Workbook Exercises – Applying the Eleven Step Guide

The following practical exercises have been designed to help you apply the knowledge gained throughout the course using real-world scenarios.

Each exercise presents a different building type, fire scenario, and system objective (either life safety or property protection), giving you the opportunity to use the eleven step guide in a variety of contexts.

You will be required to interpret building layouts, fire loads and heat release rates, then calculate smoke mass flow rates and system requirements. This includes determining ventilation areas, fan or ventilator specifications, reservoir layouts, and checking for potential design issues such as stratification, stagnation or plugholing.

These exercises will reinforce your understanding and give you the confidence to assess the adequacy of smoke control designs and check compliance against relevant guidance, preparing you for real-life assessment and enforcement duties.

Exercise 1

A twin span sprinklered building is used for the storage of miscellaneous goods up to a height of 7m. The smoke exhaust system is for property protection only.

The assumed heat release rate for the goods stored is 625 kWm^{-2}.
The expected size of the fire is 3m x 3m = 9. The building is 60m by 150m with a height of 8.5 m to the eaves and 11m to the ridge.
The ventilators are located on the centre line as shown here. A natural ventilation system is proposed.
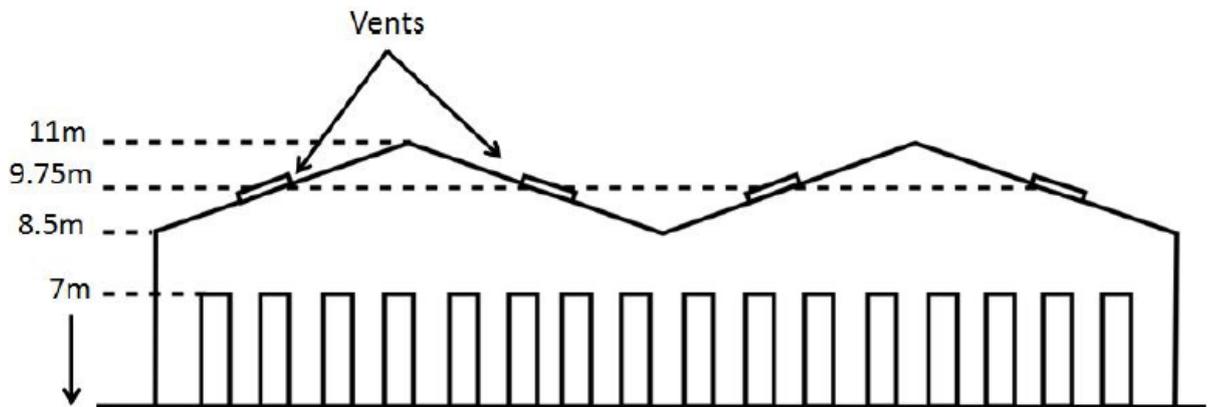
Determine the ventilation requirements using the eleven step guide?
Calculate the mass flow rate of smoke and the temperature of the smoke?
Carry out a stratification check?
Determine the number of reservoirs, the required area of ventilation in each reservoir and decide how many ventilators are required and where they should be located?
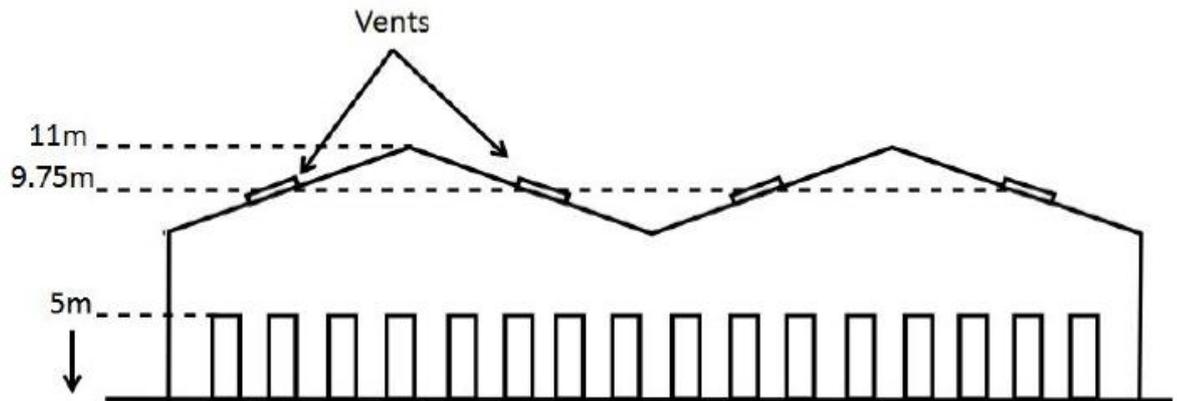Carry out a stagnation check if required and a plugholing check?
Ensure that the air inlet velocity does not impede the means of escape.

