

‘Design Fires’ for Tunnel Water Mist Suppression Systems

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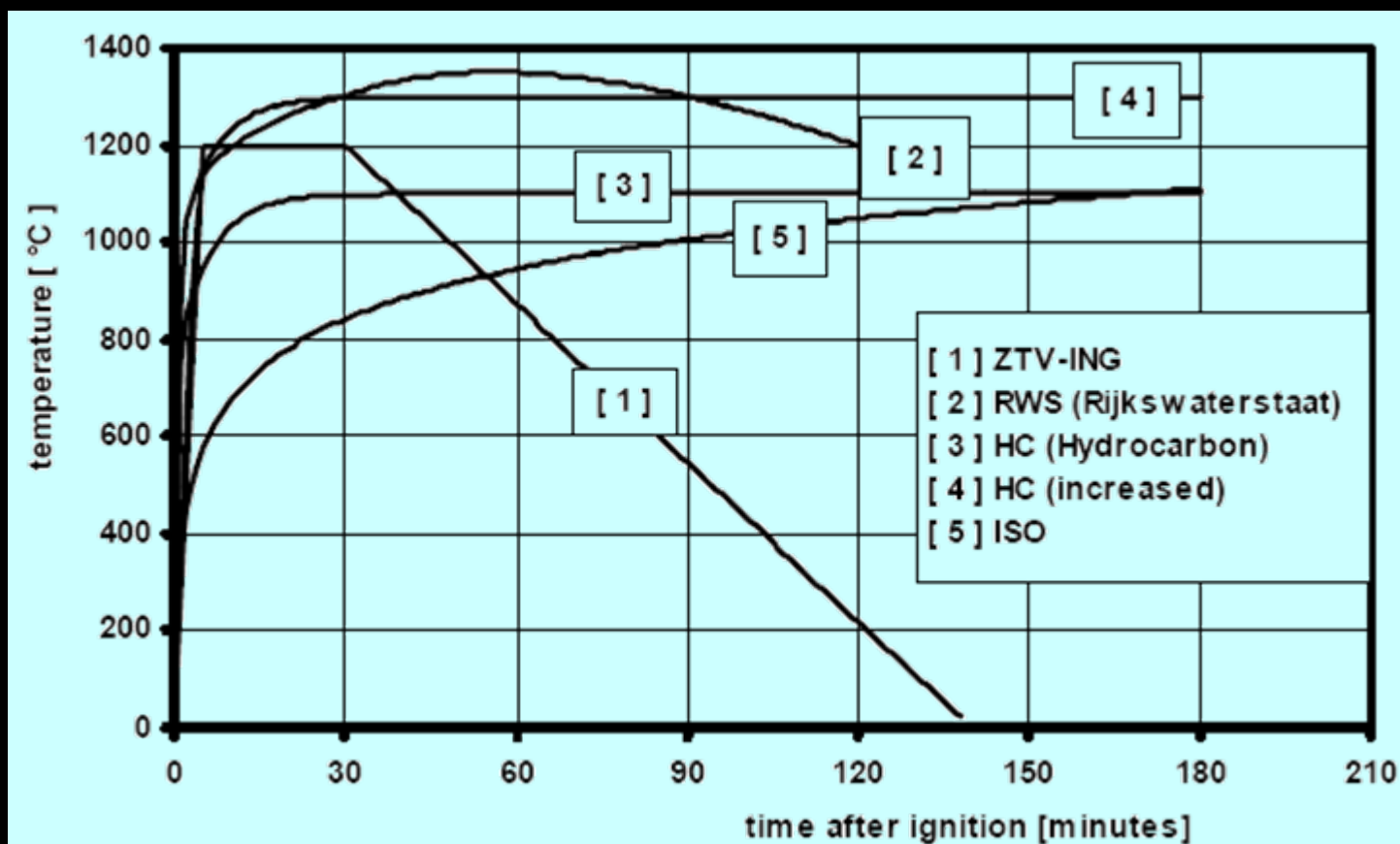


Overview

- Design fires for tunnels
 - Structural integrity
 - Smoke control
 - Water mist systems
- Real & experimental fires in tunnels
- Observations on tunnel fire experiments
 - Initial fire growth
 - Rapid fire growth
- Proposal of three 'design fires' for water mists

