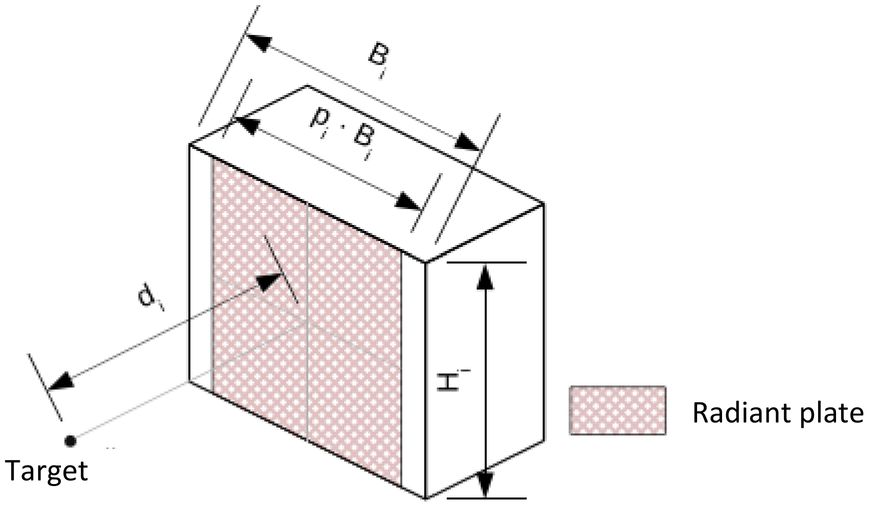


Image 6: Schematisation of the radiating surface

5. The emissive power of the conventional fire E_1 is applied as follows according to the specific fire load q_f of the compartment behind the ith radiating surface:

   if $q_f > 1\,200$ MJ/m²:

   $$E_1 = \sigma \cdot T^4 = 5.67 \cdot 10^{-8} \cdot (1\,000 + 273.16)^4 = 149 \text{ kW/m}^2 \qquad 11$$

   if $q_f \leq 1\,200$ MJ/m²:

   $$E_1 = \sigma \cdot T^4 = 5.67 \cdot 10^{-8} \cdot (800 + 273.16)^4 = 75 \text{ kW/m}^2 \qquad 12$$

6. The flame emissivity ε_f is calculated as follows:

   $$\varepsilon_f = 1 - e^{-0,3 \cdot d_f} \qquad 13$$

   where:

   d_f flame thickness, equal to 2/3 of the height of the opening from which the flame is emitted [m]

   Note When taking values from Tables 78 and 79. as referred to in the tabular method, the df is equal to 2 m.

7. When the compartment behind the ith radiating surface is equipped with performance level IV fire protection measures (chapter S.6.), the relative separation distance d_i can be halved.

8. For this analytical method, the *separation distance* d in an open-air space between the source and target is assumed to be equal to the highest value of the d_i distances obtained for all of the *radiating surfaces* relating to the *radiating plane* in question.

Note The separation distance calculated with the analytical method may differ from that obtained with the tabular method described in paragraph S.3.11.2 due to the approximations included in Tables 78 and 79

B_i [m]	H_i [m]																			
	3		6		9		12		15		18		21		24		27		30	
	α	β	α	β	α	β	α	β	α	β	α	β	α	β	α	β	α	β	α	β
3	2.5	1.0	4.0	0.9	5.0	0.7	5.7	0.6	6.2	0.5	6.5	0.4	6.8	0.4	7.0	0.3	7.1	0.3	7.2	0.3
6	3.2	1.6	5.2	1.8	6.8	1.7	8.1	1.5	9.2	1.4	10.1	1.2	10.9	1.1	11.5	1.0	12.0	0.9	12.5	0.8
9	3.5	2.1	6.0	2.5	8.0	2.6	9.6	2.5	11.0	2.4	12.3	2.2	13.4	2.1	14.4	1.9	15.3	1.7	16.0	1.6
12	3.7	2.6	6.6	3.1	8.8	3.3	10.7	3.3	12.4	3.3	13.9	3.2	15.2	3.0	16.5	2.9	17.6	2.7	18.6	2.6
15	3.7	2.9	7.0	3.6	9.5	3.9	11.6	4.1	13.4	4.1	15.1	4.1	16.6	4.0	18.1	3.9	19.4	3.7	20.6	3.6
18	3.7	3.3	7.3	4.1	10.0	4.5	12.3	4.8	14.3	4.9	16.1	4.9	17.8	4.9	19.4	4.8	20.9	4.7	22.3	4.5
21	3.6	3.6	7.5	4.5	10.4	5.0	12.9	5.4	15.1	5.6	17.0	5.7	18.9	5.7	20.6	5.7	22.2	5.6	23.7	5.5
24	3.5	3.9	7.6	4.9	10.7	5.5	13.4	6.0	15.7	6.2	17.8	6.4	19.8	6.5	21.6	6.5	23.3	6.5	24.9	6.4
27	3.3	4.1	7.6	5.3	11.0	6.0	13.8	6.5	16.3	6.8	18.5	7.0	20.6	7.2	22.5	7.3	24.3	7.3	26.0	7.2
30	3.2	4.4	7.7	5.6	11.2	6.4	14.2	7.0	16.8	7.4	19.1	7.7	21.3	7.9	23.3	8.0	25.2	8.0	27.0	8.1
40	2.6	5.1	7.5	6.7	11.6	7.8	15.0	8.5	18.0	9.1	20.8	9.5	23.3	9.9	25.6	10.2	27.8	10.4	29.8	10.5
50	2.2	5.6	7.0	7.7	11.5	8.9	15.4	9.9	18.8	10.6	21.9	11.2	24.7	11.7	27.3	12.1	29.7	12.4	32.0	12.7
60	1.8	6.1	6.5	8.5	11.3	10.0	15.5	11.1	19.3	12.0	22.6	12.7	25.7	13.3	28.6	13.8	31.2	14.2	33.8	14.6

For B_i and H_i values between those listed in the table, the value immediately following is taken. Alternatively, the analytical method described in paragraph S.3.11.3 can be used iteratively.

Table 78: Coefficients α and β for premises with a specific fire load q_f > 1 200 MJ/m²

B [m]	**H [m]**																			
	3		**6**		**9**		**12**		**15**		**18**		**21**		**24**		**27**		**30**	
	α	**β**	**α**	**β**	**α**	**β**	**α**	**β**	**α**	**β**	**α**	**β**	**α**	**β**	**α**	**β**	**α**	**β**	**α**	**β**
3	1.7	0.5	2.6	0.3	3.1	0.2	3.3	0.2	3.4	0.2	3.5	0.2	3.5	0.1	3.6	0.1	3.6	0.1	3.6	0.1
6	2.0	1.0	3.5	0.8	4.6	0.7	5.3	0.5	5.9	0.4	6.2	0.3	6.5	0.3	6.7	0.3	6.8	0.2	7.0	0.2
9	1.9	1.4	3.9	1.3	5.4	1.2	6.5	1.0	7.4	0.8	8.1	0.7	8.6	0.6	9.0	0.5	9.4	0.5	9.7	0.4
12	1.8	1.7	4.1	1.8	5.8	1.7	7.2	1.5	8.4	1.3	9.3	1.2	10.1	1.0	10.8	0.9	11.4	0.8	11.8	0.7
15	1.6	2.0	4.1	2.2	6.0	2.2	7.7	2.0	9.0	1.9	10.2	1.7	11.2	1.5	12.1	1.4	12.9	1.2	13.5	1.1
18	1.4	2.2	4.0	2.6	6.1	2.6	8.0	2.5	9.5	2.4	10.9	2.2	12.1	2.0	13.1	1.9	14.0	1.7	14.9	1.6
21	1.3	2.4	3.9	2.9	6.2	3.1	8.1	3.0	9.9	2.9	11.4	2.7	12.7	2.6	13.9	2.4	15.0	2.2	16.0	2.1
24	1.1	2.6	3.7	3.2	6.1	3.5	8.2	3.5	10.1	3.4	11.7	3.3	13.2	3.1	14.6	2.9	15.8	2.7	16.9	2.6
27	1.0	2.7	3.5	3.5	6.0	3.8	8.3	3.9	10.2	3.9	12.0	3.8	13.6	3.6	15.1	3.4	16.4	3.3	17.6	3.1
30	0.9	2.9	3.4	3.8	5.9	4.2	8.2	4.3	10.3	4.3	12.2	4.2	13.9	4.1	15.5	4.0	16.9	3.8	18.2	3.6
40	0.6	3.2	2.8	4.5	5.4	5.2	7.9	5.5	10.3	5.7	12.5	5.7	14.5	5.7	16.3	5.6	18.0	5.5	19.6	5.3
50	0.4	3.4	2.3	5.1	4.8	6.0	7.4	6.6	10.0	6.9	12.3	7.0	14.6	7.1	16.6	7.1	18.6	7.1	20.4	7.0
60	0.2	3.5	1.9	5.6	4.3	6.7	6.9	7.5	9.5	7.9	12.0	8.2	14.4	8.4	16.6	8.5	18.8	8.5	20.8	8.5
For B_i and Hi values between those listed in the table, the value immediately following is taken. Alternatively, the analytical method described in paragraph S.3.11.3 can be used iteratively.																				

Table 79: Coefficients α and β for premises with a specific fire load $q_f \leq 1\,200$ MJ/m^2

S.3.12 References

1. The following references are provided with regard to the creation of fire compartments:

   a. Eurocode 1, UNI EN 1991-1-2;

   b. UNI EN 12101-6.

2. The following are referenced with regard to calculating separation distances:

   a. R E H Read, *'External fire spread: building separation and boundary distances'*, BRE report Cl SfB 98 (F47) (K22), 1991

   b. BS 9999, Section 36;

   c. J R Howell, *'A Catalog of Radiation Heat Transfer Configuration Factors'*, University of Texas, Austin, 2^{nd} edition, 2001;

   d. T L Bergman, F P Incropera, *'Fundamentals of Heat and Mass Transfer'*, Wiley, 2011;

   e. NFPA 80A, '*Recommended practice for protection of buildings from exterior fire exposures*';

   f. NFPA 555, '*Guide on methods for evaluating potential for room flashover*'.

3. The following are referenced with regard to the dimensions of smoke shafts for smokeproof filters:

   a. G T Tamura, C Y Shaw, '*Basis for the design of smoke shafts*', Fire Technology, Volume 9, Issue 3, September 1973.

Chapter S.4 Evacuation

S.4.1 Preface

1. The purpose of the *evacuation system* is to ensure that the occupants of the premises can reach a *place of ultimate safety* or remain safe, autonomously or with assistance, before the fire leads to *incapacitating* conditions in the settings (areas) in which the occupants are located.

Note Occupants reach the state of *incapacitation* when they become unable to make themselves safe due to the effects of the fire (chapter M.3).

2. The evacuation system must provide the required performance regardless of the intervention of fire fighters.

Note For example, the required function of the *areas of rescue assistance* is to allow the occupants to await assistance from rescuers in order to complete their evacuation to a place of ultimate safety.

3. The *evacuation* methods laid down are as follows:
   a. *simultaneous evacuation*;
   b. *phased evacuation*;

Note A phased evacuation takes place, for example, in: very tall buildings, hospitals, multiplexes, shopping centres, large offices, distributed premises, premises with a significant R_{env} risk profile, etc.

   c. *progressive horizontal evacuation*;

Note A progressive horizontal evacuation takes place, for example, in hospital wards.

   d. *area of refuge (in place protection)*.

Note Areas of refuge are used, for example, in shopping centres, malls, airports, etc.

4. This chapter does not deal with issues relating to *crowd management*.

Note The definitions of *simultaneous evacuation, phased evacuation, progressive horizontal evacuation, area of refuge, and crowd management* can be found in chapter G.1

S.4.2 Performance levels

1. Table 80 lists the performance levels attributable of the *settings* (*areas)* of the premises for this fire protection measure.

Performance level	Description
I	The occupants reach a *place of ultimate safety* before the fire leads to incapacitating conditions in the settings (areas) of the premises that occupants must pass through during the evacuation.
II	The occupants are protected from the effects of the fire in the place where they are located.

Table 80: Performance levels

S.4.3 Assignment criteria for performance levels

1. Table 81 lists the *generally accepted* criteria required for the individual performance levels.

Performance level	Assignment criteria
I	All premises
II	Settings (Areas) in which is it not possible to ensure performance level I (e.g. due to the dimensions, location, ability of the occupants, type of property, particular geometric characteristics, architectural constraints, etc.)

Table 81: Required criteria for the performance levels

S.4.4 Design solutions

S.4.4.1 *Deemed-to-satisfy solutions for performance level I*

1. The evacuation system must be designed iteratively as follows:
   a. the *input data* referred to in paragraph is defined: reference R_{life} risk profile and crowd;
   b. the *minimum fire protection requirements* of paragraph S.4.7 are met;
   c. the diagram of the escape routes leading to the *place of ultimate safety* is defined and the dimensions comply with the indications of paragraphs S.4.8 and S.4.9: number of escape routes and exits, dead-ends corridors, temporary places of safety and travel distances, escape route and fire exit widths, surface areas of places of ultimate safety and areas of rescue assistance, etc.
   d. the correspondence of the evacuation system with the *characteristics* listed in paragraph S.4.5 is verified. If the verification shows that it does not meet the requirements, the procedure is repeated.
2. The *additional fire prevention requirements* of paragraph S.4.10 may be employed.
3. When the premises is mainly open-air, the indications referred to in paragraph S.4.11 must also be applied in full.

S.4.4.2 *Deemed-to-satisfy solutions for performance level II*

1. No deemed-to-satisfy solution is indicated.

Note The alternative solutions laid down in paragraph S.4.4.3. may be used.

S.4.4.3 *Alternative solutions*

1. *Alternative solutions* are allowed for all performance levels.
2. To demonstrate that the *performance level* has been achieved, the designer must employ one of the methods outlined in paragraph G.2.7..
3. Table 82 lists several *generally accepted* methods for designing alternative solutions. The designer may nevertheless employ methods other than those listed.

Object of the solution	Design method
Characteristics of the place of ultimate safety (§ S.4.5.1.)	Demonstrate that such places are not affected by the effects of the fire that lead to incapacitating conditions for the occupants.
Characteristics of the temporary place of safety (§ S.4.5., of the escape routes (§S.4.5.3.)	Demonstrate that such places are not affected by the effects of the fire that lead to incapacitating conditions during the evacuation of the occupants.
Characteristics of the doors (§ S.4.5.7) , minimum number of independent exits (§ S.4.8.1)	Demonstrate, including through descriptions, how *localised overcrowding* at the exits of the specific premises is made improbable thanks to specific evacuation management measures.
Seating arrangement (§ S.4.5.11)	Demonstrate that the seating arrangement does not make the evacuation any slower than an evacuation without obstacles.
Minimum number of independent exits (§ S.4.8.1), dead-end corridors (§ S.4.8.2)	Demonstrate that it is improbable that the evacuation of the occupants will be impeded by the fire along the dead-end corridor or in connected areas.
Travel distance (§ S.4.8.3)	Demonstrate that different travel distances allow the occupants to evacuate the compartment where the fire broke out before the fire leads to incapacitating conditions.
Minimum widths of horizontal escape routes (§ S.4.8.7), of vertical escape routes (§S.4.8.8), of fire exits (§S.4.8.9)	Demonstrate that the various widths of the escape routes are sufficient for the occupants using them, given a small crowd that does not lead to the formation of queues, for specific evacuation management measures that make conditions of *localised overcrowding* improbable.
All cases	Demonstrate that the safety objectives for the occupants have been achieved by employing the methods of chapter M.3 and the information that can be found in the references (§ S.4.12)

Table 82: Design methods for alternative solutions

S.4.5 Characteristics of the evacuation system

Note The definitions of *evacuation system, place of ultimate safety, temporary place of safety, escape route, exit access* and *area of rescue assistance* can be found in chapter G.1.

S.4.5.1 Place of ultimate safety

1. A *place of ultimate safety* for the premises must comprise *at least* one of the following solutions:
   a. a *public road*,
   b. any other *open-air space* that is safely linked to a public road in any fire situation, that is not affected by the products of combustion, in which the maximum radiation from the fire reaching the occupants is limited to 2.5 kW/m^2, in which there is no risk of structural collapse, that is suitable for holding the occupants who use it during their evacuation.
2. The conditions of point 1, letter b are deemed to be met when all of the following criteria are applied:
   i. The separation distance that limits the radiation to the occupants is calculated using the methods outlined in chapter S.3; said distance is deemed to be precautionary including when combustible products are present;
   ii. when the building is awarded a fire resistance level of less than performance level III (chapter S.2), unless more in-depth assessments are

carried out by the designer, the minimum distance to avoid the danger of collapse is equal to the building's maximum height;

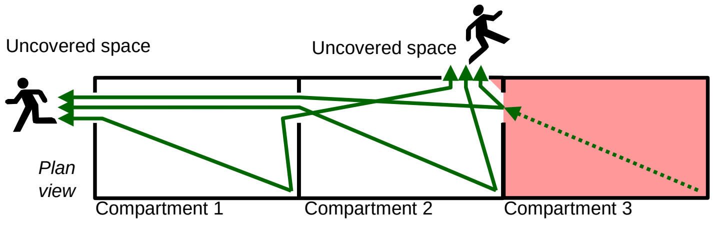
iii. the minimum gross surface area is calculated taking into consideration the minimum surface area per occupant as listed in Table 115

Note Table 112 shows an example of calculating the minimum gross surface area.

3. The place of ultimate safety should comply with standard UNI EN ISO 7010-E007, as illustrated in Table 87.

S.4.5.2 Temporary place of safety

1. With regard to a compartment, a *temporary place of safety* is deemed to be any other *compartment* or *uncovered space*, that can be crossed by the occupants to reach the *place of ultimate safety* as part of the evacuation system without re-entering the compartment in question.



Compartments 1 and 2 are *temporary places of safety* for compartment 3.

Compartment 1 is a *temporary place of safety* for compartment 2 and vice versa.

The two uncovered spaces are *temporary places of safety* for all of the compartments.

Table 83: Examples of temporary places of safety

S.4.5.3 Escape routes

1. The following are not considered to be escape routes:
   a. ladders;
   b. lifts;
   c. ramps with a slope in excess of 20 %;

   Note Ramps with a slope in excess of 5 % are deemed to be *vertical escape routes*. In general, occupants with motor disabilities cannot autonomously use ramps with a slope in excess of 8 %. Ramps with a slope in excess of 12 % must only be used for evacuation in exceptional circumstances.

2. escalators and moving walkways not designed according to the indications of paragraphS.4.5.5.

3. ed cage ladders is permitted where they serve areas with a low level of crowding and only specially trained personnel are present (e.g. plant or service rooms, signal boxes, plant ducts, etc.).

4. None of the underfoot surfaces of the escape routes may be slippery or have dangerous depressions or protrusions, and must be in a condition that allows for the safe movement and transit of the occupants.

5. The smoke and heat of the fire that is removed or evacuated from the premises must not disrupt the escape routes.

Note For example, openings for smoke and heat shafts or vents (chapter S.8) are not permitted underneath or adjacent to external escape routes.

S.4.5.3.1 Protected escape route

1. *Protected exit pathways* (e.g. corridors, stairs, ramps, foyers, etc.) must be in dedicated protected spaces.

   In such spaces, the presence of technological systems and auxiliary facilities for the functioning of the premises is generally permitted, provided the requirements of chapters S.10 and V.3 are met.

   Note For example, lifts, goods lifts, bed lifts, escalators, moving walkways, civil electrical systems, fire protection systems, etc.

2. The protected escape stairs must lead to a place of ultimate safety either directly or at least through a protected exit pathway.

   Note On these routes, the provisions relating to the presence of technological systems and services also apply.

S.4.5.3.2 Smokeproof escape route

1. *Smokeproof exit pathways* (e.g. corridors, stairs, ramps, foyers, etc.) must be in dedicated smokeproof spaces.

   In such spaces, the presence of technological systems and auxiliary facilities for the functioning of the premises is generally permitted, provided the requirements of chapters S.10 And V.3 are met.

   Note For example, lifts, goods lifts, bed lifts, escalators, moving walkways, civil electrical systems, fire protection systems, etc.

2. The smokeproof escape stairs must lead to a place of ultimate safety either directly or through a smokeproof exit pathway. When the exit pathway to a place of ultimate safety is only *protected*, the entire escape route can be considered equivalent to a protected escape route.

   Note On these routes, the provisions relating to the presence of technological systems and services also apply.

S.4.5.3.3 External escape route

1. *External escape routes* (e.g. stairs, ramps, gangways, walkways, etc.) must be completely external to the building. In addition, during the evacuation of the occupants, they must not be subject to radiation caused by the fire that is above 2.5 kW/m^2 and must not be reached by the products of combustion.

   The proximity of technological systems and auxiliary facilities for the functioning of the premises is generally permitted, provided the requirements of chapters S.10 and V.3 are met.

   Note For example, lifts, goods lifts, bed lifts, escalators, moving walkways, civil electrical systems, fire protection systems, etc.

2. The conditions of point 1 are deemed to have been met when at least one of the criteria outlined in Table 84 are applied.

3. For the purposes of the performance levels, an external escape route is considered to be equivalent:

   a. for storeys with an elevation ≤ 24 m, to a *smokeproof* escape route with the characteristics of a *filter*;

b. in all other cases to a *protected* escape route with the characteristics of a *filter*.

Note Wherever the text requires a *smokeproof escape route*, *smokeproof escape route* with the characteristics of a *filter*, *protected escape route*, or a *protected escape route* with the characteristics of a *filter*, an external escape route can be employed, provided it complies with the requirements of this point.

Note The *external escape route* has a higher level of protection than a simple escape route crossing an open-air space.

4. The external escape stairs must lead to a place of ultimate safety either directly or through a smokeproof exit pathway or external escape route. When the exit pathway to a place of ultimate safety is only *protected*, the entire escape route can be considered equivalent to a protected escape route.

Note On these routes, the provisions relating to the presence of technological systems and services also apply.

S.4.5.3.4 Unprotected escape route

1. *Unprotected escape routes* are all those that are not classified as *protected*, *smokeproof* or *external*.

Note: As described in illustration, escape routes with a certain level of fire protection are distinguished from all others, which are referred to as *unprotected*.

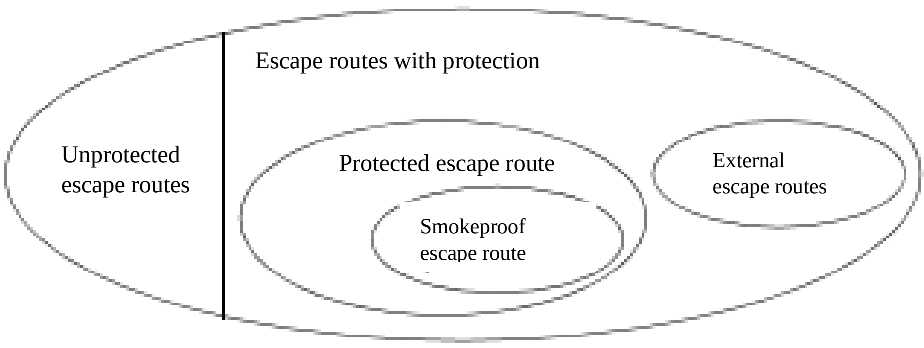


Image 7: Classification of escape routes according to the level of fire protection

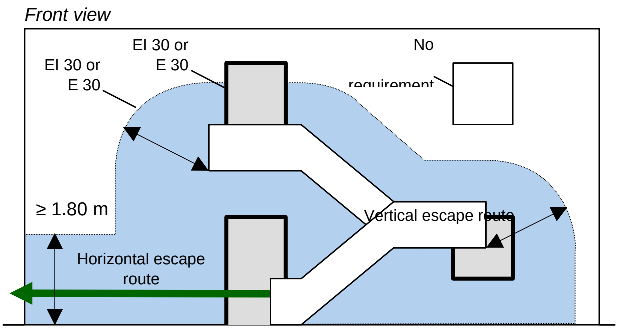
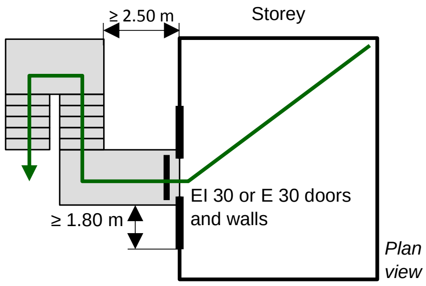
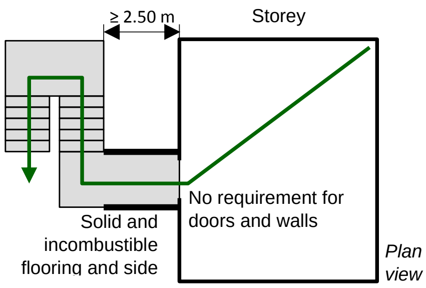
<table>
<tr><th>Criterion</th><th>Characteristics</th><th>Example</th></tr>
<tr><td>1</td><td>The portion of the building's boundary on which the external escape route (horizontal or vertical, also adjacent to the building) is located must have fire resistance characteristics of no less than EI 30, or E 30 in the case of escape routes made from incombustible materials and structures.
This portion is obtained as a zone of influence of the projection of the underfoot surface of the escape route on the building with an r_{offset} equal to 1.80 m.
The portion obtained is extended perpendicularly to reach the lowest storey of reference or the ground.
The window fixtures, even if only partly included in the portion, must have the same fire resistance rating.</td><td>
</td></tr>
<tr><td>2</td><td>The external escape route (horizontal or vertical) must be at least 2.5 m away from the building and from exhausts and vents for the smoke and heat caused by the fire.
It must be connected to the doors of the storey by gangways made from incombustible materials. The gangways must be protected from the fire through the use of the solutions of criterion 1.</td><td>
</td></tr>
<tr><td>3</td><td>The external escape route (horizontal or vertical) must be 2.5 m away from the building and from exhausts and vents for the smoke and heat caused by the fire.
If connected to the doors of the storey by gangways, these gangways must be made from incombustible materials. The gangways must be protected from the fire by means of solid flooring and side partitions, made from incombustible material; the height of the side partitions must be no less than 2 m from the underfoot surface.</td><td>
</td></tr>
</table>

Table 84: Criteria for horizontal or vertical external escape routes

S.4.5.4 *Escape stairs*

1. When a sloped floor leads to an escape stair, the slope must end at a distance from the stairs of at least the length of said slope.
2. Escape stairs must be equipped with side handrails. Escape stairs with a width of greater than 2 400 mm should be equipped with one or more central handrails.
3. The escape stairs must allow the occupants to be evacuated without obstacles. As such:
   a. the steps must have a constant riser height and tread width;
   b. they must be broken up by landings.
4. Steps with a variable riser height and tread width are permitted for short, signed sections along escape routes from settings (spaces) where only specially trained personnel are present or where a limited number of occupants is occasionally present for a brief period (e.g. plant or service rooms, small storage rooms, etc.), or according to the results of a specific risk assessment.
5. Escape stairs composed of a single step that constitutes a trip hazard should be avoided. If the single step cannot be removed, it must be clearly signed.

S.4.5.5 *Escape escalators and moving walkways*

1. Escalators and moving walkways can be considered for the purposes of calculating the escape routes in the following conditions:
   a. the premises must be equipped with a performance level IV fire detection and alarm system (chapter S.7);
   b. the premises must have a performance level III fire safety management plan (chapter S.5.) and the management options for escalators and moving walkways must be included in the emergency plan;
   c. a risk assessment of any obstacles present along the route that may hinder the evacuation of the occupants (e.g. trolleys, goods, etc.) must be carried out.
2. The following management options for escalators and moving walkways are permitted in the case of emergencies: closing them and keeping them stationary; keeping the motor running; closing them and reversing the motor.

   The aim of each management option must be to conduct the evacuation as safely as possible.

Note For example, by gradually stopping or reversing the motor, accompanied by visual and audio warnings.

Note Escape escalators and moving walkways must also comply with the requirements of chapter.10.

S.4.5.6 *Escape ramps*

1. When connecting to accesses or exits, escape ramps must have landings with dimensions of at least the total width of the opening.

Note If the purpose of the ramp is to pass architectural barriers, the relevant provisions must also be respected. See also paragaph S.4.9..

S.4.5.7 *Doors along escape routes*

1. The doors installed along *escape routes* must be easy for all occupants to identify and open.
2. The opening of the doors must not obstruct the discharge of the occupants along the escape routes.

Note For example, doors that open onto landings or corridors must not reduce the calculated width of the escape route or create a hazard for the occupants during the evacuation.

3. Doors must open onto flat, horizontal areas with a depth that is at least equal to the total width of the doorway.
4. If it is necessary to protect the doors from improper use for business or anti-intrusion security needs, the adoption of suitable and safe control systems and door openings is permitted. In such cases, the fire safety management plan (chapter S.5) must provide for methods to ensure that such doors open reliably, immediately and simply in emergencies.

S.4.5.7.1 Manual doors

1. To ensure that manual doors open reliably, immediately and simply in conditions with a high occupant density, each door must meet the requirements of Table 85 based on the characteristics of the setting (space) served and the number of occupants of the space who are using that door in the most severe evacuation conditions.

Note Calculation examples are given in Table 86

2. As an alternative to doors equipped with the opening devices listed in Table 85 , doors that open in the direction of the evacuation are also permitted, provided that they are designed and made in line with best practices (industry standard) and that they open with a simple push on any part of the door.

S.4.5.7.2 Automatic doors

1. Automatic doors of the specific type stipulated by standard UNI EN 16005 are permitted along escape routes. These doors must not hinder the evacuation of the occupants, in particular in emergencies, in the absence of electricity, and in the case of faults.

   Note Automatic fire doors must comply the essential requisites for health and safety of annex I to the directive 2006/42/CE of 17th May 2006.

2. Automatic doors must be included in the fire safety management plan for the premises (chapter S.5.).

S.4.5.7.3 Turnstiles

1. Turnstiles and automatic gates to control access along the escape routes are permitted. These turnstiles must not hinder the evacuation of the occupants, in particular in emergencies, in the absence of electricity, and in the case of faults.

Note For example, this can be achieved with an automatic turnstile release system connected to the fire detection and alarm system, with a turnstile monitoring and release system controlled from a remote location or with a redundant opening mechanism.

2. Turnstiles and their drive, control and command systems and accessories must be included in the fire safety management plan (chapter S.5).

Setting (Area) served	Door characteristics		
	Occupants served [1]	**Opening direction**	**Opening device**
Settings (Areas) of the premises not open to the public	n > 50 occupants	In the direction of the evacuation [2]	UNI EN 1125 [3]
Settings (Areas) of the premises open to the public	n > 25 occupants		
Areas with specific risks	n > 10 occupants		
	n > 5 occupants		UNI EN 179 [3] [4]
Other cases		According to the results of the risk assessment [5]	

[1] Number of occupants using the single door in the most severe evacuation conditions, taking into account the redundancy check referred to in paragraph S.4.8.6.

[2] If the evacuation can take place in two directions, specific measures must be employed (e.g. different doors for each direction, doors that open in both directions, automatic doors, variable signage, etc.). Automatic sliding doors are exempt from the requirements governing the direction of opening.

[3] Or device for specific needs, to be selected based on the results of the risk assessment (e.g. EN 13633, EN 13637, etc.).

[4] UNI EN 179 devices are designed to be used by specially trained personnel.

[5] Where possible, it is preferable for the direction of opening to be in the direction of the evacuation, including if the ordinary opening device is retained.

Table 85: Characteristics of manual doors along escape routes

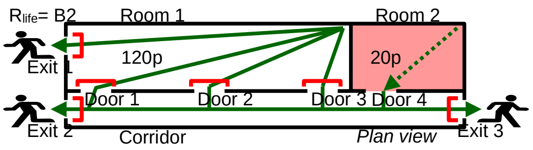
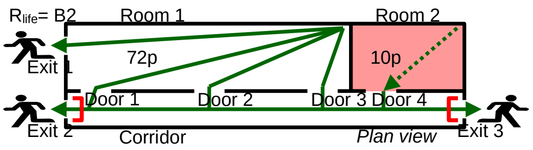
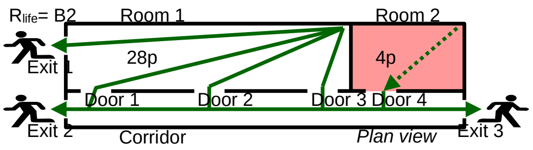
<table>
<tr><th>Example</th><th colspan="2">Calculation</th></tr>
<tr><td rowspan="3">
</td><td>Room 1</td><td>[1] 120p: 3 = 40p > 25p [3]
[2] UNI EN 1125, in the direction of evacuation</td></tr>
<tr><td>Room 2</td><td>[1] 20p ≤ 25p
[2] According to the risk assessment</td></tr>
<tr><td>Corridor</td><td>[1] 120p: 4 · 3 + 20p = 110p > 25p [4]
[2] UNI EN 1125, in the direction of evacuation</td></tr>
<tr><td rowspan="3">
</td><td>Room 1</td><td>[1] 72p: 3 = 24p ≤ 25p [3]
[2] According to the risk assessment</td></tr>
<tr><td>Room 2</td><td>[1] 10p ≤ 25p
[2] According to the risk assessment</td></tr>
<tr><td>Corridor</td><td>[1] 72p: 4 · 3 + 10p = 64p > 25p [4]
[2] UNI EN 1125, in the direction of evacuation</td></tr>
<tr><td rowspan="3">
</td><td>Room 1</td><td>[1] 28p: 3 ≈ 10p ≤ 25p [3]
[2] According to the risk assessment</td></tr>
<tr><td>Room 2</td><td>[1] 4p ≤ 25p
[2] According to the risk assessment</td></tr>
<tr><td>Corridor</td><td>[1] 28p: 4 · 3 + 4p = 25p ≤ 25p [4]
[2] According to the risk assessment</td></tr>
<tr><td colspan="3">[1] Number of occupants served by the single door in the most severe evacuation conditions
[2] Opening device and direction of opening of all doors in the room
[3] With redundancy verification, assuming any of the escape routes of room 1 is unavailable
[4] In the most severe evacuation conditions for the redundancy verification, assuming Door 2 or Door 3 is unavailable
UNI EN 1125 manual opening device</td></tr>
</table>

Table 86: Examples of determining the characteristics of doors along escape routes

S.4.5.8 *Fire exits*

1. The *fire exits* must be positioned so as to allow the rapid evacuation of the occupants to the place of ultimate safety.
2. The fire exits should be labelled on the outside of the premises with a UNI EN ISO 7010-M001 sign bearing the message *'Emergency exit, keep clear'* as shown in illustration.