Exercise 2

The building illustrated in this diagram is to be used as a storage warehouse. It is to be installed with a sprinkler system complying with the LPC rules, an area of fire of 9m² can be assumed.

The premises will have a smoke control system for property protection. The warehouse will store goods to a height of 5m and a heat release rate of 425kWm⁻² can be assumed.

Vents

11m
9.75m

5m

Determine the ventilation requirements using the eleven step guide?
Calculate the mass flow rate of smoke and the temperature of the smoke?
Carry out a stratification check?
Determine the number of reservoirs, the required area of ventilation in each reservoir and decide how many ventilators are required and where they should be located?
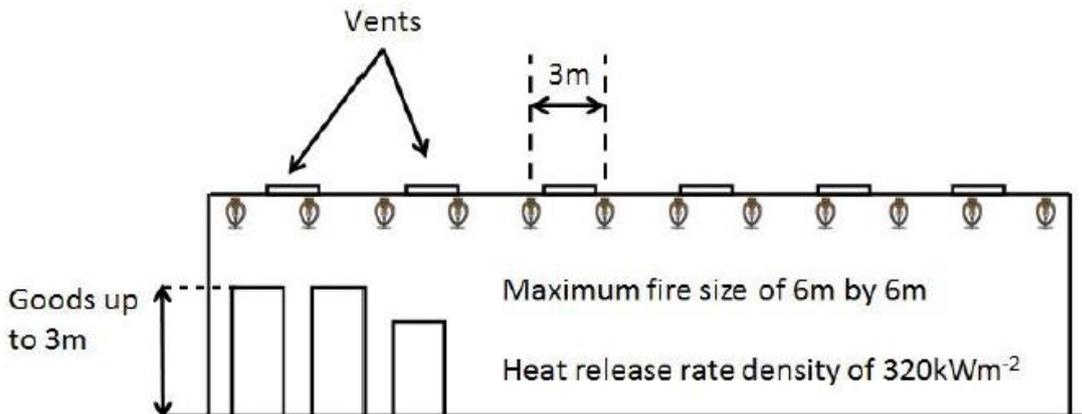Carry out a stagnation check if required and a plugholing check?
Ensure that the air inlet velocity does not impede the means of escape.

Exercise 3

The building illustrated in this diagram is to be used as a factory. The factory will deal with a variety of goods to a height of 3m. The heat release rate density can be taken as 320 kWm^{-2} for the contents at this height. The building is to be installed with a sprinkler system with sprinklers spaced 3m apart.

The largest assumed fire will be contained to 6m by 6m by the sprinklers. The premises will have a natural smoke control system for life and property protection.

Determine the ventilation requirements using the eleven step guide?
Calculate the mass flow rate of smoke and the temperature of the smoke?
Carry out a stratification check?
Determine the number of reservoirs, the required area of ventilation in each reservoir and decide how many ventilators are required and where they should be located?
Carry out a stagnation check if required and a plugholing check?
Ensure that the air inlet velocity does not impede the means of escape.

Exercise 4

A smoke control system is to be installed to maintain a clear layer height in a single storey shopping mall of 3m. It is desired that the smoke should not enter any shop unit and the lowest shop unit is 3.4m. The height to the natural ventilators in the mall is 9m.

