Positive Pressurisation Ventilation Review

Generic Application to Stair Lobbies & place of Special Fire Hazard

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1.0 INTRODUCTION

This generic report is intended to document an alternative approach to protecting residential stair lobbies from the ingress of smoke and is intended to provide the necessary justification to allow Building Regulation Approval for the protected lobbies under B1 of Approved Document B Volume 1 2019 (ADB) incorporating 2022 & 2022 amendments for means of escape purposes using Positive Pressurisation Venting.

This report will look at the Code requirements for basement stair lobbies, a practical overview of the existing systems, discussion on the pressurisation approach, research carried into pressurisation, information on the system components and an overview so as to allow Building Regulations Approval of the Daisy Positive Pressurisation Venting Unit (PPV).

2.0 CODE REQUIREMENTS

General guidance on meeting the requirements of the Building Regulations is outlined in Approved Document B V1 2019 (ADB) incorporating 2022 & 2022 amendments.

In relation to residential lobbies opening onto escape stairs, this is covered in B1 which covers Means of Escape. Section 3.75 as in previous ADB editions, provides clarification on the requirements to meet the objectives of ADB as shown in Diagram A below.

3.75 Where a stair serves an enclosed car park or place of special fire hazard, the lobby or corridor should have a minimum 0.4m² of permanent ventilation or be protected from the ingress of smoke by a mechanical smoke control system.

NOTE: For refuse chutes and storage see paragraphs 3.55 to 3.58.

36 **Approved Document B Volume 1, 2019 edition** Building Regulations 2010

ONLINE VERSION

Diagram A- ADB Extract

The traditional approach is the natural 0.4m² opening which connects the lobby to an area outside the building.

The alternative approach outlined in ADB is mechanical smoke control. Further clarification is provided in the Smoke Control Association (SCA) Guidance Document on Residential Buildings as shown in Diagram B below.

7.6 Ventilation of lobbies to ancillary accommodation

The prescriptive codes recommend for means of escape that ancillary accommodation (e.g. car park or places of special fire hazard) is separated from the staircase by means of a natural ventilated lobby (e.g. where ADB recommends for a small single staircase building a 0.4 m² vent). This is normally achieved by a fire rated plenum or smoke shaft linking the lobby to the outside of the building allowing any smoke in the lobby to be ventilated.

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This natural ventilation provision cannot always be easily achieved. An alternative approach may be to use one of the following mechanical ventilation systems:

1. Mechanical extraction from the lobby at a rate equivalent to the natural vent and a pressure not exceeding 20 Pa across the lobby doors. The fan discharge should be ducted to the outside.
2. Positive pressurisation of the lobby above the surrounding space.

In developing the above system, the replacement air should be taken from the sterile area ensuring smoke is not actively drawn into the lobby. This could be from the staircase or riser and where dedicated active openings are provided, they should be controlled by a local smoke detector.

Duty and standby fans should be provided to ensure the system operates in the event of component failure.

All testing during commissioning should be carried out with the doors closed.

Diagram B – Extract from SCA Residential Guidance

This is from the 2020 Rev 03 version of the document which has carried the same text for the past 5 years through each of the revisions. Approving Bodies, Fire Services and Consultants comment on the SCA Guide on numerous occasions and this text remains constant.
This document provides two methods to meeting the above mechanical smoke control requirement.

This SCA guide is a referenced document source for smoke control systems design within the British Standards BS9991:2015.

The ADB gives no consideration to fire fighting operations within the lobby, apart from a smoke clearance system from the general car park area, unless the lobby is 10m below ground level.

3.0 ANALYSIS OF THE VENTILATION OBJECTIVES

It is unclear as to the basis of the venting of the lobby space apart from trying to prevent smoke entering the stair or lift lobby where it could rise and effect occupants on the upper floors.

Some people are of the view the ventilation is to act as a release for the expansion of gases as they are forced from the car park into the lobbies around the door seals which form an area of relief. In this case the temperatures must be low as FDS are not aware of any fires where the door intumescent seals have activated. The various researches identify the expansion of gases at the top of the door to be around 6 pa.

Other people believe it is to do with occupants escaping from the car park through the ventilated lobby and the smoke following them. As discussed later, this is unlikely due to the volume of the space and the effects the hot gases would have on the escaping occupants. If this was the intent, some of the smoke would continue to follow them into stair.

Regardless of the various views, Section B1 Means of Escape of the ADB accepts that smoke will enter the lobby and the $0.4m^2$ opening or a mechanical smoke control system is intended to act as a path to prevent smoke entering the stair.

In reviewing car park volumes, the height of the car park would be a minimum of 2.3m and the escape door into the lobby is generally 2m in height forming a reservoir of 0.3m at high level before smoke builds down and enters the lobby.

As residential car parks have a low occupancy, it would be expected the occupants would have left the car park prior to the smoke layer building down below the escape door height, thus the car park door would be closed. In addition, if it was the later stages of escape the lobby would contain the small quantity of smoke.

Car parks are also provided with smoke clearance systems, which assist with reducing temperatures and in turn the volume of the gases.

In mechanically ventilated car parks, air is forced out of the space with replacement air coming from all leakage paths including some from the lobby.

Natural ventilated car parks rely on cross flow ventilation and the buoyancy of the gases to clear smoke from the car park which would be a simpler route, than entering a lobby.

The $0.4m^2$ natural duct normally runs from the lobby to the perimeter of the building terminating in the vertical position which can be influenced by the prevailing winds. Within the route of the duct (from lobby to outside), the ducts need to step around beams and would contain bends. The surface area of the duct creates a temperature loss to the smoke with its driving force effectiveness questionable.

In modern day buildings creating a termination for ducting on the perimeter façade is not feasible due to construction techniques and floor area availability.

To achieve the free area within the lobbies, a full height louvre is generally provided reducing the effectiveness of the system as the smoke would be at high level.

By smoke entering the lobby, the horizontal protection is already reduced.

3.1 Time Line Consideration

In reviewing evacuation times, consideration should be made to the expected occupant movements.

Time 0	Driver parks car or fire occurs while their driving the car. Driver stops.
Time 10 seconds	Driver decides to leave the space and travels 45m to nearest exit (45m x 1m/s). Smoke starts to spread through the car park at high level and building down to above the escape doors.
Time 120 seconds	Driver has escaped into escape stair, operates the fire break glass. Smoke detector operates and fire alarm operates. 2.5% natural smoke ventilation or 10 air change smoke extraction system operates assisting with the removal of smoke. Although the car park occupancy is generally low, any other Occupants would quickly hear the alarm and see the smoke
185 second	The Occupants would commence their evacuation. A code compliant distance would be (45m x 1m/s) plus an opening time at the door.

It is very unlikely in the early stages of a fire while an occupant is escaping that the smoke would be below the door height and following them into the protected lobby.

If the occupant feels threatened, they would have left the spaces in the early stages of evacuation.

The above review is the same regardless what ventilation system is provided within the stair lobby but tries to add a practical side to movement times.

4.0 CONCEPTS TO MEET THE CODE REQUIREMENTS

In looking at the various concepts to protect lobbies, there are 4 possible smoke management systems which could be adopted including the natural ventilation of the lobby, mechanical extraction from the lobby, positive pressurisation of the lobby and car park depressurisation. The following section looks briefly at the possible systems:

4.1 0.4m^2 Natural Ventilation

The permanent natural ventilation of residential lobbies was incorporated within ADB many decades ago. This solution is achieved by running a 0.4m^2 fire resistant plenum from the stair lobby to the outside of the building. Based on this approach, it is envisaged that the code accepts the lobby will have smoke within it. Any smoke entering the lobby is expected to rise to high level and travel along the inside of the plenum to the perimeter of the building where it will be discharged. This plenum is generally built around beams, bends and terminating through louvres possible in the direction of the prevailing wind.

As developments become more complex with services running through the car park, the heights are reducing to minimise ground earth works. This is creating a problem for the lobby ducting. The dimensions of the ducting to meet the above heights are generally 0.3m high by 1.4m wide creating problems in low car parks with beams, services and clearance height requirements of 2.1m making this approach unworkable.

4.2 Mechanical Extraction from the Lobby

Mechanical extraction from lobbies currently involves locating fans within the lobbies. The fans turn on in the event of smoke detected in the lobby extracting smoke from the lobby and discharging back into the car park. There are inherent problems with pulling smoke into the lobby and dampers which open to maintain compartmentation between the car park and lobby. Some designs include smoke extracted from the lobby and discharged to the outside of the building. This can be provided by discharging smoke to outside either by a vertical riser (smoke shaft) or horizontal duct to outside. This provides a similar unworkable solution to the natural ducting.

Further to the above, the performance of the mechanical smoke extraction is highly reliant on the provision of inlet air supplied. This can be provided from the staircase (via an automatic damper provided onto the staircase wall).

4.3 Positive Pressurisation of the Lobby

Positive pressurisation of spaces dates back to World War 2 where important areas within buildings were pressurised to ensure that in the event poison gas or bacteriological sprays, these agents would not infiltrate into the protected area. In peace times, it has been used to obtain a dust free atmosphere in work rooms, and in buildings where radioactive gas or dust could escape, it can ensure that the area of contamination is confined.

In the case of stair lobbies, positive pressurisation involves using the lobby as a buffer zone and raising the space to a higher pressure to that of the car park. The pressurised air comes from the stair side and escapes into the car park ensuring the movement of air is always away from the stair into the car park. Pressurisation has been around for over 40 years and design principals for more complex systems are outlined in the BS EN 12101: Part 6.

Over the years, Fire Services have carried out research on the concept and the approach has become known as Positive Pressurisation Venting (PPV).

4.4 Car Park Depressurisation System

Mechanical extraction car park systems are now starting to incorporate designs where the inlet air paths are throttled down, drawing air from the lobbies and preventing the airflow from entering the stair. This can be hard to achieve in practice and generally involves larger kit and greater control on dedicated inlet paths.

5.0 APPLICATION OF POSITIVE PRESSURISATION VENTILATION

As discussed above, PPV involves pressurising the basement lobby to a higher pressure to the car park or places of special fire hazard. The inlet air needs to come from the sterile stair side of the lobby with door leakage into the car park or special fire hazard. This is achieved by locating a PPV unit on the stair wall side which would inject the air into the lobby raising the space to a higher pressure with onward leakage of air into the car park or place of special fire hazard. Leakage is required from the risk space such as the car park or stores to the external to ensure the pressure difference is maintained.

In order to ensure the pressurised air is kept in the protected lobby, it is always recommended the doors open into the protected pressurise lobby ensuring they remain closed when the PPV unit is running as shown below.

The general principals of pressurisation are outlined in BS EN 12101: Part 6, although basement stair lobbies with closed doors are not addressed in this document. To meet the means of escape requirements of ADB, the basement lobby would need to be raised to 50pa above that of the car park or places of special fire hazard with the door closed.

The general concept is shown in Diagram C below.