Image 8: Example of fire exit signage

S.4.5.9 *Evacuation and wayfinding signs*

1. The evacuation system (e.g. escape routes, places of ultimate safety, areas of rescue assistance, etc.) must be easy for the occupants to identify and use thanks to appropriate *safety signage*.

   This can also be achieved with the use of additional *environmental indicators* such as:

   a. visual and tactile access to the information;
   b. degree of architectural differentiation;
   c. use of signage to correctly identify the direction, e.g. UNI EN ISO 7010;
   d. orderly geometric configuration of the building, including as regards mobile and temporary furniture.

2. The evacuation signage must be sufficient given the complexity of the premises and must orient the occupants (*wayfinding*). As such:

   a. special simplified, correctly oriented floor plan signs must be installed on every storey of the premises, indicating the location of the reader (e.g. *'You are here'*) and the *layout* of the evacuation system (e.g. escape routes, areas of rescue assistance, places of ultimate safety, etc.). For this purpose the indications of standard UNI ISO 23601 '*Safety identification – Escape and evacuation plan signs*' can be applied;
   b. the additional indications of standard ISO 16069 '*Graphical symbols – Safety signs – Safety way guidance systems (SWGS)*' can be applied.

 E007 Place of ultimate safety	 E024 Area of rescue assistance	 E001 Escape route	 E026 Escape route to an area of rescue assistance	 E060 Evacuation chair

Table 87: Examples of UNI EN ISO 7010 signs

S.4.5.10 *Emergency lighting*

1. Emergency lighting must be installed along the escape routes if the lighting could at any point be insufficient to permit the evacuation of the occupants.

   Note For example, activities carried out in the afternoon and at night, areas lacking natural light, etc.

2. During the evacuation, the safety lighting must provide sufficient horizontal floor lighting to allow the evacuation of the occupants, in accordance with the indications of standard UNI EN 1838 and in any case ≥ 1 lx along the centre of the escape route.

   Note The emergency lighting must also meet the requirements of chapter S.10.

3. In settings (areas) where activities are carried out in the absence of or with reduced ordinary lighting (e.g. cinema screens, theatres, etc.) any steps along the escape route must be equipped with steplights.

S.4.5.11 *Fixed and mobile seating arrangement*

1. Seating (*seats*) must be grouped into separate *sections* from one another through the use of lengthwise and widthwise *aisles between the sections*. These aisles between sections must be the same size as escape routes or, if any section contains fewer than 300 seats, be ≥ 1 200 mm wide.

2. The aisles between the rows of seats must be included in the calculation of the *travel distance* and the *dead-end corridor*, as sections of the escape route.

3. *The width of the aisles between the rows of seats* must permit the easy movement of the occupants toward the exit. This width is measured horizontally between the largest protrusions of the seats. If the seats are automatic flip-up seats, the measurement is taken with the seat in its raised position.

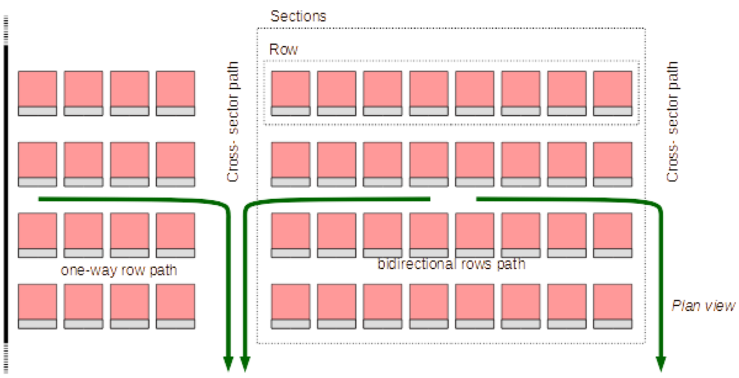


Image 9: Seating arrangement in sections and rows

S.4.5.11.1 Fixed seating

1. The number of seats firmly fixed to the floor that make up the row must be no greater than the number stated in Table 88 depending on the width of the aisle between the rows of seats and the possibility of the occupants moving in one or two directions in order to exit the section (sector).

S.4.5.11.2 Mobile seating

1. Each section (sector) must be composed of no more than 10 rows of mobile seats rigidly connected together in each row.
2. The number of mobile seats that make up the row must be no greater than the number stated in Table 89 depending on the possibility of the occupants moving in one or two directions in order to exit the section (sector).
3. The width of the *aisles between the rows of seats* must be ≥ 300 mm.
4. The use of mobile seats, including those not rigidly connected to each other, in settings (areas) of the premises where it is demonstrated that the presence of mobile seats does not hinder the safe evacuation of the occupants (e.g. rooms with a low occupant density, theatre stages, restaurants, etc.) is permitted.

<table>
<tr><th rowspan="2">Width of aisles between rows of seats [mm]</th><th colspan="2">Maximum number of seats per row</th></tr>
<tr><th>Aisle between unidirectional rows</th><th>Aisle between bidirectional rows</th></tr>
<tr><td>W < 300</td><td>1</td><td>2</td></tr>
<tr><td>300 ≤ W < 325</td><td>7</td><td>14</td></tr>
<tr><td>325 ≤ W < 350</td><td>8</td><td>16</td></tr>
<tr><td>350 ≤ W < 375</td><td>9</td><td>18</td></tr>
<tr><td>375 ≤ W < 400</td><td>10</td><td>20</td></tr>
<tr><td>400 ≤ W < 425</td><td>11</td><td>22</td></tr>
<tr><td>425 ≤ W < 450</td><td rowspan="4">12</td><td>24</td></tr>
<tr><td>450 ≤ W < 475</td><td>26</td></tr>
<tr><td>475 ≤ W < 500</td><td>28</td></tr>
<tr><td>W ≥ 500</td><td>Limited by the travel distance</td></tr>
</table>

Table 88: Maximum number of fixed seats per row of the section

Maximum number of seats per row	
Per unidirectional exit	**Per bidirectional exit**
5	10

Table 89: Maximum number of mobile seats per row of the section

S.4.5.12 Installations for spectators

1. Installations for spectators (e.g. stands, etc.) are permitted if designed, built and managed pursuant to best practices (industry standard) (e.g. UNI EN 13200 series of standards, etc.).

2. Seating (*seats*) must be grouped into separate *sections (sectors)* from one another through the use of lengthwise and widthwise *aisles between the sections*. These aisles between sections must be the same size as escape routes or, if any section contains fewer than 600 seats, be ≥ 1 200 mm wide.

3. The number of seats that make up the row must be no greater than the number stated in Table 90 depending on the possibility of the occupants moving in one or two directions in order to exit the section (sector).

Maximum number of seats per row	
Per unidirectional exit	**Per bidirectional exit**
20	40

Table 90: Maximum number of seats per row of the section in installations for spectators

S.4.5.13 *Common evacuation systems*

1. In order to prevent the spread of smoke and heat during the evacuation, when there are premises under the responsibility of different *premises managers* within the building, specific assessments must be performed to determine whether separate escape systems are needed or whether specific design precautions will suffice.

Note For example, protected escape routes, smokeproof escape routes, management measures, emergency plans and alarm procedures shared between the different premises, etc.

2. If a civil premise shares escape routes with other premises of any type, including those under the responsibility of different *premises managers*, said escape routes must be smokeproof, in the absence of specific design precautions and shared emergency plans and alarm procedures.

S.4.6 Input data for designing the evacuation system

1. The design of the evacuation system depends on the input data for each compartment specified in paragraphs S.4.6.1 and S.4.6.2.

S.4.6.1 *Reference R_{life} risk profile*

1. Each component of the evacuation system is sized on the basis of the *most severe, for evacuation purposes,* of the R_{life} risk profiles of the compartments served.

S.4.6.2 *Crowd*

1. The *maximum* crowd size in each room is determined:

   a. by multiplying the *occupant density* from Table 91 by the *gross surface area* of the room in question.

   b. by applying the *criteria* of Table 92;

   c. according to the indications of the vertical technical rule.

   When the indications relating to the crowd are not available as indicated in letters a and b, reference to technical standards or documents issued by European or international bodies that are recognised in the fire protection sector is permitted.

2. The premises manager can declare a *lower* crowd value than that determined pursuant to paragraph 1.

3. The premises manager is required to adhere to the *crowd* size and the *occupant density* declared for each setting (area) and in each condition of use of the premises.

Type of premises	Occupant density
Outdoor settings (areas) intended for shows or entertainment that are bordered and without seating	2.0 persons/m^2
Indoor show or entertainment rooms (e.g. concert halls, dance halls, etc.) without seating and furniture, with a specific fire load $q_f \leq 50$ MJ/m^2	
Exhibition settings (areas)	1.2 persons/m^2
Settings (Areas) intended for shows or entertainment (e.g. concert halls, dance halls, etc.) with furniture or with a specific fire load $q_f > 50$ MJ/m^2	
Settings (Areas) designated for catering	0.7 persons/m^2
Settings (Areas) used for educational and laboratory activities (without seating)	0.4 persons/m^2
Waiting rooms	
Offices	
Sales settings (areas) of *small* retail businesses with food or mixed-use sections	
Sales settings (areas) of *medium* and *large* retail businesses with food or mixed-use sections	0.2 persons/m^2
Sales settings (areas) of retail businesses without food sections	
Reading rooms in libraries, archives	
Outpatient clinics	0.1 persons/m^2
Sales settings (areas) of wholesale businesses	
Sales settings (areas) of *small* retail businesses with a specific range of non-food goods	
Residential buildings	0.05 persons/m^2

Table 91: Occupant density per type of premises

Type of premises	Criteria
Public car parks	2 persons per parked vehicle
Private car parks	1 person per parked vehicle
Inpatient clinics	1 patient and 2 visitors per bed + staff
Settings (Areas) with seating or beds (e.g. meeting rooms, school rooms, dormitories, etc.)	Number of beds + staff
Other settings (areas)	Maximum number present (staff + public)

Table 92: Criteria per type of premises

S.4.7 Minimum fire protection requirements for the evacuation

1. The minimum number of vertical and horizontal escape routes for each setting of the premises is determined pursuant to the requirements of paragraph S.4.8.1 for the minimum number of escape routes and those of paragraph S.4.8.2 for the acceptability of dead-end corridors.
2. To avoid the spread of fire effluents to the escape routes:
   a. the vertical escape routes connecting the premises' compartments must be *protected* by doorways with a fire resistance determined according to chapter S.2 and in any case with a rating of no less than 30 with fire doors of at least E 30-S_a;

   Note For example, it is not necessary to protect stairs that descend from a mezzanine that is included in the same compartment, and *unprotected stairs* can be used inside *multi-storey compartments* (chapter S.3).

   b. for *smokeproof* vertical escape routes coming from connected compartments, the use of fire doors rated at least E 30 is permitted.
3. To prevent the spread of fire effluents to the above-ground escape routes, when the building has storeys with an elevation < -5 m, the underground escape routes, if they are not smokeproof, must be in separate compartments to those of the above-ground escape routes.

   Note For example, for this purpose it is sufficient to separate the above-ground vertical escape routes from the underground escape routes with fire doors in the communicating doorways on the ground floor.

4. To evacuate the occupants from the building's most remote storeys, depending on the reference R_{life} risk profile (paragraph S.4.6.1):
   a. when there are *storeys with an elevation above* that listed in Table, all above-ground storeys must be served by at least two independent escape routes;
   b. when there are *storeys with an elevation below* that listed in Table, all underground storeys must be served by at least two independent escape routes.

R_{life}	Storeys with a lower elevation	Storeys with a higher elevation
B1, B2, B3	< -5 m	> 32 m
B1 [1], B2 [1], B3 [1], D1, D2	< -1 m	> 12 m
Cii1, Cii2, Cii3, Ciii1, Ciii2, Ciii3	< -1 m	> 32 m
Other cases	< -5 m	> 54 m
[1] Areas with an occupant density > 0.4 p/m^2		

Table 93: Elevations of the threshold storeys for two independent escape routes

5. The escape routes from *settings* (*areas) open to the public* must not cross *settings* (*areas) not open to the public* if they are not exclusively dedicated to the evacuation, unless there is a specific risk assessment and additional measures that will allow the evacuation to take place safely under any conditions.

   Note For example, an evacuation from areas of a premises that are open to the public cannot cross processing or storage areas, unless there are specific measures in place to protect the occupants from the risks present in the areas they will cross.

6. As far as possible, the evacuation system should be designed bearing in mind that, in the event of an emergency, occupants who are not familiar with the layout of the premises tend to usually exit by travelling *back the way they came in*.

Note For example, this condition can be met by requiring that some of the escape routes are the same as the premises' ordinary access routes and that these are sufficiently large to evacuate at least 60 % of the occupants of the rooms served.

7. The *convergence* of the flows of occupants from different escape routes must not be obstructed (e.g. by fixed or mobile furniture, by the site's geometric configuration, by occupant flows entering the area in opposing directions, etc.).
8. Where there are high numbers of occupants or a high occupant density, steps must be taken, as far as possible, to ensure that the rescuers or occupants do not have to travel along escape routes against the flow of occupants. For this reason, separate routes may be established for specific needs.

S.4.7.1 *Fire protection requirements in the case of a phased evacuation*

1. In the case of a *phased evacuation* the following requirements must also be met:
   a. all storeys of the premises to which the phased evacuation applies must be served by at least two independent escape routes;
   b. the premises must be equipped with a performance level III fire detection and alarm system and an EVAS/EVAC system (chapter S.7);
   c. the premises must be equipped with a performance level II fire safety management plan (chapter S.5);
   d. each storey of the premises must be in a separate compartment and the compartmentalisation must be of performance level III (chapter S.3);
2. *Phased evacuation* methods must not be used for storeys with an elevation of < -5 m.

S.4.8 Design of the evacuation system

Note The evacuation system is sufficiently sized so as to allow the occupants to evacuate the compartment in which the fire breaks out and reach a *temporary place of safety* (e.g. adjacent compartment) or the *place of ultimate safety* directly, before the fire leads to *incapacitating* conditions in the settings (areas) of the premises where the occupants are, as described in the references of paragraph S.4.12.

S.4.8.1 Independent escape routes and exits

1. Escape routes and exits are deemed to be *independent* when the likelihood of them being simultaneously made unavailable due to the effects of the fire is minimal.

S.4.8.1.1 Minimum number of independent escape routes

1. In order to limit the likelihood of the occupants' evacuation being obstructed by the fire, at least two independent escape routes must be provided.
2. The presence of *dead-end corridors* is permitted in accordance with the provisions of paragraph S.4.8.2.

S.4.8.1.2 Minimum number of independent exits

1. In order to limit the likelihood of *localised overcrowding* occurring at the exits, each *room* or *open-air space* of the premises must have at least the number of independent exits specified in Table 94 based on the reference R_{life} risk profile and the crowd size in the setting (area) served.

R_{life}	Crowd size in the area served	Minimum number of independent exits
Any	> 500 occupants	3
B1 [1], B2 [1], B3 [1]	> 150 occupants	
Other cases		2
If dead-end corridors are permitted in accordance with the provisions of paragraph S.4.8.2		1
[1] Areas with an occupant density > 0.4 p/m²		

Table 94: Minimum number of independent exits from a room or open-air space

S.4.8.1.3 Determining the independence of horizontal escape routes and exits

1. Pairs of horizontal escape routes are deemed to be *independent* when at least one of the following conditions is met:
   a. the angle formed by the straight routes is ≥ 45°;
   b. there is an adequate full-height fire-rated separation between the routes with fire resistance characteristics of at least EI 30.
2. Pairs of exits from a *room* or *open-air space* are deemed to be *independent* when at least one of the conditions of point 1 is met by the routes leading to them.

Note Examples of independent horizontal escape routes and exits are given in illustration and in Table . The shaded areas show the points where independence is not guaranteed, i.e. dead-end corridors.

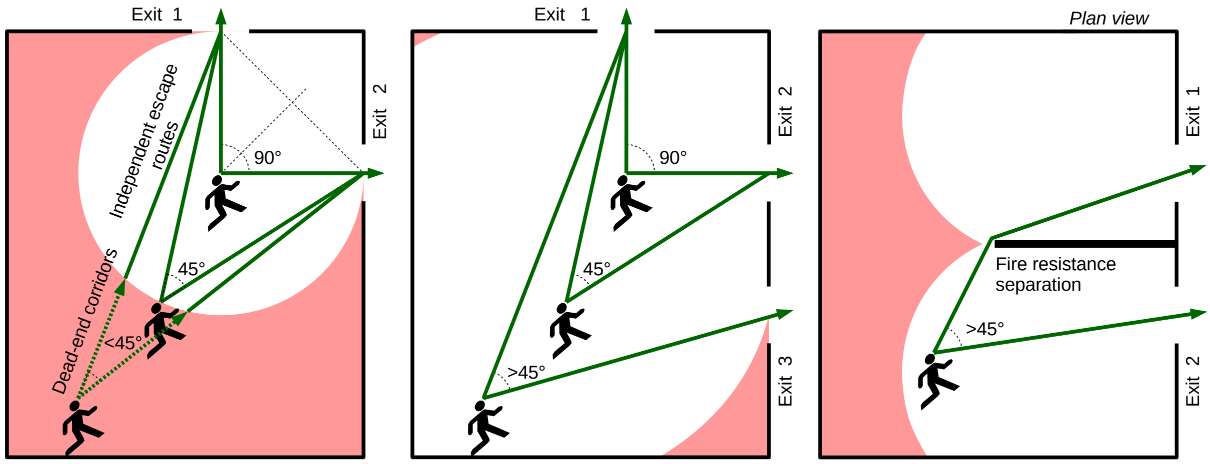


Image 10: Examples of independent horizontal escape routes and exits

S.4.8.1.4 Determining the independence of vertical escape routes

1. Pairs of vertical escape routes are deemed to be *independent* when located in separate compartments, or when at least one of the two is an *external escape route*.

   Note For example, the following are independent: two separate protected escape stairs, a protected escape stairs and an unprotected escape stairs, two unprotected escape stairs located in separate vertical compartments, one unprotected stairs and one external stairs, two external stairs, etc.

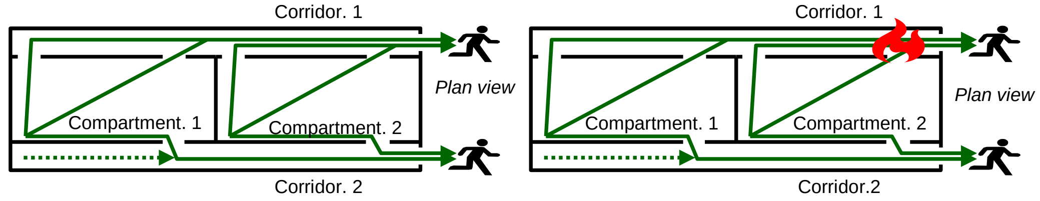
2. Pairs of unprotected vertical exits located in the same *compartment* can be deemed to be *independent* in the following conditions:
   a. neither is used by more than 100 occupants,
   b. none of the storeys served has an elevation of < -1 m,
   c. there are no dead-end corridors on the connected upstream or downstream routes.

The height difference between all storeys served by the compartment's unprotected vertical escape routes must be < 7 m.

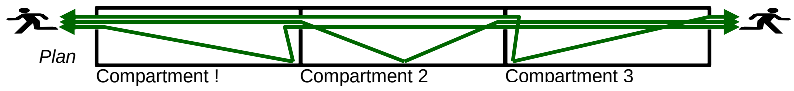
Note For example, two unprotected stairs serving a mezzanine in the same compartment, and which are spaced sufficiently far apart, can be deemed to be independent. An example is given in Table 96

3. Pairs of unprotected vertical escape routes that link different storeys of the same stepped or sloping room can be deemed to be independent provided that the downstream escape routes connecting to them are independent.

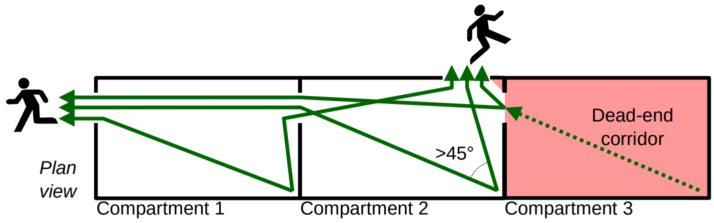
Note For example, two unprotected stairs located in stepped lecture theatres, auditoriums, cinema screens, etc. and which are spaced sufficiently far apart, can be deemed to be independent.



Each compartment has two escape routes in a protected corridor and three *independent* exits. In the event of a fire in corridor 1, one escape route and two exits for each compartment are made unavailable. The first section of corridor 2 is a *dead-end corridor* because it is unidirectional.

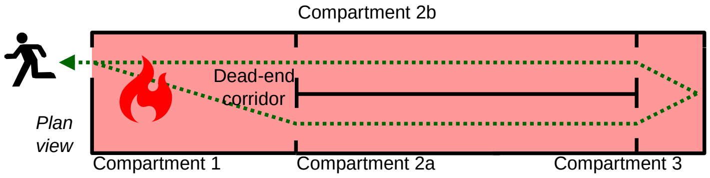


Each compartment has two escape routes and two *independent* exits.



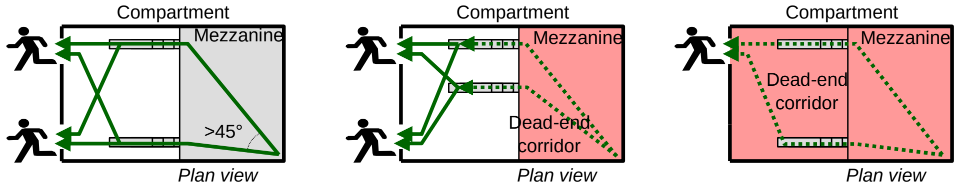
Compartments 1 and 2 have two escape routes and two *independent* exits.

In the first section, compartment 3 has one single escape route and exit which creates a *dead-end corridor*.



Compartments 1, 2a, 2b and 3 have a single escape route in a *dead-end corridor*. Both routes are made simultaneously unavailable by the effects of the fire in compartment 1.

Table 95: Examples of independent escape routes, independent exits and dead-end corridors



Taking into account the requirements of point 2 of paragraph S.4.8.1.4, in the first case the two *unprotected* stairs in the same compartment are considered independent of one another. In the second case, the two stairs are not independent because there is a dead-end corridor upstream. In the third case, the two stairs are not independent because there is a dead-end corridor downstream.

Table 96: Examples of unprotected independent escape routes

S.4.8.2 *Dead-end corridors*

Note The definitions of *dead-end corridor* and *dead-end corridor length* can be found in chapter G.1.

1. From the setting (area) served, the *dead-end corridor* offers the occupants *a single escape route* with no alternative. As far as possible, it is best to avoid the creation of unidirectional routes.
2. For each *dead-end corridor* the following conditions must be verified according to the reference R_{life} risk profile:
   a. to limit the *number of occupants* who could be trapped by the fire, the overall *crowd* size in the spaces served by the dead-end corridor must not exceed the maximum values stipulated in Table97.
   b. to limit the *probability* of the occupants being trapped by the fire, the *length of the dead-end corridor* must not exceed the maximum L_{cc} values of Table 97.

Note An example is given in Table 98.

3. As regards the highest level of protection offered, the section of *continuous* and *final* dead-end corridor with one of the characteristics of Table 99 can be *omitted* from the verification of the conditions of Table 97.

Note The omitted section is *final* because it ends at the point where at least two independent escape routes become available or it ends directly in a place of ultimate safety.

R_{life}	Max crowd size	Max length L_{cc}	R_{life}	Max crowd size	Max length L_{cc}
A1	≤ 100 occupants	≤ 45 m	B1, E1	≤ 50 occupants	≤ 25 m
A2		≤ 30 m	B2, E2		≤ 20 m
A3		≤ 15 m	B3, E3		≤ 15 m
A4	≤ 50 occupants	≤ 10 m	Cii1, Ciii1		≤ 20 m
D1		≤ 20 m	Cii2, Ciii2		≤ 15 m
D2		≤ 15 m	Cii3, Ciii3		≤ 10 m

The reference values of the maximum dead-end corridor lengths L_{cc} can be increased in relation to the *additional fire protection requirements*, according to the methods of paragraph S.4.10..

Table 97: Conditions for dead-end corridors

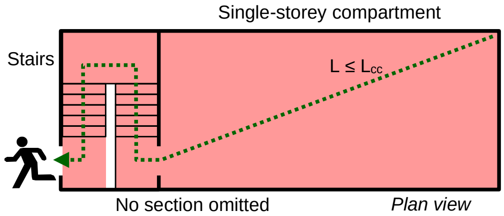
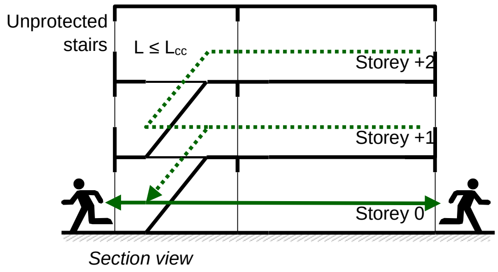
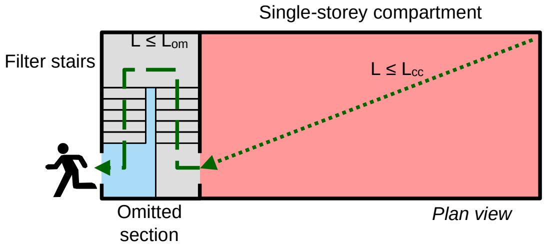
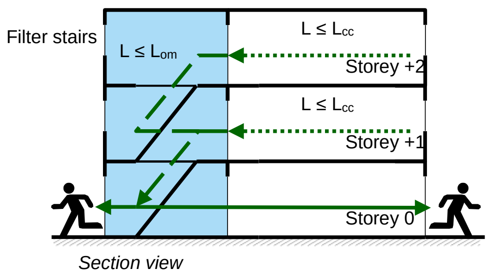
<table>
<tr><td>
</td><td>If no section of the dead-end corridor is omitted, the *crowd* size and the *dead-end corridor length* L_{cc} (TablE 97)) must be verified for the entire unidirectional route. In this case, the crowd to be considered on the stairs is the total for the storeys served regardless of the evacuation method chosen (e.g. *simultaneous* or *phased*).</td></tr>
<tr><td>
</td><td>For example, storeys +1 and +2 are served by a single stairs (*dead-end corridor*).
To verify the dead-end corridor (Table 97), if R_{life} = A2, the overall crowd size on these two storeys must be ≤ 100 occupants and the length of each dead-end corridor must be ≤ 30 m (L_{cc}).
The maximum L_{cc} length can be increased according to the methods of paragraph S.4.10.</td></tr>
</table>

Table 98: Example without omitting a section of a dead-end corridor

<table>
<tr><th>Characteristics of the omitted section</th><th>Max omitted length L_{om} [1]</th><th>Additional provisions</th></tr>
<tr><td rowspan="2">With *filter* characteristics (example in Table 100)</td><td>≤ 45 m</td><td>None</td></tr>
<tr><td>≤ 90 m</td><td>[2]</td></tr>
<tr><td rowspan="2">With *filter* and *smokeproof* characteristics</td><td>≤ 120 m</td><td>None</td></tr>
<tr><td>Unlimited</td><td>[2]</td></tr>
<tr><td>Also unprotected, ending directly at the *fire exit* or in a *place of ultimate safety* (example in Table 102)</td><td>≤ 15 m</td><td>None</td></tr>
<tr><td>From the *fire exit* to the *place of ultimate safety*, in an *external escape route* (example in Table 103)</td><td>Unlimited</td><td>None</td></tr>
<tr><td colspan="3">The settings (areas) served must have an occupant density of ≤ 0.4 p/m² and, if open to the public, a total of ≤ 300 occupants, otherwise a total crowd size of ≤ 500 occupants. In these settings (spaces), the presence of significant quantities of hazardous substances or mixtures, or of hazardous works with a fire risk, is not permitted. Each room in which occupants may sleep must be protected and have doors of at least E 30-S_a.
[1] If composed of several continuous sections with different characteristics, the *max omitted length* L_{om} is calculated as the *weighted average*, without taking into account the sections with an *unlimited* L_{om} (example in Table 101). The protection characteristics must increase in the direction of the evacuation.
[2] The areas served are equipped with a performance level III fire detection and alarm system (chapter S.7.) and have a performance level II fire safety management plan (chapter S.5).</td></tr>
</table>

Table 99: Conditions for omitting a section of a dead-end corridor

<table>
<tr>
<td>


</td>
<td>If the only stairs serving the multi-storey building is omitted, the crowd size and maximum dead-end corridor length L_{cc} (Table 97) are only verified for the parts of the dead-end corridor that end at the exit to that storey, for each storey.</td>
</tr>
<tr>
<td>


</td>
<td>For example, storeys +1 and +2 are served by a single stairs (dead-end corridor).

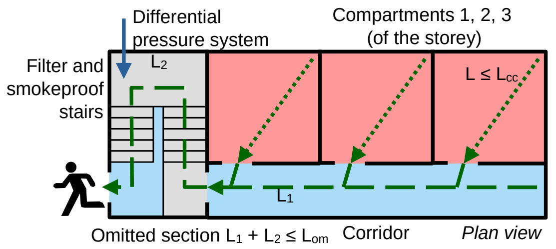
According to one of the possibilities of Table 99, if the only stairs has filter characteristics and a length of $\leq$ 45 m (L_{om}), it can be omitted from the verifications of Table 97.

To verify the dead-end corridor (Table 97), if R_{life} = A2, the overall crowd on each of the two storeys must be $\leq$ 100 occupants and the length of each dead-end corridor leading to the storey's exit must be $\leq$ 30 m (L_{cc}).

The maximum L_{cc} length can be increased according to the methods of paragraph S.4.10</td>
</tr>
</table>

Table 100: Example of omitting a section of a dead-end corridor with protection

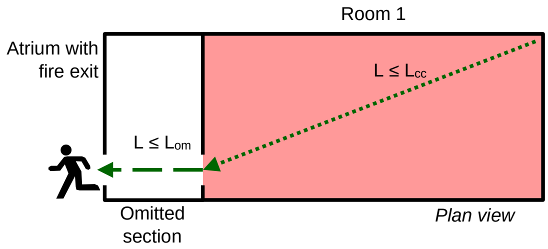
Note The length of the stairs is measured using the plumb/straight line method. Generally, in civil buildings, the length of the stairs for a single storey is around 12.50 m.



In this case, the only stairs serving the multi-storey building and the single-storey corridors, which have different characteristics, are omitted. The *max omitted length* L_{om} is equal to the *weighted average* of the relative values of Table 99

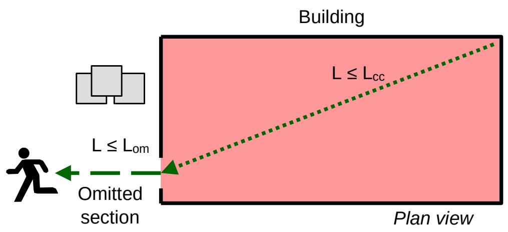
$$L_{om}=\frac{L_1\cdot L_{om(1)}+L_2\cdot L_{om(2)}}{L_{om(1)}+L_{om(2)}}$$

Table 101: Example of omitting different sections of a dead-end corridor

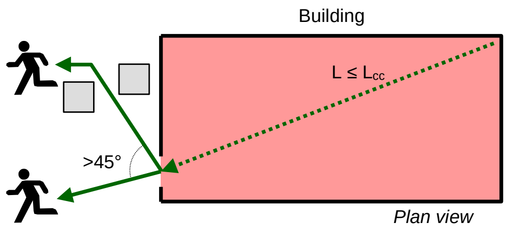


The atrium, which is also *unprotected*, ends directly at the *fire exit* (e.g. apartment block entrance hall). If it has the required characteristics of Table 99 it can be deemed to be an *omitted section of a dead-end corridor*.

Table 102: Example of omitting a section of a dead-end corridor leading to the fire exit



The open-air unidirectional route from the *fire exit* to the *place of ultimate safety*, along the *external escape route* (paragraph S.4.5.3.3), can be deemed to be an *omitted section of a dead-end corridor*.



In this case, the building has two independent escape routes leading to a place of ultimate safety, therefore the dead-end corridor ends at the *fire exit*.

Table 103: Example of omitting a section of a dead-end corridor on an external escape route

S.4.8.3 *Travel distances*

Note The definition of *travel distance* can be found in chapter G.1.

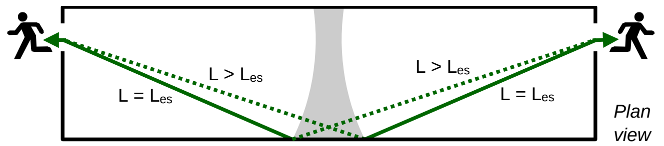
1. In order to limit the time required by the occupants to evacuate the compartment in which the fire broke out, at least one of the *travel distances* determined from any point of the premises must not exceed the maximum L_{es} values of Table 105 according to the reference R_{life} risk profile, as shown in Table 105.
2. When the first section of the escape route is composed of a *dead-end corridor*, the requirements relating to the *travel distance*, including the distance travelled in a dead-end corridor, and the conditions of paragraph S.4.8.2 for dead-end corridors, must also be verified.
3. Escape routes with *filter* characteristics and external escape routes can be *omitted* from the verification of the *travel distance* referred to in point 1, as it is deemed unlikely that a fire will break out in these locations.

Note For example, it is not necessary to verify the travel distance in protected escape stairs that have *filter* characteristics.

