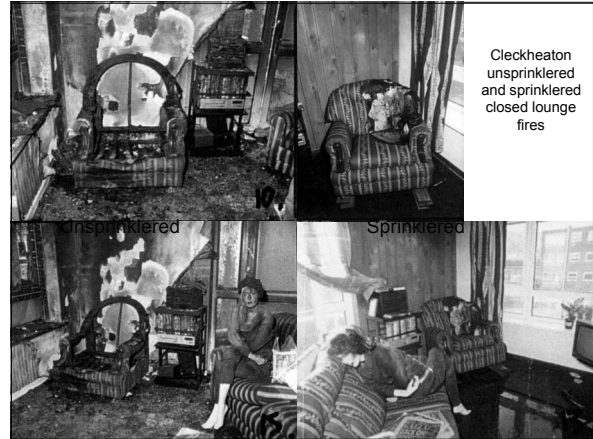


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Cleckheaton domestic sprinkler fires



Cleckheaton unsprinklered and sprinklered closed lounge fires

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Cleckheaton - unsprinklered and sprinklered open bedroom fires



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Cleckheaton maisonette – lower floor sprinklered lounge and kitchen



Lounge: 44.8 m<sup>3</sup> Total lower floor 86.8 m<sup>3</sup>  
Kitchen: 22.3 m<sup>3</sup>  
Hall: 19.7 m<sup>3</sup>

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Cleckheaton maisonette – upper floor sprinklered bedroom

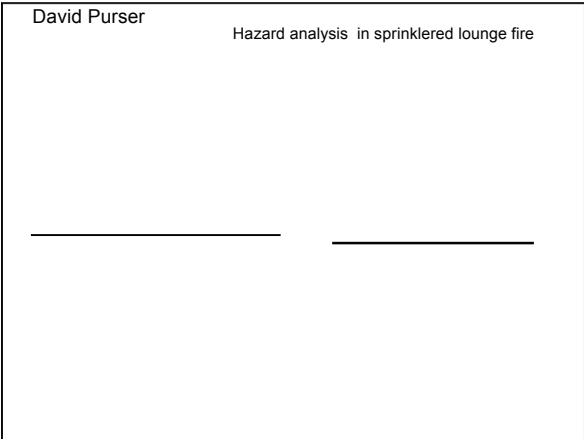
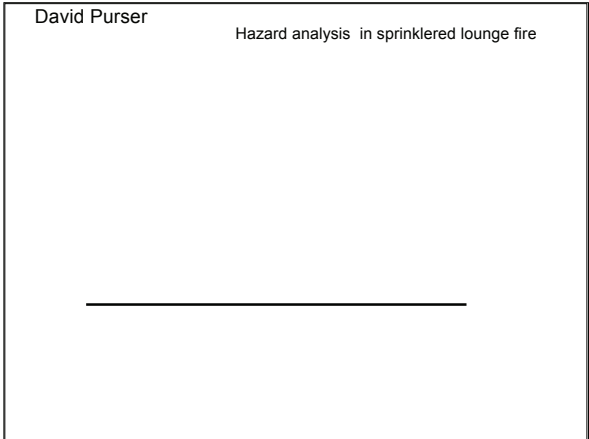
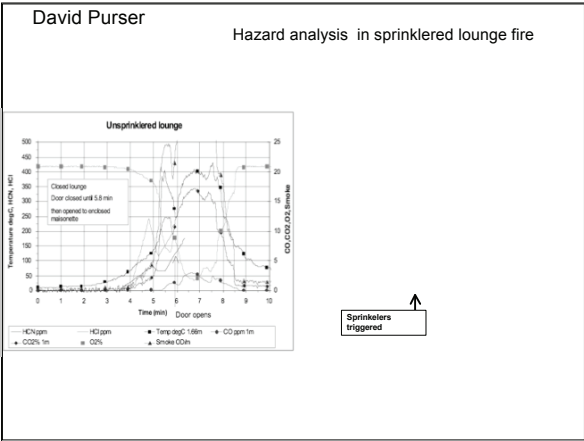
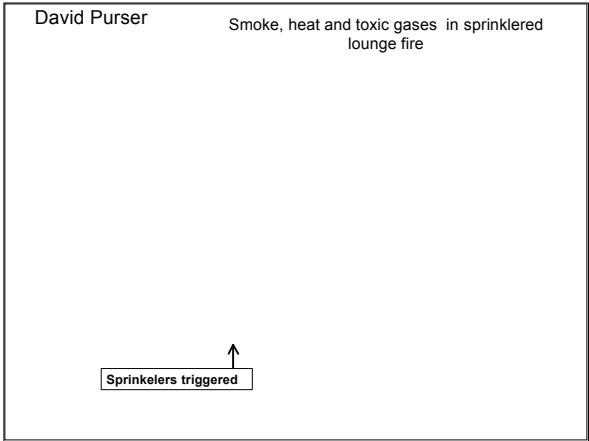
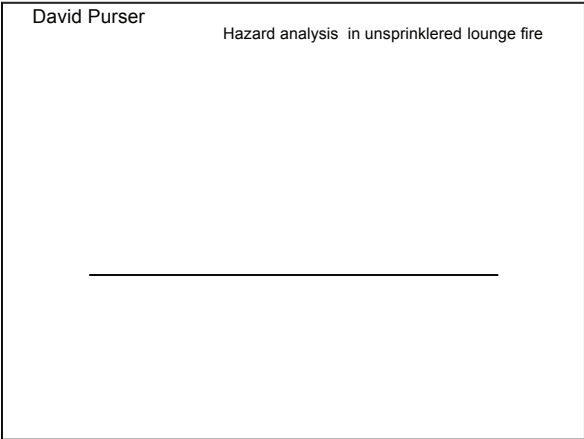
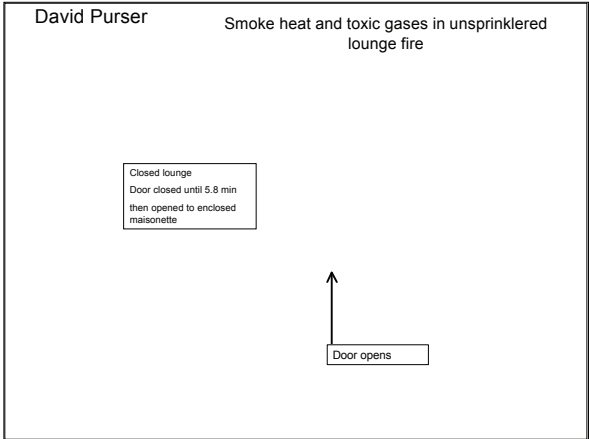