The building is to be installed with a life safety sprinkler system complying with the LPC rules. The premises are to be provided with a mechanical smoke control system and there are 2 reservoirs which are 6m x 50m.
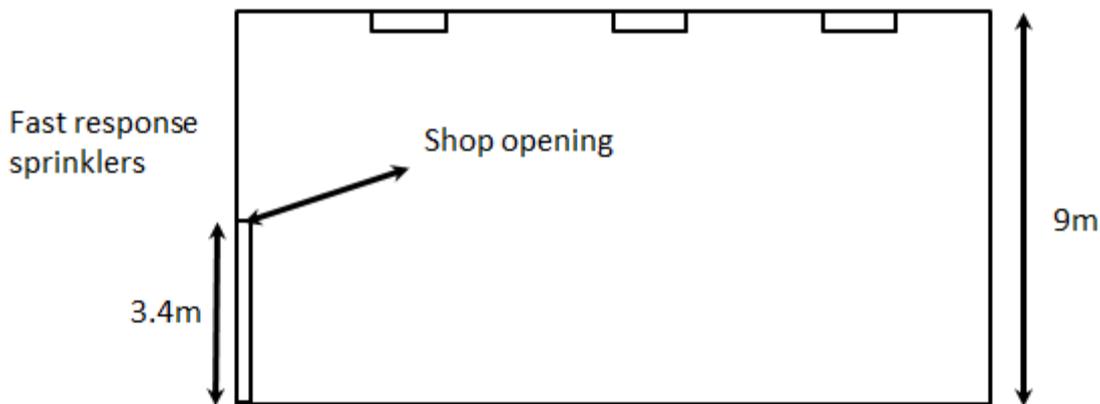
Determine the ventilation requirements using the eleven step guide?
Calculate the mass flow rate of smoke and the temperature of the smoke?
Carry out a stratification check?
Determine the number of reservoirs, the required area of ventilation in each reservoir and decide how many fans are required and where they should
be located?
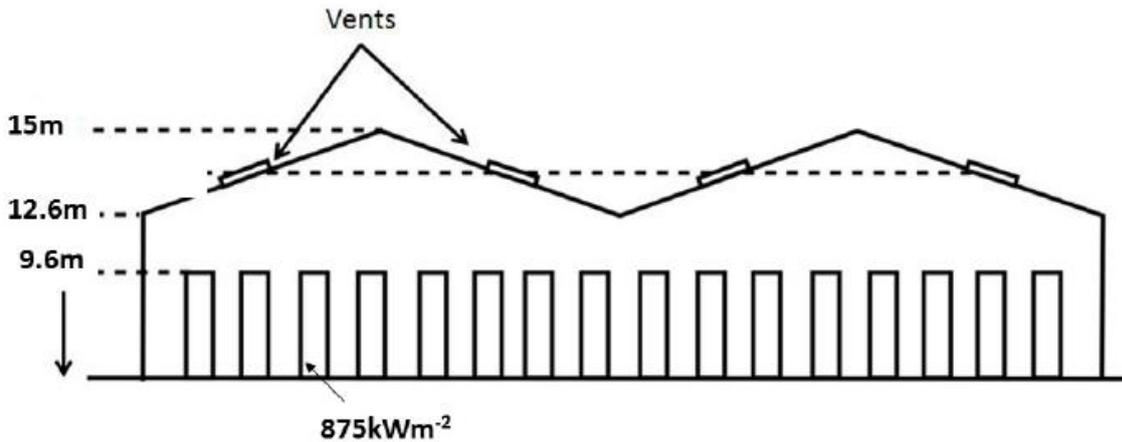Carry out a stagnation check if required and a plugholing check?
Determine the minimum area of air inlets required to ensure that the system does not affect the means of escape?

Exercise 5

A twin span sprinklered building is used for the storage of goods up to a height of 9.6m.
The assumed heat release rate for the goods stored is 875 kWm^{-2}.
The expected size of the fire is 4m x 4m = 16m^2

The building is 80m by 140m with a height of 12.6 m to the eaves and 15m to the ridge

The ventilators are located on the centre line as shown here and therefore the depth of the smoke layer from the ventilators will be 13.7m – 10.1m = 3.6m
(This assumes a 0.5m clear layer height above the stores).

