Design Fire Scenario-Physics and Policy

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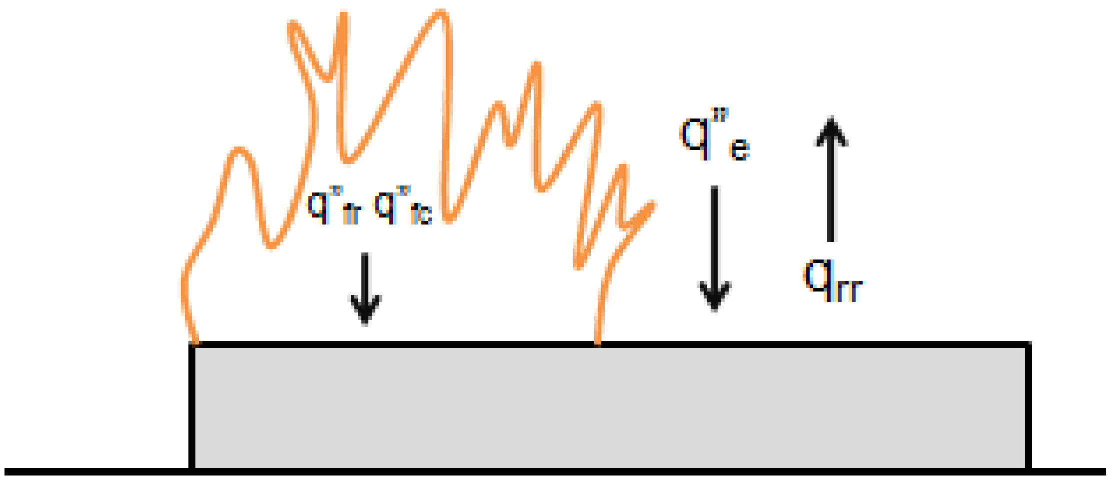
Design Fire Scenario-Physics and Policy Background

- Physics
  - Tests
  - Vehicle Construction
  - Fire physics
- Policy
  - Flashover
  - Nonflashover

