Experimental and numerical studies to assess the benefits of water mist system in Mont-Blanc tunnel

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1. OVERVIEW

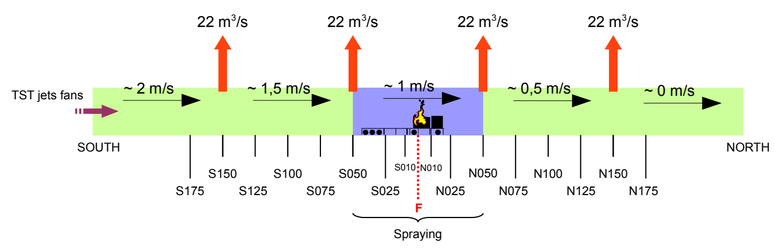
Study of the use of water mist system in the Mont-Blanc tunnel :

- Bibliographic review of existing fixed fire-fighting systems (FFS)
- Experimental performance assessment of several types of FFS at scale 0.8
- Numerical simulations to evaluate the interaction of water mist system with existing safety equipment and procedures

2. EXPERIMENTAL CAMPAIGN

15 fire tests carried out in the TST tunnel tests facility (San Pedro, Spain) [1, 2].

- 3 FFS technologies : SPK, low-pressure water mist, high-pressure water mist
- 2 fire load compositions: 30 MW wood, 50 MW wood and gasoil
- 2 activation strategies : as fire detected, at t = 7 min (firefighters arrival)
- Monitoring of temperature, velocity, gas composition, heat flux, etc.



High-pressure water mist system provides the best performance (gas cooling and fire suppression).

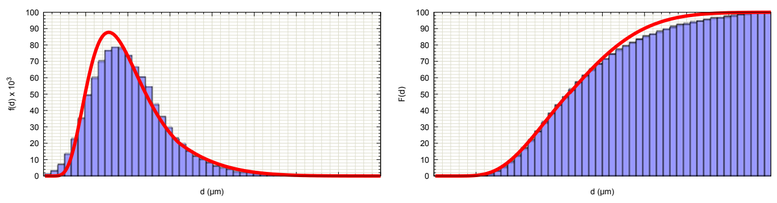
3. NUMERICAL STUDY

Working approach

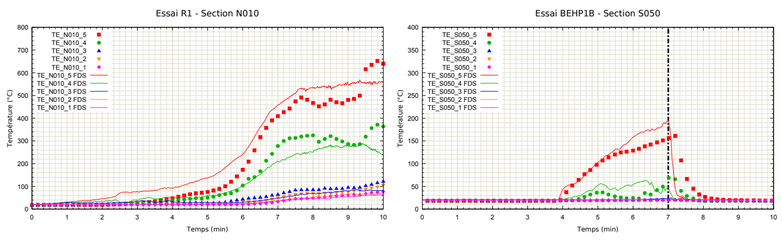
- CFD modeling using FDS (NIST, USA) [3]
- Spray parameters validation by simulating 6 experimental tests
- Extensive use of FDS to simulate realistic fire scenarios

Rosin-Rammler/log-normal droplets size distribution:

$$F(D) = \begin{cases} \frac{1}{\sqrt{2\pi}} \int_0^d \frac{1}{\sigma d'} \exp\left(-\frac{[\ln(d'/d_m)]^2}{2\sigma^2}\right) \mathrm{d}d' & (d \le d_m) \\ 1 - \exp\left(-0.693 \left(\frac{d}{d_m}\right)^{\gamma}\right) & (d > d_m) \end{cases}$$