Introduction: Design fires for tunnels

- Design fires for structural integrity
 - These are generally specified in terms of a ‘temperature-time curve’





Introduction: Design fires for tunnels

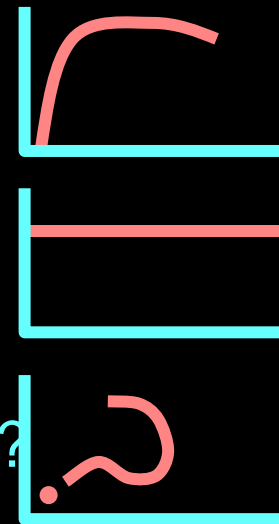
- Design fires for smoke control systems
 - These are often specified in terms of a **peak** ‘smoke production rate’ or ‘heat release rate’
 - For lorries / HGV (non dangerous goods):
 - PIARC (1987): 60 m³/s ~ 15 MW
 - RABT (1994): 60-90 m³/s ~ 15-30 MW
 - CETU (1997): 80 m³/s ~ 25 MW
 - NFPA 502 (1998): 60 m³/s ~ 15 MW
 - EUREKA HGV test (1992): 240 m³/s 120 MW

Introduction: Design fires for tunnels

- Design fires for Water Mist Systems?

– How should we specify this?

- In terms of a 'time-temperature curve'?
- In terms of a 'peak heat release rate'?
- In terms of something else?





Introduction: Design fires for tunnels

- What are we designing the Water Mist System to do?
 - Prevent the fire growing to its peak value
 - Using a 'peak heat release rate' is inappropriate
 - Minimise or stop fire growth
 - The design fire should be a **growing** fire
 - Deal with real tunnel fire incidents
 - The design should be based on **reality**...



Real fires in tunnels

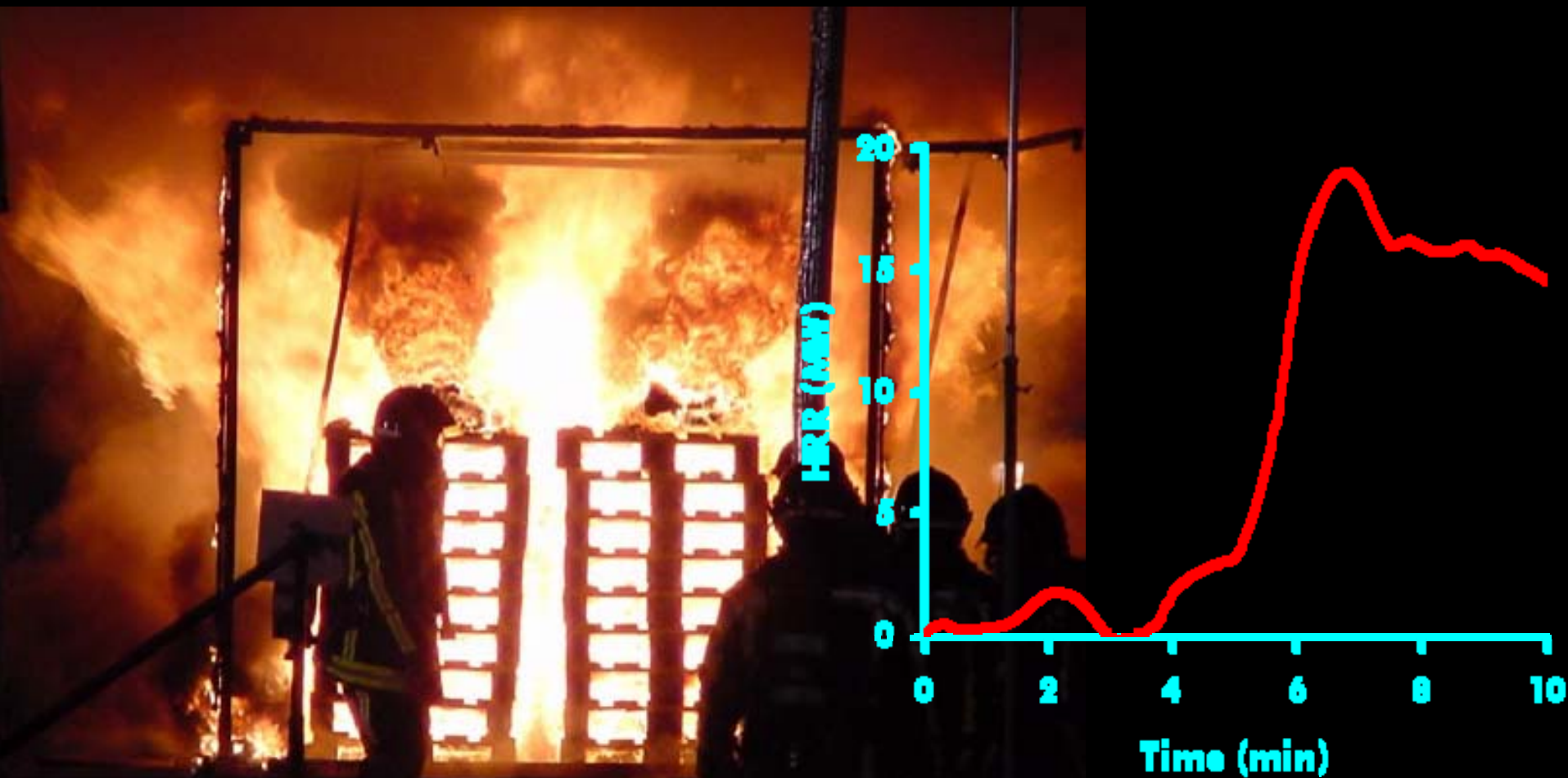
- What does a real fire in a tunnel look like?



