The standpipe

A link between fire prevention and fire fighting

1 Introduction

On July 29th of 2003 at 20:44, the London fire service is called out to a fire alarm in a high-rise building. The report of Assistant Divisional Officer Dudeney describes the events as follows: *The Telstar House* in London is an office building that was constructed during the late 60's. The building has a surface area of about 1700 m² (17 x 100 m). The building does not have a sprinkler installation and the floors are set up with open space office landscapes. There are dry standpipes in the building. The London fire service typically answers such calls by sending out two fire engines and one aerial or ladder truck.

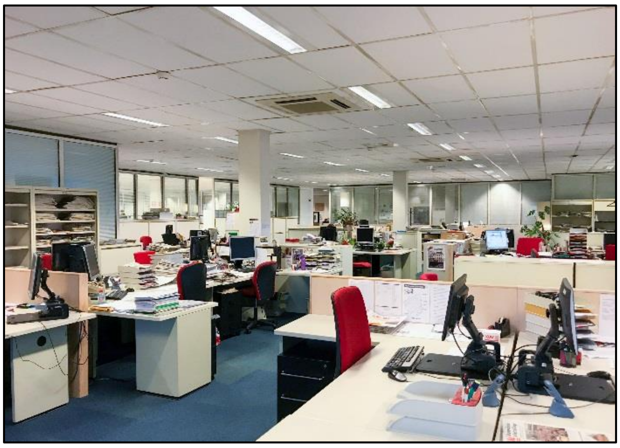

figure 1 Example of an open space office.

The first engine arrived three minutes after the call. Upon arrival, there were no visible signs of fire showing from the exterior. The crew therefor thought that this was going to be exactly like all the other fire alarm calls in office buildings. The company officer talked to the security guard of the building and was told that the fire detection system had relayed an alarm on the 7th floor.

A crew was sent up with a 45 mm hose line. They took the elevator to the sixth floor. There they were met with someone of the cleaning crew who directed them up and then fled down the stairwell. When they arrived at the door of the offices on the 7th floor, they could clearly see smoke and flames. This was communicated to the company officer, who had stayed downstairs. The crew asked for the standpipe to be charged. Meanwhile the 45 mm hose line was being connected while firefighters tried to extinguish the fire with a wall mounted fire hose reel. Their attempt was unsuccessful. The office space that they were trying to extinguish, was totally engulfed in flames. The crew had to pull back.

Just as they closed the door behind them, two colleagues were coming up with the 45 mm line. The hose line was charged. A second fire attack was launched a few minutes after the first attempt had failed. As soon as the crew entered the compartment, they felt a tremendous heat. The crew had to withdraw again. Around that time, the company officer outside heard a loud bang and noticed that part of the windows on the 7th floor had collapsed.

The company officer raised the alarm level and requested 2 additional fire engines. The fire service has only been on scene for 6 minutes at that time. In those six minutes, London firefighters have done a size up and sent a crew to the 7th floor. The standpipe was located and pressurized and two attacks on the fire were done (one with a fire hose reel and one with a 45 mm hose line). That is quite the accomplishment with just two engines on scene.

figure 2 Most of the windows have collapsed and flames exiting the building are a threat to the floor above. *(Photo: London evening news)*

Around 20:57, another four minutes later, two more additional engines are requested. Meanwhile crews are sent up to the 6th and 8th floor. A bridgehead is established on the 6th floor and crews are performing a search on the 8th floor with a 38 mm hose line protecting them. When the search crew attempts to enter the 8th floor, it is already completely smoke filled. However, it appears that there is no working fire on the 8th floor at this time. Most of the windows on the 7th floor have collapsed by now. Flames are flying up against the building. This causes a massive thermal assault on the 8th floor windows.

Conditions on the fire floor have improved somewhat due to increased ventilation. All of the windows are now open. Another attack is started, but the flow of the hose lines is not enough. Because all the windows are now open, the entire floor area has become engulfed. We are talking over 1000 m²!

Again, the fire attack fails because it is just too hot, and crews are forced to pull back. Around this time, the fire extends into the 8th floor. The alarm level is raised again so that a total of 10 engines as well additional ladder trucks are called on scene.

Our colleagues from the London fire service started experiencing heat stress related problems. One firefighter had to be rescued by his colleagues. The situation deteriorated further. In the end, it took 20 engines and 4 ladder trucks. A total of 135 firefighters were called on scene. Finally, at 2 a.m., the fire was halted on the 11th floor. A total surface area of 5000 m² had been burning in the building.

2 Travelling fires

Over the past years, a lot of focus has been placed on fire behavior training. Firefighters today are much more able to describe a fire's development than their colleagues 15 years ago. Today, everyone knows the fire development in a ventilated compartment. The fire starts, it grows and after about 4 minutes flashover occurs and the entire compartment is ablaze.

