Smoke Ventilation of Common Access Areas of Flats and Maisonettes
Appendix H – Summary of final report on the smoke management of corridors in residential apartments

The authors of this report are employed by BRE. The work reported herein was carried out under a Contract placed by the ODPM. Any views expressed are not necessarily those of the ODPM.

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University of Ulster undertook the task of providing analytical methods for the design of smoke management in corridors and common areas of residential apartments. Following the first Steering Group meeting of the project, the decision was taken to consider the arrangement of a room of fire origin having the door slightly open into a corridor and / or lobby. One of the objectives was to determine the tenability conditions in the corridor assuming steady conditions were established for a medium size fire. This investigation was intended to lead to a practical assessment of the relative effectiveness of the current requirements for automatic opening vents (AOVs) at the end wall of a corridor opening to the outside environment.

Two preliminary reports were submitted. In the first report, several situations were considered and methods were proposed on how to do the transient calculations for the filling times if no smoke management has been employed. In the second report, only steady state conditions were considered for a configuration, which was also examined experimentally and numerically by BRE. These calculations involved corridors of length 18 m, width 1.5 m and height 2.2 m. The fire compartment was set to be 5 m by 5 m in cross-section, with an open vent at the back. However, the purpose of the fire compartment was to generate a smoke plug source at the narrow door opening to the corridor or lobby, and to this end a fire source of about 1/4 MW seemed to be suitable. The door connecting the apartment to the opening was only 10 cm open.

The analytical investigation has provided the following guidelines for the assessment of tenability conditions in the room / corridor system considered here:

1. The clear layer height determines the entrainment rate of mass for the flow requirements of the rising thermal plumes both in the room of fire origin and in the plume of hot gases emerging from the opening.
2. Means of withdrawing the amount of this entrained mass must be provided for example through AOV (naturally), a smoke shaft (naturally) or by mechanical extraction.
3. Means must exist to supply fresh air equal to the required entrainment by the rising plumes (this is the so-called make up air). The supply air can be

naturally provided by vents opening to outside near the bottom of one or both the end walls.

The entrainment needed to sustain a given height of clear layer in the corridor is approximated based on the following considerations:

a) Because of the small door opening, the smoke layer will be near the floor in the room of fire origin. It is worthwhile to notice that this result is supported independently by the experiments in the model scale facility at BRE.

b) The heat flow for the room of fire origin to the corridor will be equal to the heat release rate from the fire i.e. 250 kW.

c) From a) and b), it is possible to conclude that the entrainment into the rising plume in the corridor is equal to the entrainment to a plume having heat release rate 250 kW with its origin near the floor adjacent to a wall.

Thus the entrainment form the corridor to the plume is equal to half the entrainment rate of a plume twice the size of the plume in the room of fire origin.

$$\dot{m}_{entr} = 0.07(2\dot{Q}_c)^{1/3} Z_c^{5/3} / 2 \qquad \text{(kg/s)} \qquad (1)$$

Here the heat release rate is 250 kW and the height of clear layer is Z_c (in m). Moreover the average temperature of the upper layer is:

$$\Delta T_c = T - T_o = \frac{\dot{Q}_c}{\dot{m} C_p} \qquad \text{(K)} \qquad (2)$$

When evaluating a smoke management system at steady state conditions it should be kept in mind that equality must apply for the entrainment rate, the extraction rate and the supply rate. In addition, the extraction system should withdraw only from the smoke volume whereas the supply system should provide air into the clear layer.

Several method for extracting the smoke are considered:

1. Extraction by mechanical ventilation is well controlled if it is designed to extract from multiple points in the ceiling of the corridor, with make up air to be provided by vents near the bottom of the end walls of the corridor. The extraction rate is given by Eq.1 for a given clear layer height

Z_c . Such a design will generate a depressurization in the system that has the benefit that smoke would not enter other rooms or the staircases.

2. Extraction by mechanical ventilation through a smoke shaft located at one end of the corridor, either open or closed at its base. This situation, when the extraction rate is exactly given by Eq.1, results in the withdrawal of fresh air together with the smoke volume from the corridor which may lead to “choking” of the entrainment to the plume and hence, to smoke recirculation and smoke logging. This behaviour will occur even if a vent to the outside is located near the bottom of the other end of the corridor.

3. Extraction by natural ventilation from the end of the corridor through an AOV which, when opened, creates an opening from the top of the corridor down to ¾ the height of the corridor. In this case, assuming no wind but with vents at the bottom of both ends of the corridor, the smoke layer can be vented for any fire independent of heat release rate.

4. Extraction by natural ventilation from one end of the corridor through a smoke shaft. If the shaft is closed at the bottom and can also withdraw more air than specified by Eq.1 (for example because it is very tall), this system will experience the same behaviour as the similar system in case 2. If the shaft is open at the bottom and it is sufficiently large, its behaviour will be similar to the behaviour in system in case 3.

Concluding remarks

An important observation is that an AOV can provide acceptable tenability conditions for smoke removal (i.e. clear layer height of 1.8 m) if there is no wind and if

(a) when the AOV opens half of the wall from top down is open over the whole width of the corridor, and
(b) vents to outside at the bottom part of the end walls are installed.

This behaviour is independent of the heat release rate if the heat losses along the corridor are small. It follows that the critical tenability condition will be specified by the permissible temperature in the upper layer, which is usually assumed to be 200 K above ambient. Consequently, using Eqs.1 and 2, it is found that critical conditions for tenability will be developed if the heat release rate is greater than 115 kW. However, this result does not agree with the scale experiments, which presumably reproduce a full-scale fire of 250 kW for which the hot layer temperature rise in the corridor was measured to be about 60 K. A possible explanation is that cooling of the hot gases in the model fire occurs owing to the cold smoke injected around the base of the fire for visualization of the smoke layer.