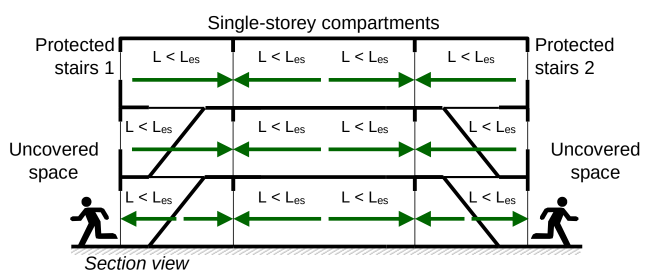
Note Examples of verifying the travel distance are listed in Table 105

R_{life}	Max travel distance L_{es}	R_{life}	Max travel distance L_{es}
A1	≤ 70 m	B1, E1	≤ 60 m
A2	≤ 60 m	B2, E2	≤ 50 m
A3	≤ 45 m	B3, E3	≤ 40 m
A4	≤ 30 m	Cii1, Ciii1	≤ 40 m
D1	≤ 30 m	Cii2, Ciii2	≤ 30 m
D2	≤ 20 m	Cii3, Ciii3	≤ 20 m
The reference values of the maximum travel distance can be increased in relation to the *additional fire protection requirements*, according to the methods of paragraph S.4.10			

Table 104: Maximum travel distances



In the shaded area, the travel distances are greater than the maximum permitted distance; the verification is unsuccessful.



The protected escape stairs are *temporary places of safety* for the single-storey compartments; the *travel distances* end at the exits to each storey.

For protected stairs the *temporary place of safety* is the single-storey compartments, through which it is possible to reach the other escape stairs. On the ground floor, besides the compartment adjacent to each escape stairs, the uncovered space is also a *temporary place of safety*.

If the *travel distances* are less than the maximum permitted, the verification is successful.

Table 105: Examples of verifying the travel distance

S.4.8.4 *Escape route heights*

1. The minimum *height* of escape routes is 2 m.
2. Lower heights are permitted for short, signed sections along escape routes from settings (areas) where only specially trained personnel are present or where a limited number of occupants is occasionally present for a brief period (e.g. plant or service rooms, small storage rooms, etc.), or according to the results of a specific risk assessment.

S.4.8.5 *Escape route widths*

1. The *width* of the escape route is the minimum measured from the underfoot surface to a height of 2 m, subtracting the height of any protruding objects with the exception of fire extinguishers. Handrails and door opening devices protruding ≤ 80 mm are not deemed to be protruding objects.
2. The width of the escape routes must be assessed along the entire escape route.
3. After identifying the most severe conditions for the components of the evacuation system by verifying the redundancy referred to in paragraph S.4.8.6, the *minimum width* of the escape routes is determined as described in paragraphs S.4.8.7, S.4.8.8, S.4.8.9, S.4.8.10..

   Note Calculation examples are given in Table 112, 113, and 114

4. In premises with an occupant density of ≥ 0.7 persons/m^2, there *must* be no reduction in the width of any horizontal escape route from one end to the other in the direction of the evacuation in order to limit the likelihood of *localised overcrowding* occurring. This *should* also be provided for in the other premises.
5. For the sections of escape route used as *rescuer access routes* the provisions of paragraph S.9.6 must also be applied.

S.4.8.6 *Verifying the redundancy of escape routes*

1. If a setting (an area) (e.g. compartment, storey, mezzanine, room, etc.) is served by more than one escape route, the fire could make one of them unavailable.
2. For the redundancy verification, one escape route must be made unavailable at a time and the remaining independent escape routes must be shown to be sufficiently wide in total to evacuate the occupants.

   Note For the considerations of paragraph S.4.8.1 any non-independent escape routes must be made simultaneously unavailable.

3. *Smokeproof* escape routes with *filter* characteristics are considered *always available* and must not be subject to redundancy verifications, unless the designer has carried out a more restrictive risk assessment.
4. During the redundancy verification there is no need to perform further verifications of the *dead-end corridors* and the *travel distances*.

S.4.8.7 *Calculating the minimum width of horizontal escape routes*

1. The minimum width L_O of the horizontal escape route (e.g. corridor, door, exit, etc.) that permits the steady evacuation of the occupants using it is calculated as follows:

   $$L_O = L_U \cdot n_O \quad (14)$$

   where:

   L_O minimum width of the horizontal escape route [mm]

   L_U *unit width* for the horizontal escape route determined by Table 106 based on the reference R_{life} risk profile [mm/person]

   n_O number of occupants using the horizontal escape route, in the most severe evacuation conditions (paragraph S.4.8.6).

2. The width L_O may be subdivided between multiple routes. In order to limit the probability of *localised overcrowding* occurring, in particular in the case of significant crowds or occupant densities or where the occupants are not distributed as expected, the width of each route must comply with the criteria of Table 107, or be subject to a specific risk assessment.

Note Examples can be found in Table 112.

R_{life}	Unit width	Δt_{queue}	R_{life}	Unit width	Δt_{queue}
A1	3.40	330 s	B1, C1, E1	3.60	310 s
A2	3.80	290 s	B2, C2, D1, E2	4.10	270 s
A3	4.60	240 s	B3, C3, D2, E3	6.20	180 s
A4	12.30	90 s	-	-	-
The unit width values are expressed in mm/person and ensure a queueing time, for occupants using that escape route, of no longer than Δt_{queue}.					

Table 106: Unit widths for horizontal escape routes

Width	Criterion
≥ 1 200 mm	Crowd size in the setting (space) served > 1 000 occupants
≥ 1 000 mm	Crowd size in the setting (space) served > 300 occupants
≥ 900 mm	Crowd size in the setting (space) served ≤ 300 occupants Width adapted to occupants using mobility aids
≥ 800 mm	Doorways of setting (areas) served with ≤ 50 occupants
≥ 700 mm	Doorways of setting (areas) served with ≤ 10 occupants (e.g. individual offices, hotel rooms, domestic rooms, apartments, etc.)
≥ 600 mm	Setting (Area) served where only specially trained personnel are present or where a limited number of occupants is occasionally present for a brief period (e.g. plant or service rooms, small storage rooms, etc.).
The *crowd size in the setting (area) served* corresponds to the total number of occupants using each of the escape routes that leaves said area.	

Table 107: Minimum widths for horizontal escape routes

S.4.8.8 *Calculating the minimum width of vertical escape routes*

1. Depending on the evacuation method adopted (paragraph S.4.1), the minimum width L_v of the vertical escape route (e.g. stairs, etc.), which allows the steady evacuation of the occupants who use it, is calculated as specified in paragraph S.4.8.8.1 or S.4.8.8.2.
2. The width L_V may be subdivided between multiple routes. In order to limit the probability of *localised overcrowding* occurring, in particular in the case of significant crowds or occupant densities or where the occupants are not distributed as expected, the width of each route must comply with the criteria of Table 111, or be subject to a specific risk assessment.

Note Examples can be found in Table 113.

S.4.8.8.1 Calculation in the case of a simultaneous evacuation

1. If the *simultaneous evacuation* method is applied in the premises, the vertical escape routes must be capable of allowing the simultaneous evacuation of *all* the occupants evacuating from all of the storeys served.
2. The width L_v is calculated as follows:

$$L_V = L_U \cdot n_V \quad (15)$$

where:

L_V minimum width of the vertical escape route [mm]

L_U *unit width* determined by Table 108 according to the reference R_{life} risk profile and the total number of storeys served by the vertical escape route [mm/person]

n_V total number of occupants using the vertical escape route, coming from all of the storeys served, in the most severe evacuation conditions (paragraph S.4.8.6).

S.4.8.8.2 Calculation in the case of a phased evacuation

1. If the *phased evacuation* method is applied in the premises, the vertical escape routes must be capable of allowing the evacuation of occupants from all of the storeys served during *each phase*.
2. The width L_v is calculated as follows:

$$L_V = L_U \cdot n_V \quad (16)$$

where:

L_V minimum width of the vertical escape route [mm]

L_U *unit width* determined by Table 108 according to the reference R_{life} risk profile and applying a total number of storeys served by the vertical escape route of 2 [mm/person]

n_V total number of occupants using the vertical escape route, coming from two of the storeys served, taking into account the two storeys, including if they are not adjacent, with a larger crowd, in the most severe evacuation conditions (paragraph S.4.8.6).

R_{life}	Total number of storeys served by the vertical escape route										Δt_{queue}
	1	**2 [F]**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**> 9**	
A1	4.00	3.60	3.25	3.00	2.75	2.55	2.40	2.25	2.10	2.00	330 s
B1, C1, E1	4.25	3.80	3.40	3.10	2.85	2.65	2.45	2.30	2.15	2.05	310 s
A2	4.55	4.00	3.60	3.25	3.00	2.75	2.55	2.40	2.25	2.10	290 s
B2, C2, D1, E2	4.90	4.30	3.80	3.45	3.15	2.90	2.65	2.50	2.30	2.15	270 s
A3	5.50	4.75	4.20	3.75	3.35	3.10	2.85	2.60	2.45	2.30	240 s
B3, C3, D2, E3	7.30	6.40	5.70	5.15	4.70	4.30	4.00	3.70	3.45	3.25	180 s
A4	14.60	11.40	9.35	7.95	6.90	6.10	5.45	4.95	4.50	4.15	90 s

The unit width values are expressed in mm/person and ensure a queueing time, for occupants using that escape route, of no longer than Δt_{queue}.

The unit width values must be increased for *stairs* according to the indications of Table 109, or for *ramps* according to the indications of Table.

[F] Also used in the *phased evacuation*

Table 108: Unit widths for vertical escape routes

Riser	**Tread**		
	tread ≥ 30 cm	**25 cm ≤ tread < 30 cm**	**22 cm ≤ tread < 25 cm**
riser ≤ 17 cm	0 %	+10%	+25 % [1]
17 cm < riser ≤ 18 cm	+5%	+15%	+50% [1]
18 cm < riser ≤ 19 cm	+15%	+25%	+100% [1]
19 cm < riser ≤ 22 cm	+25 % [1]	+100% [1]	+200% [1]

Steps with a tread < 22 cm or riser > 22 cm are not permitted, unless from rooms where only specially trained personnel are present, or where a limited number of occupants is occasionally present for a brief period.

Winder stairs are permitted; the tread and riser are measured 300 mm from the inside edge of the stairs.

[1] These combinations are permitted only where a specific risk assessment has been performed.

Table 109: Unit width increase of escape stairs in relation to the steps

Ramp gradient (slope)		
gradient ≤ 8 %	**8 % < gradient ≤ 12 %**	**12% < gradient ≤ 20%**
0 %	+50 %	+200% [1]

[1] These combinations are permitted only where a specific risk assessment has been performed.

Table 110: Unit width increase of escape ramps in relation to the gradient

Width	Criterion
≥ 1 200 mm	Crowd size in the setting (space) served > 1 000 occupants
≥ 1 000 mm	Crowd size in the setting (space) served > 300 occupants
≥ 900 mm	Crowd size in the setting (space) served ≤ 300 occupants
≥ 600 mm	Setting (Area) served where only specially trained personnel are present or where a limited number of occupants is occasionally present for a brief period (e.g. plant or service rooms, small storage rooms, etc.).
The *crowd size in the area served* corresponds to the total number of occupants using each of the escape routes that leaves said area.	

Table 111: Minimum widths for vertical escape routes

S.4.8.9 *Calculating the minimum width of fire exits*

1. The minimum width of the fire exit L_F, which allows the steady evacuation of the occupants coming from horizontal or vertical escape routes, is calculated as follows:

$$L_F = \sum_i L_{O,i} + \sum_j L_{V,j} \quad (17)$$

where:

L_F minimum width of the final exit [mm]

$L_{O,i}$ width of the ith horizontal escape route that leads to the fire exit, as calculated with equation 15. [mm]

$L_{V,j}$ width of the jth vertical escape route that leads to the fire exit, as calculated with equations 16 or 17, respectively in the case of a *simultaneous evacuation* or a *phased evacuation* [mm]

2. The width L_F may be subdivided between multiple routes. The width of each route must meet the criteria of Table 107.

3. The *convergence* of the flows of occupants from the horizontal and vertical escape routes to the fire exit must not be obstructed (e.g. by fixed or mobile furniture, etc.).

For this purpose, when at least two of the merging escape routes leading to the same fire exit are each used by more than 50 occupants, the distance measured on the plan between the fire exit and the point at which all of the escape routes leading to the fire exit merge must be ≥ 2 m, as shown in illustration.

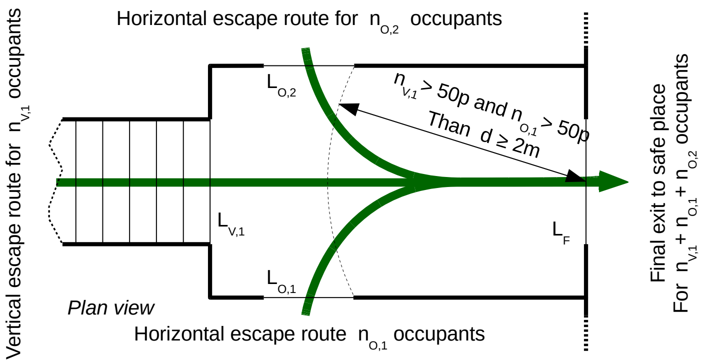


Image 11: Example of merging flows leading to the fire exit

S.4.8.10 Calculating the minimum width for escape escalators and moving walkways

Note Where they form part of the escape route, escape escalators and moving walkways must be considered in all of the verifications described in this paragraph including when used in motion (e.g. redundancy check, travel distance, etc.).

S.4.8.10.1 Stationary escalators and moving walkways

1. The minimum width of escape escalators and moving walkways that are *stationary* during the emergency (paragraph S.4.5.5) is calculated in the same way as for horizontal (paragraph S.4.8.7) or vertical (paragraph S.4.8.8.) escape routes, depending on their gradient (slope).

S.4.8.10.2 Escalators and moving walkways in motion

1. The minimum width for escape escalators and moving walkways used *in motion* during the emergency (paragraph S.4.5.5) is verified according to the following procedure:

   a. the *theoretical transport capacity* is determined (e.g. pursuant to standard EN 115-1) and is reduced by 50 %;

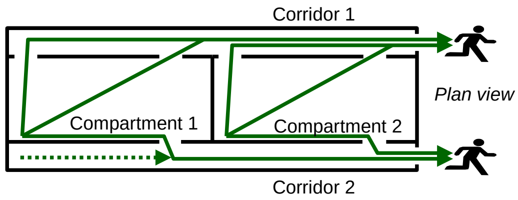
   b. the time needed, from the sounding of the alarm, for the motor to be reversed in the direction of the evacuation is determined;

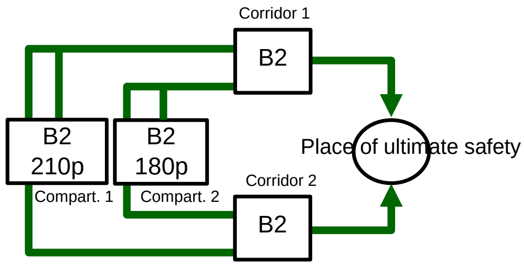
   c. the time needed to transport the occupants using this escape route is added to the time needed to reverse the motor, giving the maximum queueing time for the occupants;

   d. if the time calculated in this manner is less than the Δt_{queue} values of Tables 106 and 108, based on the reference R_{life} risk profile, the use of the escalator or moving walkway to evacuate the occupants is verified.

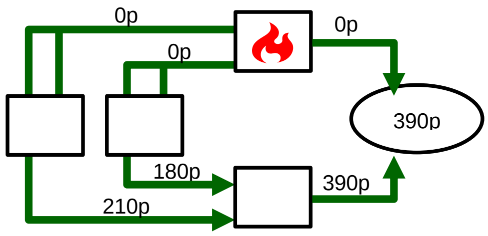
   Note A calculation example is given in Table 114..

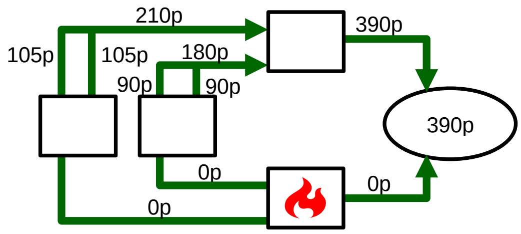
2. The *width of the steps or segments* of escape escalators and moving walkways must be ≥ 800 mm.



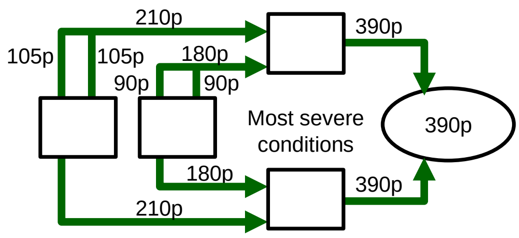


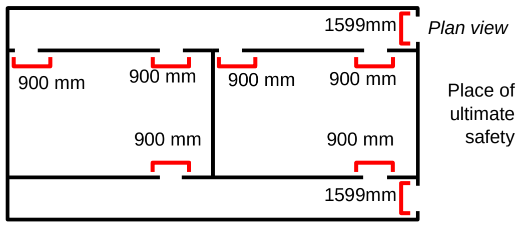
Based on the geometry of the premises, the escape route *plan* is drawn up and the input data is defined (§ S.4.6.): reference R_{life} risk profile and crowd. In this case, the crowd size in the transit corridors is deemed to be unimportant. Taking into account the minimum fire protection requirements (§ S.4.7), after defining the minimum number of escape routes and exits (§ S.4.8.1), any dead-end corridors (§ S.4.8.2) and the travel distances (§ S.4.8.3) are verified.





The redundancy check (§S.4.8.6) is performed by identifying the most severe conditions for the components of the evacuation system. In the above figures, only the most severe results are given.





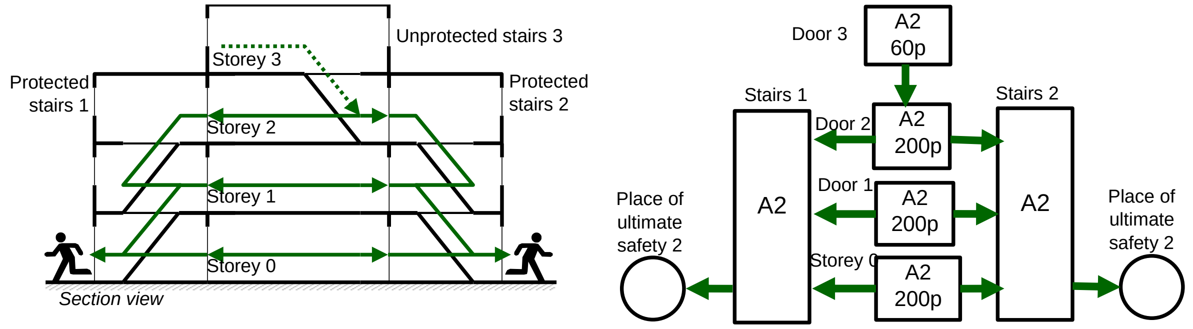
The minimum widths (§S.4.8.5) are calculated using the most severe conditions, for example:

- L_O = 390 p · 4.10 mm/p = 1 599 mm ≥ 1 000 mm (crowd size in the area: 210 p +180 p = 390 p)
- L_O = 210 p · 4.10 mm/p = 861 mm < 900 mm (crowd size in the area: 210 p)
- …

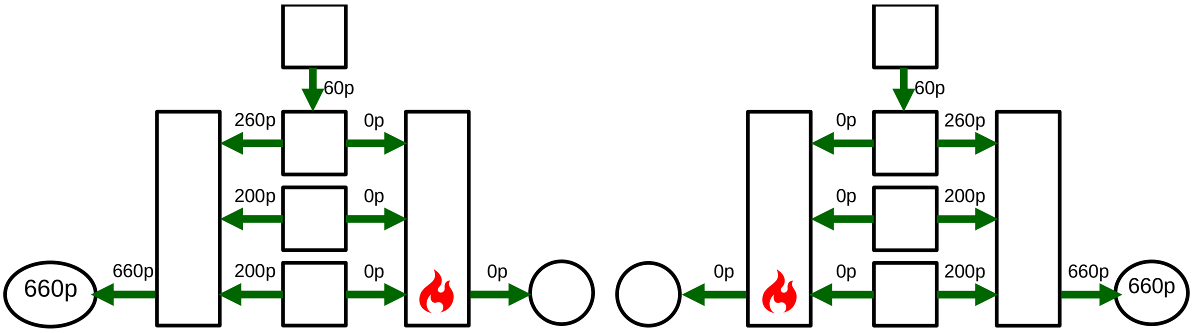
The minimum gross surface area of the place of ultimate safety is verified (S.4.5.1): S = 390 p: 0.7 p/m^2 = 558 m^2

Lastly, the opening direction and devices of manual doors are determined (§ S.4.5.7.1).

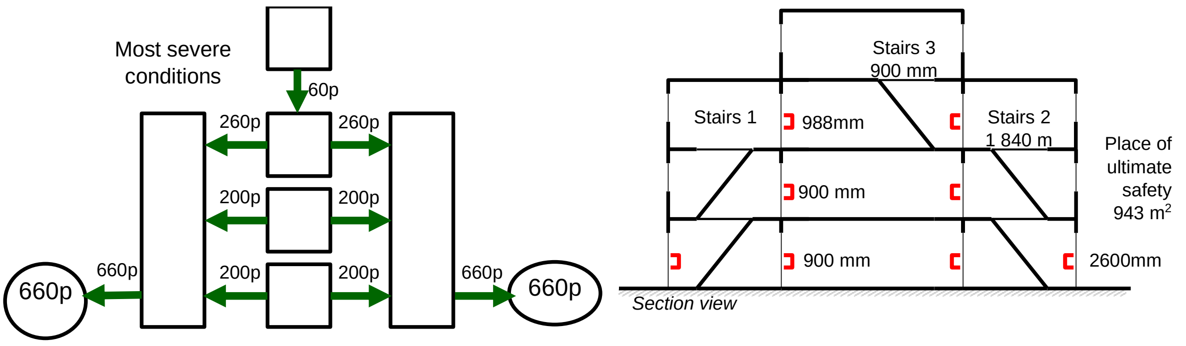
Table 112: Example of the dimensions of horizontal escape routes



Based on the geometry of the premises, the escape route *plan* is drawn up and the input data is defined (§S.4.6): reference R_{life} risk profile and crowd. Taking into account the minimum fire protection requirements (§S.4.7), after defining the minimum number of escape routes and exits (§S.4.8.1), any dead-end corridors (§ S.4.8.2) and the travel distances (§S.4.8.3) are verified.



The redundancy check (§ S.4.8.6) is performed by identifying the most severe conditions for the components of the evacuation system. In the above figures, only the most severe results are given.



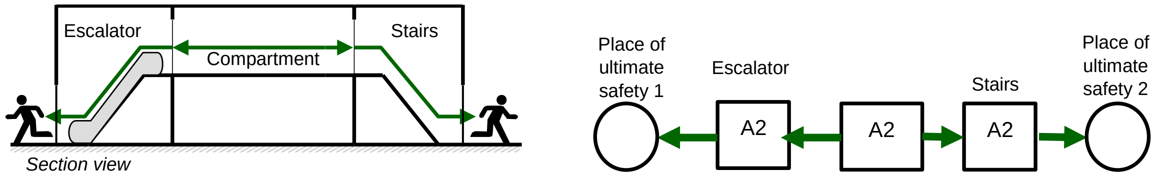
The minimum widths (§ S.4.8.5) are calculated using the most severe conditions, for example:

- L_O = 260 p · 3.80 mm/p = 988 mm ≥ 900 mm (number of occupants in the area: 260 p)
- L_O = 200 p · 3.80 mm/p = 760 mm < 900 mm (crowd size in the area: 200 p)
- Stairs 3: L_V = 60 p · 4.55 mm/p = 273 mm < 900 mm (1 storey, crowd size in the area: 60 p)
- Stairs 1 and 2: L_V = (260 p +200 p) · 4.00 mm/p = 1 840 mm ≥ 1 000 mm (2 storeys, crowd size in the area: 460 p)
- Fire exits: L_F = 1 840 mm + 760 mm = 2 600 mm ≥ 1 000 mm (crowd size in the area: 660 p)

The minimum gross surface area of the places of ultimate safety is verified (§ S.4.5.): S = 660 p: 0.7 p/m^2 = 943 m^2

Lastly, the opening direction and devices of manual doors are determined (§ S.4.5.7.1).

Table 113: Example of the dimensions of horizontal and vertical escape routes



An escalator and ordinary stairs are intended to be used to evacuate 200 occupants from a compartment.

For the redundancy verification (§ S.4.8.6.), in the most severe conditions, each option can be used by all 200 occupants.

The escalator is 1 000 mm wide, which is greater than the allowed minimum of 800 mm. Its nominal speed is 0.65 m/s, therefore it has a *theoretical transport capacity* of 2 persons/s, pursuant to standard EN 115-1. It is assumed that, once the alarm is sounded, the time taken to reverse the motor in the direction of the evacuation is 30 s.

Pursuant to paragraph S.4.8.10.2, the time occupants spend queueing at the escalator is:

200 p: (2 p/s · 50%) + 30 s = 230 s

If R_{life} for the compartment is A2, based on Table 108 the Δt_{queue} = 290 s, which is greater than the calculated time of 230 s.

The use of this escalator for the evacuation is therefore permitted.

For the ordinary stairs and the fire exit:

$L_V = L_F$ = 200 p · 4.55 mm/p = 910 mm ≥ 900 mm (1 storey, crowd size in the area: 200 p)

Table 114: Example of the dimensions of evacuation escalators

S.4.9 Removing or crossing architectural barriers during evacuation

Note The design of the evacuation system must respect the provisions of the Presidential Decree of 6th June 2001, No 380 '*Consolidating act of the legislative and regulatory provisions concerning construction*', including as regards removing or crossing architectural barriers.

1. On all storeys of the premises in which there may be a non-occasional presence of occupants who are unable to *autonomously* reach a place of ultimate safety via the vertical escape routes, at least one of the following must be adopted:

   a. use of *areas of rescue assistance* according to the indications of paragraph S.4.9.1;

   b. *progressive horizontal evacuation* according to the indications of paragraph S.4.9.2;

   c. horizontal evacuation to a place of ultimate safety.

   For the other storeys, appropriate measures must be implemented to manage the specific needs of occupants (chapterS.5).

Note Specific facilities built for these occupants in the premises are indicators of a non-occasional presence (e.g. disabled spaces in car parks, disabled toilets, stair lifts, etc.).

2. Compartments with an R_{life} risk profile of D1, D2:

   a. must have at least one fireproof lift that is large enough to be used by all of the occupants, including non-ambulatory occupants (e.g. wheelchair, stretcher, etc.);

   b. must have horizontal escape routes that are large enough to allow the premises' beds and stretchers to be easily moved in the event of fire.

Note In order to allow all occupants, regardless of their ability, to autonomously use the evacuation system of the premises, the requirements and recommendations contained in standard ISO 21542 '*Building construction – Accessibility and usability of the built environment*' can be applied.

S.4.9.1 *Area of rescue assistance*

Note The definition of an *area of rescue assistance* can be found in chapter G.1. An example is given in illustratiion ..

1. To allow the occupants to await and receive assistance, the area of rescue assistance must:
   a. be adjacent to and communicating with an escape route or be part of an escape route, without obstructing the evacuation;
   b. be sized so as to be able to accommodate all of the occupants of the storey who need it, in accordance with the minimum surface area per occupant of Table 115.
2. Each area of rescue assistance must contain:
   a. a two-way communications system that allows the occupants to indicate their presence and request assistance from rescuers;
   b. any apparatus to be used for providing assistance (e.g. evacuation chair or stretcher, etc.);
   c. instructions on how to behave while awaiting the arrival of rescuers.
3. The area of rescue assistance must be signed with UNI EN ISO 7010-E024 signage, as illustrated in Table 87.

S.4.9.2 *Progressive horizontal evacuation*

Note The definition of *progressive horizontal evacuation* can be found in chapter G.1..Examples can be found in Table 116.

1. In order to allow the progressive horizontal evacuation, the storey of the premises must be subdivided into at least two compartments. Each compartment must:
   a. be able, in an emergency, to hold, besides its normal occupants, the maximum number of occupants using it for the progressive horizontal evacuation, in accordance with the minimum surface area per occupant of Table 115.;
   b. have escape routes that are sufficient to evacuate the number of its occupants plus 50 % of the maximum number of occupants using it for the progressive horizontal evacuation;
   c. have at least two independent escape routes to separate adjacent compartments, or one *smokeproof* escape route with *filter* characteristics.
2. When the progressive horizontal evacuation *is assisted* by specially trained staff, the direction in which the doors between the compartments open can be limited to only the main direction of the evacuation.
3. When the progressive horizontal evacuation *is not assisted* by specially trained staff, the compartments in question must also have the characteristics of *areas of rescue assistance* (e.g. two-way communication system, signage, etc.).

Type	Minimum surface area per occupant
Walking occupant	0.70 m^2/person
Occupant using a wheelchair	1.77 m^2/person
Bedridden occupant	2.25 m^2/person
The handling spaces required to use any mobility apparatus (e.g. bed, wheelchair, etc.) must be added to the minimum surface area for occupants.	

Table 115: Minimum surface area per occupant

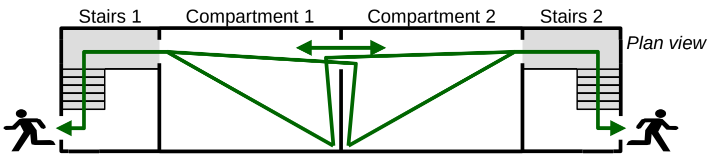
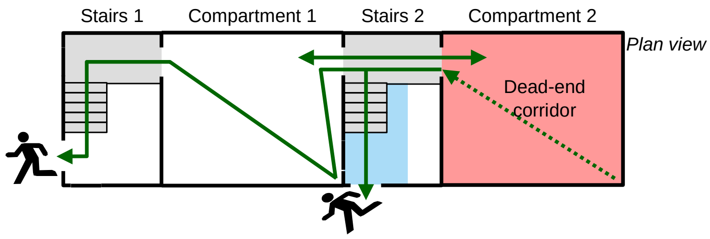
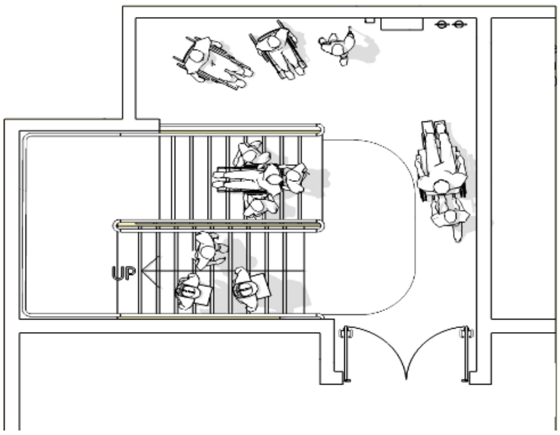
	Each of the compartments, 1 and 2, has two independent escape routes, therefore the progressive horizontal evacuation can take place. Additional measures are not required for the stairs.
	Compartment 1 has two independent escape routes. Compartment 2 has a single escape route in a *dead-end corridor*. A progressive horizontal evacuation can only be performed if stairs 2 is *smokeproof* and has *filter* characteristics.

Table 116: Examples of progressive horizontal evacuation



mage 13: Example of an area of rescue assistance in accordance with ISO 21542

S.4.10 Additional fire protection requirements for the evacuation

1. As regards the presence of *additional fire protection requirements*, some of the measures indicated in this chapter can be modified as outlined below.

2. It is possible to increase the maximum *travel distance* L_{es} of Table 104 as follows:

   $$L_{es,d} = (1 + \delta_m) \cdot L_{es} \quad (18)$$

   where:

   $L_{es,d}$ max designed travel distance [m]

   δ_m factor calculated according to point 4

3. It is possible to increase the maximum *dead-end corridor length* L_{cc} of Table as follows:

   $$L_{cc,d} = (1 + \delta_m) \cdot L_{cc} \quad (19)$$

   where:

   $L_{cc,d}$ max designed dead-end corridor length [m]

   δ_m factor calculated according to point 4

4. The factor δ_m takes into account the different *additional fire protection requirements* of the compartment served by the escape route and is calculated as follows:

   $$\delta_m = \sum_i \delta_{m,i} \quad (20)$$

   where:

   $\delta_{m,i}$ factor relating to the *additional fire protection requirement* of Table 117.

   Under no circumstances may δ_m exceed the maximum permitted variation of 36 %.

5. For compartments with an R_{life} risk profile equal to A4, no variation in the values of Tables and 104 is permitted.

Additional fire protection requirements		$\delta_{m,i}$
Performance level IV detectors and alarms (chapter S.7)		15%
Performance level III smoke and heat control systems (chapter S.8)		20%
Average height of the space served by the escape route, h_m in metres [1]	≤ 3 m	0 %
	> 3 m, ≤ 4 m	5%
	> 4 m, ≤ 5 m	10%
	> 5 m, ≤ 6 m	15%
	> 6 m, ≤ 7 m	18%
	> 7 m, ≤ 8 m	21%
	> 8 m, ≤ 9 m	24%
	> 9 m, ≤ 10 m	27%
	> 10 m	30%
[1] When the escape route serves multiple rooms, the smallest of the average heights is used.		

Table 117: Parameters for defining the factors $\delta_{m,i}$

S.4.11 Evacuation for open-air premises

Note The definition of *open-air premises* can be found in chapter G.1.

Note The evacuation system of the *open-air premises* is sized by limiting the maximum Δt_{queue} time that the occupants spend queueing along the escape route before they are able to move away, as described in the references referred to in paragraph S.4.12.

1. In the *open-air premises*, the likelihood that the effects of the fire will obstruct the evacuation of the occupants is considered to be less relevant with regard to the other premises, because the smoke and heat from the fire will disperse straight into the atmosphere.

   The evacuation system of open-air premises must be designed as described in this chapter, applying the additional indications referred to in this paragraph in full.

Note The design of the evacuation system leading to the *place of ultimate safety* from any indoor sections of *open-air premises* is excluded from this paragraph.