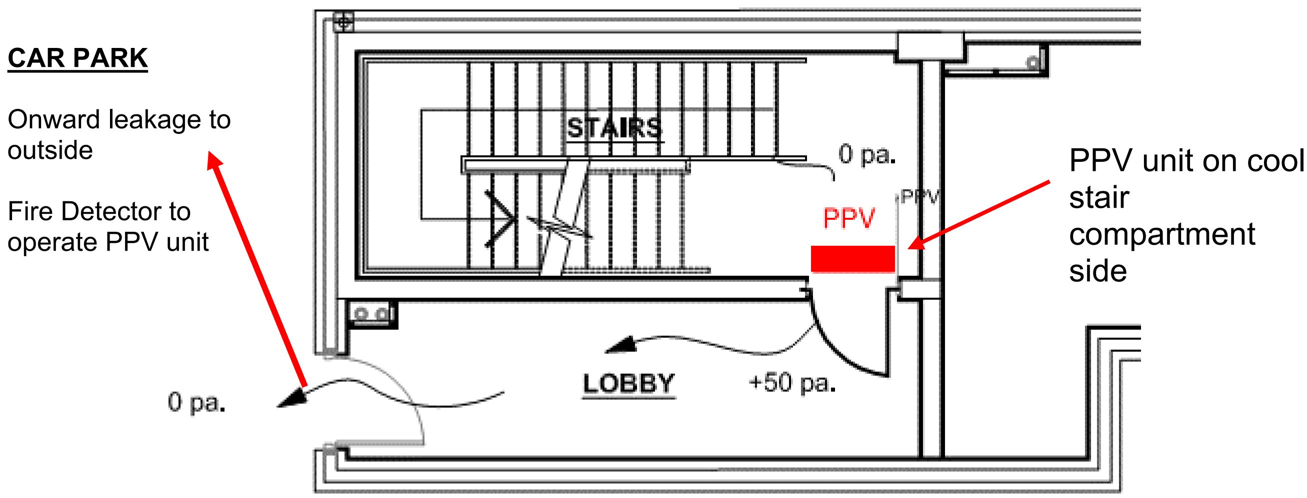


Diagram C – Lobby Pressurisation Concept

As discussed in Section 2.0, the Smoke Control Association Guidance Document on Residential buildings provides further guidance on the pressurisation of residential basement lobbies as one of the methods of smoke control to meet section 3.75 of the ADB for lobby ventilation. This is shown in Diagram B in Section 2.0.

Item 2 of the diagram identifies that the stair lobby should be pressurised to a higher pressure with the testing carried out with all the doors closed so the pressures can be recorded across the closed doors.

The guidance recommends the replacement air should be taken from the sterile area of staircase or risers with the PPV unit located on the cool side of the pressurised space protecting the casing as shown above.

This diagram identifies the requirements of the PPV system.

Further guidance on the application of the PPV Concept is provided in the Design Note referenced DMS -DN01 in Appendix E of this report.

6.0 POSITIVE PRESSURISATION VENTILATION RESEARCH

As discussed above positive pressurisation is a concept of protecting the protected space from the ingress of smoke.

6.1 Review of Research Conducted on Pressurisation Concepts

In the mid-1960's, the spread of smoke, especially in high rise buildings, started receiving considerable attention. The desire to control the spread of smoke from a fire led to research being conducted in the United States, Canada, England, Japan, Australia, France, and West Germany which mainly looked at pressure difference across spaces opposed to velocities. This research consisted of full-scale tests, field studies, and computer simulations. In addition, some buildings were constructed with various innovative fire protection features as a means to test "smoke control systems."

Some of the earliest studies were conducted in a four story building in Switzerland by Cerberus AG. In these tests, wood and other cellulose-based materials were used for flaming and smouldering tests. One conclusion developed from the tests is the effectiveness of closed doors. The authors' state "closed rooms are protected adequately for a long time from the effects of smoke."

In 1968, researchers at the National Research Council in Canada (NRCC) identified some of the major issues associated with smoke and fire in high rise buildings, specifically evacuation, fire fighting and smoke control. The authors suggest that due to the significant time required to walk up and down stairs in a high rise "it seems unreasonable to continue to forbid the use of lifts during fire emergencies." "Ways must be found so that they can be used safely in the hands of the fire brigade, both for fire fighting and for controlled evacuation."

In their book titled Smoke Control in Fire Safety Design, Butcher and Parnell cite several examples of "case histories demonstrating rapid vertical smoke movement through buildings". In one example, a fire occurred in an electrical panel located in the second basement of a reinforced concrete airport building. The building was six stories high with two basement levels. Unsealed cable shafts and open stairways allowed the smoke and fire to spread throughout the building resulting in fire damage to approximately 6,000m^2 and another 30,000m^2 damaged by smoke. A second example describes a fire that occurred in a fifty story high rise building in New York City. The fire started in a concealed space on the 32nd floor and spread rapidly due to the presence of plastic materials and the failure of some smoke dampers. The fire resulted in 2 deaths, 30 injuries, and 10 million dollars damage. This fire demonstrated the dangers of transmission of fire from floor to floor, the potential for smoke distribution throughout a building, the failure of lifts, and difficulties in venting fire gases. A third fire in a 21 story high rise, located in Seoul, South Korea, killed 163 people. According to a report by the National Fire Protection Association, the fire and smoke travelled up vertical shafts and ducting igniting items on the upper floors. The fire then burned from the lower three floors and the upper floor towards the middle floors of the building.

Several factors have been identified as influencing the movement of smoke and hot gases from a fire. Smoke can move as a result of the buoyancy difference between the hot smoke and the ambient air. Smoke also moves due to the expansion of the hot gases. In a building, smoke movement can be influenced by "stack effect", the pressure differential created by the temperature difference between the air inside the building and that outside the building. Wind can significantly influence the movement of smoke in a building. Finally, the mechanical air handling equipment can control where smoke moves in a building. In an effort to develop methodologies for controlling the spread of smoke, researchers have conducted numerous experiments designed to measure the various pressure differences generated by these fire phenomena.

The pressures developed above a fire have been measured by several researchers. The pressure increases with increasing gas temperature and distance above the neutral plane. The neutral plane is a location in an opening above which hot fire gases flow away from the source of the fire and below which cold ambient air flows into the fire area. This flow is caused by a pressure difference across the opening. The height of the neutral plane is the point where the pressure difference is zero.

The concept of using pressurisation to control smoke originated in the late 1950's. However, research into the use of pressurisation and its impact on smoke flow did not start until the mid to late 1960's.

In 1964, the Fire Research Station at Borehamwood conducted a series of four experiments in a new three story department store to examine the feasibility of using pressurisation to control smoke (FRS Research Note 566). The experiments used a single fan, with a rated flow of 1.4m^3/s, located at the top of the un-lobbied stairs to provide the pressurisation as shown below. Smoke was generated using a specially designed apparatus capable of producing smoke from the controlled combustion of various cellulosic materials. However, the apparatus did not produce smoke in quantity or temperature typically found in building fires. From the tests, it was concluded that an excess pressure of 12.5 Pa would keep areas sufficiently free of smoke and allow the occasional opening of some doors.

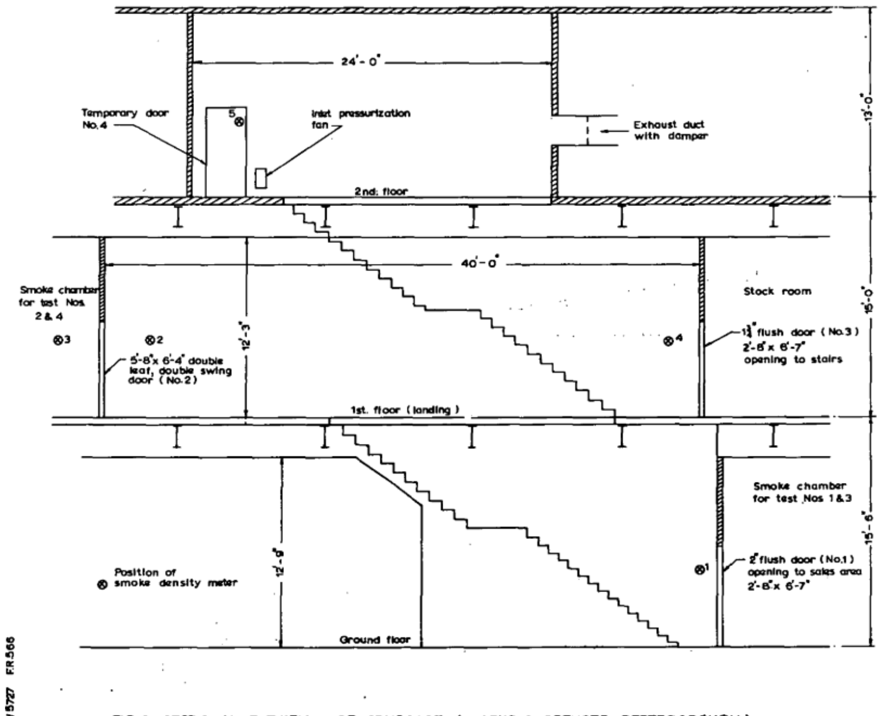


FIG. 2. SECTIONAL ELEVATION. OF STAIRCASE. (MARKS & SPENCER PETERBOROUGH)

Another series of experiments was conducted in 1971 by the Fire Research Station at Borehamwood, using a 4 story test building (FRS Research Symposium No 4). The building had a single un-lobbied stair leading to an adjacent room on each floor. Two fans connected to a series of ducts could be used to pressurise the stair. The smoke source was burning wood cribs located in the first floor room adjacent to the stair. Several issues were examined as part of the experimental work. First, the pressure developed at the top of a normal door, 2m above the floor, was measured and found to reach a limiting value of 6 Pa for the experimental conditions. A second part of the study dealt with examining the impact of weather conditions by conducting a series of experiments during the winter months. The maximum pressure differential measured between the fire room and the stair was 12.5 Pa. The third part of the study measured the airflow across the door and the associated pressure differential. It was found that a flow of 0.075m^3/s produced a pressure differential of 50 Pa. The fourth part of the study investigated the effectiveness of pressurisation to control smoke. Using the wood crib fire source and no pressurisation, the stair became completely smoke filled in 11 min, flames penetrated into the stair in 18 min, and the door failed at 25 min. With a pressure difference of 50 Pa, there was no penetration of smoke into the stair.

Nayuki and Kuroda performed tests in a model of a smoke proof tower in 1970. The model was 0.3 m by 0.3 m by 1.8 m high with a Ni-Chrome wire heater located at the bottom. Air was allowed to enter on one side near the bottom. Measurements of temperature and velocity were taken at the inlet and the outlet at the top. Initial velocities due solely to the starting of the heater were 0.5 to 1.2 m/s. From this work, equations for estimating velocities in the smoke proof enclosure were developed.

In the summer of 1972, a series of full scale fire tests was conducted in a 22 story office building located in New York City. A large fan, approximately 18.9 m^3/s, was placed at the bottom of a stair shaft for pressurisation while a smaller fan, approximately 4.7m^3/s, was installed at the top of the shaft to provide smoke exhaust. With all doors closed, a pressure differential of 75 Pa could be obtained at the top of the stairs with a difference of 250 Pa at the bottom of the stair, and a differential of 75 Pa at the bottom would yield a difference of 20 Pa at the top of the stair. A series of four tests were performed using typical office furnishings and other combustible materials distributed in rooms of various sizes to obtain fuel loads of 24.5 to 44 kg/m^2. In one test, the fire source was located on the seventh floor while it was located on the tenth floor for the other three tests. The tests demonstrated the feasibility of stair pressurisation to maintain smoke-free stairs in high rise buildings, that as many as three doors could be open and still allow the system to maintain effective pressurisation in the stair, and that the test stair provided a “clear and safe passage” for occupants and firefighters even though the corridor and adjacent lobby on the fire floor had heavy smoke levels

Also in the summer of 1972, tests were conducted in a 14 story hotel in Atlanta, Georgia. Fans were installed at the bottom of each shaft to provide a maximum flow of $10.4m^3/s$ to the stair shaft and $17.5m^3/s$ to the lift shaft which was common to three lifts. In addition, fans were provided to maintain the approach lobby to the stairwell at either higher or lower pressure than the surrounding areas. With these fans, pressure differences in the stairwell of 200 Pa at the bottom and 25 Pa at the top with all doors closed could be obtained. In the lift shaft, a pressure difference of 12.5 Pa could be maintained across the closed lift door at the fifth floor near the fire location when the fan was operating at maximum. Fire tests were performed with the fire located on either the fifth floor or the third floor. Old furniture or wood pallets were used to obtain an approximate fuel load of 19.6 kg/m^2. The pressurisation system was used to obtain a pressure difference of 37.5 Pa between the stairwell and the fire floor and a pressure difference of 12.5 Pa between the lift and the fire floor lobby. Based on the study, the authors concluded that pressurisation of stairwells and lift shafts was feasible and effective for limiting smoke migration into these shafts.