Comparison with experimental data

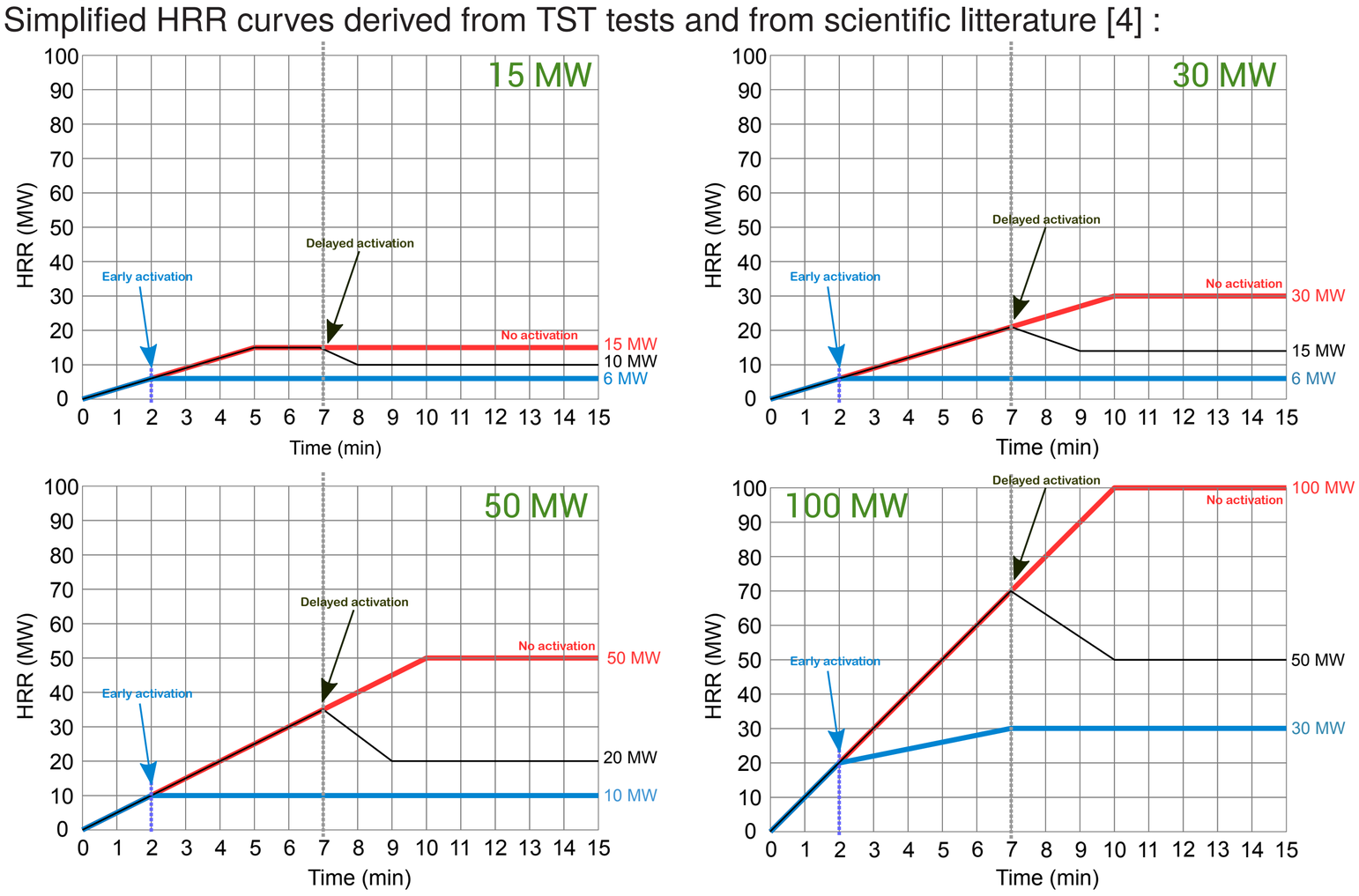


Good agreement ⇒ possible use of FDS to simulate fire scenarios in the tunnel.

