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CHANGES IN THE REQUIREMENTS FOR ENSURING SAFE EVACUATION OF PEOPLE

Abstract: *The report analyses the requirements for ensuring safe evacuation of people from buildings, arising from the latest amendment to Ordinance No. Iz-1971 on construction and technical rules and norms for fire safety in the Republic of Bulgaria, as well as their consequences. The regulatory requirements determining the length of the evacuation route – both within a room and to the final evacuation exit – are examined. The normative requirements for the permissible evacuation time from rooms and buildings are presented, along with two calculation methods for determining the evacuation time from a building.*

Keywords: *evacuation, evacuation time, calculation methods, evacuation route*

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INTRODUCTION

Ensuring safe conditions for the evacuation of people from buildings is a fundamental element of the fire safety and life safety system. Recent amendments to Ordinance No. Iz-1971 (2009) in the Republic of Bulgaria have introduced significant changes in the regulatory requirements governing the organisation and parameters of evacuation processes. The amendments are aimed at refining the criteria for determining the number of residents, the length of evacuation routes, and the permissible evacuation time, as well as improving the methods for evacuation time calculation.

This report aims to analyse the current regulatory requirements for safe evacuation, considering their practical aspects and applicability in the design and operation of buildings. Particular emphasis is placed on the impact of the new regulations on occupant safety, the need to provide adequate evacuation routes and the time constraints imposed for leaving hazardous areas. The analysis also covers the different calculation methods used to estimate evacuation times according to the specificity of the built environment and the functional use of the facilities. Part of this matter is covered in (Dimitrov, 2019)

To determine the fire safety requirements, the buildings, according to Ordinance No. Iz-1971 (2009), are subdivided into five fire resistance levels – I-V. As the degree of fire resistance decreases, the time in which the individual structural elements of the building will lose their properties under fire conditions decreases. The main criteria required of structural building elements are fire resistance: R – load-bearing capacity (the structure retains stability in a fire), E – impermeability (no passage of flames/hot gases), I – thermal insulating capacity (no passage of dangerous levels of heat), and reaction to fire – A1-E. The degree of fire resistance required for any building is directly dependent on its functional use, storey rating, and fire compartment area. The required class of reaction to fire of the building elements and external and internal finishes is also determined in relation to the degree of fire resistance of the buildings. For buildings for which fire resistance class V is permissible, there are no normative requirements for fire resistance class and reaction class of structural elements.

DETERMINATION OF THE NUMBER OF RESIDENTS

To ensure safe conditions for evacuation from a building, it is important to anticipate the number of occupants, based on which, the required number of evacuation exits, their single and total widths, door swing direction, as well as the need for anti-panic locks, are determined. The number of occupants in a building is determined as the sum of the number of people in each room in the building.

Several ways of determining the number of residents in a premises are regulated.

The first way is according to the number of seats or workplaces designated by the investment project.

The second way is through the calculation of the area of the room and the occupancy density defined in Table 8 to Ordinance No. Iz-1971 (2009). The calculation area of the room (floor) is determined by deducting from the floor area of the room the areas of sanitary rooms, elevator shafts, stairwells, racks for the placement of goods and equipment, and storage areas in which visitor access is restricted (Ordinance No. Iz-1971, 2009).

The third way of determining the occupancy of auditoriums where benches are provided is in relation to the numbered seats or, if there are none, 0.70 m/person. In the case of garages, the number of occupants shall be determined by reference to the number of car parking spaces provided, with two persons for each car.

Anti-panic locks shall be provided on doors to rooms that may be crowded with more than 100 persons, and on escape routes from these rooms to the final exits. Panic exit barriers shall be implemented in accordance with EN 1125 Building hardware – Panic exit devices operated by a horizontal bar, for use on escape routes – Requirements and test methods (2008). They shall be implemented with documents complying with the European requirements and detailed in Simeonova (2025).

DETERMINATION OF THE LENGTH OF THE ESCAPE ROUTE

The length of the escape route is the distance a person must travel from the farthest point in the building or facility to the nearest safe exit that leads out of the hazard area. This distance includes passage through rooms, corridors, stairways, and other transitional spaces that form part of the escape route.