As part of an acceptance test by the local jurisdiction, an actual fire test was required in a six story office building in Hamburg, Germany. The smoke control system for the building was designed to provide a pressure difference between stairs and lift shafts and the associated lobbies of 15 Pa under normal conditions and 50 Pa under emergency conditions. The fire load consisted of 370 kg of wood arranged in two groups of eight cribs with large slabs of expanded polystyrene foam. The fire room was approximately 4m by 15m and located on the second floor. While a comprehensive set of measurements were obtained during the fire test, only one fire test was performed. No information is available concerning the flows in the building during a fire without pressurisation.

Air leakage through lift and stair doors was measured experimentally by Tamura and Shaw. At a pressure difference of 75 Pa, the air leakage through a lift door was determined to vary approximately linearly with the width of the crack between the door and doorframe. For a crack width of 2.0 mm, the air leak rate per door was measured at 0.10 m^3/s. For a crack width of 7.0 mm, the air leakage per door was 0.45 m^3/s. Typical crack widths for lift doors range from 4.8 to 6.8 mm compared to stair door clearances of 2.0 to 4.6 mm.

Several studies have been conducted in the experimental fire tower at the National Research Council in Canada to determine the pressure differences occurring in lift shafts during a fire. In one set of tests, a propane gas burner was used as the fire source and located on the second floor of the 10 story test facility. Pressure differences were measured in the lift shaft at the 3.08m level on the fire floor. They varied from 9 Pa to 14 Pa. In another series of tests with a similar fire source arrangement, pressure differences were measured with all outside wall vents closed and with two outside vents open. In the test with vents closed, the pressure immediately increased to 31 Pa, quickly dropped to 16 Pa, and subsequently gradually decreased to 6 Pa when the fire room temperature stabilized at 600°C. In the test with open vents, the pressure difference peaked at 9 Pa and gradually decreased to 7 Pa.

Wind can also have an effect on the pressure difference across a lift lobby wall. Tamura investigated the effects of a 7 m/s (15.7 mph) wind on the 10 story test facility at the NRCC. Using the floor space pressure as the reference, pressure differences varied from 0.1 Pa to 0.5 Pa with all vents closed. When the 0.46 m^2 vent was opened on the windward side of the building at the 2nd floor fire location, the pressure difference ranged from 1.5 Pa to 9.6 Pa. When the leeward vent was the only one open, the pressure difference was 0.0 Pa to 6.0 Pa; with all vents open, the pressure difference was 0.1 Pa to 1.8 Pa. The values for the leeward vent open only case represent flows in the direction from the lift shaft into the lobby. All of the other cases produced flows from the lift lobby into the lift shaft. Mechanical pressurisation of the lift shaft reduced the possibility of smoke contamination of the lift shaft and lobbies due to wind action.

Summary of the Research Review

The following summaries the main points of the various research.

Cerberus AG concluded that:

- closed rooms are protected adequately for a longer time from the effects of smoke as the smoke movement is away from the pressurised area door, improving the fire resistance performance of the door.

The FRS research showed that:

- an excess pressure of 5 Pa was sufficient to prevent the penetration of hot smoke through door cracks.
- an excess pressure of 12.5 Pa in the escape route was sufficient to keep these spaces free of smoke and allow the occasional opening of some doors for short periods as would be the case if a person passed through, did not appear to have any significant effect on the overall effectiveness of the pressurised space.
- that where the door was held open for a longer period and smoke entered the space, it was quickly cleared on closing the door returning the space to a smoke clear environment.
- the pressure developed at the top of a normal door, 2m above the floor for the expansion of hot gases, was measured and found to reach a limiting value of 6 Pa for the experimental conditions.
- the impact of weather conditions was reviewed by conducting a series of experiments during the winter months. The maximum pressure differential measured between the fire room and the stair was 12.5 Pa.
- the effectiveness of pressurisation to control smoke. Using the wood crib fire source and no pressurisation, the stair became completely smoke filled in 11 min, flames penetrated into the stair in 18 min, and the door failed at 25 min. With a pressure difference of 50 Pa, there was no penetration of smoke into the stair.
- stopping the pressurisation fan allows smoke to move through the door cracks and smoke log the protected space.
- the area to the front of the pressurised stair door was clear of smoke.
- the stair door fire resistance was improved.

1972 New York City tests demonstrated:

- the feasibility of stair pressurisation to maintain smoke-free stairs in high rise buildings,
- that as many as three doors could be open and still allow the system to maintain effective pressurisation in the stair,
- that the test stair provided a “clear and safe passage” for occupants and firefighters even though the corridor and adjacent lobby on the fire floor had heavy smoke levels.

The National Research Council in Canada research showed:

- that the pressure difference in a fire compartment 3.08m above the fire floor varied from 9 Pa to 14 Pa.
- the stack effect had little impact on a pressurisation system.

None of the research looked at open door velocities as it was considered occupants escaping through the doors was for a short period and the system would clear the smoke on the door closing.

7.0 CONCEPT APPLICATION

The PPV concept involves a fire detector located in the car park/place of special fire hazard outside the lobby door. A pressurisation unit incorporating duty & standby fans, duty & standby fire dampers and controls are located on the wall of the stair injecting the air through the opening in the stair wall to the lobby. The unit incorporates a duty and standby power supply with automatic change over on power failure.

On detection of fire on the car park/place of special fire hazard side of the lobby door, the duty fire damper and duty fan operates to achieve 50pa across the lobby/car park door. On duty fan failing, the duty fire damper will close and the standby fan and standby damper will open to maintain the 50pa across the lobby/car park door.

On duty power failure, the unit will switch over to the standby power supply. The dampers are fitted with an electronic thermal fuse which will close the damper in the unlikely situation both fans fail, returning the lobby compartmentation.

All the components are duplicated thus the PPV system is considered to be a 'Life Safety' system. The system incorporates no complicated electronics or inverters.

The system continues to run until the smoke detector is reset.

7.1 Kit Application

Diagram D below shows a schematic of the kit to be used on the PPV unit. The two systems operate as a duty and standby system. The following outlines the components used in the system and additional information is provided in Appendix B.

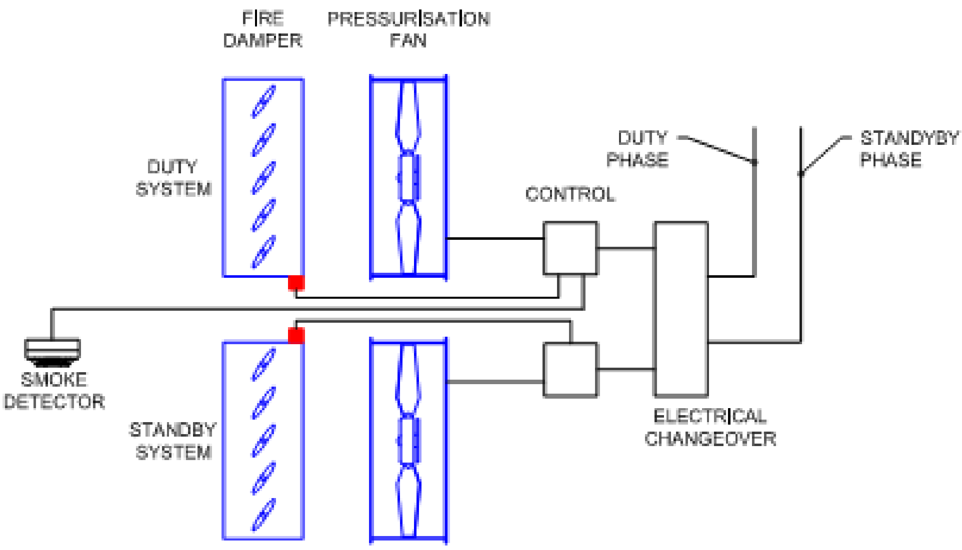


Diagram D – System Components

Fire Detector

A fire detector can be located on the car park/place of special fire hazard side of the lobby door ensuring a fire in the car park/special fire hazard is picked up and the PPV systems are turned on. The fire detector is manufactured and tested to BS5839.

On some developments, an interface may be taken from the detection system which will operate the PPV systems.

Fans

The PPV unit incorporates two ambient temperature single phase axial fans which will run as duty and standby fans. The duty fan current will be monitored ensuring the standby fan operates on duty fan failure.

The fans are tested to ISO 5801:2008 and impellers dynamically balanced to ISO 14694.

Fire Dampers

To provide the necessary compartmentation between the lobby and stair, two fire dampers will be located with the compartment wall. The dampers will be 240v motor open, spring closed. A duty damper will be located in front of the duty fan and a standby damper in front of the standby fan which will be interlocked ensuring the fan will only run when the damper is open. The fire dampers are manufactured and tested in accordance with BS EN 1366 Part 2.

Controls

The system runs at 240 volts and will be treated as 2 standalone control systems. Each system apart from fuses and a voltage regulator will apply the 240 volt straight onto the fire damper. Once open, the damper volt free contact will energise the fan to achieve 50pa across the lobby / car park door.

The duty and standby power supply will be fed into the unit ensuring on duty power failure, the unit continues to operate under standby power supply.

The operation signal will be from the smoke detector or 3rd party interface on the risk area side.

Power Supplies

All power supplies, electrical wiring and the PPV Unit should be protected against fire for 60 minutes where the effects of fire are likely to result in failure or incorrect operation of the system.

The system should be powered from the landlord power supply similar to fire fighting lifts meeting the recommendations of BS9999 for life safety power supplies. The system will operate as a single phase system with a duty and standby power supply.

Both supply cables should be ran to the PPV Unit using fire resistant cable and only coming together in the PPV unit which is located within a sterile compartment away from the car park compartment. The power supplies should be monitored by 3rd party controls.

Positive Pressurisation Ventilation Unit

All the above components will be boxed up within a unit known as a ‘Daisy PPV Unit’ which will only require the power supply cable and detection cable connected on site. The entire unit testing will be done prior to the unit delivery to site.

The installation drawings are shown in Appendix C of this report.

8.0 TESTING THE CONCEPT

Low temperature smoke testing of the PPV Concept was carried out at RVV where the vertical stair opens onto a stair lobby, which then opens onto a corridor leading to the car park. The stair lobby was already fitted with a $0.4m^2$ natural duct to the perimeter of the building. Three simple tests were carried out so a simple visual comparison could be made between the naturally ventilated lobby and the pressurised lobby during means of escape. The volume of the car park and reservoir height above the corridor car park door was ignored during the smoke test. The tests can be seen on PPV RVV Video 1 and 2.

Prior to the testing, the door between the stair and stair lobby was propped in the open position and an air tight screen provided across the opening incorporating a PPV unit allowing the stair lobby to be pressurised.
A smoke generator with heater was located in the corridor to generate smoke.
A manometer with pitot tubes was placed across the stair lobby / corridor door so the pressure difference across the door could be monitored.

<u>Test 1 – Natural $0.4m^2$ Vent from the Stair Lobby</u>

The manometer across the stair lobby/corridor door recorded a pressure difference of 1.2pa.

