fds consult

Waterside, Twickenham

Concept Smoke Venting Report
For Means of Escape & Fire Fighting

Issue 2

November 2015

fds consult

CONCEPT SMOKE VENTING REPORT CONTENTS

Issue	Date	Amendment Details	Author	Checked
01	02/11/15	-	DS	AC
02	03/11/15	Incorporating change in flow rate*	DS	AC

* Note: All changes within the report have been highlighted by a line along the right-hand margin as shown here.

1.0 INTRODUCTION

This report is intended to document the smoke venting method proposed to protect the means of escape and fire fighter access on the Waterside development in Twickenham using the mechanical smoke ventilation concept. This will allow safe evacuation from the floors and assist fire fighters in their operations.

The prescriptive method of smoke venting will be designed in accordance with Annex E of BS9991:2011. This alternative approach will achieve a higher level of safety for means of escape and improve firefighting operating conditions over current systems regardless how the building is used. This will allow the extended travel distance to be justified in accordance with the various codes.

As a result, this document is intended to justify an alternative approach and satisfies Smoke Control Association (SCA) **"Guidance on Smoke Control to Common Escape Routes in Apartment Buildings (Flats and Maisonettes)" and** the London District Surveyors **Association 'Fan Assisted Performance Requirement Report'**.

The development is to comprise of a single core with a corridor either side. The building consists of ground plus 3 levels of accommodation accessed by one lift and a single stair. Access to the apartments is gained by means of a common lobby, as shown in Figures 1 and 2 below.

The travel distances are extended to around 17m and 20m from the stair for the West and East corridors respectively. A detailed analysis of the corridors is provided by CFD modelling in Section 4.0.

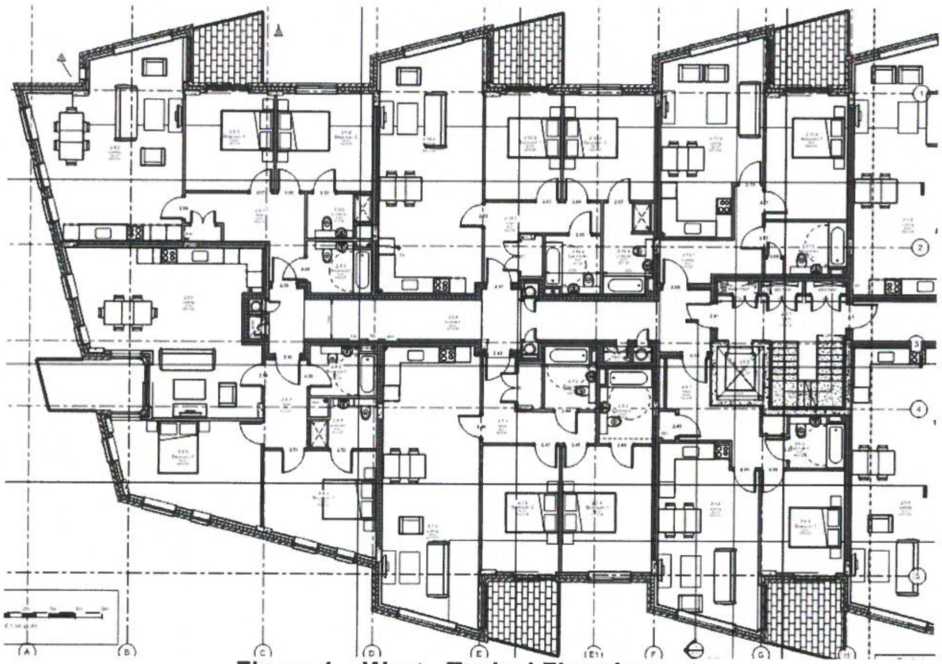

Figure 1 – West - Typical Floor Layout

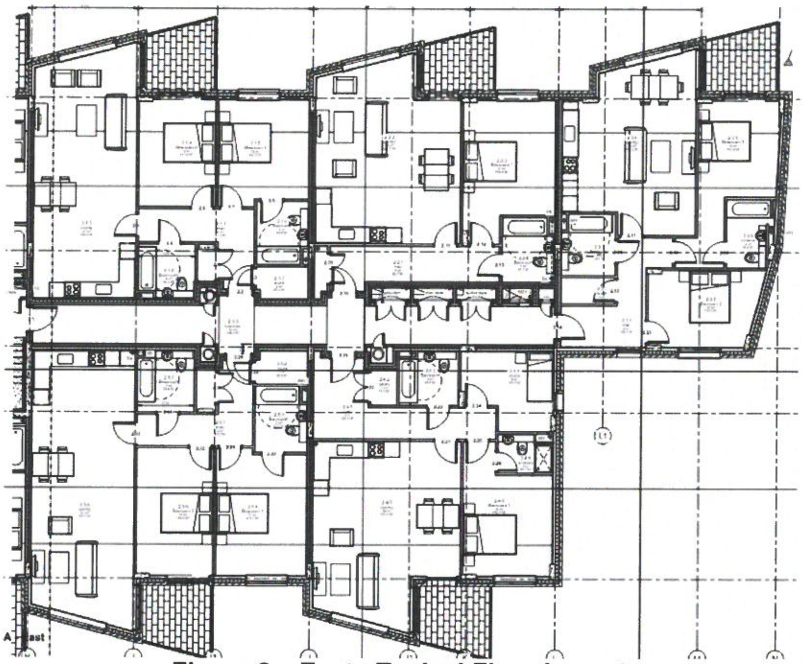

Figure 2 – East - Typical Floor Layout

To ensure the system components used are fit for purpose, the required standards of the components to be used are set out in this report, which will be achieved. The standards are formed from various discussions, full scale testing and result obtained during testing.

As with the development of any design, it is assumed the apartments, common lobbies and escape stairs are constructed and maintained in accordance with the principal compartmentation recommendations as detailed in the Approved Document B (ADB).

2.0 LEGISLATIVE REQUIREMENTS

In reviewing the legislation requirements of venting smoke from this development, two areas of the Building Regulations need to be addressed as follows;

2.1 Means of Escape

Schedule 1 of the Building Regulations requires the following functional requirements to be met in respect of B1, Means of warning and escape:

> *"The building shall be designed and constructed so that there are appropriate provisions for the early warning of fire, and appropriate means of escape in case of fire from the building to a place of safety outside the building capable of being safely and effectively used at all material times."*

The evacuation procedure applied to private residential flats is that the fire flat only is evacuated. A fire elsewhere in the building will not cause the evacuation of the flats unless it is deemed necessary by the attending fire service. Occupiers of flats other than the flat of fire origin may choose to evacuate the premises on their accord without direction from the fire service. With this type of evacuation policy being implemented it is necessary to ensure that the fire does not significantly inhibit the evacuation from adjacent flats on that level or other flats above the fire floor.

2.2 Fire Fighting Facilities

Schedule 1 of the Building Regulations requires the following functional requirement to be met in respect of B5, Access and facilities for the fire service:

> *(1) The building shall be designed and constructed so as to provide reasonable facilities to assist fire fighters in the protection of life.*
> *(2) Reasonable provisions shall be made within the site of the building to enable fire appliances to gain access to the building.*

Although the above may be the building regulation requirements, there are no additional requirements for smoke venting residential buildings during firefighting operations.

3.0 MECHANICAL SMOKE VENTILATION SYSTEMS

A mechanical smoke ventilation system (MSVS) is an alternative method discussed in Approved Document B, BS9991:2011 and BS EN 12101 Part 6. Detailed recommendations on how these systems should be designed are given in the Smoke Control Association (SCA) "**Guidance on Smoke Control to Common Escape Routes in Apartment Buildings (Flats and Maisonettes)**".

The MSVS system is based on a mechanical extract and natural inlet. It comprises of a mechanical extract shaft that serves the common corridor and replacement air is provided from the stairs by means of a pressure controlled door closer (that is free swinging), thus depressurising the stair and allowing a large quantity of fresh air to be pulled through the lobby. The effect of this is that smoke cannot flow in to the stair.

On detection of smoke within a lobby, the fire damper to the shaft on the fire floor only opens (all other floors will be locked out) and the vent at the head of the stair case opens. After a short period the fan at the top of the smoke shaft operates to mop up the smoke within the lobby and prevents migration into the adjacent apartments, lift shaft or stair. Replacement air is provided automatically from the stair ensuring the flow of air is away from the stair at all times and ensuring the pressure differences are kept to a minimum. The fire service has the facility to switch between means of escape and firefighting mode. This switch will be provided at each floor level and in a place of relative safety (usually the stair) as recommended in the SCA guide.

The MSVS **is not affected by wind directions and all the necessary equipment is kept in the landlord's** area allowing simple ongoing control, similar to the maintenance of smoke detectors, emergency lighting, automatic natural opening vents, etc.

3.1 Design Criteria

In reviewing the design requirements on this development the means of escape (flat door closed condition) needs to be considered. To improve conditions in the corridor for fire fighters, the flat door open condition will also be considered. The criteria will produce two specific extract volumes (running at $1m^3/s$ in means of escape mode and $4m^3/s$ in firefighting mode), to satisfy the means of escape and firefighting conditions. The basis for design of both are summarised below.

3.1.1 Means of escape mode

As identified in the various codes the following needs to be assumed in the design of any development and will be the same for any of the systems.

- All fire doors to flats are fitted with door closers and will be closed (the internal fire doors from the hall to the accommodation are ignored).
- All fire doors to the stairs are fitted with door closers and will be closed.
- A fire will only occur within one flat.
- When an occupant escapes through a door, it will return to the closed position.

The system will only come into operation when smoke is detected in the common lobby and it should return the corridor to a smoke clear (or tenable, i.e. at least 10m visibility with smoke at 2m from the finished floor level at no more than 50°C) environment within 90-120s of the ventilation system being activated.

The following table looks at the cause and effect during the escape period from the flats.

	Event	Occupied Flat
1	Fire in flat	Medium growth rate within fire box (bedroom or kitchen)
2	Detection in flat	The smoke flows into the flat hall or the occupant observes the fire and commences their escape.
3	Flat occupant egress	Occupant leaves the flat and the door returns to the closed position

4	Smoke into common lobby	As the occupant escapes, a quantity of smoke follows them. The quantity would be low at this stage, as they would have been overcome by smoke if the quantities were great. The quantity of smoke entering the lobby would have to be reasonably significant to activate the smoke detector in the common lobby. If a significant amount of smoke is not drawn into the corridor then the system is unnecessary and will not activate. Eventually smoke may leak into the lobby under the fire door.
5	Detection in common lobby	The escaping occupant phones the emergency services via **neighbours' phone or by personal mobile. The smoke** is detected by the AFA panel.
6	AFA Panel into alarm mode	The fire floor is identified by the smoke detection system and a signal is sent to the smoke control panel.
7	Smoke Control Panel	The panel receives the signal and opens the shaft damper on the fire floor and the inlet vent at the top of the stair.
8	Fan Start Up	The fan is activated in means of escape mode extracting at $1m^3/s$. The fan moves the air from the stair shaft through the stair door into the lobby mopping up smoke and extracts through the vertical shaft. Fresh air will clear smoke in lobby. The degree of smoke entering the lobby will depend upon the construction standard of the door and in particular its smoke seals. The stair door closer closing force is sized so as not to encourage more smoke being drawn into the lobby.
9	Power failure	**The landlord system and the tenant's apartments are on** different supplies. However in this unlikely event, the power supplies to the system including fans, control panel and dampers fail, the system will automatically switch to the second emergency maintained power supply in accordance with BS9999.
10	Fan failure	The system will be maintained and the fans have a running bearing life in excess of 40,000 hours running time. Assuming the system was turned on for 5 minutes every week, the fan bearings could run for 9,000 years before requiring a service. However in the unlikely event of fan failure, the system will switch automatically to the standby fan which will run at full duty.
11	Both power supplies and both fans fail.	Should all the systems fail the stair door will close to achieve the required compartmentation. This is not a design condition that would be considered in standard life safety systems.

3.1.2 Firefighting mode

As identified in the various codes the following needs to be assumed in the design of any development. This is the same for any of the systems.

- All fire doors to flats are closed.
- All fire doors to stairs and corridors are closed.
- When the fire service turns up they will connect the fire hose from the pump appliance to the internal fire main.
- The fire fighters will enter the building to ascertain the floor of detection before moving to the floor below and charging their hoses.
- As the fire fighters move through the stair lobby door they will switch the fan assisted system to firefighting mode.
- The fire fighters will open the apartment door approximately 200mm and apply a jet of water to the ceiling to cool the gases and drive them back into the flat. This procedure is repeated before entering the apartment ensuring the fire fighters are not exposed to high gas temperatures.

The primary consideration in this mode of operation is to demonstrate that the staircase will be maintained clear of smoke.

The following table looks at the cause and effect during the firefighting period.

	Event	Fire fighters hose from the stair
1	Fire Service arrives	Fire panel tells location of fire. Information card summarise operation of smoke venting system. Card fixed beside panel and each dry riser outlet.
2	Investigation	The fire service takes the lift to two floors beneath the fire floor. They will walk up the stair to the fire floor to ascertain the severity of the fire.
3	Fire hose connected	Fire fighters connect onto the dry riser outlet on the fire floor and on the floor below. As hose is moved through the stair door opening into the lobby the door will return on the hose.
4	Decision on fan speeds	Depending on severity of the fire, the fire fighter decides whether to turn system onto higher speed. This is simply done by pressing the fire switch on the stair side. If the fire fighter believes the system is too strong they may simply press the volume switch to low returning the fan speed to means of escape mode. Assume system is set to higher speed (i.e. $4m^3/s$).
5	Stair door	As the door to the stair opens into the lobby and the MSVS door closer closing force is adjustable, the door becomes an automatic pressure relief damper.
6	Flat door is opened	Flowing gases are cooled so the fire service can enter the flat. The gases are mopped up by the MSVS ensuring cool air is drawn from the stair. In the event the glazing is shattered in the flat, the gas temperatures will drop and firefighting conditions should ease. The system will still mop up all smoke exiting the flat.
7	Fire Extinguished	When the fire alarm panel is reset, the system is turned off.

3.2 CFD modelling of the system

CFD modelling has been carried out and is shown in Section 4.0 to show the worst case scenarios that may be experienced in this development. The modelling programme used is Smartfire. The software has been developed by Greenwich University and is being used in a bench mark study being carried out with the ODPM. The Section shows slices of the output files from the CFD model to form a recorded summary of the model. A full demonstration of the live model will be given to the approving authorities, where different positions can be examined.

3.3 System Components

As indicated in numerous codes and generally requested by the Fire Service, the system needs to be kept simple and be automatic in operation. This is because the attending fire service team(s) may not have the knowledge of the MSVS and will have limited available time.

Basic system operation details will be provided as part of the overall package of premises information for firefighters.

The correct application of the system components and associated testing criteria are essential for the successful operation of the system. The standard of the components required for the system are outlined below.

Vertical Smoke Shaft

The compartmented vertical smoke shaft will rise through the height of the building to channel hot gases from the fire floor to the mechanical smoke extract fans. The vertical shaft should achieve the building fire resistance both inside to outside and outside to inside.

The shaft should be of air tight construction with a maximum air leakage rate of 3.8m³/h/m² at 50 pa pressure difference.

Smoke Shaft Ductwork

The smoke shaft which terminates externally at roof level should extend to the smoke extract fans by means of ductwork ensuring the smoke is removed from the smoke shaft.

Section 8.2.6 of the **Smoke Control Association "Guidance on Smoke Control to Common Escape Routes in Apartment Buildings (Flats and Maisonettes)"** provides guidance on this ductwork. The guidance states that 'ductwork needs to maintain the cross sectional area at elevated temperatures matching the fan specification, typically 300°C for 60 minutes'. This is achieved by the use of DW144 ductwork.

