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Fire resistance of timber doors – Part 1: Test procedure and classification

DANIEL IZYDORCZYK, BARTŁOMIEJ SĘDŁAK, PAWEŁ SULIK

Fire Research Department of Building Research Institute

Abstract: This paper discusses the main issues related to the fire resistance of timber doors. Fire resistance tests methodology and way of classification of such elements have been presented.

Keywords: *timber glazed door, fire resistance, integrity, thermal insulation, radiation*

INTRODUCTION

Fire resistant door assemblies (doors) for pedestrian or industrial traffic with frame, leaf or leaves, rolled or folded curtain etc. are designed for installation in the openings of the building's vertical internal partitions.

The building and its associated equipment shall be designed and made so that in case of fire it ensures the necessary load bearing capacity of the structure for the time specified in national regulations, limitation of fire and smoke propagation within the building, limitation of fire propagation onto the adjacent buildings and evacuation of people, and it provides safety of the rescue teams.

The above specified detailed requirements are not usually considered individually (e.g. ensuring proper evacuation is connected with the structural load bearing capacity, fire and smoke propagation within the building, and rescue team safety), therefore individual elements of buildings can play several roles during a fire.

This also refers to the building elements such as doors which are usually required in terms of design and execution to ensure that in case of fire they shall for a specific period of time prevent its development from the room or a specific zone where the fire started, and that for the period of time the fire and smoke shall not propagate to other rooms or zones, allow evacuation of people by limiting heat radiation, and facilitate rescue team activities. Doors with proper fire resistance classification allow meeting such requirements.

Every country has different requirements regarding fire resistance of doors (specified by indication of the minimum fire resistance classes of **EI_1**, **EI_2, E and EW**). The requirements are regulated by national regulations and depend, among other issues, on the purpose and use of the building – hotel, hospital, office building, residential building etc., functions assigned to the building doors – separation of the indicated fire zones, separation of apartments or rooms from horizontal gangways, separation of rooms from general gangways, staircase from the garret or attic etc., designation of the room where they are installed – basement, boiler room, garage etc.

Three different types of door designs can be distinguished: metal doors (usually steel or aluminium) with metal frames, timber doors with metal frames or timber doors with timber frames. All the above door design solutions can be made as panelled or glazed (using special fire resistant glazing). The special group being the subject of this paper are the designs made entirely of wood-based materials (timber doors, panelled, in timber frame). The materials used in the timber door assemblies, with full panelling and wooden frame, allow perfect adaptation to the specific character of many rooms, in addition to providing all the above mentioned functions, and make an excellent decorational element of the building interior. Their applications mainly include most public buildings – schools, office rooms and hotels, where privacy, intimacy and general aesthetics are important considerations.

FIRE RESISTANCE TESTING AND CLASSIFICATION [1], [2]

The timber door fire resistance class cannot be calculated or assessed based on comparisons. The sole method allowing to obtain a realistic and clear classification of a specific element is the fire resistance testing. According to standard EN 13501-2 [3], the classifications of fire resistance of fully panelled timber doors shall be developed based on the tests carried out in accordance with standard EN 1634-1 [4] (fire integrity assessment (**E**), fire insulation assessment (**I**), and radiation assessment (**W**)), and the tests carried out in accordance with standard EN 14600 [8] (self-closing feature assessment (**C**)).

The following fire resistance classes are defined (acc. to [3]):

Table 1 *Fire resistance classes of doors*

class									
E	15	20	30	45	60	90	120	180	240
EI_1	15	20	30	45	60	90	120	180	240
EI_2	15	20	30	45	60	90	120	180	240
EW		20	30		60				

*(**E** – fire integrity, **I** – fire insulation, **W** – radiation)*

Fire resistance testing shall be carried out on a specially selected sample, which shall be specified by the test laboratory as a result of comparison of the scope of applications indicated by the Ordering Party with the scope of applications of the test results, as defined in the test standard (in the case of timber doors, it is EN 1634-1 [4]) and in the standard extending the test results application (in the case of timber doors, it is EN 15269-03 [7]). This designates the structure of the element to be tested, type of support to which the doors shall be fixed, type of hardware, as well as the number of necessary tests to be performed. The timber door sample subjected to testing shall be fully representative for the doors used in practice. The doors are required to be classified in the scope of fire resistance on both sides, therefore two sample elements shall be tested (each for one side), unless the element is fully symmetrical i.e. identical on both sides of the axis symmetry as measured in the thickness of the lateral cross section. The hinged or pivoted timber doors in a timber frame are a special type of structure which is sufficiently predictable to allow identification of the "worse" test side of the door for such a door assembly. Positive results of the test of a timber door in a timber frame when heated from the hinge side can be transposed without testing onto the opposite side of the door, i.e. the side opposite to hinges. The timber door in a timber frame tested for heating from the hinge side is the only case where identification of the heating direction can be done during the test, allowing to obtain the classification for the opposite direction of action for the criteria of integrity, insulation, and radiation. It must also be noted that only in the case of the timber door in a timber frame the result of the test in the rigid supporting construction can be applied to the same door assembly when installed in a flexible construction, and the test result for the standard flexible supporting construction can be applied to the door installed in a rigid supporting structure.