The $0.4m^2$ natural duct in the stair lobby was left uncovered.

The smoke generator with heater running was left running in the corridor for 45 seconds.

<u>Observations</u>

Smoke started leaking through the stair lobby/ corridor door, between the door and frame while in the closed position.

When the door was open 150mm smoke started moving into the stair lobby.

The stair lobby became smoky, but no smoke moved towards the high level duct.

Test 2 – PPV system running in the Stair Lobby

The 0.4m^2 natural duct in the stair lobby was sealed.

The PPV unit was activated.

The manometer across the stair lobby/corridor door recorded a pressure difference of 52pa.

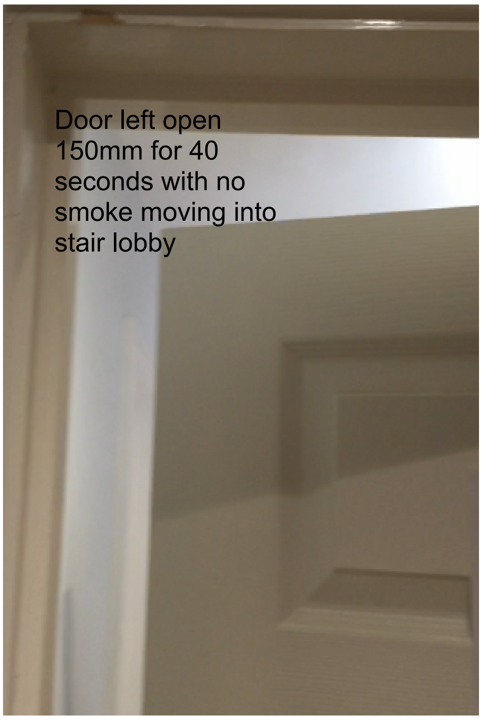
The smoke generator with heater running was left running in the corridor for 45 seconds.

Observations

No smoke leaked through the stair lobby/corridor door when closed.

When the door was open 150mm no smoke moved into the stair lobby.

The stair lobby remained clear of smoke with movement of smoke away from the pressurised stair lobby space.



Test 3 – PPV system running in the Stair Lobby with escaping occupant passing through stair lobby door

Questions get raised as to what will happen when the occupant passes through the stair lobby door and the fact that the PPV system is not designed to deal with an open door velocity.

In the following test, the volume of the car park and height of the reservoir above the corridor stair door was ignored.

The test was intended to review the effects of the occupant escaping through an open door.

The 0.4m^2 natural duct in the stair lobby was sealed.

The PPV unit was activated.

The manometer across the stair lobby/corridor recorded a pressure difference of 52pa.

The smoke generator with heater running was left running in the corridor for 45 seconds.

Observations

No smoke leaked through the stair lobby/corridor door when closed.

When the door was opened as the person escaped through, the smoke movement was away from the pressurised space which was at a higher pressure with the rush of air moving to the lower pressure space.

The door open condition was approximately 5 seconds.

The condition is unlikely due to the car park ventilated space, large volume, reservoir above the stair car park door and the fact that an occupant would have left the space by the time the smoke would be building down.

The stair lobby remained clear of smoke with the smoke movement away from the pressurised space.

9.0 SYSTEM CAPABILITY

The Daisy PPV unit incorporates one small duty and standby supply fan housed within the enclosure. Each of the fans is capable of delivering 0.5m^3/s at an operating pressure of 50pa. This will provide a pressure difference of 50 pa across a total leakage area of 0.08m^2 assuming an air tight fire compartment.

It is critical the stair lobby is an air tight compartment as the pressure difference will not be achieved from a leaky enclosure as the fan is developing a volume to overcome the British Standard fitted fire door leakage only.

Table 1 below shows the typical leakage areas for British Standard tested and fitted fire and lift doors and is an extract from BS EN 12101: Part 6 (Table A.3).

Element	Leakage area (m^2)	Volume to achieve 50pa (m^3/s)
PPV unit capability	0.08	0.500
Single leaf door in rebated frame opening into a pressurised space (2m high, 0.8m wide)	0.01	0.060
Single leaf door in rebated frame opening outwards from a pressurised space (2m high, 0.8m wide)	0.02	0.120
Double leaf door (2m high, 1.6m wide)	0.03	0.180
Lift landing doors (2m high, 1.6m wide)	0.06	0.350

Table 1 – Leakage Areas for BS Doors

When all the doors opening onto the pressurised lobby are added together, the leakage area cannot exceed 0.08m^2.

In addition to the above the swing of the door also needs to be considered. Where the fire door opens into the pressurised space, the door stops will prevent the door being pushed out as the pressure builds up.

On lobbies with the doors opening out of the space, door closures of a heavy duty will be required to keep the door closed against the pressures.

9.1 Important Considerations

Pressurised lobby enclosure needs to be of an air tight construction with only leakage through the fire doors.

All circulation route fire doors, cupboard fire doors within the pressurised lobby and any HVAC systems running through should be considered.

The overall leakage area should not exceed 0.08m^2.

10 CONCUSIONS

The Approved Document B recognises that during means of escape, smoke enters the stair lobby in residential buildings.

The $0.4m^2$ natural opening or mechanical smoke control in Section 3.75 of ADB is seen as a way of preventing the smoke entering the stair during means of escape.

Section 7.6, item 2 of the Smoke Control Association Guidance Document on Residential buildings identifies the requirements to meet the mechanical smoke control option in ADB.

The research papers identified that pressurisation prevents smoke entering the protected space during closed door condition and is not influenced by the expansion of hot gases, stack effects or wind.

The research papers identified that as the low number of occupants pass through the escape doors, the smoke is prevented from entering the protected space.

The research showed that where the door is held open for a longer period and smoke enters the protected space, it is quickly dispersed on closing the door assisting with protecting the stair.

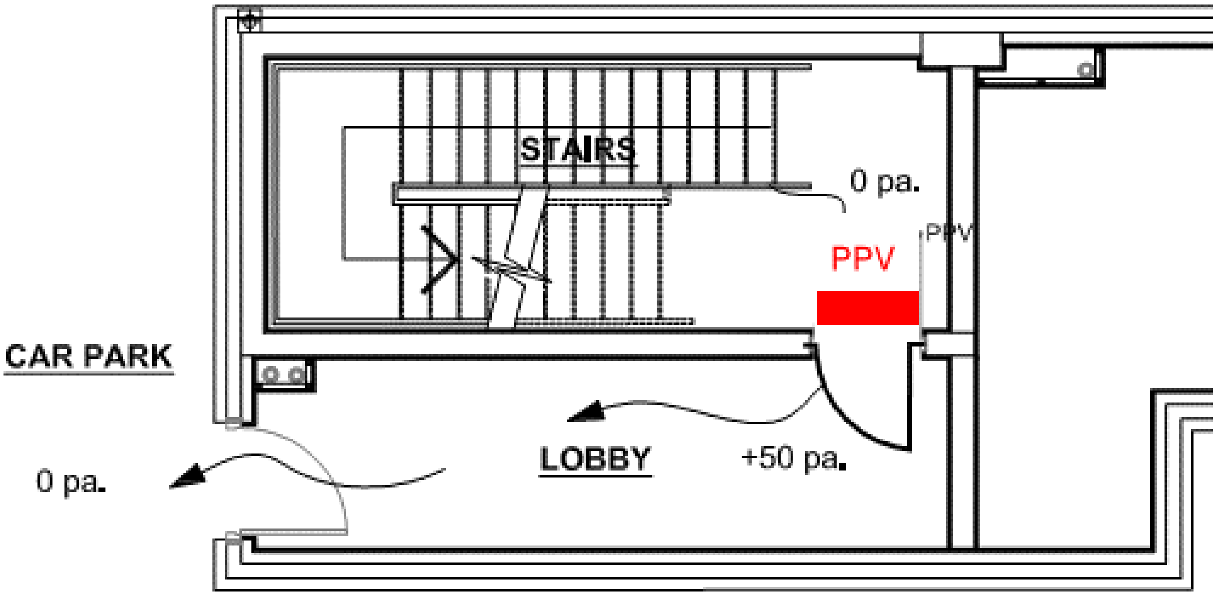
Using PPV to protect the lobby, a higher level of protection is provided to the stair during means of escape.

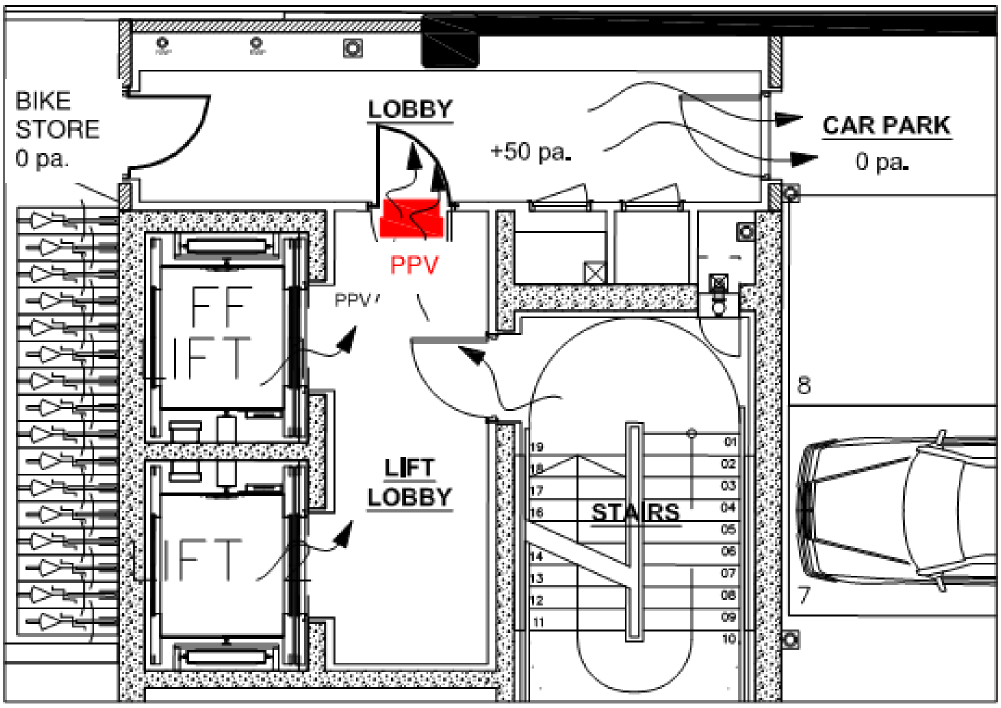
No additional provisions are provided under the ADB for Fire Fighting operations, apart from the smoke clearance from the car park.