Smoke Extract Fans

The mechanical smoke extract fans are tested and certificated to the requirements of Classification E 300°C for one hour in accordance with BS EN 12101 Part 3. As demonstrated by the CFD model, this temperature is not exceeded. The flexible connections linking the ducting to the fans will provide a similar temperature rating to the fans.

As it is essential that the smoke extract fan remains operational during a fire condition, a standby fan will be provided to allow for the possibility of duty fan failure. The standby fan will be designed to run at maximum volume only on a simple direct on line starter (DOL) by passing the controls as this is to form a failsafe solution.

Supply Air Plenum

The supply plenum is only required to deliver air at ambient temperature to the space. The stair will be used as the supply plenum ensuring the space is under negative pressure preventing smoke movement into the stair.

Stair Ventilator

An automatic opening stair ventilator should be provided at the head of the stair which will provide the necessary replacement air to the stair plenum. This ventilator should be tested in accordance with the BS EN 12101 Part 2.

The ventilator will be automatic in operation.

Shaft Smoke Extract Damper

The smoke extract dampers will be provided at high level below the ceiling opening into the smoke shaft. The damper will be driven open and designed to ensure that once open, it will remain open regardless of the gas temperatures. Similarly, closed dampers will remain closed regardless of gas temperatures. On resetting the system the damper will close automatically.

In looking at expected extraction temperatures, these should be below 300°C where hose operations are taken into consideration. However, a temperature with a level of safety has been used during testing. The damper will achieve as a minimum one hour fire resistance for integrity and stability when tested at 300°C to BS476 Part 20.

Stair Lobby Door

The stair lobby door will be modified so it swings into the lobby acting as a pressure relief damper. The door will be fitted with an adjustable door closer and should satisfy the requirements of Approved Document M.

In accordance with the **Smoke Control Association "Guidance on Smoke Control to Common Escape Routes in Apartment Buildings (Flats and Maisonettes)"**, the force across the stair door will not exceed 100N when the smoke extraction system is in operation.

Standby Power Supply

The Client is to provide a maintained (duty & standby) 3-phase power supply to the smoke extract fan panel. This maintained power supply should be in accordance with the BS9999:2008 for life safety and the status of the power supplies should be identified at fire service entry level similar to the requirements for firefighting lifts.

System Activation

The smoke extraction system should be operated by means of a smoke detector located within the ventilated space. Smoke detection will be provided in accordance with BS5839 Part 1 to an L5 Standard.

The detection system controls should be programmed to give a signal which will open the shaft damper on the floor of detection and lock out any subsequent floor damper signals ensuring dampers on other levels remain closed.

Electrical Controls

Controls and wiring to the fan units are an integral part of the smoke control system and will be adequately protected from fire so they continue to function in the event of a fire.

The fan control panel located on the upper floor will receive a fire signal from the detection system at which time the duty fan will commence operation and continue to run. On detection of duty fan failure the standby fan will be brought into operation.

The panel is provided with a number of outputs which will be monitored at fire fighters entry level and will identify the following status:

- Smoke extraction system active,
- Shaft damper open,
- Duty fan running
- Standby fan running.

A fire fighter Auto/Off switch will also be provided at fire fighters entry level, which will allow the smoke extract fan to be turned off where necessary by the fire fighters.

The system is automatic in operation with no interaction required by the fire fighters, apart from resetting the system or turning the fan off in the case of fire.

Volume Control

As the smoke extraction system is to form a two speed system, a fire fighters selector switch will be provided. The selector switch will switch the duty fan between low and high modes by means of an inverter. In the case of the standby fan, the controls are to be bypassed with the fan running on a direct on line (DOL) starter.

The selector switch will be provided at each floor level and in a place of relative safety (usually the stair) as referenced in Section 8.2.12 of the Smoke Control Association **"Guidance on Smoke Control to Common Escape Routes in Apartment Buildings (Flats and Maisonettes)"**.

The switch will be labelled 'Corridor Smoke Extraction, **LOW/BOOST**' (wording agreed with the Fire Service).

3.4 Commissioning

As seen during the full scale testing, the theoretical calculations provide a means of assisting with the design of an installation. The success of the system is dependent on the successful commissioning to achieve the design criteria values identified earlier in the report. This will allow the leakage paths to be considered and the pressure sensing on the fire door to the stair lobby adjusted accordingly.

For clarification, pass criteria have been provided in Appendix A, which will aid in the approval of the installed MSVS system.

4.0 COMPUTATIONAL FLUID DYNAMICS

The CFD will need to prove that the corridor can be returned to a smoke clear (or tenable) environment within 90-120s of the smoke detector in the common corridor being activated. The modelling should also demonstrate that additional smoke is not drawn in from the fire flat once the fire compartmentation is re-instated (closing of fire compartment door).

The CFD should also demonstrate that the system does not adversely affect the firefighting operations. The primary consideration for the modelling is to demonstrate that the staircase will be maintained clear of smoke, however it should demonstrate that the chosen system is capable of achieving conditions within the corridor that are at least, if not better, than the corridor conditions created by a traditional AOV.

As levels have travel distances exceeding 7.5m, an MSVS is required in order to show compliance with the Building Regulations. The smoke shaft will be provided in the corridor from first to the 3rd floor level and will be linked to the smoke detection system. On detection of smoke in the relevant corridor the shaft damper will open, the vent at the head of the stair will open and the fan will commence operation. As the stair lobby door opens into the lobby it will open as necessary to provide the replacement air.

For analysis purposes, the fire has been considered in the living / kitchen area and the hot gases / smoke allowed to flow freely into the apartment hall (fire door ignored), which has been treated as a sterile area. The chosen fire size has been chosen at 2.5MW, with a 10% soot yield, based on Table 5.1 of the Smoke Control Association "Guidance on Smoke Control to Common Escape Routes in Apartment Buildings (Flats and Maisonettes)" shown below.

Fire size in dwelling (kW)	Dwelling door opening width (m)	Approx temperature of smoke at door (°C)	Flow of smoke from room		Stair door opening width (m)	Condition
			Mass (kg/s)	Heat (kW)		
250	0.1	210	0.2	40	closed	Early stages of fire, relevant for MOE from fire compartment
1000	0.5	360	0.9	350	closed	Later stage of fire, relevant for MOE from other compartments ~~and arrival of fire service~~
2500	0.78	690	1.4	1100	0.78	Late stages of fire, relevant for fire service intervention

- The proposed layout for the CFD model with the chosen fire locations are shown in Figure 3 and 4 below.

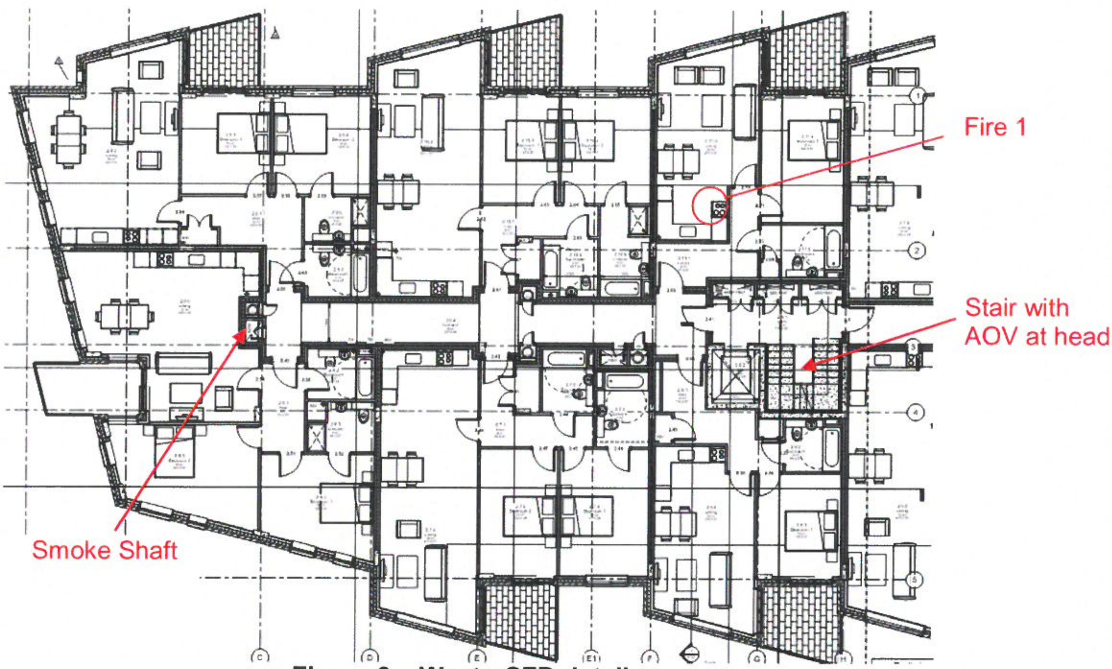

Figure 3 – West - CFD details

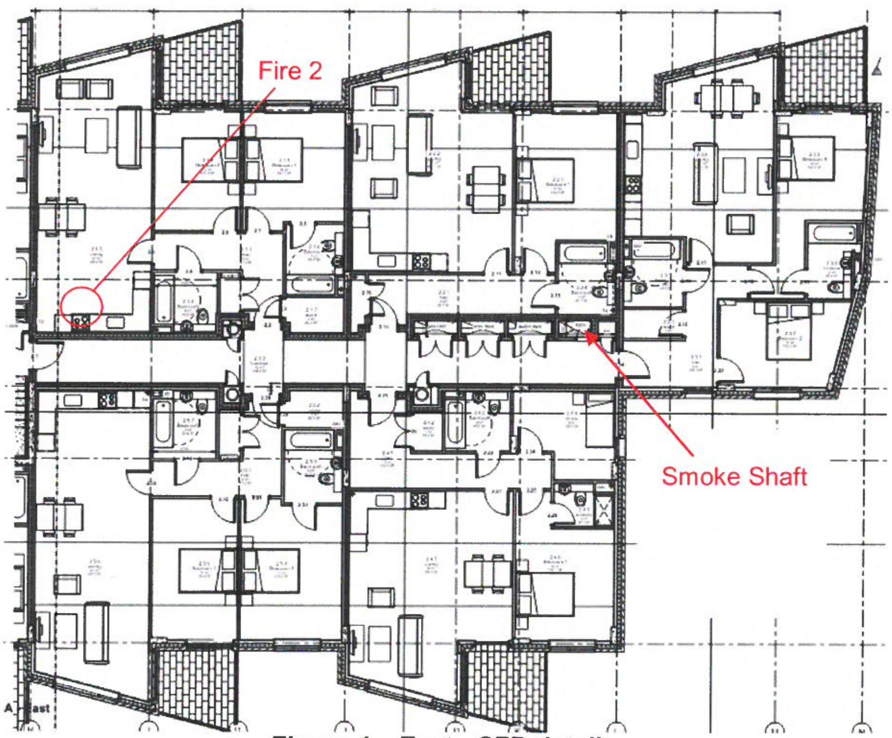

Figure 4 – East - CFD details

- The models assume that the fire is in the apartment which, in our experience, represents the worst case scenario for smoke spread in the corridor. The scenario has been set up to model and predict the actual events that would be expected as the fire grows.

- Both the CFD models have been carried out using the assumption that smoke has entered the corridor (with the escape of the fire room occupant) and has activated the system from time step

330s in accordance with the LDSA agreed Design Criteria. However, if no smoke leaves the flat then the system will not be activated until the fire service arrive, in which case it can be assumed that the corridor will remain clear of smoke.

- The models also demonstrate that the plume temperature in the shaft is lower than 300°C. This ignores any cooling provided by firefighting activities. In fact with the expected fire sizes and window fracture scenario, the temperature of the plume rising up the shaft is more likely in the range of 140°C to 170°C.

- The modelling has assumed that, during the means of escape mode, the door between the flat and the corridor remains closed with an effective 2.5mm gap under the door, which will allow smoke leakage under the door into the corridor. The modelling has then assumed that the door between the stair and the corridor remains open during firefighting mode.

- A full building height CFD model does not need to be carried out, since the flow velocity is calculated at each damper.

- The wind effects on the system are not critical because the system is a mechanical system designed to overcome pressure drops.

The fire room is assumed to have adequate ventilation from the start of the modelling so that the fire is always considered to be well ventilated. This means that the fire will continue to grow to its peak theoretical output and hence allows the room temperature to build up to its maximum expected temperature before the firefighting period commences, which is the most hazardous condition.

A small vent has been provided in the outer wall to replicate the effects of the kitchen extract and bathroom extract ducts. These extract fans are assumed to be non-operating during the full period of the modelling but can freely allow in and outflow proportionate to their area. The vent also represents the structural leakage that will be experienced (through the walls, ceiling and floor of the flat). For an even more conservative estimate, the 30 minute fire rated lobby within each of the apartments have been ignored. If these were included then the temperature profile across the door would be lower.

The windows in the kitchen / living space have been modelled as the same size shown in the architectural drawings. When the maximum air temperature (adjacent to the window) exceeds 350°C, then the window is fractured to allow ventilation to the exterior of the building over the full area of the window. Sufficient grid cells are always provided along the window height to allow fully developed bi-directional flow – as would typically be seen in most vented compartment fires. External vents in the building are always generated with a sufficiently large extended region which moves the neutral pressure (outlet) boundary to a suitable distance so that vent flows will be accurately modelled.

The door to the flat has a leakage represented by a porosity area of 0.1m high by 0.8m wide with a porosity value of 0.03 (equivalent to a full width gap of 2.5mm). This is a conservative estimate since the smoke will reach down to the porosity patch before it would reach the bottom of the door.

The models also include leakages that would be expected from apartments that are adjacent to the fire apartment. These adjacent apartments are modelled as a small volume just inside the apartment door and the same effective 2.5mm gap under the door leading to the whole apartment effective vent area of 0.4m by 0.4m. Without these leakages, the corridor would be unrealistically represented and the modelled corridor pressure drop, due to fan operation, could be over-estimated.

After a period of 900 seconds, the MSVS is switched from means of escape mode to firefighting mode. The door to the stair is opened at this time followed by the flat door which is opened 30 seconds later. The CFD modelling uses a variable time step size with time steps sizes of between 0.01s and 5.0s depending on the prevailing conditions. Small time step sizes are used to accurately model those periods where there are critical changes in flow or geometry (e.g. just after the opening of a door, just after window fracture and just after a change in fan rate). This is necessary to ensure that the model is able to correctly calculate the increased flow and is suitably stable over periods of maximal change. A pre-configured regime is used to bring the time step back up to the prescribed time step size, after any such critical event.

The CFD results in Sections 4.1 and 4.2 describe the smoke (in kgm^{-3}), temperature (in Kelvin) and velocity (in m/s) profiles throughout the models. The model has been allowed to stabilise by running for extended periods of time.

Absolute temperatures within the fire are in the region of 1000°C+. Due to conductive and radiative losses to the fabric of the building, etc., the temperature profile across the door is around 700°C. Due to the large volumetric rate of drawing fresh inlet air to the corridor, the temperature of the gases up the shaft are significantly lower than 300°C.

Most of the outputs seen in the model slices are easy to read. In most cases an iso-surface data visualization capture is also included. This shows the value of the output results, such as the temperature or pressure at a particular simulated time. When viewing the smoke visibility, the iso-surface shows a critical mass fraction (kg of smoke per kg of air) concentration of smoke. This iso-surface value can be interpreted as an approximate visibility in metres. The way in which this is converted is as follows:

S (light reflecting visibility) = 3 / K

Where,

$K \approx 7.6 \times 10^3 m_s$

K is the light extinction co-efficient (m^{-1}) and m_s is the mass concentration of smoke (kgm^{-3}). For practical purposes a smoke mass fraction iso-surface at $3.95e^{-5}$ is used to show the extent of the region that has a visibility distance of 10m or greater (higher value iso-surfaces are also displayed – representing progressively lower visibility distances – to definitively show the clear air region).

