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Fire resistance tests for fire dampers

Passive fire protection is civil engineering discipline which is very popular for research and development of new construction products and test standards. The primary function of passive fire protection product is to achieve the declared fire resistance. Fire resistance of a construction product is expressed as a time interval (30 min, 60 min, 90 min, 120 min ...) in which certain properties of the tested product are preserved. In the given time intervals, it is necessary for the tested product to maintain the thermal insulation properties (I), integrity (E) and additional properties prescribed by the test standard related to the tested product. The fire damper represents part of HVAC system installed on walls which are fire resistance barriers [2]. Additional properties related to fire-resistant service installations- fire dampers (hereinafter only fire dampers) are the leakage on the fire damper in the cold state and the leakage of fire damper (S) during the fire test. In order to determine the previous properties, a test installation for fire dampers was formed, which consists of: installed damper in the test wall, duct and pipeline system, system for measuring the volume flow, cooler and a fan. All the obtained results are graphically presented in the paper and serve for the purpose of determining the mentioned fire properties of dampers and for the purpose of fire resistance classification of construction products.

1 Introduction

The fire resistant damper can be tested in vertical and horizontal positions depending on of end-use application of fire damper. In the Laboratory for Thermal Technique and Fire Protection of the IMS Institute (hereinafter only the Laboratory), products are tested in a vertical position on a vertical test furnace. The standard fire test and fire curve is obtained according to SRPS EN ISO 1363-1 [1]. The fire curve represents the standard temperature logarithmic curve in the test furnace while the test standard for fire resistant dampers is SRPS EN 1366-2 [2]. The test was performed on two fire-resistant dampers of rectangular cross-section. The reason why the test is performed on two fire dampers (on the largest and on the smallest) is for the purpose of fire classification of dampers in accordance with the standard [3].

2 Fire resistance test –general conditions

The fire resistance testing of construction products is performed on standard test in horizontal and vertical furnace, which usually has dimensions of 3000 x 3000 mm, while the depth or height of the furnace is not specifically determined. Test samples are installed on the wall of the test furnace, the primary function of sample is to be barrier of spreading fire from the exposed side of the sample (side inside the furnace) to the unexposed side of the sample (side of the sample outside the furnace).

Inside the volume of the furnace, the standard [1] defines the temperatures as a function of time and the pressure gradient along the height of the furnace. The temperature curve in the furnace (exposed side of the sample) as a function of time is defined by the logarithmic fire development curve given by the following expression:

$$T[°C] = 345 \log_{10}(8t + 1) + 20 \quad (1)$$

where t is a time in minutes. In Figure 1 the standard fire test logarithmic curve is showed:

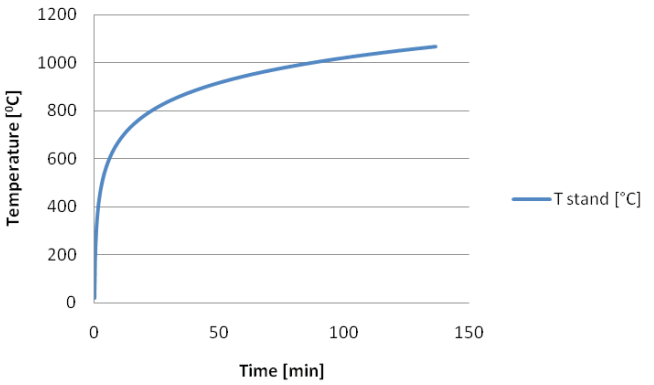


Figure 1: The stanard logarithm fire curve

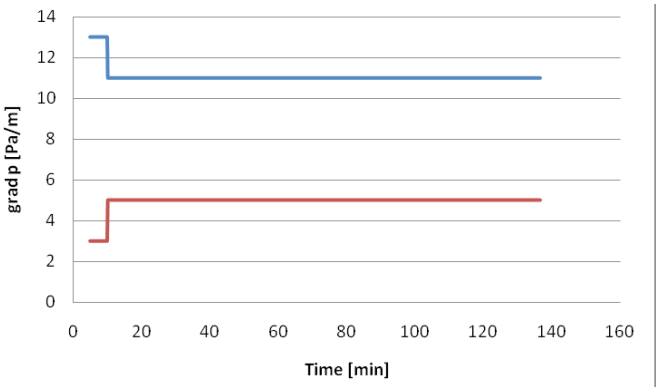


Figure 2: The limits of the pressure gradient inside the furnace

The pressure gradient in the furnace is also defined by standard [1] where the limits of the pressure gradient during the test are showed. Due to the heating of the furnace at the beginning of the test,

the tolerance of the pressure gradient is higher and that is shown in Figure 2. After 5 minutes of testing, it is necessary to achieve pressure gradient inside the defined limits of the pressure gradient. The most common value of the pressure gradient in the furnace is 8.5 Pa/m.

Within the volume of the furnace, the 6 thermocouples, type K, are installed, in a horizontal position, so that each of the thermocouples covers an area of 1.5 m². Thermocouples inside the furnace were installed in accordance with standard [1] at a distance of 100 mm from the test sample.

3 Testing of thermal insulation properties of the fire dampers

The thermocouples T-type were placed on the unexposed side of the sample. The task of thermocouples on the unexposed side of the sample is to edit the current temperature on the sample during the entire test period. The purpose of using thermocouples on the non-exposed side of the sample is to keep track of thermal insulation properties of the fire dampers (I). It is considered that the thermal insulation properties of the fire dampers are conserved if temperature increases of 180˚C or 140˚C on the unexposed side are not reached, depending on the position of the measuring point defined by the test standard [2]. In order to understand testing method of thermal insulation properties during the test period, the installed thermocouples for the tested damper are given in Figure 3.

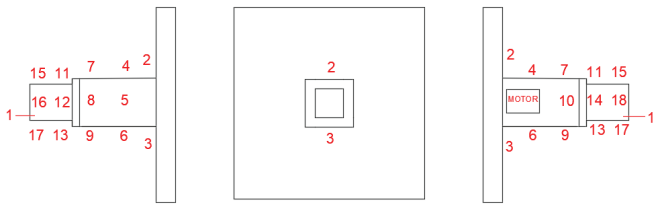


Figure 3: The schedule of thermocouples on unexposed side of the damper

There are two prescribed rules for placing thermocouples on the unexposed side of the sample. First rule is placing thermocouples on distance of 25 mm and second one is on distance of 300 mm. Thermocouples 2 and 3 on the Figure 3 are thermocouples on the test wall which are placed 25 mm from the penetration of the dampers through the test wall. While thermocouples 3,4,5,6 are also at a distance of 25 mm from the wall. Thermocouples 11,12,13,14 are placed 25 mm from the edge of the installed thermal insulation of the ventilation duct. For thermocouples that are placed at a distance of 25 mm, the allowed temperature increase is 180˚C (in practice, the term maximum temperature increase is used). The other thermocouples are set at distance of 300 mm to determine average temperature increase; the allowed average temperature increase is 140˚C (in practice, the term average temperature increase is used).

Thermocouple number 1, is located on the central line of the ventilation duct and it measure temperature of the gases in the ventilation duct.

4 The integrity test of fire dampers

Integrity (E) as a property of a construction product tested to fire resistance test means preventing the penetration of a sustained flame towards the unexposed side of the sample. Methods for checking the integrity of construction products are prescribed by standard [1] and relate to the assessment of the integrity of the penetration of the ventilation duct of the dampers.

In the case of fire dampers, there is an additional condition for the assessment of integrity, which is determined by using a measuring installation for testing dampers. The integrity of the damper is failed if the measured volumetric flow reduced per unit area of the damper is more than 360 m³ / (m² • h). The installation for testing fire-resistant dampers is shown in Figure 4.