It is less known to firefighters that this description of fire development is but a model, a simplified version of reality. This model is very useful to us because it is often correct. However, the model of the ventilated fire behavior really only applies to a single room that is limited in size. We typically think of a bedroom, a living room, … The Belgian fire service mainly faces smaller fires (< 60 m²). For these fires, the above model is very useful. In the case of the Telstar House Fire, the compartment was over 1000 m². In such large rooms, the model loses its applicability. It is no longer the case that the entire room becomes engulfed in flames once flashover happens. At some point in time, conditions that resemble flashover, will appear at certain locations in the room. A limited surface area of the room is completely engulfed in flames, but farther in that same room, the fire will still be in the growth stage. And even farther still in the room, nothing is burning at all. Only smoke coming from the neighboring area is found there.

More and more office spaces are being built using an open floor plan. In Belgium, compartments measuring up to 2500 m² are allowed. Worldwide, there are many skyscrapers in which entire floors are one single large open office space. During the past decades, there have also been several large fires in such buildings. That is why scientific research has been done on fires in these types of compartments.

The university of Edinburgh in Scotland has done a lot of work in this area and has developed the theory of *Travelling Fires*. The theory poses that a fire is burning locally while at the same time moving through the area. This means that the fire has reached its maximum heat release rate in a specific area (per m² that is on fire). Next, there will be an adjacent area that is starting to burn but has not yet reached the maximum HRR. In the later stages of fire development, there will be an area where the fire is in decay. Here, it will still generate a certain heat release rate per m². Again, next to this area there is a space where the fire is reaching its maximum heat release rate. And next to that, there is an area that is in growth stage. This is how the fires travels through the room (see figure 3).

In his excellent book Eurofirefighter 2, Paul Grimwood describes that 22 m² per second is a realistic estimate of fire spread. This figure stems from the analysis of several different fires in large open office spaces. The number may seem large, but in a landscape office floor there are no walls hindering the fire spread – as opposed to a building with smaller compartments.

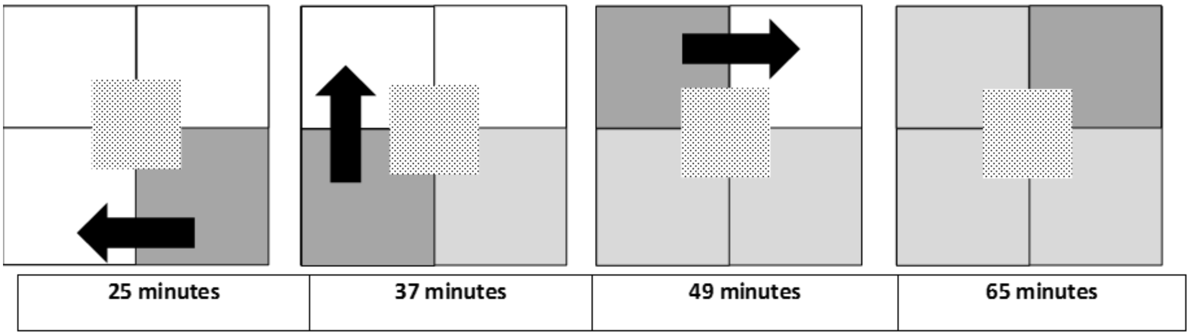

figure 3 Schematic representation of a travelling fire. Twenty-five minutes after the start, the fire is in the lower right corner. After 37 minutes, this area is in decay, but the lower left corner is now burning fiercely. After 49 minutes, the fire is most intense in the upper left corner while the two bottom areas are in decay. After 65 minutes the fire has reached its peak in the upper right corner while all the other areas are in decay. During all this time, the fire has been moving through the entire floor. *(Drawing: Paul Grimwood)*

This number is a good indication of the trouble that can be expected at such fires. *How long does the fire department take to arrive on scene? In other words, what is the response time?* In Belgium, the aim is to achieve a response time of maximum 8 minutes. That would mean that the fire by then would be 172 m² large. By our standards, that is a pretty big fire already. And just because the fire service has arrived on scene, does not mean that they immediately have got water on the fire. In reality, it will take up to 15 minutes before fire extinguishment commences. After all, we have to get up there first, do a decent size up, put hose lines in place. The higher up the fire is burning, the longer this will all take. The fire crew will be facing a fire of 330 m² or more.

Belgian fire safety regulations allow for compartments of 2500 m². In theory it is possible to build an open floor plan office space on the 30th floor of that size.

3 Which flow rate is needed for all this?

This brings us to the question of which flow rate is needed to tackle such a fire. This topic has also been subject of numerous scientific studies. Important researchers in this area were Grimwood, Särdqvist and Hadjisophocleous.