If the fire grows to this size, a water mist system will not be able

Experimental fires in tunnels

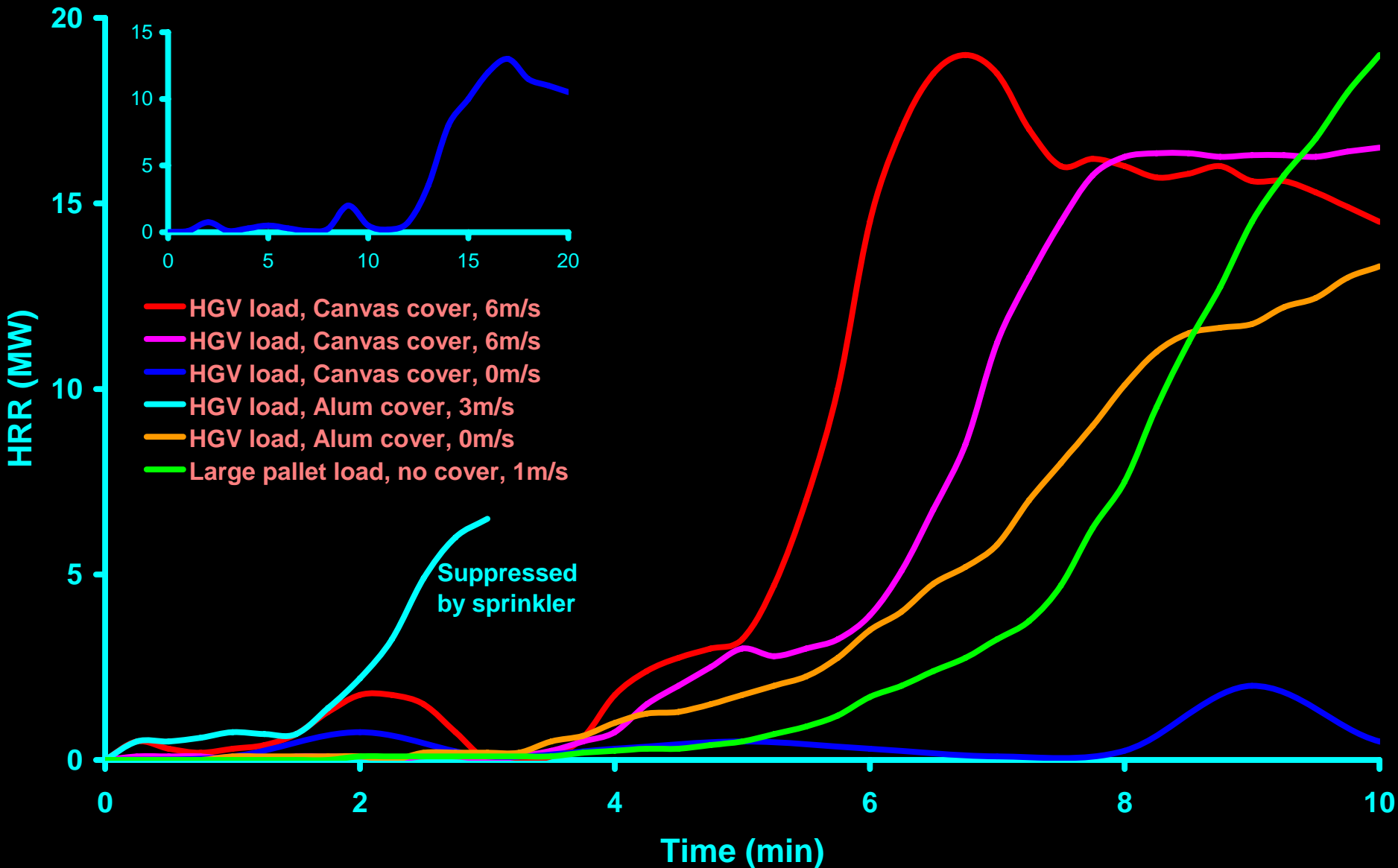
- What does an experimental tunnel fire look like