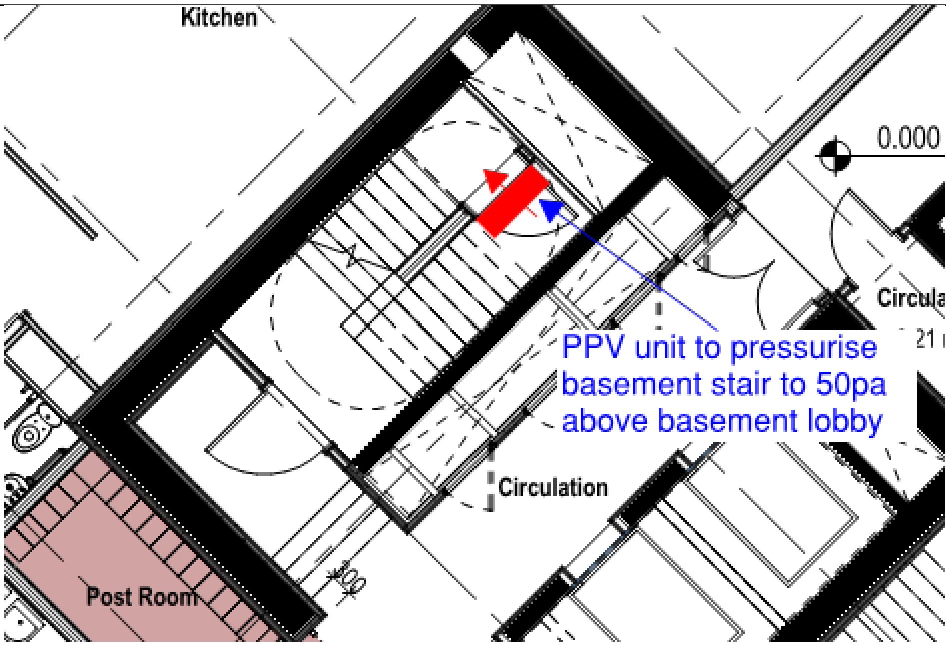
The PPV system incorporates variable volume fans which allows the required pressure difference to be achieved for the specific lobby, where the guidance is followed. The fan speed controller is adjusting during commissioning on site to give a fixed speed, until the 50pa is achieved for the closed door condition.

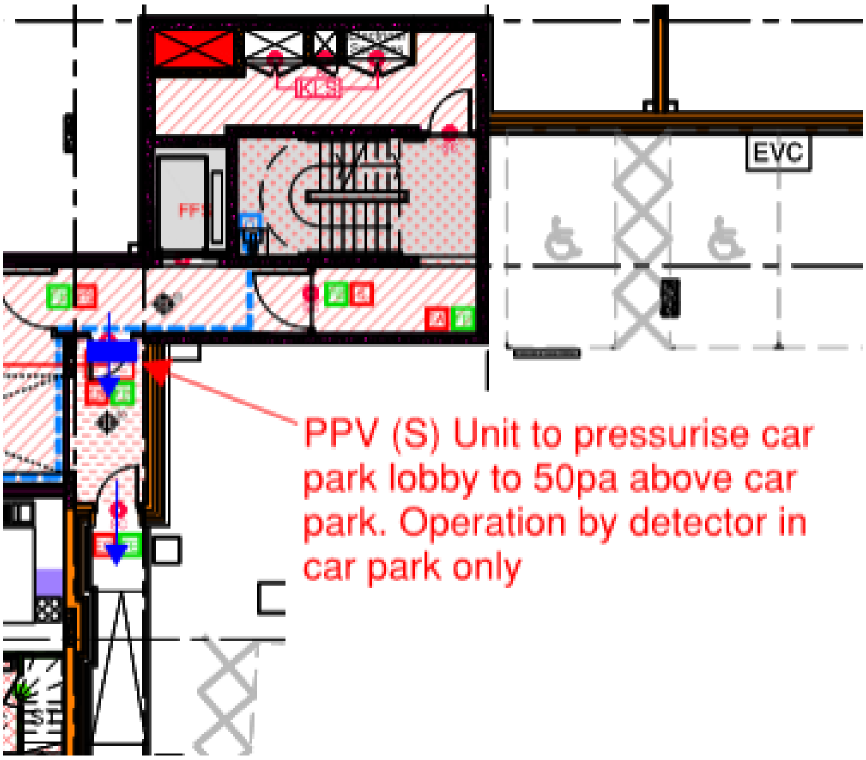
In conclusion, the PPV system protects the lobby and stair providing a higher standard of smoke management to that of a $0.4m^2$ natural vent which is unworkable on some developments.

APPENDIX A – LOBBY APPLICATIONS






Kitchen
0.000
Circula
PPV unit to pressurise basement stair to 50pa above basement lobby
Circulation
Post Room


EVC
PPV (S) Unit to pressurise car park lobby to 50pa above car park. Operation by detector in car park only

APPENDIX B – TECHNICAL INFORMATION ON THE COMPONENTS

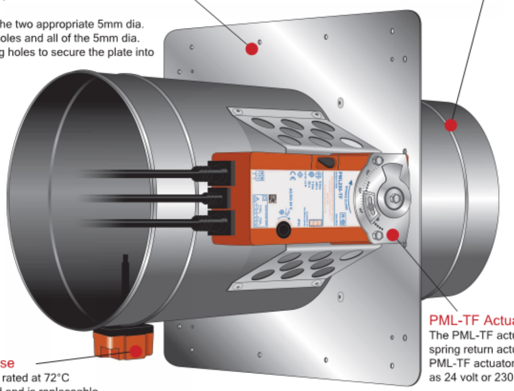
Fire Damper

Single Blade Fire and Smoke Dampers - Product Specification

Installation Plate
The installation plate allows the damper to be fixed into place from one side only with no infill material being required on the other open side

Use either of the two appropriate 5mm dia. corner fixing holes and all of the 5mm dia. mid span fixing holes to secure the plate into position.

Case
Galvanised mild steel to BS EN 10346 DX 51D Z275 0.8±0.1mm
Damper casing conforms to BS EN 1506.



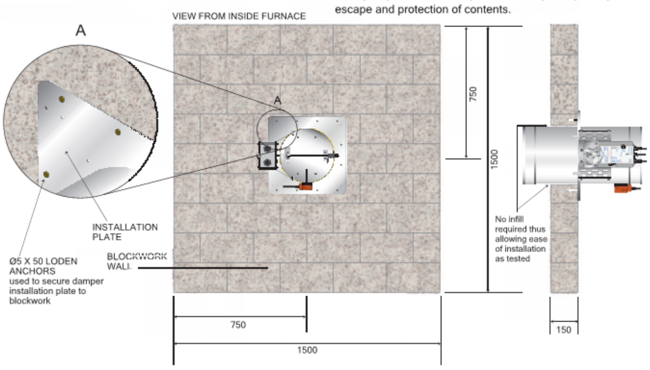
PML-TF Actuator
The PML-TF actuator is a spring return actuator. The PML-TF actuator is available as 24 volt or 230 volt.

Thermal Fuse
Thermal Fuse rated at 72°C is factory fitted and is replaceable external to the damper case.
The thermal fuse is fitted with a green LED indication light which provides a quick visual check that the actuator is receiving power and that the thermal fuse is

Tested to BS EN 1366-2
The FSD-C series damper has been tested both ways, with access side inside the furnace and non-furnace side.

- Tested to BS EN 1366-2 and BS EN 13501-3
- E180 integrity classification.
- ES120 integrity classification.
- ES90 horizontal concrete floor.
- Complies with classes A, B & C of DW144.
- Surpasses minimum requirements on case leakage
- Surpasses minimum requirements on blade leakage

Test Conclusions:
The FSD-C combination Fire and Smoke Damper satisfied the requirements of BS EN 1366-2 and BS EN 13501-3 achieving the lowest closed blade leakage of any damper within its class.
Dampers were tested affixed to the inside of the furnace wall and also to the external wall of the furnace with the damper closed blade being fully exposed to the furnace rapid rising temperature.
The achieved ES classification ensures that in a fire condition the non fire side is fully protected (from radiated heat) for the achieved period, providing vital time for the emergency services to respond, ensuring safe passage of escape and protection of contents.



The addition of the PML actuator allows this tested product to become fully automatic in its operation via the fire detection system or one of the BSB control panels. To comply with the forthcoming revision of the fire damper test standard.

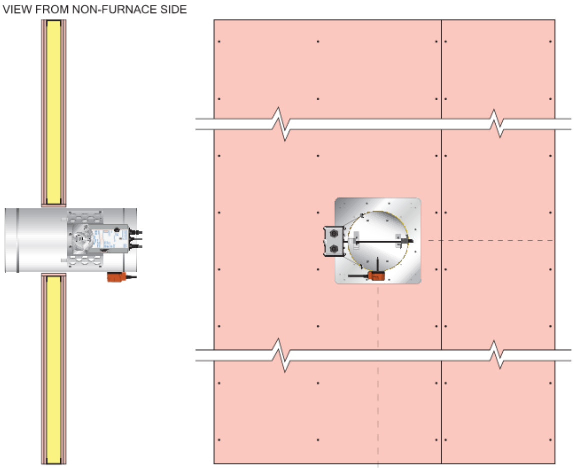
FSD-C in Dry Wall - Actuator inside and outside of furnace

Tested to BS EN 1366-2
Test Report No. 279799 refers

- Tested to BS EN 1366-2 and BS EN 13501-3
- E120 integrity classification.
- ES120 integrity classification.
- Complies with classes A, B & C of DW144.
- Surpasses minimum requirements on case leakage
- Surpasses minimum requirements on blade leakage
- Damper casing conforms to BS EN 1506

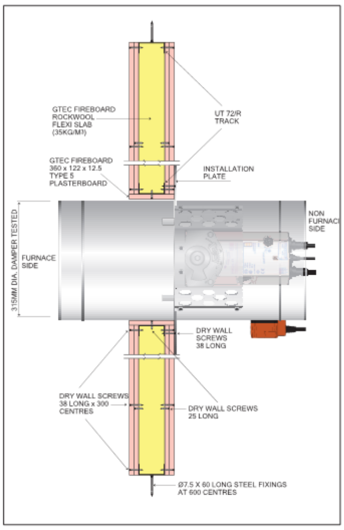
Test Conclusions:
The FSD-C combination Fire and Smoke damper satisfied the requirements of BS EN 1366-2 and BS EN 13501-3 achieving the lowest closed blade leakage of any damper within its class.
Dampers were tested affixed to the inside of the furnace wall and also to the external wall of the furnace with the damper closed blade being fully exposed to the furnace rapid rising temperature.
The achieved ES classification ensures that in a fire condition the non fire side is fully protected (from radiated heat) for the achieved period, providing vital time for the emergency services to respond, ensuring safe passage of escape and protection of contents.

VIEW FROM NON-FURNACE SIDE

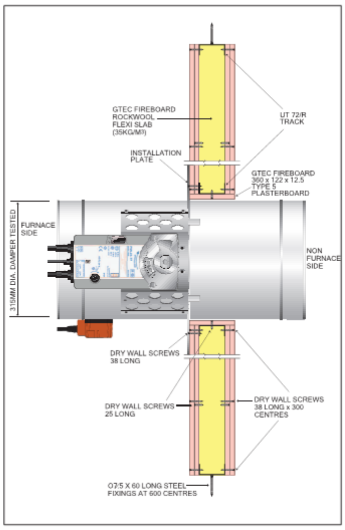


The FSD-C single blade combination fire and smoke damper with its unique feature of requiring only a single installation plate when being installed within tested applications, and without the need for any infill between the damper body and the structure that it sits within. Is the first damper of its type to achieve and exceed the requirements of classification EN1366-2.

FSD-C in Dry Wall
Test Report No. 279799 refers
Actuator outside of furnace



FSD-C in Dry Wall
Test Report No. 279799 refers
Actuator inside of furnace



Testing and Conformities
Tested to EN1366-2. See installation details for full details.
Damper casings conform to BS EN 1506
Tested/assessed and achieved equivalent classification to:

ES Classification (BS EN 1366-2/BS EN 13501-3)
- BSB FSD-C fitted with Installation Plate
  - E180 - Blockwork/Masonry wall
  - ES120 - Blockwork/Masonry wall
  - ES90 - Concrete floor
  - ES120 - Horizontal application (please refer to BSB sales office)
  - ES90 - Horizontal application (please refer to BSB sales office)
  - E120 - Dry Partition wall
  - ES120 - Dry Partition wall

Integrity only (BS 476-20/22 - ADB)
Meets the requirements of BS 476-20/22 - Refer to BS 476-10.6.6.3

FSD-C Blade leakage (BS EN 1751)
- Class 2

Corrosion Testing
BBA test report 50447 issue 2 refers
- Tested to BS EN 60068-2-11:1999

Conventional Photoelectric Smoke Detector
SLR-E3N

Features

- Removable, High Performance chamber
- Remote Indicator output
- Wide voltage range (9.5 ~ 30 V dc)
- Low profile design with one piece outer cover
- Twin fire LEDs allow 360° viewing
- Range of mounting bases
- Approved by LPCB & VdS
- Also available in white and black

Description

The SLR-E3N is a Photoelectric Smoke Detector, which is fully compatible with the majority of existing Conventional systems.

