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Efficient firefighting measures in hall-type buildings

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From the beginning of the 1990s hall type buildings started to spread within the territory of Hungary. Hypermarkets, warehouses and logistic centers were built one after another. Fires have different behavior in such buildings compared to structures with smaller area and ceiling height. Before that time this type of buildings was so rare, that we have very little experience about these specialties. In case of a fire, the fire-stress per square meter in these halls can raise multiple times higher than in a "normal" building. We would like to summarize in this article, what are the advantages of built-in early fire warning and efficient heat and smoke exhaust systems during firefighting in these special hall-type buildings.

Introduction

A lot of big, hall type shopping centers (like CORA, AUCHAN, METRO, TESCO, etc.), warehouses and logistic centers were built in Hungary in the last fifteen years. There were very little amount of these buildings before that time. Because of their extreme dimensions, fire has a non-conventional behavior in these buildings. This is due to their huge inner volume, where the fire-feeding gas (air) exists in great amount at a time, and their elevated ceiling height (or inner altitude, 10–12 meters) and because of a lot of goods stored on built-in shelves. This way the fire-stress can be multiple times higher than in a "normal" building.

Until the 80's the existed engineering regulations on fire protection were not ready for such cases, which means that for example conditions for effective smoke and heat exhaust were not developed, and automatic fire signal systems were not effective in the case of such ceiling height. What's more, the automatic built-in water-based fire extinguisher system (sprinkler) also has a low profile in the case of "high-storage".

Legal background for the smoke and heat exhausting systems in hall type buildings came to our country in 1994. Regulations arose from the German Standard System (DIN). Compared with the previous regulation from 1982, this standard has a lot of advantages (and some disadvantages also, which revealed later, after building some of this structures).

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Advantages

In the case of fire, correctly planned and operated heat and smoke exhausting systems (based on the DIN standards) should result smoke-free air at least in the lower half of the ceiling height. This causes further new advantages:

- In hall type shopping center buildings, where thousands of customers can be inside at the same time, the quick, panic-free evacuation is the most important. Existence of smoke-free air greatly eases secure life-saving efforts, because in a building with 10 meters of ceiling height a minimum of 5 meters of fresh air above the ground should exist for a long time.
- Another advantage, that firefighters can find the source of the fire quickly, this way they can locate and extinguish the fire with appropriate forces and accessories.

So the rescue of personnel, the evacuation to secure areas can be safe and quick, which is the most important, and the work of firefighters also quicker and safer, rescuing their own lives much less and minimize costs due to damage.

Regulations for automatic fire signal systems came from 1985. After the regime change, good quality products with cutting edge technology flooded our country from Western-Europe and overseas. But concerning the very tall ceiling height of the halls few of them matches the requirements. This has thermodynamic causes.

Regulations for automatic built-in water-based fire extinguisher systems (sprinklers) came from 1981. This standard uses regulations for normal, conventional sprinkler systems and does not consider extreme ceiling height, engineering drawbacks emanating from complex self-storage and with extended temporary heat-stresses. This resulted some times that the automatic system could not extinguish the fire, just followed it.

Automatic water sprinkler systems came to Europe and Hungary from the US, where specialists achieved further developments from that time. The so called “ESFR” type sprinklers are dedicated for hall type buildings with extreme ceiling height and complex self-storage. Unfortunately this suitable system is not built into the Hungarian regulations, yet.

Circumstances affecting firefighting in hall type buildings

A majority of the goods and wrapping materials stored in a hall, or even the hall itself, can contain particles, which in case of a fire can generate intensive smoke. Thus, without a sufficient smoke and heat exhaust ventilation system, the hall will fill with smoke within minutes. Even considering the shortest alarm reaction time, firefighters will almost certainly face a smoke-filled accident site. As a consequence, it becomes difficult for the

firefighters to determine the magnitude and the spread of the fire, the safety hazard caused by the stored materials or even the damage done to the building structure itself. The fire chief will have a difficult job deciding about the adequate action tactics in a matter of seconds, without having access to concrete information. He will only be familiar with the size of the fire section, which therefore becomes his primary source of information when determining the tactics and tools for the needed measures.

