Methods of Control of Mechanical Smoke Ventilation Systems for Higher Risk Residential Buildings

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Mechanical smoke shafts are the most common method of smoke control for the common escape routes from high rise apartments. As they are not yet one of the standard solutions included in Approved Document B, they are a fire-engineered solution with a wide variety of products and design approaches in common use.

The primary purpose of a mechanical smoke shaft is to maintain a clear escape route for occupants of the building in the event of a fire in an apartment, known as Means of Escape Mode. For tall buildings there is also a requirement to maintain safe conditions for the fire brigade to enter the building to fight the fire, commonly known as Firefighting Mode.

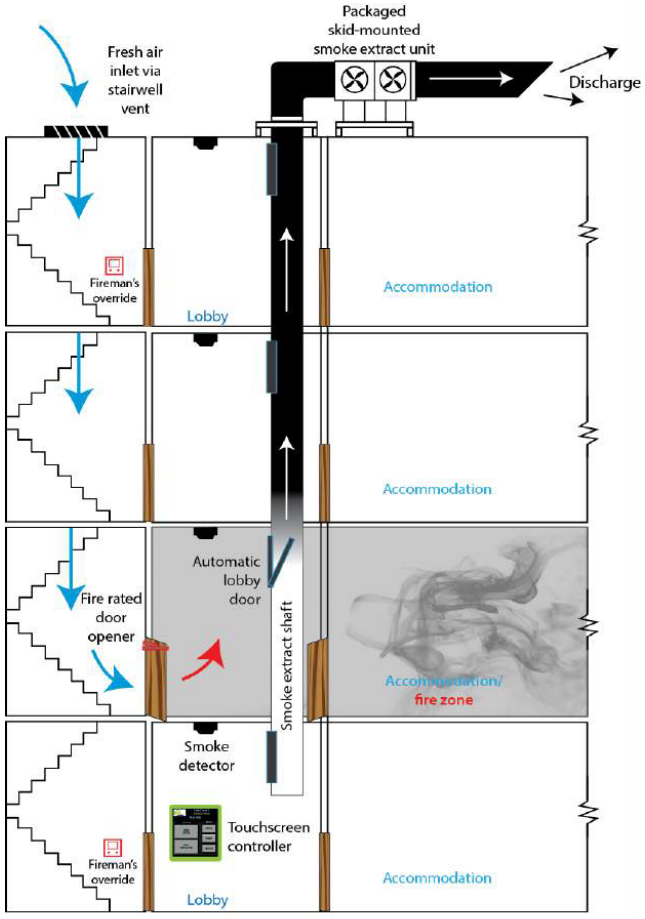

Figure 1. Mechanical smoke shaft illustration

Means of Escape Mode

Each apartment in a building is a separate fire compartment so in theory a fire in one apartment should not affect any other dwellings – and occupants of flats not affected by the fire would not necessarily be aware of the incident. Anyone leaving the apartment during the early stages of the fire would exit by the door onto the common lobby and this could allow some smoke to flow into the lobby in the time that the front door is open. In the Means of Escape Mode, the smoke shaft would be used to extract any smoke that has leaked into the lobby to ensure the stairs and lobbies remain relatively smoke free to allow other occupants of the building to leave safely should the need arise.

Firefighting Mode

In buildings with a floor higher than 18m above ground level, the fire brigade would have to enter the building to fight the fire as this is beyond the reach of the tallest ladder. Under these circumstances, the firefighters would open the door to the apartment containing the fire allowing a lot of smoke to enter the lobby. In this condition, the mechanical smoke shaft would be required to exhaust this smoke and prevent it from entering the stairwell.

Switching between modes

Where the Means of Escape and Firefighting Modes are treated separately in the system design it is usual practice to provide a manual "Boost Switch" to be operated by the fire service. The design, positioning and precise function of these switches can vary greatly from one supplier to another and also from building to building. There are key switches (often without keys), touchscreens and break glass call points of various colours and types. They are sometimes positioned near fire alarm call points, which may be likely to confuse building occupants during an incident which could lead to erroneous triggering of the system.

Figure 2. The design, positioning and precise function of switches can vary greatly from one supplier to another and from building to building

It is unrealistic for the fire brigade to gain a thorough understanding of the particular fire safety systems of individual buildings, particularly when these are bespoke to the building and not conforming to a common standard or type. The London Fire Brigade and the BSI produce quarterly fire engineering thematic technical reports on trends from building regs consultations and fire engineering audits and the use of boost switches for smoke control systems was highlighted as a serious problem in the March 2020 report as follows:

"The location and useable signage of MSVS FF booster switches and the like (i.e. the yellow break-glass or key-operated boxes) was very poor and potentially would not be understood by attending firefighting crews with limited knowledge of such systems."