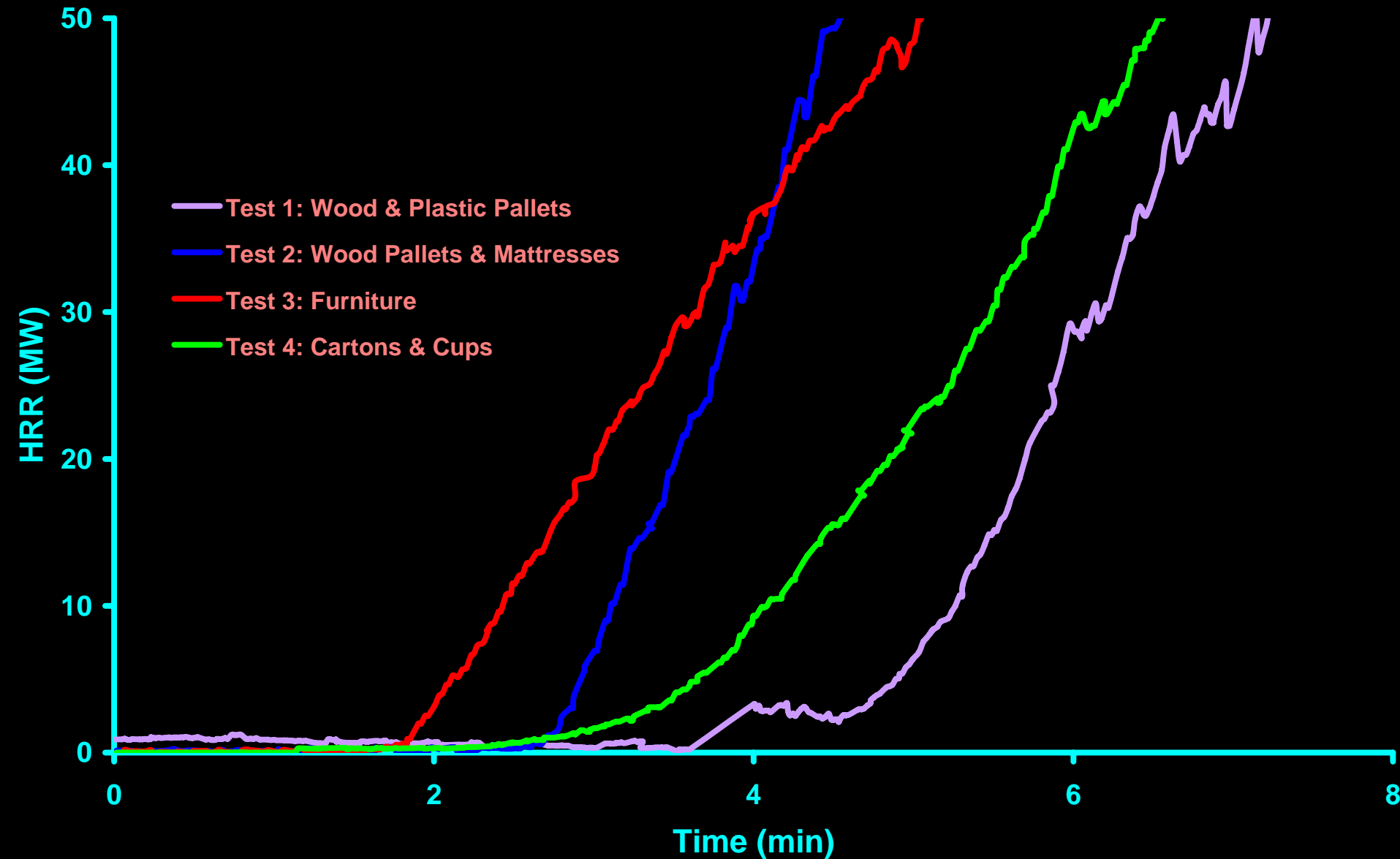
Experimental fires in tunnels

- Which experimental fires?
 - HGV fire test, Hammerfest tunnel, 1992
 - Simulated HGV truckload, Hammerfest tunnel, 1992
 - 3 HGV load tests with canvas cover, 2nd Benelux Tunnel, 2002
 - 2 HGV load tests with alum cover, 2nd Benelux Tunnel, 2002
 - Large pallet load test (no cover), 2nd Benelux Tunnel, 2002
 - 4 HGV trailer load tests, Runehamar Tunnel, 2003

Experimental fires in tunnels (Benelux tests)



Experimental fires in tunnels (Runehamar)





Did you notice any patterns there?

HRR

All the tests seem to follow a 'two-step', more or less linear pattern.

