Protecting Occupants Escaping Fire in High-Rise Buildings

System Design Criteria

Single Fire on Single Floor
One of the most significant system design criteria set out in relevant British Standards and other guidance, is that smoke control systems should be based on one fire scenario on a single floor, and that, should the fire migrate to upper or lower floors and is detected on other floors, the smoke control system should ignore those signals.

In adopting this system design criteria, the principal concern is that, by activating or opening extract dampers on other floors, the original fire floor will be starved of extract air, and, subsequently, control of the smoke will be lost. The counter argument is that, where smoke does migrate to other levels, no protection is given to occupants on those unprotected levels.

Make-up Air
One of the most common practices for inducing make up air into a multi-storey building is to allow the suction of the smoke extract system to pull open the stairwell fire door that links to the common corridor on the fire floor. Whilst no guidance advises this practice, it is a commonly adopted practice. The downside of this form of providing make up air to the smoke control system is that the stairwell is placed under suction, meaning that smoke may be induced from smoke within the building or from outside, into the stairwell

Push/Pull Systems
The layout in some multi-storey buildings do not lend themselves to the use of a single smoke shaft, and a second or third shaft may have to be installed. In such cases, what is referred to as a “push/pull” design may be used.

This type of system entails splitting the smoke control system into fire zones, with the smoke shaft within the fire zone being activated in extract mode with the other shafts providing the make up air. In such cases, system balancing is critical and attention must be given to protecting any possibility of smoke migration into the stairwell.

The more shafts, or zones applied to the system, the greater the challenge of balancing the system to achieve effective smoke control.

In the event that reversable fans are not used in the designated supply shafts, but are switched off and allowed to idle for the shafts to provide a “natural” route for make up air, a greater extract pressure will be required from the extract fan serving the fire zone to overcome the resistance of the supply shaft(s) and idling fan(s). This will create a larger suction pressure in the common corridors and, therefore, extra care will be needed to ensure that then opening forces on both the stairwell doors and the apartment doors do not exceed the required 100N maximum.

Escape

Those escaping from a burning building will face numerous hazards such as smoke, heat, restricted visibility, and panic driven escaping occupants of the building to name just the obvious.

The smoke will cause respiratory and visual problems. Of course, the risks associated with smoke are very well known; disorientation (like driving in fog), the heat will sap one’s strength and the lack of oxygen and toxic gases within the smoke will ultimately cause asphyxiation. All these hazards are exactly what the smoke control system is intended to control, maintaining tenable conditions for those escaping from the building.

Pressurisation

The fundamental differences between a pressurisation system and a depressurisation systems are:

A pressurisation system WILL:

- Resist smoke migration into escape routes.
- Maintain the stairwell and refuge areas clear of smoke.
- Improve conditions for firefighter access and rescue operations
- Keep the firefighting lift clear of smoke migration

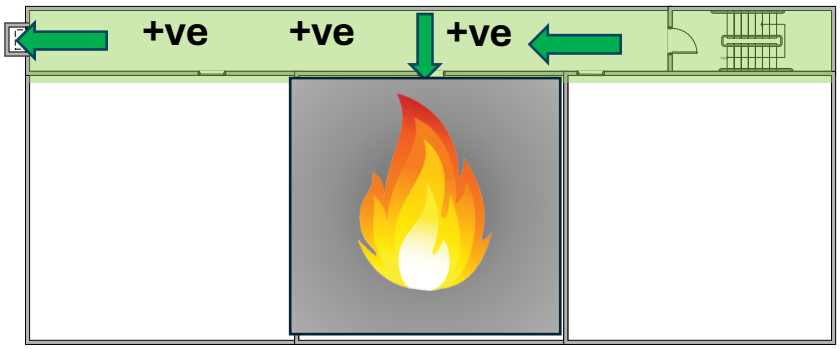

Figure 1 – Pressurisation system

The benefit to firefighters is that cool air will be forced into an escape stairwell and corridor; as a consequence, firefighters will have cool air behind them, and smoke is being forced away from their approach to the fire. This is often not the case in a depressurisation system.

The benefit to those escaping the fire is that they will be travelling against the cool tenable air stream and visibility will be substantially improved for their escape.

A depressurisation system WILL :

- Create a negative pressure in the escape route
- May induce smoke into the common escape routes from the fire compartment.
- May rely on pulling open the fire door to the stairwell in order to induce make up air
- Where higher system resistances are created, e.g. where make up air is drawn through supply shafts, higher suction pressures will be necessary, creating greater opening forces to be necessary to open escape doors and, potentially, apartment doors.

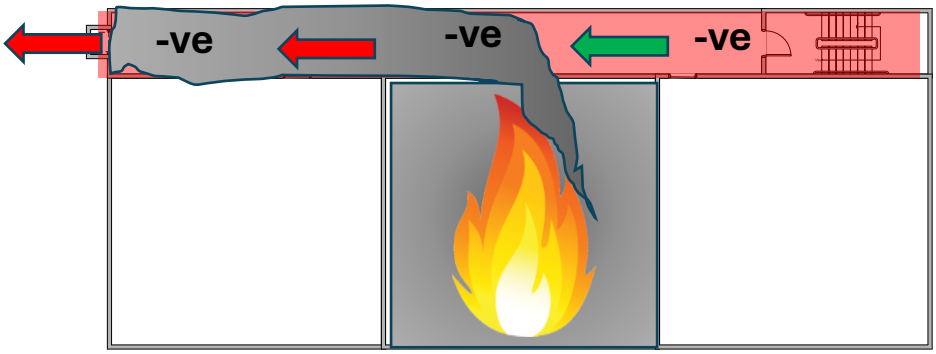

Figure 2 – depressurisation System

Commissioning – *The Practical Test of Design*

The commissioning of the installed system is the first opportunity to truly test the performance of the installed smoke control system.