In both fire scenarios, the velocity plots show that upon window fracture, the smoke leaves the apartment via the windows. Once the fan in the smoke shaft is activated the smoke in the corridor as well as the air that flows in from the stairs is induced to flow towards the smoke shaft and travel up the shaft to atmosphere.

Upon activation of the fan in the smoke shaft into fire mode, the velocity plots show the increase of the volume flow rate of the fan by using larger velocity vectors.

Times used during CFD modelling

0 seconds	– Fire commences within the flat.
300 seconds	– Flat door opens for 10 seconds as the occupant escapes.
330 seconds	– The MSVS commences operation in means of escape mode reaching the required flow rate at 340s.
900 seconds	– System switched to firefighting mode and stair door is opened.
930 seconds	– Fire flat door opened
1200 seconds	– Analysis ends

The following shows a series of screen captures for the CFD model, which will be discussed with the approving authorities.

4.1 CFD Results – Fire 1

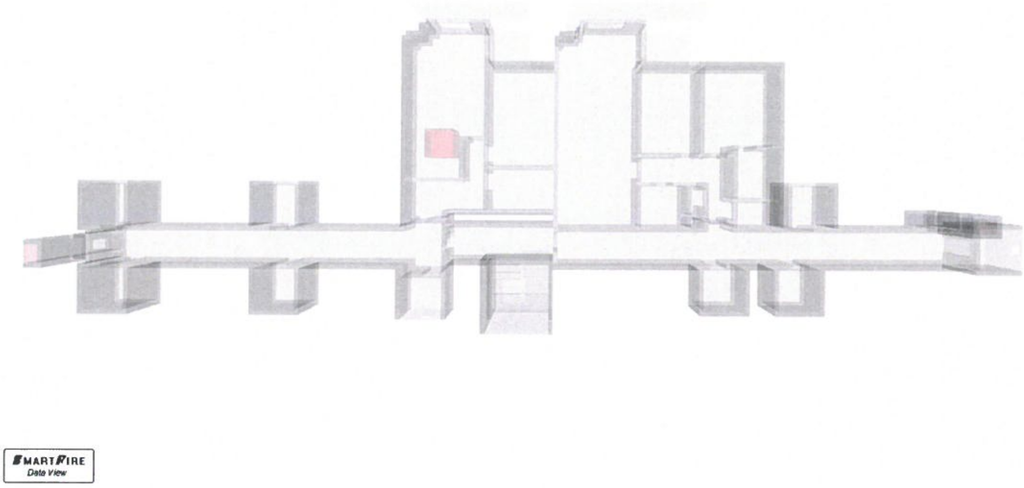

Figure 5 – Layout of corridor

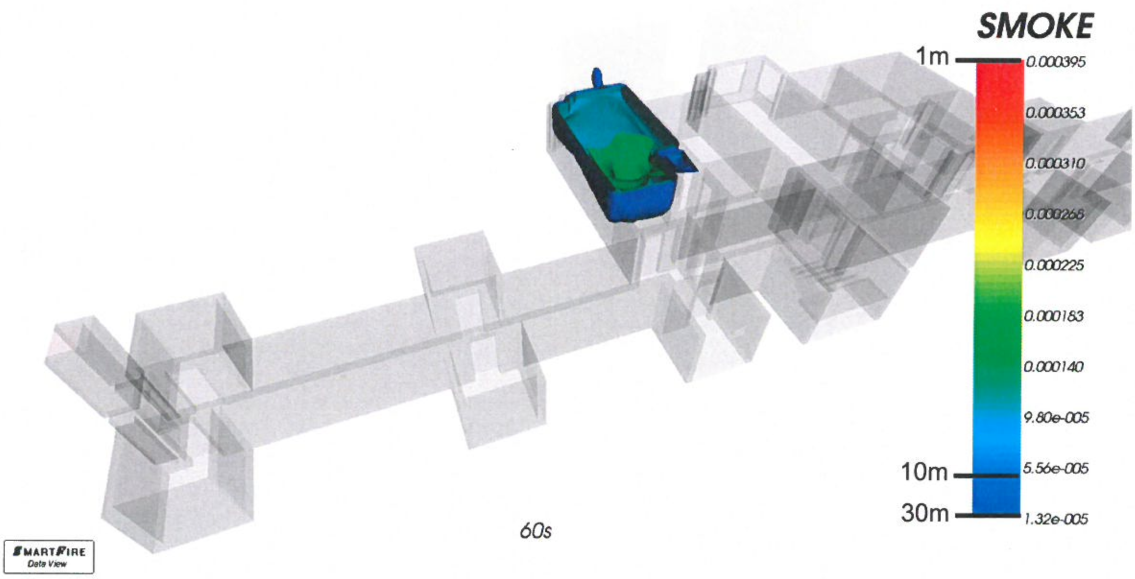

Figure 6 – 60s into run – Smoke filling fire flat and beginning to vent through small vent opening

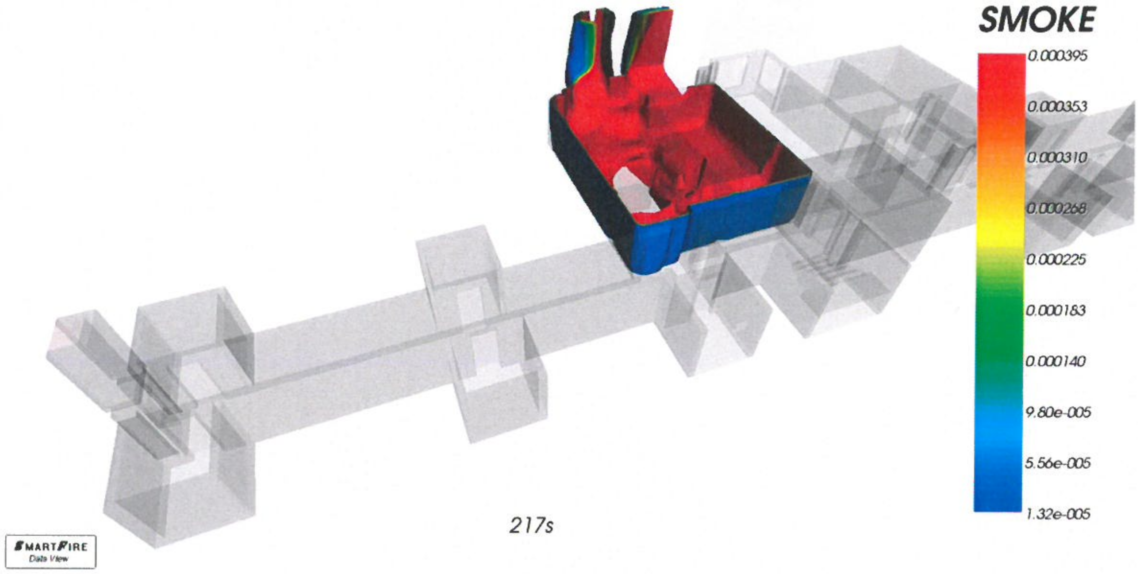

Figure 7 – Window fracture occurs at 217s

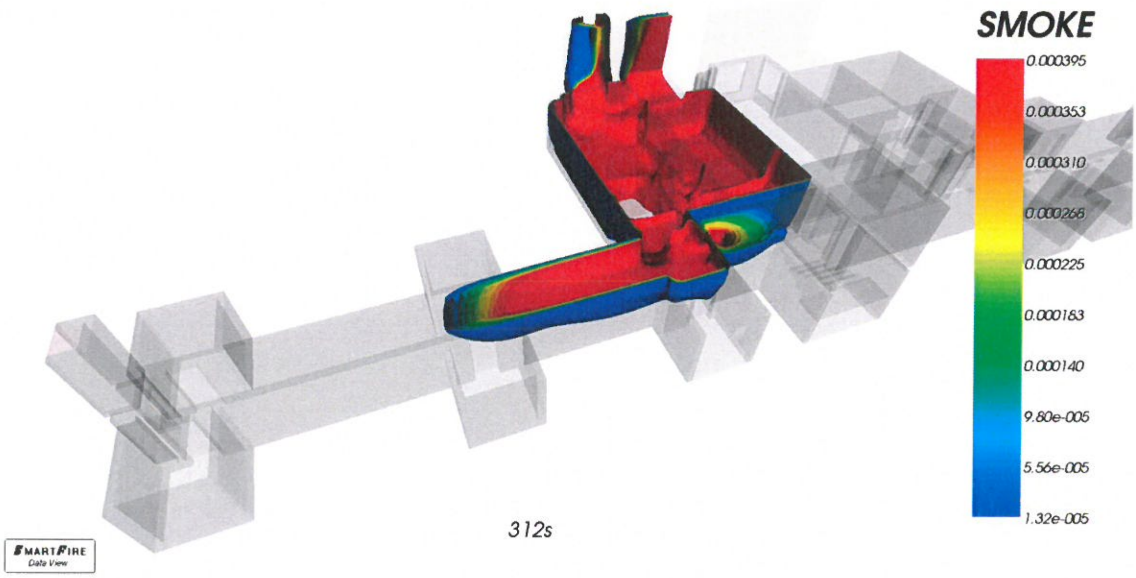

Figure 8 – Door open at 300 seconds for 10s during escape of occupants in flat

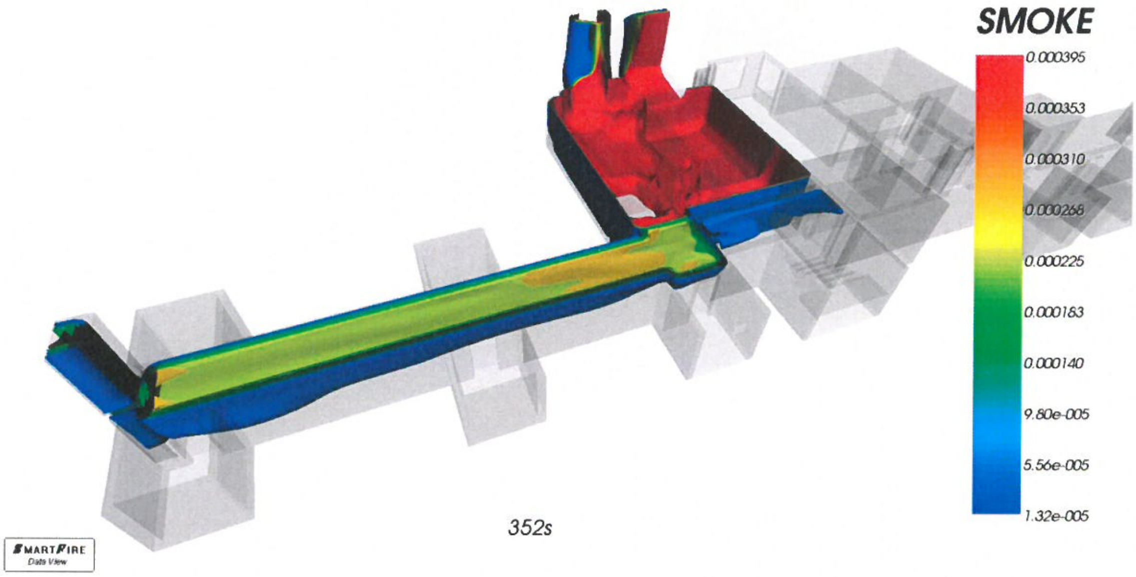

Figure 9 – Smoke shaft operates at 340 seconds and begins to draw smoke. Section of corridor currently smoke logged (350s)

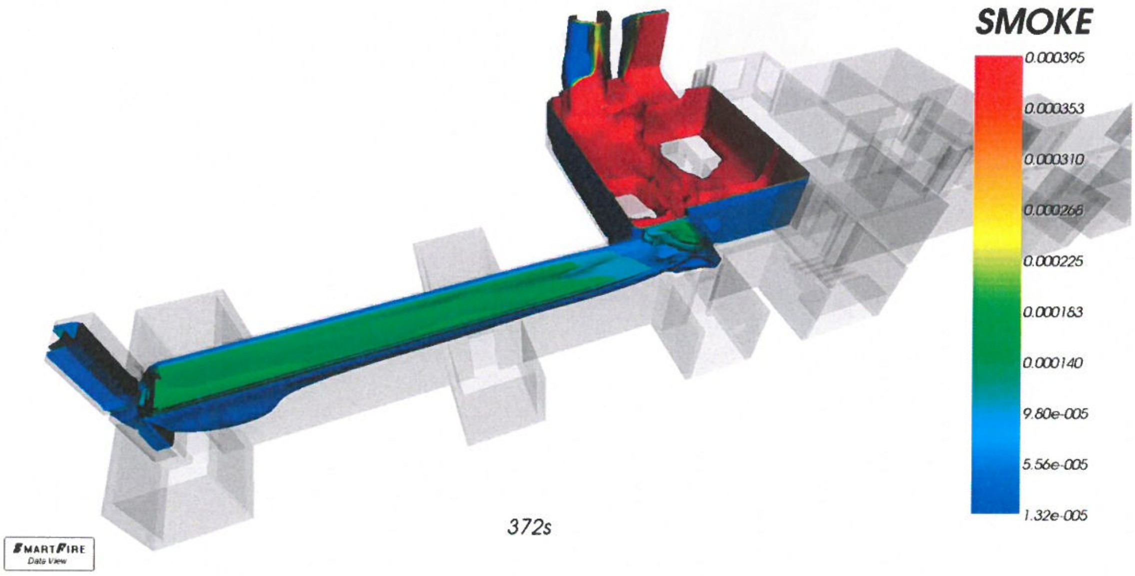

Figure 10 – 30s after smoke shaft operates (370s). Smoke clearing from the corridor.

