Natural Ventilation of a Short Road Tunnel – Application of FDS+EVAC

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DECK PARK OVERBUILD

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CODE REQUIREMENTS: NFPA 502

Section 11.1.1:

Emergency ventilation shall not be required in tunnels less than 3280 feet in length, where it can be shown by an engineering analysis that the level of safety provided by a mechanical ventilation system is equaled or exceeded by enhancing the means of egress or the use of natural ventilation.

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How do we show equivalent level of safety quantitatively?

EXISTING SHORT TUNNELS

Name	Length m (ft.)	Urban / rural	Traffic	Year	Ventilation
I5 Tunnel, Seattle, WA	167 (547)	U	Uni	1988	Natural
Dyer Avenue, New York	168 (550)	U	Bi	*	Mechanical
Rockville, Intercounty Conn, Maryland	195 (640)	R	Bi	2010	Natural
Pasadena, I210, California	271 (889)	U	Uni	2003	Natural
College Avenue Tunnel, Milwaukee, WI	277 (910)	U	Uni	2010	Mechanical

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NFPA 502 Section 11.2.2:

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— *Use tenable egress path criteria to demonstrate safety*

TENABLE EGRESS PATH CRITERIA

— Traditional methods use visibility > 10 m to define tenability

— For some fire scenarios in short tunnels, might not be able to show visibility of 10 m (e.g. fuel tanker fire)

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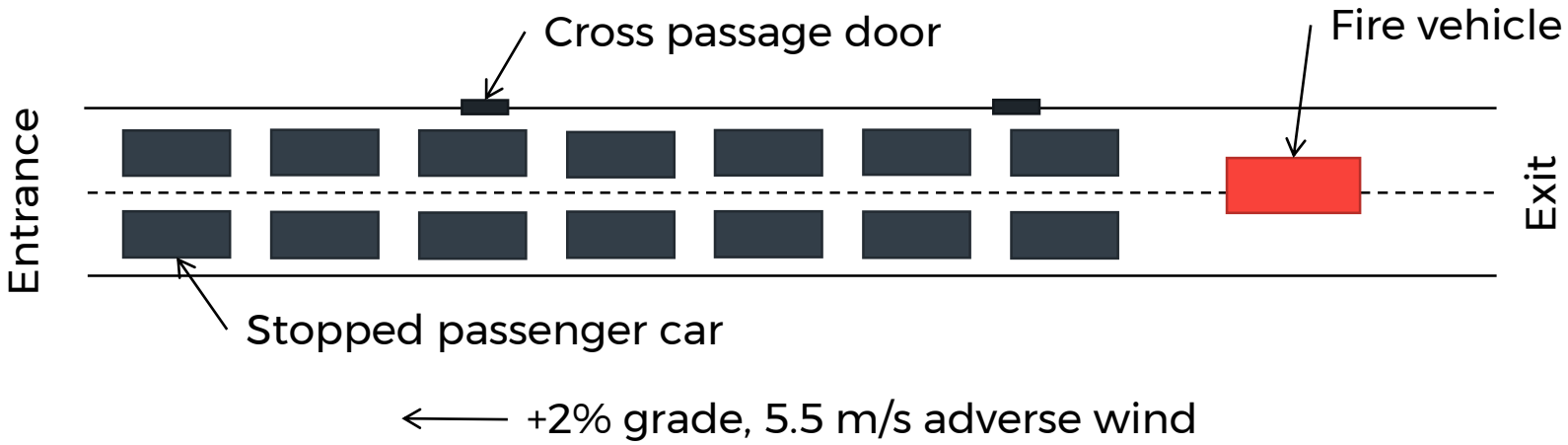
- Fractional effective dose (FED) and fractional irritant concentration method
- Track FED of toxic gases and heat exposure
- Track FIC of toxic gases
- Set criteria so more susceptible occupants can self evacuate

TENABLE EGRESS PATH CRITERIA

- Toxic gas FED based on Purser's equation (used in EVAC)
- Heat exposure FED calculated based on NFPA 502 Annex B equations
  - *Output visibility and temperature profiles to calculate this for a theoretical occupant*

- To be considered a passing result:
  - *Toxic gas FED < 0.3*
  - *Heat exposure FED < 0.3*
  - *Toxic gas FIC < 0.3*