Bedroom 1: 32.4 m<sup>3</sup> Total upper floor 60.9 m<sup>3</sup>  
Landing: 8.9 m<sup>3</sup> Total maisonette volume 147.7 m<sup>3</sup>  
Bathroom: 8.9 m<sup>3</sup>  
Bedroom 2: 10.7 m<sup>3</sup>

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Kirklees fires

- Unsprinklered lounge fire ignited in chair with No.7 crib lounge door and windows closed, small ventaxia fan duct near ceiling level
- Rapid early growth in chair, then dies down as vitiation occurs to a minimum at 5.8 minutes when due to minor pressure changes the lounge door opens, allowing fresh air to enter from the remaining internal volume of the maisonette.
- The fire grows to a larger size than originally, then uses oxygen which drops to around 2% at head height. Curtains catch fire and there is some damage to the PVC window frame. Double glazed windows remain intact.
- Fire dies down again, but fire fighters enter and extinguish fire.
- Sprinklered fire rapidly extinguished with minimal fire damage but considerable smoke logging.



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#### Kirklees fires

- Unsprinklered bedroom fire involves made bed assembly and toy animal stuffed with polystyrene chips. Fire ignited using crib placed between polyester pillow and covers.
- Door to upper storey and stairwell left fully open, bedroom window open a few inches on a windy night.
- Fire grew rapidly to a peak at around 4 minutes when the oxygen decreased to around 13%. The fire then decreased in size but continued to burn at a reduced level.
- Camera looking up stairs shows base of smoke layer at around upper floor level, depth oscillating slightly with wind, but no smoke coming down to lower storey.
- Even when the front door to the maisonette was opened there was no development of flashover

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#### Smoke heat and toxic gases in unsprinklered bedroom fire

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#### Hazard analysis in unsprinklered bedroom fire

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#### Smoke heat and toxic gases in sprinklered bedroom fire

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#### Hazard analysis in sprinklered bedroom fire

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#### Summary of test results

##### Lounge Fires:

##### • Unsprinklered:

- Rapid fire growth
- Peak temperature >400°C
- Peak carbon monoxide 30,000 ppm
- Minimum oxygen 2%
- Peak HCN concentration 200 ppm (>1000 ppm in other furniture fires)
- Peak HCl, 250 ppm
- Peak smoke OD/m >5
- Times to incapacitation (min): Smoke 3(-1), Heat and Asphyxia 5.5
- Fire damage to 1/3rd room

