Means of escape
Open plan layouts with sprinklers - are they safe?

In recent years there has been an increasing desire for open plan layouts in flats and houses allowing occupants to use their accommodation without the hindrance of doors and partitions. A few years ago the Building Research Establishment (BRE) carried out experiments on sprinkler controlled fires and tenability1. This helped us understand whether occupants could escape though an outer living room from an inner bedroom without suffering from the effects of smoke toxicity and heat exposure. A number of different fire scenarios were tested and the results were available for interpretation.

Most fire engineers who interpreted these results concluded that sprinklers were not able to provide tenable conditions. Whilst the heat exposure was kept within acceptable limits, in most cases smoke toxicity and visibility was not and due to sprinkler spray causing a downdrag of the smoke, could worsen the situation. A recent publication by the National House Building Council (NHBC) has suggested in certain limited scenarios, it could be shown that a sprinkler controlled fire with smoke detection would be no worse than a conventional design with a protected route.

The NHBC document is the result of work they commissioned the BRE to undertake. The document takes a different approach from assessing tenability; it compares the effects of a sprinkler controlled fire with the traditional approach taken by the building regulations in Approved Document B. If the tenability conditions are no worse compared to those given by the latter design – then surely an open plan layout protected by sprinklers would be acceptable? On the face of it, this seems a well-reasoned argument. However we need to dig a bit deeper into the document to reveal all.

Fire doors left open
The Approved Document compliant design relies upon a protected hallway. In comparing the two strategies the NHBC document considers the doors to the rooms were left open for a percentage of the time using a computer based risk model.

Quote:
“In the current edition of AD B, self-closing devices are no longer necessary on fire-resisting doors located within a dwelling. Some engineers have argued that it can be assumed that these doors will be left in the open condition for the purposes of comparative studies and effectively the dwelling will be open plan.”

In other words if we were to compare an open plan layout with a sprinkler controlled fire to a protected hallway with the fire doors left open – the two situations would be very similar. Both would be untenable. Lets take a moment to discuss the philosophy behind the omission of self closers in dwellings.

The most difficult time for occupants of residential buildings to escape is at night, the Communities and Local Government’s advice as presented at the launch of the 2006 Approved Document B, was to emphasise the need for occupants to close their doors at night, (the time when escape will take the longest, as occupants will be asleep).

It could be argued, this advice should have been broadcast louder to the population at large – it is promising to hear from the NHBC document that based upon a survey, 40% of people do close their fire doors at night (even with no publicity). The NHBC document therefore considers fire doors may be left open for 60% of the time in the scenarios considered.

Tenability comparison
The document concludes that where sprinklers are fitted the tenability is no worse than an Approved Document B design with doors open 60% of the time. Tenability comprises three significant factors, smoke toxicity, visibility and heat exposure. Let us consider a comparative fire in an open plan living room and one in a conventional Approved Document B (ADB) design. In the 40% of cases where occupants have closed their doors at night, the tenability will be maintained with a small amount of smoke leakage around door gaps as was demonstrated by the original BRE research.

However let us for the moment go along with the idea that the fire doors are left open to the protected hallway for 60% of the cases considered. Initially smoke from the fire will rise up to the ceiling in a plume and spread outwards across the ceiling and build down as a layer. In the open plan room design the route from any inner bedrooms will be through this area. In the ADB design smoke will encounter a downstand above the door to the hall, the layer will shortly build down and smoke will travel into the hall and will start to fill the hallway. The ADB design will have a slight advantage but the smoke detection will only activate when smoke has reached the hall. At this point the rate of smoke filling between the open plan room and the hallway will be in the favour of the hallway case, as smoke will be slightly restricted. In both cases the smoke will be starting to descend below normal standing height, although in both cases the clear layer beneath will be tenable for occupants.

At this point we will say the temperature at ceiling level has reached 68°C and the sprinkler in the open plan case activates. The sprinkler spray will cause the previously stable smoke layer to drop due to turbulence, and the smoke will be distributed into the previously clear lower layer. This phenomenon is known as sprinkler downdrag and the

layer will not recover. In the ADB design the smoke layer will remain stable but will continue to slowly descend. Significantly though, the conditions in the ADB design case will be tenable under the smoke layer. Although occupants will have to duck below the layer.

The NHBC report states - when sprinkler downdrag occurs occupants will not enter the access room from the inner bedroom due to the smoke filled conditions in the access room caused by the sprinkler downdrag. At the same point in time in the ADB design there would be a clear layer under which occupants can escape. If occupants did decide to attempt escape in the sprinklered open plan layout, they would be faced with untenable conditions. The Fire Kills TV campaign - ‘drowning in smoke’ tells us that two to three breaths will cause unconsciousness. It is therefore difficult to see what benefit the sprinklers will provide as sprinklers do not reduce toxicity but remove the clear layer under the smoke due to the downdrag of sprinkler flow.

A further consideration is the assumption made in the document that upon operation of a sprinkler the fire will be immediately extinguished. The sprinkler tests in the original BRE research has shown sprinklers will stop the further growth of a fire but not necessarily extinguish it and even when extinguished this did not happen immediately. During the time the sprinklers are controlling the growth, the fire will continue to produce toxic gases. This does not appear to have been analysed by the report.

A practical aspect of human behaviour is related to occupants who would attempt in the first instance to put out the fire in order to save their belongings - this would be judgemental for the occupant and would be based upon their perception of whether they feel they could tackle the fire. Most people have no practical experience and would abandon the attempt at a certain point. In the ADB design they could simply go out of the room and close the door to the hall and evacuate the remainder of the family. In the open plan case the sprinkler downdrag would probably stop their attempt and then they are faced with toxic conditions.

There is a particular concern with how a family would escape from such an open plan situation, escape becomes more time consuming with children and elderly relatives - both groups are more susceptible to lower toxicity levels than a fit healthy young adult. The hallway case with the capability of closing (even an open door) to the fire room is more reassuring.

**Conclusion**

It is pleasing the NHBC have decided to commission this study as we should be looking for solutions which embrace the architectural aspirations of the building design team. However if there is a flaw in our current system where doors are left open 60% of the time, should we regard this as an acceptable criteria to assess an alternative design?

The NHBC report therefore shows a sprinkler/smoke detection system is only as good as a protected route with doors closed at least 40% of the time.

More significantly the document has highlighted that if occupants do keep their doors closed at night, the ADB solution gives us a very sound design achieving tenable conditions. If 40% of occupants keep their doors closed at night without a publicity campaign, just think what such a nationwide publicity campaign would do?

But of course this does not help the use of open plan layouts. It is important to continue the search for a solution to this problem.

As the NHBC document quite rightly states, solving escape from inner rooms with early warning smoke detection alone is too dangerous. A fire can develop to fully involved flashover in as little as a couple of minutes - therefore heat exposure is a real problem for inner rooms.

The pipe dream would be a re-engineered sprinkler or water mist system which is able to activate at a growth stage in the fire where the toxicity has not reached untenable levels Perhaps FED of 0.2 - 0.3 for example. Now is there a suppression system designer who would like to meet that challenge?

A simulation of a sprinkler controlled fire in a flat can be seen at the RBKC’s Youtube Channel at: www.youtube.com/user/RBKCBuildingControl (http://www.youtube.com/watch?v=h_QJHmxxEWk)

Above: conditions in sprinkler controlled fire - the route to the door (shown dotted) is obstructed by toxic smoke

Above: the Approved Document B design with protected hallway - allows a clear layer for occupants to escape even if occupants do not close their fire doors at night

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2. FED is a commonly used measure of toxicity (FED Stands for Fractional Effective Dose).