Determine the ventilation requirements using the eleven step guide?
Calculate the mass flow rate of smoke and the temperature of the smoke?
Carry out a stratification check?
Determine the number of reservoirs, the required area of ventilation in each reservoir and decide how many ventilators are required and where they should be located?
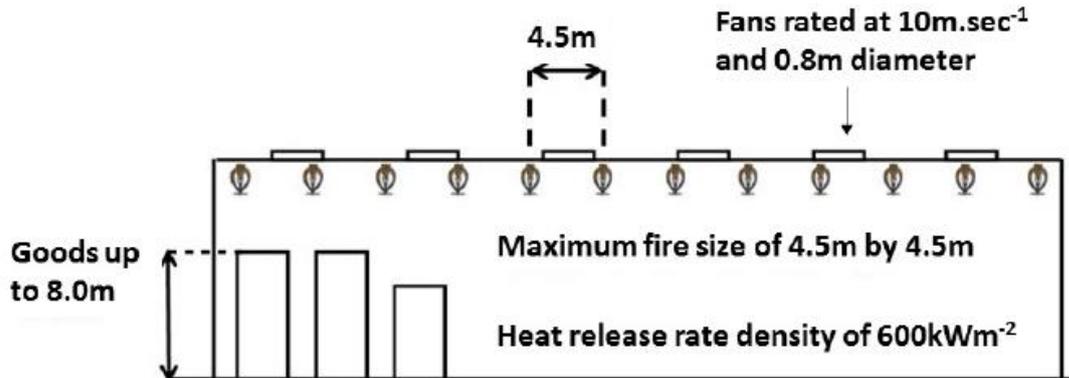Carry out a stagnation check if required and a plugholing check?
Ensure that the air inlet velocity does not impede the means of escape.

Exercise 6

This building is to be used as a storage warehouse for finished goods in cardboard cartons stored to a height of 8m. The estimated heat release rate density is 600 kWm^{-2}.

The building is to be installed with a sprinkler system complying with the LPC rules, an area of fire of 20.25m^2 can be assumed. The premises are to be provided with a mechanical smoke control system for property protection. Fans with a capacity of 10 $m^3s.^{-1}$ and a throat diameter of 0.8 m have been proposed.

Determine the ventilation requirements using the eleven step guide?
Calculate the mass flow rate of smoke and the temperature of the smoke?
Carry out a stratification check?
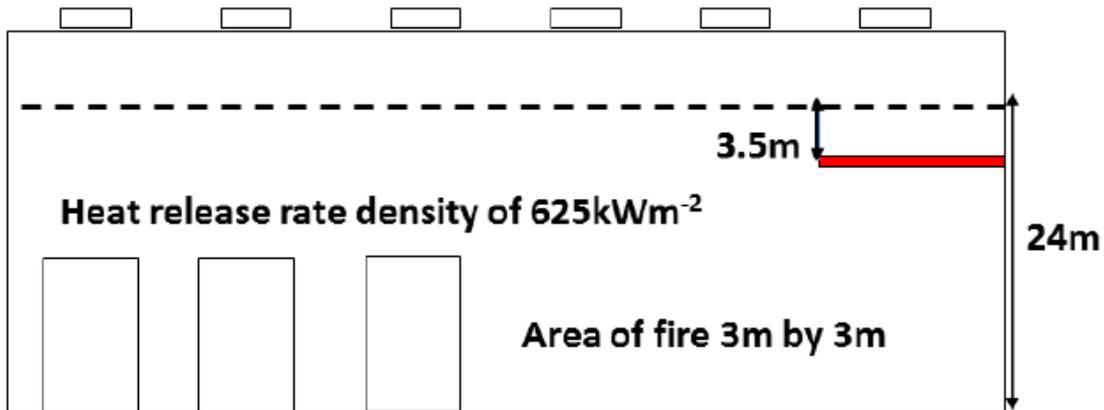Determine the number of fans required in each reservoir?
Carry out a stagnation check if required and a plugholing check?
Ensure that the air inlet velocity does not impede the means of escape.

Exercise 7

A large factory development, as shown in this diagram, has agreed a worst case fire scenario where, in order to maintain means of escape from a mezzanine, the height of rise of smoke to the base of the established smoke layer, z, will be 24m. The worst case fire will be 3m by 3m with a heat release rate density (q_f) of 625 kWm^{-2}.

A figure of 0.8 has been agreed as the appropriate value of chi (convective portion of heat output). The factory will have a flat roof.

