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

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

Keywords: timber glazed window, fire resistance, integrity, thermal insulation, radiation

INTRODUCTION

Fire resistant openable window assemblies with frame, leaf or leaves including any side or over panel(s) 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 to be 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. It must be added that fire resisting and smoke control openable windows (and doorsets) can only provide their designed fire resistance or/and smoke control capacity when they are in the closed position.

Every country has different requirements regarding fire resistance of windows (specified by indication of the minimum fire resistance classes of **EI_1**, **EI_2, E or 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 windows and designation of the room where they are installed – basement, boiler room, garage etc.

Three different types of window designs can be distinguished: metal windows (usually steel or aluminium) with metal frames, timber windows with metal frames or timber windows with timber frames. All the above window design solutions can be made as not translucent (filled with panel) or translucent - glazed with fire resistant glazing [15]. The special group being the subject of this paper are the designs made of wood-based materials and glass (timber windows, glazed, in timber frame). The materials used in the timber window assemblies, with glazing, 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 factors.

Fire resistance testing and classification [7 – 14]

The timber widows fire resistance class cannot be calculated or assessed based on comparisons or mathematical calculations. 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 [1], the classifications of fire resistance of timber windows shall be developed based on the tests carried out in accordance with standard EN 1634-1 [2] (fire integrity assessment (**E**), fire insulation assessment (**I**), and radiation assessment (**W**)), and the tests carried out in accordance with standard EN 14600 [6] (self-closing feature assessment (**C**)).
The following fire resistance classes are defined (acc. to [1]):

Table 1 Fire resistance classes of windows (**E** – fire integrity, **I** – fire insulation, **W** – radiation)

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				

Fire resistance testing shall be carried out on a specially selected sample (test specimen), which shall be specified by the test laboratory as a result of comparison of the scope of applications indicated by the Sponsor with the scope of applications of the test results, as defined in the test standard [2] and in the standard extending the test results application [5]. This designates the structure of the element to be tested, type of support construction to which the windows shall be fixed, type of hardware devices, as well as the number of necessary tests to be performed.

The timber window sample (test specimen) subjected to testing shall be fully representative for the windows used in practice (as well as the way of installation of the test specimen). Generally the glazed windows 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). The hinged timber windows in a timber frame are a special type of structure which is sufficiently predictable to allow identification of the "worse" test side of the window assembly. Positive results of the test of a timber window in a timber frame when heated from the hinge side can be transposed without testing onto the opposite side of the window, i.e. the side opposite to hinges. The timber window 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 window in a timber frame the result of the test in the rigid supporting construction can be applied to the same window assembly when installed in a flexible construction, and the test result for the standard flexible supporting construction can be applied to the window 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 windows, 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 window into the furnace interior),
– existence of flame on the unexposed surface (continuous flame lasting more than 10 s),
– a cotton pad is ignited or glows (when touching the surface of the unexposed side of the tested element for 30 seconds).

Fire integrity classification (**E**) also depends on whether the window 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 glazed window is classified without regard to the fire insulation performance, the cotton pad ignition criterion is not considered.

Fire insulation (denoted for the windows 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 window 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 window leaf surface, without consideration of the measurement of temperature on the window leaf within the area located at less than 25 mm distance from the border line of the visible window leaf edge,
  - measurement of the temperature rise at any point of the window frame, measured at the distance of 100 mm from the visible edge of the unexposed window leaf surface, provided the window frame is wider than 100 mm, or otherwise, at the window 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 window 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 window leaf surface, without consideration of the measurement of temperature on the window leaf within the area located at less than 100 mm distance from the border line of the visible window leaf edge,
  - measurement of the temperature rise at any point of the window frame, measured at the distance of 100 mm from the visible edge of the unexposed window leaf surface, provided the window frame is wider than 100 mm, or otherwise, at the window frame/supporting structure border, which should be limited to 360°C.

According to Table 1, the windows 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 **I_1** or **I_2** also meets the **W** requirements for the same period of time.

The fire resistance tests of windows include measurements of displacement measured at the characteristic points of the window assembly, as specified in standard EN 1634-1 [2].
The test is ended as a result of one of the following reasons: exceeding criteria, reaching satisfactory results, request of the Sponsor, hazard to the personnel or potential damage to the testing equipment.

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Streszczenie: *Odporność ogniowa okien drewnianych – Część 1: Metodyka badania oraz sposób klasyfikacji.* W niniejszym artykule omówione zostały główne problemy związane z odpornością ogniową rozwieranych okien drewnianych pełnych. Przedstawiona została metodyka badania w zakresie odporności ogniowej oraz sposób klasyfikacji tego typu elementów.

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