4. RESULTS

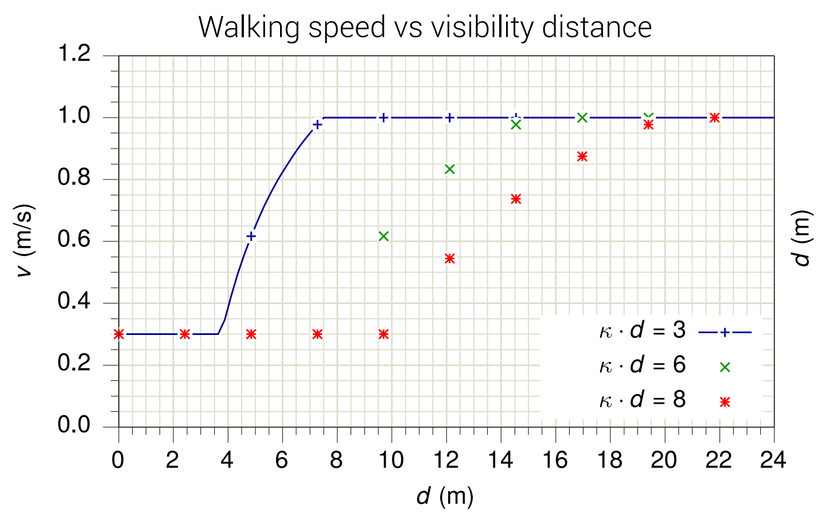
Design heat release rate curves

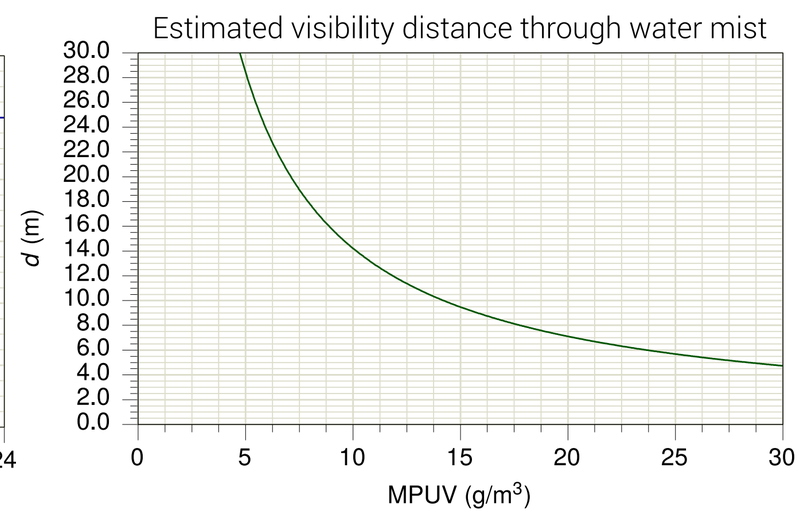
Simplified HRR curves derived from TST tests and from scientific litterature [4] :

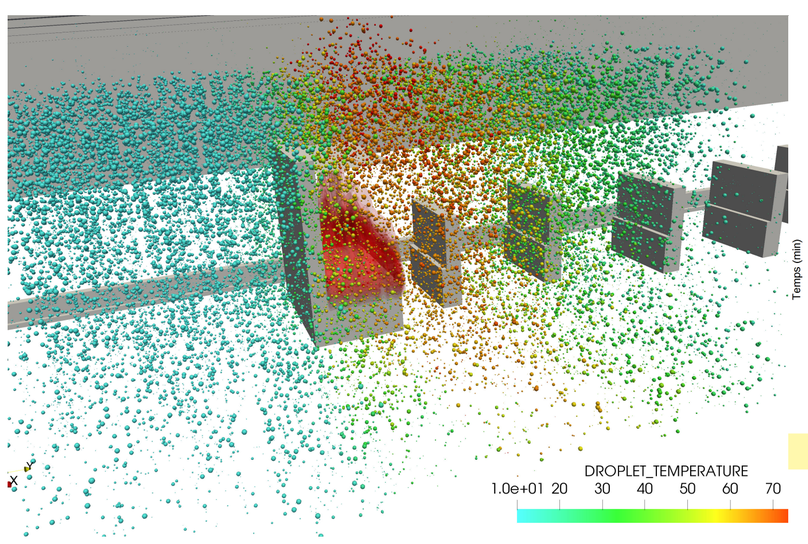


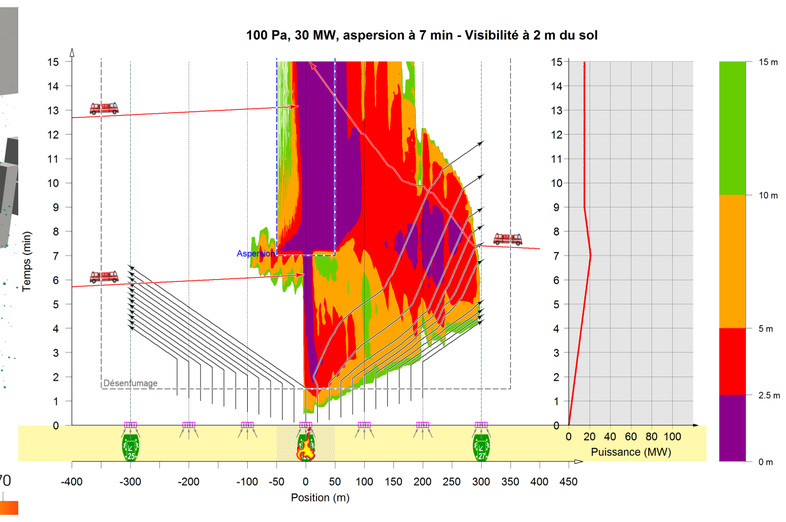
Numerical results analysis

- FDS results postprocessing to analyse water mist effect and to identify evacuation conditions along the tunnel
- Intensive use of REVAC in-house numerical model for simulating evacuation and firefighters intervention (including traveling speed reduction and fractional effective dose for users incapacitation derived from [5])









5. CONCLUSION

- 36 realistic fire scenarios (4 fire loads, 3 natural draught conditions, 3 FFS activation)
- Significant degradation of visibility and temperature in the flooding area
- No real asset for safety of users because the smoke management system is effective
- Good results to protect structure and equipment when facing big fires

6. REFERENCES

- SETEC TPI-CSTB : Campagne de tests de sfli par le GEIE TMB, 2013. Réf. 003-23776/6/T/145/JMV-TU-FR-20121114-v2.
- IFAB : Campagne de tests des systèmes fixes des lutte contre l'incendie pour le tunnel du Mont-Blanc, dossier de présentation du tunnel d'essai, 2011.
- NIST Special Publication 1019. *Fire Dynamics Simulator User's Guide*, 2017.
- SOLIT : Safety of life in tunnels, water mist fire suppression for road tunnels, final report, 2007.
- SFPE : *SFPE Handbook of Fire Protection Engineering, Third edition.* National Fire Protection Association, Quincy, 2002.

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