##### • Sprinklered:

- Rapid fire growth to 125°C then rapidly extinguished by sprinklers
- Peak temperature 125°C for 20 seconds then dropped to 25°C
- Peak carbon monoxide 700 ppm
- Minimum oxygen 19%
- Very low HCN and HCl
- Peak smoke OD/m >5 when sprinklers triggered
- Times to incapacitation (min): Smoke 3
- Fire damage to small part of armchair ignited

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Summary of test results

Lounge Fires:

• Unsprinklered:

– Rapid fire growth

– Peak temperature >400°C

– Peak carbon monoxide 30,000 ppm

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– Peak HCN concentration 200 ppm (>1000 ppm in other furniture fires)

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– Fire damage to 1/3rd room

• Sprinklered:

– Rapid fire growth to 125°C then rapidly extinguished by sprinklers

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– Minimum oxygen 19%

– Very low HCN and HCl

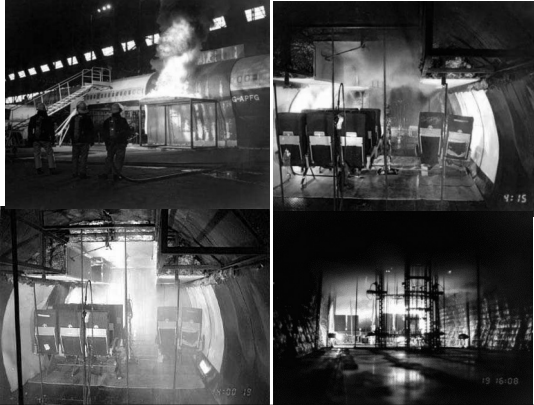
– Peak smoke OD/m >5 when sprinklers triggered

– Times to incapacitation (min): Smoke 3

– Fire damage to small part of armchair ignited

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Aircraft cabin spray mist system



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Toxic gases and heat in unsprayed and sprayed aircraft cabin fires

Unsprayed cabin

Zone spray mist system

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Hazard development in unsprayed and zone sprayed aircraft cabin fires



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Particle size distribution from Anderson sampler  
Aircraft cabin fires

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Vehicle fire in enclosed tunnel garage

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Vehicle fire in enclosed tunnel garage

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Sprinkler calorimeter test rig



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Sprinkler test rig – open rig