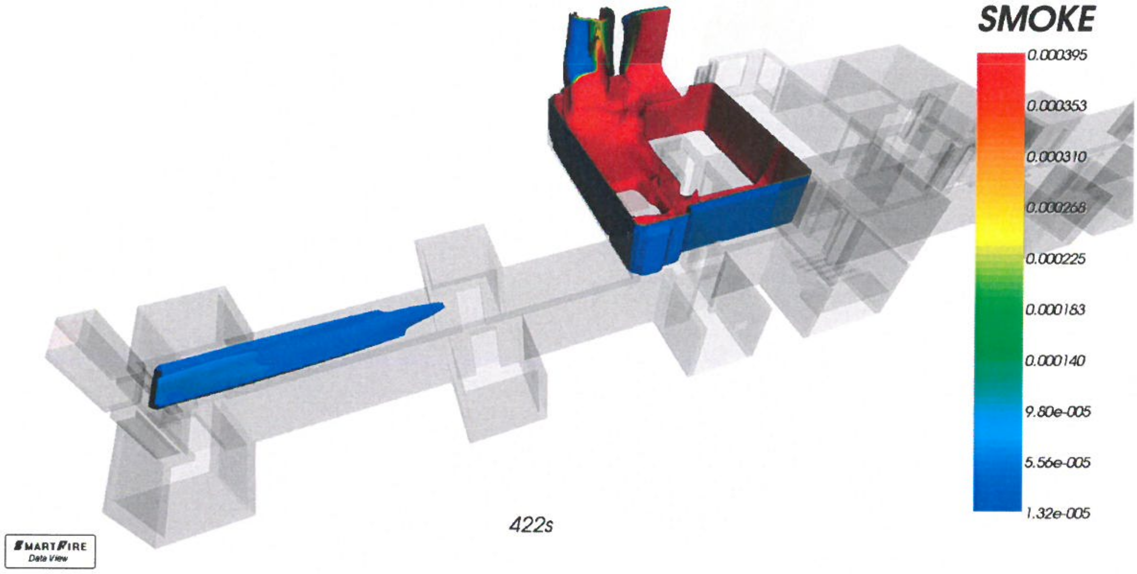

Figure 11 – 2mins after the apartment door is opened (420s). Corridor returning to tenable conditions

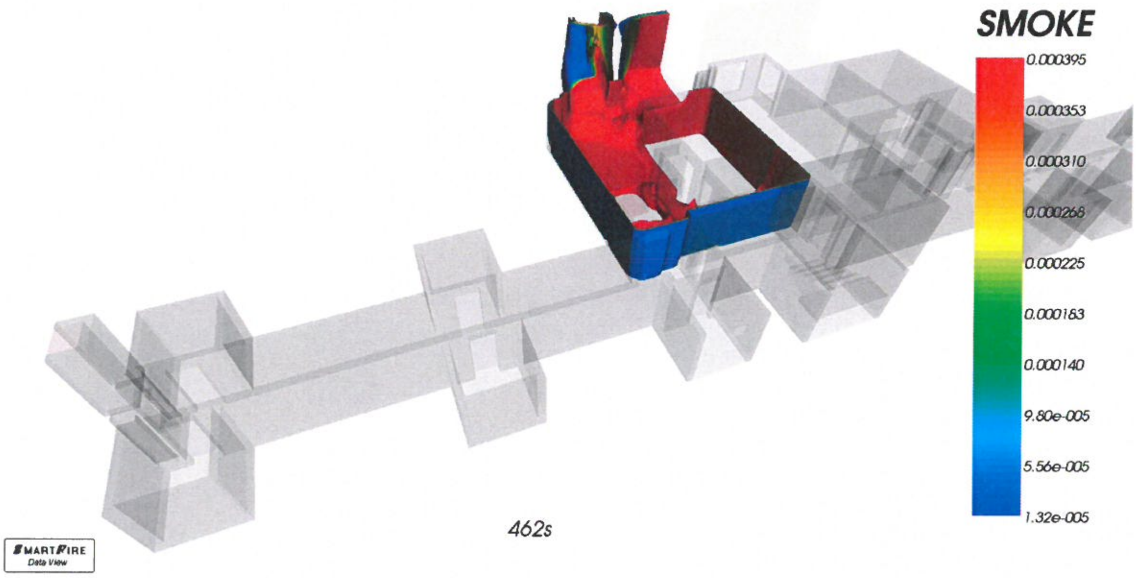

Figure 12 – 120s after system operation (460s). Tenable conditions in the corridor

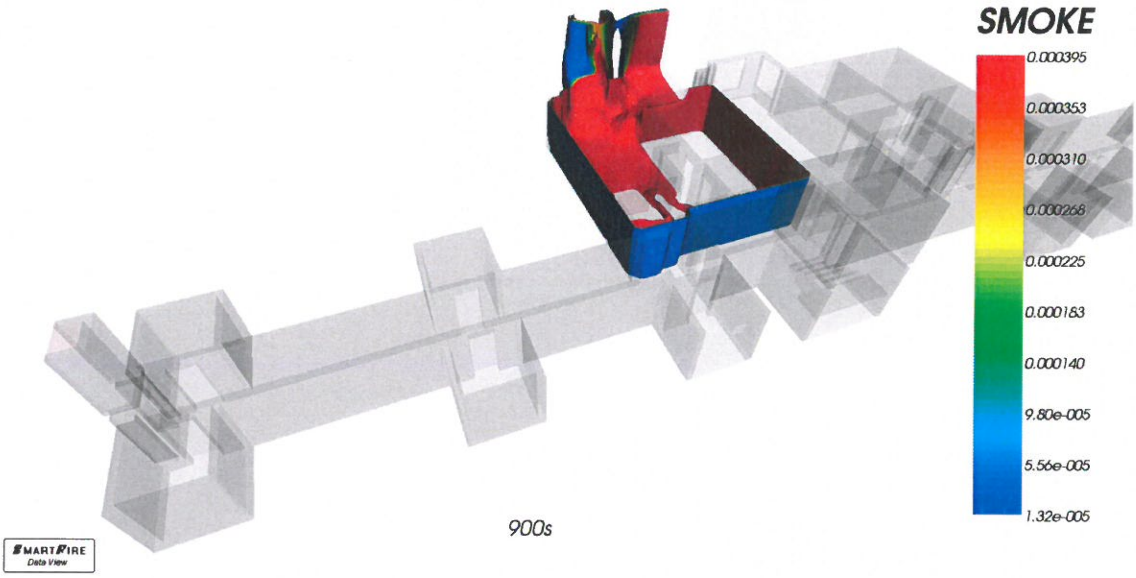

Figure 13 – 900s after fire initiation – Just prior to firefighting operations system running at full flow rate (4m³/s). Stair door fully open and fire flat engulfed in high density smoke

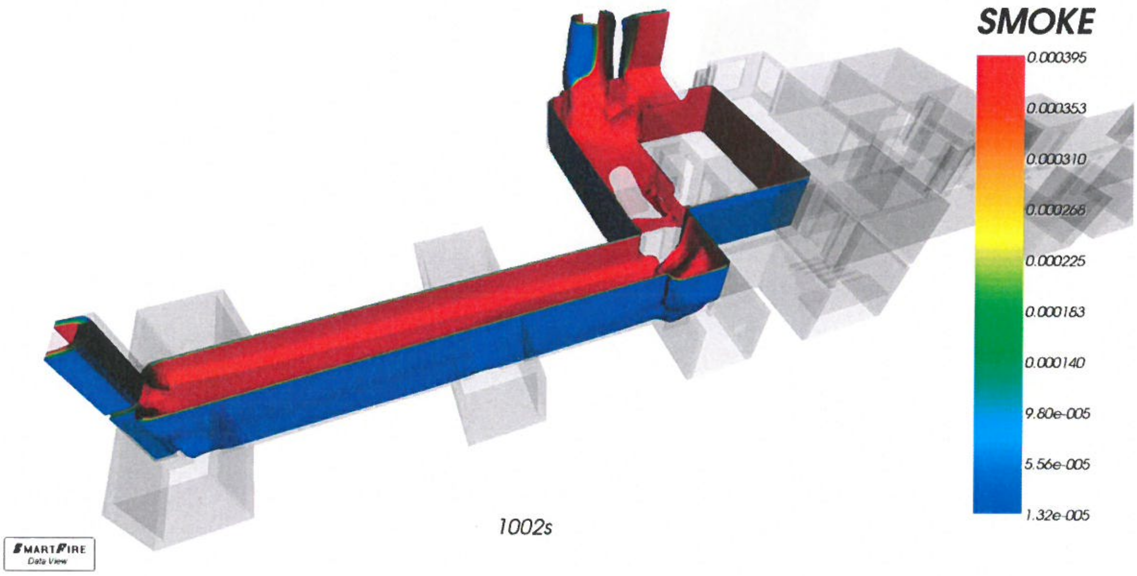

Figure 14 – 1000s after fire initiation – Fire flat and section of corridor engulfed in high density smoke but stairs (still with the door fully open) clear of smoke

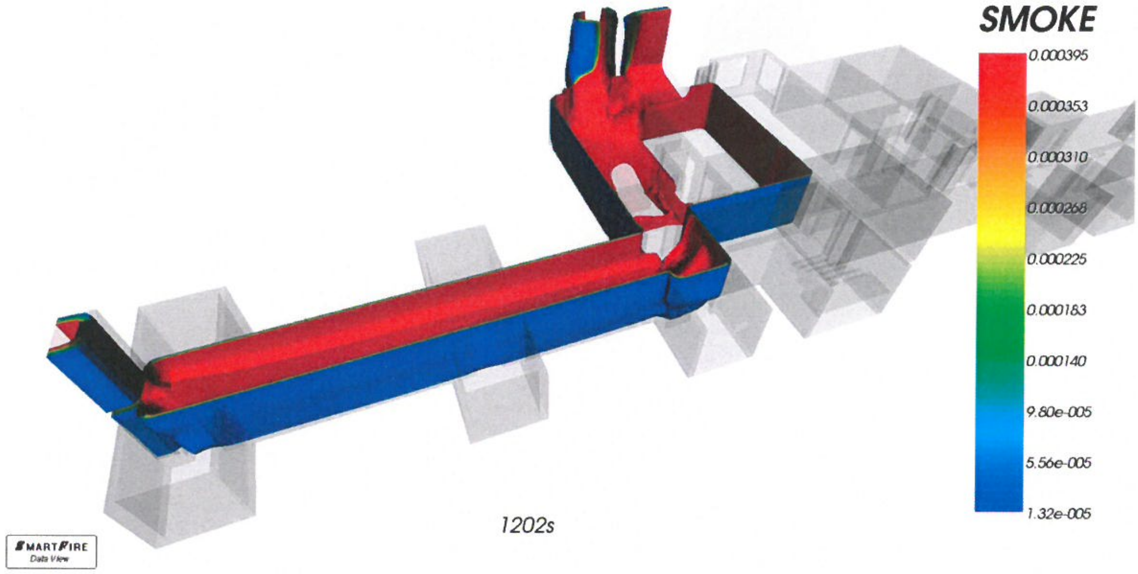

Figure 15 – 1200s into run – Well into firefighting. Stair is clear of smoke

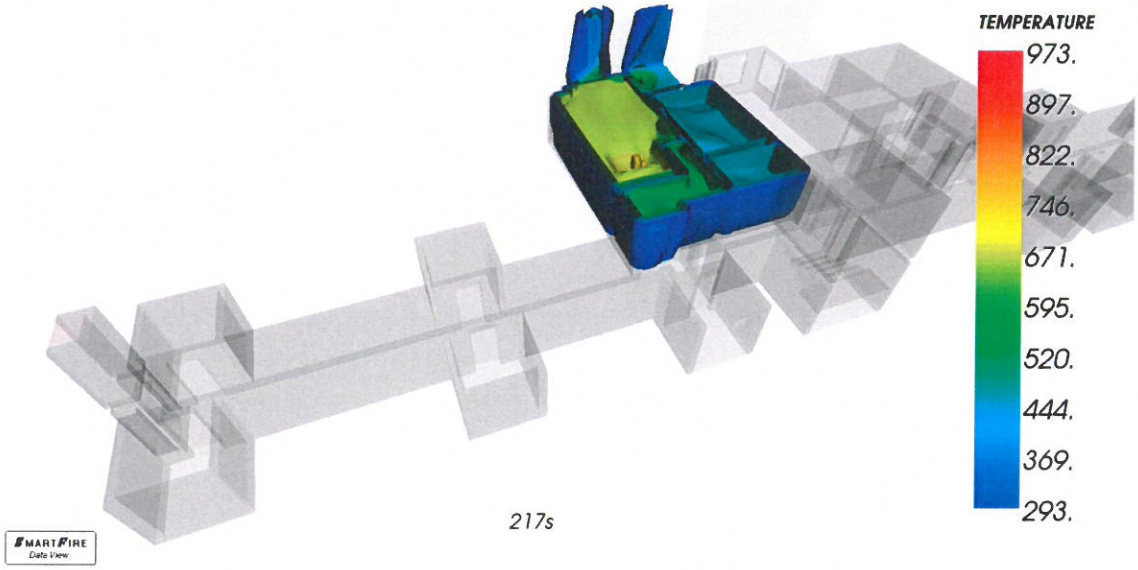

Figure 16 – Temperature profile in flat upon window fracture

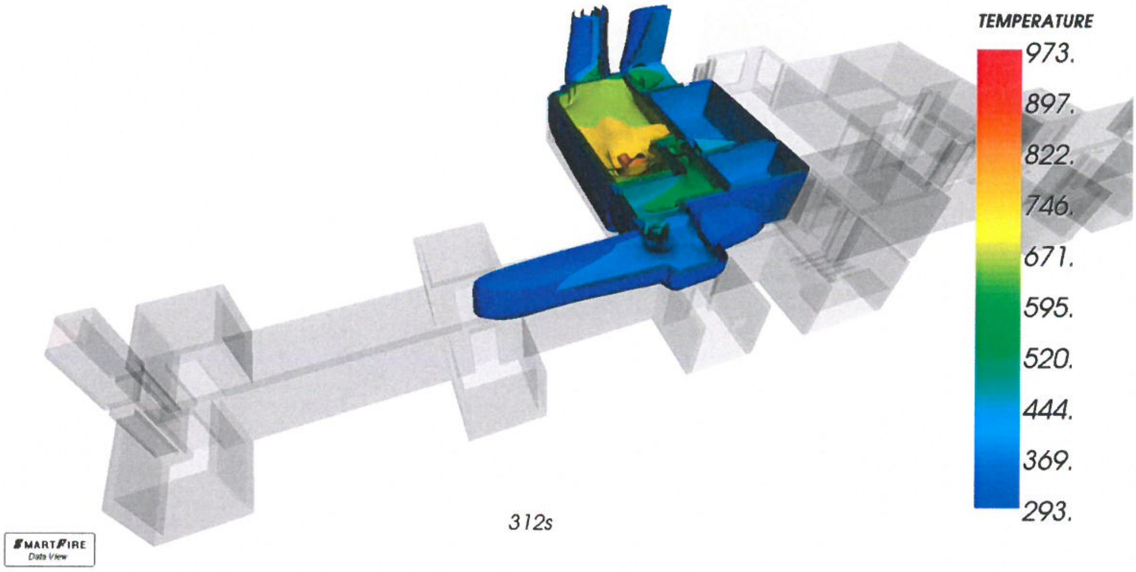

Figure 17 – Smoke temperatures in corridor once flat door opens over 100°C

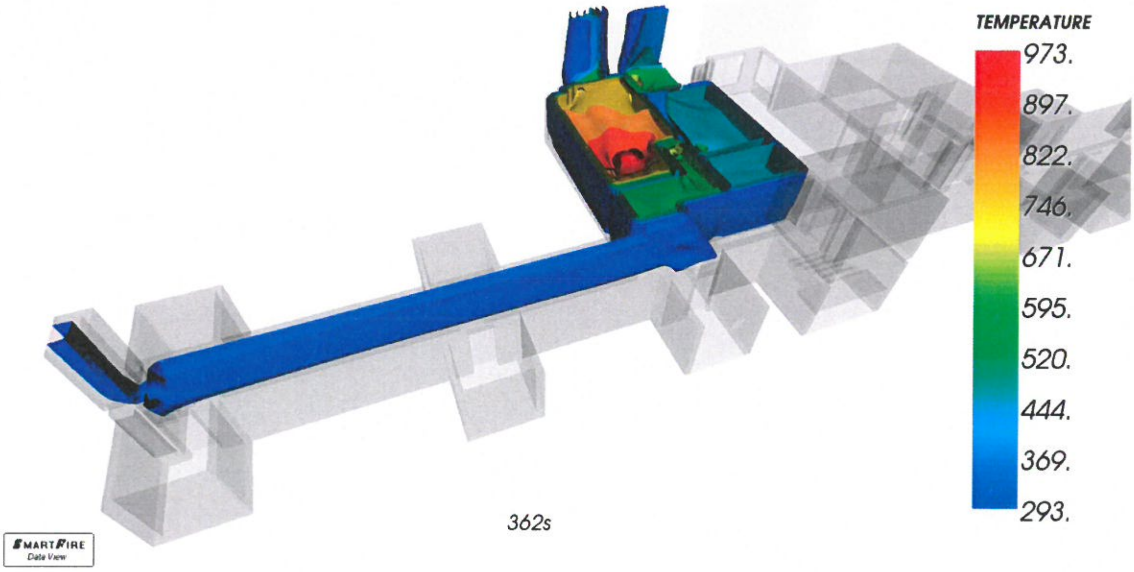

Figure 18 – 360s (20s after smoke shaft operates). Smoke temp lower than 50°C in corridor