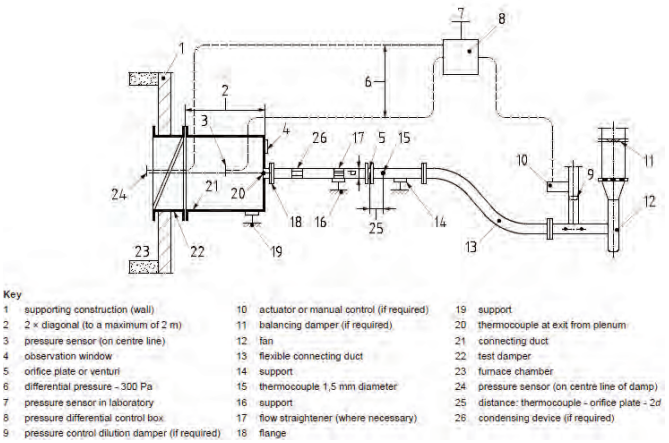


Figure 4: The installation for testing fire dampers with technical details, Source: Standard (EN 1366-2)

5 Technical details of the fire dampers testing

On the Figure 4 is shown the installation for testing fire dampers in a vertical test furnace. The damper (22) is symmetrically installed in the furnace wall (23). An auxiliary ventilation duct is added to the damper where the length of duct corresponds to twice value of the diagonal length of the rectangular damper or the diameter of the damper (2). A circular flange (18) is placed on the ventilation duct, where flexible pipe is connected.

Due to the achieving a turbulent velocity profile within the channel of circular cross-section on the installation for testing dampers within the IMS Institute, Laboratory for Thermal Technique and Fire Protection, no fluid rectifier was used (17). The technical staff of the Laboratory has designed a condensing unit (26) whose task is that the temperature behind the measured aperture (15) does not exceed a temperature of 40˚C. The standard measuring aperture (5) was not used to measure the volume flow, but the hot-wire method for measuring the flow rate was used.

The entire installation is connected to a fan (12) whose task is to achieve a pressure drop on the closed damper (pressure drop of 300 Pa between points (24) and (3) located on the central line of the damper). Other technical details are shown and numbered in Figure 4

are carried out on the measuring installation.

6 Installed test method in Laboratory

The Figure 5 shows damper with a square cross-section with dimensions 150 x 150 mm, which is insulated with mineral wool coated with a fire-retardant coating on the exposed and non-exposed sides of the damper. The damper is installed in a flexible gypsum wall with a total thickness of 250 mm. An auxiliary ventilation duct is installed on the damper; the length of auxiliary ventilation duct is doubled value of the diagonal of the damper. Figure 5 also shows a probe for measuring the pressure inside the furnace and green plastic tube for measuring the under pressure behind the damper in order to achieve a pressure difference of 300 Pa during the entire test period.

Figure 5: The damper installed in a flexible wall

Figure 6: Test equipment installed in Laboratory

In the Figure 6 the manner in which the test installation was performed has been shown. The auxiliary ventilation duct is connected to a spiral steel pipe that is connected to a heat exchanger (flue gas - water) developed within the Laboratory. After the heat exchanger, a measuring pipeline was installed, on which the velocity of the lue gas is measured by the hot-wire method. After the pipeline for determining the flow rate (Figure 7), a flexible pipe was installed which is connected by a flange to a radial fan which is controlled by a frequency regulator (Figure 8).