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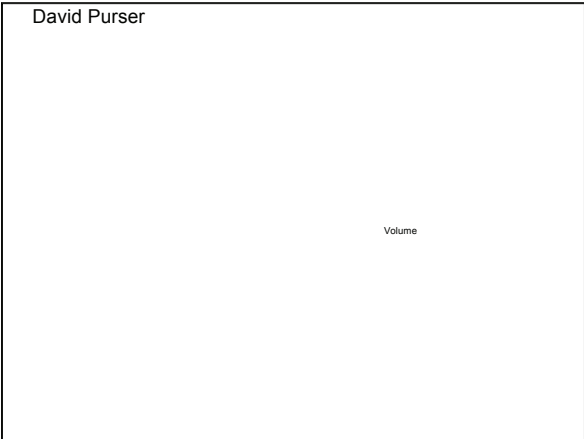
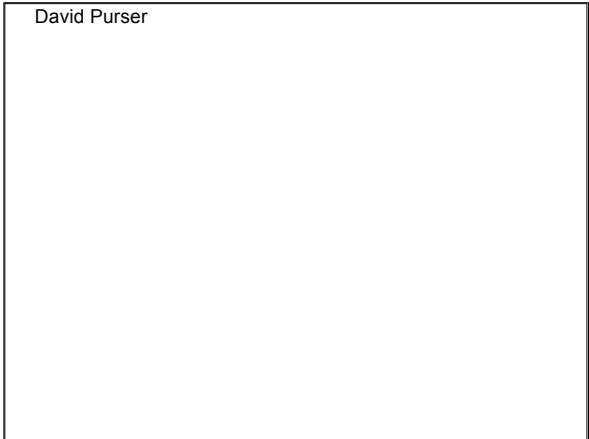
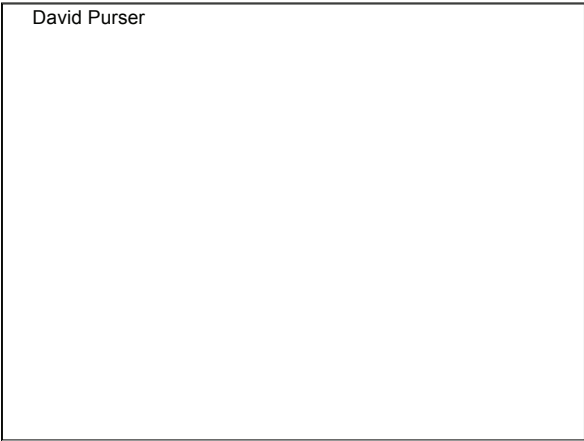
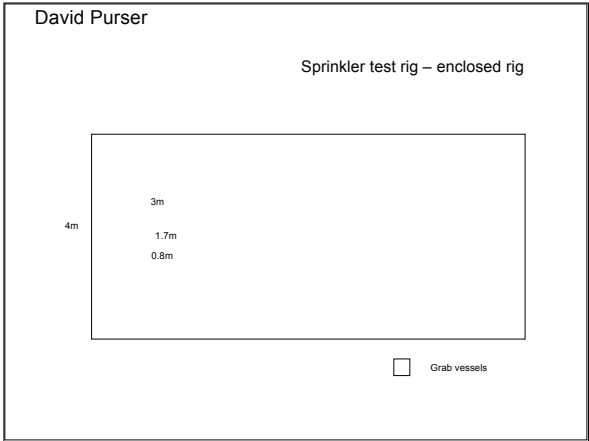
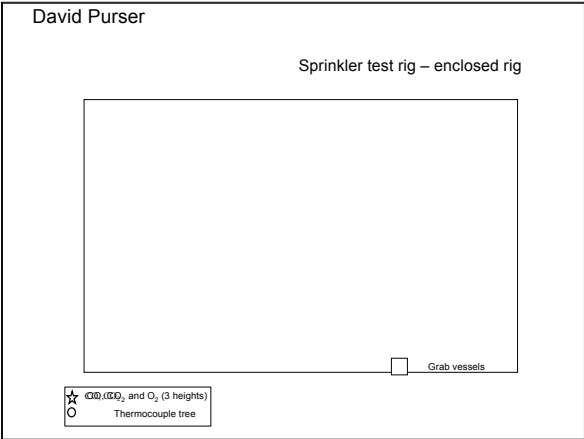
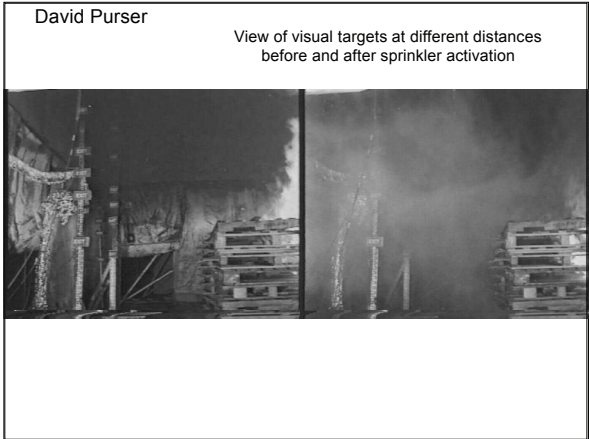
Sprinkler test rig – open rig