SCENARIO SCHEMATIC



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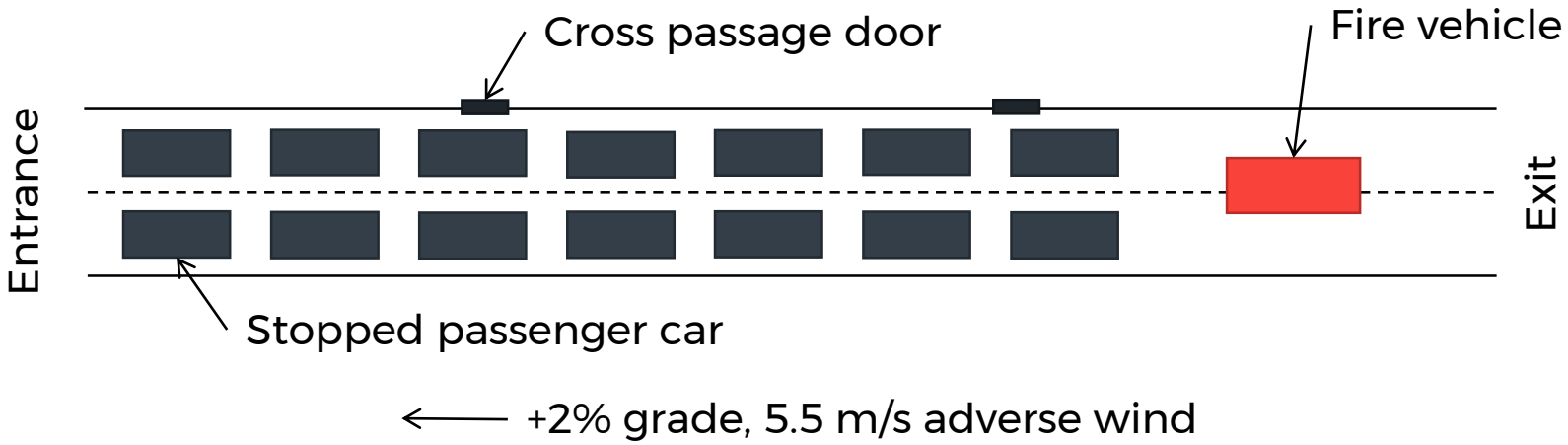


