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HOW DIFFERENT KINDS OF BUILT-IN FIRE PREVENTION EQUIPMENT WORK TOGETHER

Abstract

In increasingly complex buildings planned heat and smoke exhaust is critical to ensure safe escape routes. The cooperation of various types of fire prevention equipment was examined in full-scale tests. Meanwhile, the developments in measurement methods allowed for more detailed investigations. Full-scale tests demonstrated so far that targeted smoke extraction is essential in places both protected and unprotected by sprinklers. However, both functions should be considered when creating a system. A series of French studies, concluded in 2020, in addition to further reaffirming the current principles in regulation, presented the 10 golden rules of natural smoke extraction.

Keywords: seamless cooperation of fire prevention equipment, full-scale fire tests, heat and smoke extraction, effective life protection, sprinkler.

A BEÉPÍTETT TŰZVÉDELMI BERENDEZÉSEK EGYÜTTMŰKÖDÉSÉNEK VIZSGÁLATA

Absztrakt

Az egyre összetettebb kialakítású épületekben a tervezett hő- és füstelvezetés kritikus fontosságú a menekülési útvonalak biztonságos kialakításakor. A cikkben a szerző a különböző típusú tűzvédelmi berendezések együttműködési lehetőségét vizsgálja teljes körű teszteken keresztül. A mérési módszerek fejlődése lehetővé tette a részletesebb vizsgálatokat. A korábbi teljes körű tesztek már bebizonyították, hogy a célzott füstelvezetés elengedhetetlen mind az esőztetők által védett, mind pedig a védelem nélküli helyeken. A rendszer létrehozásának

vizsgálatakor azonban mindkét funkciót figyelembe kell venni. Egy 2020-ban lezárt francia vizsgálatsor a szabályozás jelenlegi alapelveinek további megerősítése mellett bemutatta a természetes füstelvezetés úgynevezett 10 aranyszabályát.

Kulcsszavak: tűzvédelmi berendezések együttműködése, teljes körű tűzvizsgálatok, hő- és füstelvezetés, hatékony életvédelem, sprinkler.

1. INTRODUCTON

Based on the publications in the topic so far, it can be stated that the research in the field of fire protection is very extensive. These publications and examinations deal with the topic of the fire protection in smart cities [1], or with the evaluation of BIM-based workflows in fire safety engineering [2]. Other research analyses the evacuation strategy [3], or the vulnerability of Portland cement, the advantage of geopolymer [4].

From the specific measurement results, it should be highlighted the fire resistance thermodynamic test of self-supporting double skin metal faced sandwich panels [5], and the effects causing the burning of plastic coatings of fire-resistant cables and its consequence [6].

2. DIFFERENT EQUIPMENT AND PROTECTION GOALS

The content of the paper is based on the Hungarian fire protection regulations. During the examinations I will present the main stages of the developments supported by tests.

The Decree No 54/2014 of 5 December of the Ministry of Interior on the National Fire Protection Regulations is a huge step forward in this field. It is more than a set of regulations, it sets principles and priorities: it lays the foundation of structured thinking for fire protection planners. The regulation puts life protection goals (escape and rescue) before value protection goals (operation, property, equipment, market loss, optimization) [7].

From this, the priorities of installed fire protection equipment can be well deduced, such as

Life protection

- quick alarm
- providing the conditions of escape and rescue – a layer of air with low smoke content

and

Value protection

- decreasing the time needed for fire detection
- decreasing the time needed to start extinguishing the fire
- providing the conditions needed for firefighter deployment
- reduction of heat and smoke load

Firefighters realized early on that fire suppression tactics used in small buildings are not viable in larger buildings due to open air, so they initially cut openings for controlled exhaust of heat and smoke. Supporting the escape in case of a fire in the increasingly large complex spatial structures made the planned heat and smoke exhaust essential. Meanwhile, in order to avoid large fires, automatic fire alarm devices and – because of the growing value concentration, more and more often – automated extinguishing devices were installed for property protection. So, by solving some problems, new ones emerged.