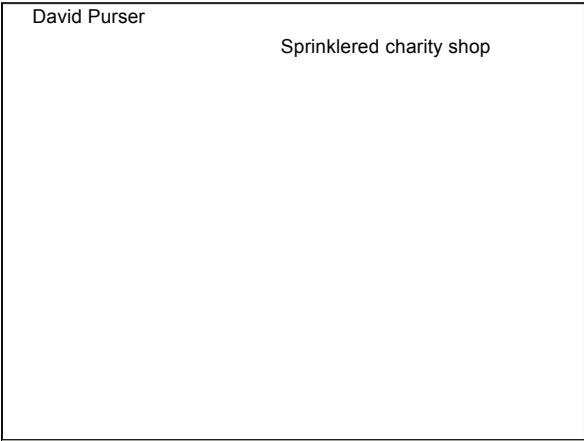
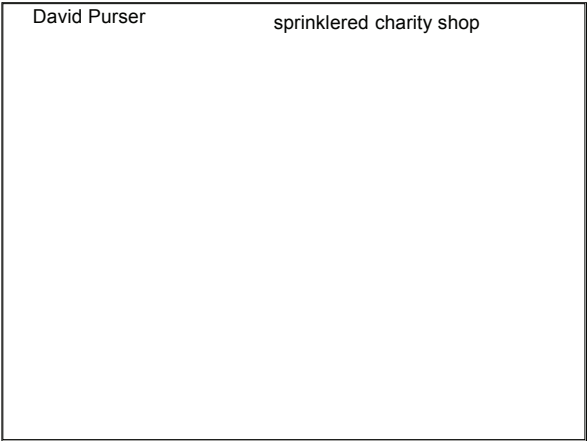
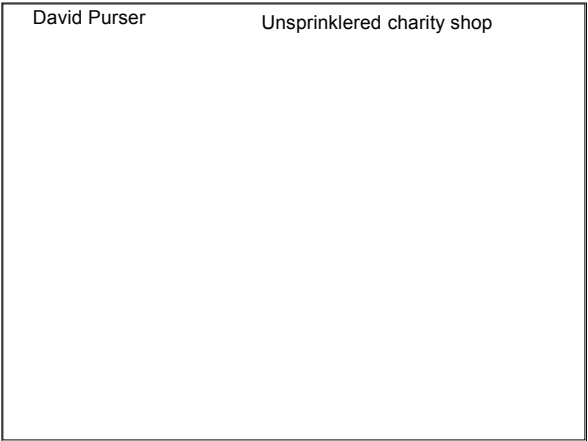
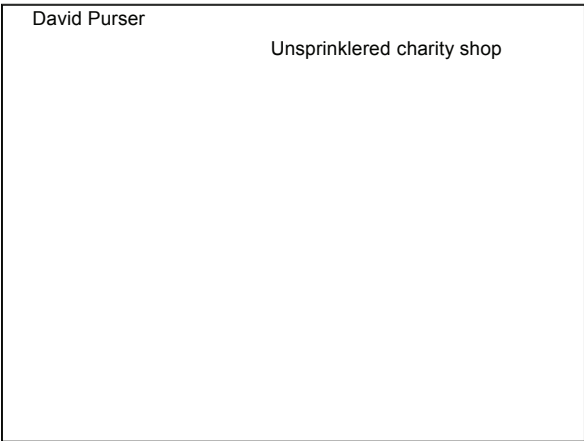


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Sprinkler test rig - effects of sprinkler discharge on visibility



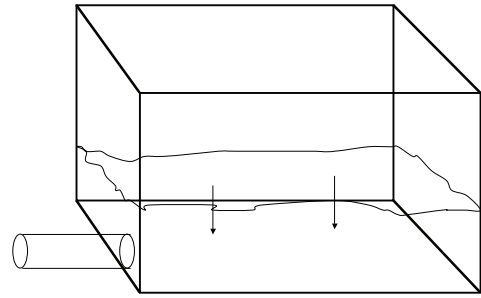




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Unsprinklered charity shop - FED

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Unsprinklered clothes fire



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## Unsprinklered clothes fire

Heat release rates during a "Sports shop" clothing fire in an open calorimeter rig compared with standard  $t^2$  fire growth rate curves

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## Unsprinklered clothes fire

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## Unsprinklered clothes fire

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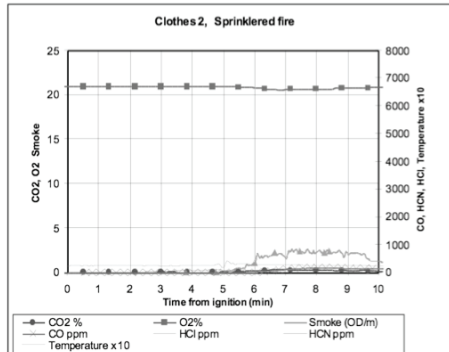
## Sprinklered clothes fire

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## Sprinklered clothes fire

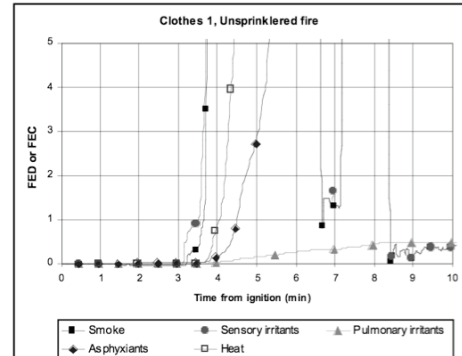
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### Sprinklered clothes fire