2. The *additional fire protection requirements* of paragraph S.4.10 do not apply.

S.4.11.1 Design of the open-air evacuation system

S.4.11.1.1 Dead-end corridors

1. The maximum crowd size and the maximum lengths of dead-end corridors L_{cc} as per Table 97 are doubled.

S.4.11.1.2 Travel distances

1. The verification of the travel distances L_{es} of paragraph S.4.8.3 can be omitted.

S.4.11.1.3 Escape route widths

1. Table 106, regarding ‘Unit widths for horizontal escape routes’, is *replaced* by Table 118..
2. Table 108, regarding ‘Unit widths for vertical escape routes’, is *replaced* by Table 119.

S.4.11.2 Removing or crossing architectural barriers during open-air evacuations

1. It is possible to use an *open-air space* with the same characteristics as a *place of ultimate safety* as an *area of rescue assistance* (paragraph s.4.5.1), provided it is clearly defined and adjacent to an escape route, exclusively intended for this purpose, and easy for rescuers to access.
2. It is possible to perform a *progressive horizontal evacuation* to an *open-air space* with the same characteristics as a *place of ultimate safety* (paragraph S.4.5.1), provided it is clearly defined and adjacent to an escape route, exclusively intended for this purpose, and easy for rescuers to access.

R_{life}	Unit width	Δt_{queue}
A1, A2	1.90	600 s
B1, B2, C1, E1, E2	2.40	460 s
Other cases	3.70	300 s
The unit width values are expressed in mm/person and ensure a queueing time, for occupants using that escape route, of no longer than Δt_{queue}.		

Table 118: Unit widths for horizontal escape routes from open-air premises

R_{life}	Total number of storeys served by the vertical escape route										Δt_{queue}
	1	2	3	4	5	6	7	8	9	> 9	
A1, A2	2.20	2.10	1.95	1.85	1.75	1.70	1.60	1.55	1.50	1.40	600 s
B1, B2, C1, E1, E2	2.85	2.65	2.45	2.30	2.15	2.05	1.95	1.85	1.75	1.65	460 s
Other cases	4.40	4.05	3.75	3.50	3.30	3.10	2.95	2.75	2.65	2.50	300 s
The unit width values are expressed in mm/person and ensure a queueing time, for occupants using that escape route, of no longer than Δt_{queue}. The unit width values must be increased for *stairs* according to the indications of Table 109, or for *ramps* according to the indications of Table.											

Table 119: Unit widths for vertical escape routes from open-air premises

S.4.12 References

1. The following references are provided:

a. ISO 13571 '*Life-threatening components of fire – Guidelines for the estimation of time to compromised tenability in fires';*

b. ISO/TR 16738 '*Fire-safety engineering -–Technical information on methods for evaluating behaviour and the movement of people*'.

c. ISO 21542 '*Building construction – Accessibility and usability of the built environment*';

d. prEN 17210 '*Accessibility and usability of the built environment – Functional requirements*';

e. BS 9999, Section 5 – '*Designing means of escape'*;

f. IFC, '*International Fire Code 2009*', Chapter 10;

g. NFPA 101 '*Life safety code*', Chapter 7;

h. '*The SFPE Handbook of fire protection engineering*', 5th edition, SFPE/NFPA, 2016;

i. UK (England) Department of Health, '*Health Technical Memorandum 05-02: Firecode – Guidance in support of functional provisions (Fire safety in the design of healthcare premises)*', 2014;

j. UK (England) Department for Communities and Local Government Publications, '*Technical Risk Assessment Guide on Transport Premises and Facilitie*s', 2007;

k. UK (England) Sports Grounds Safety Authority (SGSA), '*Safety of Sports Grounds Guidance – Green Guide*', 6th Edition, 2018;

l. Gissi E, Ronchi E, Purser D A, '*Transparency vs magic numbers: The development of stair design requirements in the Italian Fire Safety Code*', Fire Safety Journal, 91, 882–891, 2017;

m. Fruin J J, '*The causes and prevention of crowd disasters*', First International Conference on Engineering for Crowd Safety, London, England, 1993.

n. Still G K, '*Introduction to Crowd Science*', CRC Press, 2014

Chapter S.5 Fire safety management

S.5.1 Safety management during operation activity

1. The correct management of fire safety during operation contributes to the effectiveness of the other fire prevention measures adopted.
2. Fire safety management during operation must include at least:
   a. the reduction of the probability of fire ignition by adopting fire prevention measures, good practices during operation and maintenance planning, as reported in paragraph S.5.5;
   b. the control and maintenance of firefighting systems and equipment, referred to in paragraphs S.5.7.1 and S.5.7.3;
   c. preparation for emergency management, through the planning of actions to be carried out in case of emergency, fire drills and periodic evacuation tests, referred to in paragraphs S.5.7.4 and S.5.7.5.

Note The planning must foresee all of the actions until the activity safety conditions are restored.

S.5.7.1 Checks Register

1. The activity manager must prepare a register of periodic checks where they shall record:
   a. controls, checks, systems, devices and equipment maintenance and other fire prevention measures adopted;
   b. information and training activities, in accordance with the current legislation for work activities;
   c. evacuation drills.
2. This register must be kept constantly updated and available to the control bodies.

S.5.7.2 Plan for maintaining the fire safety level

1. Where required by the identified designed solution, the activity manager must take care of the preparation of a plan aimed at maintaining safety conditions, respecting the prohibitions, limitations and operating conditions.
2. Based on the activity risk assessment and on the design results, the plan must include:
   a. check activities in order to prevent fires in accordance with current regulations;
   b. the planning of information and training activities for the personnel assigned to the structure, including drills on firefighting and use of emergency evacuation means, taking into account the activity risk assessment;
   c. the specific information to the occupants;
   d. the evacuation routes checks in order to guarantee their usability and that of safety signs;
   e. the scheduling of the maintenance of systems, devices, equipment and facilities relevant to fire safety;
   f. the procedures of ordinary and extraordinary maintenance and modifications execution, which must include at least:

g. hazard identification and risk assessment related to modification or maintenance intervention;

Note The evaluation of the risks related to the intervention must also highlight if the modification or maintenance, for the purposes of fire safety, is not relevant, is relevant but without additional risk or with an increase in risk.

i. the safety measures to be implemented;
ii. the responsibilities assignment;
iii. any other necessary actions during the execution phase or after the intervention;

Note The necessary actions may include information or training activities, maintenance plan updates, IRAD updating, FSM documents updating, etc.

h. the programming of periodic revisions referred to in paragraph S.5.7.8

S.5.7.3 *Checks and maintenance of firefighting systems and equipment*

1. The control and maintenance of the firefighting systems and equipment must be carried out in compliance with the laws and regulations in force, in accordance with best practices, following industry standard in accordance with the relevant standards, TS and TR, and the facility's use and maintenance manual and equipment.
2. The manual for use and maintenance of firefighting systems and equipment is prepared in accordance with the applicable regulations or technical regulations and is provided to the activity manager.

Note The definition of *user and maintenance manual of the system* can be found in chapter G.1.

3. The operations of control and maintenance of the systems and the firefighting equipment and their timing are at least those indicated by the relevant standards, TS and TR, as well as by the facility's use and maintenance manual.
4. Maintenance of firefighting systems and equipment is carried out by expert personnel in the field, based on industry standard (best practices), which guarantees the correct execution of the operations carried out.
5. Table 127 indicates the main reference standards for the maintenance and control of firefighting systems and equipment.

Fire protection system or equipment	Standards and TS for verification, control, maintenance
Extinguishers	UNI 9994-1
HS (RI)	UNI 10779, UNI EN 671-3, UNI EN 12845
SPK	UNI EN 12845
FDAS	UNI 11224
SEFC	UNI 9494-3
Differential pressure systems	UNI EN 12101-6
Powder systems	UNI EN 12416-2
Foam systems	UNI EN 13565-2
Water spray systems	UNI CEN/TS 14816
Extinguishing system with condensed aerosol	UNI ISO 15779
Oxygen reduction systems	UNI EN 16750
Fire-resistant doors and windows that open	UNI 11473
Extinguishing systems with gas extinguishing	UNI 11280

Table 120: Standards and TS for verification, control and maintenance of firefighting systems and equipment

S.5.7.4 Emergency preparation

1. The emergency preparation, in the context of fire safety management, is expressed:
   a. by planning the actions to be performed in the event of an emergency, in response to the hypothesised incident scenarios;
   b. in work activities, with the training and periodic instruction of personnel assigned to the implementation of the emergency plan and evacuation drills. The frequency of emergency plan implementation tests must take into account the complexity of the activity and the possible replacement of the personnel employed.
2. The minimum requirements for emergency preparedness are shown in Table 128.
3. The emergency preparation must include floor plans and documents that contain all the information necessary for emergency management, including instructions or procedures for occupant evacuation, indicating in particular measures to assist occupants with specific needs.

   Note For example: indication of tasks and functions in an emergency by setting up a *command and control chain*, destinations of the various areas of the activity, fire compartments, evacuation system, specific risk areas, facility deactivation and activation device security systems, etc.
4. Near the entrances of each activity floor, there must be exhibited:
   a. explanatory plans of the evacuation system and the location of the firefighting equipment;
   b. instructions on the behaviour of the occupants in the event of an emergency.

Performance level	Emergency preparation
I	The emergency preparation can be limited to informing staff and occupants about what to do. It must include: ● instructions for the call for public assistance and the information to be provided to enable effective rescue; ● initial fire prevention instructions, through: ○ actions of the activity manager in relation to rescue teams; ○ actions of any firefighters in relation to firefighting and evacuation, including the use of protective devices and equipment; ○ actions for the safety of equipment and systems; ● instructions for the evacuation of occupants, also by means of suitable signs; ● general instructions for assisting occupants with specific needs; ● specific instructions to assist occupants with specific needs, in the case of non-occasional presence; ● instructions for restoring safety conditions after the emergency.
II, III	Emergency preparation must include emergency management procedures. In particular: ● alarm procedures: alarm mode, information to the occupants, mode of diffusion of the evacuation order; ● activation procedures of the emergency management centre, if required; ● internal communication procedures and to public rescue bodies: the methods and tools of communication between the fire service operators and the emergency management centre must be clearly defined, where provided, identify the methods of call for public rescue and the information to be provided to rescue teams; ● initial fire prevention procedures, which must include the actions of the fire team to extinguish a fire start, to assist occupants in evacuation, to secure the equipment or systems; ● procedures for the evacuation of occupants and the facilitation of the evacuation; ● procedures to assist occupants with reduced or impeded motor, sensory and cognitive abilities or with specific needs; ● procedures for safely setting equipment and systems: depending on the type of system and the nature of the activity, it is necessary to define specific sequences and operations for the safety of the equipment or systems; ● procedures for restoring the safety conditions at the end of the emergency: according to the complexity of the structure, the methods with which to guarantee the safe return of the occupants and the restoring of ordinary processes of activity must be defined.

Table 121: Emergency preparation

S.5.7.5 *Preparation for emergencies in activities characterised by structural promiscuity, facility engineering, and evacuation systems*

1. If activities characterised by structural promiscuity, facility engineering, or escape route systems are exercised by different activity managers, the emergency planning of the individual activities must take into account any interference or relations with neighbouring activities.
2. A planning of site emergency actions must be foreseen in which emergency response procedures are described for the common parts and for any interference between activities for the purposes of fire safety.

S.5.7.6 *Emergency management centre*

1. Where required by the identified design solution, a special *emergency management centre* must be set up for the purpose of coordinating emergency operations, commensurate with the complexity of the activity.

2. If foreseen, the emergency management centre must be set up:
   a. in *small activities* with risk profiles included in A1, A2, A3, B1, B2, B3, C1, C2: in a room for non-exclusive use (e.g. concierge, reception, switchboard, etc.);
   b. in *other activities*: in a special room for exclusive use, constituting a fire compartment, equipped with access from the outside, also via a protected path, signalled.
3. The emergency management centre must be provided with at least:
   a. the information necessary for emergency management (e.g. planning, floor plans, functional diagrams of systems, telephone numbers, etc.);
   b. communication tools with rescue teams, staff and occupants;
   c. control units of the active protection systems or repetition of the alarm signals.
4. The emergency management centre must be clearly identified by appropriate safety signs.

S.5.7.7 *FSM (GSA) management unit*

1. The FSM (GSA) management unit monitors, revises the proposal and coordinates the emergency FSM (GSA).
2. The FSM (GSA) management unit in operation:
   a. implements the management of fire safety through the preparation of management and operating procedures and all the documents of the FSM (GSA);
   b. provides directly or through the procedures prepared for the detection of system non-conformities and fire safety, reporting them to the activity manager;
   c. updates the FSM (GSA) documentation in case of changes.
3. The coordinator of the FSM (GSA) management unit, or their substitute, in an emergency:
   a. takes measures, in the event of a serious and immediate danger, including interruption of activities, until the safety conditions are restored;
   b. coordinates the emergency management centre.

S.5.7.8 *Periodic review*

1. The FSM (GSA) documents must be subject to periodic revision at established intervals and, in any case, they must be updated when the activity changes.

Note For example, due to significant changes for the purposes of fire safety, organisational changes, changes in the persons assigned to the functions indicated in Tables 122, 123 and 124, …

S.5.2 Emergency safety management

1. Fire safety management during an *emergency* in the activity must include at least:
    a. in case of work activities: activation and implementation of the emergency plan, referred to in paragraph S.5.7.4;
    b. if it is not a working activity: activation of public rescue services, evacuation of occupants, safety of equipment and facilities;
    c. if required, activation of the emergency management centre pursuant to the indications of paragraph S.5.7.6 or of the FSM (GSA) management unit referred to in paragraph S.5.7.7.
2. The manual or automatic fire detection is generally followed by:
    a. the immediate activation of emergency procedures;
    b. in more complex activities, the verification of the actual presence of a fire and the subsequent activation of emergency procedures.
3. In work activities, the continuous presence of fire service personnel must be ensured so that emergency actions can be implemented at any time.

S.5.3 References

1. The following references are provided:
    a. UNI, INAIL, '*Linee guida per un sistema di gestione di sicurezza e salute sui luoghi di lavoro (SGSSL) (Guidelines for a workplace safety and health management system) (SGSSL)*', 2011, from http://sicurezzasullavoro.inail.it/;
    b. BS OHSAS 18001 and Guidelines BS OHSAS 18002 for *'Valutazione della Salute e Sicurezza sul lavoro (Occupational Health and Safety Assessment Series, OHSAS)'*;
    c. UNI ISO 45001 '*Sistemi di gestione per la salute e sicurezza sul lavoro – Requisiti e guida per l'uso (Occupational health and safety management systems – Requirements and use guidance)*';
    d. European guideline CFPA-E No 1:2014 F'*Fire protection management system*'.

Chapter S.6 Fire control

S.6.1 Preface

1. The purpose of this fire prevention measure is to identify the firefighting devices to be installed in the activity for:
   a. protection against a *fire start*;
   b. manual or automatic protection, aimed at *inhibiting* or *controlling* the fire;
   c. protection through complete *extinction* of a fire.
2. The firefighting devices considered are fire extinguishers and the following active fire protection systems, hereinafter referred to as *systems* (*installations)*: the hydrant network, manual or automatic inhibition control or extinction systems, using water and other extinguishing agents.

S.6.2 Performance levels

1. Table 129 shows the performance levels attributable to the *settings* (*areas)* of activity for the present fire protection measure.

Performance level	Description
I	No requirement
II	Extinction of a fire start
III	Manual fire control or extinction
IV	Inhibition, control or extinction of the fire with automatic systems extended to portions of activity
V	Inhibition, control or extinction of the fire with automatic systems extended to the whole activity

Table 122: Performance levels

S.6.3 Assignment criteria for performance levels

1. Table 130 shows the *generally accepted* criteria in assigning individual performance levels.

Performance level	Assignment criteria
I	Not allowed in the activities subject to fire regulation
II	Settings (Areas) where *all* of the following conditions are met: ● risk profiles: ○ R_{life} included in A1, A2, B1, B2, Cii1, Cii2, Ciii1, Ciii2; ○ R_{prot} equal to 1, 2; ○ R_{env} not significant; ● all the activity floors located at a height between -5 m and 32 m; ● specific fire load $q_f \leq 600$ MJ/m^2; ● for compartments with $q_f > 200$ MJ/m^2: gross area of ≤ 4000 m^2; ● for compartments with $q_f \leq 200$ MJ/m^2: any gross area; ● no hazardous substances or mixtures are held or handled in significant quantities; ● no hazardous work for the purposes of fire is carried out.
III	Settings (Areas) not included in the other assignment criteria.
IV	In relation to the results of the risk assessment in the setting and in neighbouring settings (areas) of the same activity (e.g. settings of activity with high crowding, settings of activity with complex geometry or underground floors, high specific fire load q_f, presence of substances or mixtures hazardous in significant quantities, presence of hazardous processing for the purposes of fire, etc.).
V	On specific request of the client, foreseen by technical project specifications, requested by the competent authority for constructions destined to particularly important activities, foreseen by the vertical technical rule.

Table 123: Assignment criteria for performance levels

S.6.4 Design solutions

1. This fire protection measure is designed as follows:
   a. in relation to the results of the risk assessment, the extinguishing agents are selected pursuant to the indications of paragraph S..6.5;
   b. the protection of the entire activity or of its settings (areas) is dimensioned with one or more approaches referred to in paragraphs S.6.6, S.6.7, S.6.8 and S.6.9.
2. The indications of paragraphs S.6.10 and S.6.11 must be respected concerning complementary indications and signs.

S.6.4.1 Deemed-to-satisfy solutions for performance level II

1. Fire extinguishers must be installed to protect the *entire activity*, pursuant to the indications of paragraph S.6.6 and, in case, S.6.7.

S.6.4.2 Deemed-to-satisfy solutions for performance level III

1. The requirements of performance level II must be fulfilled.
2. A *hydrant network* (HS/RI) must be installed to protect the *entire activity* or *individual compartments* in relation to the results of the risk assessment, pursuant to the indications of paragraph S.6.8.

S.6.4.3 Deemed-to-satisfy solutions for performance level V

1. The requirements of performance level III must be fulfilled.
2. An automatic system to inhibit, control or extinguish the fire must be provided to protect *settings* (*areas) of activity* in relation to the results of the risk assessment, pursuant to the indications of paragraph S.6.8 for sprinkler systems or other types of installations.

S.6.4.4 Deemed-to-satisfy solutions for performance level V

1. The requirements of performance level IV must be fulfilled.
2. The automatic system of inhibition, control or extinction of the fire must be extended to protect the *entire activity.*

S.6.4.5 *Alternative solutions*

1. *Alternative solutions* are allowed for all of the performance levels.
2. In order to demonstrate the achievement of the *performance level*, the designer shall use one of the methods of paragraph G.2.7.
3. Table 131 shows some *generally accepted* procedures for designing alternative solutions. However, the designer may use methods other than those listed.

Objective of the solution	Design method
Hydrant networks (§ S.6.8)	Describe how the fires, specific to the setting (area) considered, can be controlled manually, using other system solutions or other operating procedures.
Automatic systems for inhibiting, controlling or extinguishing the fire (§ S.6.9)	Describe how the fires, specific to the setting (area) considered, can be automatically inhibited, controlled or extinguished, using other system solutions or other operating procedures. For example, if a configuration is not provided for by the UNI EN 12845 standard, the designer can use the NFPA 13.

Table 124: Design methods for alternative solutions

S.6.5 Classification of fires and of extinguishing agents

1. For the purposes of selecting the extinguishing agents, the fires are classified as indicated in Table 132. This classification is defined according to the nature of the fuel and does not provide for a particular class of fires in the presence of a risk due to electricity.
2. Table 132 also shows some fire extinguishers suitable for each fire class.
3. The fire classes extinguishable by the devices are always indicated with appropriate *pictograms* defined by industry standard (best practices).
4. In case of fires involving live electrical systems or equipment, the choice of extinguishing agents or means of combating fire must be carried out following an assessment of the risk of electrocution to which the user may be subjected during extinction operations. The possibility of using manual means of firefighting on live electrical equipment, including operating limits, must be clearly indicated on the labelling of the identified manual means.

Fire class	Description	Extinguishing
A	Fires of solid materials, usually of an organic nature, which lead to the formation of embers	Water, water with class A additives, foam and powder are the most commonly used extinguishing substances for such fires.
B	Fires of liquid or solid materials that can be liquefied	For these types of fires the most commonly used extinguishers consist of water with additives for class B, foam, powder and carbon dioxide.
C	Gas fires	The main intervention against such fires is to block the gas flow by closing the interception valve or by blocking the leak. In this regard, reference is made to the fact that there is a risk of explosion if a gas fire is extinguished before intercepting the gas flow.
D	Metal fires	None of the extinguishing agents normally used for classes A and B fires is suitable for fires of burning metal substances (aluminium, magnesium, potassium, sodium). In these conditions, it is necessary to use special powders and work with specifically trained personnel.
F	Fires involving cooking media (vegetable or animal oils and fats) in cooking appliances	Extinguishers for class F fires extinguish mainly by chemical action by acting on the intermediate products of the combustion of vegetable or animal oils. The extinguishers suitable for class F have successfully passed the dielectric test. The use of powder extinguishers and carbon dioxide fire extinguishers against class F fires is considered hazardous.

Table 125: Classes of fires pursuant to European standard EN 2 and extinguishing agents

S.6.6 Fire extinguishers

S.6.6.1 Characteristics

1. The fire extinguisher is a basic aid complementary to other measures of active protection and safety in case of fire.
2. The extinguishing capacity of a fire extinguisher, determined experimentally, indicates its conventional fire performance.
3. The use of a fire extinguisher is referable only to a fire start and the extent of the extinguishing capacity associated with it provides a comparative degree of simplicity in extinction operations.
4. Further aspects that distinguish the extinguishers useful for risk assessment are: the weight or capacity, connected to the extinguishing charge, the dielectricity of the jet, connected to the nature of the extinguishing agent. Information on the common unwanted characteristics of the jet, such as toxicity, residues and hazardous temperatures, completes the necessary framework for identifying the most appropriate extinguisher.
5. Fire extinguishers may not be charged to more than 6 kg or 6 litres; fire extinguishers with higher charges can only be used in areas intended for process activities that are not accessible to the public unless permanently accompanied.
6. Fire extinguishers suitable for polar solvents carry the expression '*also suitable for use on polar solvents*', on the label, immediately below the pictograms representing the types of fire.

   Note For example, acetone is a polar solvent.

7. Powder fire extinguishers and carbon dioxide (CO_2) fire extinguishers are considered suitable for intervention on polar solvents.

S.6.6.2 Design

1. The type of fire extinguishers installed must be selected based on the risk assessment and, in particular:
   a. with reference to the fire classes in Table 132 (e.g. fire extinguishers for class A, multi-purpose fire extinguishers for classes AB, fire extinguishers for class F, etc.);
   b. taking into account the effects caused on the occupants by the supply of the extinguishing agent and, if required, also the effects caused on the protected goods (for example electromedical equipment, electronic devices, old books or works of art, protected assets, etc.).
   c. in enclosed areas, against the starts of class A or class B fire, water-based fire extinguishers (water fire extinguishers) should be used.

   Note The use of powder extinguishers in enclosed spaces generally causes a sudden reduction in visibility which could compromise the orientation of the occupants during the emergency evacuation or other safety operations; furthermore the powder could cause irritation to the skin and mucous membranes of the occupants.

2. Fire extinguishers must always be available for immediate use, therefore they must be located:

a. in an easily visible and reachable position, along the evacuation routes near the exits of the rooms, floor or end,

b. near specific risk areas.

3. To allow all occupants to use fire extinguishers to respond immediately to a fire start, the handles of the manual devices should be placed at a height of about 110 cm from the floor.

4. Fire extinguishers that require special skills for their use must be signalled so that they can only be used by specifically trained personnel.

Note For example: class D fire extinguishers, wheeled fire extinguishers, etc.

5. Where it is necessary to install effective fire extinguishers for several fire classes, it is preferable to use multi-purpose fire extinguishers; it is recommended to minimise the number of different types of fire extinguishers, respecting the maximum distances to be covered.

Note For example, in the case where there is no possibility of using multi-purpose fire extinguishers.

6. In the protected areas with an automatic system of inhibition, control or extinction of the fire in which only occasional and short-term presence of assigned personnel is foreseen (e.g. automated warehouses, etc.), it is necessary to provide fire extinguishers exclusively near the accesses to these settings (areas).

S.6.6.2.1 Class A fire extinguishers

1. The number, the extinguishing capacity and the position of the class A fire extinguishers are determined in compliance with the provisions indicated in the following points.

2. The protection with class A fire extinguishers must be extended to the entire activity.

3. In each floor, lof) or compartment, depending on the risk profile of reference R_{life}, a number of class A fire extinguishers must be installed in compliance with the maximum achievement distance indicated in Table 133.

4. At least one class A fire extinguisher must be installed for floor, loft or compartment.

R_{life} risk profile	Max achievement distance	Minimum extinguishing capacity	Minimum nominal charge
A1, A2	40 m	13 A	6 litres or 6 kg
A3, B1, B2, C1, C2, D1, D2, E1, E2	30 m	21 A	
A4, B3, C3, E3	20 m	27 A	

Table 126: Criteria for the installation of class A fire extinguishers

S.6.6.2.2 Class B fire extinguishers

1. The number, the extinguishing capacity and the position of the class B fire extinguishers are determined in compliance with the provisions indicated in the following points.

2. Protection with class B fire extinguishers can be limited to the compartments where this type of risk is present.

3. The extinguishing capacity and the number of class B fire extinguishers is determined according to the quantity of flammable liquids stored or being processed in each floor, loft or compartment as indicated in Table 133.
4. Fire extinguishers must be properly positioned at a distance ≤ 15 m from the sources of risk.
5. Where a high extinguishing capacity is required, wheeled fire extinguishers can also be used as described in paragraph S.6.7.
6. In the case of floors, lofts or compartments in which there are no flammable liquids stored or used in processing, but where it is possible to foresee a class B fire start due to liquefied solids (e.g. wax, paraffin, liquefiable plastic material, etc.), the fire extinguishers installed for the class A fire start according to Table 133 must each also have an extinguishing capacity not less than class 89 B.

Note The plastic materials that form burning embers are classified as class A fires

Amount of flammable liquid stored or in process L	Minimum extinguishing capacity	Number of fire extinguishers	Minimum nominal charge
L ≤ 50 litres	70 B	1	4 kg or 3 litres, 5 kg if CO2
50 < L ≤ 100 litres	89 B	2	
100 < L ≤ 200 litres	113 B	3	6 kg or 6 litres
	144 B	2	
L ≥ 200 litres	233 B	≥ 3 [1]	
[1] The number must be determined based on the risk assessment, taking into account the quantity and type of flammable liquid stored or being processed, the geometry of the containers and the exposed surface; in these circumstances it is preferable to also include the installation of wheeled fire extinguishers.			

Table 127: Criterion for the installation of class B fire extinguishers

S.6.6.2.3 Class F Fire extinguishers

1. Class F fire extinguishers must be installed in the settings (areas) of activity in compliance with the minimum requirements set out in Table 135.

Note For the protection of cooking appliances, reference can also be made to the UNI 11198 standard ‘*Extinguishing systems that use liquid fire extinguishing agents for fire protection in catering kitchens – Physical properties, installation design and test methods – General requirements*‘.

2. Class F fire extinguishers must be installed near the protected cooking surface.

Fire extinguishers to install	Protected cooking surface [1]
No 1 fire extinguisher 5 F	0.05 m^2
No 1 fire extinguisher 25 F	0.11 m^2
No 1 fire extinguisher 40 F	0.18 m^2
No 2 fire extinguishers 25 F	0.30 m^2
No 1 fire extinguisher 75 F	0.33 m^2
No 1 fire extinguisher 25 F, No 1 fire extinguisher 40 F	0.39 m^2
No 2 fire extinguishers 40 F	0.49 m^2
No 1 fire extinguisher 5 F, No 1 fire extinguisher 75 F	0.51 m^2
No 1 fire extinguisher 25 F, No 1 fire extinguisher 75 F	0.60 m^2
No 1 fire extinguisher 40 F, No 1 fire extinguisher 75 F	0.69 m^2
No 2 fire extinguishers 75 F	0.90 m^2
[1] Gross area in plan of the only areas of cooking equipment containing vegetable or animal oils	

Table 128: Fire extinguisher requirements for fire class F

S.6.6.2.4 Fire extinguishers for other fires or for specific risks

1. Fire extinguishers for other fires or specific risks must be installed in the activity based on the fire risk assessment and in compliance with the minimum requirements set out in Table 136.

Fire class or other risks	Minimum requirements
Class C	None, since the safe extinguishing of a class C fire by non-specifically trained occupants is done by closing the interception valve available in the vicinity.
Class D	Extinguishers suitable for working on class D fires, suitable for the intended use [1] to be installed near the source of risk.
Live electrical installations and equipment	Suitable extinguishers to be installed to work on live electrical systems and equipment near the source of risk, suitable for the intended use [2].
Polar solvents	Extinguishers suitable for operating on polar solvents suitable for the intended use to be installed near the source of risk.
[1] Class D fire extinguishers are not suitable for other fire classes. [2] Portable fire extinguishers deemed-to-satisfywith the EN 3-7 standard with extinguishing agent without electrical conductivity (e.g. powder, carbon dioxide, etc.) are suitable for use on electrical systems and equipment up to 1 000 V and at a distance of 1 m. Water-based fire extinguishers deemed-to-satisfywith the EN 3-7 standard must pass the dielectric test in order to be used on electrical systems and equipment up to 1 000 V and at a distance of 1 m.	

Table 129: Fire extinguisher requirements for other fires or specific risks

S.6.7 Wheeled fire extinguishers

1. Wheeled fire extinguishers can be used in large areas, without obstructions to movement, in the absence of steps and without bound paths. Generally, the wheeled fire extinguishers are used in settings (areas) where it is necessary to face fire starts due to class B fires (e.g. refineries, warehouses or mineral oil processing plants, etc.).
2. In the activity equipped with a wheeled fire extinguisher, there must be at least two firefighting operators trained in its use.
3. The extinguishing capacity for class B fires of wheeled fire extinguishers is shown:
   a. in Table 137 with reference to the classification index pursuant to UNI 9492:1989;
   b. in Table 138 with reference to the types of fire, pursuant to the UNI EN 1866-1 standard.

Classification index	Extinguishing capacity for class B	Classification index	Extinguishing capacity for class B
10	55 B	5	144 B
9	55 B	4	233 B
8	89 B	3	233 B
7	89 B	2	233 B
6	144 B	1	233 B

Table 130: Classification index and extinguishing capacity for wheeled fire extinguishers

Type	Number of 233 B fires	Number of 21 B fires
I B	1	1
II B	1	2
III B	1	3
IV B	1	4

Table 131: Types of fires and extinguishing capacity for wheeled fire extinguishers

S.6.8 Hydrant networks

S.6.8.1 Characteristics

1. The *hydrant network* (HN) consists of a piping system for the water supply of one or more dispensing devices. The HNs are divided into:

   a. ordinary HN destined for the protection of activities located within construction works;

   b. outdoor HN for the protection of outdoor activities.

2. HNs include the following main components: water supply; network of fixed pipes, preferably closed in a ring, for exclusive use; delivery connections for a fire engine; valves; dispensing devices.

3. HNs shall not be installed in areas where contact with water could present a danger or present contraindications.

4. In the event that HN is used together with other active fire protection systems (e.g. sprinklers, etc.) the correct functioning (e.g. contemporaneity, etc.) of all existing protection systems must be guaranteed.

S.6.8.2 Design

1. The HN designed, installed and operated pursuant to the UNI 10779 standard is considered a deemed-to-satisfy solution.
2. The hazard levels, the types of protection (internal protection or external protection) and the characteristics of the HN water supply are established by the designer based on the fire risk assessment.

   Note For example, external protection could be foreseen in activities with significant R_{env}, or with $q_f \geq 1\ 800$ MJ/m^2, in compartments with surfaces greater than 4 000 m^2 not protected by an automatic fire control system.

   Note For example, the higher water supply could be provided if the level of danger pursuant to the UNI 10779 standard is 3, or when external protection is provided.

3. For the internal protection of *civil activities* (e.g. health facilities, schools, hotels, etc.) it is preferable to install hose reels, while for *other activities* it is preferable to install wall hydrants.

4. If foreseen, subject to evaluation by the competent Fire service Command, the external protection can be replaced by the public network if it can also be used for the firefighting service, provided that it is respondent to the following indications:

   a. hydrants to be placed in the immediate vicinity of the activity itself; a path that is always usable up to a maximum of 100 m between a hydrant of the public network and the boundary of the activity is considered acceptable;

   b. the network is able to provide the total flow rate foreseen for the specified external protection; this performance must be certified by the designer using data provided by the provider or by practical delivery tests.

5. In activities with hazard level 3, evaluated pursuant to the UNI 10779 standard, for which no external protection is foreseen by the designer, at least performance level III of the *firefighting operational* measure must be guaranteed (chapter S.9).

6. In the protected settings (areas) with an automatic system of inhibition, control or extinction of the fire in which only the occasional and short-term presence of assigned personnel is foreseen (e.g. automated warehouses, etc.) it is not necessary to foresee the HN.
7. For the purpose of determining the continuity of the water supply to the aqueduct system (town main), availability can be attested by means of statistical data relating to previous years as specified by the UNI 10779 standard or equivalent criterion. The aforementioned certificates are issued by the supplying agencies or by a fire prevention professional.

S.6.9 Automatic systems for inhibiting, controlling or extinguishing the fire

S.6.9.1 *General characteristics*

1. Among the automatic systems for controlling or extinguishing the fire are included those that base their operation on extinguishing agents of the gaseous type, aerosol, powder, foam or atomised or fractionated water, deluge.

   Automatic systems to inhibit fire include depleted (reduced concentration) oxygen systems.
2. When choosing the types of systems, any incompatibility of the extinguishing agents with the material present in the activity must be taken into account, as well as the effects of the discharge of the extinguishing agent on any occupant in case present.