The SLR-E3N incorporates Hochiki's unique High Performance photoelectric smoke chamber removing the need to use Ionisation Detectors in the majority of applications. An integral third terminal provides a remote indicator output.

The smoke chamber is easily removed or replaced for cleaning and utilises a unique baffle design which allows smoke to enter the chamber whilst keeping out ambient light.

Specification			
Ordering Codes	Sensor	SLR-E3N SLR-E3N(WHT) SLR-E3N(BLK)	
	Replacement Chamber	SLV/ALK REPLACEMENT CHAMBER	
Operating Voltage		9.5 – 30 V dc	
Quiescent Current (typ)		35 µA	
Maximum Current Alarm		40 mA	
Remote Indicator Drive		20 mA (max) / 9.5 – 14 mA (typ)	
Operating Temperature Range		-10 °C to + 50 °C	
Storage Temperature Range		-30 °C to + 60 °C	
Maximum Humidity		95%RH - Non Condensing (at 40 °C)	
Ingress Protection Rating		IP42	
Colour / Case Material		Ivory, White or Black / ABS	
Weight (g)		95 (excluding base)	
Diameter (mm) / Height (mm)		100 / 38	
Compatible Bases		YBN-R/6 YBN-R/6SK	YBO-R/6R, YBO-R/6RS YBO-R/6RN, YBO-R/6PA
Base Fixing Centres (mm)		48 ~ 74	
Approvals		LPCB EN54: Part 7	
		VdS EN54: Part 7 (G208040)	

Conventional Latching Relay Mounting Base

YBO-R/6R

Features

- Integral remote indicator output
- Wide voltage range - can be used in security systems
- Rugged design
- Quick connections via square cable clamps
- Accepts 2.5 mm^2 cables
- Bayonet slot, low insertion force for detectors
- Approved by LPCB

Description

Model YBO-R/6R is a Conventional Detector Mounting Base associated with the New CDX Range of Detectors and is fully compatible with the majority of existing conventional fire alarm and security control panels.

It is supplied with square cable clamps for secure and reliable cable termination but the base does not provide line continuity during detector removal, therefore if Call Points are being used then these should be wired onto the zone first. The integrated third terminal provides remote indicator output.

Specification	
Ordering Code	YBO-R/6R
Operating Voltage	9.5 – 30 V dc
Relay Voltage	30 V dc @ 1 A (non-inductive)
Operating Temperature Range	-10 °C to + 50 °C
Storage Temperature Range	-30 °C to + 60 °C
Maximum Humidity	95%RH - Non Condensing (at 40 °C)
Colour / Material	Ivory White / ABS
Weight (g) / Diameter (mm) / Height (mm)	87 / 100 / 13
Fixing Centres (mm)	48 ~ 74
Maximum Wire Thickness	2.5 mm^2 Cables

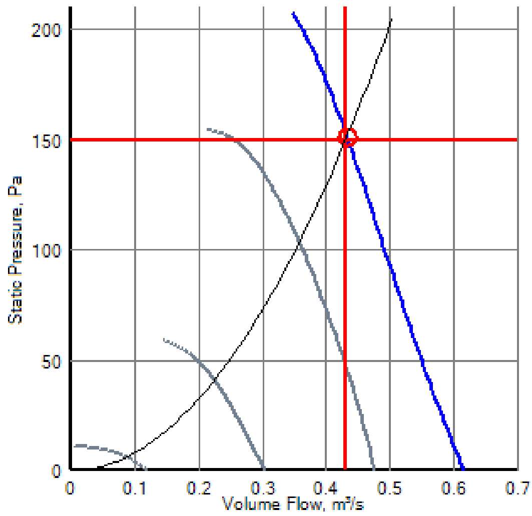
Fan

Performance - Required

Air Flow:	0.43 m³/s
Static Pressure:	150 Pa
Selection Pressure:	150 Pa
Installation Type:	n/a
Air Density:	1.204 kg/m³
Atmos. Temp.:	20 °C
Altitude: m	0 m
Humidity:	0.0 %

Actual

Air Flow:	0.43 m³/s
Static Pressure:	152 Pa
Total Pressure:	198 Pa



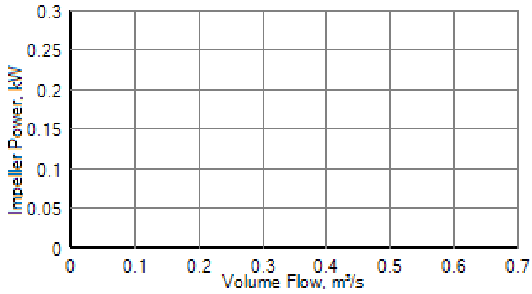
Fan Data

ial

Diameter:	250 mm		
Impeller Type:	Axial		
Blade Material:	-		
Speed:	3020 RPM	Running:	50 Hz
Power, Abs:	-	Peak:	-
Efficiency Total:	-	Static:	-
SFP:	0.53		
Fan Weight:	4.5 kg		

Motor Data (at STP)

Motor Type:	
Electrical Supply:	1ph 230V 50Hz
Motor Frame:	
Motor Power:	0.24 kW
Motor FLC/Start:	2.00A / -
Motor Speed:	-
Motor Efficiency:	-

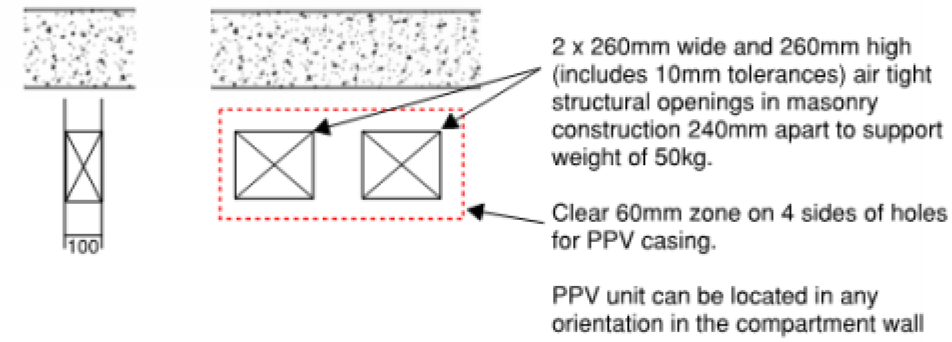


Sound Data

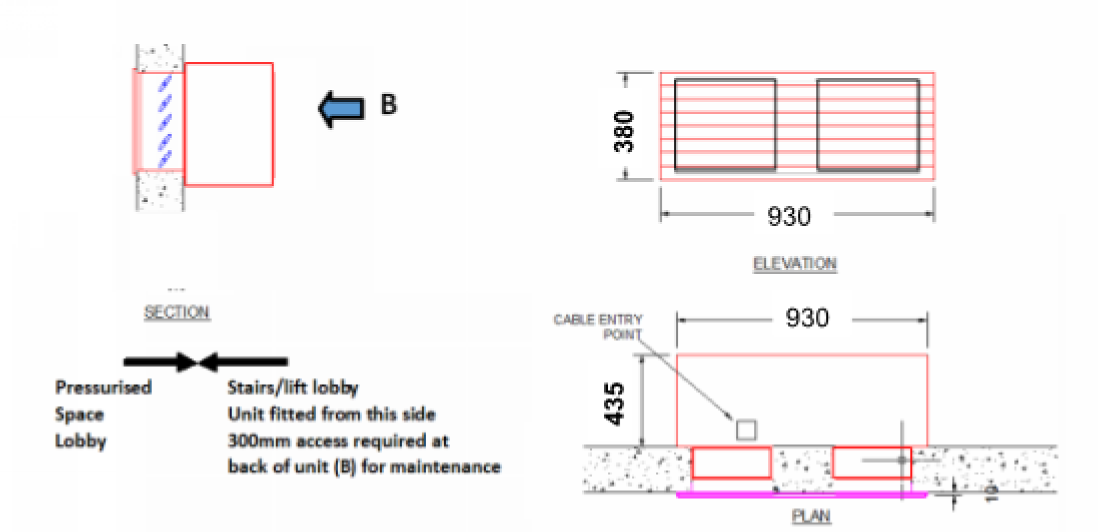
Spectrum (Hz):	63	125	250	500	1K	2K	4K	8K	dBW	dB(A) @ 3m
Inlet (dB):	86	78	79	78	74	75	72	65	88	61
Outlet (dB):	85	77	80	78	75	74	70	64	88	60

Sound levels are quoted as in-duct values. dB(A) values are average spherical free-field for comparative use only.

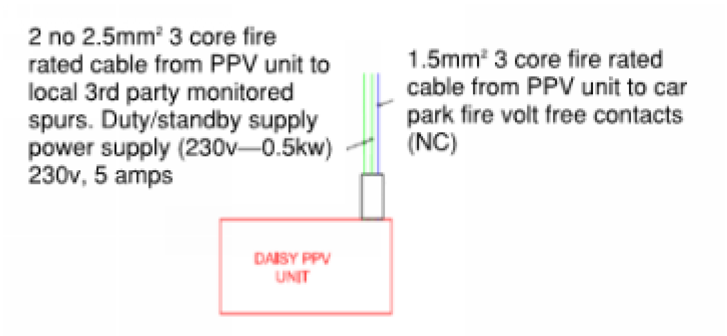
APPENDIX C – INSTALLATION DRAWINGS



PPV Builders Works



PPV Casing Size



PPV Electrical Interface

APPENDIX D – MARKETING PAGE

General Specification

Daisy Positive Pressurisation Ventilation

Technical Data Sheet

BE SAFEDIRECT

The Daisy Positive Pressurisation Venting (PPV) Unit has been designed to provide an alternative mechanical approach to the natural 0.4m^2 permanent ventilation within basement lobbies.

Section 3.75 of Approved Document B V1 2019 (ADB) and previous ADB's identifies that where lobby ventilation is required for B1 means of escape, to protect the stair this can be achieved by natural ventilation or mechanical smoke control. Section 7.6 of the Smoke Control Association (SCA) Guidance document on Residential Buildings – 2020 provides guidance on how to meet the mechanical smoke control requirements using pressure differential which the PPV follows. The PPV unit injects air into the protected lobby to raise to a higher pressure to prevent the ingress of smoke from the car park or places of fire hazard such as refuse or bike stores when the doors remain closed.
The PPV unit incorporates duty and standby fans, duty and standby fire dampers, fire detector interface, single phase automatic electrical change over switch, controls, status LED and a volt free contact for 3rd party monitoring. All the above is located within the decorative PPV enclosure box.

The system is operated by a 3rd party fire detector located in the car park or place of special fire hazard side of the lobby door. The system continues to run until the fire detector is reset.