Determine the ventilation requirements using the eleven step guide?
Calculate the mass flow rate of smoke and the temperature of the smoke?
Carry out a stratification check?
Determine the number of reservoirs, the required area of ventilation in each reservoir and decide how many ventilators are required and where they should be located?
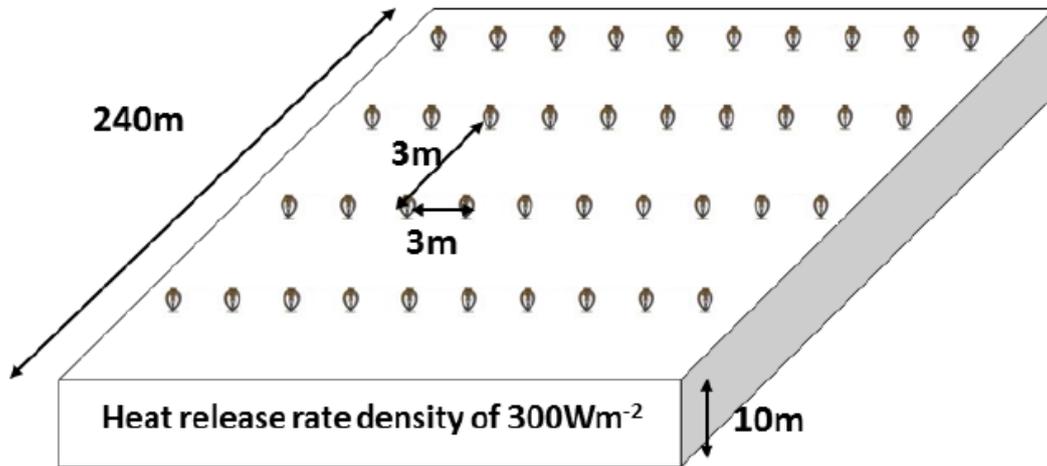Carry out a stagnation check if required and a plugholing check?
Ensure that the air inlet velocity does not impede the means of escape.

Exercise 8

An airport terminal building is 240m x 180m x 10m high, and has a flat roof. Sprinklers are fitted with a grid spacing of 3m x 3m. The largest anticipated value for qf in the building is 300kWm^{-2}

Due to large travel distances, you are to design a smoke control system for life safety. The required clear layer height = 4m. It is proposed to use natural ventilators located in the roof. The chosen ventilators have an AvCv of 1.75m^2.

Determine the ventilation requirements using the eleven step guide?
Calculate the mass flow rate of smoke and the temperature of the smoke?
Carry out a stratification check?
Determine the number of reservoirs, the required area of ventilation in each reservoir and decide how many ventilators are required and where they should be located?
Carry out a stagnation check if required and a plugholing check?
Ensure that the air inlet velocity does not impede the means of escape.

Exercise 9

An office building has a 32m high atrium. The atrium is entirely enclosed by fire resisting glazing and construction but at ground floor and first floor there are a small number of openings into the atrium from adjacent rooms. The building is sprinklered with the exception of the atrium. There is no fire loading permitted within the atrium base. The design fire is based on the figures for offices given in table 3.3 on page 18 of BR368. There will be a very small ambient temperature gradient between the top and the bottom of the atrium equal to $0.3Km_{-1}$.

The openings into the atrium are as follows:
a) Two at ground floor, both 2.6m high and 9m wide. These come from separate rooms with fire resisting walls separating them
b) One at first floor level 3.2m high and 6m wide.
c) One at second floor level 2.6m high and 5m wide. The top of this opening is 9.0m above the ground floor in the atrium.

Any spill plume would be adhered. There are no balconies outside the openings, the smoke will simply leave an opening and travel straight up the wall above it. There is a downstand at the openings. There is to be mechanical ventilation at the top of the atrium (32m above ground). The fans are rated at $11m_3$.sec with a throat diameter of 0.9mThe atrium is not large enough to require more than a single reservoir($1450m_2$) so replacement air for the SHEVS will be supplied by automatic opening doors and vents at ground and first floor level with a total geometric area of $8.2m_2$.


1. Where should the base of the smoke layer be allowed to descend to?
2. Determine the ventilation requirements of the atrium
3. Does the glass require to be insulating?

Exercise 10

This building is to be used as a storage warehouse with goods stored to a height of 8m. The estimated heat release rate density is 600 kWm^{-2}. The building is to be installed with a sprinkler system complying with the LPC rules, an area of fire of 20.25m^2 can be assumed. The premises are to be provided with a mechanical smoke control system for property protection only.