S.6.9.1.1 Characteristics of sprinkler systems

1. The *sprinkler systems* (SPK) are automatic fire extinguishing systems capable of delivering water according to appropriate configurations. They are designed to detect the presence of a fire and extinguish it in the initial stage, or to keep the fire under control so that extinction can be completed by other means.
2. SPKs include the following main components: water supply; fixed, main and terminal piping network; control and alarm station; valves; sprinkler dispensers (sprinkler heads).

   Note For example, for SPK serving settings (areas) of activity classified as OH3, HHS or HHP pursuant to the UNI EN 12845 standard, it is advisable to use the single superior water supply.
3. Sprinkler dispensers (sprinkler heads) operate at predetermined temperatures to dispense water over the affected parts of the underlying area. Their intervention temperature is generally selected so that it adapts to the ordinary temperature conditions of the installation environment, thus ensuring their activation only near the fire.
4. SPKs shall not be installed in areas where contact with water could be hazardous or present contraindications.
5. The presence of a SPK does not exclude the possible need for other means or systems to control or extinguish fires. In the case of the simultaneous presence of a SPK and different protection systems (e.g. HN, smoke and heat control systems, etc.) the correct functioning of all protection systems must be guaranteed, avoiding interference both in the activation of the installation and that of control or extinction of the fire.

S.6.9.2 Design

1. The choice of the type of automatic inhibition, control or extinction system, in relation to the extinguishing agent, effectiveness of the protection and safety of the occupants, must be made on the basis of the fire risk assessment of the activity.
2. For the purposes of defining deemed-to-satisfy solutions for the design of fire inhibition, control or extinction systems, the standards listed in Table 139 apply.
3. When desiging the system, any possible danger to the occupants due to the discharge of extinguishing agents must be taken into consideration.

Note Unnecessary occupant exposure to system extinguishing agents shall be avoided. The required safety precautions must not also cover the toxicological or physiological effects associated with the products of combustion caused by the fire.

4. Interactions and interferences between active protection systems (e.g. SPK, smoke and heat control systems, etc.) must always be verified.
5. If there is an FDAS, the communication function must be provided to indicate the status of the automatic system of inhibition, control or extinction of the fire.

Note The active protection automatic systems must communicate to the FDAS the status of any anomalies, the possible activation in the event of a fire and all the information necessary to know the state of the installation. Some automatic systems, for their activation in case of fire, must be controlled by an FDAS (e.g. deluge systems, etc.).

6. If there is no FDAS, to report the status of the automatic system of inhibition, control or extinction of the fire, measures must be provided for the purpose of emergency management (e.g. diffusion of alarms to the occupants, verification procedures by the emergency management staff, etc.).

Type	Reference	Inhibition, control or extinction system
Technical regulations	UNI EN 12845	Sprinkler systems
Technical regulations	UNI EN 15004-1	Gaseous extinguishing systems
Technical regulations	UNI EN 12416-2	Powder systems
Technical regulations	UNI EN 13565-2	Foam systems
TS	UNI CEN/TS 14816	Water spray systems
TS	UNI CEN/TS 14972	Water mist systems
TS	UNI/TS 11512	Components for gas extinguishing systems – Requirements and test methods for compatibility
Technical regulations	UNI ISO 15779	Extinguishing system with condensed aerosol
Technical regulations	UNI EN 16750	Oxygen Reduction Systems – Design, installation, planning and maintenance

Table 132: Main standards, TS and TR of reference for fire inhibition, control or extinction systems

S.6.10 Additional information

1. Fire extinguishers must comply with the regulations in force and be maintained in a proper manner following industry standard in accordance with the provisions of the specific regulations, good technical standards and the instructions provided by the manufacturer.

S.6.11 Signage

1. Firefighting devices must be indicated by safety signs UNI EN ISO 7010.

S.6.12 References

1. The following references are provided:

a. UNI EN 2 '*Classification of fires*';

b. UNI EN 3-7 '*Portable fire extinguishers – Part 7: Characteristics, performance requirements and test methods*';

c. UNI EN 1866-1 '*Wheeled fire extinguishers – Part 1: Characteristics, performance and test methods*';

d. ISO/TS 11602-1 '*Fire protection – Portable and wheeled fire extinguishers – Part 1: Selection and installation*';

e. BS 5306-8 '*Fire extinguishing installations and equipment on premises. Selection and positioning of portable fire extinguishers. Code of practice*';

f. EUROFEU technical paper '*Portable fire extinguisher section fire protection guideline for the selection and installation of portable and mobile fire extinguishers*', https://eurofeu.org/24/publications/technical-paper/;

g. BS 5306-0 '*Fire protection installations and equipment on premises. Guide for selection of installed systems and other fire equipment*';

h. Australian Standard AS 2444 '*Portable fire extinguishers and fire blankets Selection and location*';

i. International Fire Code, 2018 edition, Chapter 9 '*Fire Protection and Life Safety Systems;*

j. '*The SFPE Handbook of fire protection engineering*', 5th edition, SFPE/NFPA, 2016:

   i. Chapter 42 '*Automatic Sprinkler System Calculations*',

   ii. Chapter 44 '*Clean Agent Total Flooding Fire Extinguishing Systems*',

   iii. Chapter 45 '*Carbon Dioxide Systems*',

   iv. Chapter 46 '*Water Mist Fire Suppression Systems Foam*',

   v. Chapter 47 '*Agents and AFFF System Design Considerations*';

k. NFPA 101, Life Safety Code, 2018 Edition, Chapter 9 '*Building Service and Fire Protection Equipment'*;

l. VdS 2815en : 2001-03 (01) *'Interaction of water extinguishing systems and smoke and heat extractors'*.

Chapter S.7 Fire detection and alarm

S.7.1 Preface

1. The *fire detection and alarm systems* (FDAS) are made with the aim of monitoring the settings (areas) of an activity, detecting a fire early and spreading the alarm in order to:

   a. activate protective measures (e.g. automatic inhibition, control or extinction systems, re-compartmentalisation, smoke and heat evacuation, control or shutdown of technological service and process systems, etc.);

   b. activate the management measures (e.g. emergency and evacuation plan and procedures, etc.) designed and programmed in relation to the fire detected and the setting (area) where this fire start has developed with respect to the entire supervised activity.

S.7.2 Performance levels

1. Table 140 shows the performance levels attributable to the *settings* (*areas)* of activity for the present fire protection measure.

Performance level	Description
I	Detection and diffusion of the fire alarm by monitoring the settings (areas) by the occupants of the activity.
II	Manual detection of the fire by monitoring the settings (areas) by the occupants of the activity and consequent diffusion of the alarm.
III	Automatic detection of the fire and diffusion of the alarm by monitoring settings (areas) of the activity.
IV	Automatic detection of the fire and diffusion of the alarm by monitoring the entire activity.

Table 133: Performance levels

S.7.3 Assignment criteria to performance levels

1. Table 141 shows the *generally accepted* criteria in assigning individual performance levels.

Performance level	Assignment criteria
I	Settings (Areas of activity) where *all* of the following conditions are met: ● risk profiles: ○ R_{life} included in A1, A2; ○ R_{prop} equal to 1; ○ R_{env} not significant; ● activity not open to the public; ● crowd density ≤ 0.2 people/m²; ● not predominantly intended for occupants with disabilities; ● all the activity floors located at a height between -5 m and 12 m; ● specific fire load $q_f \leq 600$ MJ/m²; ● gross area of each compartment ≤ 4 000 m²; ● no hazardous substances or mixtures are held or handled in significant quantities; ● no hazardous work for the purposes of fire is carried out.
II	Settings (Areas of activity) where *all* of the following conditions are met: ● risk profiles: ○ R_{life} included in A1, A2, B1, B2; ○ R_{prop} equal to 1; ○ R_{env} not significant; ● crowd density ≤ 0.7 people/m²; ● all the activity floors located at a height between -10 m and 54 m; ● specific fire load $q_f \leq 600$ MJ/m²; ● no hazardous substances or mixtures are held or handled in significant quantities; ● no hazardous work for the purposes of fire is carried out.
III	Settings (Areas) not included in the other assignment criteria.
IV	In relation to the results of the risk assessment in the setting and in neighbouring settings (areas) of the same activity (e.g. settings or activities with high crowding, settings or activities with complex geometry or underground floors, high specific fire load q_f, presence of substances or mixtures hazardous in significant quantities, presence of hazardous processes for the purposes of the fire, presence of significant ignition sources, etc.).

Table 134: Assignment criteria to performance levels

S.7.4 Design solutions

1. This fire prevention measure leads to the identification and design of the most suitable systems for fire detection in the monitored settings (areas) and the subsequent spread of the fire alarm to the activity.
2. If the FDAS is used exclusively for the purpose of safeguarding property in settings (areas) characterised by the occasional and short-term presence of assigned personnel, the provisions of Table 142 dedicated exclusively to the protection of the occupants (e.g. EVAC system, etc.) may be omitted.
3. The indications in paragraph S.7.7 regarding signage must be respected.
4. For compartments with R_{life} included in Ci1, Ci2, Ci3, taking into account the greater familiarity of the occupants with the activity and the specific fire risk, the FDAS installation can be omitted and *autonomous smoke detectors with acoustic warning* can be used pursuant to the UNI EN 14604 standard, installed and operated pursuant to the UNI 11497 standard.

Note The *autonomous smoke detectors with acoustic warning* are not considered FDAS.

S.7.4.1 *Deemed-to-satisfy solutions for performance level I*

1. For the detection and diffusion of the fire alarm assigned to surveillance by the occupants, suitable procedures must be codified aimed at the rapid and safe warning of the occupants in case of fire, in the emergency procedures provided for in chapter S.5.
2. The additional requirements indicated in Table 142 must also be met, where relevant, according to a fire risk assessment.

S.7.4.2 *Deemed-to-satisfy solutions for performance level II*

1. A FDAS designed pursuant to the indications of paragraph S.7.5, implementing the main function D (*manual fire signalling by the occupants*) and the main function C (*fire alarm)* extended to the whole activity, must be installed.
2. The additional requirements indicated in Table 142 must also be met, where relevant, according to the fire risk assessment.

S.7.4.3 *Deemed-to-satisfy solutions for performance level III*

1. The requirements of performance level II must be fulfilled.
2. The main function A (*automatic fire detection*) extended to portions of the activity, must be implemented.
3. If property protection is required (e.g. protected assets, *business continuity*, etc.), those areas where the fire could compromise the production of the assets or services of the activity must also be monitored.
4. Following the results of the risk assessment, referring to the secondary functions indicated in Table 145, the following may be foreseen:
   a. automatic start-up of active protection systems, including compartmentalisation restoration systems (e.g. closing fire dampers, fire doors release, etc.);
   b. the control or shutdown of technological, service or processing plants not intended to operate in the event of a fire.

5. The additional requirements indicated in Table 142 must also be met, where relevant, according to the fire risk assessment.

S.7.4.4 *Deemed-to-satisfy solutions for performance level V*

1. The requirements of performance level III must be fulfilled.
2. The main function A (*automatic fire detection*) must be extended to the whole activity.
3. Secondary functions must be provided to allow:
    a. the control and automatic start-up of active protection systems, including the systems for closing the gates in the compartmentalisation (e.g. closing of fire dampers, release of fire doors, etc.);
    b. the control and the shutdown of technological, service or processing plants not intended to operate in the event of a fire.
4. Following the results of the risk assessment, in activities with high crowding or complex geometries the installation of an EVAC system may be foreseen pursuant to the indications of paragraph S.7.6.
5. The additional requirements indicated in Table 142 must also be met, where relevant, according to the fire risk assessment.

Performance level	Supervised areas	Minimum FDSA functions		Evacuation and alarm functions	Facility functions [1]
		Main functions	Secondary functions		
I	-	[2]		[3]	[4]
II	-	B, D, L, C	-	[9]	[4]
III	[12]	A, B, D, L, C	E, F [5], G, H, N [6]	[9]	[4] or [11]
IV	All	A, B, D, L, C	E, F [5], G, H, M [7], N, O [8]	[9] or [10]	[11]

[1] Functions for starting active protection and stopping or controlling other installations or systems.
[2] No functions are foreseen, the detection and the alarm are delegated to the occupants.
[3] The alarm is transmitted via conventional signals coded in emergency procedures (e.g. by voice, bell sound, lighting of light signals, etc.) that can be perceived by the occupants.
[4] Demand operational procedures in emergency planning.
[5] E and F functions provided only when it is necessary to transmit and receive the fire alarm.
[6] Unexpected G, H and N functions where the start-up of active protection systems and control or shutdown of other systems is referred to operational procedures in emergency planning.
[7] Function M provided only if the installation of an EVAC is required.
[8] Function O provided only in activities where home automation applications are foreseen (*building automation*).
[9] With visual and sound diffusion devices or other devices adapted to the perceptive capacities of the occupants and to the environmental conditions (e.g. optical warning signal, vibrating, etc.).
[10] For high crowd, complex geometries, an EVAC system can be provided pursuant to the UNI ISO 7240-19 standard.
[11] Automatically on command of the control unit or through autonomous control units (controlled by the master control unit), it requires the secondary functions E, F, G, H and N of EN 54-1.
[12] Common spaces, evacuation routes (also part of a common evacuation system) and neighbouring spaces, compartments with R_{life} risk profiles in Cii1, Cii2, Cii3, Ciii1, Ciii2, Ciii3, D1 and D2, areas of assets to be protected, specific risk areas.

Table 135: Conforming solutions for fire detection and alarm

S.7.4.5 *Alternative solutions*

1. *Alternative solutions* are allowed for all of the performance levels.
2. In order to demonstrate the achievement of the *performance level*, the designer shall use one of the methods of paragraph G.2.7.
3. Table 143 shows some *generally accepted* procedures) for designing alternative solutions. However, the designer may use methods other than those listed.

Objective of the solution	Design method
FDAS function A (§ S.7.5)	Describe how the given setting (area) can be monitored, using other automatic systems (e.g. video surveillance, etc.) or by the occupants themselves, specifically trained, present with continuity in the same context.
FDAS function C (§ S.7.5)	Describe how in the given setting (area) existing systems or management procedures for the diffusion of the alarm in a reliable and continuous way can be effectively used.
FDAS function D (§ S.7.5)	Describe how in the given setting (area) existing systems or management procedures for the manual signalling of fire can be effectively used in a reliable and continuous way.
FDAS function M (§ S.7.5), EVAC (§ S.7.6)	Describe how in the given setting (area) existing systems or management procedures for the diffusion of the vocal alarm in a reliable and continuous way can be effectively used.

Table 136: Design methods for alternative solutions

S.7.5 Fire detection and alarm systems

1. The *fire detection and alarm systems* (FDAS) designed and installed pursuant to the UNI 9795 standard are considered compliant. The deemed-to-satisfy solutions are described in relation to the main and secondary functions described in the UNI EN 54-1 standard and shown in Tables 144 and 145.

2. For the correct design, installation and operation of an FDAS, the *verification of the compatibility* and the *correct interconnection of the components,*, including the specific operating sequence of the functions to be performed, must be provided, in compliance with current regulations and the standards adopted by the national standardisation body. The components of the FDAS verified pursuant to the UNI EN 54-13 standard are considered compliant.

3. To allow all occupants, even those using movement aids, to send the fire alarm, the manual buttons of function D should be placed at a height of about 110 cm from the floor.

Note If the manual fire alarm buttons are not adapted to the specific needs of the occupants, it is also possible to use gripper systems (e.g. rope switches hanging from the ceiling or walls, etc.).

4. The communication of the alarm with the main function C must be conveyed through *multisensory* modalities that is perceivable by the various senses (at least two), depending on the condition of the occupants to which it is directed, in order to obtain a collaborative participation appropriate to the emergency situation.

Note To adapt to the needs of the occupants, different devices can be used, such as visual panels, new-generation pagers (e.g. *Wi-Fi paging systems*, …), vibrating devices (e.g. interconnected alarm clocks on workstations, individual smartphone vibrations or signal sounds within specifically selected frequency bands, etc.).

5. The *pre-alarm* beeps, where required by the FSM, and the *fire alarm* beeps of the main C function should have characteristics that comply with the UNI 11744 standard.

A, Automatic fire detection
B, Control and signalling function
D, Manual signalling function
L, Power function
C, Fire alarm function

Table 137: Main functions of FDAS pursuant to EN 54-1 and UNI 9795

E, Fire alarm transmission function
F, Fire alarm reception function
G, System control function or fire protection equipment
H, System or automatic fire protection system
J, Fault signal transmission function
K, Function to receive fault signals
M, Function of control and signalling of vocal alarms
N, Auxiliary input and output function
O, Auxiliary management function (*building management*)

Table 138: Secondary functions of FDAS pursuant to EN 54-1 and UNI 9795

S.7.6 Loudspeaker emergency message delivery system

1. A solution is considered to be a *loudspeaker emergency message broadcasting system* (EVAC) designed and installed pursuant to the UNI ISO 7240-19 or UNI CEN/TS 54-32 standard.
2. The selection of the EVAC system category to be installed in the activity must be made taking into account the performance level of the FSM (chapter S.5) as indicated in Table 146.

Performance level of the FSM	EVAC category
I	1
II	2 or 3
III	4

Table 139: Relationship between EVAC category and FSM performance level

S.7.7 Signage

1. Firefighting devices must be indicated by safety signs UNI EN ISO 7010.

S.7.8 References

1. The following references are indicated:

   a. ISO 7240-1 ‘*Fire detection and alarm systems – Part 1: General and definitions*‘;

   b. ISO 7240-14 ‘*Fire detection and alarm systems – Part 14: Design, installation, commissioning and service of fire detection and fire alarm systems in and around buildings*‘;

   c. UNI CEN/TS 54-14 *‘Fire detection and fire alarm systems – Part 14: Guidelines for planning, design, installation, commissioning, operation and maintenance’*;

   d. UNI EN 54-1 ‘*Fire detection and fire alarm systems – Part 1: Introduction*‘;

   e. UNI EN 54-13 ‘*Fire detection and signalling systems – Part 13 – Evaluation of the compatibility of the components of a system*‘;

   f. UNI 9795 ‘*Automatic fire detection and alarm warning systems – Design, installation and operation*‘;

   g. UNI 11744 ‘*Automatic fire detection and alarm signalling fixed systems – Characteristic of the unified acoustic signal for pre-alarm and fire alarm*‘;

   h. BS 5839-1 ‘*Fire detection and fire alarm systems for buildings. Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises*‘;

   i. CEA Base requirements for Installers of Automatic Fire Detection and Alarm Systems (AFDS), Intruder Alarm Systems (IAS) or CCTV-Systems CEA 4048: June 2006;

   j. NFPA 72 ‘*National fire alarm and signalling code*‘, National Fire Protection Association, Quincy (Massachusetts), USA;

   k. UNI 11224 ‘*Fixed fire alarm detection and signalling systems – Initial control and maintenance of fire detection systems*‘;

   l. UNI ISO 7240-19 ‘*Fixed fire alarm detection and signalling systems: Design, installation, commissioning, maintenance and operation of voice alarm systems for emergency purposes*‘;

   m. UNI CEN/TS 54-32 ‘Fire detection and signalling systems – Part 32: Planning, design, installation, commissioning, operation and maintenance of voice alarm systems’;

   n. UNI/TR 11607:2015 ‘*Guideline for the design, installation, commissioning, operation and maintenance of fire alarms and sounders*‘;

   o. UNI/TR 11694:2017 ‘*Guideline for the design, installation, commissioning, functional verification, operation and maintenance of smoke aspiration detection systems*‘;

   p. UNI EN 14604 ‘*Autonomous smoke detectors with acoustic warning*‘;

   q. UNI 11497 ‘*Design, installation and operation of autonomous smoke detectors covered by UNI EN 14604*‘.

Chapter S.8 Control of smoke and heat

S.8.1 Preface

1. The purpose of this fire prevention measure is to identify the firefighting devices to be installed in the activity to allow the *control*, the *evacuation* or the *venting* of combustion products in the event of a fire.

Note Differential pressure systems to make the compartments smoke-proof are discussed in chapter S.3.

2. In general, the fire prevention measure in this chapter is implemented through the realisation of:

   a. *openings for the emergency venting of smoke and heat* of paragraph S.8.5;

   b. *horizontal forced ventilation systems of smoke and heat* (HFVS) of paragraph S.8.6;

   c. *smoke and heat evacuation systems* (SHES) described in paragraph S.8.7.

S.8.2 Performance levels

1. Table 147 shows the performance levels attributable to the *compartments* of the activity for the present fire protection measure.

Performance level	Description
I	No requirement
II	It must be possible to vent smoke and heat of the fire from the compartments in order to facilitate the operations of the rescue teams.
III	A layer free of smoke must be kept in the compartment which allows for: ● occupants' and rescue teams' safety, ● property protection, if required. Smoke and heat generated in the compartment must not propagate to neighbouring compartments.

Table 140: Performance levels

S.8.3 Assignment criteria to performance levels

1. Table 148 shows the *generally accepted* criteria in assigning individual performance levels.

Performance level	Assignment criteria
I	Compartments where *all* of the following conditions are met: ● not used for activities involving occupants, with the exception of occasional and short-term activities of assigned personnel; ● specific fire load $q_f \leq 600$ MJ/m^2; ● for compartments with $q_f > 200$ MJ/m^2: gross area of ≤ 25 m^2; ● for compartments with $q_f \leq 200$ MJ/m^2: gross area of ≤ 100 m^2; ● no hazardous substances or mixtures are held or handled in significant quantities; ● no hazardous work for the purposes of fire is carried out.
II	Compartment not included in the other assignment criteria.
III	In relation to the results of the risk assessment in the setting and in neighbouring settings (areas) of the same activity (e.g. activities with high crowding, activities with complex geometry or underground floors, high specific fire load q_f, presence of substances or mixtures hazardous in significant quantities, presence of hazardous processing for the purposes of fire, etc.).

Table 141: Assignment criteria to performance levels

S.8.4 Design solutions

1. This fire protection measure is designed pursuant to the indications of paragraphs S.8.5, S.8.6 or S.8.7.
2. The indications in paragraph S.8.8 regarding signage must be respected.

S.8.4.1 Deemed-to-satisfy solutions for performance level II

1. For each compartment, it must be possible to *emergency venting smoke and heat* as indicated in paragraph S.8.5.
2. Following the results of the risk assessment, it is allowed to install *horizontal forced ventilation systems for smoke and heat* (HFVS) as indicated in paragraph S.8.6, also in place of smoke and heat emergency venting openings, particularly in an activity complex where it is necessary to guarantee the safety of rescue teams by creating an access road free of smoke and heat up to the position of the fire.

S.8.4.2 Deemed-to-satisfy solutions for performance level III

1. A *smoke and heat evacuation system* (SHES), *natural* (NSHES) or *forced* (FSHES) must be installed, as indicated in paragraph S.8.7.

S.8.4.3 Alternative solutions

1. *Alternative solutions* are allowed for all of the performance levels.
2. In order to demonstrate the achievement of the *performance level*, the designer shall use one of the methods of paragraph G.2.7.
3. Table 149 shows some *generally accepted* procedures for designing alternative solutions. However, the designer may use methods other than those listed.

Objective of the solution	Design method
Smoke and emergency heat venting openings (§ S.8.5)	Demonstrate, also with analytical methods, that the rescuers can vent the smoke and heat of the fire in the configuration considered or thanks to a mechanical venting installation. The design methods described in Appendix G '*Smoke and heat emergency venting*' of the UNI 9494-1 standard and in Appendix H '*Mechanical system requirements for smoke and heat emergency venting*' of the UNI 9494-2 standard may be used.
Uniform distribution of venting openings (§ S.8.5.3)	Protected access for rescuers in relation to all activity floors and availability in the vicinity of fire protection equipment and devices must be guaranteed, or achievement of safety objectives for rescuers be demonstrated by using the methods described in chapter M.3.
HFVS characteristics (§ S.8.6)	In the absence of standards, TS or TR adopted by the national standardisation body, the design principles and the installation and management methods contained in prCEN/TS 12101-11 can be used.
All cases	Demonstrate the achievement of safety objectives for occupants and rescuers using the methods described in chapter M.3.

Table 142: Design methods for alternative solutions

S.8.5 Smoke and heat emergency venting openings

1. Unlike the properly sized SHESs, *smoke and heat emergency venting* does not have the function of creating an adequate layer free of smoke during the development of the fire, but only to facilitate the work of extinguishing by rescuers.
2. The *smoke and heat emergency venting* can be carried out by means of *venting openings* of the combustion products toward the outside of the building. These openings generally coincide with those already ordinarily available for the functionality of the activity (e.g. windows, skylights, doors, etc.).

S.8.5.1 Characteristics

1. The *venting openings* must be made so that:
   a. it is possible to vent smoke and heat from all settings (areas) of the compartment;
   b. smoke and heat vented do not interfere with the escape route system, do not spread the fire to other rooms, floors or compartments.
2. *Venting openings* must be protected against accidental obstruction during operation.
3. Specific indications must be provided for the emergency management of venting openings (chapter S.5).
4. The *venting openings* are made according to one of the types of use indicated in Table 150.

   In relation to the outcomes of the risk assessment, a portion of the useful surface of the *venting openings* should be carried out using an SEa, SEb, SEc type method.

   Note For example, the exclusive presence of venting openings in a difficult to reach position is a risk factor to be evaluated.

Kind of use	Description
SEa	Permanently open
SEb	Equipped with an automatic opening system with FDAS-controlled activation
SEc	Provided with closing elements (e.g. fixtures, etc.) with opening controlled by a protected and indicated position
SEd	Provided with non-permanent closing elements (e.g. windows, etc.) which can also be opened from a non-protected position
SEe	Provided with permanent closing elements (e.g. PMMA polymer plates, polycarbonate, etc.) that are possible to open in the actual fire conditions (e.g. thermal conditions generated by natural fire sufficient to effectively melt the closing element, etc.) or the possibility of immediate demolition by the rescue teams.

Table 143: Types of construction of venting openings

S.8.5.2 *Design*

1. The *overall minimum usable area* SE of the floor vent openings is calculated as shown in Table 151 according to the specific fire load q_f (chapter S.2) and the gross surface area of each floor of compartment A.
2. The useful surface SE can be divided into several openings. Each opening should have a regular shape and a usable area ≥ 0.10 m².

Type of sizing	Specific fire load q_f	SE [1] [2]	Additional requirements
SE1	$q_f \leq 600$ MJ/m²	A/40	-
SE2	$600 < q_f \leq 1\,200$ MJ/m²	A · q_f /40 000 + A/100	-
SE3	$q_f > 1\,200$ MJ/m²	A/25	10 % of SE of SEa or SEb or SEc type
[1] With SE usable area of venting openings in m²			
[2] With A gross area of each compartment floor in m²			

Table 144: Types of sizing for venting openings

S.8.5.3 *Verification of uniform distribution of venting openings*

1. The *venting openings* should be evenly distributed in the upper portion of all rooms, in order to facilitate the venting of hot smoke from the compartment settings (areas).
2. *The uniform distribution in plan within the facility* of the venting openings can be verified by requiring that the compartment is completely covered in plan in the facility by the *areas of influence* of the venting openings relevant to it (image 14), imposing in the calculation a *radius of influence* r_{offset} equal to 20 m or otherwise determined according to the results of the risk assessment.

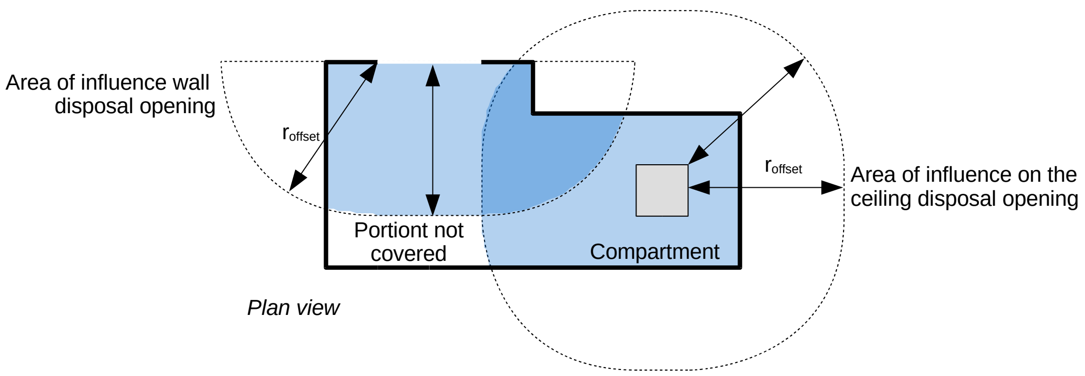


Image 14: Verification of the uniform distribution in plan in the facility of the venting opening

S.8.6 Systems of forced horizontal ventilation of smoke and heat

1. *Forced horizontal ventilation systems* can be designed for one or more of the following fire safety objectives:

   a. provide *tenable* conditions for rescue teams from an access point to the fire location;

   Note For the description of the *tenability* conditions refer to chapter M.3.

   b. protect the escape routes, with the exception of those in the first ignition compartment;

   c. facilitate the elimination of smoke and heat from the activity after the fire and quickly restore the safety conditions.

   Note Similar to *smoke and heat emergency venting openings*, also HFVS do not have the function of creating an adequate layer free of smoke during the development of the fire. HFVS can disturb the stratification of smoke and heat, in particular in the compartment of the first ignition of the fire. HFVS installation can also be limited to specific risk areas.

2. The following requirements must also be met:

   a. the activation of the HFVS must be carried out only after the evacuation of the occupants from the first ignition compartment;

   b. in case of presence of automatic systems of inhibition, control or extinction of the fire (e.g. sprinklers, etc.) the compatibility of operations with the used HFVS must be guaranteed;

   c. in the presence of FDAS, HFVS status communication and control functions must be provided.

3. Specific indications must be provided for the emergency management of the HFVS (chapter S.5).

S.8.7 Smoke and heat evacuation systems

1. The SHESs create and maintain a substantially undisturbed layer of air in the lower portion of the protected environment through the evacuation of smoke and heat produced by the fire. They keep escape routes free from smoke and heat, facilitate firefighting operations, delay or prevent *flashover* and thus the generalisation of the fire, limit damage to service or processing plants and the contents of the protected setting (area), reduce the thermal effects on the structures of the protected environment, facilitate the restoration of safety conditions of the activity after the emergency.

2. The SHESs designed, installed and managed in compliance with the following standards are considered to be a deemed-to-satisfy solution:

   a. UNI 9494-1, for SHES with *natural* evacuation (NSHES),

   b. UNI 9494-2, for SHES with *forced* evacuation (FSHES).

   Note The deemed-to-satisfy solutions for SEFCs are feasible only in the field of direct application of the UNI 9494-1 and UNI 9494-2 standards. Outside the direct field of application, another technical standard or alternative solution must be used.

3. The following requirements must also be met:

   a. in case of presence of automatic systems of inhibition, control or extinction of the fire (e.g. sprinklers, etc.) the compatibility of operations with the used SHES must be guaranteed;

   b. in the presence of FDAS, SHES status communication and control functions must be provided.

S.8.8 Signage

1. Firefighting devices must be indicated by safety signs UNI EN ISO 7010.

S.8.9 References

1. The following references are indicated:

   a. UNI 9494-1 ‘*Systems for smoke and heat control – Part 1: Design and installation of natural smoke and heat evacuation systems (NSHES)*‘;

   b. UNI 9494-2 ‘*Systems for smoke and heat control – Part 2: Design and installation of forced smoke and heat evacuation systems (FSHES)*‘;

   c. UNI 9494-3 ‘*Systems for smoke and heat control – Part 3: Initial control and maintenance of smoke and heat evacuation systems*‘;

   d. NFPA 92 – *Standard for smoke control systems*, National Fire Protection Association, Quincy (Massachusetts), USA;

   e. CEN prEN 12101-5 – *Smoke and Heat Control Systems – Part 5 Guidelines on Functional Recommendations and Calculation Methods for Smoke and Heat Exhaust Ventilation Systems*;

   f. AAVV, ‘*Fire safety in buildings, smoke management guidelines*‘, REHVA guidebook no. 24, 2018.

Chapter S.9 Firefighting operations

S.9.1 Preface

1. Firefighting operations are aimed at facilitating the effective management of fire brigade rescue operations in all activities.

S.9.2 Performance levels

1. Table 152 shows the performance levels attributable to the *construction works* for the present fire protection measure.

Performance level	Description
I	No requirement
II	Accessibility to firefighting vehicles
III	Accessibility to firefighting vehicles Immediate availability of extinguishing agents Possibility to check or stop the technological and service facilities of the activity, including safety systems
IV	Accessibility to firefighting vehicles Immediate availability of extinguishing agents Possibility to check or stop the technological and service facilities of the activity, including safety systems Protected accessibility to the Fire Brigade to all activity floors Possibility of reliable communication for rescuers

Table 145: Performance levels

S.9.3 Assignment criteria to performance levels

1. Table 153 shows the *generally accepted* criteria in assigning individual performance levels.

Performance level	Assignment criteria
I	Not allowed in the activities subject to fire regulations
II	Construction works where *all* of the following conditions are met: ● risk profiles: ○ R_{life} included in A1, A2, B1, B2; ○ R_{prot} equal to 1; ○ R_{env} not significant; ● crowd density ≤ 0.2 people/m^2; ● all the activity floors located at a height between -5 m and 12 m; ● specific fire load $q_f \leq$ 600 MJ/m^2; ● for compartments with $q_f >$ 200 MJ/m^2: gross area of ≤ 4000 m^2; ● for compartments with $q_f \leq$ 200 MJ/m^2: any gross area; ● no hazardous substances or mixtures are held or handled in significant quantities; ● no hazardous work for the purposes of fire is carried out.
III	Construction works not included in the other assignment criteria.
IV	Construction works where *at least one* of the following conditions are met: ● risk profile R_{prot} included in 3, 4; ● if open to public: total crowd > 300 occupants; ● if not open to public: total crowd > 1 000 occupants; ● total number of beds > 100 and risk profiles R_{life} included in D1, D2, Ciii1, Ciii2, Ciii3; ● hazardous substances or mixtures are held or handled in significant quantities and overall crowd > 25 occupants; ● hazardous work for the purposes of fire is carried out and total crowd > 25 occupants.