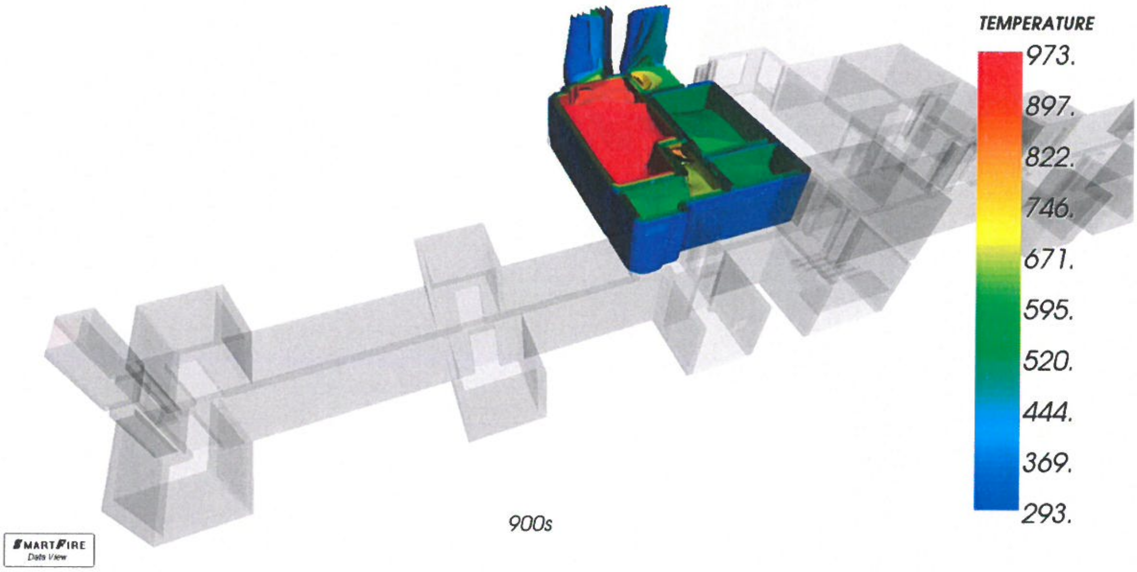

Figure 19 – 900s fire temperature ranging from 200°C to over 700°C in the flat

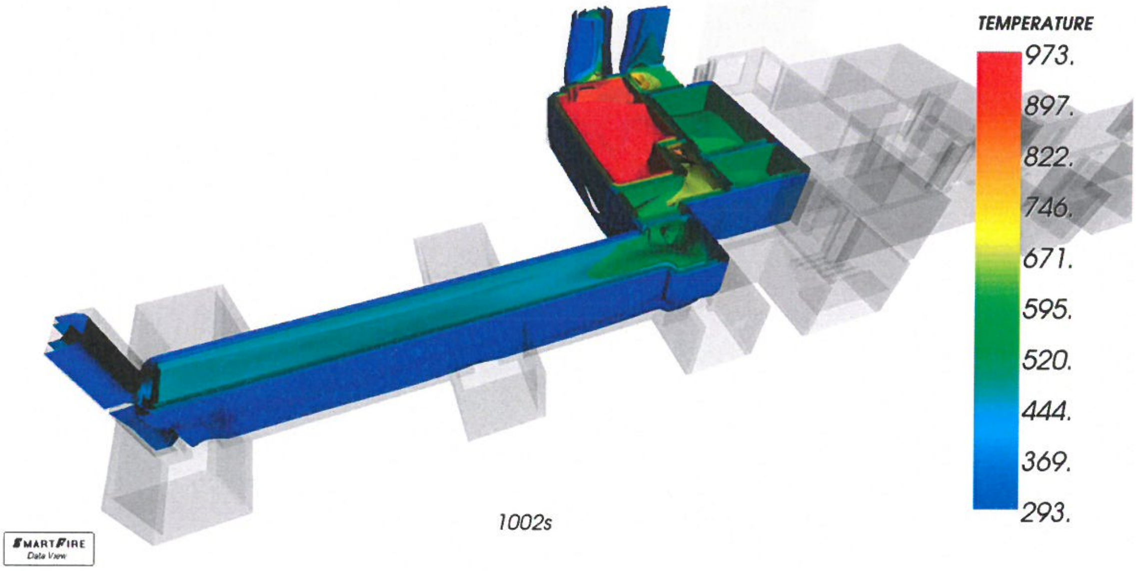

Figure 20 – 1000s into run. Smoke temp in corridor approx. 200°C whilst the temperature profile within the room is above 700°C

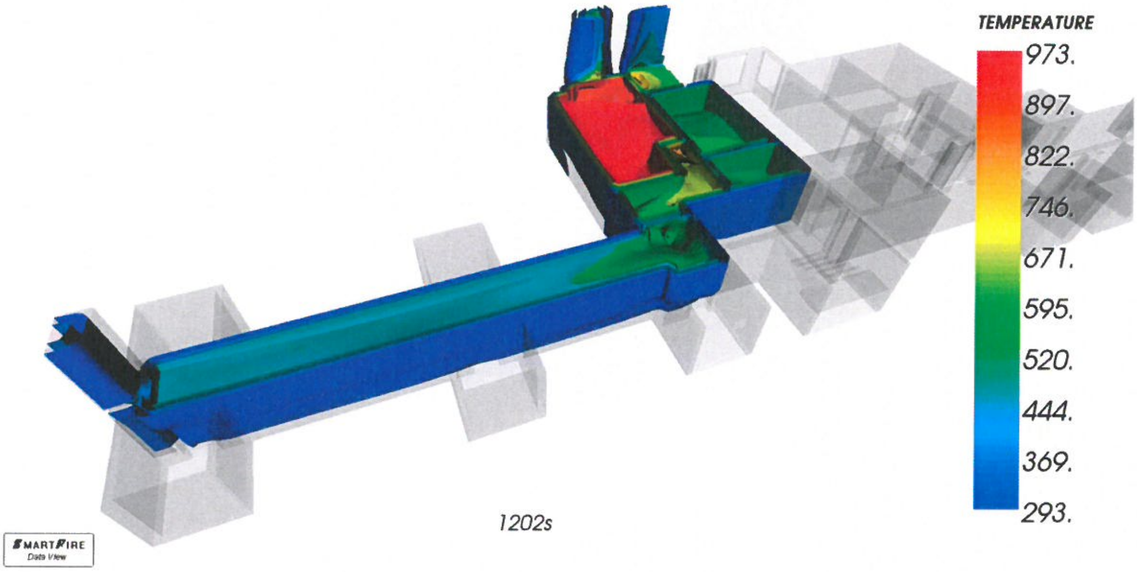

Figure 21 – 4 minutes into firefighting operations. Smoke temp in corridor approx. 200°C whilst the temperature profile within the room is above 700°C

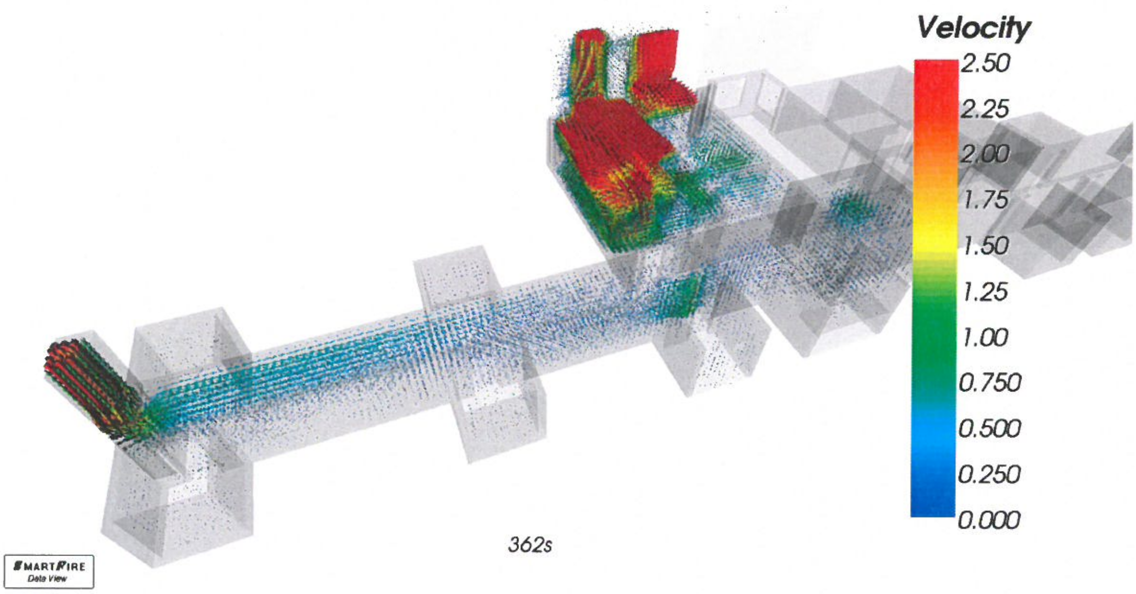

Figure 22 – 20s into activation of fan in smoke shaft. Velocities vectors show that air is drawn into the corridor from the stairs

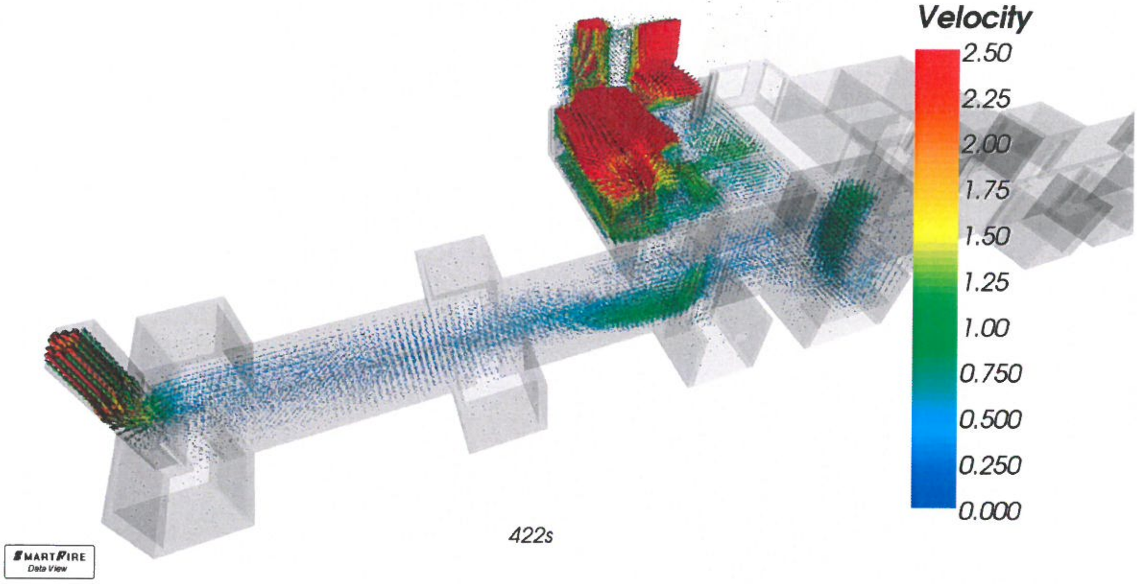

Figure 23 – 120s into system activation. High velocities shown of smoke flowing through apartment windows and air / smoke flowing up the smoke shaft

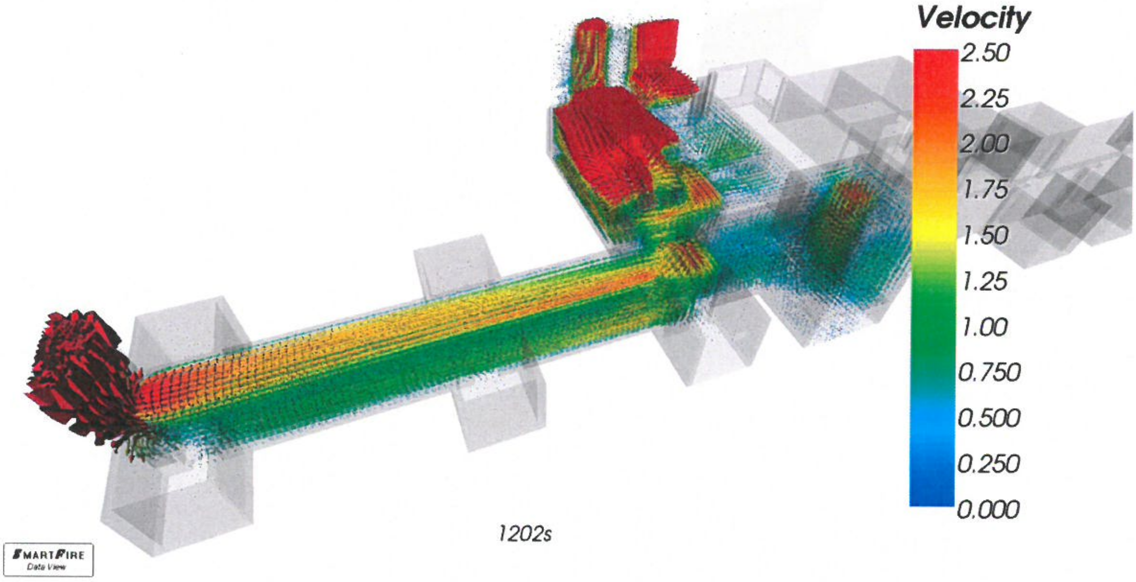

Figure 24 – Fan in smoke shaft operating in firefighting mode. Increase in velocities flowing up the smoke shaft shown by the larger vectors