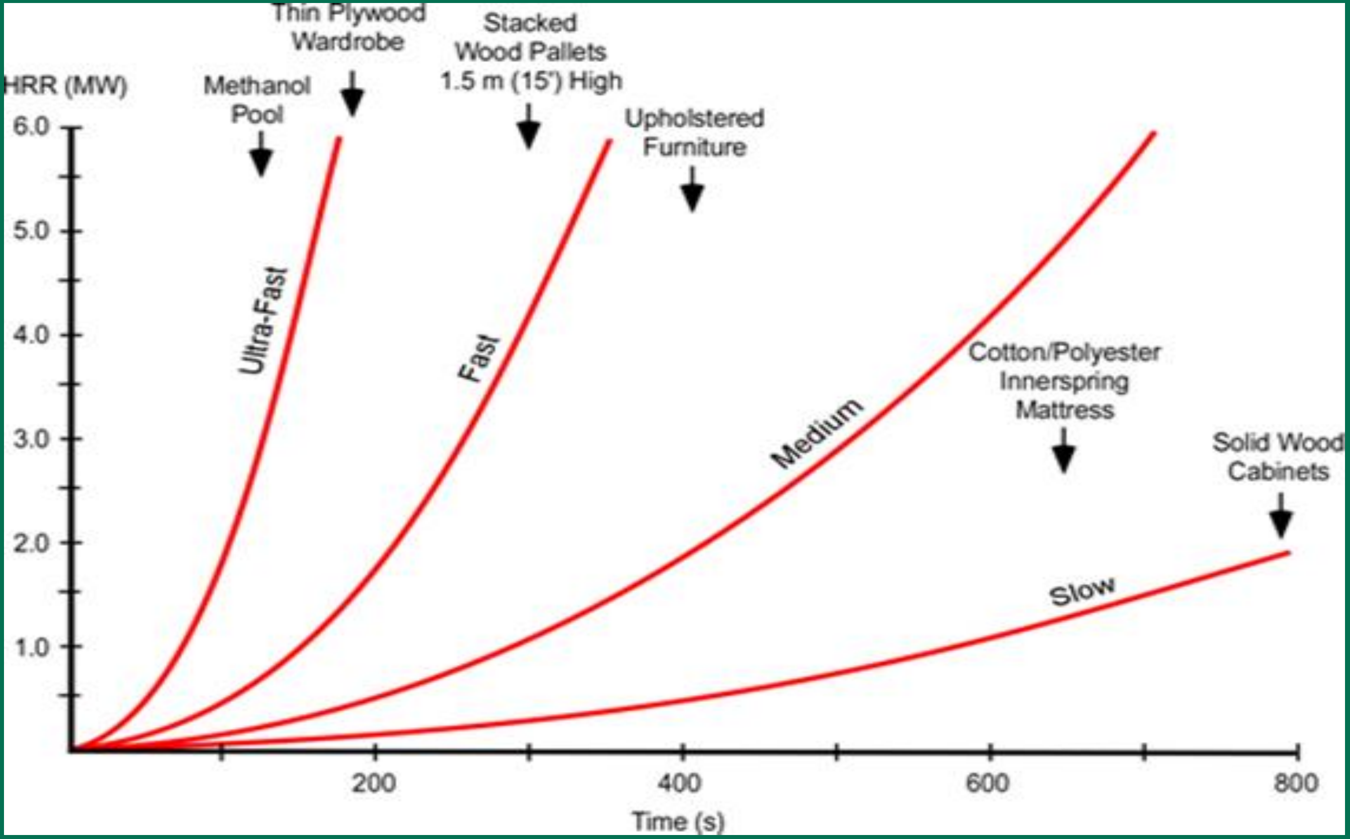
Physics-Dynamics of Fire

$$q''=(q_e''+ q''_{fr}+q''_{fc}+q_{rr})$$



Fuel-Controlled Fires

