

Fire Safety in Tunnels

Are Suppression Systems the Answer?

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Fire Safety in Tunnels
Are Suppression Systems
the Answer?

We don't know!

Overview

- Fire safety management
 - What do we want to achieve?
- Suppression systems
 - How does suppression help achieve these goals?
 - How does suppression hinder the process?
- Conclusions
- Suppression combined with other systems?
 - A quick comment

Introduction: Fire Safety Management

- What do we want to achieve?
 - Fire prevention
 - » Ideally, we want to avoid fire altogether!
 - » Minimise fuel? Identify potential risks?
 - Safe & smoke free egress
 - » Ideally, we don't want to have to evacuate!
 - Efficient fire-fighting
 - » Clear route to the fire location
 - » Fire as small as possible
 - Protection of facilities
 - Rapid return to normal operation
- How does suppression help?



Suppression vs. Fire

- What research has been carried out?
 - Suppression vs. Fire Size: **limited research**
 - » limited knowledge...
 - Suppression vs. Fire Spread: **a few observations**
 - » anecdotal knowledge...
 - Suppression vs. Fire Growth: **a few observations**
 - » anecdotal knowledge...
 - Suppression and ventilation combined: **no research**
 - » **no knowledge!**

Suppression systems

- Sprinkler / Deluge systems:

- Australian and Japanese experience:
 - » Perform very well in tests
 - » Burnley tunnel fire, March 2007
- But very little 'scientific' testing...



- Water Mist Systems:

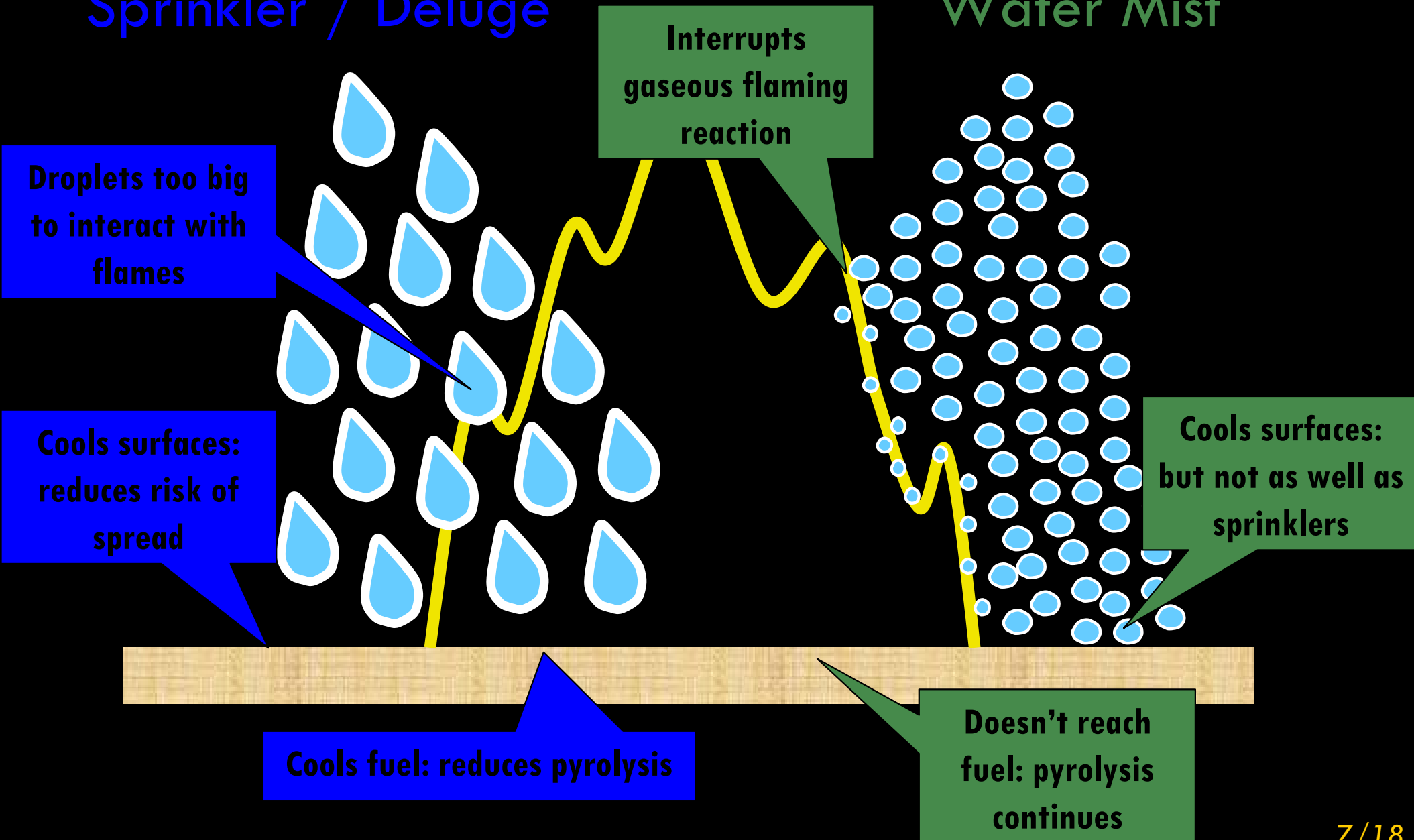
- Becoming increasingly popular
- Perform well in some tests
 - » Depends on 'success criteria' selection
 - » Many tests use fuel pools
 - » Does this tell us anything about water mist performance in a real vehicle fire scenario?