Table 146: Assignment criteria to performance levels

S.9.4 Design solutions

S.9.4.1 Deemed-to-satisfy solutions for performance level II

1. The possibility of approaching fire-rescue vehicles, adequate to the risk of fire, at a distance of ≤ 50 m from the activity *rescuers' accesses* must be permanently ensured. The designer can use the criteria set out in Table 156, as reference parameters for access to Fire Brigade vehicles.
2. In the case of activities designed for performance level I or II of fire resistance provided for in chapter S.2, the distance referred to in paragraph 1 must not in any case be less than the maximum height of the construction work. This distance must be indicated by means of a UNI EN ISO 7010-M001 sign showing the message '*Construction designed for fire resistance performance level less than III*' as showed in the image 15.

Image 125: Example of a signal for a fire resistance performance level lower than III

S.9.4.2 Deemed-to-satisfy solutions for performance level III

1. Prescriptions for the deemed-to-satisfy solutions of performance level II must be fulfilled.
2. In case of lack of internal protection of the hydrant network, in multi-storey or underground activities, the *dry column* referred to in paragraph S.9.7 must be provided.
3. In case of lack of external protection of the hydrant network belonging to the activity, at least one hydrant must be available, derived from the internal network or connected to the public network, reachable with a maximum distance of 500 m from the boundaries of the activity; this hydrant must ensure a minimum supply of 300 litres/minute for a duration ≥ 60 minutes.
4. The control and command systems of the safety services intended to operate in the event of a fire (e.g. HFVS control panels, fire extinguishing systems, FDASs, etc.) must be located in the *emergency management centre*, if provided, however in an indicated position and easily reachable during the fire. The position and operating logic must be considered in the management of fire safety (chapter S.5), also for the purpose of facilitating the work of the Fire Brigade teams.
5. The interception, control, shutdown and manoeuvring organs of technological and process installations serving the activity relevant to the fire (e.g. electrical system, natural gas supply, ventilation systems, production installations, etc.) must be located in a marked position and easily accessible during the fire. The position and operating logic must be considered in the management of fire safety (chapter S.5), also for the purpose of facilitating the work of the Fire Brigade teams.

S.9.4.3 *Deemed-to-satisfy solutions for performance level V*

1. The prescriptions foreseen for the deemed-to-satisfy solutions of performance level III must be respected.
2. At least one of the following solutions must be ensured to allow rescuers to reach all activity floors:
    a. *approachability* to all floors of the auto-ladder or equivalent means of the Fire Brigade pursuant to paragraph S.9.5;
    b. presence of *rescuers' access routes to the floors* at least of a protected type (e.g. protected ladder, external ladder, smoke-proof ladder, etc.) as per paragraph S.9.6.

Note The definition of rescuers' access routes to the floors is given in chapter G.1.

3. Depending on the geometry of the activity, the requirements of Table 154 must be met.
4. To allow eventual access of the rescuers from the top, in the activities with maximum height of the floors at > 54 m, at least one evacuation ladder must also lead to the plan of the building, if practicable.

Activity geometry	Additional requirements
Activities with floors at a height > 32 m and ≤ 54 m	At least one firefighting lift must be installed that reaches all floors above the ground floor of the activity.
Activities with floors at a height >54 m	At least one emergency lift must be installed that reaches all floors above the ground floor of the activity. An infrastructure must be installed for emergency communications of rescuers in all areas of activity
Activities with floors at a height < -10 m and ≥ -15 m	At least one firefighting lift must be installed to reach all the underground floors of the activity.
Activities with floors at a height < -15 m	At least one emergency lift must be installed to reach all the underground floors of the activity. An infrastructure must be installed for emergency communications of rescuers in all areas of activity

Table 147: Requirements related to the geometry of the activity

S.9.4.4 *Alternative solutions*

1. *Alternative solutions* are allowed for all of the performance levels.
2. In order to demonstrate the achievement of the *performance level*, the designer shall use one of the methods of paragraph G.2.7.
3. Table 155 shows some *generally accepted* procedures for designing alternative solutions. However, the designer may use methods other than those listed.

Objective of the solution	Design method
Accessibility to firefighting vehicles	The protected accessibility for the fire brigade to all activity floors and the availability in the vicinity of equipment and protection devices for firefighting operations is guaranteed.
Immediate availability of extinguishing agents	Describe how the fires, specific to the setting (area) considered, can be controlled manually, or automatically inhibited, controlled or extinguished, using other system solutions or other operating procedures.
Protected accessibility to the Fire Brigade to all activity floors	Show that the accesses to the floors for rescuers are not affected by the effects of the fire that lead to incapacitating conditions during firefighting operations.
Possibility of reliable communication for rescuers	Describe how reliable communication can be guaranteed for rescuers with alternative technical or procedural methods, in the specific fire conditions of the activity.

Table 148: Design methods for alternative solutions

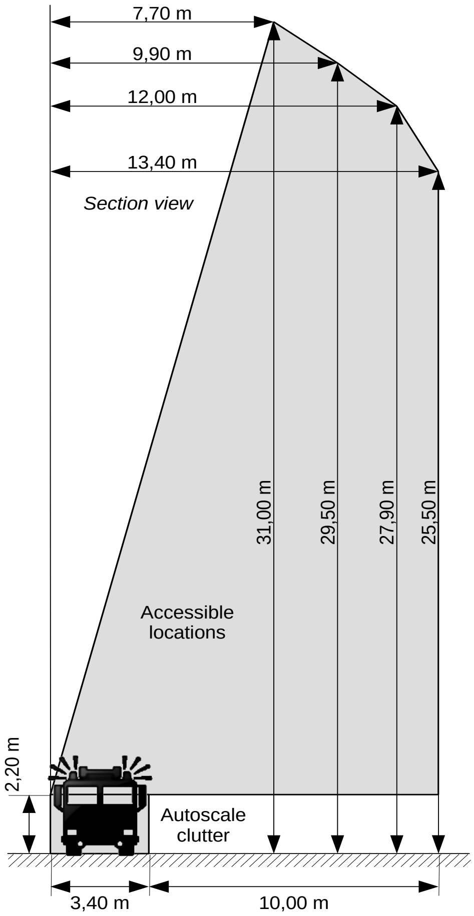


Image 16: Auto-ladder opening and accessible positions

S.9.5 Stickability of the ladder

1. To allow the intervention of the Fire Brigade auto-ladder, access to the activity from the public road must meet the minimum requirements set out in Table 156.
2. The possibility of approaching the buildings with the open auto-ladder as shown in image 16 at least one window or balcony of each floor at a height of > 12 m must be ensured.

Width: 3.50 m; Free height: 4.00 m; Vault radius: 13.00 m; Slope: ≤ 10 %; Load resistance: at least 20 tons, of which eight on the front axle and 12 on the rear axle with a 4 m wheelbase.

Table 149: Minimum requirements for access to public transport for rescue vehicles

S.9.6 Rescuers' access to floors

1. The sections of exit route used as *rescuers' access routes to floors* must have a width increased by 500 mm compared to what was calculated for the purposes of the evacuation (chapter S.4), in order to facilitate the access of rescuers in the direction contrary to the evacuation of the occupants.

Note For example, the minimum width of an evacuation scale serving four floors above ground of an activity with R_{life} equal to A2 and R_{prot} equal to 3, used by 90 occupants, which is also an access route to the floors for rescuers, is calculated as follows: L_v = 90 p · 3.25 mm/p + 500 mm = 793 mm. As L_v is less than the minimum allowed in chapter S.4, then L_v = 900 mm.

S.9.7 Dry column

1. The *dry column* allows the Fire Brigade to avoid laying flexible pipes along the access routes and vertical exit routes of the activity.
2. The *dry column* must be designed, built, operated and maintained in accordance with the rules, pursuant to the specific regulations, the good technical standards and the instructions provided by the manufacturer.
3. At the outer end of each dry column a delivery connection must be installed for fire engines.
4. In correspondence with the individual vertical escape route plans, a manual shut-off valve with a DN 45 connection must be installed, fitted with the relative closing cap. The valves at the floors must be easily accessible and protected from impact and must not constitute an obstacle to the evacuation.
5. For the design, construction and operation of the *dry column,* the indications of Table 157 must be used.
6. The delivery connections for fire engines for the dry column must:
   a. be positioned in such a way that the safe connection of the fire engine motor pump to the devices is permitted;
   b. be marked in such a way as to allow the immediate identification of the devices by means of signs bearing the wording in Table 158 showing, only in the presence of several connections for the fire engine, the specification of the area served.

7. Manual shut-off valves with DN 45 connection in the activity floor must be marked with UNI EN ISO 7010-F004 signs.
8. The dry column must undergo periodic functional checks and maintenance operations (chapter S.5). The functional verification and maintenance procedures can be obtained from the applicable indications of the UNI 10779 and UNI TS 11559 standards.

The indications of UNI 10779 and UNI TS 11559 shall be adopted, where applicable.
The simultaneous use by the Fire Brigade of no less than three DN 45 valves (or all, if less than three) in the hydraulically most unfavourable position, with a minimum flow rate of 120 l/min and one residual pressure at the valve not less than 0.2 MPa, shall be guaranteed..
Air venting devices are foreseen, in number, size and position, suitable to ensure, in relation to the plan-altimetric characteristics of the pipe, the safe use of the installation.
The pipes must be completely drainable.
Considering a supply pressure from the fire engine of the Fire Brigade equal to 0.8 MPa.

Table 150: Design indications for the dry column

DELIVERY CONNECTION FOR AN AUTO-PUMP
Maximum pressure 1.2 MPa
DRY COLUMN FOR VVF-SERVED AREA: ………………

Table 151: Sign for a dry column

S.9.8 References

1. The following references are indicated:
   a. BS 9999:2008, Section 6 – *Access and facilities for firefighting*.
   b. UNI 10779 '*Fire Extinguishing Systems – Hydrant Networks – Design, Installation and Operation*';
   c. UNI/TS 11559 '*Fire Extinguishing Systems – Dry Hydrant Networks – Design, Installation and Operation*';
   d. OSHA 3256-09R 2015 '*Fire Service Features of Buildings and Fire Protection Systems*'.

Chapter S.10 Fire safety of technological and service systems

S.10.1 Preface

1. For the purposes of fire safety *at least* the following technological and service systems must be considered:
   a. production, processing, transport, distribution and use of electricity;
   b. protection against atmospheric discharges;
   c. lifting or transporting things and people;

   Note For example: lifts, freight elevators, stretcher lifts, escalators, moving walkways, etc.

   d. storage, transport, distribution and use of solid, liquid and combustible, flammable and oxidising gases;
   e. heating, air conditioning, air conditioning and refrigeration, including the evacuation of combustion products, and ventilation of the premises.
2. For the technological and service systems included in the production processes of the activity, the designer carries out the fire risk assessment and provides adequate preventive, protective and management fire prevention measures. These measures must be in accordance with the safety objectives set out in paragraph S.10.5.

S.10.2 Performance levels

1. Table 159 shows the performance levels attributable to the *activities* for the present fire protection measure.

Performance level	Description
I	Systems designed, built, operated and maintained in accordance with industry standard (best practices), in compliance with current regulations, with specific fire safety requirements.

Table 152: Performance levels

S.10.3 Assignment criteria to performance levels

1. Performance level I must be assigned to all activities.

S.10.4 Design solutions

S.10.4.1 Deemed-to-satisfy solutions

1. The technological and service systems designed, installed, verified, operated and maintained following industry standard according to rules in accordance with the regulations in force, are deemed to comply.
2. These systems must guarantee the fire safety objectives reported in paragraph S.10.5 and also comply with the technical prescriptions given in paragraph S.10.6 for the specific type of facility.

S.10.4.2 Alternative solutions

1. *Alternative solutions* to the only provisions set out in paragraph S.10.6 are permitted.
2. In order to achieve the *level of performance*, the designer must demonstrate the satisfaction of the safety objectives referred to in paragraph S.10.5, using one of the methods of paragraph G.2.7..

S.10.5 Fire safety objectives

1. The technological and service systems referred to in paragraph S.10.1 must comply with the following fire safety objectives:
    a. limit the likelihood of constituting a cause of fire or explosion;
    b. limit the spread of a fire inside the installation and contiguous environments;
    c. do not render the other fire prevention measures ineffective, with particular reference to the compatmentalisation elements;
    d. allow occupants to leave rooms in safe conditions;
    e. allow rescue teams to operate safely;
    f. be deactivable, or otherwise manageable, following a fire.
2. The management and deactivation of technological and service systems, even those destined to remain in service during the emergency, must:
    a. be able to be carried out from protected, indicated and easily reachable positions;
    b. be provided for and described in the emergency plan.

Note For operations (chapter S.9) specific prescriptions are provided with regards to the decommissioning of the installations, including those destined to function during the emergency.

S.10.6 Additional fire safety requirements

1. The following technical prescriptions apply to the specific types of technological and service systems indicated below.

S.10.6.1 Installations for the production, transformation, transport, distribution and use of electricity

1. The installations for the production, transformation, transport, distribution and use of electricity must have structural characteristics and possibility of intervention, identified in the emergency plan, such as not to constitute a danger during the operations of extinguishing the fire and putting into use activity safety.

Note The electrical constructions are made taking into account the classification of the electrical risk of the places where they are installed (e.g. ordinary places, at greater risk in the event of fire, at risk of explosion, etc.). Generally, electrical systems are divided into several terminal circuits so that a fault cannot generate dangerous situations within the activity. If necessary, the protection devices must be chosen so as to guarantee correct selectivity. Normally, the electrical panels containing circuits that supply safety services must be located in protected, indicated and easily reachable positions.

2. It must be evaluated, depending on the destination of the premises, the time of evacuation from the same, the type of installation of the electrical conduits, the incidence of the electric cables on the other materials or installations present, the need to use cables made of materials capable to minimise the emission of smoke, the production of acid and corrosive gases.
3. The electrical panels can be installed along the escape routes provided that they do not constitute an obstacle to the outflow of occupants.
4. If the electrical panels are installed in rooms open to the public, they must be protected at least with a front door with a key lock.

5. The switching devices must always bear clear indications of the circuits to which they refer.
6. The systems referred to in paragraph S.10.1, which have a function for emergency management purposes, must have a safety power supply with the minimum characteristics indicated in Table 160.

Note All active protection systems and safety lighting must have a safety power supply.

7. Safety circuits must be clearly identified. A sign must be affixed to each circuit protection device or electrical safety system bearing the words '*Do not use in case of fire*'.

Users	Break	Autonomy
Security lighting, FDAS, emergency communication systems	Short break (≤ 0.5 s)	> 30' [1]
Escalators and moving walkways used for the evacuation [3], fire lifts, HFVS	Medium break (≤ 15 s)	> 30' [1]
Fire control or extinguishing systems	Medium break (≤ 15 s)	> 120' [2]
Emergency lifts	Medium break (≤ 15 s)	> 120'
Other installations	Medium break (≤ 15 s)	> 120'
[1] The autonomy must however be congruous with the time available for the evacuation from the activity [2] The autonomy may be less than and equal to the operating time of the system [3] Only if used on the move during evacuation		

Table 153: Minimum autonomy and interruption of the safety power supply

S.10.6.2 *Photovoltaic systems*

1. In the presence of photovoltaic systems installed on the roofs and on buildings' façades, materials must be used, design solutions and technical measures adopted that limit the probability of igniting the fire and the subsequent propagation of the same, even within the construction work and to neighbouring ones.
2. The installation of photovoltaic systems must guarantee the safety of operators in charge of maintenance operations and the safety of rescuers.

Note Useful references are the DCPST circulars No 1324 dated 7th February 2012 and DCPST No 6334 dated 4th May 2012.

S.10.6.3 *Infrastructure for charging electric vehicles*

1. In the presence of infrastructures for the recharging of electric vehicles, materials must be used, design solutions and technical devices adopted that limit the probability of triggering a fire and the subsequent propagation of the same, even within the construction work and neighbouring areas.
2. The installation of these infrastructures must guarantee the safety of the operators in charge of maintenance operations and the safety of the rescuers.

Note Useful reference is made to the DCPST circular No 2 of 5th November 2018.

S.10.6.4 *Protection against earthing and lightning*

1. A risk assessment for lightning must be performed for all activities.
2. Based on the results of the assessment of this risk, the protection systems against earthing and lightning must be made in compliance with the relative technical standards.

S.10.6.5 *Installations for lifting or transporting things and people*

1. All equipment for lifting and transporting things and people not specifically designed to operate in the event of a fire must be equipped with management, organisational and technical devices that prevent their use in the event of an emergency.

Note For example: lifts, freight elevators, stretcher lifts, escalators, moving walkways, etc.

S.10.6.6 *Fuel gas distribution systems*

1. The main pipelines of combustible gases downstream of the delivery points when they reach a construction work (e.g. public building, industrial building, etc.), must be installed visually and outside the construction works served.

Note For example: the pipes of the common utility service of a residential building supplied by the gas facility, i.e. the sub-columns and the riser columns, must be installed outside, on the façade of the building served.

2. In the event of any brief crossings of premises, the pipes referred to in paragraph 1 must be placed in a European class A1 fire reaction sheath, ventilated at both ends toward the outside and at least 20 mm in diameter greater than the internal pipe.
3. The installation of pipelines inside the construction works is permitted, provided that the risk assessment of explosive atmospheres is carried out (chapter V.2).

S.10.6.7 *Fuel storage*

1. Measures must be taken to prevent fuel leakage, for example:
   a. waterproof containment basin, protected from atmospheric agents, with a volume equal to the total capacity of the liquid fuel tanks;
   b. line interception devices with command in an accessible, protected and indicated position;
   c. feed pump shutdown devices;
   d. detection and alarm devices;
   e. protection against accidental impacts by vehicles or other elements;
   f. protection of tanks and lines against corrosion;
   g. preparation of dedicated areas, suitable connections for the safe loading and unloading of tanks;
   h. automatic devices to prevent over-filling of the tanks
   i. ordinary and emergency procedures.
2. Measures must be taken to prevent the spread of fire and mitigate its effects. For example:
   a. active protection systems;

b. interposition of suitable separation distances between fuel storage and the facility served;

c. insertion of the fuel depot and the related facility served in separate compartments;

d. if the fuel storage does not take place outdoors or in a separate compartment, the quantity of fuel stored is limited to the minimum necessary for the functionality of the activities served.

3. The vapour vent pipe from tanks is adequately sized, leading to at least 2.5 m from the floor and set at a suitable distance from other activities.

S.10.6.8 *Medical gas distribution systems*

1. The distribution of medical gases must normally take place through centralised systems.
2. These systems must meet the following criteria:
   a. the geometric layout of the primary network pipes must be such as to guarantee the supply of other compartments not affected by the fire. The system of a compartment must not be derived from another compartment, but directly from the primary distribution network;
   b. the system must be compatible with the fire compartmentalisation system and must allow the interruption of the gas supply by means of manual interception devices placed outside each compartment in an accessible, protected and indicated position; suitable signs must also indicate the sections of the facility that can be sectioned following the interception manoeuvres;
   c. the distribution networks of medical gases must be arranged in such a way as not to interfere in any way with networks of other technological and service systems.
   d. the cavities passed through by medical gas systems must be ventilated with openings whose position will depend on the density of the gases involved.

Note The reference standards for the design, installation, operation and maintenance of medical gas distribution systems are the UNI EN ISO 7396-1 '*Medical gas distribution systems – Part 1: Distribution systems for compressed and vacuum medical gases*', at UNI EN ISO 7396-2 '*Medical gas distribution systems – Part 2: Anaesthetic gases evacuation systems*' and the standard UNI 11100 '*Distribution systems for compressed medical and vacuum gases and anaesthetic gas evacuation systems – Guide to acceptance, commissioning, authorisation for use and operational management*'.

S.10.6.9 *Evacuation of combustion products*

1. In the event that the flues cross or touch combustible materials, they must be properly spaced. Useful information on this is provided in paragraph S.2.12 of this document.

S.10.6.10 *Air conditioning and conditioning systems*

1. Air conditioning or ventilation systems must meet requirements that guarantee the achievement of the following additional specific targets:
   a. avoid the recirculation of combustion products or other gases considered hazardous;
   b. do not produce, due to failures or own failures, smoke that spread in the rooms served;

c. do not constitute an element of propagation of smoke or flames, even in the initial phase of the fires.

2. In the settings (areas) of activity where the occupants may be exposed to the effects of refrigerant gases, refrigerants classified as A1 or A2L should be used pursuant to ISO 817 '*Refrigerants – Designation and safety classification*'.

Note The series of standards UNI EN 378 '*Refrigeration systems and heat pumps – Safety and environmental requirements*' specifies the requirements for the safety of occupants and property, provides a guide for environmental protection and establishes procedures for operation, maintenance and repair of refrigeration and refrigerant recovery systems. Where flammable refrigerant gases are used, the UNI EN 378 series contains specific fire safety provisions.

S.10.7 References

1. The following references are indicated:

a. Applicable CEI and UNI standards.

b. S Mannan, '*Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control*', Ed. Butterworth-Heinemann, 2012.

Section V Vertical technical rules

Chapter V.1 Specific risk areas

V.1.1 Scope and field of application

1. This technical regulation contains the fire prevention indications that apply to specific risk areas.
2. Specific risk areas can be set by the vertical technical rules applicable to the activity. They are also identified by the designer based on *the fire risk assessment* and the following criteria:
   a. areas in which hazardous substances or mixtures, combustible materials, are held or treated in significant quantities;
   b. areas where hazardous work is carried out for the purposes of fire;
   c. areas where there is the presence of installations or their components relevant for the purposes of fire safety as per chapter S.10
   d. areas with a specific fire load $q_f > 1\,200$ MJ/m^2, unoccupied or with the occasional and short-term presence of assigned personnel;
   e. areas in which there is the presence of systems and equipment with process fluids under pressure or at high temperature;
   f. areas where there is the presence of surfaces exposed to high temperatures or open flames;
   g. areas where there are hazardous chemical reactions to fire;
   h. areas of activity with significant $R_{environment}$.
3. The storage of *limited quantities* of flammable liquids in metal cabinets for functional uses in the main activity is generally not considered *specific risk*.
4. Any areas serving the main activity, where there is the presence of the installations referred to in point 2 letter c, already regulated by specific technical fire prevention rules, are not considered *specific risk areas.*

V.1.2 Fire safety strategy

1. To assess the risk and characteristics of specific risk areas, at least the information that can be deduced from the following documentation must be considered:
   a. safety data sheets for hazardous substances or mixtures;
   b. applicable rules;
   c. specifications and manufacturers manuals of installations and machines.
2. In relation to the results of the fire risk assessment and to the characteristics of specific risk areas, the designer evaluates, at least, the application of the following measures:
   a. inclusion of specific risk areas in separate compartments for settings (areas) with homogeneous risk characteristics, interposition of separation distances, reduction of the gross compartment surfaces, location above ground or on floors that are not very deep underground;
   b. fire control with performance level III (chapter S.6);
   c. installation of manual or automatic systems to inhibit, control or extinguish the *on-board* fire on the machine for the specific protection of systems and equipment at specific risk of fire;

d. installation of a FDAS system with performance level III (chapter S.7);

e. installation of *on-board* systems on the machine for the automatic detection of anomalies or failures that lead to deviations from the ordinary operating parameters of the system and process equipment, with the automatic alarm and interception functions of the power supplies and hazardous fluids;

f. performing risk assessment for explosive atmospheres (chapter V.2);

g. adoption of system and construction devices to limit and confine releases of hazardous substances or mixtures;

Note For example: containment basins, availability of powders or absorbent devices, insertion of excess flow valves, automatic and manual interception of distribution systems, jacketing of pipes, ...

h. adoption of measures to limit the external impact of any release of hazardous substances or mixtures;

Note For example: separation distances that take into account the propagation of effluents in environmental matrices, ...

i. adoption of detection and alarm systems, management procedures for monitoring and control of critical process parameters;

Note For example: maximum-level alarms for tanks, ...

j. education, information and training of workers involved in the management of hazardous works and processes;

Note Such education, information and training must include notions regarding the critical parameters of the operation of works and hazardous processes, the methods and procedures for starting and stopping the systems in safety, the management of alarm and emergency states, etc.

k. availability of specific rescue equipment, collective and individual protection devices;

3. In the case of multi-compartmentalisation of the activity (chapter S.3.), the areas at specific risk must in any case be included in a separate compartment.

4. The results of the specific risk assessment and the relative preventive, protective and managerial measures adopted must be considered for the purpose of managing the safety of the activity (chapter S.5.).

Chapter V.2 Areas at risk for explosive atmospheres

V.2.1 Scope and field of application

1. This vertical technical regulation deals with the assessment and risk reduction criteria for explosive atmospheres in the activities subject to fire regulation.
2. In the settings (areas) of activity where *flammable substances* are present in the form of gases, vapours, mists or *combustible dusts* in storage, processing or a transformation cycle, in transport, handling or manipulation systems, the risk for explosive atmospheres must be assessed, identifying the technical measures necessary to achieve the following objectives, in order of decreasing priority:
   a. to prevent the formation of explosive atmospheres,
   b. to avoid the ignition sources of explosive atmospheres,
   c. to mitigate the damage caused by an explosion so as to guarantee the health and safety of occupants.

   Whether it is not possible to prevent the formation of explosive atmospheres or to eliminate ignition sources, the probability of simultaneous presence of explosive atmospheres and sources of ignition should be reduced as far as reasonably *practicable* or *obtainable*, according to the ALARP (*as low as reasonably practicable*) or ALARA (*as low as reasonably achievable*) approaches.
3. The objectives of paragraph 2 are achieved through:
   a. the *explosion risk assessment* referred to in paragraph V.2.2;
   b. the adoption of the *prevention, protection and management measures* referred to in paragraph V.2.3.

V.2.2 Explosion risk assessment

1. The explosion risk assessment must be carried out according to the following phases, detailed in the following paragraphs:
   a. identification of the *general conditions of explosion hazard*;

   Note In this phase the settings (areas) of activity with the presence of flammable substances or combustible dusts must be identified. For example: containment systems from which the release of flammable substances or combustible dusts is possible, both in normal operation or in the event of malfunctions; environmental conditions for the mixing of the released substances and the formation of explosive atmospheres; installations with presence of sources of ignition effective in normal operation or in the event of malfunctions, ...

   b. identification of the *characteristics* of flammable substances or combustible dust which can give rise to explosive atmospheres;
   c. classification of zones with hazard of explosion, by estimating the probability of presence, duration and extent of explosive atmospheres;
   d. identification of the potential *ignition hazard* and estimation of the probability that the identified *ignition sources* can become effective;
   e. assessment of the extent of the foreseeable *effects* of an explosion;
   f. quantification of the *protection* level.

V.2.2.1 *Identification of the general conditions of explosion hazard*

1. The identification of the general conditions of hazard of explosion involves the study of the dangerous settings (areas) of the activity, of the equipment and of the process and technological systems present, also considering the organisation of work and the functions performed in the settings (areas) being assessed.
2. The analyses to be carried out on the equipment and on the process and technological systems must be aimed at identifying:
    a. potential emission sources;
    b. potential ignition sources present;
    c. construction, installation, use and maintenance characteristics by checking compliance with:
        i. any specific legislative provisions or harmonised technical product specifications;
        ii. applicable rules;
        iii. the manufacturers' instructions.

V.2.2.2 *Identification of flammable substances or combustible dust characteristics*

1. For flammable substances and combustible dust, the chemical–physical characteristics relevant to the explosion must be identified, in all significant environmental conditions and the characteristics of the treatment, deposit or storage systems provided.

V.2.2.3 *Classification of areas with explosion hazard*

1. The activities, where flammable substances or combustible dust are processed or stored, must be designed, manufactured, operated and maintained so as to minimise the emissions of flammable substances and the consequent extensions of the areas affected by the release, with reference to *frequency* or *probability of occurrence, duration* and *quantity* of the emissions.
2. The settings (areas) at risk of explosion must be divided into zones based on the probability of the presence of the explosive atmosphere as defined in Table 161. The identification of the hazardous zones and the relative probability of occurrence must be carried out pursuant to the applicable regulations.
3. The subdivision in zones of the places with hazard of explosion can also be carried out through the use of recognised calculation codes that allow a classification according to Table 161 .
4. For the purposes of complying with the indications in Table 161, the classification of the zones should be based on the failure rates of the emission sources and the environmental control systems (e.g. ventilation, suction, pressurisation, ...).

Zone for the presence of gas, vapours and mists	Zone for the presence of dusts	Classification of areas with risk of explosion	P [1]	D [2]
0	20	Place where an explosive atmosphere is present permanently or for long periods or frequently (the hazard is present always or frequently)	$P > 10^{-1}$	$D > 10^3$
1	21	Place where an explosive atmosphere is likely to occur occasionally during normal operation (the hazard is sometimes present)	$10^{-3} < P \leq 10^{-1}$	$10 < D \leq 10^3$
2	22	Place where an explosive atmosphere is unlikely to occur during normal operation, but which, if it occurs, persists only for a short time (the hazard is rarely or almost never present)	$10^{-5} < P \leq 10^{-3}$	$10^{-1} < D \leq 10$
NP		Place where the probability of the presence of the explosive atmosphere is negligible (*negligible presence*). NP zones are considered non-hazardous.	$P < 10^{-5}$	-
NE		Place where the volume of the explosive atmosphere is of *negligible extent*. Generally, the *NE zones are considered non-hazardous*.	-	-
[1] Probability P of the presence on an annual basis [events/year] [2] Duration D of ATEX presence on an annual basis [hours/year]				

Table 154: Classification of areas with the presence of an explosive atmosphere.

V.2.2.4 *Identification of potential ignition hazards*

1. The hazards of ignition are strictly linked to the presence of *ignition sources* and to the *ignition properties* of potentially explosive mixtures.
2. A list of possible ignition sources to be searched for in the equipment, in processing plants and in technological and service systems is shown in Table 162.
3. The ignition of an explosive atmosphere is strictly dependent on the possibility with which the ignition sources manifest themselves and become effective, in contact with the explosive mixture. To this end, the ignition sources can be classified as follows:
   a. ignition sources that can occur *continuously or frequently*, generally present during normal operations;
   b. ignition sources that can occur in *rare* circumstances, generally due to foreseeable malfunctions;
   c. ignition sources that can occur in *very rare* circumstances, generally due to extremely rare malfunctions.
4. In terms of equipment, protection systems and components used, the classification of the preceding paragraph must be considered equivalent to:
   a. ignition sources that can occur during the *normal operation*;
   b. ignition sources that can occur only following *foreseen malfunctions*;
   c. ignition sources that can occur only following *rare malfunctions*.

5. Since it is necessary to ensure an adequate level of protection, in no one of the hazardous areas of Table161 (0/20, 1/21, 2/22) frequent or continuous ignition sources are allowed.

Note It is possible to consider as reference the probability values of the ignition sources shown in Table C10 of the EI 15:2015 standard '*Model code of safe practice Part 15: Area classification for installations handling flammable fluids*'.

Hot surfaces
Flames, gas, hot particles
Sparks of mechanical origin
Electrical equipment and installations
Stray currents, cathodic protection
Static electricity
Lightning
Radio frequency from10^4 Hz to $3 \cdot 10^{11}$ Hz
Electromagnetic waves from 3 10^{11} Hz a $3 \cdot 10^{15}$ Hz
Ionising radiations
Ultrasound
Adiabatic compression and shock waves
Exothermic reactions

Table 155: Ignition sources taken from the UNI EN 1127-1 standard

V.2.2.5 *Assessment of the extent of the foreseeable effects of an explosion*

1. In order to assess the foreseeable effects of an explosion it is necessary to take into account the consequences on any exposed occupants, on the structures and on the installations of the following *physical effects* of an explosion:
   a. flames and hot gases;
   b. thermal radiation;
   c. pressure waves;
   d. projection of fragments or objects;
   e. releases of hazardous substances.
2. To verify the occupants' safety goal, at least the following effects must be considered:
   a. damage to the compartmentalisation elements not resistant to explosion according to NTC and in general to mechanical impacts;
   b. out of service of the active protection systems inside the room of origin of the explosion;
   c. domino effect (e.g. damage to other containment systems, installations or equipment with release of hazardous substances, ...);
   d. damage to the protection measures adopted on the ignition sources with consequent ignition of the explosive atmospheres produced by the released substances.

Note Particular attention must be paid to the possible presence of occupants within the effects foreseen by the explosion with specific reference to work that takes place adjacent to the ATEX zones (e.g. loading or emptying operations of flammable liquids or combustible dust, ...).

3. In cases where the explosion could be followed by a fire, this last scenario must be assessed taking into account the unavailability of what was damaged by the explosion.

4. In cases where an explosion could occur following a fire, the latter scenario must be assessed taking into account the unavailability of what was damaged by the fire.

5. For the *possible* determination of the overpressures that develop in the explosions, simplified formulations present in the norms or empirical expressions that connect the most significant quantities of an explosion can be used. The most widely used simplified empirical models are the equivalent TNT, the TNO Multienergy and the CCPS QRA.

6. In addition to the empirical methods and the simplified models, for the estimation of the overpressures that develop as a result of explosions, recognised calculation codes can be used.

V.2.2.6 Quantification of the protection level

1. In general, the level of protection against explosions is considered adequate when the failure of three independent *means of protection* must be verified so that an explosive atmosphere can be triggered by an effective ignition source.

Note The concept of *protection* refers to the provisions on equipment and protection systems intended for use in an explosive atmosphere as well as the provisions on health and safety in the workplace.

V.2.3 Prevention, protection and management measures

1. The measures that can be adopted against the risk of explosion to achieve the established level of protection are divided into:
   a. *prevention* measures, which concern the reduction of the probability of the presence and ignition of an explosive mixture, shown in Table 163;
   b. *protective* measures, which involve the mitigation of the effects of an explosion within acceptable limits, shown in Table 164;
   c. *management* measures which provide for the reduction of the risk of explosion by adopting procedures for the correct organisation of work and production processes, shown in Table 165.
2. Prevention and management measures are always preferable to protective measures; protection measures must be used when it is not possible to reduce the level of risk to an acceptable level with the sole application of prevention and management measures.
3. Activities with presence of risk arising from explosive atmospheres must have the technical documentation attesting the suitability of the products and systems installed for the specific use in the place of use, also in accordance with the group and category, as well as all the indications provided by the manufacturer and necessary for their safe operation.