3. HOW DO THESE SYSTEMS WORK TOGETHER? DO THEY INTERFERE WITH EACH OTHER?

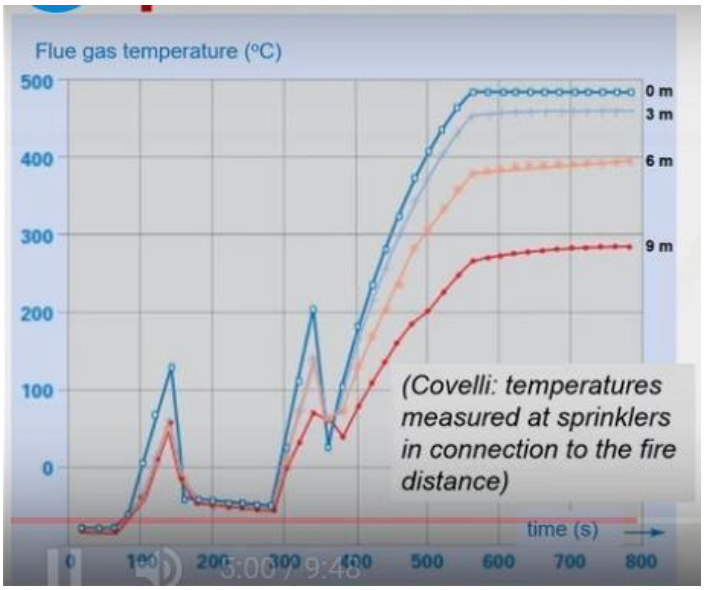
The real scientific answer was provided in 1998 by the famous full-scale fire experiment in Gant. This was actually not a single experiment, but a set of five.

A 20 by 50 by 12 m building was fitted with sprinklers, smoke extraction domes, air inlet vents and a mobile smoke curtain. The study followed the principles of classical experiments: the combustion material was 50 kg of wood in the first three instances, while 30 kg of polyethylene in the last two.

The study demonstrated that the different fire protection systems were only able to provide the expected level of safety when used in combination and working together seamlessly.

The development of extinguishing technology and heat and smoke extraction (ESFR) has again raised doubts. For instance:

- *Flue gases cooled by the sprinklers prevent thermal build-up.*
- *The thermal release of the NSHEV is delayed due to the cooling effect of the sprinkler.*
- *NSHEV prevents the sprinkler from extinguishing the fire and pushing out the oxygen.*



Sprinkler placement compared to the fire	With NSHEV	Without NSHEV
Center	139 sec	140 sec
3 meters	334 sec	344 sec
3 – 6 meters	367 sec	405 sec
6 – 9 meters	420 sec	437 sec

Figure 1-Temperatures measured at sprinklers in connection to the fire distance. Created by the Author.

Developments in measurement methods have made it possible to examine the cooperation between built-in fire protection equipment in more detail. Real-scale tests by Dr. Covelli et al. demonstrated that targeted smoke extraction is essential in places both protected and unprotected by sprinklers, and there is no significant difference regarding the activating times of the sprinklers [8]. However, both functions should be considered when creating a system.

The test illustrates the interoperability well, albeit a bit simplified. The thermal load is drastically reduced.

Between 2018 and 2020, in a complex study with 113 full-scale tests and 400 computer simulations, a summary of the latest results of heat and smoke extraction was published by the French Fire Prevention Association. The aim of this summary is to comprehensively analyse the regulations and methods based on previous experience with scientific, real tests and computer models [9].