Suppression systems

Sprinkler / Deluge

Water Mist



Suppression systems

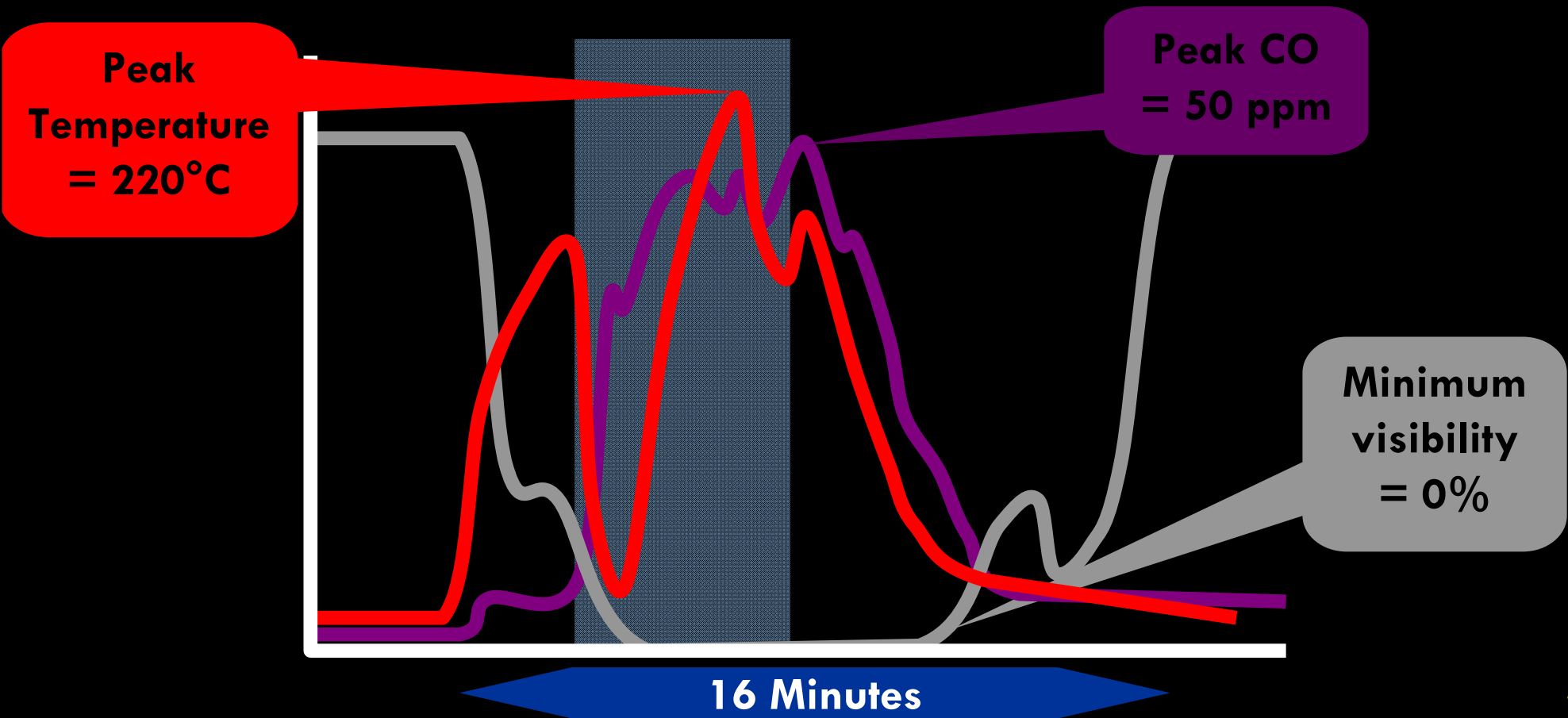
- What do Water Mists do to the fire?
 - Pool fire data: Selzthal Tunnel (Austria), 2000
 - » Sturm, et al. International Water Mist Conference, Vienna, Austria, 4-6 April 2001. pp 59-70.
 - Pool fire data: IF test tunnel (Norway), 2002 & 2004
 - » Opstad & Stensaas; 2nd Int. Symp. on Safe & Reliable Tunnels, Lausanne, Switzerland, 2006.
 - » Kratzmeir; Technische Überwachung, January/February issue 2006, pp. 10-13.
 - » Kratzmeir; Proc. Int. Tech. Congress on Fire Safety in Terrestrial Passenger Transportation, University of Cantabria, Santander, Spain, 20th October 2005. pp. 155-164
 - Pool fire data: Virgolo Tunnel (Italy), 2005
 - » "Test Report – Virgl/Virgolo Tunnel" Report no. 875-05-004, dated 3rd October 2005. Department of Structural Engineering and Natural Hazards, University of Natural Resources and Applied Life Sciences, Vienna. Produced as part of the UPTUN project.
 - » Bergmeister, et al. Proc. Int. Tech. Congress on Fire Safety in Terrestrial Passenger Transportation, University of Cantabria, Santander, Spain, 20th October 2005. pp139-153
 - Car fire data: Hagerbach (Switzerland), 2005
 - » Guigas, et al. International Congress on Safety Innovation Criteria Inside Tunnels, Gijón, Spain, June 29th – July 1, 2005, pp.163-173