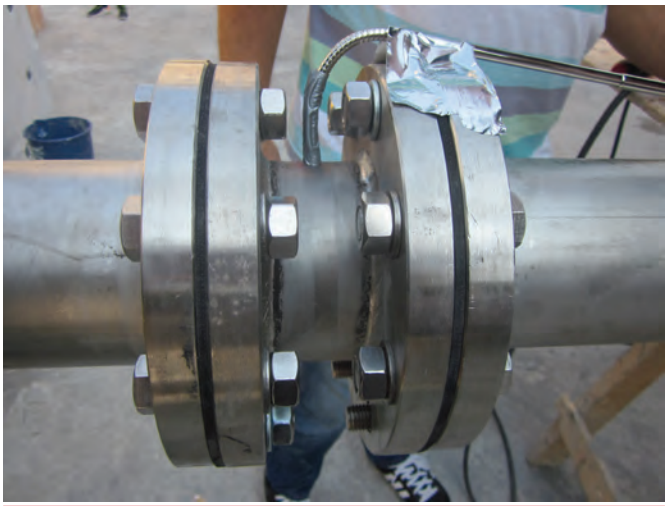


Figure 7: Flow rate measurement

Figure 8: Frequency regulator and device for measuring the pressure difference

7 Checking the tightness of the test instalation

The first procedure that needs to be carried out according to the test standard is to check the tightness of the testing installation shown in Figure 4. The check is carried out by closing the damper and placing a flat flange in front of the damper. The next step in testing dampers is to achieve a pressure drop of 300 Pa on the dampers and measure the volumetric flow which assesses the tightness of the measuring system.

If the volume flow at ambient conditions is ≤ 12 m³/h, then it is considered that the tightness of the measuring system is achieved.

8 Damper tightness test - determination of S class

Another procedure that needs to be performed according to the test standard is to check the tightness of the damper, which is determination of the volumetric flow when the damper is closed. This test is performed in the cold and hot state (in case of fire) for the largest damper, while for the smallest dampers this type of test is optional and it is usually only performed in the cold state.

Except in the cold state, the tightness of the damper is monitored during the fire test for large dampers, where the measure of damper tightness is volume flow reduced per unit cross-sectional area of the damper ≤ 200 m³/h m². If the value of the volumetric flow is lower than the prescribed limit during the entire duration of the test, the damper is assigned S class.

9 Fire test of the dampers

After the previous tests, the main test is conducted, a fire test. Before activating the burner, it is necessary to achieve an air flow velocity of 0.15 ± 0.02 m/s inside the auxiliary ventilation duct. After fulfilling this request, the burners are activated and the time for which the damper closes is recorded (damper sensor response time). If the damper is not closed, the test is considered unsuccessful.

In the first five minutes of the test after closing the damper, it is necessary to achieve a pressure drop on the damper of 300 Pa.

During the testing of the damper, the thermal insulation properties (I), the integrity (E) and the tightness of the damper (S) are monitored, i.e. properties of products used for the purpose of fire classification of fire-resistant dampers.

10 Test results

In this chapter the results of fire tests for the largest and smallest dampers of the same construction has been presented. The tested dampers are installed in a segment of gypsum wall that is stiffened into a wall of aerated concrete. Dampers measuring 150 x 150 mm and 1500 x 800 mm were tested within the Laboratory for thermal technique and fire protection.

Verification of thermal insulation properties (I) is determined on the basis of the values of measured temperatures on the non-exposed side of the sample. In chapter 3 are presented the detailed procedure for evaluating thermal insulation properties, while the following diagrams show the measured temperatures on the unexposed side of the sample that are below the prescribed limits in the test duration interval of 120 min.

Integrity (E) is determined on the basis of the prescribed values of volumetric flow reduced per unit area of the damper cross-section - Chapter 4. In addition to volumetric flows on dampers during the test period, other integrity-related product properties were observed, such as sustainable flame and burning of cotton pad.