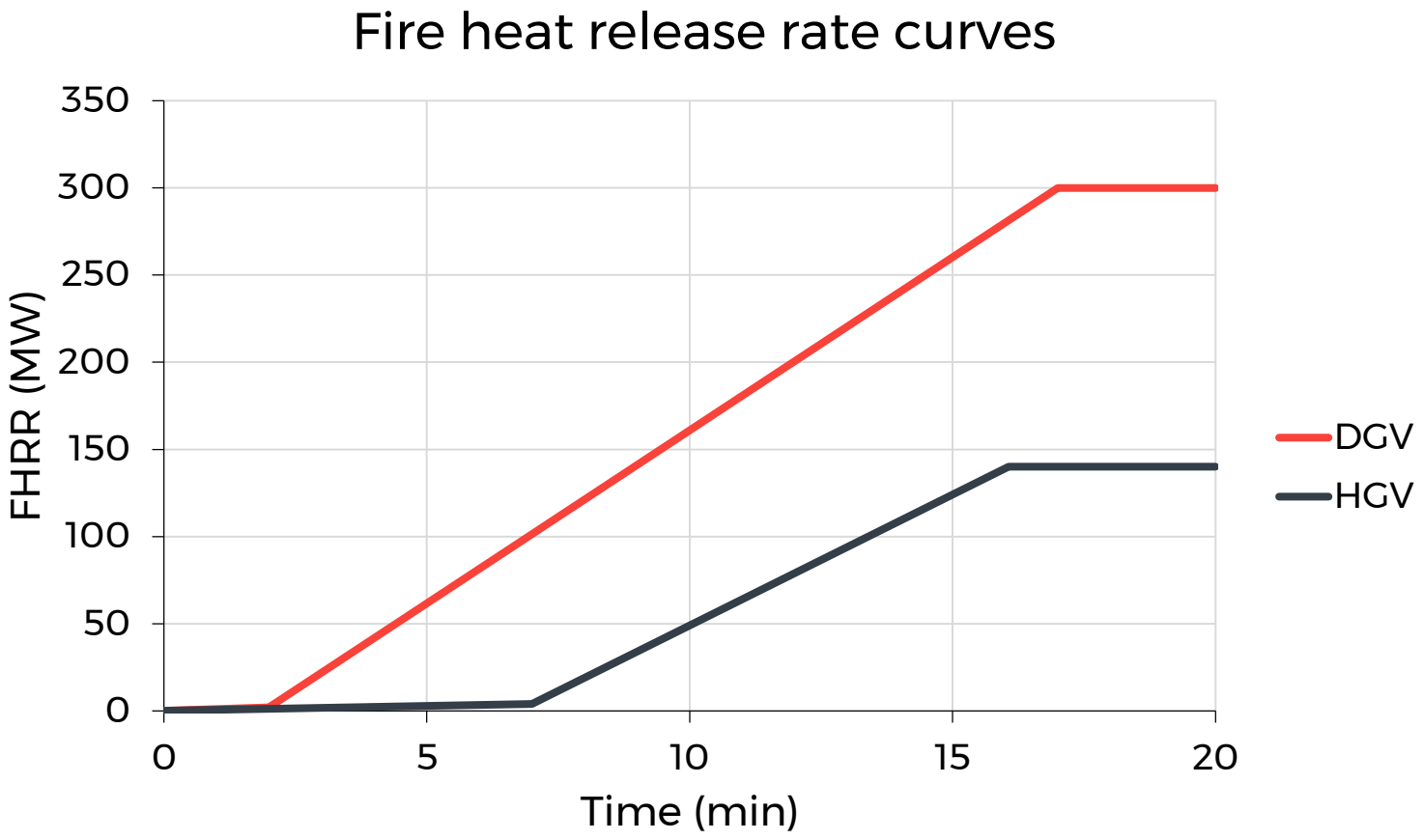
— Dangerous goods vehicle (DGV) fires versus heavy goods vehicle (HGV) fires

— Quantity of egress doors

— Length of tunnel (600 ft. and 1000 ft.)

— 2 lane vs. 6 lane tunnels

FIRE SCENARIO



COMBUSTION REACTION

— Emissions from an experimental vehicle fire used as a basis (Lonnermark and Blomqvist)

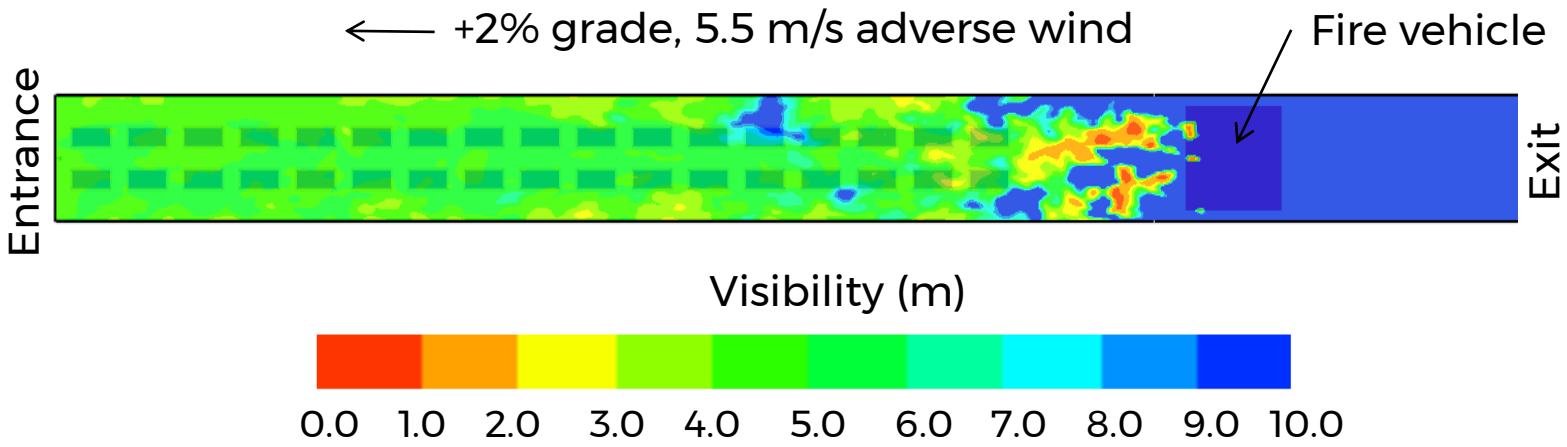
— Reaction included: CO, NO_2, HCN, HCl, SO_2, C_3H_4O, and CH_2O, soot