Between
n 2 and
12

minutes

'Incipient' or 'delay' phase

Growth phase

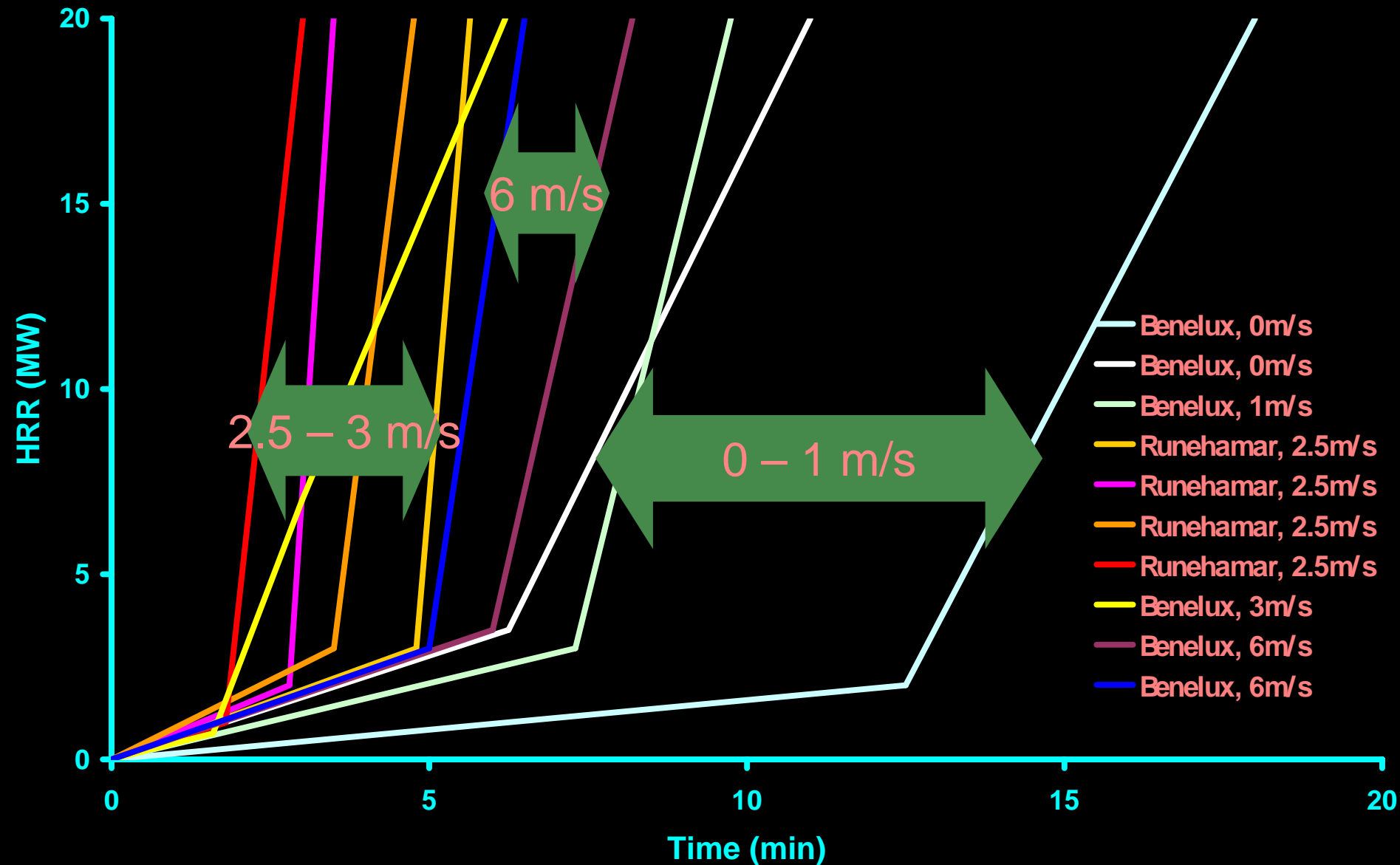
Between
n 2 and
26

MM/min

Time



Observations on experiments



Observations on experiments

- At low ventilation velocities ($0 - 1 \text{ ms}^{-1}$)
 - The 'delay' phase is 6 – 10 minutes
 - The 'growth' rate is 2 – 7 MW/min
- At high ventilation velocities ($\sim 6 \text{ ms}^{-1}$)
 - The 'delay' phase is 5 or 6 minutes
 - The 'growth' rate is 8 – 11 MW/min
- At medium ventilation velocities ($2 - 3 \text{ ms}^{-1}$)
 - The 'delay' phase is 2 – 5 minutes (shortest)
 - The 'growth' rate is 6 – 26 MW/min (fastest)