Early research tried to answer the question of what the minimum flow rate is to extinguish a given fire. This was called the critical flow rate (CFR). If a fire attack is made with a flow rate that is less than the CFR, the fire will not be extinguished. It will continue to burn until eventually it will run out of fuel. The most common number for the CFR is 2 liters per minute per m² (2 lpm/m²). This number relates to the surface area that is on fire, not the size of the compartment. The surface area of the compartment however is the potential burning area. The fire will spread quickly if the fire service can't get enough water on it.

Paul Grimwood did a study on flow rates in the '90s. He came up with the concept of tactical flow rate (TFR). The tactical flow rate is the flow (in liters per minute) with which a fire can be knocked down in a short amount of time and with which the total of water used (in liters) is as low as possible. He stated that the TFR is 4 lpm/m² for *medium fuel loads* and 6 lpm/m² for *heavy fuel loads*. To get a good sense of these numbers it is important to realize that typical house furnishings are considered heavy fuel loads. In a later version of his work, Paul suggested using 5 lpm/m² as a rule of thumb on the fire scene. These rules of thumb are good tools because of their simplicity and they are easy to use on the fire ground. They translate into a maximum surface area on fire of 30 m² for a high-pressure line and 60 m² for a low pressure Ø 45 mm hose line (calculated with 6 lpm/m²).

In 2015, Paul Grimwood completed a PhD. study into this subject. He distinguishes between all the different purposes that buildings can have. For office fires he found the following formula:

$$F = 61 \times A_{fire}^{0.57}$$

This of course is difficult to use practically by firefighters on the fire ground. However, this formula can be used to calculate whether a standpipe allows sufficient flow to extinguish a fire on a given floor. When a value 1000 m² is entered into the equation, the formula yields a flow rate needed of 3128 liters per minute. The formula is intended for architects and could be added into fire safety regulations. Architects will then be obliged to design standpipes so that a large enough flow rate is guaranteed for the fire service.

However, the flow rate is not the only parameter that matters. Pressure is equally important. Modern firefighting nozzles require higher operating pressures than their counterparts of 50 years ago. In Los Angeles, a minimum pressure of 7 bars was introduced for every standpipe in 1993. The large office fire at the *First Interstate Bank* in 1988 probably had something to do with this. Because of this rule, firefighters now have adequate flow rate and adequate operating pressure to tackle such fires. Usually standpipes are built into stairwells. This allows firefighters to connect their attack lines at a safe location and subsequently attack the fire.

figuure 4 Nowadays there are modern variants of this old nozzle. In the US, this type of nozzle is called "Smooth bore". *(Photo: Warre St-Germain)*

In Belgium, many fire services are using the G-Force nozzle. This nozzle still produces a decent jet at lower pressures (< 4 bar). The nozzle allows firefighters to operate in high rise buildings while connected to the standpipe, even when there is hardly any pressure.

In Kent, Paul Grimwood has introduced a modern variant of an old nozzle (see figure 4). Such nozzles are called *smooth bore* nozzles in the US. They cannot be used for gas cooling. Due to the solid water stream being formed, they have a larger reach even at lower pressure. Such nozzles have less friction losses than the modern nozzles. Worldwide (and also in Europe), a lot of fire services use these types of nozzles for high rise firefighting to offset the lower water pressure. They opt for a less safer approach of the fire (no gas cooling possible) in exchange for a larger extinguishing capacity. If there would be standpipes with sufficient pressure everywhere, we could use gas cooling without the loss of extinguishing capacity.

4 What does the future hold in Belgium?

4.1 Place of the standpipes and hose outlets.

In Belgium it is prohibited to place a standpipe in a stairwell. This stipulation in the fire safety rules is regrettable. This leads to hose outlets being placed in the center of open floor office spaces. Firefighters would have to search for the outlet on the floor below the fire. Even when they do not have to force any doors, time will be needlessly lost. As stated above, a fire in an open landscape office can spread very quickly. Every minute counts!

It would be better if this stipulation in our legislation (art. 4.2.2.7) were to be altered. The obligation to have to standpipe located in the stairwell would lead to a quicker fire attack without increasing the building costs.

4.2 Water pressure in the standpipe

The minimum water pressure required in Belgian standpipes is 2.5 bar. There not a whole lot you can do with that. In many countries, this demand has been already raised. Some countries demanded a minimum pressure of 7 bar long before our fire safety rules existed. A number of fire departments already demand higher pressures on standpipes. To prevent a water pressure that's too high, the fire service could use pressure relief valves. Without these valves crews on top floors would have nozzle pressures of 7 bars while 60 meters lowers, firefighters would be facing 13 bars on their nozzles. The latter is impossible to handle properly. There would have to be a pressure range for hose outlets in a building. For instance, between 7 and 10 bars.