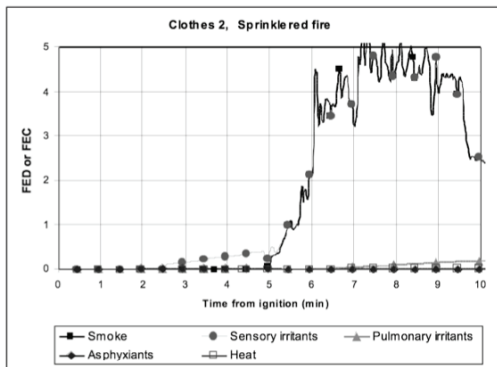
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### Unsprinklered clothes fire



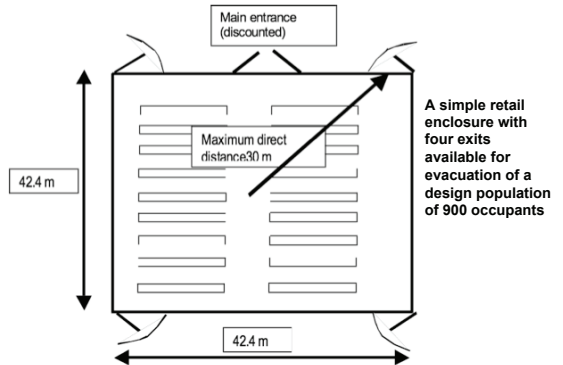
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### Sprinklered clothes fire



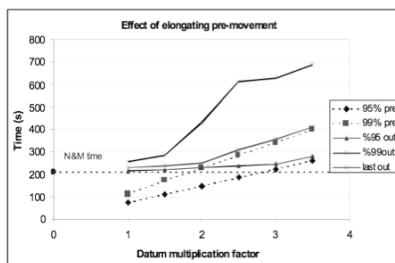
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### Retail enclosure (2000 m<sup>2</sup> – ceiling height 3 m)



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### Evacuation times for retail store



Calculated evacuation times from an 1800 m<sup>2</sup> retail store, assuming different levels of management producing different pre-movement time distributions.

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### ASET- RSET comparison for retail store case

- Evacuation time - well managed case:
  - 3.8 minutes for 99% of occupants, which is almost the minimum possible based upon the flow capacity of the exits and approximately 20 seconds to queue formation.
  - For less well managed case with the pre-movement time distribution x 3 (level 2 management), then the evacuation time increases to approximately 6 minutes.
- For a generic example approximately 0.5 minutes allowed for the pre-movement time of the first few occupants to move, plus 0.5 minutes for queue formation (Level M1) and 1 minute plus 0.5 minutes for level M2. The generic evacuation times were 4.5 and 5 minutes respectively.
- To this must be added the detection time (assume 1.5 minutes) and the alarm time. For the Level M1 case and A1 alarm system was assumed giving an alarm time of 0 minutes, and for the M2 case a two- stage (A2) alarm with an alarm time of 2.5 minutes.
- These therefore give escape times of 6.5 and 9 minutes for the Level M1 and M2 cases.

David Purser     ASET- RSET comparison for retail store case

ASET times:

- Charity shop fire tests: time to loss of tenability due to smoke would be approximately 3 minutes for an unsprinklered case and 4 minutes for a sprinklered case.
- Open calorimeter using an unsprinklered fire approximated to a medium  $t^2$  growth curve during the first 3 minutes of the fire followed by a very rapid rate of growth that was much more rapid than the ultrafast curve. Tenability was lost at 3.5 minutes.
- A number of incidents in unsprinklered retail stores have produced very rapid fire growth resulting in occupants being unable to escape before being enveloped in dense smoke.
- Simple ASET calculations for a 1800 m<sup>2</sup> 3 m high retail space were carried out using simple tenability criteria consisting of a 2 metre smoke layer height or 200°C upper layer temperature. Two methods were used, that in DD240 (BS7974) and that in the SFPE Handbook. For a fast fire growth curve, this gave an ASET time of approximately 4 minutes (SFPE method) and 4.5 minutes (BS7974 method).
- Based simple calculations, the test results and incidents reports - time required for escape from a retail store filled to design capacity with occupants is uncomfortably close to estimated times to loss of tenability.
- For sprinkler case, possibility that occupants may be exposed to some smoke (due to sprinkler down-drag and loss of plume buoyancy), results showed that smoke would not be dense, with low concentrations of toxic products, so conditions should remain tenable for sufficient time for a safe evacuation.