# Smoke, stacks, and second stairs

LAST MONTH marked six years since the Grenfell tragedy. It was a deeply painful blow for British society and the trauma of it continues to resonate. It was also a shock to the fire safety and construction industry - a wake-up call. It was obvious that action had to be taken and it had to be done quickly.

Therefore, in 2021, a draft update to BS 9991 (Fire safety in the design, management and use of residential buildings. Code of practice) was released. It regulates fire safety in residential building design, management, and use, and provides specifications and practices for appropriate fire safety measures. The previous update took place in 2015, while the current version is out for consultation.

One of the new requirements in the draft document is for buildings higher than 18m (10.1) to have at least two escape staircases or to meet additional conditions, one of which is overpressure protection of the escape route. This is a change to the previous provision 14.1.3 in the 2015 document, which allowed for a single staircase, giving a very wide range of measures for buildings higher than 11 m (natural ventilation or mechanical extraction or pressurisation).

Following this, the DLUHC proposed an amendment to the Approved Document B to prohibit single staircases in new blocks of flats over 30 m in height, and the Mayor of London has ordered that residential buildings over this height must have a second staircase in order to get planning permission. However, at this time it is not part of any new legislation and there are many experts who believe this is not the way forward.

This article will look at both of the solutions proposed in those revisions, consider what consequences the choice of each alternative may have, and also attempt to answer the question: are the solutions in fact alternatives to each other?

## Second staircase - is this a solution?

Banning single-staircase high-rise residential buildings was not one of Dame Judith Hackitt's report recommendations, but it was a consequence of a lack of trust in the stay-put strategy after Grenfell. This is hardly surprising as the incorrect compartmentation, the rapid fire's development along the façade, and the resulting smoke in the stairwell meant that evacuating as quickly as possible was the only solution that allowed people to survive.

Following the opinion of the National Fire Chiefs Council "*a correctly designed second staircase removes the risk of a single point of failure, buying critical time for firefighting activities, and providing residents with multiple escape routes.*" This is true. The second staircase gives an alternative. It doubles the capacity of people flow, so makes it easier for firefighters to reach the fire floor uninterrupted.

Still, it is unclear what height of building makes the use of two staircases necessary - 30m, 18m, or 11m? The economic cost of this solution (on an investment and economic scale) is also being estimated. It has been estimated that adding a second staircase causes a loss of £215,000 per storey (assuming £1,000 per $ft^2$) through reduced saleable space, and will cost £1.6bn over a decade for the industry (£2.5bn for 18m-plus buildings), not only through reduced viability but also changes to existing plans and delays. This is not a problem exclusive to developers - this cost will be passed onto residents, will be reflected in savings on other elements (smoke control systems for instance), or will result in buildings being built as tall as possible to compensate for the loss.

Moreover, it is also still unclear whether such a prescriptive solution is the most efficient way to ensure the safety of evacuees. There is considerable concern about whether this order will be interpreted as a panacea that will exempt investors from seeking performance-based solutions. Or to be clearer – whether this passive solution shouldn't be complemented by active measures, such as a pressurisation system.

After all, what is the point of having two staircases if both of them are filled with smoke?

## Pressurisation systems - is this a solution?

There is a solution that can keep smoke out of escape routes, whether in one or two stairwells. It is widely used in continental Europe, the US, the UAE, and many other places. However, pressure differential systems are not highly trusted in the UK and for good reason. It is true that popular, simple systems have been failing to cope with the stack effect in tall buildings (and the BS EN 12101-6:2005 standard helped to cover this up) and that the passivity of constant-rate systems meant that they were unable >>>

# *Radek Sikorski examines two different, and not mutually exclusive, methods of enabling safe exit routes from high-rise buildings*

**Radek Sikorski, International Business Development Manager at Smay Ventilation Systems**

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to respond to dynamically changing conditions, such as the impact of temperature, the influence of wind, or the changing airtightness of the space over time.

Other concerns were raised as well, such as compatibility with the chosen evacuation strategies or the reliability of systems – concerns that were all justified for the systems used at the time. However, this does not mean that pressurisation is a poor choice per se. It just means that it must be done right.

## Innovation for safety – the Polish experience

As pressurisation systems are mandatory in Poland for most buildings over 25m, and over the last 30 years the country has experienced unprecedented economic development followed by a boom in high-rise buildings, the Polish market has a very wide range of applications for these systems. At the same time, being aware of the disadvantages of this solution mentioned earlier there has been a drive for improvements to create a fully functional pressure differential system for high-rise buildings.

The SMAY research group spent two years (2008-2010) carrying out field research on a 92m high testing rig in Krakow. They aimed to find a solution to mitigate the stack effect - a directed air movement in vertical spaces caused by temperature differences, resulting in uneven pressure distribution. This can make it difficult to maintain the correct pressure in a pressurised stairwell.