— All species included in FDS+EVAC FED/FIC calculation

RESULTS SUMMARY

Length (m)	Lanes	Design fire	Provisions to meet NPFA 502 with natural ventilation
180	2	HGV	Portal egress
180	2	DGV	Additional egress doors
180	6	DGV	Portal egress
305	2	HGV	Additional egress doors
305	6	DGV	Additional egress doors

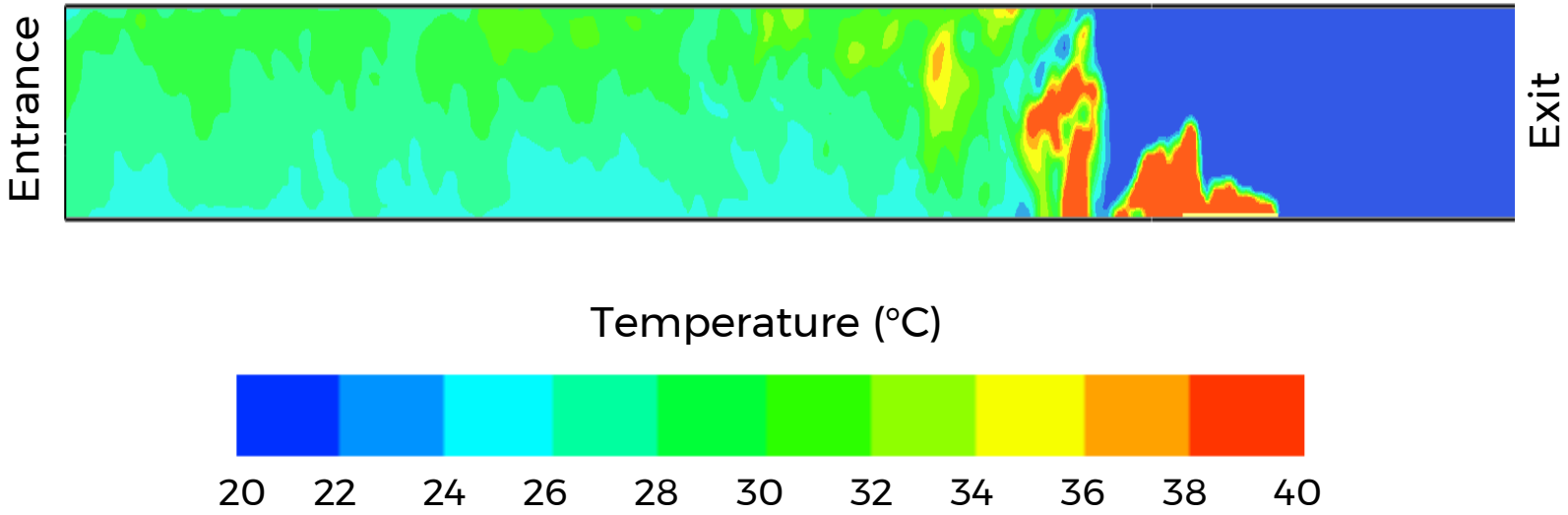
VISIBILITY AT 2.4 M ABOVE ROADWAY



— 180 m tunnel, HGV fire

— Slice taken at 310 seconds (last occupant exits)

