The Fire Column

By Paul Hanson

Sprinklers instead of protected routes?

In recent years there has been speculation regarding the use of sprinklers in lieu of protected stairway enclosures, particularly in the case of dwelling houses. This article seeks to separate the fact from the fiction and deliver a clear opinion based upon scientific fact whether sprinklers can provide an appropriate level of protection in place of a protected route.

Where did the idea come from?

It is unclear where the idea to use sprinklers in place of protected routes originated. I can really only list the documented references where the idea is supported.

1. Health Technical Memorandum 88 permits an open stairway in a house where sprinklers are fitted in a building occupied by persons with learning difficulties. (This document is not currently sited in Approved document B - although the previous version is – which does not mention sprinklers).

2. The Local Government Association in their document 'Automatic Fire Sprinklers - a toolkit for domestic premises' state that 'relaxations can be permitted to allow open stairways an inner rooms with sleeping risk where sprinklers are fitted'.

3. In the USA open plan dwellings are permitted where sprinklers are fitted.

4. Some sprinkler installers are supporting the idea. A particular sprinkler installer states on their website that sprinklers can allow the omission of protected routes.

In the case of 1 and 2 no reason or references are given in these documents to explain why sprinklers are considered to be effective. I have consulted the Local Government Association and they have said:-

'The guidance was written before the BRE research was published, and has not been updated since, so does not take the research into account. The examples given in the toolkit were included to show that local authorities have altered Building regs if sprinklers are fitted rather than as specific guidance … if we republish the toolkit we will make sure that we remove the two examples you highlight as they are clearly not appropriate ones to highlight.'

In the case of 4, I contacted the sprinkler installer referred to and they stated their use of sprinklers were in combination with smoke ventilation (Although this is not mentioned on their website).

As for USA perspective this is a complex issue as there are cultural and historic issues which appear to have led to the use of sprinklers. This will be discussed later in the article.

How could sprinklers assist means of escape?

The guidance of Approved Document B and BS 5588: Part 1 both recommend that dwelling houses over two storeys be provided with a protected stairway delivering to a final exit. This effectively means an open plan staircase delivering into the ground floor living room is not possible in a house exceeding two stories.

There are two problems which occupants of a house face when escaping from an upper floor through a ground floor living room containing a fire - smoke and heat. Both these phenomena will incapacitate the occupants. Smoke produces a cocktail of substances, which cause irritation, unconsciousness and death. Heat will create a condition, which will range from intense skin pain resulting in burns to heat exposure; which will prevent a person from escaping and ultimately cause death.

Sprinklers are very effective in preventing the build up of heat. Normally most of the heat which occupants are exposed to is transported by way of the smoke, which forms in a layer at ceiling level from the smoke plume produced by the fire. Sprinklers have a cooling effect, which reduces the heat in the smoke layer to temperatures which do not cause extreme discomfort. However it is smoke, which causes most people to die in fire conditions or afterwards due to the effect of smoke inhalation. Sprinklers would be effective if they were able to prevent the build-up of toxic smoke products for the period in which escape needs to take place.

Speed of Toxicity build-up to FED 0.1 in room sprinklered and unsprinklered (Slower is better)		
Type of fire	**Un-sprinklered room**	**Sprinklered room**
TV	**Slower**	**Faster**
Sofa	Marginally **Slower**	Marginally **faster**
Bed	**Faster**	**Slower**
Table	**About the same**	
Chip pan	**About the same**	

Research

In 2004 the Building Research Establishment (BRE) at the request of the ODPM set out to investigate this problem by carrying out realistic fire tests in sprinklered and unsprinklered situations [1]. Human survival in smoke conditions (tenability) was determined by using work previously done by David Purser. Smoke toxicity is determined by a number of factors, which have been effectively simplified into a calculation, which represents the combined cocktail of toxic elements. This is known as the Fractional Effective Dose (FED). Experiments had previously been conducted which determined that a FED of 1 would render a fit healthy adult unconscious [2]. As David Purser points out, not all of our population are fit and healthy or adult and fire safety design should allow for *'essentially all occupants to survive uninjured'* [3].

Therefore a scaling down of the FED value needs to be considered. PD 7974: Part 6 states that a FED of 0.3 will enable 90% of the population to survive. FED of 0.1 with enable *essentially all* occupants to survive. The choice of which FED level is acceptable comes down to what we hope our means of escape strategy will achieve. With protected routes we do not assume 10% of our population will die so FED 0.1 would appear to be the most appropriate level of acceptance and it

also complies with David Pursers advice that *essentially all occupants will survive* including elderly, children and those subject to heart conditions or asthma.

Escape time

This comprises three elements. Time to detection, pre-movement time and escape time. Of the three, pre-movement time is the longest. This is the time between the sounding of the alarm and the time taken for the family to move towards the exit. In a domestic house 5-10 minutes is expected where a well maintained smoke detection system is installed [4]. Time to detection is somewhere in the region of 1 - 4 minutes depending upon the type of fire [1]. The time to escape is then added, and this depends upon the mobility of occupants.