4.2 CFD Results – Fire 2

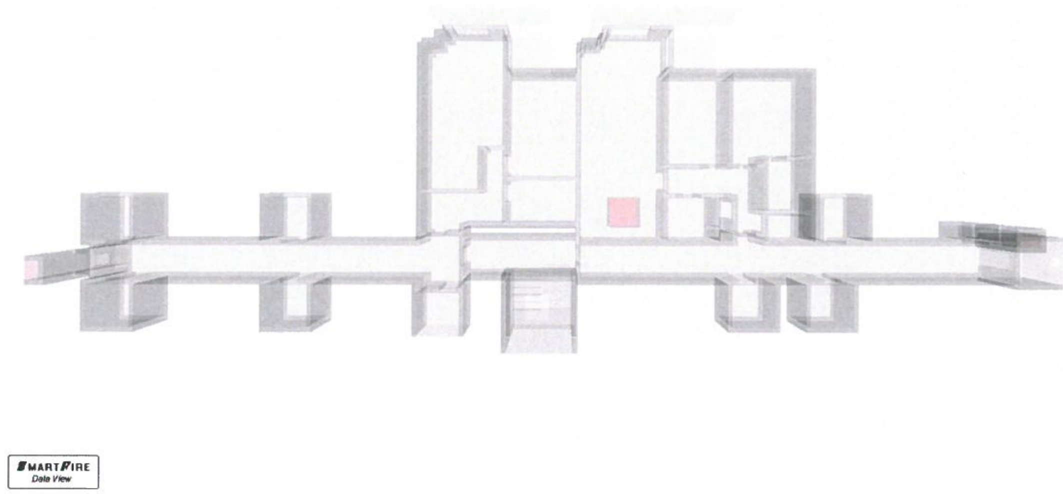

Figure 25 – Layout of corridor

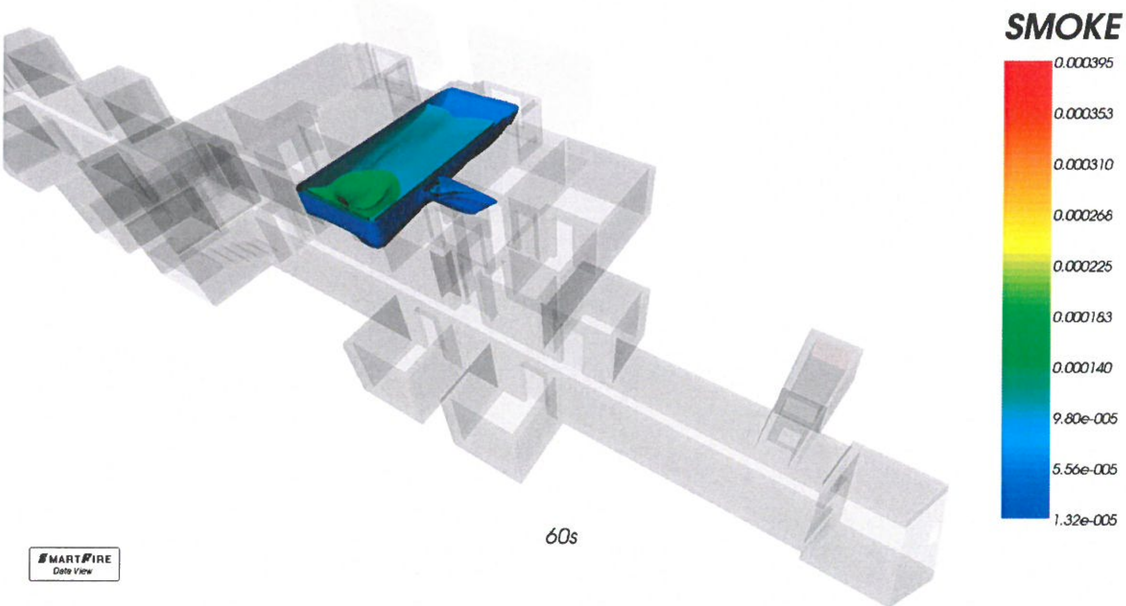

Figure 26 – 60s into run – Smoke filling fire flat and beginning to vent through small vent opening

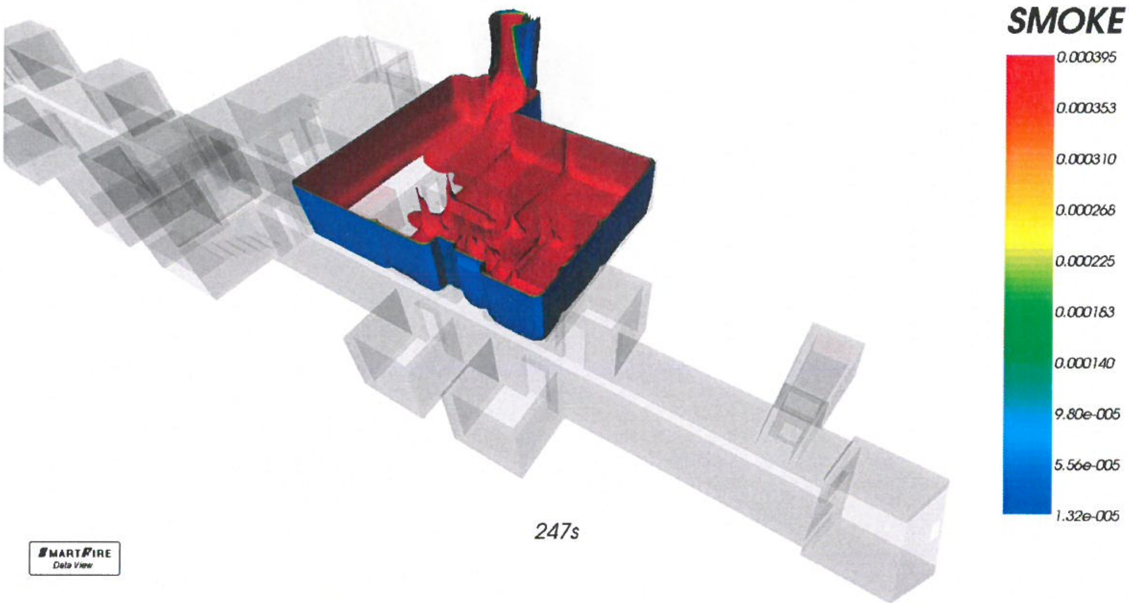

Figure 27 – Window fracture occurs at 247s

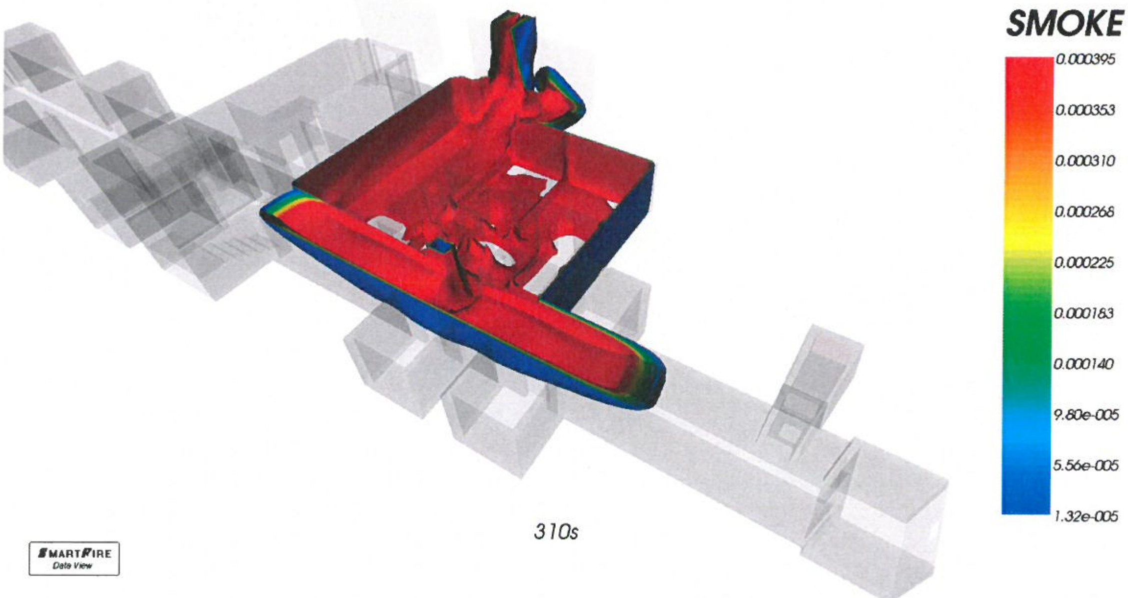

Figure 28 – Door open for at 300 seconds for 10s during escape of occupants in flat

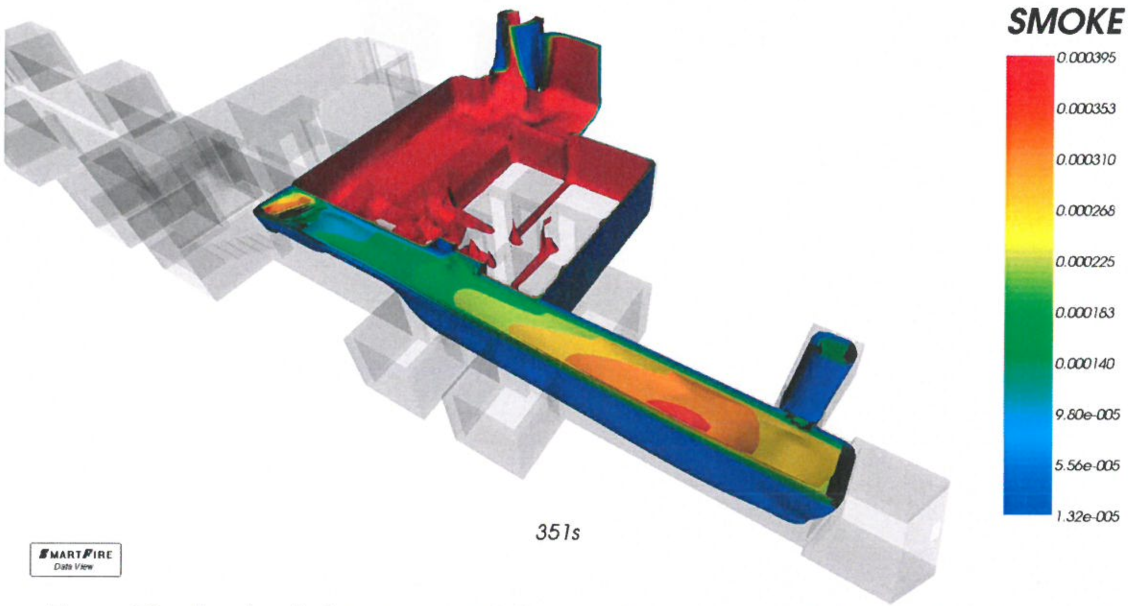

Figure 29 – Smoke shaft operates at 340 seconds and begins to draw smoke. Section of corridor currently smoke logged (350s)

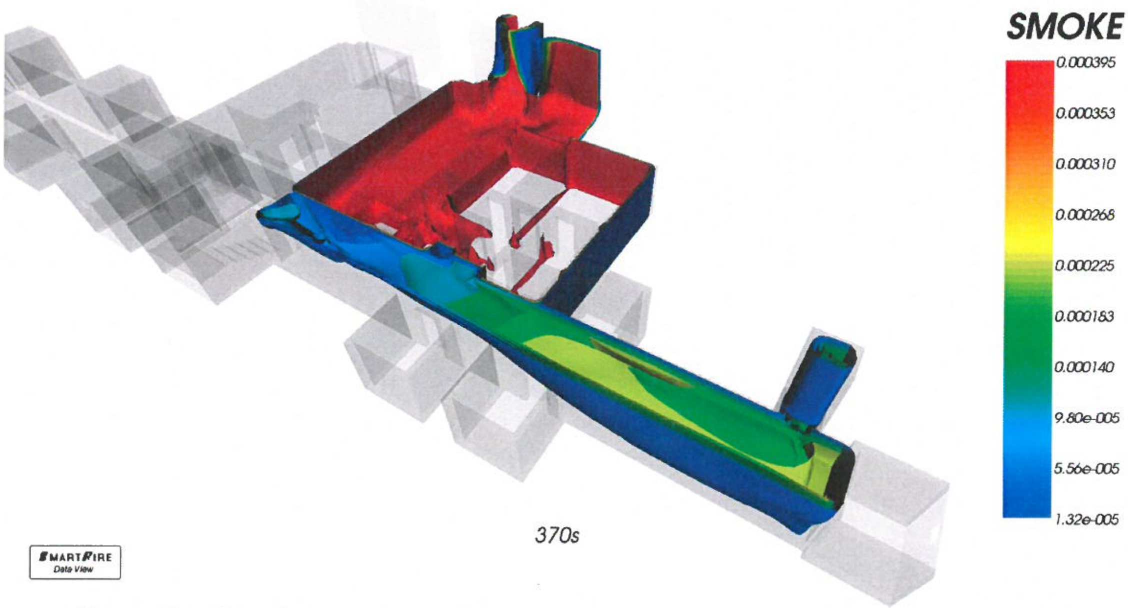

Figure 30 – 30s after smoke shaft operates (370s). Smoke clearing from the corridor

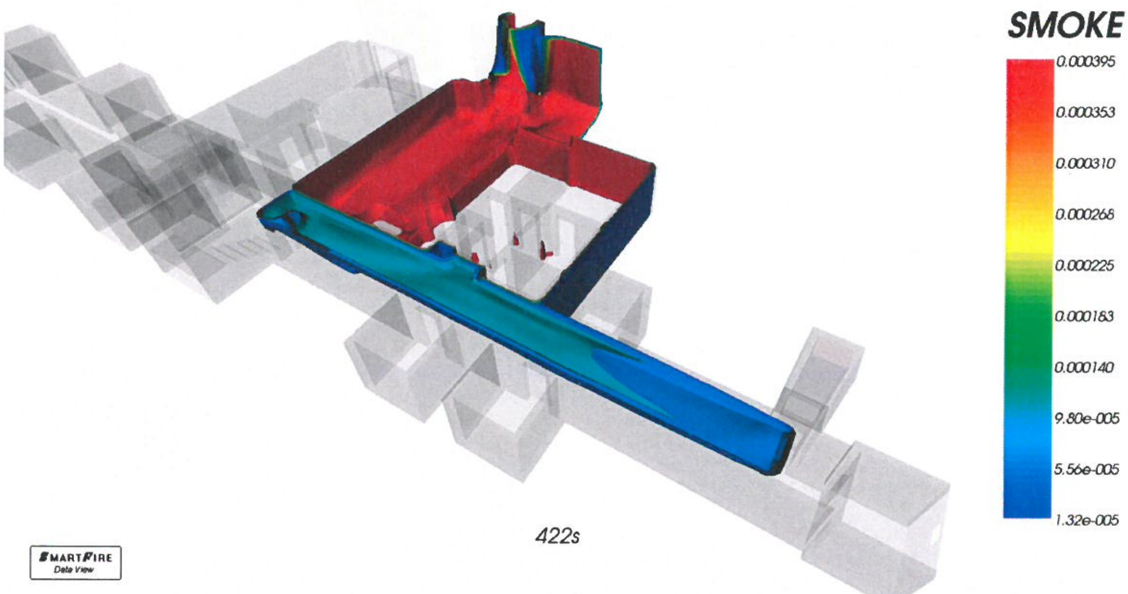

Figure 31 – 2mins after the apartment door is opened (420s). Corridor returning to tenable conditions

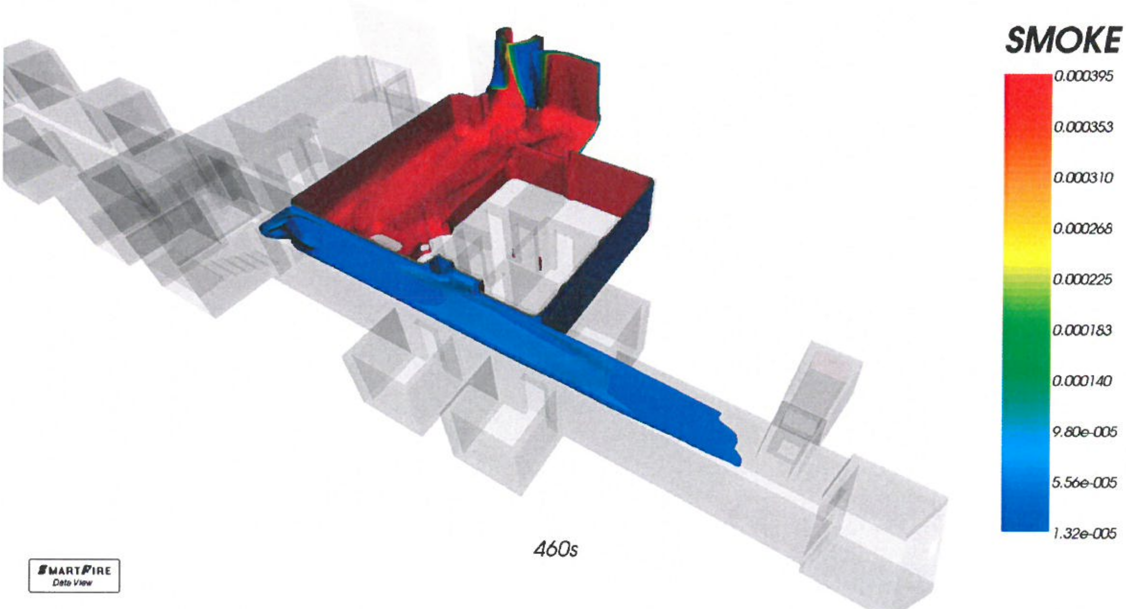

Figure 32 – 120s after system operation (460s). Tenable conditions in the corridor as smoke is at a height of 2m above finished floor level