SECTION VIEW OF TEMPERATURE



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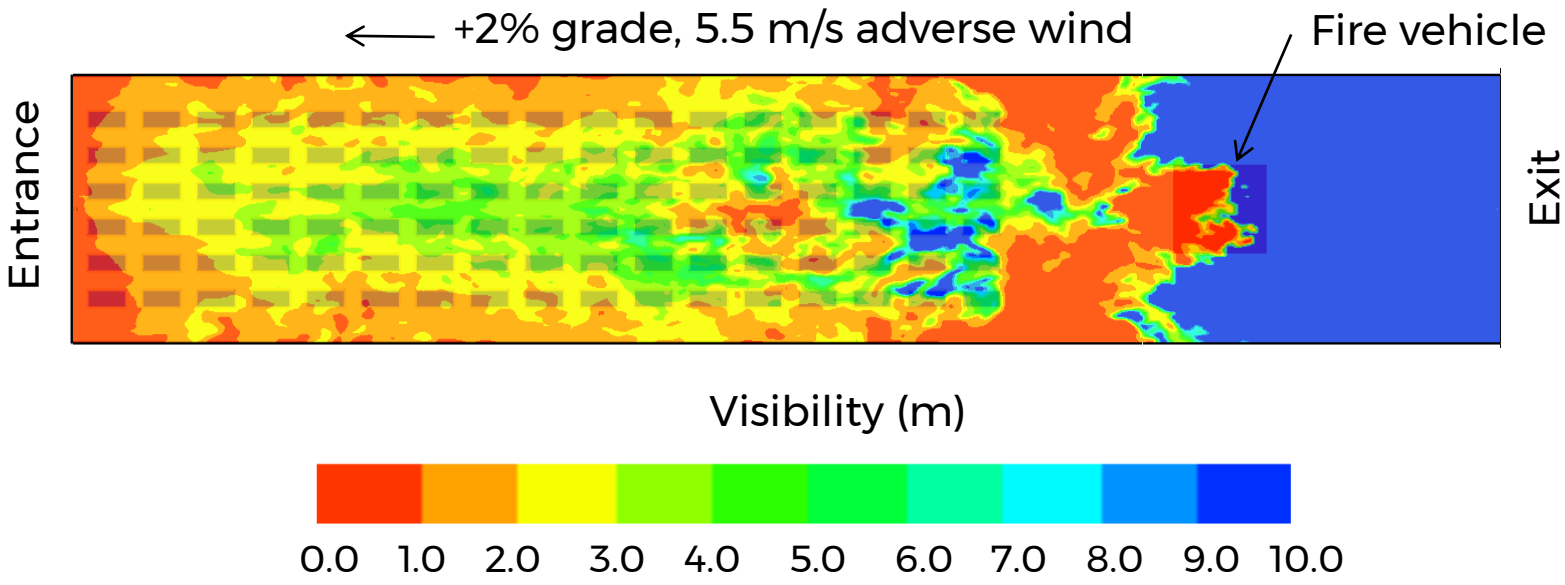

— 180 m tunnel, DGV fire

— Slice taken at 335 seconds (last occupant exits)

RESULTS SUMMARY

— Results are consistent with recent work by Purser, suggesting that occupants can move through visibilities of 2 m for 20-60 minutes

— Can use this quantitative approach to form a basis for approval by the authority having jurisdiction (AHJ)

SIMULATIONS

Case number	Ventilation	Egress doors	FHRR (MW)	Tunnel length	Lanes	Max. FED, toxic gases	Max. FED, heat	Max. FIC	Pass/ fail
FEM-01-01	Natural	0	300	180	2	0.081	1.00	1.00	Fail
FEM-01-02	Mechanical	0	300	180	2	0.003	0.02	0.20	Pass
FEM-01-03	Natural	2	300	180	2	0.013	0.00	0.05	Pass
FEM-01-04	Natural	0	140	180	2	0.002	0.01	0.05	Pass
FEM-01-05	Mechanical	0	140	180	2	0.002	0.01	0.05	Pass
FEM-01-06	Natural	2	140	180	2	0.001	0.00	0.05	Pass
FEM-01-07	Natural	0	300	180	6	0.003	0.02	0.20	Pass
FEM-01-08	Mechanical	0	300	180	6	0.001	0.01	0.10	Pass
FEM-01-10	Natural	0	140	305	2	0.012	0.06	0.35	Fail
FEM-01-11	Mechanical	0	140	305	2	0.002	0.01	0.05	Pass
FEM-01-12	Natural	0	300	305	6	0.067	0.20	0.55	Fail
FEM-01-13	Mechanical	0	300	305	6	0.001	0.01	0.10	Pass