EXAMPLE OF PROVIDING DESIGN PARAMETERS OF SMOKE VENTILATION

EXEMPLO DE FORNECIMENTO DE PARÂMETROS DE PROJETO DE VENTILAÇÃO DE FUMO

EJEMPLO DE PROPORCIONAR PARÁMETROS DE DISEÑO DE VENTILACIÓN DE HUMOS

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Abstract
Ensuring the safety of people during evacuation in the event of a fire in a building is one of the highest priorities in the design of smoke ventilation systems (hereinafter SVS). Engineers are faced with the question of how to achieve the required parameters and fulfil all the relevant requirements for systems according to regulatory documentation. Often, design experience must be combined with activities directly related to supervision of compliance with the installation of a developed and released project at the facility itself. The purpose of this study is to demonstrate one of the problems in the design of SVS systems and to propose a way to solve it, based on practical experience.

Key words: safety, air balance, smoke ventilation, evacuation

Resumo
Garantir a segurança das pessoas durante a evacuação em caso de incêndio em um edifício é uma das maiores prioridades no projeto de sistemas de ventilação de fumaça (doravante SVS). Os engenheiros se deparam com a questão de como atingir os parâmetros exigidos e cumprir todos os requisitos relevantes para sistemas de acordo com a documentação regulamentar. Muitas vezes, a experiência de projeto deve ser combinada com atividades diretamente relacionadas à supervisão do cumprimento da instalação de um projeto desenvolvido e lançado na própria instalação. O objetivo deste estudo é demonstrar um dos problemas no projeto de sistemas SVS e propor uma forma de resolvê-lo, com base na experiência prática.

Palavras-chave: segurança, balanço de ar, ventilação de fumaça, evacuação

Resumen

Garantizar la seguridad de las personas durante la evacuación en caso de incendio en un edificio es una de las máximas prioridades en el diseño de los sistemas de ventilación de humos (en adelante SVS). Los ingenieros se enfrentan a la cuestión de cómo lograr los parámetros requeridos y cumplir con todos los requisitos relevantes para los sistemas de acuerdo con la documentación reglamentaria. A menudo, la experiencia de diseño debe combinarse con actividades directamente relacionadas con la supervisión del cumplimiento de la instalación de un proyecto desarrollado y lanzado en la propia instalación. El propósito de este estudio es demostrar uno de los problemas en el diseño de sistemas SVS y proponer una forma de resolverlo, basado en la experiencia práctica.

Palabras clave: seguridad, balance de aire, ventilación de humos, evacuación

1. INTRODUCTION

According to the Code of Rules 7.13130.2013 (2013) "Heating, ventilation and air conditioning. Fire safety requirements" from Amendment No. 1, 2 (there is a disagreement with (Code of Rules 253.1325800.2016, 2017)) when operating smoke removal systems (hereinafter referred to as the SRS) and smoke removal compensation systems (hereinafter referred to as the SCS), it is required to ensure a pressure drop on the doors from the inter-apartment corridor of no more than 150 Pa. In buildings with a height of less than 75 meters residential and less than 50 meters public systems work as a single fire compartment (Zakharov, Zabalueva, 2022). According to the Code of Rules 253.1325800.2016 (2017). "Engineering systems of high-rise buildings" with amendment No. 1, a breakdown by fire compartments is required for fire protection systems to ensure the possibility of setting up the system and compliance with the requirement not to exceed 1000 Pa on the network. According to the requirements of Federal Law No. 123 (July 14, 2022) “Technical Regulations on fire safety requirements”, design engineers must ensure the possibility of safe evacuation of people (Vinichenko et al., 2021; Artamonova et al., 2022). Considering the totality of the above requirements, we must analyse two fundamentals (Fig.1):

1. The fans of the remote control and the remote control are located within a single floor;
2. The fans of the remote control and SCS are located on different floors.

Their location directly affects the pressure drop created in the corridor, since the resulting imbalance shifts the value of the pressure drop on the floor for the worse – in the direction of increasing the pressure drop. This can serve as one of two scenarios, where the first is the formed positive imbalance, which directly affects the inflating of the fire. The second option is the negative imbalance created, which leads to a deterioration of the conditions for evacuation. Both of these options do not suit us, and we strive to find the most optimal way to solve this problem. One of them is proposed to be considered in the framework of this article. It consists in creating additional resistance on the valves that are closer to the ventilation system, and as you move away from the fan, this resistance should decrease (Duisenova et al., 2020; Berezhnov, 2022). This should be organized by reducing the size of the valve. The additional resistance created in this way will largely neutralize the difference in the pressure drop on the corresponding floors and will not prevent the opening of the evacuation door, nor will it further inflate the fire (Zenin, Nekrasov, 2022; Martirosyan et al., 2022).

It is worth noting that this method is effective for installations located at different levels. Fans that stand on the same floor do not need this optimization of the size of valves on the network of smoke ventilation ducts (Xiang et al., 2023). The stages of this study with the relevant conclusions are presented below.