The accuracy of that test will depend on a number of factors, including the experience and competence of the individual carrying out the commissioning and the equipment being used.

There are several vital performance criteria of a pressure differential system, these are highlighted in the two relevant British Standards:

BS12101: Pt.: 2013 (Kits) and
BS12101: Pt.13: 2013 (System Design)

All pressure differential systems, by their very nature, are based on airflow rates and pressure. In addition, there are specific performance requirements laid down in the standards for door opening forces and system response times to changing system conditions, e.g. doors opening and closing.

Commissioning - *The Equipment*

The first piece of "equipment" needed on the day of commissioning is the smoke control brief, that is the full technical specification with drawings and cause & effect chart prepared by the design team.

Next, the right measuring equipment is needed to verify the installed system is compliant with the designed intent detailed in the technical specification contained in the brief and drawings (see figure 3 below)..

Commissioning Procedure

A pressurisation system will operate on two modes of operation, simply put, doors open and doors closed.

The "doors open" condition relates to the increased leakage path directly affecting the protected spaces, such as common corridors, lobbies and stairwells openings that are created as doors open and close as occupants escape. This condition will, of course, require an increased airflow to restrict the migration of smoke into the protected space. A design air velocity across an open doorway is quoted in BS12101: Pt 13; for two classes of system, Class 1 at 1m/s and Class 2 system it would be 2m/s.

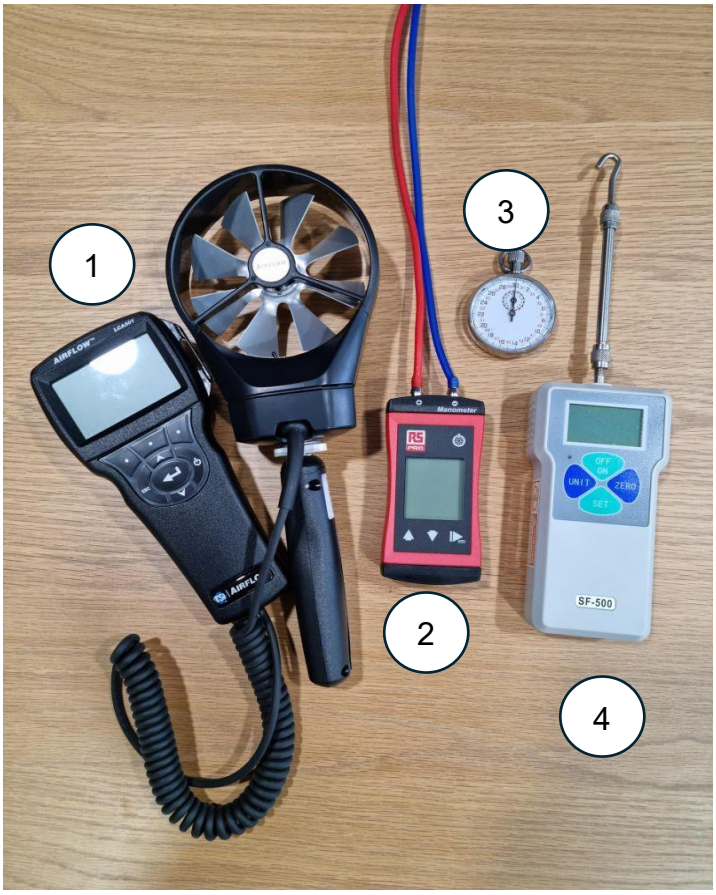

Figure 3 Typical devices required during commissioning:

1. Vane anemometer
2. Pressure differential measurement
3. Stop watch
4. Door force indicator

The “doors closed” condition restricts the openings through which air can pass and the system performance becomes pressure based, creating an increase in pressure difference between the protected space and the potential source of smoke contamination. A typical pressure difference created between the smoke source and protected space is 5Pa.

The key critical tests of the system should include, but not be limited to:

- Measure time for equipment to activate from fire signal.
- With all doors closed, measure the pressure differential across each door over all floors.

- Check escape door opening forces with doors closed. These should not exceed 100N.
- Measure the air velocity across each open doorway for each floor, having activated the relevant smoke detector
- Check for door slamming and over pressure when doors start to close.
- Using force gauge on door and stop watch, check the system is compliant with BS12101-06, by timing how quickly the system responds to the changing conditions and the pressure dissipates to enable door opening within the 100N criteria.
- Create a theoretical escape route for each escape door and check opening/closing reaction times and air velocity are compliant with the design criteria for the system.
- Check all the above with the ground floor main entrance door both open and closed.

It is important that all equipment used in the commissioning process is accurately calibrated and supported by an up to date calibration certificate.

BS 7346-8:2013 Code of practice for planning, design, installation, commissioning and maintenance provides good guidance on commissioning of smoke control systems.