Fans with a capacity of 10 m^{3}s^{-1} and a throat diameter of 0.8 m have been proposed.

Goods up to 8.0m

Heat release rate density of 600kWm^{-2}
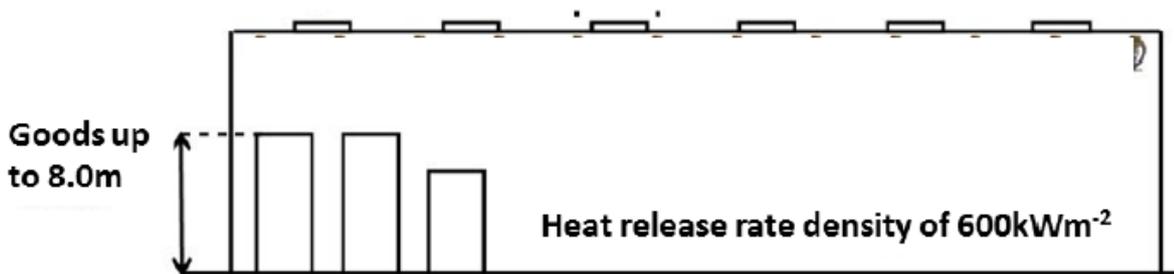
Q. Determine the ventilation requirements of this building.

Exercise 11

The building illustrated in this diagram is to be used as a storage warehouse for finished goods stored to a height of 9.1m. The estimated heat release rate density is 825 kWm^{-2}. The building is to be installed with a sprinkler system complying with the LPC rules, an area of fire of 16m^2 can be assumed. The premises are to be provided with a natural smoke control system for property protection and life safety due to extended travel distances.
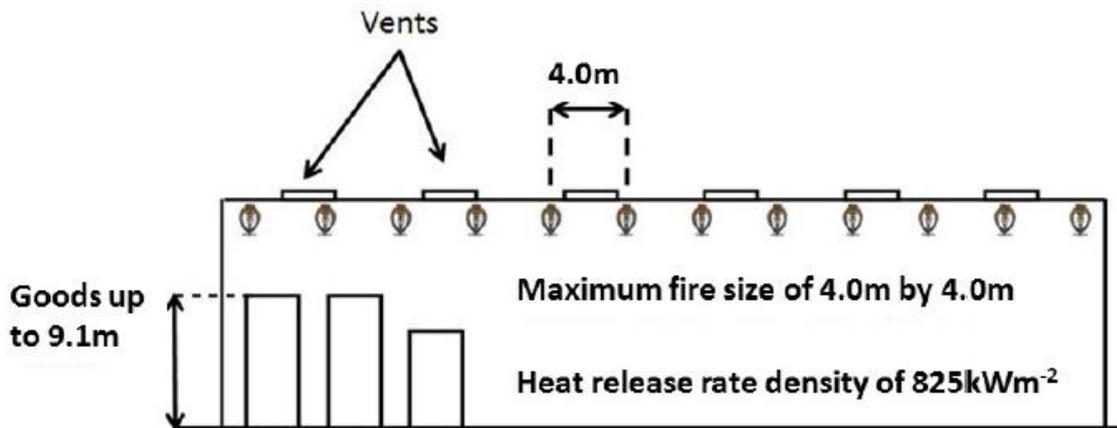
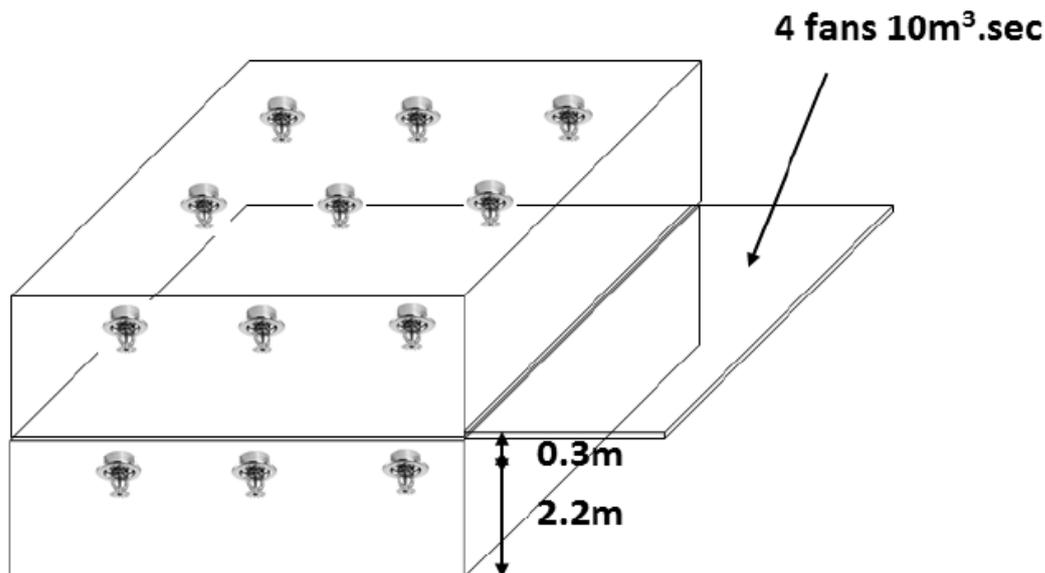Q. Determine the smoke requirements of this building