4.3 Flow rate

Belgian fire safety rules demand a standpipe with a 70 mm diameter. This standpipe has to guarantee a flow rate of 500 lpm at 2.5 bar. The early work of Grimwood teaches us that such a flow rate allows fire crews to effectively attack a fire of 100 m². The *Telstar house* case is a fine example of what can happen if the fire service cannot get adequate flow on the fire fast enough. The fire spreads and the damage becomes much more than what it should have been. Firefighters are also exposed to serious risks.

The theory of travelling fires perfectly illustrates that the fire service will always face a fire that is larger than 100 m². Only smoldering fires or fires that cannot spread because the fuel load is not divided optimally, can be extinguished. At all other genuine growing fires, the expectation is that the fire will be larger than 100 m². Actually, we know that a real fire in an open floor office space without sprinklers or where the sprinklers are broken, will lead to an inferno.

There should be a guideline in our current fire safety laws regarding the required flow rate in relation to the size of the compartments. The current flow rate (500 lpm) is acceptable in most apartment buildings. Residential flats are seldom larger than 100 m². Most of the time there are also several interior walls in an apartment that slow down fire spread to less than 22 m² per minute. In stores and offices however, large areas are not uncommon. Especially when these areas are in high rise buildings, it makes sense that firefighters are *delayed* before arriving on scene. Fire crews have to reach the fire floor first and that takes time.

5 Influence of the large surface area

Large compartments can lead to very large fires that are also very high above ground level. Such fires demand a very large number of firefighters on scene. After all, a lot of resources have to be transported up. We are talking hose lines, breathing apparatuses, food and beverages for the crews, first aid material, …

When the standpipe does not have enough flow to fight the fire, an alternative solution has to be found. In the Brussels fire service uses the *mobile standpipe* procedure. This procedure means hose lines of Ø 70 mm are deployed from a cassette in the stairwell. Every engine has two cassettes of 70 mm. Such a cassette has 40 m of hose line in it which will take the crew four floors up. Each engine thus has the option of deploying hose lines up to the eighth floor. In theory it is possible to transport water up the 40th floor in this way.

At some point however, pressure problems will arise. A standard fire engine can build water pressure up to 15 bars. The higher the engine has to pump the water, the bigger the hydrostatical losses and the friction losses will be. At some point, there will not be enough pressure left at the nozzle.

This problem could be overcome by transporting portable pumps up by elevator. At half the height needed, the hose line could be connected to the pump in order to increase water pressure. Fire departments that have open floor offices in high-rise buildings should at least contemplate this problem. Not every portable pump is suited for transport with an elevator. The driving mechanism of the portable pump must be considered as well. An electrical pump will require a working outlet with sufficient current. A motor pump will produce combustion products. Preplanning has to look at these things in advance and they will have to be practiced as well.

A fire in a large surface area can lead to a very lengthy fire ground operation as well. High temperatures in combination with a lot of stairs will put a large strain on fire crews. These crews will become fatigued at some point or they will suffer heat stress and have to be replaced. A lot of office fires had firefighters working in 3 crews that would each fight the fire for 15 to 20 minutes after which they would rest for 30 or 40 minutes. Many of these fires lasted for hours. This has a big impact on the fire crews.

If the fire service has an adequate flow rate at its disposal from the beginning, this will lead to shorter firefighting operations. The risk of firefighter accidents will be greatly reduced. This alone is reason enough to change the current fire safety rules. In residential apartment buildings, the demand of a minimum water pressure of 2.5 bar needs to be altered. In office spaces, there also needs to be an adequate flow rate.

For the Telstar house fire, the London Fire Brigade mobilized 135 firefighters. Recently at the Grenfell tower fire there were 400 firefighters put in action. London has a very large fire service compared to all Belgian fire departments. As the largest fire service, Brussels has a minimum of 160 people stationed in different fire houses. Some 50 of these are on ambulance duty. Which means that initially about a hundred firefighters can be dispatched. The very big fire services, such as London and New York, can overcome failing fire prevention measures by deploying a very high number of firefighters. Their daily operations are not hindered when a couple 100 people are dispatched to a single incident. This is not the case for the Belgian fire departments. Major Brugghemans, fire chief of the fire department of Antwerp, suggested that if a high-rise fire occurs, the 5 biggest fire services of the country should cooperate to tackle it together. This seems a very sensible idea. Aside from that we desperately need an update of our fire safety regulation in regard to standpipes if we want to prevent an inferno such as the Telstar house fire.

6 Fire safety laws

We have very good fire safety laws in Belgium. Over the past decades, many professionals have worked very hard to achieve this. By and large most of our buildings are very safe as well. When it comes to high-rise firefighting, there are still some improvements we can make. Hopefully these can be achieved in the coming years.

7 Bibliography

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