Here I would like to focus on three important points which are:

1. fire detection
2. automated smoke exhaust
3. activation of sprinklers

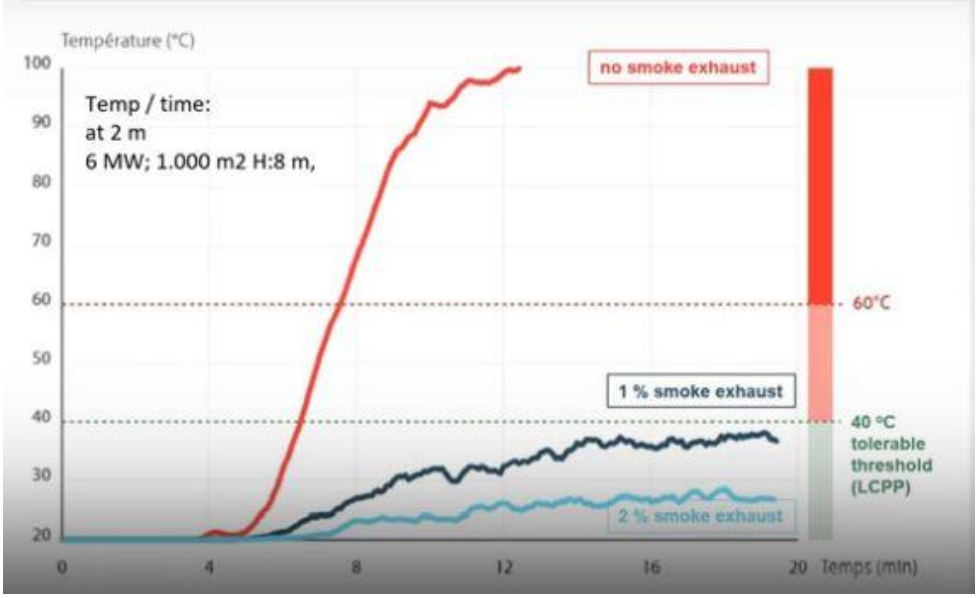


Figure 2 - Complex tests between 2018 and 2020. Created by the Author.

4. HOW IS IT POSSIBLE TO MAINTAIN A TOLERABLE TEMPERATURE THRESHOLD WITH THE USE OF THE EFFECTIVE OPENING OF THE NSHEV?

In a medium-sized room (1,000 m^2, 8 m ceiling height) with a 6 MW fire, the tolerable 40 °C threshold at 2 metre is maintained easier by increasing the effective opening surface, thus saving time before the French firefighter deployment average of 18 minutes.

What is the effect of the wind on the NSHEV on the facade?

The figure shows the effect of wind 5 and 10 minutes after opening the smoke extraction and air inlets vents. Tests have shown that placing the air inlets and smoke vents on the same facade gives better results.

Up to 80% of soot can be extracted – this can be said from a study of a 4 300 m^3 commercial facility where 20 smoke extractors and 528 sprinkler heads worked together.

The most important result is that the earlier the natural smoke extraction structures open (before the sprinklers), the less soot accumulates in the room.

This three-year study, while confirming the current principles in regulation, presented the 10 golden rules of natural smoke extraction.