Exercise 12

A plan has been submitted to convert two adjacent shop units into a single shop unit. The width of the proposed shop front will be 14m wide and 2.2m high. The shop is fitted with fast response sprinklers.

The units are on the ground floor and the mall has two storeys. There are balconies above the ground floor shop fronts as shown in this diagram which represents a section through the shop unit and mall outside it. The appropriate value for the coefficient of entrainment within the shop is 0.21.

The down stand at the shop front is 0.5m deep. Assume the ambient temperature to be 288K or 15°C. Because the new large shop unit would spill smoke into two separate reservoirs, the designer proposes to create a small reservoir outside the shop unit to contain the smoke and to extract it mechanically from there.

The small reservoir will be 14m wide and 5.6m from the shop front downstand to the containment screen at the edge of the underside of the balcony. They have proposed to have 4 ventilators rated at $10m^3/s$ with a throat diameter of 0.9. The inlet air is provided by doors and automatic opening vents with an area of $11m^2$



4 fans $10m^3$.sec

0.3m

2.2m

Can you check the submission?

Exercise 13

A shopping mall is fitted throughout with standard response sprinklers. There is a proposal to convert two adjacent shop units into a single shop unit. The width of the proposed shop front will be 12.2m and it will be 2.4m high. The units are on the ground floor and the mall has two storeys. There are balconies above the ground floor shop fronts as shown in this diagram which represents a section through the shop unit and mall outside it

The appropriate value for the coefficient of entrainment within the shop is 0.21. The down stand at the shop front is 0.5m deep. Assume the ambient temperature to be 288K or 15C.Because the new large shop unit would spill smoke into two separate reservoirs, the designer proposes to remove the down stand and use mechanical slot extraction at the front of the shop to stop any smoke from leaving the shop into the mall.

They have proposed a system which will extract 45m³/s


Slot extraction
45m³.sec

12.2m

2.4m
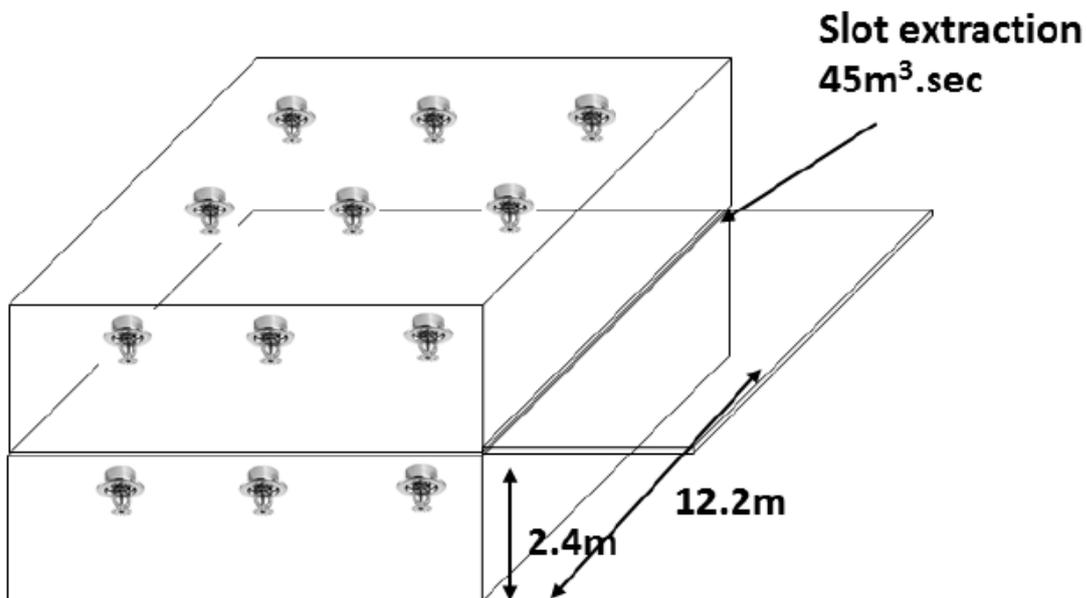
As a building control inspector can you check that the system will be adequate?