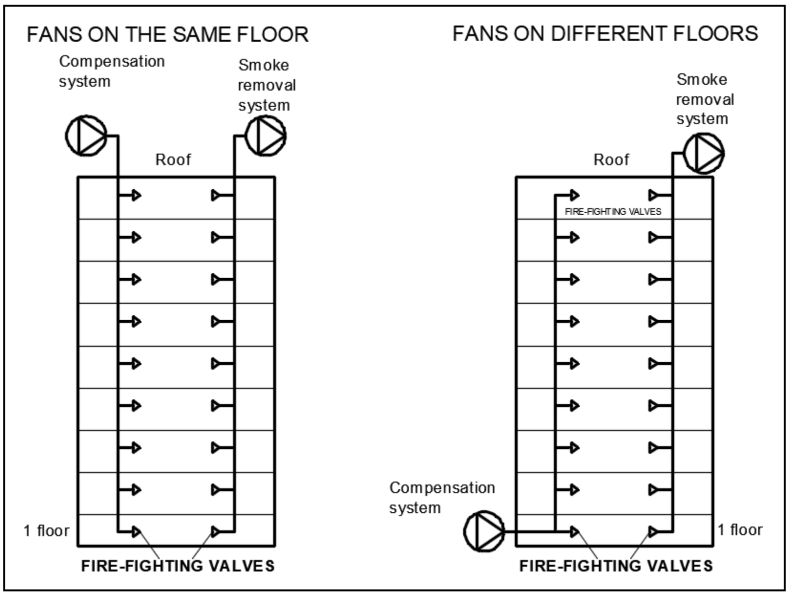

Figure 1. Arrangement of fans

2. METHODOLOGY

To carry out calculations, it is necessary to refer to methodological recommendations No. 5.5.1 "Smoke ventilation systems of residential and public buildings" (2023), which contains formulas for calculating the option under consideration, namely, the location of installations on different floors within one fire compartment. As a basis, one of the standard projects was adopted, for which a smoke removal system was calculated in the standard version and then an analogue of simulating a change in resistance over the network by changing the section of the smoke valves was performed. The goal was to obtain two values that are accepted for the selection of the fan-this is the volume-hour flow rate, m^3/h and the pressure that the fan needs to overcome. Consider the calculation of the smoke removal system.

To find the volume-hour flow rate, it is required to calculate the mass-second flow rate according to the formula (1) and the smoke temperature (2) in the inter-apartment corridor, from where the evacuation to the protected rooms and spaces takes place.

Then the mass flow rate on the fire floor is determined by the following formula (1):

$$G = kB \cdot H^{3/2} \quad (1)$$

The mass flow rate of leaks/suction through leakages of fire-fighting valves should be determined by the formula (2):

$$G_i = \left(\frac{\Delta P}{S}\right)^{1/2} \quad (2)$$

The second indicator is smoke, depending on the type of corridor it is calculated according to one of the following dependencies:

<u>for a corridor of angular configuration</u>

$$T = (-0{,}0488x^2 - 0{,}8243x + 77{,}346) + T_{in} + \frac{1{,}22 \cdot (T_0 - T_{in})(2h_{sm} + \frac{F}{l})}{l}\left(1 - \exp\left(\frac{-0{,}58l}{2h_д + \frac{F}{l}}\right)\right) \quad (3)$$

<u>for a straight-line corridor configuration</u>

$$T = (0{,}0368x2 - 3{,}9259x + 119{,}81) + T_{in} + \frac{1{,}22 \cdot (T_0 - T_{in})(2h_{sm} + \frac{F}{l})}{l}\left(1 - \exp\left(\frac{-0{,}58l}{2h_д + \frac{F}{l}}\right)\right) \quad (4)$$

<u>for a ring configuration corridor</u>

$$T = (0{,}0067x2 - 4{,}3122x + 88{,}453) + T_{in} + \frac{1{,}22 \cdot (T_0 - T_{in})(2h_{sm} + \frac{F}{l})}{l}\left(1 - \exp\left(\frac{-0{,}58l}{2h_д + \frac{F}{l}}\right)\right) \quad (5)$$

In this study, it is supposed to consider a rectilinear corridor and use formula (4).

Further, according to formula (6), knowing the mass-second flow rate and the temperature of smoke, through density we translate the obtained values into volume-hour flow rate according to formula (7).

Determination of smoke density:

$$\rho_N = \frac{353}{T} \quad (6)$$

Determination of the volume-hour flow rate:

$$L = \frac{3600 \cdot (G + \sum G_i)}{\rho_N} \qquad (7)$$

3. RESULTS OF THE CALCULATION

Consider the second required value-pressure. To determine the final value, similarly to the principle of determining the flow rate, it is necessary to calculate the pressure on the floor of the fire according to the formula (8) and then, by subsequent iterations, recalculate the redistribution of pressure over the next floors (9).