Observations on experiments

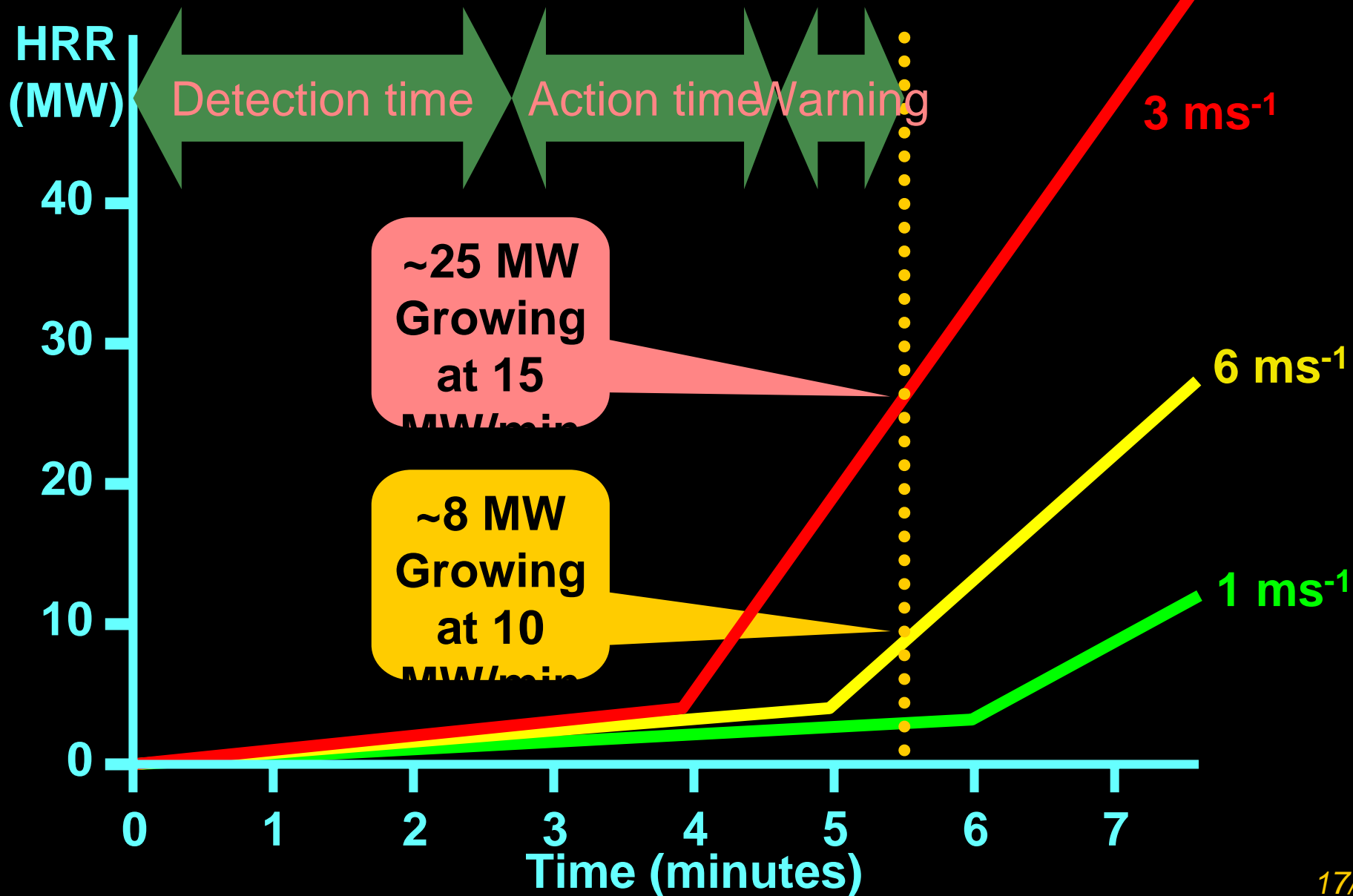
- The **shortest delay phase** and the **fastest fire growth** are both observed at $2 - 3 \text{ ms}^{-1}$
- Unfortunately, this is the range of most reported values of '**critical ventilation velocity**' recommended for smoke control
- These observations are based on a very simple analysis, more research is needed to confirm these trends!

Design fire proposals

- But what if it is true?
- What should our design fires look like?
- A few more questions first?
 - How good is our detection system?
 - Time between detection and activation?
 - Confirm fire on CCTV?
 - Close tunnel?
 - Evacuate people?
 - Establish timeline (e.g. 3 minutes detection time, 2 minutes to close tunnel, 30 seconds 'warning' time = 5.5 minutes)