The outcome was the development of the Flow System, consisting of two reversible units located at the extreme ends of the staircase. When the system is activated, the temperature difference is measured and the units are set on supply or extract. Then, they operate variably on the basis of a continuous pressure difference measurement. The airflow through the stairwell compensates for the pressure difference and thus allows an even pressure distribution to be achieved throughout the height of the protected space, regardless of the time of day or season, as soon as the system is activated. The effective performance of this approach was later proven on dozens of tall buildings, including more than a dozen >120m and several >200m.

Variable air supply is also a perfect tool for reacting to dynamically changing conditions (wind influence, new leakages), as well as increasing the flexibility of the system (no need for a pressure relief damper, can be used in the vestibule without unsealing). However, for safety reasons, it is very important that the control system is able to achieve the required airflow in less than 3 seconds, yet is stable so oscillations do not occur when the setting is changed frequently.

Replacing the tracking algorithms with a predictive algorithm based on machine learning has been implemented as one of the solutions. By memorising all the settings and corresponding operating points, the system knows exactly what parameters need to be achieved in a given situation. This significantly increases the speed and safety of operation, but also the range of operation.

## The need for a holistic approach

The ability to overcome some of the most basic physical challenges with advanced solutions is a big step forward toward a fully operational pressurisation system. However, this is a necessary, but not sufficient prerequisite. Equally important is the approach to the system as a whole – product- and design-wise.

Pressurisation systems not only require fans and pressure relief dampers, but also control panels, smoke detectors, pressure and temperature sensors, motorised dampers of dual intake system, and more. The standards for these products vary widely, and most are not tested for fire safety. If a device is tested for a feature such as electromagnetic compatibility or tightness, this will tell us nothing about its durability after 10,000 operating cycles.

This is why it is important to test all parts of devices and systems as a whole to meet the requirements given in the BS EN 12101-6:2022. Systems that haven't been verified in medium-scale tests at independent laboratories are like a car handmade by your neighbourhood mechanic in their garage - the car can run well if they are skilled and competent, but the lack of safety testing, repeatable production, or quality control makes cars from the factory a much better choice, even if the mechanic is skilled and competent.

*The Warsaw skyline showing some of the buildings protected by the SMAY pressurisation system*

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A system, no matter how smart it is, will never be smarter than its designer. Therefore, the know-how of the designers, supported by the experience of specialists working with the systems on a daily basis, is absolutely vital. All passive and active fire protection systems - detection, dampers, smoke extraction and its compensation, as well as aspects such as the location of pressure measurement points, potential rearrangements, and specific evacuation strategies - can all have an impact on the performance of the systems and must be taken into account at the design concept stage. It is also very good practice to validate concepts using computational fluid dynamics (CFD) or other mathematical methods of analysis. Such validation is also a requirement for buildings higher than 60m, due to the stack effect.

One of the criticisms of pressurisation is the challenge of a simultaneous evacuation scenario. If a system protects only a stairwell, the airflow through all the doors will result in the required pressure not being reached and in a risk of smoke entering the stairwell.

It is therefore much more advantageous to use individual systems for the vestibules, controlled by measuring the pressure in this space. In this arrangement, the staircase system is designed to achieve 1 Pa higher pressure so that all air from the vestibule is directed to the corridor at 2m/s. If the required pressure is not achieved, then the air volume splits into the stairwell and into the corridor, while the flow to the latter would still reach circa 1m/s. This is sufficient for a fire not yet fully developed. This, combined with mechanical extraction as the air release path (to ensure the staircase does not have less resistance), keeps the staircase smoke-free.

## Summary

Second staircases may increase the safety of users to some extent, as the increased capacity will facilitate the operations of the fire brigade, but they are associated with a very high cost and still do not completely protect escape routes against smoke. A more effective method of ensuring the absence of smoke is the use of pressurisation systems that actively prevent its inflow to protected spaces.

These systems, due to numerous physical, design, and reliability challenges, have not been widely used in the UK to date, but during this time they have been under development in Poland. Thanks to this, it has been possible to create systems that deal with the stack effect and wind impact, are self-adapting, self-testing, that offer a lot of flexibility in design, and are reliable in terms of all the components working together. This makes it a very robust solution for securing a single staircase.

However, these systems should not be seen as an alternative to a second staircase. Active systems, such as pressurisation, complement well with fixed measures, such as compartmentation or the additional escape route. Both solutions are not mutually exclusive and can combine well to increase safety. But if the economic criterion excludes the use of both at the same time, then those responsible for the construction process should have the ability to make a fact-based analysis of all the solutions, together with their impact on safety. The prescriptive forcing of one may exclude the more effective solution.

You can learn more about SMAY's research into pressure differential systems through their webinar available at **smay.pl/pds**