The pressure on the considered floor of the fire:

$$\Delta P_{valve} = \frac{\varsigma \cdot \rho_i \cdot V_{valve}^2}{2}. \qquad (8)$$

Redistribution of pressure on the remaining floors:

$$P_{sh_i} = P_{sh_{i-1}} - \lambda \cdot \frac{h_i}{d} \cdot \frac{\rho_{sh_{i-1,i}} \cdot V^2_{sh_{i-1,i}}/1{,}2}{2}. \qquad (9)$$

Having found out how to determine the basic values, let's consider the pressure redistribution graph for the case when all fire-fighting valves were the same within one fire compartment and additionally display a visual difference in pressure redistribution when one fire compartment was conditionally divided into several zones and, accordingly, different valve sections were adopted for each zone.

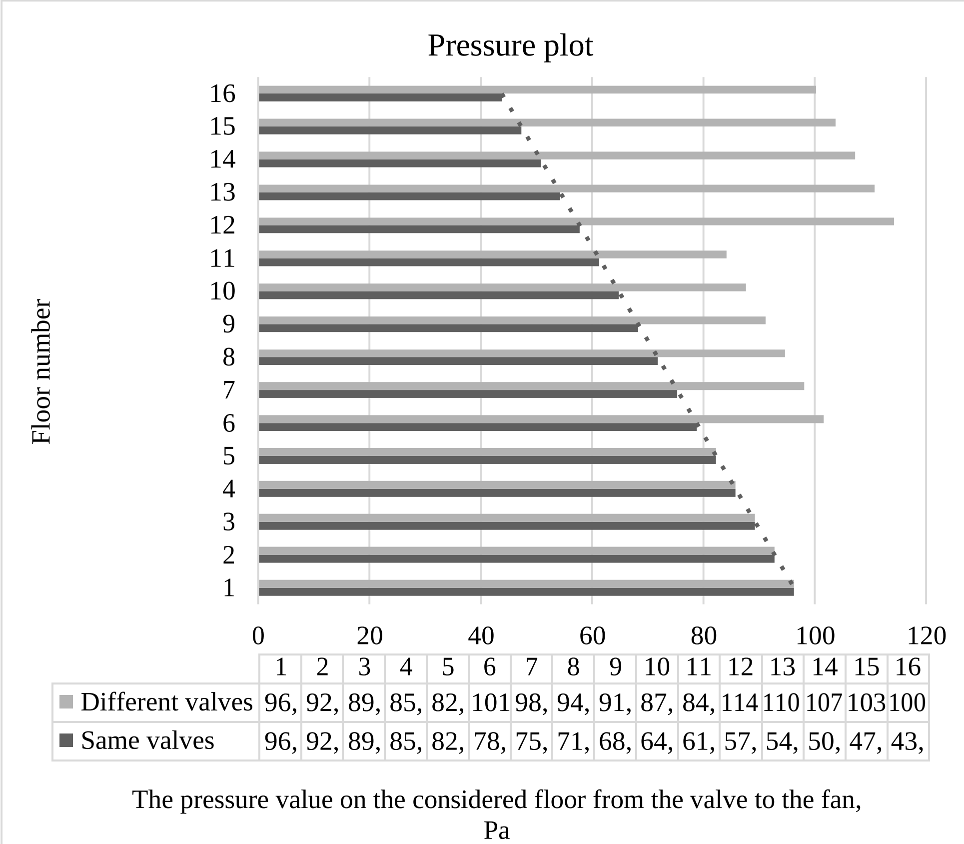

Figure 2. Plot of pressure distribution across floors for identical and different fire-fighting valves

It should be understood that the gradation step of the valve cross-section starts from 50 millimetres, so the balancing accuracy is significantly reduced. In this case, it is impossible to reach the conditional straight line of the pressure distribution diagram. But by implementing the developed method for smoke removal and compensation systems in the inter-apartment corridor throughout the entire network with different fan locations, it will largely be able to neutralize the problem of significant pressure drops, since the introduction of this method in the development of projects cannot worsen the operating mode of the systems (Khoruzhy et al., 2022; Li et al., 2022). This method is safer and more cost-effective due to the reduction of consumable material. The development of the topic will have the opportunity to implement this into a real building project and check all the described methods and methods of regulation (Manuylenko et al., 2022).

4. CONCLUSION

The following tasks possessing a theoretical significance have been performed in this work:

1) A method of regulating the pressure drop on the floors was demonstrated when the installations are located on different floors.

2) Calculations are performed and a pressure redistribution plot is derived in the case of identical and different valves.

3) The vector of development of this topic has been formed for using this method in aerodynamic tests and obtaining empirical values.

Based on the data obtained, we first of all urge the professional community to pay attention to the fact that it is impossible to identify this problem at the design stage. It is faced by specialists conducting aerodynamic tests of systems, but having covered this topic, we hope that we will receive a response and, in the future, we will see no project carried out with such an approach to ensuring the safety of evacuation of people during a fire.

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