Design fire proposals





Design fire proposals

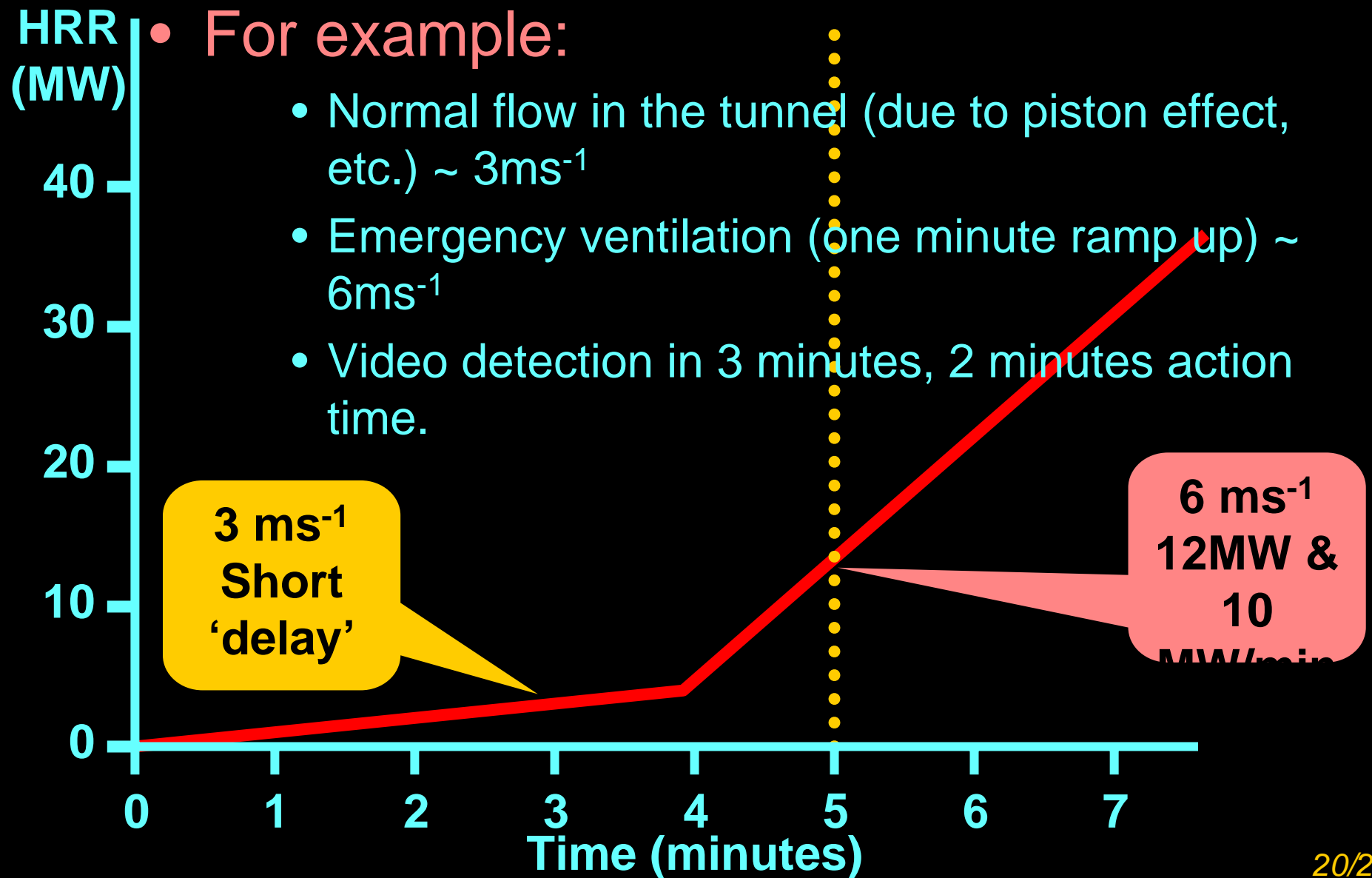
- The aim of the system is to **stop growth** and (hopefully) **reduce fire size**.
- Thus, even if the 'design fire' is an 8 MW fire (growing at about 10 MW/min) it is important to use a **larger fuel load**, which **could grow beyond this limit** (perhaps to as much as 20MW or more) in order to demonstrate this capability.



Design fire proposals

- To specify a design fire you need:
 - To know the likely ventilation conditions before detection
 - This specifies the length of the delay phase.
 - To know the emergency ventilation conditions (and ramp time)
 - This specifies the rate of fire growth in the growth phase.
 - To have a good idea of the detection/activation timeline
 - This specifies the characteristics of the fire at the point of activation.

Design fire proposal (example)





Conclusions

- A method for creating design fires for tunnel water mist systems has been presented
- This is based on observations from a small number of experimental tunnel fires (more research is required to confirm the observed trends)
- It has been observed that ventilation velocities previously proposed as 'critical ventilation velocities' for smoke control may lead to the worst conditions for fire growth