 - » Tuomisaari; Proc. 3rd Int. Symp on Tunnel Safety & Security, Stockholm, Sweden, March 12-14, 2008. pp. 181-193
 - Wooden crib fires: San Pedro de Anes facility (Spain), 2006
 - » Kratzmeir & Lakkonen; Proc. 3rd Int. Symp on Tunnel Safety & Security, Stockholm, Sweden, March 12-14, 2008. pp. 195-203
 - » Mawhinney & Trelles; Proc. 3rd Int. Symp on Tunnel Safety & Security, Stockholm, Sweden, March 12-14, 2008. pp. 29-42

Suppression systems

- What do Water Mists do to the fire?
- Observations:
 - Often beneficial influence on temperature
 - Generally reduce (destroy) visibility in the locality of the fire
 - Occasionally improve visibility at locations distant from the fire
 - Fire growth rate is generally slowed
 - Occasionally fire growth is halted altogether
 - Sometimes 'peak' fire size is reduced
 - Fire spread is often (but not always) prevented
 - Tunnel structure is generally protected
 - Water mists appear to work by interrupting the gaseous flaming reaction:
 - » They do not cool the fuel itself (except indirectly)
 - » Production of CO and other toxic gases is increased
- Some specific observations:

Suppression systems

- Some observations on Water Mist tests
 - Decreasing visibility & Increasing toxicity
 - Not always beneficial influence on temperature
 - » Pool fire: Virgolo Tunnel (Italy), 2005