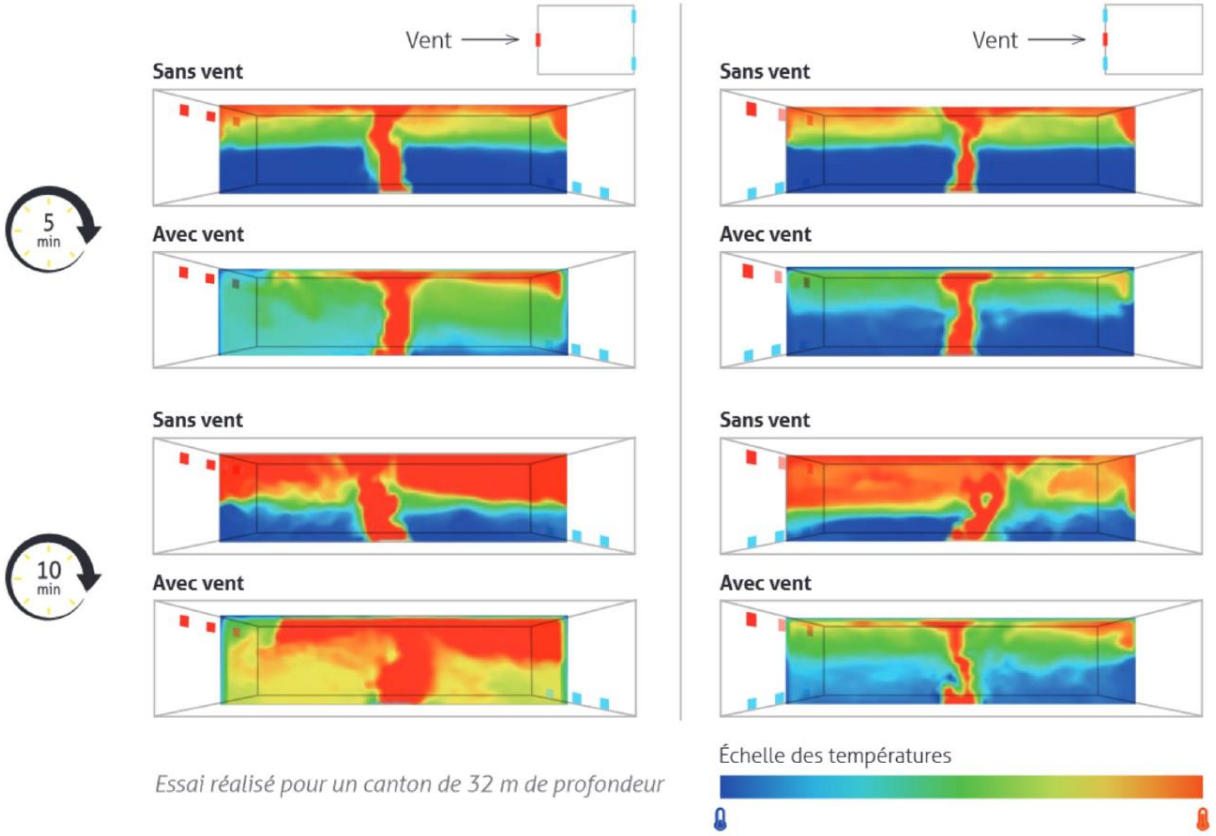


Figure 3 - Effect of the wind on the NHSEV on the facade

10 golden rules of natural smoke extraction:

- Effective regardless of the number and size of the vents, if the effective opening surface is adequate.
- Effective with both facade and roof smoke extraction.
- *More efficient if*
    - using smaller smoke compartments (more prevalent thermal drafts)
    - increasing the size of the effective opening surface
    - increasing the size of the air inlet surface
    - the air inlet surfaces are located as close to the ground as possible
    - in a building exposed to wind, the facade smoke and air inlet vents are located on the same facade.

- NSHEV and sprinkler systems complement each other if the smoke extraction vents are opened before the activation of the sprinklers.
- *Natural smoke extraction and sprinkler systems are more effective if*
    - the effective opening surface is distributed over several smoke extraction vents,
    - the sprinkler head is located under the smoke extraction device.

As I mentioned earlier, Hungarian Fire Protection Regulation is a huge step forward [OTSZ].

It established structured thinking in fire prevention design. This also comes with a certain responsibility: engineers should follow research results.

5. SUMMARY

During the examinations I will present the main stages of the developments supported by tests. After that I was looking for two answers. The first was how to work the built in fire prevention equipment together and the second one was how these interfere with each other. With the help of real-scale tests I presented that targeted smoke extraction is essential in places both protected and unprotected by sprinklers, and there is no significant difference regarding the activating times of the sprinklers.

In the second part of my paper I analysed the tolerable temperature threshold with the use of the effective opening of the NSHEV. At the end of my examination I presented the 10 golden rules of natural smoke extraction.

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