In the majority of hall structures, the goods are stored on a high shelf system. This makes the quick and efficient fire source detection difficult. The firefighter will only see a curtain of thick smoke upon entering the building and cannot see the exact position of the shelves and on the top of that, he is not familiar with the escape routes. This can be the situation the firefighters must face with if the building was in lack of an efficient smoke and heat exhaust ventilation system and was only equipped with sprinklers.

Figure 1. Efficient heat and smoke exhausting

We can talk about efficient smoke and fire exhaust ventilation system only, when the goods are adequately stored with consideration for size and material, the depth of the walls is in unison with the sizing of smoke-free air, and last but not least when the fire exhaust ventilation domes ensure the intake of fresh air to the lower third of the hall.

Figure 2. Heat and smoke exhausting without fresh air refill

Due to the lack of these domes, the chimney effect will not work, leaving the building without efficient ventilation and this way nothing will lead away heat and smoke from the building. It is not enough for the domes to open shortly after the fire is detected, there is also a need of intensive fresh air intake in order to start the chimney effect. If this does not happen, the smoke will become only thicker due to moderate air supply. The firefighters will thus be faced with a completely smoke-filled building, and efficient smoke exhaust ventilation by opening the manual ventilation doors will mean a great delay. As a tactical measure, the chimney effect can be enhanced by applying mobile air intake fans. This, however, does not help the rescue and evacuation situation of any people trapped inside the building.

This was certified with the fire-experiment carried out by one of the co-authors of this article on 17th January, 2005. Fire was initiated, and the measurement of heat and smoke ventilation efficiency was carried out in 3 different circumstances during the experiment:

1. When the heat and smoke exhaust system and fresh air refill doors open immediately after fire signal

2. When heat and smoke exhaust system opens after the decision of the officer-in-charge (from signal to reconnaissance approx. 15 minutes) together with fresh air refill doors.
3. When the heat and smoke exhaust system opens immediately after fire signal and we use neighboring domes to open instead of fresh air refill doors.

The aim of the experiment was to find out, whether the heat and smoke exhaust system had been effective without fresh air refill. Furthermore, was it enough to open the doors for “cold air” intake after the arrival of the firefighters or not?

Figure 3. Effecting heat and smoke exhausting together with a sprinkler

The experiment certified, that the heat and smoke exhaust system was effective only when both systems were operated together immediately after the fire signal.

In buildings equipped with a sprinkler system, the current regulations prohibit the functioning of an automated smoke and heat exhaust ventilation system which activates upon fire alarm in protection of the sprinkler system. In our opinion, this regulation is professionally inadequate, because an efficient smoke and heat exhaust ventilation system serves the quick and safe evacuation of the people trapped inside by creating a layer of smoke free air. In other words, its primary aim is to save lives, while the sprinklers will only activate over a given temperature without regard for smoke spread, having been designed primarily for goods protection purposes. According to current

regulations, a goods protection system is favored to a life-saving (evacuation) system, which, considering efficient fire protection, is unacceptable.

This regulation is furthermore not necessary, which was proven in a 1998 Belgian fire experiment where it was clearly shown that an efficient fire and heat exhaust ventilation system does not have any negative effects on the sprinkler system.

Conditions of safe and effective firefighting

Considering the above, it becomes clear that one of the most important factors in fire protection of hall-type buildings is the creation and installation of fire and heat exhaust ventilation system. Thus, the safe and quick evacuation of any people trapped inside can be ensured. Furthermore, firefighters arriving to the site will be able to see the fire source, the position of the shelves and other hindrances, and last but not least the state of the bearing construction in the building. Upon determining the hazards of the necessary measures, firefighters will be able to make a conclusion about the mission.