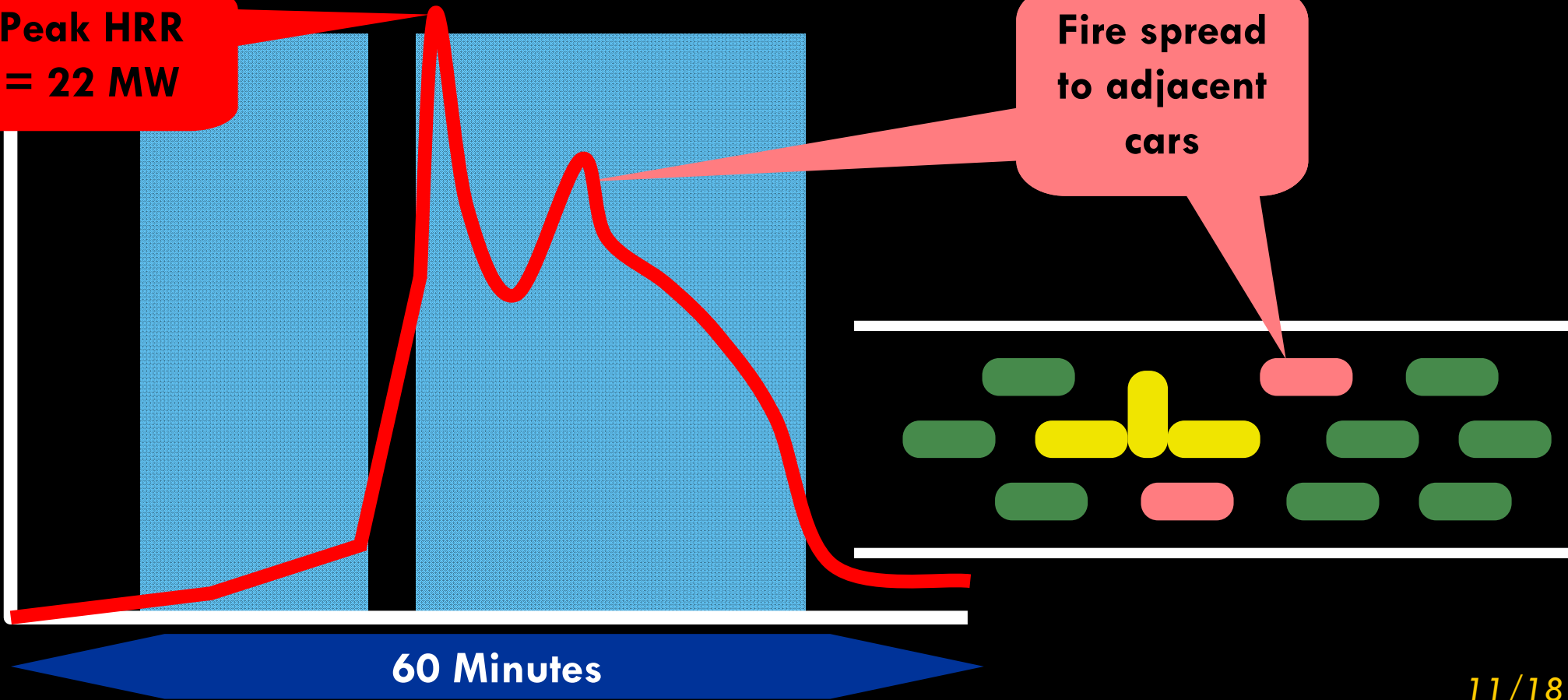
Suppression systems

- Some observations on Water Mist tests
 - Fire continues to grow during mist activation
 - Fire observed to spread while mist active
 - » Car fire test: Hagerbach (Switzerland), 2005 ('Test C')