Exercise 14

A plan has been submitted to convert two adjacent shop units into a single shop unit. The width of the proposed shop front will be 11.5m wide and 2.4m high. The shop is fitted with standard response sprinklers

The units are on the ground floor and the mall has two storeys. There are balconies above the ground floor shop fronts as shown in this diagram which represents a section through the shop unit and mall outside it. Because the new large shop unit would spill smoke into two separate reservoirs, the designer proposes to create a small reservoir outside the shop unit to contain the smoke and to extract it mechanically from there. The small reservoir will be 11.5m wide and 4.8m from the shop front downstand to the containment screen at the edge of the underside of the balcony

They have proposed to have 4 ventilators rated at $12m^3$.sec with a throat diameter of 1.1m. The inlet air is provided by doors and automatic opening vents with an area of $12.5m^2$
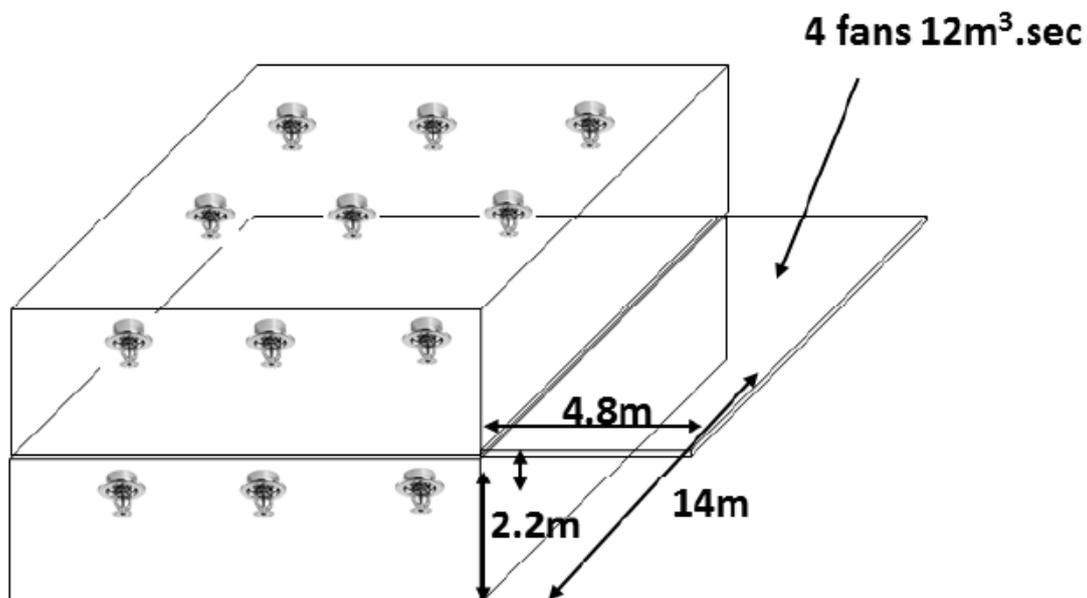
Can you check the submission?

Conclusion

The eleven step guide is a method which if followed will go through the various steps needed to determine the requirements of a smoke control system. If the system falls down in any step the fire engineer should make the appropriate adjustments or demonstrate how the system is still deemed to be safe. This may involve the requirement to run a CFD model which will indicate that the system will indeed meet the system design objectives, however, the enforcer will need to be happy that the inputs for the CFD model are appropriate.