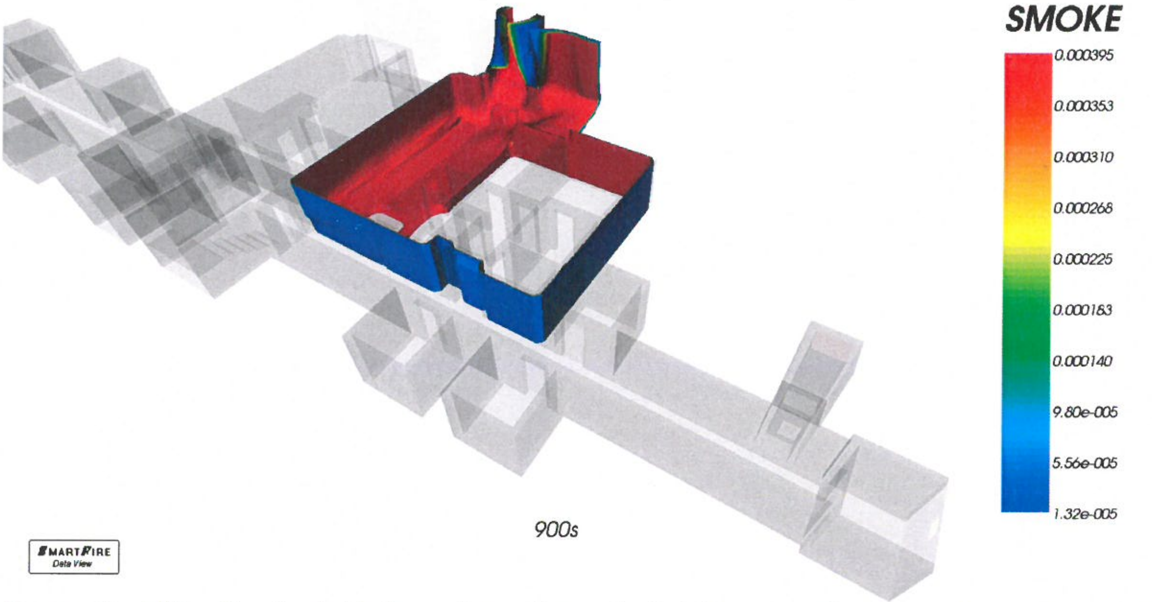

Figure 33 – 900s after fire initiation – Just prior to firefighting operations system running at full flow rate (4m^3/s). Stair door fully open and fire flat engulfed in high density smoke

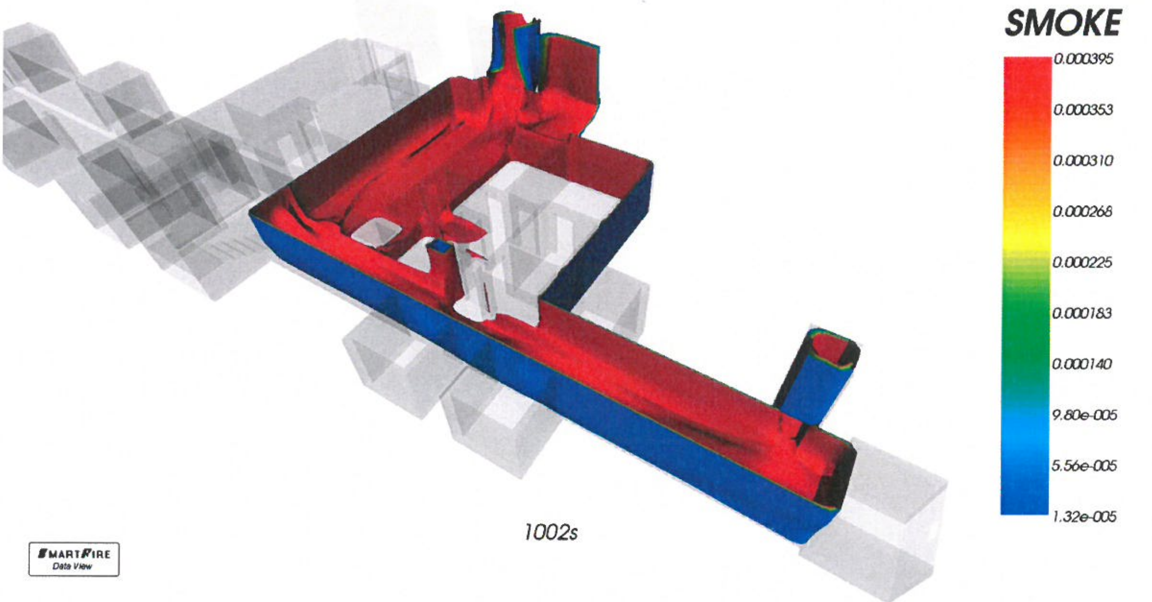

Figure 34 – 1000s after fire initiation – Fire flat and section of corridor engulfed in high density smoke but stairs (still with the door fully open) clear of smoke

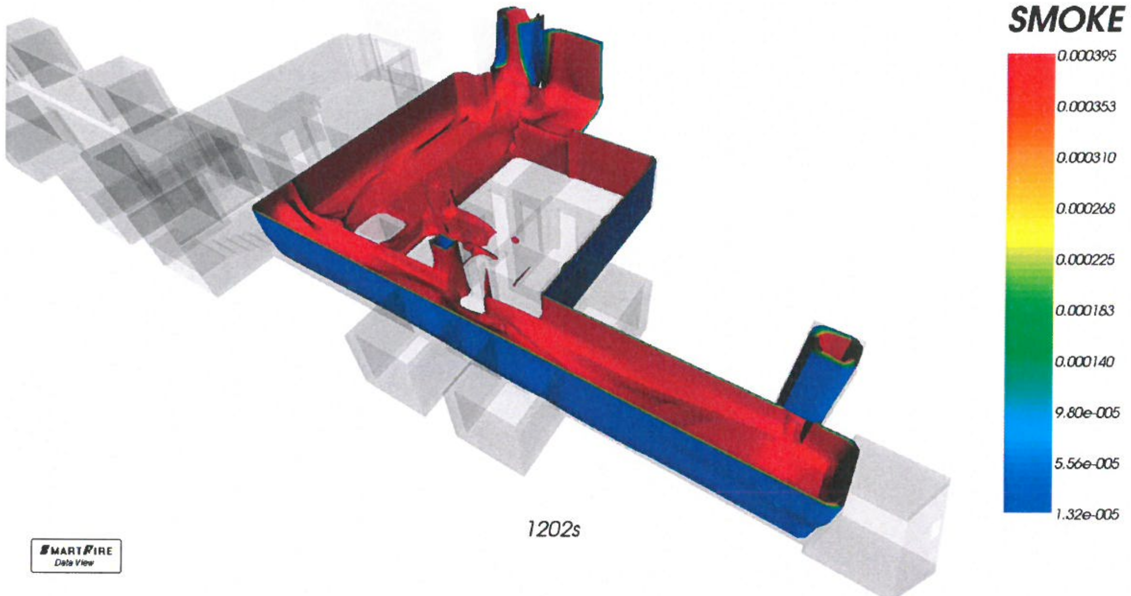

Figure 35 – 1200s into run – Well into firefighting. Stair is clear of smoke

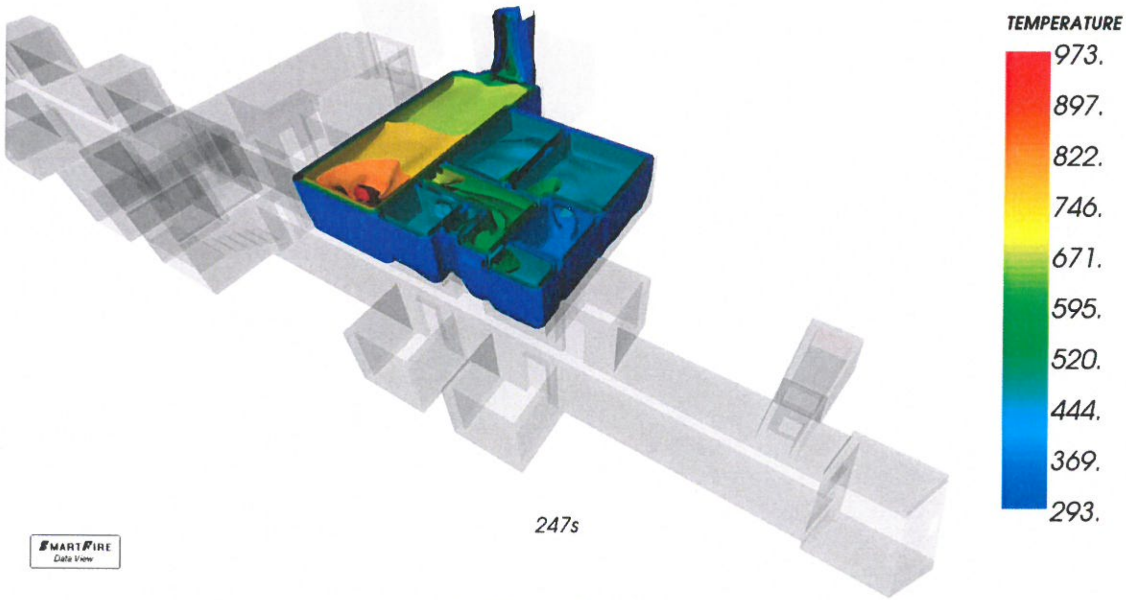

Figure 36 – Temperature profile in flat upon window fracture

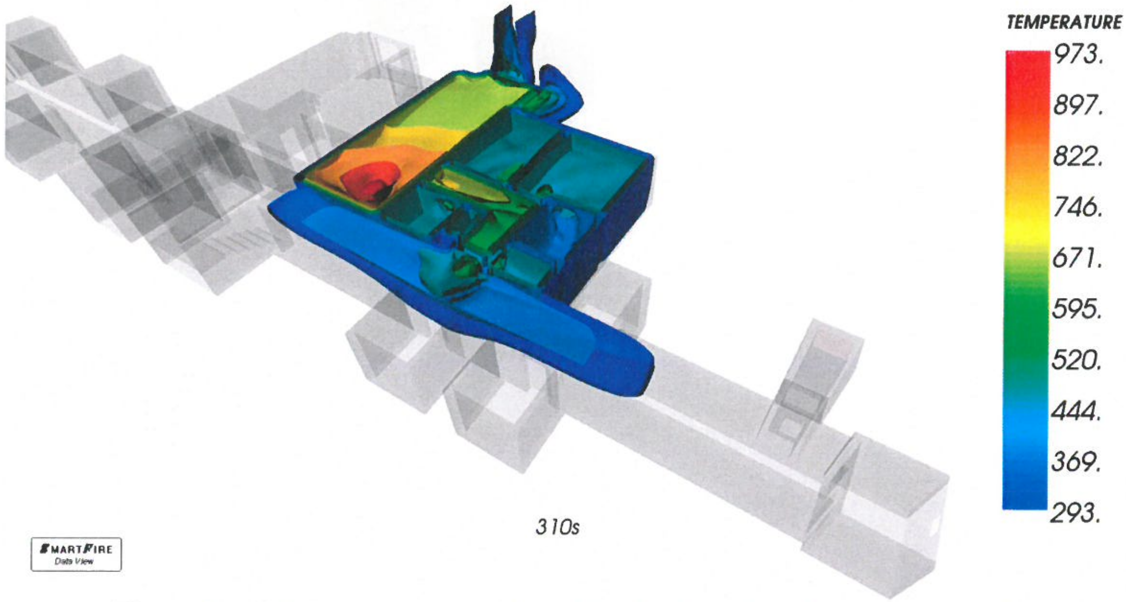

Figure 37 – Smoke temperatures in corridor once flat door opens over 150°C

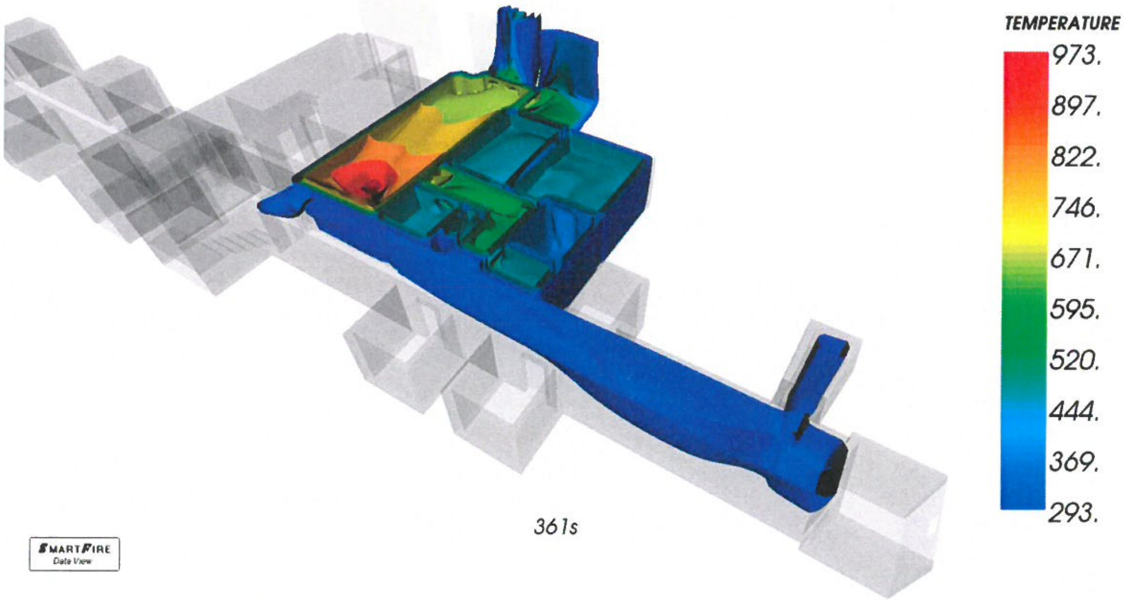

Figure 38 – 360s (20s after smoke shaft operates). Smoke temp lower than 50°C in corridor