Prevention measures
Reduction of the number of emission sources present on containment systems, of the probability of release into the environment or of the duration of the release of flammable substances.
Realisation of dispersion, dilution or reclamation systems of flammable substances in the environment in order to achieve one of the following objectives: ● to keep the concentration of potentially explosive mixtures out of the explosive limits; ● to reduce the extension of the hazardous atmosphere to negligible volumes, pursuant to the applicable standards, for the purposes of consequences in the event of ignition; ● to confine the hazardous atmosphere in areas where there are no effective ignition sources.
Installation of flammable substances detection systems for: ● activation of safety measures for emission sources and ignition sources; ● evacuation of persons prior to ignition of the explosive atmosphere.
Installation inside zones with hazard of explosion of installations, equipment and related connection systems that cannot cause ignition.
Installation of ignition source detection systems (e.g. sparks, hot surfaces, ...).
Installation of equipment inerting systems in order to reduce the concentration of oxygen below the limit concentration (LOC).
Installation of products deemed-to-satisfywith EU legislation in places with hazard of explosion.

Table 156: Prevention measures

Protective measures
Installation of systems to mitigate the effects of an explosion to minimise the risks represented for occupants by the physical consequences of an explosion, chosen from the following: ● protection systems by venting the gas explosion; ● protection systems by venting the dust explosion; ● explosion isolation systems; ● explosion suppression systems; ● explosion-proof appliances. Adoption of a layout of the construction work and of the installations with the aim of reducing the number of occupants exposed to the effects of an explosion (e.g. overpressure, heat, projection of fragments, ...), installing hazardous processes: ● outside buildings occupied by people, suitably screened or spaced; ● within buildings where only the occasional and short-term presence of occupants is foreseen; ● in rooms equipped with measures (e.g. a flammable substances detection system, ...) that allow occupants to reach a safe place for the purpose of explosion prior to ignition; ● inside construction works that are resistant to explosions, in an appropriately shielded position with respect to fixed work stations.

Table 157: Protective measures

Management measures
Professional training of workers, assigned to places where explosive atmospheres may arise, in the field of explosion protection.
Preparation of work permits for hazardous activities and for activities that can become hazardous when they interfere with other work operations.
Allocation to operator workers of portable equipment and work clothes not capable of triggering an explosive atmosphere.
Assignment to operator workers of portable equipment for the detection of explosive atmospheres.
Preparation of specific work and behaviour procedures for operator workers.
Signalling of the hazards of the formation of explosive atmospheres.
Adoption of specific procedures in case of emergency for the safety of emission sources and ignition sources.
Implementation of safety checks (initial verification, periodic check and maintenance) of the systems and equipment installed in the workplace with areas where explosive atmospheres may form, in compliance with the applicable standards.

Table 158: Management measures

V.2.3.1 *Products*

1. The products can be used or put into service in an explosive atmosphere only after checking the compatibility of the zone in which they are called to perform their function.

   These products must comply with the ATEX product directive, which includes different categories in relation to the use in each classified zone.

2. For products that can be used in industries and surface activities (II Group of the ATEX product directive), the following categories are defined:

   a. *Category 1 – very high level of protection*.

      The products must not be a cause of ignition even in case of exceptional failure. The protection means are such that in the event of failure of one of the protection means, at least one second independent means ensures the required safety level, or if two failures independent of each other occur, the required level of protection is guaranteed;

   b. *Category 2 – high level of protection*.

      The protection means guarantee the required level of protection even in the presence of recurrent anomalies or defects in the functioning of the devices which must normally be taken into account.

   c. *Category 3 – normal level of protection*.

      The protection means guarantee the level of protection required for normal operation.

3. Table 166 shows the compatibility of the products with the zones classified for the presence of explosive atmospheres.

Explosive atmosphere	Zone	ATEX Category [1]
Gas	0	1G
	1	1G, 2G
	2	1G, 2G, 3G
Dust	20	1D
	21	1D, 2D
	22	1D, 2D, 3D
[1] G for *gas* and D for *dust*		

Table 159: Product compatibility due to the presence of explosive atmospheres

V.2.3.2 *Installations*

1. *Installations* refer to equipment, systems and related connection devices that are not *products* pursuant to the ATEX directive, if they represent a hazard of ignition or emission of flammable substances.
2. The systems and all their connection devices can be used or put into service in an explosive atmosphere only after verifying the compatibility of the zone in which they are called to perform their function.
3. The safety level of the systems must comply with the indications contained in the standards chosen for the design and construction. For the installations without standards with such a scope, reliability analysis techniques can be used, such as *Failure Mode and Effect Analysis* (FMEA, EN 60812), *Fault tree analysis* (FTA, EN 61025), *Markov* (EN 61165) or by applying design based on functional safety (IEC 61511 '*Functional safety – Safety instrumented systems for the process industry sector*').

V.2.3.3 *Construction works designed to withstand explosions*

1. In general, construction works can be designed in such a way as to limit the effects of explosions within them or on neighbouring buildings.
2. Structural design strategies depend on the established safety goals:
   a. life safety of the occupants within the building;
   b. life safety of the occupants of neighbouring buildings;
   c. protection of assets contained in buildings;
   d. limitation of damage to the building in which the explosion originates;
   e. limitation of damage to neighbouring buildings;
   f. limitation of domino effects.
3. The phases of the design of structures resistant to explosions, in order to safeguard the life of the occupants and limit structural damage, are:
   a. modelling of the effects of the explosion, quantification of the actions;
   b. structural analysis;
   c. construction design and verification.
4. The *modelling of the effects of the explosion* is conducted with reference to the effects caused and the related consequences as indicated in Table167, taken from the NTC and the NAD of the UNI EN 1991-1-7 standard.
5. In order to *quantify the actions* acting on the structures in the event of an explosion, the combination of loads for exceptional actions must be used as per the NTC, bearing in mind that:
   a. for construction works at risk of explosion with effects of category 1 (falling therefore in the class of consequence CC1), the actions deriving from explosion must not be considered;
   b. for construction works at risk of explosion with effects of category 2 (falling therefore in the class of consequence CC2), the quantification of the actions is carried out with reference to:
      i. NTC, for the design overpressure to be used for checks in the event of explosions confined to gases, vapours or mists;
      ii. UNI EN 1991-1-7 integrated by the respective NAD, for the design overpressure due to dust explosions;
   c. for construction works at risk of explosion with effects of category 3 (falling therefore in the class of consequence CC3) analyses must be carried out using advanced methods that take into account:
      i. the effects of *venting* and the geometry of environments in the calculation of overpressure;
      ii. the non-linear dynamic behaviour of structures;
      iii. the risk analysis carried out with probabilistic methods;

iv. the economic aspects for the optimisation of solutions.

6. The *structural analysis* can be carried out with simplified models of the static equivalent type in the case of construction works in class CC2 or with non-linear dynamic analyses for construction works in class CC3.
7. The *constructive design* of construction works characterised by the risk of explosion generally requires the adoption of measures to reduce damage from explosion.
8. For the purpose of *checks*, no structural checks are required for construction works falling within the category of action 1. For construction works falling into category 2 or 3, verification of the structural elements is required for the combination of exceptional actions, which demonstrates, in addition to the requirement of robustness, that the load-bearing capacity of the entire structure is guaranteed for a sufficient time to implement the foreseen emergency measures (e.g. evacuation and rescue of occupants, ...).

Category of actions due to explosions (NTC)		**Classes of consequences (NAD EN 1991-1-7)**	
1	Negligible effects on structures	CC1	• Construction works with only the occasional presence of occupants, agricultural buildings.
2	Localised effects on part of the structures	CC2 lower risk	• Construction works whose use includes normal crowding, without hazardous content for the environment and without essential public and social functions. • Industries performing activities that are not harmful to the environment. • Bridges, infrastructural works, road networks not falling within the consequently higher classes.
		CC2 higher risk	• Construction works whose use includes significant crowds. • Industries performing activities that are harmful to the environment. • Suburban networks that do not fall under consequence class 3. • Bridges and rail networks the interruption of which may result in emergency situations.
3	General effects on structures	CC3	• Construction works with important public or strategic functions, also with reference to the management of civil protection in the event of a disaster. • Industries performing activities that are particularly harmful to the environment. • Bridges and rail networks of critical importance for maintenance of communication channels.

Table 160: Classification of actions due to explosions (NTC) and the related classes of consequences (NAD EN 1991-1-7)

V.2.4 References

1. Legislative Decree No 81 of 9 April 2008 *'Consolidated text on health and safety at work'*.
2. Legislative Decree No 85 of 19 May 2016 '*Implementation of Directive 2014/34/EU concerning the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres*'
3. Decree of the President of the Republic No 126 of 23 March 1998 *'Regulation laying down rules for the implementation of Directive 94/9/EC on equipment and protection systems intended for use in potentially explosive atmospheres'*.
4. Directive 1999/92/EC of the European Parliament and of the Council of 16 December 1999 concerning the minimum requirements for improving the protection of health of workers who may be exposed to the risk of explosive atmospheres.
5. Directive 94/9/EC of the European Parliament and of the Council of 23 March 1994 on the approximation of the laws of the Member States relating to equipment and protective systems intended for use in a potentially explosive atmosphere.
6. Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of Member States relating to equipment and protective systems intended for use in a potentially explosive atmosphere.
7. Decree of the Minister for Infrastructure 17 January 2018 *'Update of technical standards for construction'*.
8. Decree of the Minister for Infrastructure and Transport 31 July 2012 *'Approval of the national appendices bearing the technical parameters for the application of the Eurocodes'*.
9. CEI EN 60079-10-1 (CEI 31-87) '*Explosive atmospheres Part 10-1: Classification of places. Explosive atmospheres caused by the presence of gas*'.
10. CEI EN 60079-10-2 (CEI 31-88) '*Explosive atmospheres Part 10-2: Classification of places – Explosive atmospheres caused by the presence of combustible dusts*'.
11. IEC 61511 series '*Functional safety – Safety instrumented systems for the process industry sector*'.
12. CEI 65-186 '*Guideline for the application of the standard of the CEI EN 61511 series Functional safety – safety instrumented systems for the process industry sector*'.
13. IEC 61508 series '*Functional safety of electrical/electronic/programmable electronic safety-related systems*'.
14. ISO/IEC 80079-20-1 '*Explosive atmospheres – Part 20-1: Material characteristics for gas and vapour classification – Test methods and data*'.
15. ISO/IEC 80079-20-2 '*Explosive atmospheres – Part 20-2: Material characteristics – Combustible dust test methods*'.

16. '*Guidelines for Mechanical Integrity Systems*', Centre for chemical process safety (CCPS), AIChE, 2006.
17. '*Layer of Protection Analysis: Simplified Process Risk Assessment*', Centre for chemical process safety (CCPS), AIChE, 2001.
18. EI 15:2015 '*Model code of safe practice Part 15: Area classification for installations handling flammable fluids*', Energy Institute.
19. IGEM/SR/25 Ed. 2 – '*Hazardous area classification of Natural Gas installations Communication number 1748*', Institute of Engineers and Managers.

Chapter V.3 Lift shafts

V.3.1 Scope and field of application

1. The purpose of this vertical technical rule is the issuing of fire prevention provisions concerning the shafts of the *lifts for transporting people and goods* installed in the activities subject to fire regulation.
2. The *lift shafts* are intended as:
   a. machinery premises;
   b. the return pulleys premises;
   c. the hoistways;
   d. the work areas for lifting systems.

V.3.2 Classifications

1. The lift shafts are classified as follows:

   SA: open shafts;

   SB: protected shafts;

   SC: smoke-proof shafts;

   SD: fireproof lift shafts;

   SE: emergency lift shafts.

V.3.3 Fire safety strategy

1. The provisions of this chapter must be applied without determining risk profiles.

V.3.3.1 Common requirements

1. They must consist of material belonging to the GM0 fire reaction group (chapter S.1):
   a. walls, doors and access hatches;
   b. the partition walls between the runway, the machine room and the pulley room;
   c. the cabin support frame.
2. The communication holes through the partition walls for the passage of ropes, cables or pipes must have the minimum indispensable dimensions.
3. The lift should be built in compliance with the UNI EN 81-73 standard.

   Note For example, if the compartments are served by a FDAS facility, means should be provided to return the lift to the main reference floor or to an alternative one, not affected by the fire, and then stop it. Otherwise there should be a management measure to return the lift to the main reference floor or to an alternative one, not affected by the fire, and then stop it.
4. In the event of a fire, the use of lifts not specifically designed for this purpose is prohibited. These lifts must be marked with appropriate signs in accordance with industry standard (best practices) and easily visible to all floors.
5. Near the access to the spaces or the machine room, where present, a fire extinguisher must be positioned according to the criteria set out in chapter S.6.

V.3.3.2 *Requirements for type SB*

1. The SB-type lift shafts must be protected or inserted in a protected stairwell.
2. The fire resistance class must correspond to that of the compartments served and in any case ≥ 30.
3. The walls, floor and roof of the cabin must consist of materials belonging to the GM2 group of reaction to fire as defined in chapter S.1.
4. For lift shafts, performance level II of the smoke and heat control measurement must be satisfied (chapter S.8).

V.3.3.3 *Requirements for type SC*

1. The prescriptions for type SB must be complied with.
2. The type SC lift shaft must be of a *smoke-proof type coming from the activity* or be inserted in a *smoke-proof stairwell coming from the activity*.

V.3.3.4 *Requirements for type SD*

1. The requirements for type SC must be complied with.
2. The lift should be built in compliance with the UNI EN 81-72 standard.

Note The lifts must conform to the essential requisites of health and safety according to annex I of directive 2014/33/EU of 26th February 2014.

3. The fire resistance class of the lift shafts must correspond to that of the compartments served and in any case ≥ 60.
4. Protected lobbies must have at least the characteristics required for the filter (chapter S.3). The gross surface area of the protected atrium cannot be < 5 m^2.
5. The landing of the lift on the reference floor must enter onto a safe place directly or by a protected route.
6. The walls, floor and roof of the cabin must be made of non-combustible material.

V.3.3.5 *Requirements for type SE*

1. All the requirements for the SD type must be complied with.
2. The protected lobbies of rescue lifts must be independent of the system of escape routes of the activity, to avoid interference between the work of the Fire Brigade and the evacuation.
3. The number of rescue lifts must be defined in such a way as to serve with them the entire surface of each floor of the building.
4. The internal dimensions of the cabin and protected lobbies must be established by the designer in accordance with the UNI EN 81 series.
5. The landing and cabin doors must be manually operated, the cabin door must have one or more horizontal sliding doors.
6. A key switch, placed on each floor served, must allow the fire brigade to call the emergency lift directly.

7. The lift must be equipped with a suitable control system, operable even in the absence of electrical power, capable of returning the cabin to the *reference floor of the compartment*. This command must be reported and easily accessible for rescuers.
8. In order to ensure the availability of the system, even in the event of improper use, a device must be installed which, when the time the cabin is parked on a floor other than the reference level of the compartment exceeds 2 minutes, automatically returns the cabin to the *reference floor of the compartment*. A luminous and acoustic alarm must signal the failure of this manoeuvre to the personnel of the building; this alarm must not be operative when the lift is under the control of the Fire Brigade.

Section M Methods

Chapter M.1 Methodology for fire safety engineering

Preface

1. The application of the principles of fire safety engineering allows, similarly to other engineering disciplines, to define solutions suitable for the achievement of design goals through *quantitative* analysis.

   The designer defines the *purpose* of design, then specifies the *fire safety goals* that they intend to guarantee and translates them into quantitative *performance thresholds*. Subsequently, identifies the *design fire scenarios*, the most serious events that can reasonably occur in the activity.

   Then, thanks to analytical or numerical modelling tools, the designer describes or calculates the effects of *design fire scenarios* in relation to the hypothesised *design solution* for the activity. If the effects thus calculated retain an adequate *safety margin* compared to the previously established *performance thresholds*, then the analysed design solution is considered acceptable.

Note It is not always necessary to use *numerical models* (e.g. CFAST, FDS, etc.) to assess the effects of fire scenarios, often objective considerations that use properly the tools made available by this document are sufficient. For example, the designer can conclude that the effects of the fire do not propagate towards a *smoke-proof* compartment made according to a deemed-to-satisfy solution, avoiding the use of numerical simulations.

Note It is not always necessary to use *advanced numerical models* (e.g. FDS, etc.) to evaluate the effects of fire scenarios. For example, the designer may conclude that a compartment is *smoke proof*, if the level of the hot smoke layer simply assessed with CFAST does not fall below the architraves of the gaps in communication between the compartments.

2. This chapter describes in detail the design methodology of fire safety engineering (or *performance-based fire design*)
3. For other technical aspects of performance-based fire design, the indications given in the following chapters shall be used:
   a. Chapter M.2 Fire scenarios for performance-based design;
   b. Chapter M.3 Life safety with performance-based design.
4. For aspects of performance-based fire design not explicitly defined in this document, reference can be made to the international industry standard (best practices).

M.1.2 Phases of the methodology

1. The performance-based design methodology consists of two phases:
   a. first phase, *preliminary analysis:*

      the steps that lead to identifying the most representative conditions of the risk to which the activity is exposed are formalised together which the *performance threshold*s are to which to refer in relation to the safety targets to be pursued;

   b. second phase, *quantitative analysis:*

      using calculation models, the qualitative–quantitative analysis of the effects of the fire is performed in relation to the goals assumed, comparing the results obtained with the *performance thresholds* already identified and defining the design to be submitted for final approval.

M.1.3 First phase: preliminary analysis

1. The preliminary analysis phase consists of the following subphases necessary to define the risks to be counteracted and, consequently, the objective criteria for quantifying them necessary for the subsequent numerical analysis.

M.1.3.1 Design definition

Note In international references, *Define project scope*

1. The *purpose* of the fire design is defined in this subphase.
2. The designer identifies and documents at least the following aspects:
   a. use destination of the activity;
   b. purpose of performance-based fire design;
   c. any design constraints deriving from regulatory provisions or from specific requirements of the activity;
   d. fire hazards associated with the intended use;
   e. boundary conditions for the identification of the data necessary for the evaluation of the effects that could be produced;
   f. characteristics of the occupants in relation to the type of building and the intended use destination.

M.1.3.2 Identification of fire safety goals

Note In international references, *Identify goals, define objectives*

1. After establishing the purpose of the project, in particular the destination and modes of use of the activity, the designer specifies the *fire safety goals*, among those provided in this document, in relation to the specific needs of the activity in question and to the design purposes.
2. With the fire safety goals, for example, the level of protection of the occupants' safety, the maximum damage tolerable to the activity and its content, the continuity of operation following an incidental event are qualitatively specified.

M.1.3.3 Definition of the performance thresholds

Note In international references, *Develop performance criteria*

1. The next step is to transform the fire goals into *performance criteria.* These are quantitative and qualitative thresholds in relation to which the objective evaluation of fire safety can be carried out.
2. By choosing the *performance thresholds* the thermal effects on the structures, the propagation of the fire, the damage to the occupants, the goods and the environment become *quantitative*.
3. These *performance thresholds* must be able to be used in the second phase of the design in order to objectively discriminate the design solutions that satisfy the fire safety goals from those that do not reach the required performances instead.
4. For the purposes of designing the safeguard of life *the life safety criteria* are established. These are the thresholds used to define the *incapacitation* of occupants exposed to fire and its effects. Chapter M.3 contains examples of numeric values that can be used for these designs.

5. By definition, occupants reach *incapacitation* when they become unable to get secure themselves autonomously. The death of the subject follows in a short time.
6. Chapter S.2 defines the *performance thresholds* for designs whose purpose is to maintain the bearing capacity of all or part of a construction work.

M.1.3.4 Identification of design fire scenarios

Note In international references, *Develop fire scenarios*

1. Fire scenarios represent the schematisation of the most serious events that can reasonably occur in the activity (*credible worst-case scenarios*), in relation to the characteristics of the fire, of the building and the occupants.
2. The procedure for identifying, selecting and quantifying design fire scenarios is described in chapter M.2.

M.1.4 Second phase: quantitative analysis

1. The quantitative analysis phase is made up of some subphases necessary to carry out the safety checks of the scenarios identified in the preliminary phase.

M.1.4.1 Development of design solutions

Note In international references, *Develop trial designs*

1. The fire prevention professional elaborates one or more design solutions for the activity, congruent with the purposes already defined in paragraph M.1.3.1., to be submitted to the subsequent verification of satisfaction of the fire safety goals.

M.1.4.2 Evaluation of design solutions

Note In international references, *Evaluate trial designs*

1. In this phase the designer calculates the effects that the design fire scenarios would determine in the activity for each design solution developed in the previous phase.
2. To this end, the designer uses an *analytical* or *numerical* model: the application of the model provides the quantitative results that allow for describing the evolution of the fire and its effects on the structures, occupants or the environment, according to the design purposes.
3. The modelling of the effects of the fire makes it possible to calculate the effects of the single scenarios for each design solution.
4. The modelling results are used to verify compliance with the performance thresholds for the design solutions for each design fire scenario.
5. Design solutions that do not meet all the performance thresholds for each design fire scenario must be rejected.

M.1.4.3 Selection of suitable design solutions

Note In international references, *Select final design*

1. The designer selects the final design solution from among those that have been positively verified with respect to the design fire scenarios.

M.1.5 Design documentation

1. The design documentation must be supplemented by:
   a. for the first phase (preliminary analysis):
      i. *technical summary*, signed jointly by the designer and the activity manager, where the process followed to identify the design fire scenarios and the performance thresholds is summarised, as described in paragraph M.1.6;
   b. for the second phase (quantitative analysis):
      i. specific *technical report* where the results of the analysis and the design process followed are presented, as described in paragraph M.1.7;
      ii. *programme for the management of fire safety*, as described in paragraph M.1.8, with the specific procedures for implementing the *fire safety management* measures as per chapter S.5.

M.1.6 Technical summary

1. The technical summary must contain the following information:
   a. indication of the activity manager;
   b. identification of the general fire safety design manager;
   c. identification of designers who use fire safety engineering and who define the specific fire safety management measures, whether different from the general fire safety design manager;
   d. purposes for which the performance method is applied (e.g. analysis of the thermal fields, of the smoke diffusion and verification of the escape routes, assessment of the evacuation times, evaluation of the load-bearing capacity of the structures, protection of assets or environment in case of fire, business continuity of the activity). Aspects of fire safety design excluded from performance-based design must be clearly highlighted.
2. The technical summary must be signed by the activity manager and by all the parties involved in the design.

M.1.7 Technical report

1. The technical report must show the design solutions to the design fire scenarios.
2. The outcome of the analysis must be summarised with tables, drawings, graphical schemes, images, which present the parameters relevant to the achievement of the fire safety goals in a quantitative manner.
3. Specifically, the following information must be provided:
   a. calculation models used: the designer must provide elements to support the choice of the model used so that the consistency of the choices made with the design fire scenario adopted is demonstrated;
   b. associated parameters and values: the initial choice of the values to be assigned to the parameters at the base of the calculation models must be adequately justified, making specific reference to norms, technical-scientific literature, experimental tests;

c. origin and characteristics of the calculation codes: indications must be provided regarding the origin and characteristics of the calculation codes used, with reference to the name, the author or distributor, as well as the theoretical classification of the calculation method and its numerical translation and indications regarding the recognised reliability of the codes. Furthermore, by reference to the user manuals, it must be indicated that the calculation code is used in its *field of application* and in compliance with the *limitations of use* for engineering applications, *validated* for applications similar to the object of modelling, *verified*;

d. comparison between modelling results and performance thresholds: based on the methodology adopted to carry out the assessments related to the fire scenario considered, all the elements that allow to verify compliance with the performance thresholds indicated in the preliminary analysis must be adequately illustrated, in order to highlight the adequacy of the fire safety measures to be adopted;

4. The printouts related to the calculation and the related input data must be made available.

Note The documentation showing the results and the design path ensures that all interested parties understand the limitations imposed on the activity in relation to the design solution. This documentation must make explicit the criterion with which the safety conditions of the design were assessed, in order to guarantee the correct realisation and maintenance over time of the agreed choices.

M.1.8 Additional requirements for fire safety management

1. With the application of the performance-based methodology the designer bases the identification of the design fire prevention and protection measures on specific hypotheses and operating limitations: therefore, specific measures of *fire safety management* (chapter S.5) must be foreseen so that the reduction in the safety level initially ensured cannot occur.

2. The specific *fire safety management* measures must *refer* to the aspects dealt with in performance-based design, with particular regard to the specific design solutions, to the fire prevention and protection measures adopted, to the maintenance of the operating conditions from which the values of the input parameters in performance-based design derive.

3. On specific *fire safety management* measures, they are subject to periodic checks by the activity manager according to the timing already defined in the design.

4. As part of the programme for the implementation of fire safety management, the measures taken in relation to the following points must be assessed and explained:

   a. personnel organisation;

   b. identification and assessment of the hazards arising from the activity;

   c. operational check;

   d. modifications management;

   e. emergency planning;

   f. safety of rescue teams;

   g. performance monitoring;

h. maintenance of protection systems;

i. control and revision.

5. If the active protection systems are considered in order to reduce the thermal power released by the RHR(t) (chapter M.2) fire or otherwise contribute to mitigating the effects of the fire, *higher availability systems* must be installed.

Note The definition of *higher availability system* is given in chapter G.1.

M.1.9 Criteria for choosing and using models and calculation codes

1. The fire safety professional can opt among the calculation models that the technical know-how of the sector makes available, based on evaluations concerning the complexity of the design.
2. The designer who adopts sophisticated calculation models must possess a particular competence in their use, as well as an in-depth knowledge of both the theoretical foundations underlying them and the dynamics of the fire.
3. At present the most frequently used models are:

   a. analytical models,

   Note For example, correlations for localised fire models or *fire plumes* by Zukoski, Heskestad, McCaffrey, Thomas, Hasemi and Nishiata, Alpert, ...

   b. numerical models including:

      i. fire zone simulation models for enclosed spaces,

      Note For example, CFAST, Ozone, ... calculation codes.

      ii. field fire simulation models,

      Note For example, CFX, FDS, Fluent, ... calculation codes.

      iii. evacuation simulation models,

      Note For example, FDS+EVAC, ... calculation codes.

      iv. thermo-structural analysis models.

      Note For example, Abaqus, Adina, Ansys, Diana, Safir, ... calculation codes..

4. In their field of application, the analytical models guarantee accurate estimates of specific effects of the fire (e.g. the calculation of the *flashover* time in a room). For more complex analyses involving time-dependent interactions of multiple physical and chemical processes present in the development of a fire, numerical models are generally used.
5. For the most relevant input parameters of the model, a *sensitivity* analysis of the results to the variation of the input parameter must be carried out. For example, the results of the analysis should not be significantly dependent on the size of the calculation grid.
6. The simultaneous use of several types of models is allowed. For example:

   a. specific models can be used for the evaluation of the activation time of a detection or extinguishing system and of the breaking of a glass as a function of temperature, to then insert the data obtained in a modelling carried out with field models;

   b. a zone model can be used to initially evaluate the most critical conditions of the phenomenon, to then deepen the treatment of the effects with field models.

M.1.10 References

1. The main references on the subject are the following:

   a. ISO 23932 ‘*FSE – General principles*‘;

   b. BS 7974 ‘*Application of FSE principles to the design of buildings – Code of practice*‘;

   c. BS PD 7974-0 ‘*Application of FSE principles to the design of buildings – Part 0: Guide to design framework and FSE procedures*‘;

   d. ‘*SFPE Engineering Guide to Performance-Based Fire Protection*‘, 2nd ed., 2007;

   e. B Karlsson, J Quintiere, ‘*Enclosure Fire Dynamics*‘, CRC Press, 1999.

Chapter M.2 Fire scenarios for performance design

M.2.1 Preface

1. This chapter describes the procedure for *identifying*, *selecting* and *quantifying* the *design fire scenarios* that are used in the quantitative analysis by the *designer* who uses fire safety engineering.
2. The *fire scenarios* represent the detailed description of the events that can reasonably occur in relation to three fundamental aspects:
    a. fire characteristics;
    b. activity characteristics;
    c. occupant characteristics.
3. The documentation of the procedure of *identifying*, *selecting* and *quantifying* the *design fire scenarios* must comply with the indications of this document, to allow the evaluation of the design by the competent structures of the Fire Brigade.
4. This procedure consists of the following steps:
    a. *identification* of the possible *fire scenarios* that can develop in the activity, on which the outcome of the entire evaluation depends, according to the performance-based method;
    b. *selection* of the *design fire scenarios* among all the possible identified fire scenarios;
    c. *quantitative description* of selected design fire scenarios.

M.2.2 Identification of possible fire scenarios

1. The first step of the procedure consists in *identifying all the possible fire scenarios* that can develop during the useful life of the activity. Related to this, all reasonably foreseeable *operating conditions* must be considered.

    Note For example: temporary setups, different spatial configurations of combustible materials, modification of exit routes and crowding, ...

2. To identify fire scenarios, the designer can develop a specific *event tree* starting from each relevant and credible initiator event. The process can be carried out in a *qualitative* way, or in a *quantitative* way if statistical data are available from authoritative and shared sources.
3. Each identified fire scenario must be fully and unequivocally described in relation to its three fundamental aspects: the characteristics of the fire, the characteristics of the activity and the characteristics of the occupants.
4. In any case, the designer must specify whether the hypothesised fire scenario is related to a *pre-flashover* condition or a *post-flashover* condition, depending on the goal to be achieved.

    Note For example: safeguarding the occupants, maintaining the carrying capacity of the structures, ...

5. In the phase of identification of the scenarios, the designer must take into account the fires that have affected buildings or activities similar to the one under examination by historical analysis and must describe:
    a. *the ignition event* characterised by a fire outbreak and by the surrounding environment conditions;

b. *spread* of fire and combustion products;

c. *action of technological systems* and active protection against the fire;

d. actions carried out by *members of the company team* dedicated to firefighting present in the environment;

e. distribution and behaviour of the *occupants*.

M.2.3 Selection of design fire scenarios

1. In the first step of the procedure a large number of possible fire scenarios in the activity is generally identified. The purpose of this second step of the procedure is to reduce the number of fire scenarios to the minimum reasonable number, in order to lighten the subsequent work of verifying the design solutions.

2. The designer selects the *fire scenarios* and extracts the subset of the *design fire scenarios*, making explicit in the design documentation the reasons that lead to exclude some from the subsequent quantitative analysis, referring to the tree of events already developed in the previous step or with other mode.

3. The designer selects the *heaviest* among the *credible* fire scenarios.

4. The *design fire scenarios* thus selected represent for the activity a fire risk level no less than that fully described by the set of all *fire scenarios.* The design solutions, respecting the *performance thresholds* required in the context of the *design fire scenarios*, therefore guarantee the same degree of safety even with respect to all of the other *fire scenarios*.

5. The selection of fire scenarios is strongly influenced by the goal that the designer intends to achieve. For example, if safeguarding of occupants is the main pursual during the evacuation phase, scenarios such as those indicated below may be selected:

   a. a fire of short duration and fast growth, which is accompanied by high production of smoke and combustion gas (for example, the burning of a upholstered furniture), is more critical than one that releases more thermal power, but which has a slow growth and lasts longer, even if the latter thermally stresses the present building elements more severely;

   b. a fire of limited dimensions, which however develops in the vicinity of the evacuation routes of a room with a high density of crowding, may be more dangerous than one which emits greater thermal power, but which originates in a confined environment and which is located away from zones where occupants are expected to be present.

M.2.4 Quantitative description of design fire scenarios

1. After the selection of the design fire scenarios, the designer must proceed with the *quantitative description* of each of them.

2. The designer translates the qualitative description of the design fire scenarios, already elaborated in the first step, into numerical input data appropriate for the calculation methodology chosen for the verification of the design hypotheses.

3. In relation to the purpose of the analysis, the designer specifies the input data for activities, occupants and fire, listed in detail in the following paragraphs.

M.2.4.1 Activities

1. The characteristics of the activity influence the evacuation of the occupants, the development of the fire and the spread of combustion products. Depending on the objective of the analysis, the quantitative description of the activity may include the following elements:
   a. Architectural and structural features:
      i. location and geometry of the activity, dimensions and distribution of the internal environments;
      ii. structural description, characteristics of the relative load-bearing and separating construction elements;
      iii. description of non-structural and finishing materials;
      iv. evacuation system: dimensions, distribution and emergency exits;
      v. size, location and state of effective opening/closing/breaking of design and potential ventilation openings, such as doors, windows, skylights, glazed surfaces;
      vi. barriers that influence the movement of combustion products.
   b. Installations:
      i. active fire protection systems;
      ii. fire detection, signalling and alarm systems;
      iii. technological systems serving the activity, such as air conditioning, distribution or process installations.
   c. Management and operational aspects:
      i. destination of use of the activity and the production process that takes place there;
      ii. organisation of the hosted activity;
      iii. possible actions implemented by the rescuers, foreseen in the emergency plan, able to alter the propagation of the products of combustion; these actions must be considered only exceptionally and evaluated case by case.

Note For example: closing doors and manually activating alarm systems that can affect the development of the fire and the evacuation of the occupants.

   d. Environmental factors that influence the fire performance of the activity.

Note For example: external temperatures, windiness of the area, noise level which has an impact on the perception of the alarm.

M.2.4.2 Occupants

1. Depending on the objective of the analysis, the designer describes the characteristics of the occupants in detail, in relation to the impact they may have on the fire scenario.
2. In particular, the description must take into account at least the following aspects where relevant for the purposes of the type of analysis:
   a. overall crowding and distribution of occupants in the activity environments;
   b. type of occupants;

Note For example: workers, occasional visitors, the elderly, children, patients, ...

c. familiarity of the occupants with the activity and the system of escape routes;

d. occupant waking/sleeping status.