Most important condition of efficient smoke and heat exhaust ventilation is that it must activate as early as possible. Thus a fire alarm is crucial to functioning, for it regulates the system. It is therefore vital to select the most efficient fire detection system. This is also a difficult task, because in halls, the practically unstoppable smoke spread makes the detection time of any alarm delayed, and under unfavorable conditions, a prolonged reaction time has to be taken into consideration. When applying smoke detectors in buildings with different structure height, manufacturers generally make the following recommendation:

Ceiling height (metres)	Spot-type detectors	Linear detectors
1.5–4.5	Good	Adequate
4.5–7.5	Good	Adequate
7.5–9.0	Adequate	Good
9.0–20.0	Adequate with conditions	Good
20.0–40.0	Inadequate	Adequate

Looking at these figures, it becomes clear that spot-type smoke detectors can be used at ceiling heights between 9 and 20 meters, while linear smoke detectors can be used in ceiling heights between 20 and 40 meters.

Applying the right smoke detectors will, however, not guarantee that the task of a perfect fire protection in buildings with high ceilings is particularly easy. To fully grasp the problem, one has to start with the properties of smoke itself. Fire smoke usually drifts upwards, while its speed slows down, thus losing heat energy, cooling and

blending with clean air. Vertical smoke spread depends on smoke temperature and thus of the occurring heat energy and the temperature of the surrounding air.

The larger the difference in temperatures, the greater the lifting force of the heat energy. Vertical smoke spread will remain as long as smoke temperature exceeds that of the surrounding air. Horizontal smoke movement will increase as the two temperatures move closer together. In most of the cases, it is with this horizontal movement that smoke reaches the spot-type smoke detector chambers or the sensor beams of the linear smoke detectors.

Some of the fires that act as smoke sources (hidden glowing fires, undetected fires and usually all kinds of pre-flame state fires) produce so-called “cold smoke”, which is smoke with relatively low heat energy. This kind of smoke will spread mainly horizontally, as it does not have enough heat energy to lift upwards. Smoke detectors placed near the ceiling are therefore not suitable to detect this type of smoke. This often poses a problem in logistical warehouse hall buildings, as the materials stored there vary widely in type over different periods of time. Therefore, both types of smoke, the one with heat energy as well as the one without, have to be taken into consideration when constructing a fire protection plan.

In the cases like this, the above mentioned spot-type and linear smoke detectors do usually not give efficient protection. Here, the best fire protection is the so-called aspirational fire detection system. This works best at detecting a fire during its initial stage. This kind of fire detection system has a light-absence sensitivity of 0.1 per cent of a meter, and is up to 500 times as precise as spot-type detectors. Most fires start when a material is for some reason overheated. During this initial stage, particles invisible to the human eye are released as the burning process accelerates.

During the initial stage of the fire, traditional smoke and fire detectors have been known to be unreliable in detecting these particles, and as the period of incubation can be minutes or even hours, fire and smoke detection could be delayed. In the above mentioned systems, the level of sensitivity can, depending on the type of product, be set manually. This increased sensitivity makes it possible for the detection to take place even before the fire starts flaming. The system can be installed on or off-site, and it samples the protected air via a vent and a pipe system.

The pipe system is equipped with pre-defined sampling holes, through which air is taken in by the built-in unit fan. A central unit evaluates the contents and physical characteristics of the sampled air.

This system provides the earliest and most secure fire detection and it can be customized to any chosen material. Even considering fire hazard calculations, this is surely the most efficient fire detecting system.

In logistical warehouses or on sites where a longer time of rescue arrival has to be considered, the higher fire detection costs versus the cost efficiency of this kind of system is an important matter when doing fire hazard calculations.

Conclusions

The sooner the fire or traces of fire can be detected, the sooner it is possible to apply the smoke exhaust ventilation systems. This article shows that the conditions of fire extinction in a hall-type building are not always easily produced.

Having said this, it also becomes clear that in case of fire, it is the primary hazard factor, the smoke, which has to be dealt with and only after the smoke is out of the way can the actual fire extinction begin.

The experiences in the past ten or so years have proven that in protecting hall-type buildings, the so-called sectioning of the fire is not the most efficient way of fire protection. In hall-type buildings, it would be more efficient to focus on smoke sectioning instead, thus creating a more efficient and secure rescue and goods protection mission.

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