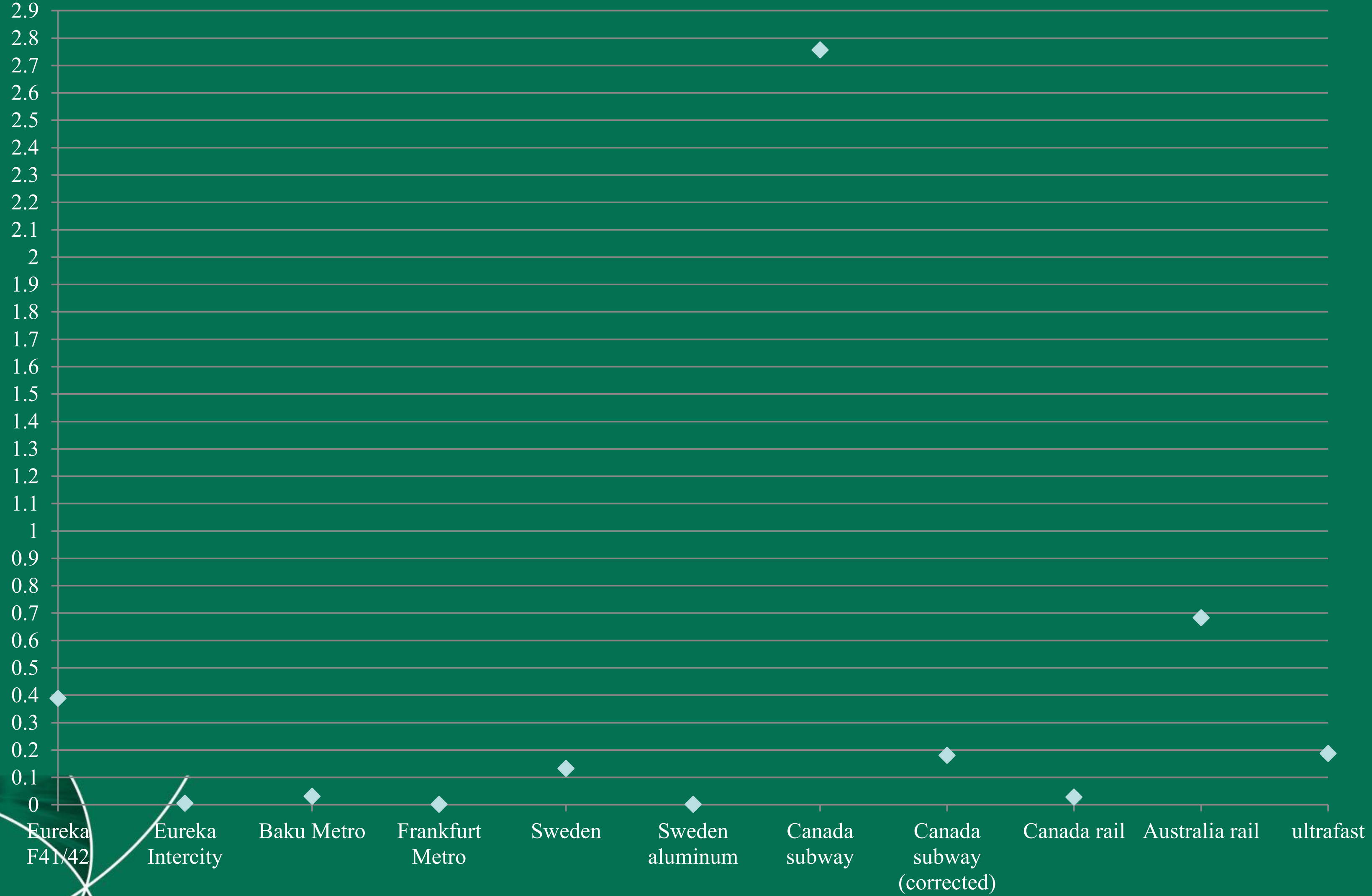
→ Design Curves



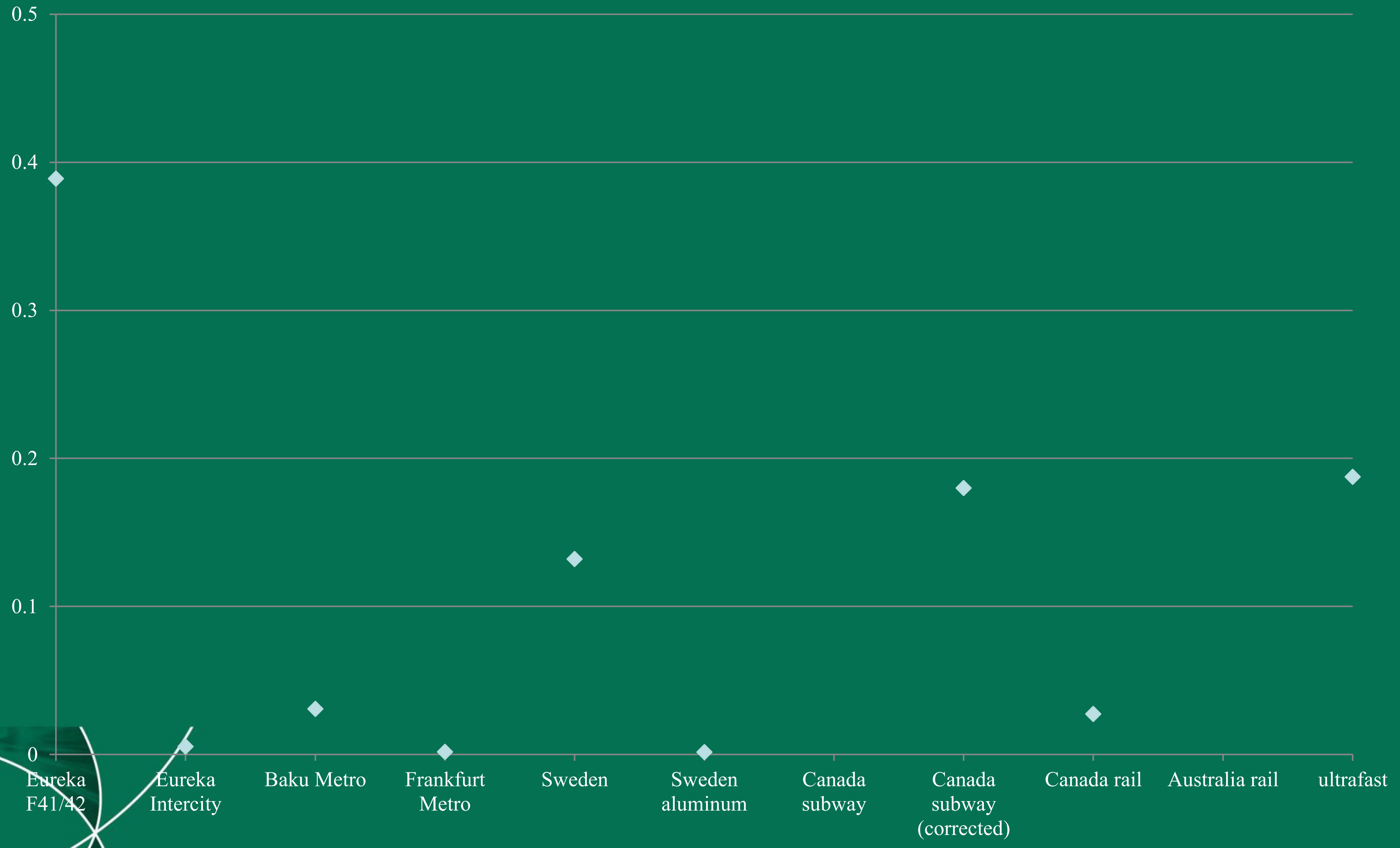
NFPA 130 Annex H Full scale tests (H.3)