The length of the escape route is normatively determined by a number of factors – the number of escape exits, the functional fire hazard class, the storey and degree of fire resistance of the building, the presence of an automatic fire alarm system, and an automatic sprinkler fire extinguishing system.

Evacuation route in a room

The length of an escape route in a room is the distance a person must travel to the nearest means of escape, not taking into account any furniture or equipment located there.

Where only one means of escape is provided, the length from the furthest point in the room to it shall not exceed 20 m. Ordinance No. Iz-1971 (2009) provides for an allowance of up to 30 m for industrial buildings in which solid combustible materials or liquids with a flashpoint exceeding 55 °C are used, provided that the room is located in a single-storey building constructed to first class fire resistance and that an automatic fire alarm system and an automatic sprinkler system are in place. In single-storey buildings with first- or second-class fire resistance, the maximum escape route distance shall be limited to 50 m if the room involves the use of non-combustible substances or materials in a hot or glowing state (emitting radiant heat, sparks, or flames), or if it contains both non-combustible and combustible substances or materials used in wet processes.

The evacuation route from any point of baths, saunas, swimming pools, spas, and the like shall be permitted to be of a one-direction length not exceeding 50 m.

Where two dispersed means of escape are provided from one room, the length of the escape route to the nearest means of escape shall not exceed 40 m. Escape routes are dispersed when the angle between the directions to them from the farthest point in the room (relative to all escape routes in the room) is greater than 45° (Ordinance No. Iz-1971, 2009).

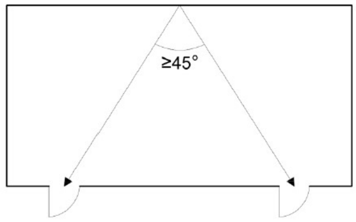

Figure 1. *Dispersed evacuation exits*

An increase in escape route lengths is permitted – up to 60 meters in rooms within industrial buildings that use solid combustible materials or liquids with a flash point above 55 °C, and up to 100 meters in rooms where non-combustible substances or materials are used in a hot or glowing state (emitting radiant heat, sparks, or flames), or where both combustible and non-combustible materials are used in wet processes. These extended lengths are allowed under conditions similar to those applied to one-way escape routes.

Where an area without direct visibility to the means of escape is provided in a room, the length of the route in that area shall be limited to 20 m, and the entire escape route to the nearest exit shall not exceed 40 m.

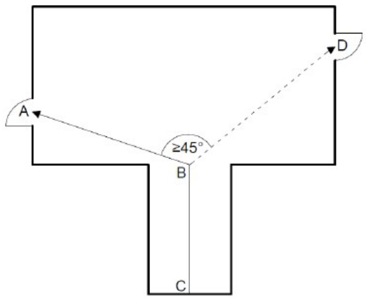

Figure 2. *Length of road from dead-end section*

CB < 20 m;
ABC or DBC < 40 m;

Where the escape route has to pass through an adjacent room, additional measures shall be provided to ensure the safety of the occupants, and the length of the escape route from the furthest point in the internal room to the escape exit from the room through which it passes shall not exceed 20 m. Evacuation through more than one adjacent room shall not be permitted.

Evacuation route to the final evacuation exit

The evacuation of occupants does not end when the occupants leave the premises. Evacuation routes continue through corridors, stairwells, lobbies, etc.

Maximum lengths of evacuation corridors are provided to ensure the safety of residents.

Where it is possible to evacuate in two or more directions, the length from the evacuation exit of each room to a stairway entrance or exit directly to the outside shall not exceed 40 m.

Where corridors are capable of one-way escape, their length shall be limited to 20 m. Similarly, corridors with one-way escape and longer than 10 m (from the doors of the rooms farthest away to the point of alternative escape) shall be separated from their adjacent rooms by self-closing smoke-tight doors with a fire resistance of no less than EI 30 for buildings of class I, II, and III fire resistance and EI 15 for buildings of class IV fire resistance. Characteristics of fire-resistant doors are described in detail in Simeonova (2024b).