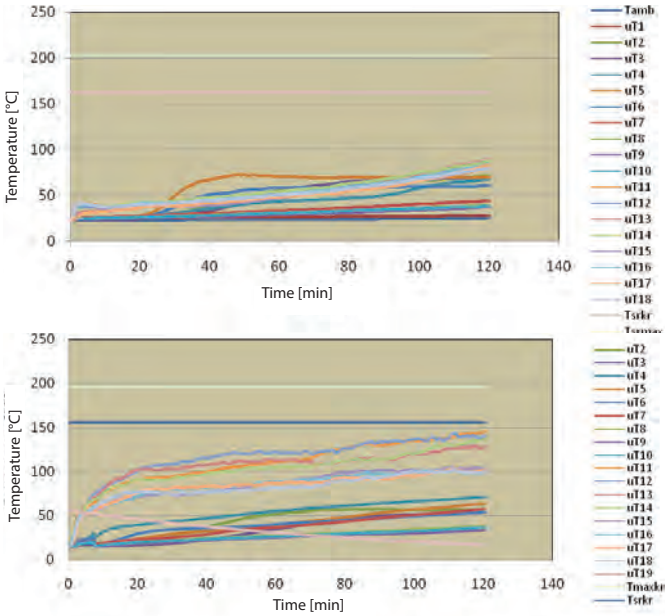
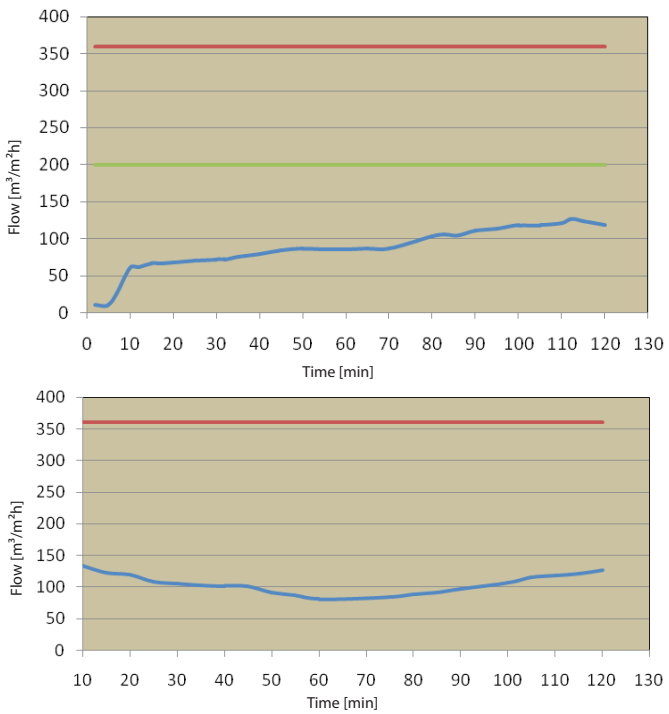


Figure 9: The measured temperatures on the unexposed side of the sample with large damper (up) and small damper (down)



Slika 10: Measured values of volumetric flow per unit cross-sectional area of the damper for large damper (up) and small dumper (down)

The fire damper tightness test (S) is determined on the basis of the prescribed values of the volumetric flow per unit area of the damper cross - section within Chapter 8.

After the test, the process of preparing the test report and classification report in accordance with the standard SRPS EN 13501-3 [3] is performed. The test report shows the test results of fire-resistant

dampers, while the classification report shows the product class in the form, EI (30, 60,..., 180) S. For the tested dampers, the class EI 120 S is achieved. The field of application of the product is also prescribed. Preparation of classification reports for construction products is mandatory and is regulated by the national rulebook [4] which is explained in [5].

11 Conclusion

In this paper a methodology for testing fire - resistant dampers in a vertical furnace with a standard curve of fire development in a test furnace has been presented. The properties of the product (integrity, thermal insulation properties and tightness of the dampers) which are used to assess the fire resistance of fire resistant dampers are explained in detail. There is also shown a standard installation for testing dampers as well as a test installation within the IMS Institute. Chapter 10 presents the test results for the smallest to the largest damper of the same construction. The results showed that the tested dampers met the class EI 120 S.

Acknowledgements

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