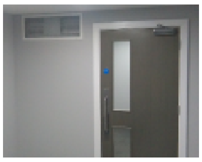
Advantages

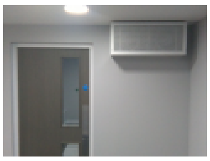
- PPV unit prevents smoke entering the stairs when door is closed.
- PPV unit occupies minimum space.
- The 0.4m^2 expensive fire rated duct can be omitted.
- Low car park heights or stepping services around the duct are not a concern.
- The car park smoke clearance system does not need to be enhanced and can remain at 10 air changes per hour.
- Can be used with natural ventilated car parks.
- No expensive fire shutters required on car ramp or control of inlet air paths for enhanced system.
- Can also be used with ventilated bin/cycle store lobby protection.
- Cost effective solution to meet the ADB & SCA Guidance.

PPV Feb23

Features

- Fire dampers tested & certified to BS EN1366-2
- ISO 5801:2008 single phase duty and standby fan.
- Operated from 3rd party IO volt free contacts (NC) .
- Single phase power supply 230v, 0.5 kw.
- The constant fan speed to develop 50pa is set up during commissioning by turning a voltage regulator switch.
- No specialist knowledge or systems required to set up.
- Fan is capable of developing 0.5m^3/s at a static pressure of 50 pa.
- Casing finish to white RAL 9003.
- Health/Fault LED.
- Fault mode relay.
- Allows lobby to be pressurised with British Standard fitted fire doors in an air tight lobby.
- Onward leakage required from risk space.
- Unit should be selected in accordance with guidance note DMS-DN01A design criteria.





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APPENDIX E – Design Note No. DMS-DN01 – Application of PPV for Basement Stair Lobby Ventilation

Design Note No. DMS-DN01B

Project **Basement Stair Lobby Ventilation**

Subject **Application of PPV for Basement Stair Lobby Ventilation**

Date **03 Feb 2023**

1.0 DOCUMENT CONTROL

Issue	Date	Description	Author	Reviewed
0	14/11/16	Design note issue	HB	DS
B	03/02/23	Design Note Updated	GS	HB

2.0 INTRODUCTION

The purpose of this Design Note is to document the application of the PPV Concept within residential developments and how it can be utilised as part of a Building Regulations Application.

This note also outlines the requirements and considerations which should be applied in the application of a PPV unit.

Prior to ordering or installing a PPV Unit, the PPV concept should be agreed with the design team and signed off by the Approving Authorities.

3.0 GUIDANCE DOCUMENTS

Schedule 1 of the Building Regulations identifies the legal requirement to be met in the design and construction of buildings.

The Approved Document B (ADB) issued by the Secretary of State provides practical guidance to meet the above Schedule and where followed, allows compliance with the Building Regulations. The Approved Document makes references to other guidance documents where further guidance can be followed.

In the case of smoke ventilation principles to the basement stair lobby, this is covered in Approved Document B (ADB) V1 2019., Section 3.75. The guidance is in B1 for means of escape and is not intended for fire fighting operations nor post-fire smoke clearance. The section identifies natural ventilation or mechanical smoke control as the two possible design provisions to achieve lobby ventilation as shown in Figure 1 below.

3.75 Where a stair serves an enclosed car park or place of special fire hazard, the lobby or corridor should have a minimum 0.4m² of permanent ventilation or be protected from the ingress of smoke by a mechanical smoke control system.

Figure 1 - (ADB) Extract

The Construction and Approval Bodies identified there was little guidance on meeting mechanical smoke control systems. The Smoke Control Association (SCA), through HVAC set up a working group to develop guidance along with other acceptable solutions.
The SCA Guidance document on Residential Buildings – 2015 identifies the two possible methods to meeting the above mechanical smoke control requirement (positive or negative pressurisation) as shown in Figure 2 below. This SCA guide is a referenced document for smoke control systems design within the British Standards BS9991:2015.

7.6 Ventilation of lobbies to ancillary accommodation

The prescriptive codes recommend for means of escape that ancillary accommodation (e.g. car park or places of special fire hazard) is separated from the staircase by means of a natural ventilated lobby (e.g. where ADB recommends for a small single staircase building a 0.4 m^2 vent). This is normally achieved by a fire rated plenum linking the lobby to the outside of the building allowing any smoke in the lobby to be ventilated.

The natural ventilation cannot always be achieved. An alternative approach may be to use one of the following mechanical ventilation systems.

1) Mechanical extraction from the lobby at a rate equivalent to the natural vent and a pressure not exceeding 20 Pa across the lobby doors. The fan discharge should be ducted to the outside.
2) Positive pressurisation of the lobby above the surrounding space.

In developing the above system, the replacement air should be taken from the sterile area ensuring smoke is not actively drawn into the lobby. This could be from the staircase or riser and where dedicated active openings are provided, they should be controlled by a local smoke detector.

Duty and standby fans should be provided to ensure the system operates in the event of component failure.

All testing during commissioning should be carried out with the doors closed.

Figure 2 - Smoke Control to Common Escape Routes in Apartment Buildings

As can be seen from the above, option 2) allows the lobby space to be pressurised to a higher pressure than the surrounding space when the doors are closed. Replacement air is to be taken from the stair or risers. Onward leakage is required from the risk area so the pressure difference can be maintained. Further guidance in the BSEN12101:Part 6 suggests a pressure difference of 50pa for a closed door condition which has become the industrial standard.

This SCA document was prepared by a working Committee from Approving Authorities, Fire Services, Fire Consultants and Manufacturers, similar to British Standard's so a workable solution could be developed that met the requirements of all interested parties. During the drafting stage, the document was circulated to external Fire Services, Building Control & Approved Inspector reprehensive bodies who commented on the draft which was then incorporated within the final document. This process, as with any standard, is intended to allow the concepts to become acceptable and allow easy approval where the guidance is followed.

The Committee who prepared the SCA document were made up of representatives from a cross spectrum of the industry as identified in Figure 3 below. This Code has now become a recognised standard in the design of smoke control systems.

Acknowledgements

Contributions to this guide are gratefully acknowledged from the following people:

Conor Logan	Colt International Ltd
Richard Brooks	Advanced Smoke Group Ltd
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Paul White	Advanced Smoke Group Ltd
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Matthew Ryan	London Fire Brigade
Guy Foster	London Fire Brigade - Fire Safety
Hugh Mahoney	PSB UK Ltd
Paul Hanson	Royal Borough of Kensington & Chelsea
Will Perkins	SE Controls
Michael Duggan	Smoke Control Association / FETA

Figure 3 – Contributors to the SCA Guidance Documents

The SCA guidance document has gone through revisions with the current 2020 Rev 03 edition providing the same guidance.

4.0 CONCEPT OF POSITIVE PRESSURISATION VENTILATION

As discussed above, PPV involves pressurising the basement lobby to a higher pressure to the car park or places of special fire hazard. The inlet air needs to come from the sterile stair side of the lobby with door leakage into the car park or special fire hazard. This is achieved by locating a PPV unit on the stair wall side which would inject the air into the lobby raising the space to a higher pressure with onward leakage of air into the car park or place of special fire hazard as shown in Figure 4 below. Leakage is required from the risk space such as the car park or stores to the external to ensure the pressure difference is maintained. In order to ensure the pressurised air is kept in the protected lobby, it is always recommended the doors open into the protected pressurise lobby ensuring they remain closed when the PPV unit is running as shown below.

The general principals of pressurisation are outlined in BS EN 12101: Part 6, although basement stair lobbies with closed door requirements only are not addressed in this document. To meet the means of escape requirements of ADB for the closed door condition, the basement lobby would need to be raised to 50pa above that of the car park or places of special fire hazard with the door closed. This 50pa across a closed door has become an acceptable industrial standard and will be utilised with the PPV concept.

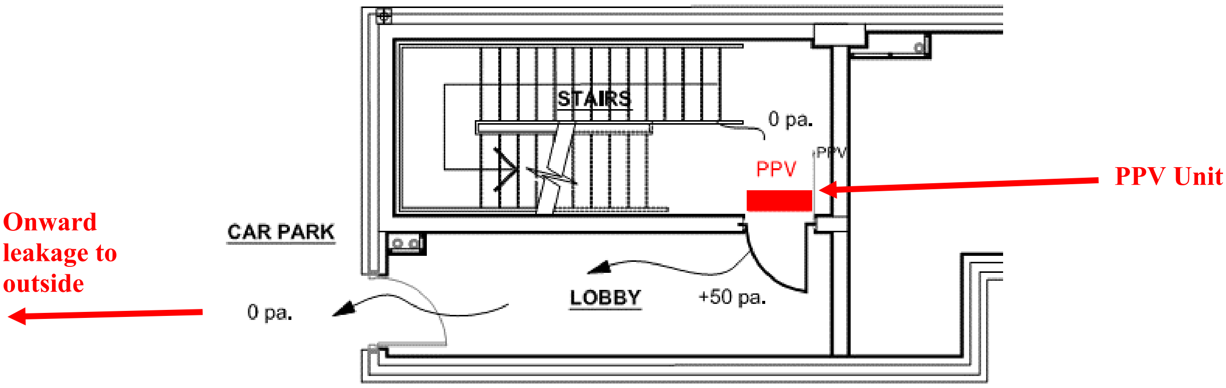


Figure 4 – Lobby Pressurisation Concept

The unit incorporates duty and standby fans, duty and standby fire dampers, fire detector interface, single phase automatic electrical change over switch, controls, status LED and a volt free contact for 3rd party monitoring duty conditions. All the above is located within the decorative PPV enclosure box.

The PPV concept involves a fire detector located in the car park/place of special fire hazard outside the lobby door. On detection of fire in the car park/place of special fire hazard side of the lobby door, the duty fire damper and duty fan operate to achieve 50pa across the closed lobby/car park door. On duty fan failing, the duty fire damper will close, and the standby fan and standby damper will open to maintain the 50pa across the closed lobby/car park door.

On duty power failure, the unit will switch over to the standby power supply. In the unlikely event of standby power or standby fan failure, the fire damper will close. returning the lobby compartmentation.

All the components are duplicated thus the PPV system is considered to be a ‘Life Safety’ system. The system incorporates no complicated electronics or inverters.

The PPV unit is a fixed volume system which is commissioned with all the doors closed to achieve 50pa across the closed door between the lobby and car park/storerooms depending on application. This involves setting the fan to the necessary fan speed at which the system will then run, following activation of the fire detection system.

The system will continue to run until the fire detector is reset.

5.0 SYSTEM CAPABILITY

The Daisy PPV unit incorporate one small duty and one standby supply low temperature fan housed within the enclosure. Each of the fans is capable of delivering $0.5m^3/s$ at an operating pressure of 50pa. This will provide a pressure difference of 50 pa across a total leakage area of $0.08m^2$ assuming an airtight fire compartment.

It is critical the Client is advised of the importance of an **airtight compartment** with the only leakage through the access fire doors. The pressure difference will not be achieved from a leaky enclosure as the fan is developing a volume to overcome the leakage across a British Standard fitted fire door.

Table 1 below shows the typical leakage areas for British Standard tested and fitted fire and lift doors and is an extract from BS EN 12101: Part 6 (Table A.3).

Element	**Leakage area (m^2)**	**Volume to achieve 50pa (m^3/s)**
PPV unit capability	0.08	0.500
Single leaf door in rebated frame opening into a pressurised space (2m high, 0.8m wide)	0.01	0.060
Single leaf door in rebated frame opening outwards from a pressurised space (2m high, 0.8m wide)	0.02	0.120
Double leaf door (2m high, 1.6m wide)	0.03	0.180
Lift landing doors (2m high, 1.6m wide)	0.06	0.350

Table 1 – Leakage Areas for BS Doors

When all the doors opening onto the pressurised lobby are added together, the leakage area cannot exceed $0.08m^2$.