Additional requirements for escape routes

The length of escape routes shall be normalized to an exit leading to the outside, an entrance to an escape stairway, or a protected area. A protected area is an area protected by fire-resistant barriers from other areas and is provided with an independent escape route (Ordinance No. Iz-1971, 2009). Partitions to other areas shall be designed as fire walls with fire resistance EI 60, and doors in them shall be self-closing, smoke-tight, and EI 60 fire-resistant. All requirements for fire doors are described in Simeonova (2024a).

Evacuation time

Permissible evacuation time

The maximum permissible time for leaving the premises and buildings is set in the regulations of the Republic of Bulgaria. This time is in direct correlation with the degree of fire resistance. For leaving premises intended for more than 100 persons in public buildings, it is 1 minute, for buildings of class I or II fire resistance, it is 2 minutes. The times for leaving the building are 1 minute and 6 minutes, respectively.

The permissible evacuation time from auditoriums with more than 3000 seats shall be determined in relation to the volume of the room accordingly (Ordinance No. Iz-1971, 2009):

- up to 30 000 m^3 – 2.0 min;
- up to 100 000 m^3 – 2.2 min;
- up to 200 000 m^3 – 3.0 min;
- greater than 200 000 m^3 – 4.0 min.

Production and storage rooms where the formation of an explosive vapour-air or dust-air mixture is possible must be evacuated in less than 0.5 minutes. In production and storage rooms in which solid combustible materials or liquids with a flammable temperature above 55 °C are used or stored, the evacuation of occupants must be completed in less than 1 minute.

Fire hazards directly affect the ability to safely exit a building by threatening human life, but they also significantly complicate the process of evacuation from buildings. These hazards include high temperature, smoke, toxic gases, and reduced visibility and they commonly lead to panic.

Calculation methods for determining the evacuation time

To determine the calculated evacuation time, it is necessary to divide the evacuation path of the residents into separate sections. Separate sections shall be provided where there is a passageway or doorway, a stairway, or a change in width of the path. Escape routes shall be subdivided into horizontal and inclined routes.

The home stretch is where people's movement is formed – the aisles between workstations, between rows of chairs in viewing rooms, around equipment, etc.

The total length of the escape routes shall be determined along their centrelines and shall be equal to the sum of the lengths of the individual sections. In determining the computational evacuation time, the time of the farthest person is sought, which is formed either by the longest evacuation path or by the path that is travelled at the highest density of human flow.

"Escape route length" method

This method is suitable for determining the calculated evacuation time from rooms designed for fewer than 50 persons.

For each of the sections, the human flow density Da_i [person/m^2] and the section length l_i [m] are determined.

For intermediate values of human flow density in the section, the nearest higher value of Da_i from Table 11 of Ordinance No. Iz-1971 (2009) shall be assumed.

Values of Da_i above the cutoff are assumed to be the human flux density cutoff.

The duration of the movement in individual sections is determined by the following formula:

$$\tau = \frac{1}{v}\ [min]. \quad (1)$$

The time to leave the room is calculated as the sum of the travel times through the sections, starting from the farthest point of the room.

$$\tau = \sum \tau_1 + \tau_2 + \tau_3 + \cdots + \tau_n\ [min] \quad (2)$$

"Specific throughput of escape route sections" method

This method takes into account the intensity of human movement, which makes it more accurate when the number of people in a room exceeds 50. Also, the method takes into account the delay time when the specific throughput of the evacuation section is greater than the maximum for this type of section (horizontal or inclined).

The method for calculating the time required to leave the initial sections of the room is analogous to the "escape route length" method.

$$\tau = \frac{1}{v}[min] \quad (3)$$

For each subsequent section, its specific capacity is calculated as a function of the specific capacities and widths of the preceding sections that flow into it.

$$q_i = \frac{q_{i-1}\cdot\delta_{i-1}}{\delta_i}\ [people/m.min], \quad (4)$$

where:

q_i – the specific throughput of section i [people/m.min];

δi – calculated width of section i [m];

$\delta_{(i-1)}$ – the calculated width of the previous section i-1[m].