Peak HRR
= 22 MW

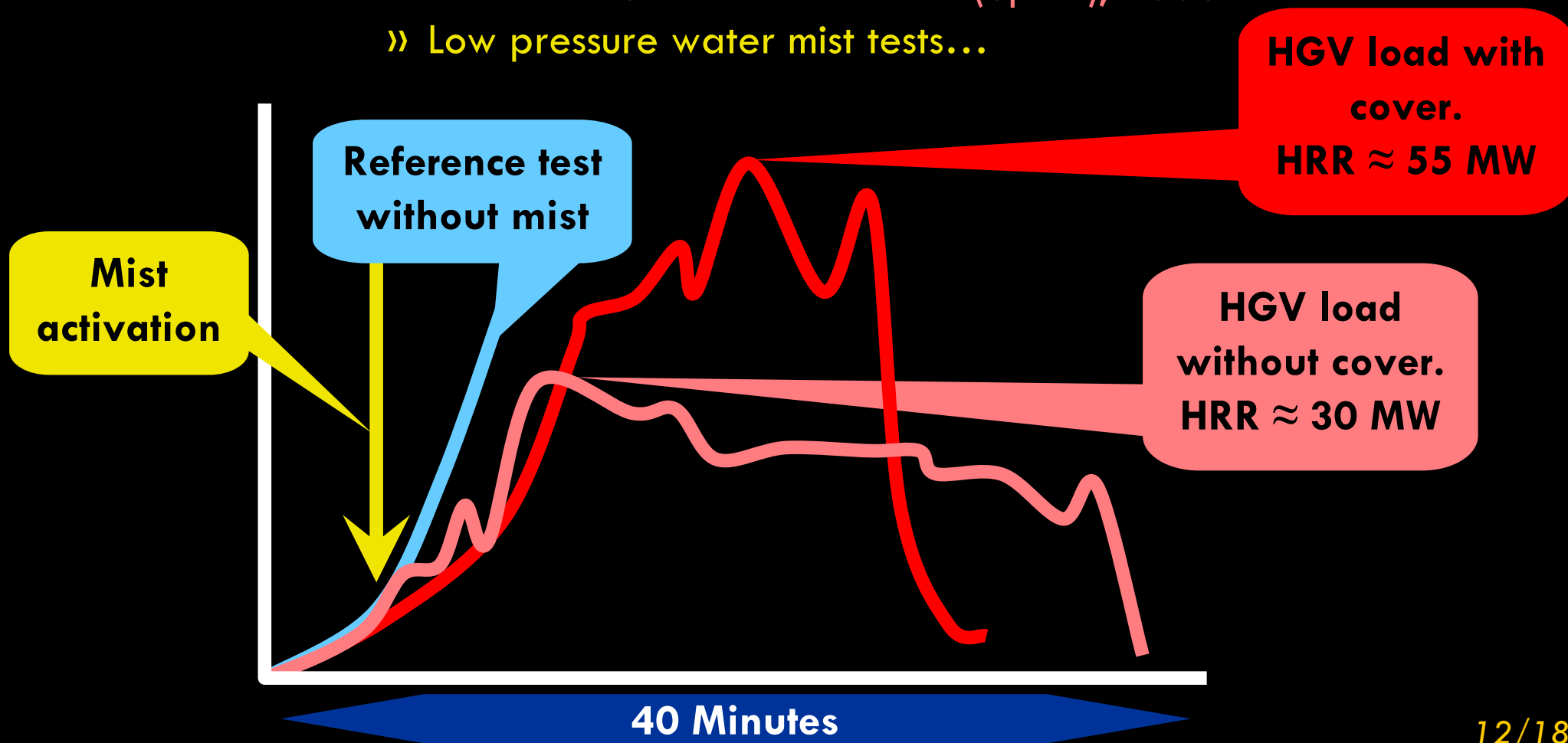
Fire spread
to adjacent
cars

60 Minutes



Suppression systems

- Some observations on Water Mist tests
 - Mist slows fire growth rate, but fire still grows
 - Covered loads are a problem
 - » Test data: San Pedro de Anes (Spain), 2006
 - » Low pressure water mist tests...



Suppression systems

- Some observations on Water Mist tests
 - Fire continues to grow a lot after mist active
 - Effectiveness of suppression depends entirely on cargo type
 - Certain cargoes are a problem!

» Test data: San Pedro de Anes (Spain), 2006
 » High pressure water mist tests...