- Eureka Intercity
  - 12 MW @ 25 min
- Eureka Metro
  - 35 MW @ 5 min
- Baku Metro
  - 100 MW @30-40 min
- Frankfurt Metro
  - 5.6 MW @30 min
- Sweden
  - 76.7 MW @12.7 minutes
  - 77.4 MW @117.9 minutes (aluminum)
- Canada
  - 52.5 MW @ 2.3 minutes (subway)
  - 32 MW @18 minutes (railway)
- Australia
  - 13 MW @2.3 minutes (passenger rail)

Fire Growth Rates (α) of All Referenced Tests

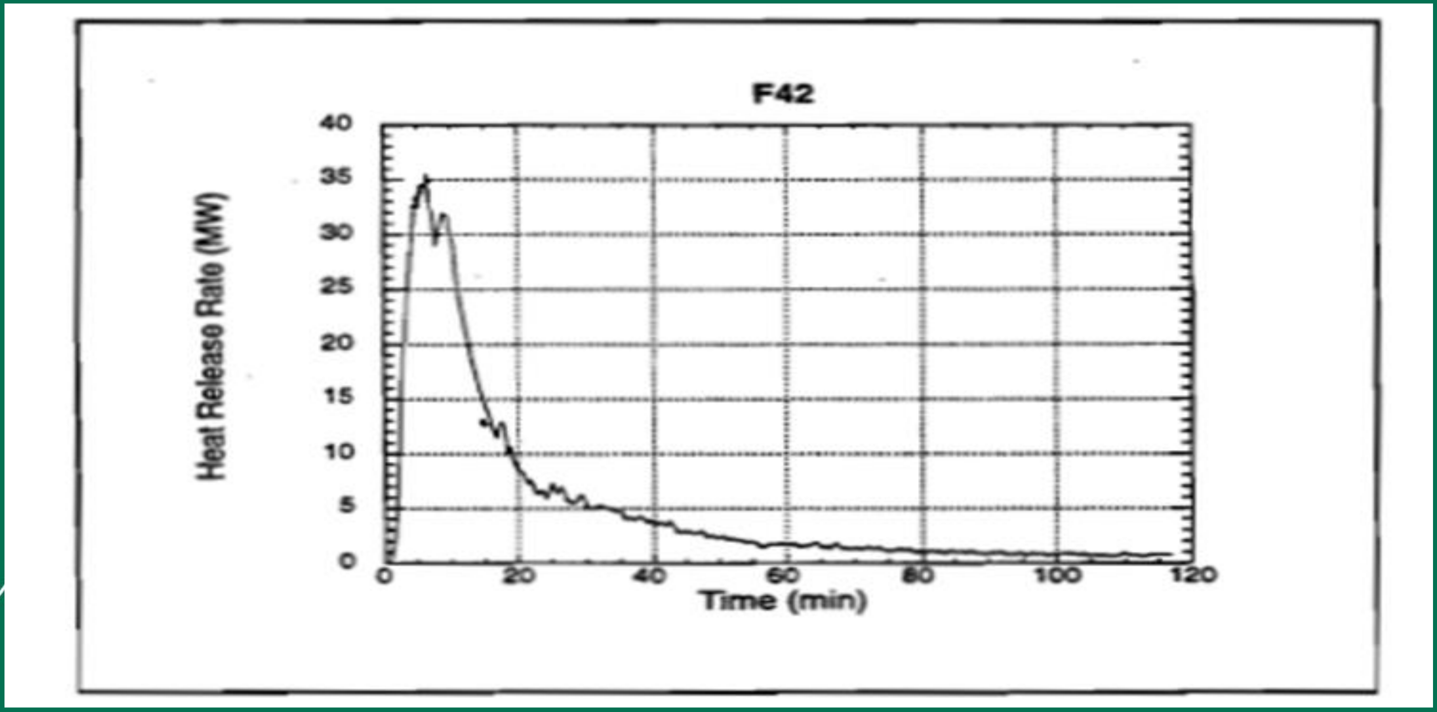


Fire Growth Rates (α) of Most Tests

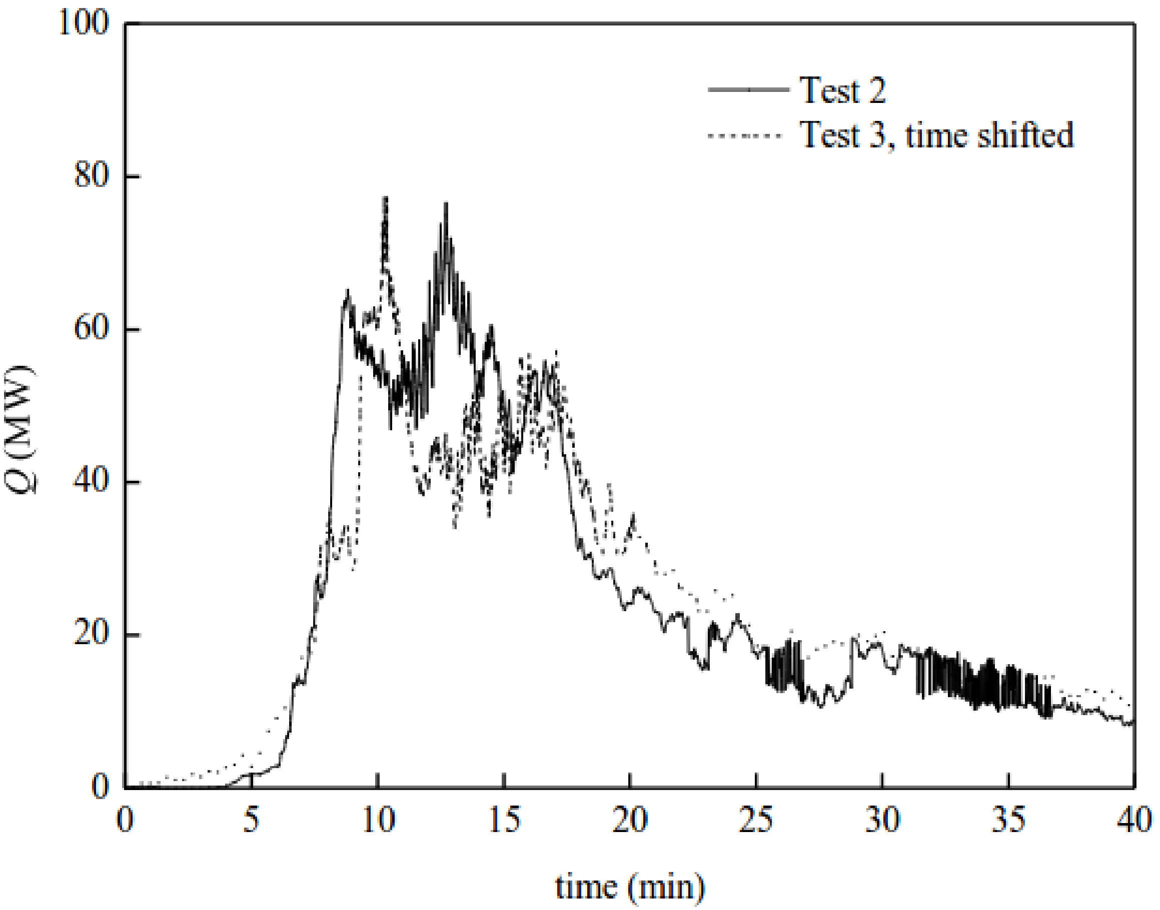


Physics-Tests
Eureka Fire Test F41/F42

Accelerant	Results
0.7 kg	Self-extinguishing 20 min.
6.2 kg	Partial window failure 1 min. Observations end 14 min.