If more than one upstream reach flows into the reach under consideration, its specific capacity is determined as follows:

$$q_i = \frac{\sum q_{i-1}\cdot\delta_{i-1}}{\delta_i}[people/m.min]. \quad (5)$$

After determining q_i, it is necessary to check against the maximum q_{max} for this type of section (horizontal or inclined).

If $q_i < q_{max}$, then there is no delay in the movement of people in this section and their traversal time will be calculated using the formula

$$\tau = \frac{1}{v}\ [min]. \quad (6)$$

If $q_i > q_{max}$, it means that there will be a slowdown in the flow of people in the section under consideration. This leads to the need to calculate the delay time, which will increase the travel time through the section.

The transit time of a section where there is a delay is calculated using the formula

$$\tau_i = \frac{l_i}{v_{limit\ value}} + N_i\left(\frac{1}{q_{limit\ value}\cdot\delta_i} - \frac{1}{\sum q_{i-1}\cdot\delta_{i-1}}\right). \quad (7)$$

Thus, the time to pass through each of the evacuation sections is calculated, and the time to leave the room is calculated, similarly to the "evacuation path length" method – the sum of the times to pass through the sections starting from the farthest point of the room.

$$\tau = \sum\tau_1 + \tau_2 + \tau_3 + \dots + \tau_n\ [min] \quad (8)$$

Building evacuation time

After determining the calculation time for leaving the room, it is necessary to make a comparison with the legally permissible one. If the calculation time is less than the normative time, then a check shall be performed for the time required to leave the endangered area – to an exit leading directly outside or to a protected area.

The time for leaving the building shall be similar to that for leaving the premises.

It is necessary to calculate the travel time through each of the evacuation sections as well as the cumulative time required to leave the building. It shall then be checked whether the calculated time is less than the norm.

Doorways/passage

Doorways/passage openings shall be defined as separate sections. Two cases are possible in relation to the width of the doors – up to 1.6 m or 1.6 m or more. For each of the options, their specific throughput is tabulated, and for those up to 1.6 m wide, the limiting value is assumed in all cases.

In a similar way to the "specific throughput of escape route sections" method, the specific throughput for the section is calculated.

There are three possible cases against the result:

- If $q_i < q_{max}$ and ℓ<0.7 m, then $\tau_i = 0$ [min];

ℓ – length of the passage (depth of the door frame);

- If $q_i < q_{max}$ and ℓ>0.7 m, then the transit time is calculated using the formula

$$\tau = \frac{1}{v}\ [min]; \quad (9)$$

- If $q_i > q_{max}$, then the transit time is calculated by determining the delay time using the formula

$$\tau_i = \frac{l_i}{v_{limit\ value}} + N_i\left(\frac{1}{q_{limit\ value}\cdot\delta_i} - \frac{1}{\sum q_{i-1}\cdot\delta_{i-1}}\right)[min]. \quad (10)$$

The resulting times required to pass through the doors need to be added to the times required to pass through the evacuation sections in the room or building and the resulting sum will represent the calculated time to exit.

CONCLUSION

The analysis of the recent amendments to the legislation regulating the requirements for safe evacuation of people from buildings in the Republic of Bulgaria shows a significant step towards raising fire safety standards. Refining the criteria for determining the number of occupants, optimising the permissible lengths of evacuation routes, and updating the methods for calculating evacuation times have a direct impact on the protection of human life in crises.

The requirements introduced impose greater responsibility in the design, operation, and maintenance of buildings, emphasising the need for a holistic, systematic approach to risk assessment. Applying the regulations in practice requires not only strict adherence to the prescriptions, but also a thorough understanding of the basic principles of fire safety, in the context of the specific architectural and functional characteristics of each site.

The continuous improvement of the regulatory framework and its adaptation to modern conditions constitute the basis for the sustainable development of a safe and secure living and working environment.

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