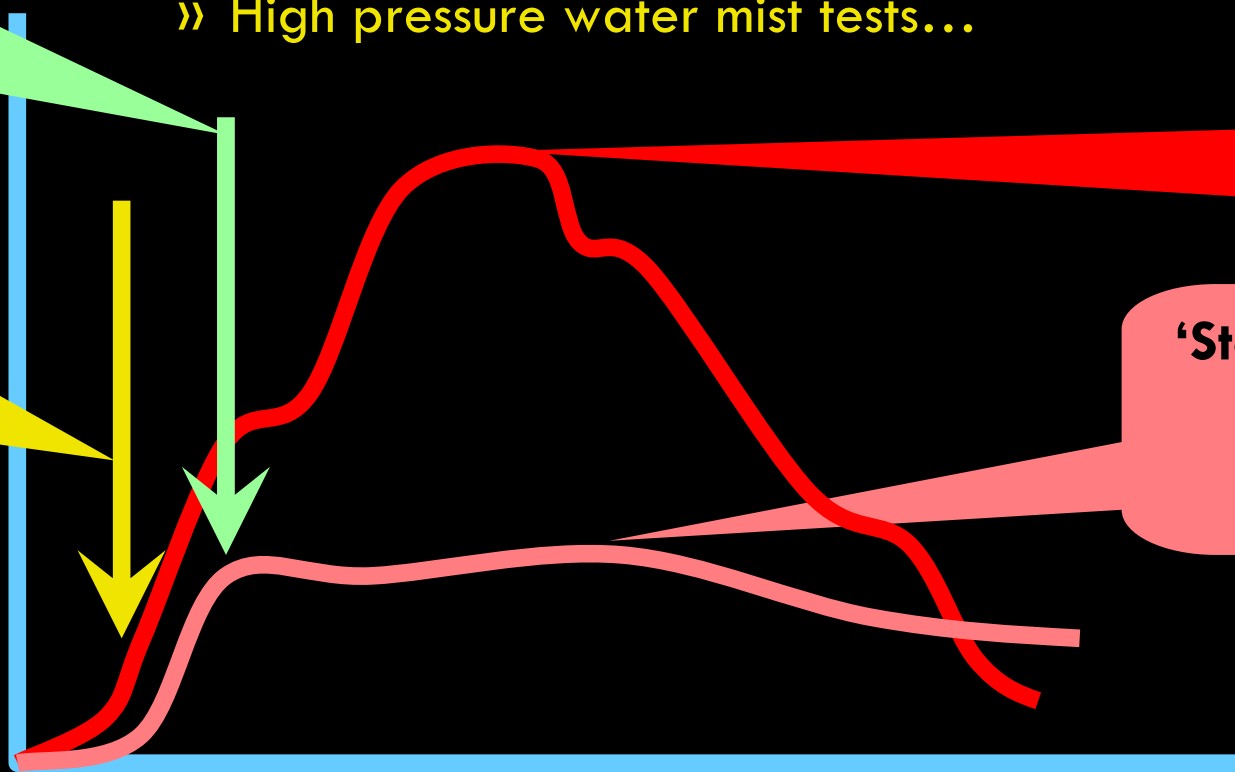
Mist activation at 20 MW

Mist activation at 10 MW

'High severity' HGV load
 HRR \approx 70 MW

'Standard severity' HGV load
 HRR \approx 20 MW

40 Minutes



Conclusions: Fire vs. Suppression

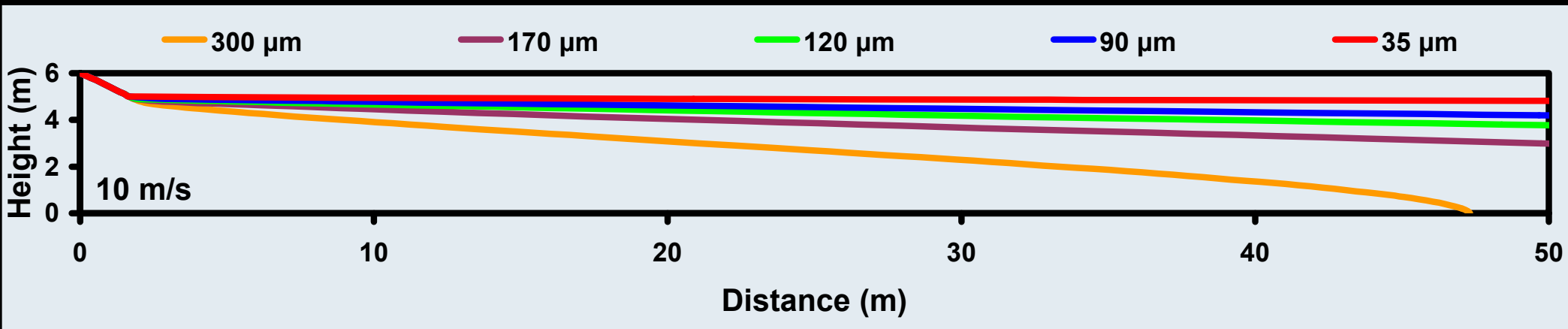
- Fire Safety Management?
 - Safe & smoke free egress
 - » Problem. Visibility in suppression may be worse than in smoke!
 - » Smoke / suppression mixture much harder to extract!
 - » Visibility away from the suppression zone may be OK.
 - Clear route to the fire location for fire brigade
 - » Perhaps. Visibility may be a problem.
 - Fire as small as possible
 - » Fire may be contained
 - » Fire spread may be prevented, but this is not assured.
 - » For some cargoes, fire growth may be slowed
 - » For some cargoes, fire size may be reduced, but this is not assured.
 - Protection of facilities
 - » Yes. Suppression does offer some protection to the structure.