M.2.4.3 *Fire*

1. Depending on the objective of the analysis, the description of the fire consists in the quantitative characterisation of the fire outbreak, as a source of *thermal energy* and of *combustion products*, according to the following parameters where relevant for the purposes of the type of analysis:

   a. location of the fire outbreak;

   b. type of outbreak: smouldering or with flame;

   c. quantity, quality and spatial distribution of the combustible material;

   d. ignition sources;

   e. RHR curve (*rate of heat release, firepower)*, as thermal power produced by the fire as time varies RHR(t) ;

   f. generation of the combustion products taken into consideration (e.g. CO and particulate matter).

2. For purposes of quantitative characterisation of the fire, the designer can:

   a. employ experimental data obtained from direct measurement in the laboratory according to established scientific methodology;

   b. use data published by authoritative and shared sources. The designer *always quotes* these sources with precision and *verifies the correspondence* of the experimental test sample (quantity, composition, geometry and test modalities) with the one foreseen in the design fire scenario, using a reasonably conservative approach;

   c. use *estimation methodologies*. Paragraph M.2.6 describes some estimation methods borrowed from the literature cited in paragraph M.2.8.

3. Alternatively, the designer can use the predefined fires referred to in paragraph M.2.7 within the limits specified therein.

M.2.5 Duration of design fire scenarios

1. The entire evolution sequence of the fire must be described, starting from the initiator event for a time interval that depends on the safety goals to be achieved as shown in Table 168.

Fire safety goal	Minimum duration of design fire scenarios
Safeguarding the lives of the occupants (Occupants life safety)	From the initiator event until the moment when all occupants of the activity reach or remain in a safe place. If the safe place is near or inside the construction work, any interactions between the maintenance of the load-bearing capacity of the construction work and the safe place must be evaluated.
Safeguarding the lives of rescuers (Rescuer life safety)	From the initiator event up to 5 minutes after the end of the operations planned for the rescuers or the arrival of the fire brigade teams at the activity. The reference time for the arrival of the Fire Brigade can be assumed to be equal to the average of the arrival times taken from the *Statistical Yearbook of the Fire Brigade* (http://www.vigilfuoco.it), considering the data of the last year available, referring to the provinces area.
Maintaining load-bearing capacity in the event of a fire (Structural safety)	From the initiator event until the structural analysis stop, in the cooling phase, to the moment in which the effects of the fire are considered not significant in terms of temporal variation of the characteristics of the stress and displacements

Table 161: Minimum duration of design fire scenarios

M.2.6 Estimate of the RHR curve

1. The quantitative definition of the various phases of the fire reported here refers to the qualitative curve of the image .
2. This methodology can be used:
   a. to construct natural curves with an advanced numerical fire model as per chapter S.2, for the evaluation of the bearing capacity in fire conditions of the construction works;
   b. evaluate the smoke flow rate during the fire for the design of SHES systems.

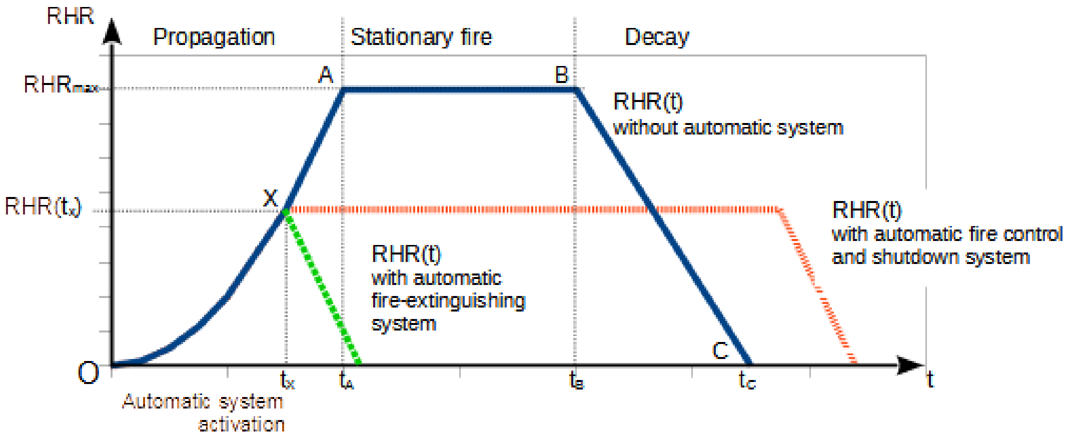


Image: Phases of the fire

M.2.6.1 *Fire propagation phase*

1. During the propagation phase, the thermal power released by the fire at different times RHR(t) can be represented by:

$$RHR(t) = 1000 \left(\frac{t}{t_\alpha} \right)^2 \quad per\, t < t_A \qquad (21)$$

where:

RHR(t) thermal power released by the fire [kW]

t time [s]

t_α required for the heat output to reach 1 000 kW, as defined in chapter G.3. [s]

For some activities, this value can be derived from the tables of Appendix E of Eurocode 1, UNI EN 1991-1-2. For the other activities the value of t_α can be determined based on expert judgment by analogy.

M.2.6.2 *Effect of active fire protection systems*

1. If the activity includes *automatic fire control systems* (e.g. sprinkler system), the trend of the thermal power released RHR(t) does not reach the maximum RHR_{max} value, calculated pursuant to the provisions of paragraph M.2.6.3, which could have reached in relation to the fuel and environmental conditions, but can be assumed to be constant and equal to the value of $RHR(t_X)$ reached at the time t_X of entry into operation of the automatic system. This value remains for an interval of time equal to the duration of the power supply foreseen for the installation, within which it is assumed that the controlled fire is definitively extinguished by manual intervention.

Note At present, in the absence of validation technical reports, oxygen depletion systems cannot be considered to modify the trend of the thermal power released RHR (t).

2. If, instead, *automatic fire extinguishing systems are provided for in the activity* (e.g. ESFR, water mist, etc.), their effect must be assessed on a case-by-case basis in relation to their effectiveness and operational reliability.
3. In any case, the designer is required to implement the operational measures and limitations foreseen in the FSM for the automatic active fire protection systems considered in the design phase, so that the reduced level of assured safety cannot be verified (chapter M.1).
4. Unlike the activation of the automatic systems, the manual intervention carried out by the *firefighting teams* cannot be considered in the design phase for the purpose of modifying the curve trend RHR(t).

M.2.6.3 *Stationary fire phase*

1. In most cases, the thermal energy potentially contained in the fire compartment is sufficient to produce the *flashover* condition and it is assumed that, even after the flashover, the curve grows with the trend still proportional to t^2 up to the time t_A which corresponds to the maximum power RHR_{max} released from the fire in the specific fire compartment.

2. If in the activity there are no automatic control or extinguishing systems for the fire, it is assumed that from the time t_A until t_B the thermal power produced by the fire will stabilise at the maximum value RHR_{max}:

   $RHR(t) = RHR_{max}$ for $t_A \leq t \leq t_B$ 22

3. If the development of the fire is *controlled by the fuel*, as it happens *outdoor* or in buildings with *a high ventilation surface*, the value of RHR_{max} can be provided by the following expression:

   $RHR(t) = RHR_{max}\ A_f$ 23

   where:

   RHR_f value of the maximum thermal power released per unit of gross surface area. For some activities, this value can be derived from the tables of Appendix E.4 of Eurocode 1, UNI EN 1991-1-2. [kW/m²]

   A_f gross area of the compartment in the event of uniform distribution of the fire load, or gross surface actually occupied by the fuel or operational area of automatic fire control systems [m²]

4. If the development of the fire is *limited by the value of the ventilation surface*, as generally occurs in buildings with *ordinary ventilation* surfaces, then the value of RHR_{max} must be reduced as a result of the amount of comburent available that can flow from the ventilation surfaces present in the post-flashover phase. In this case, if the compartment walls have only vertical openings, it is possible to determine the reduced RHR_{max} value through the following simplified expression:

$RHR_{max} = 0.10\ m\ H_u\ A_v \sqrt{h_{eq}}$ 24

where:

m factor of participation in the combustion referred to in chapter S.2 of this document.

H_u lower calorific value of wood equal to 17 500 kJ/kg.

A_v total area of *vertical openings* on all compartment walls [m²]

The equivalent height of the vertical openings h_{eq} is calculated with the following relation:

$$h_{eq} = \frac{\sum_i A_{v,i} h_i}{\sum_i A_{v,i}}$$ 25

where:

h_{eq} equivalent height of vertical openings [m]

$A_{v,i}$ the i-th vertical opening area [m²]

h_i the i-th vertical opening height [m]

If, instaed, the compartment walls also have *horizontal openings* (e.g. SHES), any reduction in the RHR_{max} value must be evaluated with more sophisticated models, for example the fire simulation field models considering all the ventilation surfaces open since the fire started.

5. Given the value of RHR_{max}, the time t_A of the beginning of the stationary fire phase is calculated with the following expression:

$$t_A = \sqrt{RHR_{max} \frac{t_\alpha^2}{1000}} \qquad 26$$

where:

t_A start time of the stationary fire phase [s]

6. The stationary fire phase ends at time t_B, the start time of the decay phase, in which 70 % of the *initially available thermal energy* $q_f \cdot A_f$ has been released into the fire compartment. The value of the energy q_f is evaluated according to the indications contained in chapter S.2..

7. If the thermal energy initially available is *sufficient* for the fire to exceed the propagation phase and reach the maximum RHR_{max}, that is:

$$70\ \%\ q_f \cdot A_f \geq (1/3)\ (1000/t_\alpha^2)\ t_\alpha^3 \qquad 27$$

then the time t_B of the end of the stationary fire phase is calculated with the following expression:

$$t_B = t_A + \frac{70\%\ q_f\ A_f - \frac{1}{3}\frac{1000}{t_\alpha^2} t_A^3}{RHR_{max}} \qquad 28$$

where:

t_B end time of the stationary fire phase [s]

q_f specific fire load [kJ/m^2]

8. If the thermal energy initially available is not *sufficient* for the fire to exceed the propagation phase, the RHR curve reaches its maximum value for a few seconds and then passes directly to the decay phase.

M.2.6.4 *Decay phase*

1. The time t_C, after which the thermal power released by the fire goes to zero, is calculated considering that in the decay phase the remaining 30 % of the initially available thermal energy is consumed:

$$t_C = t_B + (2 \cdot 30\ \%\ A_f / RHR_{max}) \qquad 29$$

where:

t_C time with null thermal power released by fire [s]

2. During the decay phase the trend of the power produced by the fire is linear and therefore:

$$RHR(t) = RHR_{max}\ (t_C - t) / (t_C - t_B)\ \text{for}\ t_B \leq t \leq t_C \qquad 30$$

M.2.6.5 *Other indications*

1. If the definition of the curve propagation phase RHR(t) based exclusively on the characteristic time t_α were considered not representative of the actual evolution of the fire during the propagation phase, in particular in civil buildings, a more detailed definition of the fire growth curve, with specific attention to the spread

of fire and combustion products, which represent the phenomena of greatest interest for the problems of *life safety*, will be necessary

2. The designer can therefore assess the possibility that the fire spreads from items already involved in flames to other combustible elements, by means of an appropriate fire risk assessment. This assessment must be justified during the quantitative analysis.

3. An example of this approach is clearly addressed in NFPA 92 and NFPA 555. These documents show some correlations that can be used to verify whether, in the early stages of fire development, the thermal power released by a burned item could cause the fire to spread to other items due to thermal radiation, depending on the type of materials and on the distance that separates them from items already ignited.

4. The RHR curve can thus be reconstructed as follows:

    a. hypothesise the combustible material initiating the fire;

    b. evaluate the sequence with which the various combustible elements present in the environment are affected by the spread of the fire;

    c. calculate the overall RHR(t) curve, by summing of the contributions over time of the single items. The curves RHR(t) of many types of combustible items present in civil buildings can be easily found in literature.

M.2.7 Predefined fire

1. If assessments are to be omitted regarding the quantitative description of the fire referred to in paragraph M.2.4, the *predefined fires* described quantitatively pursuant to the method indicated in paragraph M.2.6, using the values of the parameters indicated in Table 169, can be used.
2. The use of predefined fires is excluded in cases where it is assessed that the fires expected are more onerous than those indicated in Table 169.

Parameter	Predefined fire	
	for civil activity	for other activities
Characteristic time of fire growth t_α	150 s (*fast*)	75 s (*ultra-fast*)
RHR_{max} total RHR_{max} per m^2 of fire surface	5 MW 250-500 kW/m^2 [1]	50 MW 500 -1 000 kW/m^2 [1]
Particulate yield Y_{soot}	Pre-flashover: 0.07 kg/kg [2.3] Post-flashover: 0.14 kg/kg [2.3]	Pre-flashover: 0.18 kg/kg [4] Post-flashover: 0.36 kg/kg [4]
Carbon monoxide yield Y_{CO}	Pre-flashover: 0.10 kg/kg [5] Post-flashover: 0.40 kg/kg [5]	
Actual combustion heat ΔH_C	20 MJ/kg [3]	
Carbon dioxide yield Y_{CO2}	1.5 kg/kg [3.6]	
Water yield Y_{H2O}	0.82 kg/kg [3.6]	
Radiation fraction of RHR (*Radiative fraction*)	35 % [3]	

[1] To be used as an alternative to the total RHR_{max} considering the maximum surface area of the fire, equal to the fire compartment in the case of uniformly distributed fire load, but which may be a lower value in the case of a localised fire.

[2] Robbins A P, Wade C A, Study Report No 185 *'Soot Yield Values for Modelling Purposes – Residential Occupancies'*, BRANZ, 2008

[3] *'C/VM2 Verification method: Framework for fire safety design'*, New Zealand Building Code

[4] *'SFPE handbook of fire protection engineering'*, NFPA, 4th ed., 2008. Table 3-4.16, page 3-142, from *polyurethane flexible foams*.

[5] Stec A, Hull T R, *'Fire Toxicity'*, Woodhead Pub., 2010. § 2.4 con Φ = 1.25 (*under-ventilated fire*)

[6] As an alternative to Y_{CO2} and Y_{H2O} yields, the $CH_2O_{0.5}$ generic fuel can be imposed in the calculation code.

Table 162: Predefined fires

M.2.8 References

1. The following documents provide a useful guide to the designer from a methodological point of view.
2. Fire scenarios identification:
    a. ISO 16732-1 *'Fire safety engineering – Fire risk assessment',* describes the application to fire risk assessment of the risk analysis methodologies, such as the fault tree and the event tree;
    b. NFPA 551 *'Guide for the evaluation of fire risk assessment'*.
3. Selection of design fire scenarios:
    a. ISO/TS 16733 *'Fire safety engineering – Selection of design fire scenarios and design fires';*
    b. NFPA 101 *'Life Safety Code'*.
4. Estimate of the RHR curve:
    a. Eurocodice 1, UNI EN 1991-1-2 '*Part 1-2: Actions in general – Actions on structures exposed to fire*';
    b. NFPA 92 *'Standard for smoke control systems';*
    c. NFPA 555 *'Guide on methods for evaluating potential for room flashover'*.
5. Quantitative description of the fire:
    a. '*The SFPE Handbook of fire protection engineering*', 5th edition, SFPE/NFPA, 2016.

Chapter M.3 Life safety with performance-based design

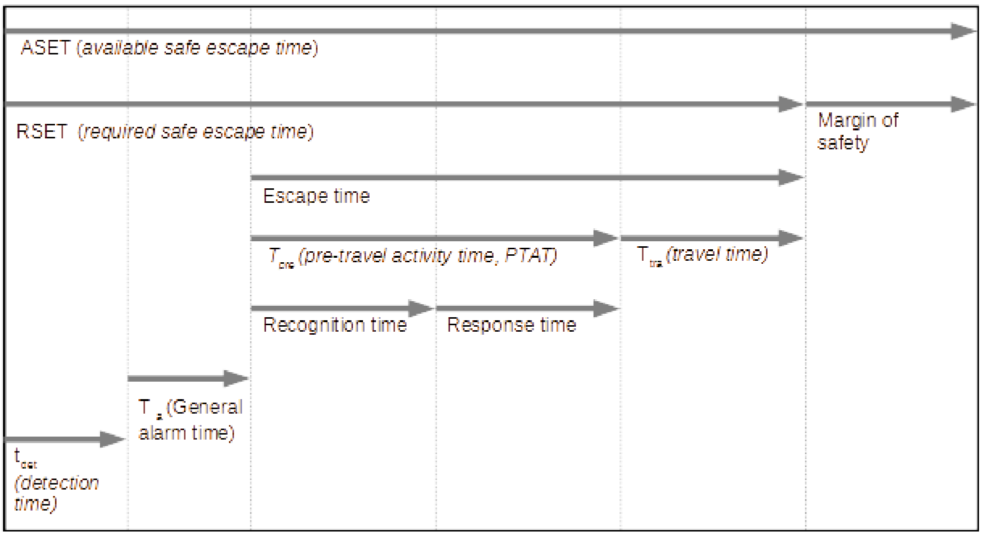
M.3.1 Preface

1. In applying the fire safety performance-based method to life safety, the designer's goals can be:

    a. the direct and explicit demonstration of the possibility for all occupants of an activity to reach or stay in a safe place, without this being prevented by an excessive exposure to the effects of the fire;

    b. the demonstration of the possibility for the rescuers to operate in safety, according to the indications of Tables 171 and 172.

2. The design must follow one of the internationally recognised procedures for assessing the position and condition of the occupants during the evolution of the fire scenarios foreseen for the activity.



Fire scenarious foreseen for the activity

Image 137: Comparison between ASET and RSET

M.3.2 Performance-based design for life safety

M.3.2.1 Ideal criterion

1. The ideal design of an evacuation system should ensure that occupants can reach a safe place or stay put safely, without ever encountering the effects of the fire. This is therefore the first criterion to be used for most of the occupants of the activity.
2. There are situations where the criterion of paragraph 1 is not applicable, in particular for occupants who are in the first ignition compartment of the fire.

M.3.2.2 ASET > RSET criterion

1. To resolve the provisions of paragraph 2 of paragraph M.3.2.1., the standard introduces the ASET > RSET criterion, exemplified in the image.

   The performance-based design of the escape route system consists essentially in the calculation and comparison of two time intervals defined as follows:

   a. ASET (*available safe escape time);*

   b. RSET (*required safe escape time)*.
2. The evacuation system is considered to be effective if ASET > RSET, that is, if the time in which non-incapacitating environmental conditions remain for the occupants is greater than the time necessary for them to reach a safe place, and not be subject to such unfavourable environmental conditions due to the fire.
3. The difference between ASET and RSET represents the *safety margin* of the performance-based design for life safety:

   $$t_{marg} = ASET - RSET \qquad 31$$

   In the comparison between different design solutions, the designer maximises the t_{marg} safety margin in relation to the hypotheses assumed, in order to consider the uncertainty in the calculation of the ASET and RSET times.

   Unless specific assessments are made, $t_{marg} \geq 100\ \%$ RSET is assumed. In the case of specific assessments on the reliability of input data used in performance-based design, it is permissible to assume $t_{marg} \geq 10\ \% \cdot$ RSET.

   In any case, it must be $t_{marg} \geq 30$ seconds.

   Note The specific assessments upon $t_{marg} \geq 10\ \%$ RSET should be supported by consolidated literature or technical standardisation data.

M.3.3 ASET calculation

1. *ASET,* the time available to the occupants to save themselves, depends strictly on the interactions in the fire-building-occupant system: the fire ignites, propagates and spreads its effects, smoke and heat in the building. The building resists fire by means of active and passive protection measures: fire prevention systems, compartmentalisation, smoke and heat control systems. Occupants are exposed to the effects of the fire in relation to the activities they carry out, their initial position, their path in the building and their physical and psychological condition.
2. As a result of paragraph 1, each occupant has an own ASET value. This complexity is solved by the designer with statistical considerations, with numerical calculation models or by assuming the simplifying hypotheses described in paragraph M.3.3.2.
3. The following paragraphs present the *calculation methods* of ASET allowed by the standards:
   a. advanced calculation method;
   b. simplified calculation method.

M.3.3.1 Advanced calculation method for ASET

1. The ASET calculation requires the estimation of the concentrations of toxic products, of the temperatures and of the density of the smoke in the environments following the fire and their variation over time, in so far as the occupants can move in the smoke, which in complex cases can be reasonably processed only with fluid dynamic calculation models. It is in fact the type of fire and activity that together determine the trend of these variables with time.
2. The ISO 13571 standard is the most authoritative reference for the ASET calculation. Global ASET is defined therein as the smallest of the ASETs calculated according to four models:
   a. model of *toxic gases*;
   b. model of *irritant gases*;
   c. model of *heat*;
   d. model of obscuring *visibility* from smoke.

M.3.3.1.1 Toxic gases model

1. The toxic gases model uses the concept of inhaled dose (*exposure dose)* and of *FED (fractional effective dose)*. The *exposure dose* is defined as the dose measurement of a toxic gas available for inhalation, i.e. present in the inhaled air, calculated by integrating the concentration-time curve of the substance for the exposure time. The *FED* is the ratio between this *exposure dose* and the toxic gas dose that determines incapacitating effects on the exposed average subject. When FED = 1 the average subject is considered incapacitated.

Note For example, the incapacitating dose of CO, carbon monoxide, provided for in the ISO 13571:2012 standard is 35 000 ppm · min. This assumes that the average subject exposed to a concentration of 3 500 ppm for 10 minutes is incapacitated. In this case the subject's FED is equal to 1 and ASET for the CO is equal to 10 minutes.

M.3.3.1.2 Irritating gas model

1. The irritant gas model uses the concept of *FEC, fractional effective concentration.* The *FEC* is defined as the ratio between the concentration of an irritant gas available for inhalation and the concentration of the same gas which determines incapacitating effects on the exposed average subject.
2. In order to simplify the analysis, if in the design fire scenarios no combustible materials are identified in the fire that can constitute a specific source of irritating gases (e.g. hazardous substances or mixtures, electric cables in significant quantities, ...) the verification of the model irritant gases may be omitted.

M.3.3.1.3 Heat model

1. For the radiated and convective heat model the standard proposes an approach, based on the FED, similar to that of toxic gases. The proposed equation is the following:

$$X_{FED}=\sum_{t1}^{t2}\left(\frac{1}{t_{Irad}}+\frac{1}{t_{Iconv}}\right)\Delta t \quad (32)$$

The values of t_{Irad} and t_{Iconv} are the times of incapacitation due to radiant heat and convective heat calculated with other relations depending on the condition of the clothing of the subjects, available in the ISO 13571 standard.

2. The verification of the heat model can be simplified by conservatively assuming the following *performance thresholds*:
   a. radiation on occupants ≤ 2.5 kW/m^2;
   b. room temperature around the occupants ≤ 60 °C.
3. These values correspond to an ASET beyond 30 minutes with any clothing condition.

M.3.3.1.4 Visibility model

1. The model of obscuring visibility from smoke is based on the concept of the minimum perceptible contrast, i.e. the minimum difference in brightness visible between an item and the background.
2. To link the value of visibility L to the smoke volume mass (density) ρ_{smoke}, the following experimental correlation is applied to each point of the calculation domain:

$$C=\sigma\rho_{smoke}L \quad (33)$$

where:

L	visibility	[m]
C	dimensionless constant equal to 3 for non-illuminated reflective exit signs or 8 for backlit signage	
σ	mass extinction coefficient of light equal to 8.7 m^2/g or different value adequately justified by the designer	[m^2/g]
ρ_{smoke}	*smoke aerosol mass concentration*	[g/m^3]

Thanks to this correlation, the fluid dynamic calculation codes return the ρ_{smoke} directly and calculate the visibility L for each point of the simulated environments.

M.3.3.1.5 Performance threshold for FED and FEC

1. The values of FED and FEC equal to 1 are associated with *incapacitating* effects of the evacuation calibrated on occupants of average sensitivity to the effects of fire products.
2. To take into account the weaker or more sensitive categories of the population, which would be incapacitated well before the achievement of FED or FEC equal to 1, it is considered reasonable to use the value 0.1 as a *performance threshold* for FED and FEC (limiting to 1.1 % the portion of occupants incapacitated upon reaching the threshold pursuant to ISO 13571), leaving however to the designer the burden of selecting and justifying the most suitable value for the type of population involved.

M.3.3.2 Simplified calculation method for ASET

1. ISO/TR 16738 provides for the possibility of using the simplification hypothesis of *zero exposure*.
2. Instead of checking all of the models in paragraph M.3.3.1. ,the designer uses the following very conservative performance thresholds:
    a. minimum height of the stratified smoke from the walking surface equal to 2 m, below which the undisturbed layer of air remains and
    b. average temperature of the hot smoke layer ≤ 200 ° C.

    These criteria allow the occupants to escape into undisturbed air, unpolluted by the products of combustion, and a value of the radiation from smoke to which they are exposed of less than 2.5 kW/m^2: all of the models referred to in paragraph M.3.3.1. are therefore automatically satisfied and the analysis is considerably simplified because it is not necessary to perform occupant exposure calculations to toxics, irritants, heat and obscured visibility. It is in fact sufficient to evaluate analytically or with numerical zone or field models the height of the pre-flashover smoke layer in the building.

M.3.3.3 Field of applicability of the simplified method

1. The simplified calculation method referred to in paragraph M.3.3.2 is applicable only if the power of the fire related to the geometry of the environment is sufficient to guarantee the formation of the upper layer of hot smoke: the designer is obliged to check that this condition occurs.

M.3.4 RSET calculation

1. RSET is calculated between the ignition of the fire and the moment when the occupants of the building reach a safe place. RSET also depends on the interactions of the fire-building-occupant system: the occupants' escape is strongly conditioned by the building's geometry and is slowed by the effects of the fire.
2. The reference document for the calculation of RSET is ISO/TR 16738.
3. RSET is determined by various components, such as the *detection time* t_{det}, the *general alarm time* t_a, the *pre-travel activity time, PTAT* t_{pre}, the *travel time* t_{tra}:

   $$RSET = t_{det} + t_a + t_{pre} + t_{tra} \quad (34)$$

4. For the purpose of calculating RSET, the designer must develop the *most appropriate design behavioural scenario* for the specific case, because the pre-movement activity and the evacuation speeds depend on the type of population considered and on the methods of use of the building.

   Note The parameters vary greatly if the occupants are awake and familiar with the building, such as in a school building, or sleeping and do not know the structure, as in a hotel.

5. As already indicated for ASET, each occupant also has an own value of RSET.

M.3.4.1 Detection time

1. The *detection time* t_{det} is determined by the type of detection system and the fire scenario. It is the time required for the automatic detection system to notice the fire. It is calculated analytically or with specific numerical modelling of fire scenarios and of the detection system.

M.3.4.2 General alarm time

1. The *general alarm time* t_a is the time that elapses between the detection of the fire and the diffusion of information to the occupants, of the general alarm.
2. The general alarm time will therefore be:
   a. equal to zero, when the detection directly activates the general alarm of the building;
   b. equal to the delay assessed by the designer, if the detection alerts an emergency management centre that verifies the event and then activates the manual alarm.
3. In large and complex buildings the alarm mode must be taken into account, which can be diversified, for example, in the case of a multi-phased evacuation.

M.3.4.3 Pre-travel activity time

1. The *pre-travel activity time* t_{pre} is the object of the most complex evaluation, because it is the time necessary for the occupants to carry out a series of activities that precede the actual movement toward the safe place. The literature indicates that this phase often takes up most of the total evacuation time.
2. The t_{pre} time is made of a *recognition* time and a *response* time.

3. During the recognition time the occupants continue the activities they were carrying out before the general alarm, as long as they recognise the need to respond to the alarm.
4. In response time the occupants cease their normal activities and dedicate themselves to activities related to the development of the emergency, such as: gathering information on the event, stopping and safely setting the equipment, grouping their own group (work or family), fighting the fire, researching and determining the appropriate way of evacuation *(wayfinding)* and other activities, sometimes even incorrect and inappropriate.
5. Depending on the design behavioural scenario, these times can last even several tens of minutes. Table 170 shows some examples of evaluation taken from ISO/TR 16738.
6. The designer can use values different from those indicated in the literature as long as they are adequately justified, also with reference to evacuation drills reported in the control register.

Parameters describing the activity taken from ISO/TR 16738	**Pre-travel activity times ISO/TR 16738**	
	$\Delta t_{pre\ (1st)}$ first fleeing occupants	**$\Delta t_{pre\ (99th)}$ last fleeing occupants**
Example 1: medium complexity hotel ● occupants: *Ciii, sleeping and unfamiliar;* ● alarm system: automatic detection and general alarm mediated by employee verification; ● building geometric complexity: *multi-floor building and simple layout;* ● safety management: *ordinary*.	20’	40’
Example 2: large production activity ● occupants: *A, awake and familiar;* ● alarm system: automatic detection and general alarm mediated by employee verification; ● building geometric complexity: *multi-floor building and complex layout;* ● safety management: *ordinary.*	1’ 30’	3’ 30’
Example 3: nursing home care ● occupants: *D, sleeping and unfamiliar;* ● alarm system: automatic detection and general alarm mediated by employee verification; ● building geometric complexity: *multi-floor building and simple layout;* ● safety management: *ordinary;* ● presence of employees in sufficient quantity to manage the evacuation of the disabled.	5’	10’

Table 163: Examples of the evaluation of the pre-movement time, taken from ISO/TR 16738

M.3.4.4 *Travel time*

1. The *travel time* t_{tra} is the time taken by the occupants to reach a safe place from the end of the pre-travel activities described above.
2. The t_{tra} is calculated with reference to some variables:
   a. the distance of the occupants or groups of them from exit routes;
   b. the evacuation speeds, which depend on the type of occupants and their interactions with the built environment and the effects of the fire. It is demonstrated that the presence of smoke and heat considerably slows down the speed of evacuation as a function of visibility conditions;
   c. the extent of evacuation routes, due to geometry, dimensions, sharp differences in height and obstacles.
3. In reality, when the occupants of densely crowded buildings flee along the evacuation routes, long lines are formed in the narrowings, furthermore, according to the development of the design fire scenarios examined, some paths may become impassable or blocked.

   The calculation of the t_{tra} must take these phenomena into account.
4. Currently, two groups of models are commonly used for the calculation of the movement time: *hydraulic models* and *agent-based models.*
5. Hydraulic models predict with reasonable precision some aspects of occupant movement (e.g. flows through exits), but do not include important factors of human behaviour, such as familiarity with the building, person-to-person interactions and the effect of smoke on their movement.
6. Other types of models (e.g. *macroscopic/microscopic, coarse network/fine network/continuous models*) are the subject of intense scientific research and experimentation; currently only partial validations of the results still exist. Therefore the results must be evaluated with caution.

M.3.5 Performance thresholds for life safety

1. The performance thresholds for life safety determine the incapacitation of the occupants and rescuers when subjected to the effects of fire.
2. The designer chooses suitable performance thresholds for the specific activity, in relation to the design fire scenarios, and in particular with reference to the characteristics of the occupants involved (e.g. elderly, children, with disabilities, ...).
3. Compliance with the performance thresholds for life safety must be verified:
   a. for the *occupants*: in all zones of the activity where there is a simultaneous presence of occupants, permanent or moving, and effects of the fire.
   b. for the *rescuers*:
      i. only if they have a clearly defined role in the emergency planning of the activity,
      ii. in all zones of the activity where there is a simultaneous presence of rescuers, stationary or moving, and effects of the fire.
4. By way of example, in Tables 171 and 172 the performance thresholds for occupants and rescuers are reported with reference to advanced and simplified calculation methods.

Model	Performance	Performance threshold	Reference
Obscuring visibility from smoke	Minimum visibility of reflective panels, not backlit, evaluated at a height of 1.80 m from the walking surface	Occupants: 10 m Occupants in premises of gross surface area < 100 m^2: 5 m	ISO 13571:2012
		Rescuers: 5 m Local rescuers in premises of gross surface area < 100 m^2: 2.5 m	[1]
Toxic gases	FED, *fractional effective dose* and FEC, *fractional effective concentration* due to exposure to toxic gases and irritating gases, evaluated at a height of 1.80 m from the floor level	Occupants: 0.1	ISO 13571:2012, limiting to 1.1 % the portion of occupants incapacitated at the reaching the threshold
		Rescuers: no evaluation	-
Heat	Maximum exposure temperature	Occupants: 60°C	ISO 13571:2012
		Rescuers: 80°C	[1]
Heat	Maximum thermal radiation from all sources (fire, fire effluents, structure) of occupant exposure	Occupants: 2.5 kW/m^2	ISO 13571:2012, for exposures of less than 30 minutes
		Rescuers: 3 kW/m^2	[1]
[1] For the purposes of this table, rescuers are understood to mean the members of the company teams appropriately protected and trained in firefighting, in the use of airway protection devices, to operate in conditions of poor visibility. Further indications can be obtained for example from documents of the Australian Fire Authorities Council (AFAC) for hazardous conditions.			

Table 164: Example of performance thresholds that can be used with the advanced calculation method

Performance	Performance threshold	Reference
Minimum height of the stratified smoke from the walking surface below which the undisturbed layer of air remains	Occupants: 2 m	Reduced by ISO/TR 16738:2009, Section 11.2
	Rescuers: 1.5 m	[1]
Average temperature of the hot smoke layer	Occupants: 200°C	ISO/TR 16738:2009, Section 11.2
	Rescuers: 250°C	[1]
[1] For the purposes of this table, rescuers are understood to mean the members of the company teams appropriately protected and trained in firefighting, in the use of airway protection devices, to operate in conditions of poor visibility. Further indications can be obtained for example from documents of the Australian Fire Authorities Council (AFAC) for hazardous conditions.		

Table 165: Example of performance thresholds that can be used with the simplified calculation method

M.3.6 References

1. The ISO has published two fundamental documents for the analysis of the more technical aspects of *life safety* design:

   a. ISO 13571 '*Life-threatening components of fire – Guidelines for the estimation of time to compromised tenability in fires*';

   b. ISO/TR 16738 '*Fire-safety engineering – Technical information on methods for evaluating behaviour and movement of people*'.

2. *Life safety*, which includes the problems related to the evacuation of the building, is subsystem 6 of BS 7974.

   In this context, the specific reference document for the design of the evacuation system is the *published document PD 7974-6 'The application of fire safety engineering principles to fire safety design of buildings – Part 6: Human factors: Life safety strategies – Occupant evacuation, behaviour and condition (Sub-system 6)'*.