In addition to the above the swing of the door also needs to be considered. Where the fire door opens into the pressurised space, the doorstops will prevent the door being pushed out as the pressure builds up. This is the recommended door swing.

On lobbies with the doors opening out of the space, door closures of a heavy duty may be required to keep the door closed against the pressures. These needs to be considered by the Design Team and Approving Authorities. Door closer can only be selected after the PPV unit is commissioned.

The following section looks at the leakage due to fire doors both for circulation and lifts.

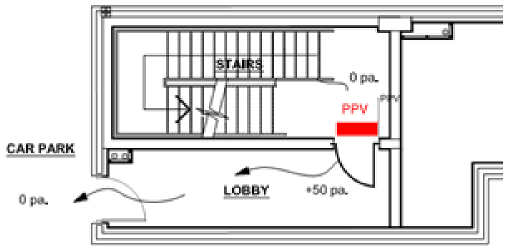
Case 1

PPV unit fitted on stair wall side of stair/lobby door injecting air from the stair into the lobby to raise the lobby to 50pa above the surrounding spaces.

Two single fire doors (0.01m^2 + 0.01m^2) =

0.02m^2 leakage area

Pressurised lobby acceptable as less than 0.08m^2 leakage from lobby



Case 2

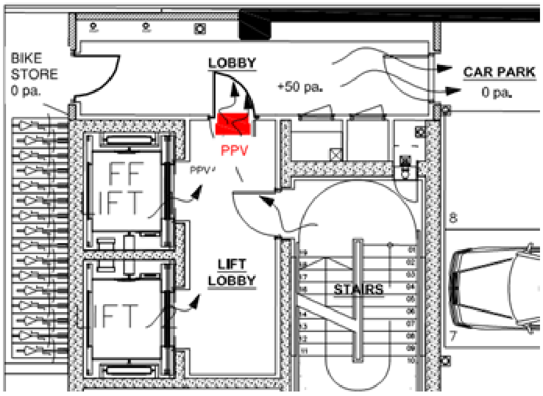
PPV unit fitted on lift lobby side of lift lobby/lobby door injecting air from the lift lobby into the lobby to raise the lobby to 50pa above the surrounding spaces. This includes the car park and the bin store.

Three single fire doors (0.01m^2 x 3) =

0.03m^2 leakage area

The two small cupboards to right of lift lobby/lobby door are horizontally fire stopped at ground level, thus no leakage.
The bin store needs to have onward leakage to the outside to avoid the store reaching equal pressure to lobby.

Pressurised lobby acceptable as less than 0.08m^2 leakage from lobby



Case 3

If we look at Case 2 but try to pressurise the lift lobby, we will have 2 lift doors and one single door to consider in the leakage calculation. This would be as follows:

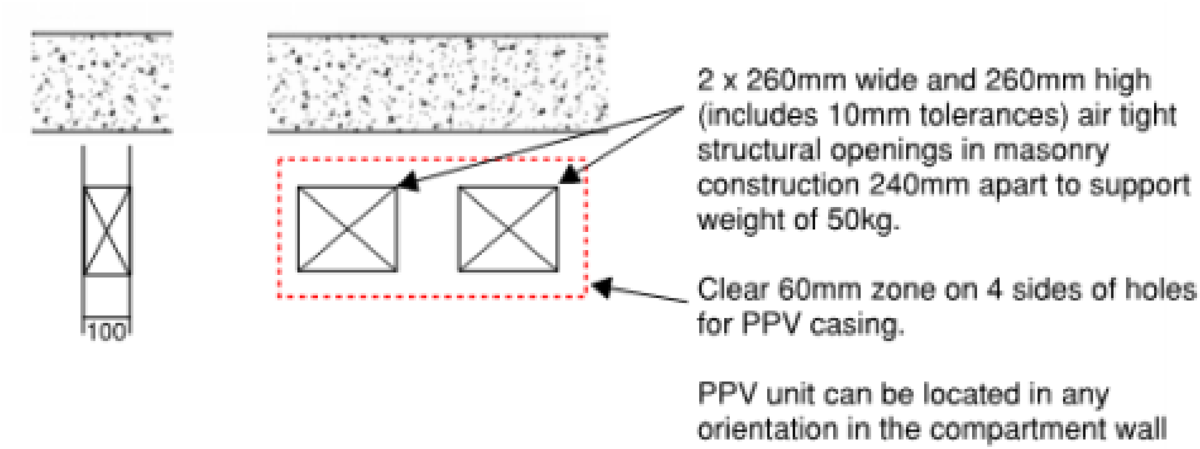
Two lift doors (0.06m^2 x 2) + lobby door (0.02 m^2)

0.14m^2 leakage area

Pressurised lift lobby would not be acceptable as leakage area exceeds 0.08m^2 leakage from the lift lobby. This demonstrates why we cannot have a lift within the pressurised lobby.

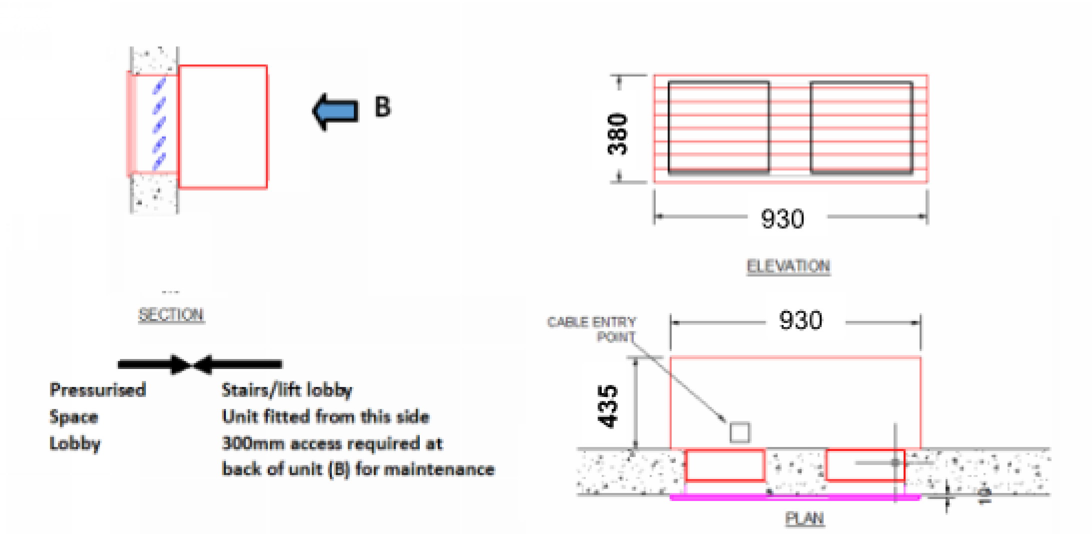
6.0 INSTALLATION

The PPV unit dampers should fit into the 2 structural compartment wall openings as shown below. The space between the two holes must be of solid construction and form part of the compartment wall.



PPV Builders Works

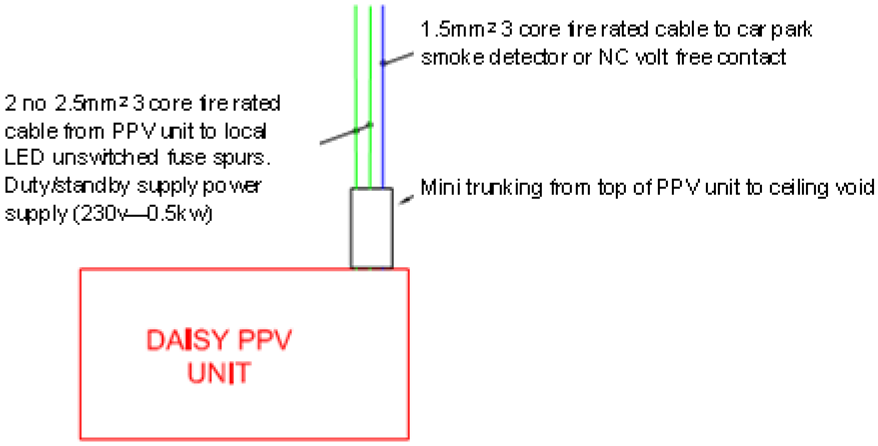
The PPV unit dampers fit into the structural opening from the sterile side with the PPV fire damper sitting in the structural opening to provide the necessary compartmentation. The PPV dimensions are shown below.



PPV Casing Size

Access is required to the back of the unit at position 'B'. This is where commissioning and maintenance is carried out.

The diagram below shows the cable requirements to the PPV unit.



PPV WIRING REQUIREMENTS

7.0 IMPORTANT CONSIDERATIONS

1) Pressurised lobby enclosure needs to be of airtight construction with the only leakage between circulation doors and the frames. No other leakage paths are allow from the pressurised lobby.
2) The PPV unit should be positioned on the non-risk cold wall side of the pressured space as shown in Figure 4 so the sterile clean air is injected into the pressurised space. This will also protect the PPV unit from the hot gases impinge on the PPV casing.
3) Sufficient makeup air should be available to the PPV unit fan inlet.
4) To allow the pressure difference to be maintained, it is necessary to have leakage from the risk area outside the pressurised space to outside the building. In the case of car parks, this is normally achieved by the car ramp or ventilation. In the case of stores, dedicated natural ventilation should be provided.
5) The PPV unit can be positioned in the vertical or horizontal position.
6) Lift door should be avoided in the pressurised lobby as they create a large leakage area. It is our recommendation not to pressurise a lobby containing a lift door.
7) Fire doors should be fitted to the British Standard tested criteria.
8) Leakage consideration should be made to all fire doors, lift doors, cupboard doors and any openings within the pressurised lobby.
9) Vertical riser compartments should be made airtight at floor and ceiling level.
10) The leakage area across all openings should not exceed 0.08m^2.
11) Double doors add an additional 50% leakage area.
12) Where any ventilation grills are provided, they will need to be of an airtight standard during fire mode.
13) We recommend doors should open into the pressurised space to ensure they remain closed when the PPV unit is running. Where the Client chooses not to follow this recommendation, they need to discuss implication with the design team and Approval Authorities.
14) We recommend the power supplies are monitored by 3rd party controls which will allow power supply failure to be identified.
15) Prior to ordering or installing a PPV Unit, the PPV concept should be agreed and signed off by the Approving Authorities.

8.0 DOCUMENTATION

Further documentation of the concept is provided by a 3rd party Fire Consultancy, in their report titled ‘Positive Pressurisation Ventilation Review, Generic Application to Stair Lobbies & Place of Special Fire Hazard’. This includes documentation on the research carried out.

Information on the Installation & maintenance is provided in the document titled ‘Daisy PPV Unit, Installation & Maintenance Manual’.

9.0 CONCLUSION

Approved Document B identifies natural ventilation or mechanical smoke control as the two possible solutions to protect basement stair lobbies.

The Smoke Control Association Guidance document on Residential Buildings – 2015 identifies pressurisation of the basement stair lobbies with the doors closed as a method to meeting the above mechanical smoke control requirement.

The SCA Guide is an accepted document for the design of smoke control systems and is referenced in the British Standard BS9991:2015.

The Organisations identified in Figure 3, along with consultation with other Approval Organisations produced the SCA guidance document which is intended to allow designs of systems to be approved as they have followed the simple guidance.

The PPV unit develops a 50pa pressure difference across a closed door which is intended to prevent smoke entering the protected lobby in accordance with the SCA guidance document.

The PPV Concept is outlined in this Design Note including design criteria, leakage, documentation, and Important Considerations prior to the installation of the PPV Unit.

Prior to ordering or installing a PPV system, the PPV concept should be agreed with the design team and signed off by the Approving Authorities.