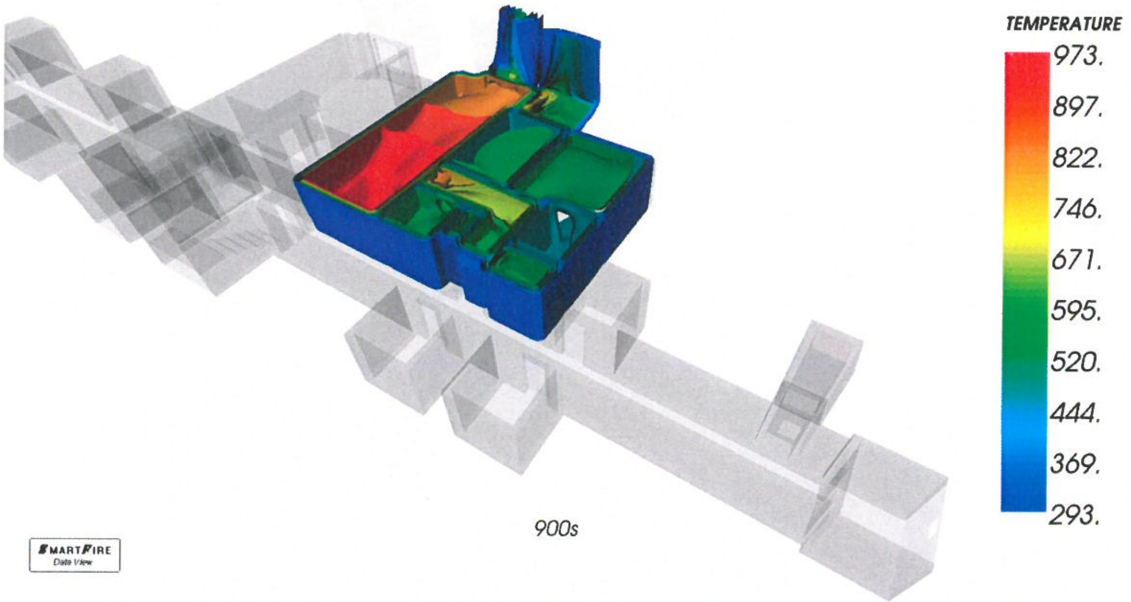

Figure 39 – 900s fire temperature ranging from 250°C to over 700°C in the flat

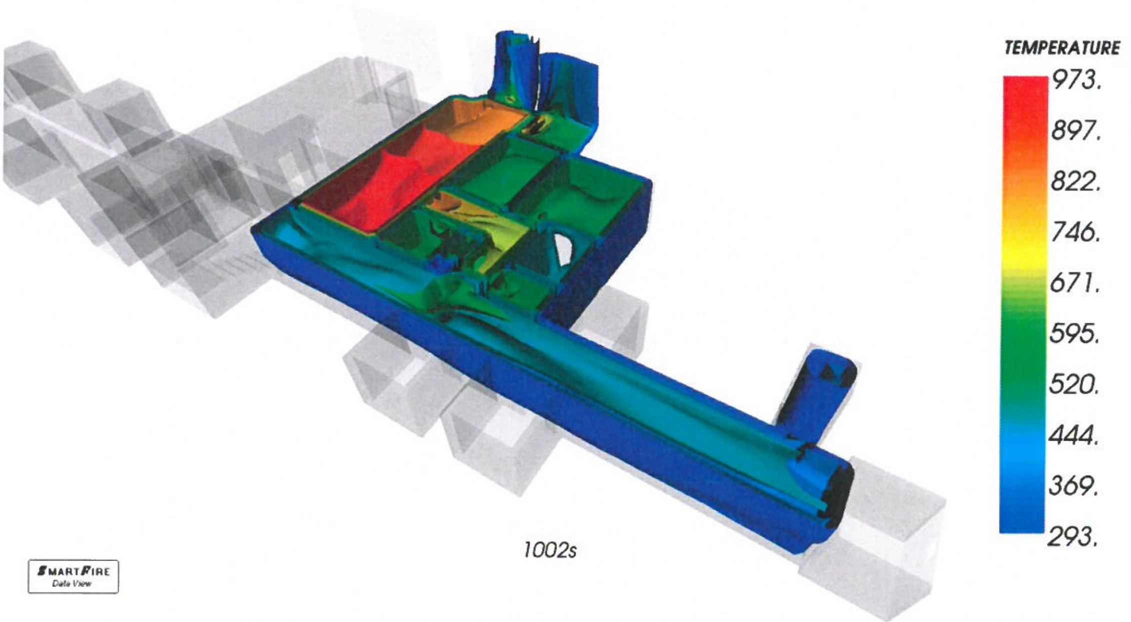

Figure 40 – 1000s into run. Smoke temp in corridor approx. 200°C whilst the temperature profile within the room is above 700°C

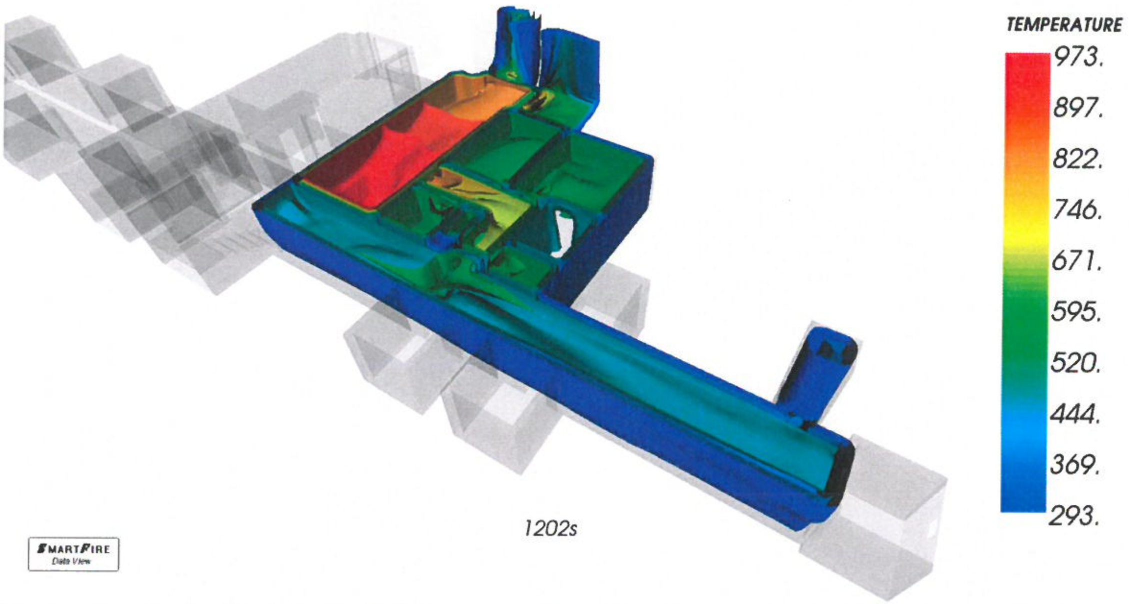

Figure 41 – 4 minutes into firefighting operations. Smoke temp in corridor approx. 200°C whilst the temperature profile within the room is above 700°C

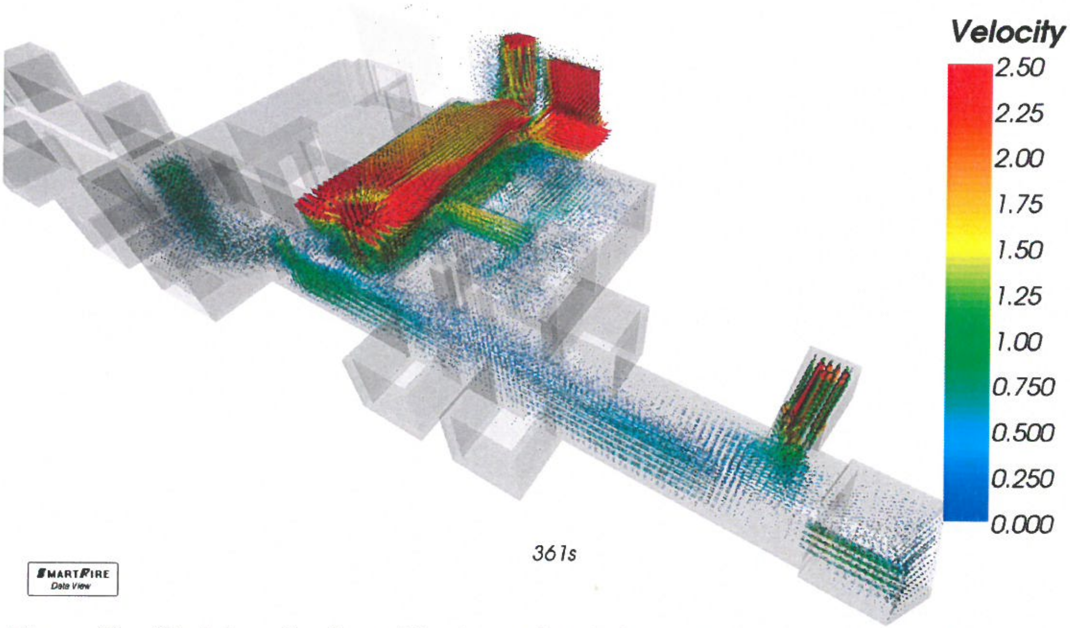

Figure 42 – 20s into activation of fan in smoke shaft. Velocities vectors show that air is drawn into the corridor from the stairs

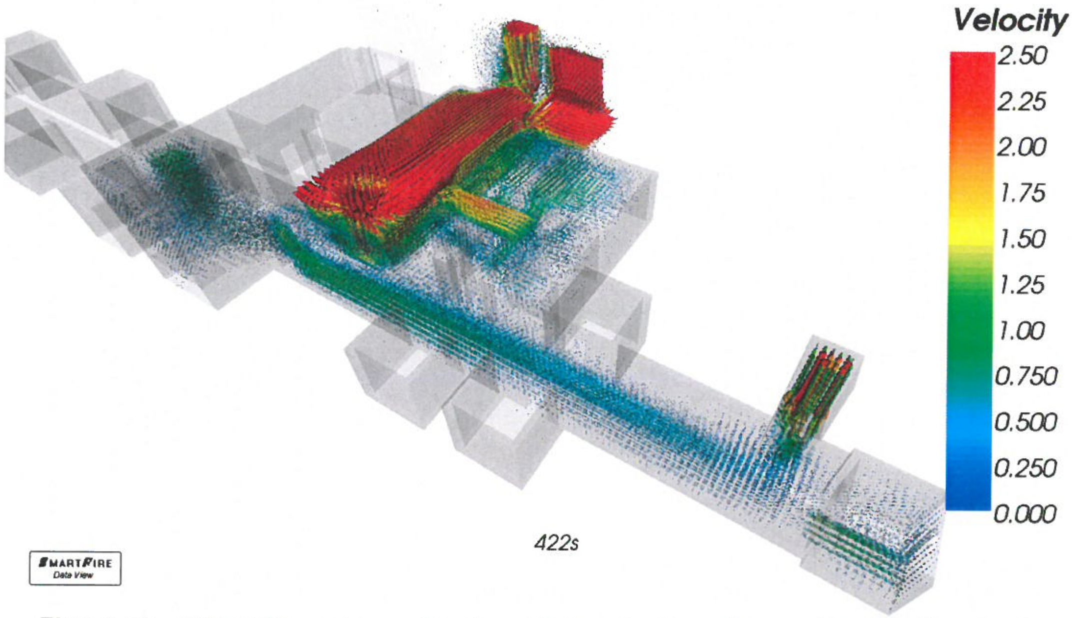

Figure 43 – 120s into system activation. High velocities shown of smoke flowing through apartment windows and air / smoke flowing up the smoke shaft

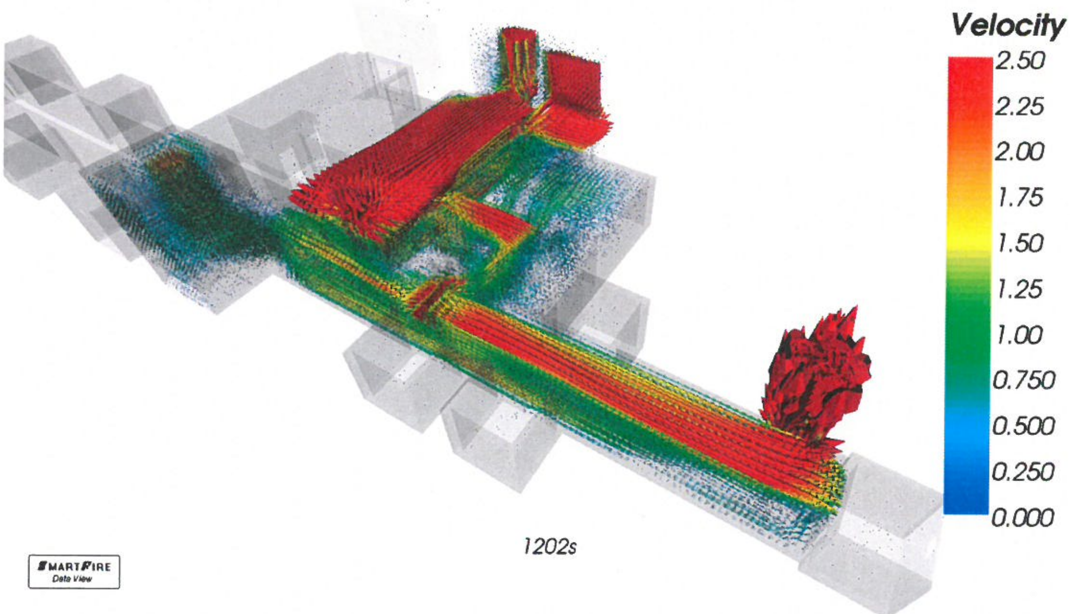

Figure 44 – Fan in smoke shaft operating in firefighting mode. Increase in velocities flowing up the smoke shaft shown by the larger vectors

5.0 CONCLUSIONS

The mechanical smoke ventilation system will be provided to the corridors in accordance with BS9991:2011 and will satisfy the recommendations given in Smoke Control Association "Guidance on Smoke Control to Common Escape Routes in Apartment Buildings (Flats and Maisonettes)".

Smoke of a significant density (visibility <10m) will be prevented from migrating into the escape stair and adjacent flats ensuring minimum smoke damage.

As indicated in this report the engineered fan assisted option provides the highest level of reliability for protecting the stair and removing smoke from the corridors so that the extended travel distances become acceptable.

Firefighting operations can be carried out from the fire floor.

The components of the system will be located within the common areas allowing the system to be maintained without any disturbance to the occupants within the flats.

All the components are tested to the relevant British Standard or other recognised international standards.

APPENDIX A – APPROVING AUTHORITIES SYSTEM DEMONSTRATION PASS CRITERIA

The CFD modelling is used as a tool to estimate the necessary smoke extraction rates and demonstrate air paths. As it would be unpractical to light a fire within an apartment, the following outlines the System Demonstration Pass Criteria and will be carried out following commissioning of the smoke extraction system.

1) The cold smoke generator is positioned within the corridor outside the apartment door modelled. The generator is allowed to release smoke for 10 seconds similar to the occupant escaping from an apartment as per the modelling.
2) The smoke detector may need to be activated by a smoke spray can as the cold smoke may not have the buoyancy to rise and activate.
3) On activation of the detector, the corridor shaft damper should open, the vent at the head of the stair should open and the smoke extract fan should commence operation.
4) The smoke should be prevented from flowing into the stair and corridor should be cleared of smoke (or returned to tenable conditions, i.e. at least 10m visibility with smoke at 2m from the finished floor level) within 2 minutes of fan activation.
5) The system is switched into firefighting mode.
6) The stair door and any cross corridor doors are held open. The cold smoke generator is positioned within the corridor near the staircase door and allowed to release enough smoke to smoke log part of the corridor.
7) The smoke should be prevented from flowing into the stair.
8) The fire fighters switch at entry level should be turned to 'off' and the smoke extraction fan should turn off. The switch can then be turned to 'Auto' again.
9) The smoke detection system should be reset which should reset the smoke extraction system. This means the smoke extract fan should close down, the stair vent and shaft damper close down.
10) The fan auto changeover can be tested by operating the duty fan, turning the duty fan isolator off at which time the stand by fan should commence operation.

The Smoke Venting Contractor has no control over the incoming maintained power supply. This could be tested by the Client as above by operating the system and isolating the duty power supply. The stair vent and shaft damper should remain open with the extract fan closing down while the alternative power supply is brought on at which time the fan should commence operation.

The above forms a summary of the design criteria for the smoke extract system and the method of demonstrating the system operation.