In our experience the fire service is reluctant to use unfamiliar manual controls, and these should be avoided where possible.

Replacement air

Replacement air must be brought into the lobby to replace the smoke being extracted to prevent the lobby becoming depressurised which could make it difficult or impossible to open doors on the escape route. Air is usually introduced by opening the stairwell smoke ventilator and allowing the air to reach the lobby by one of several methods. It is recommended that whichever method is used that the

mechanical smoke shaft is located as far as practical from the stair/lobby door and where the smoke discharge is at roof level that it is located a minimum of 5m from the inlet ventilator. Common methods of introducing replacement air are discussed below.

Monitoring the lobby pressure and fluctuating fan speed

It is possible to monitor the pressure difference between the lobby and stairwell and to adjust the fan speed to prevent excessive build-up of pressure in the lobby. This entails altering the fan speed as doors are opened and closed on the escape route to maintain a maximum pressure difference, commonly 25Pa. Although commonly specified, this relies on the use of inverters to control the fan speed in an emergency condition which is an application that may not be certifiable under BS EN 12101:3 Smoke and heat control systems. Specification for powered smoke and heat control ventilators (see below).

Other issues with using pressure monitoring systems are the reliability of pressure sensing equipment as it is not tested to any emergency standard or fire rated. There is also a lag between the pressure difference occurring when doors are opened and the fan speed change taking effect which makes it difficult to control the pressure difference.

Speed control of fans in emergency mode

Inverter drives (also known as variable speed drives or VSDs) are commonly used in smoke control applications to limit and modulate fan speed to suit a particular system design. For example, when using smoke extract to protect escape lobbies it is common to vary the speed of the fan according to the pressure in the lobby to prevent the lobby becoming depressurised which could make it difficult to open exit doors. VSDs also provide useful soft-start functionality to reduce large fan start-up currents reducing stress on essential power supply networks and generators.

Many inverter manufacturers provide a fire mode option that disables the control functions and motor protection in an emergency and allows the motors to run to destruction if necessary; however, as there is no standard test for a speed-controlled fan in fire conditions there is a lack of certainty about their performance. The current version of BS EN12101-3 (2015) states that use of a VSD is acceptable if any one of the following conditions are met:

1. The system has a bypass facility to switch from inverter control to DOL (Direct On Line) during smoke control mode. This is not possible if a pressure control system is used in a mechanical smoke shaft system as the inverter is required to control the fan speed in emergency mode.

2. The fan/motor is tested alone and certified to BS EN12101-3 and both of the following sub-conditions are met:

    - The fan is derated (i.e. oversized) by 20%
    - All VSDs are supplied with output filters [dU/dt or Sine Wave]. Output filters provide additional protection to motor insulation.

3. Each fan/motor is tested together with the VSD it will be used with in that specific application. This combination is certified under BS EN12101-3 however as the test is carried

out with the fans at full speed and not modulating it is uncertain whether this permits the fans to be used in multiple speeds in emergency operation.

Automating the stair/lobby door

It is possible to open the door between the stair and the lobby with an automatic door opener to allow fresh air to be drawn into the lobby while maintaining sufficient velocity to prevent smoke entering the stairwell. This method has the advantage of allowing the fans to run at full speed on smoke detection thereby eliminating the need for manual firefighter intervention. Whilst doors have commonly been used to provide replacement air for smoke control systems in areas like atria and shopping centres for decades, there is no particular standard applying to door automation systems for use in smoke control systems.

Reversing the stair/lobby door

Another method is to reverse the opening direction of the door such that it opens into the lobby against the escape travel direction. The theory behind this is that the negative pressure within the lobby would be sufficient to pull the door open to relieve the pressure in the lobby. It is difficult to predict precisely how far the door would open in practice, so it is imperative that sufficient tests are carried out during commissioning to verify that the design conditions are achieved. This approach contradicts the advice in Approved Document B which recommends that doors on escape routes open in the direction of escape.

Summary

Smoke shafts are an important element of a building's fire safety regime and they must be of a suitably robust nature to function as required, when required, in all likely circumstances. The introduction of unnecessary complication should be avoided wherever possible. The use of pressure control by fan modulation is the most complex approach with multiple areas of risk including, sensor failure, inability to commission due to time lag between door opening and pressure change and speed control of fans in fire conditions. Manual switching between Means of Escape and Firefighting should be avoided as the likelihood of the fire brigade using such a facility is low and there is the added risk of erroneous triggering of a fireman's override rendering the system inoperable.

Recommendations

Based on the level of risk associated with multiple speed fan systems it is recommended that a single speed approach (direct to firefighting duty if applicable) is adopted with a guaranteed make-up air supply in place before fan initiation.