Heating of the tested element is carried out according to the standard temperature/time curve. This relationship is the model of a fully developed fire in a room, and is described with formula (1.1).

$$T = 345\ log_{10}(8t + 1) + 20 \qquad (1.1)$$

During the fire resistance testing of timber doors, the following performance efficiency criteria are verified:

Fire integrity (denoted with the symbol **E**) is the ability of the structure element that acts as a partition to withstand fire applied at one side, without transferring the fire to the unexposed

side as a result of flame or hot gas penetration to the other side. Fire integrity assessment is carried out according to three aspects:

- fractures or holes exceeding given dimensions, verified by penetration of a gap gauge of diameters of 6 mm and 25 mm (the integrity is compromised when the 6 mm diameter gap gauge can be inserted into the gap caused by fire action and can be moved on a distance of 150 mm or if the 25 mm diameter gap gauge can be pushed right through the door into the furnace interior),
- a cotton pad is ignited or glows (when touching the surface of the unexposed side of the tested element for 30 seconds),
- existence of flame on the unexposed surface (continuous flame lasting more than 10 s).

Fire integrity classification (**E**) also depends on whether the door is also classified in terms of fire insulation. If an element is classified both in terms of fire integrity and fire insulation ($\mathbf{I_1}$ or $\mathbf{I_2}$), the integrity value is determined using one of the three above criteria which is exceeded as the first. If the timber, fully panelled door is classified without regard to the fire insulation performance, the cotton pad ignition criterion is not considered.

Fire insulation (denoted for the doors with symbols $\mathbf{I_1}$ or $\mathbf{I_2}$) is the ability of the structure element to withstand fire applied at only one side, without transferring the fire to the unexposed side as a result of significant heat transfer from the heated side to the unheated side. Fire insulation assessment is carried out according to the following:

- in the case of fire insulation class $\mathbf{I_1}$:
  - measurement of the mean temperature rise of the unexposed surface of the door leaf, which should be limited to 140°C above the initial mean temperature,
  - measurement of the maximum temperature rise, which should be limited to 180°C at any point of the unexposed door leaf surface, without consideration of the measurement of temperature on the door leaf within the area located at less than 25 mm distance from the border line of the visible door leaf edge,
  - measurement of the temperature rise at any point of the door frame, measured at the distance of 100 mm from the visible edge of the unexposed door leaf surface, provided the door frame is wider than 100 mm, or otherwise, at the door frame/supporting structure border, which should be limited to 180°C.
- in the case of fire insulation class $\mathbf{I_2}$:
  - measurement of the mean temperature rise of the unexposed surface of the door leaf, which should be limited to 140°C above the initial mean temperature,
  - measurement of the maximum temperature rise, which should be limited to 180°C at any point of the unexposed door leaf surface, without consideration of the measurement of temperature on the door leaf within the area located at less than 100 mm distance from the border line of the visible door leaf edge,
  - measurement of the temperature rise at any point of the door frame, measured at the distance of 100 mm from the visible edge of the unexposed door leaf surface, provided the door frame is wider than 100 mm, or otherwise, at the door frame/supporting structure border, which should be limited to 360°C.

According to Table 1, the doors cannot be classified only in terms of fire insulation. The classes denoted with symbols $\mathbf{EI_1}$ and/or $\mathbf{EI_2}$ refer to the fire integrity and fire insulation capabilities. In this case, reaching of any of the fire integrity criteria also means loss of fire insulation, regardless of whether the individual temperature limits of insulation are exceeded or not.

Radiation (denoted with the symbol **W**) is the ability of the structure element to withstand action of fire applied at only one side, to limit the possibility of transferring fire as a result of significant heat radiation by the element or by its unexposed surface to the nearby materials. The elements for which the radiation criterion has been assessed shall be identified by adding

the symbol **W** to the classification (e.g. **EW**). Classification of such elements shall be expressed in the time for which the maximum value of radiation, as measured using the method given in standard PN-EN 1363-2 [6], does not exceed the value of 15 kW/m^2. It is assumed that the element which meets fire insulation properties $\mathbf{I_1}$ or $\mathbf{I_2}$ also meets the **W** requirements for the same period of time.
The fire resistance tests of doors include measurements of displacement measured at the characteristic points of the door assembly, as specified in standard EN 1634-1 [4].
The test is ended as a result of one of the following reasons: exceeding criteria, reaching satisfactory results, request of the Ordering Party, hazard to the personnel or potential damage to the testing equipment.

REFERENCE

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3. *European Standards*
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Streszczenie: W niniejszym artykule omówione zostały główne problemy związane z odpornością ogniową rozwieranych drzwi drewnianych pełnych. Przedstawiona została metodyka badania w zakresie odporności ogniowej oraz sposób klasyfikacji tego typu elementów. Omówione zostały rozwiązania techniczne pozwalające na osiągnięcie oczekiwanej klasy odporności ogniowej. Ponadto przedstawiono oraz porównano przykładowe wyniki przyrostów temperatury na nienagrzewanej powierzchni drewnianych zespołów drzwiowych.

Corresponding author:

Paweł Sulik, p.sulik@itb.pl