Interaction with other systems?

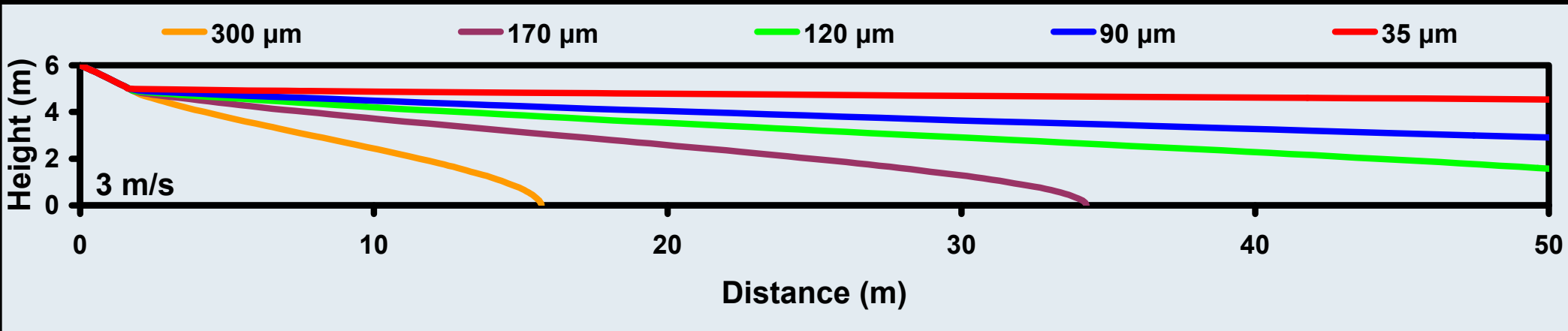
- What about ventilation & suppression together?
 - PIARC “Road Tunnels: An Assessment of Fixed Fire Fighting Systems”
 - “In most cases, FFFS are not capable of extinguishing vehicle fires. The aims are to: slow down fire development, reduce or completely prevent fire from spreading to other vehicles, provide for safe evacuation, maintain tenability for fire-fighting operations, protect the tunnel structure and limit environmental pollution. To fulfil these purposes, the FFFS must [...] be designed to handle air velocities in the range of 10 m/s that can result from ventilation system operation or natural effects...”
 - No water mist system has ever been tested under these conditions!
 - We simply do not know if it will work
 - And the mist will probably be blown away.

Modelling droplet travel distances

- 50m zone with 10ms^{-1} flow:



- 50m zone with 3ms^{-1} flow:



Closing comments

- We need to identify the optimum ventilation conditions for effective fire suppression
 - » Discussions with L-SurF
 - » Testing intended by FogTec
- We need to reconsider ‘critical ventilation velocity’ [CVV] required for smoke control
- CVV in a misty environment will be different [most likely less than] in a dry environment.
 - » Lower ventilation flow required
 - » Can you reduce ventilation capabilities?

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More information (paper downloads, online presentations, etc.) at:

www.tunnelfiresafety.co.uk