The results from the BRE research showed that the toxicity build-up in a sprinkler controlled fire to FED 0.1 was faster than even the pre-movement times for occupants of a domestic house. An interesting observation from the results is that in some cases the toxicity build up to FED 0.1 was the same for an unsprinkler-controlled fire as a sprinkler controlled fire (see table below).

The results of the research for a television fire in an open lounge is summarised in the report;- *'The conditions in the lounge became untenable but remained tenable throughout the rest of the house'. The visibility remained tenable in the bedroom and loft only.'* [1]

The time to reach unconsciousness at FED 1 (For fit healthy adults) was between 5 min 51 seconds – 10 mins 33 seconds. Which is quicker than the pre-movement time. When FED 0.1 is considered as tenable conditions for all occupants, the time is reduced even further (e.g. 3 min 30 sec for a table fire) and only in the case of the bed fire was the toxicity level kept below FED 0.1 for the time needed for escape.

The USA perspective

The USA situation is not easy to interpret. Their decision to use sprinklers may be more related to cultural differences and the development of their fire safety strategy. Until the 1990's fire deaths in the USA were around twice those in the UK. Fifty percent of the USA fire deaths were remote from the room of fire origin. Compared to thirty five percent in the UK [5]. This may suggest the use of protected routes was successful in the UK. Whatever the basis for the decision to use sprinklers in place of protected routes it appears that they have carried out no actual research work in this area. All the research work carried out regarding sprinklers in the USA has been aimed at understanding their effectiveness in controlling fire growth not for assessing the role sprinklers may play in reducing the build-up of smoke toxicity.

Recently the National Fire Protection Agency (NFPA) have reported that two persons have died in a house completely sprinklered, where the system was properly operating [7]. Despite this the USA remain confident that they have improved their fire deaths by the use of sprinklers. However if protected routes were not the normal means of protection, sprinklers would show an improvement, even if some deaths occur. This is where the historic and cultural differences arise.

There certainly is no evidence from the USA to support the use of sprinklers in lieu of protected routes in the UK.

Myth and reality

In supporting the use of sprinklers it is often quoted that protected routes in dwellings are not effective because occupants leave the fire doors open. If sprinklers will allow a percentage of occupants to survive this must be better. This is an interesting point of view and does have some degree of logic, until you analyse the facts. The BRE research looked at the toxicity in a protected route when a fire door was left open. The results were surprising.

Sprinklers performed well with heat, keeping the temperature within acceptable limits throughout their time of activation. The open door kept the temperature down below tenability limits for 15 minutes. However with sprinklers and no protected route occupants would be incapacitated from smoke, 50 seconds earlier than if they were in a protected route with an open fire door. This shows that even an open door will provide better protection than sprinklers. (I am not however advocating leaving doors open – just comparing the performance).

It is also often quoted that no one has died in a building containing sprinklers. However it is important to consider whether the sprinklers were actually responsible for the result or just happen to be present. In London the statutory requirements for sprinklers are for tall or large volume buildings, which inherently have a high standard of physical means of escape protection comprising lobbied staircases delivering to protected final exits. A true test would be their use in a building containing no protected routes and as previously mentioned we have an example where the NFPA reported that two persons died in a house completely sprinklered, where the system was properly operating [7].

Conclusion

Sprinklers have the ability to reduce the heat output from a fire by containing its growth, however the main problem for means of escape is smoke. Sprinklers have been shown to reduce overall smoke toxicity, however for the critical period when persons need to escape this reduction is not sufficient to maintain tenable conditions. In some cases the time for smoke toxicity to reach a critical level is not very different from an unsprinklered fire. Therefore sprinklers are not a suitable alternative to a protected route.

The BRE research has however revealed that sprinklers when combined with protected routes in dwellings gives better protection to the protected route by reducing the toxicity of smoke in the protected route and therefore may allow the protected route to be used for longer. A possible solution where an alternative means of escape is difficult to achieve in a dwelling?

References

[1] Effectiveness of sprinklers in residential premises: Project report number 204505. Section 5: Experimental programme; February 2004; Dr Corinne Williams and Dr Stuart Campbell. (February 2004).
[2] The society of fire protection engineer's handbook; third edition; Section 2; Chapter 6; Toxicity assessment of Combustion products; David A. Purser (2002).
[3] Page 2-90 of the above.
[4] BS 7974: Part 6 Human Factors
[5] Page 2-84 of ref [2]
[6] Theme: Fire – Spacious American flats by Miller Hannah, Gary Daniels, Kevin Leahy and Terry Watson – Architect Journal focus July 2003 p7.
[7] Fire Protection Engineering (Magazine) Number 25; What have we learned about the benefits and costs of residential Fire Sprinkler Legislation. p 25.