Physics-Tests
Swedish Metro Vehicles

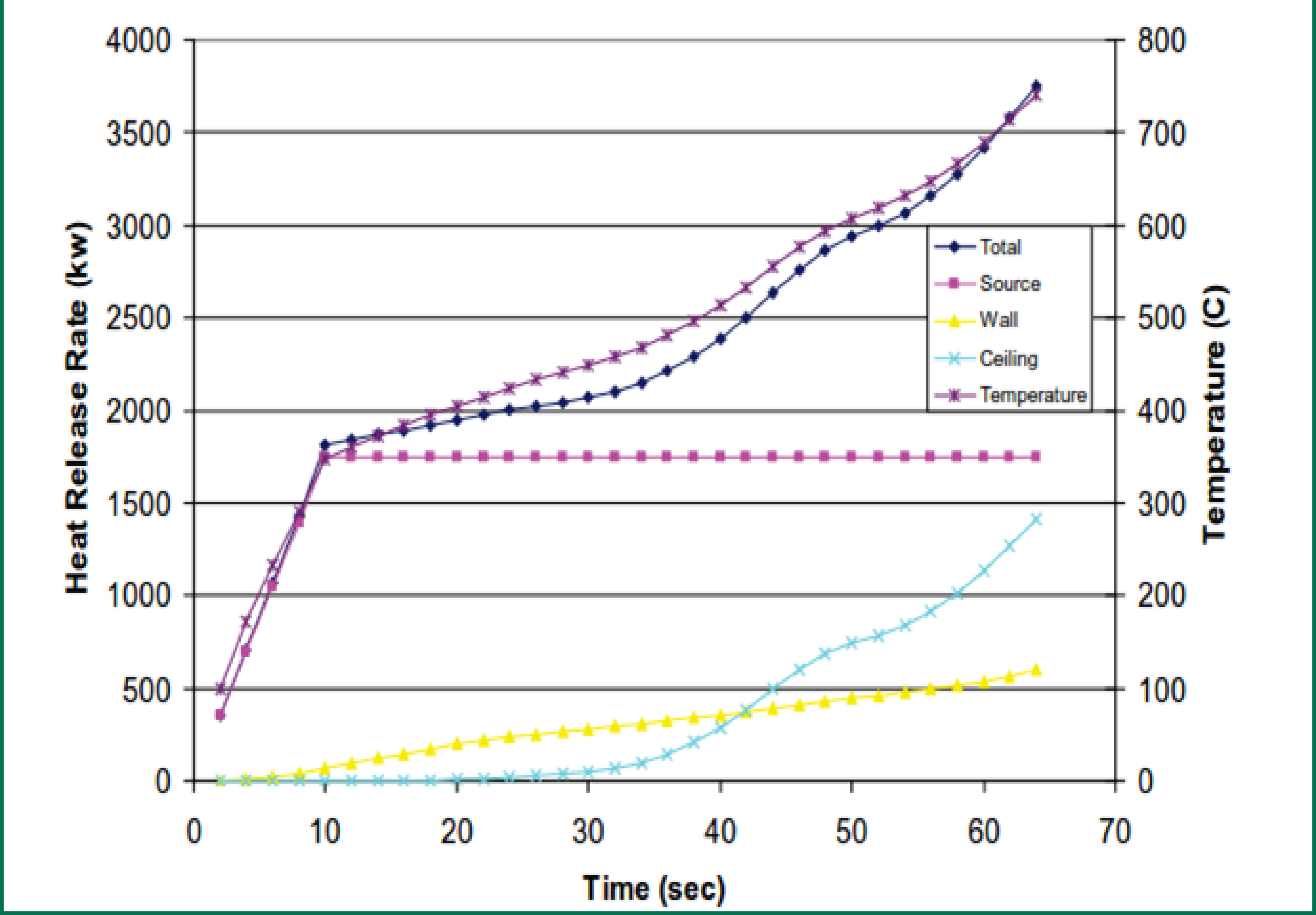


Physics –Vehicle Construction NFPA 130 Requirements

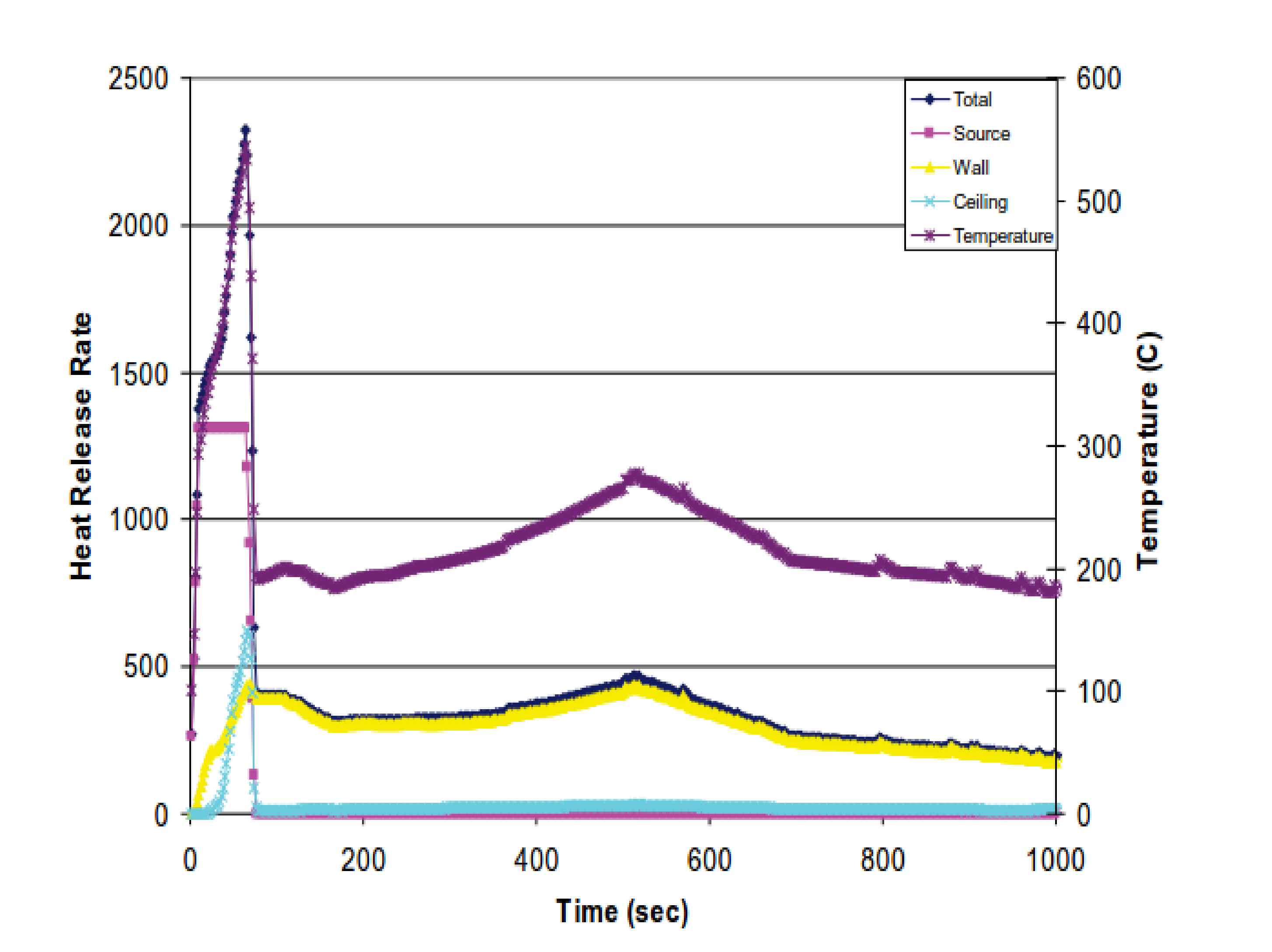
Table 8.4.1 Fire Test Procedures and Performance Criteria for Materials and Assemblies

Category	Function of Material	Test Method	Performance Criteria
Cushioning	All individual flexible cushioning materials used in seat cushions, mattresses, mattress pads, armrests, crash pads, and grab rail padding [a–e]	ASTM D3675	$I_s \le 25$
		ASTM E662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 175
Fabrics	Seat upholstery, mattress ticking and covers, curtains, draperies, window shades, and woven seat cushion suspensions[a–c, f–h]	14 CFR 25, Appendix F, Part I (vertical test)	Flame time ≤ 10 sec Burn length ≤ 6 in.
		ASTM E662	D_s (4.0) ≤ 200
Other vehicle components	Seat and mattress frames, wall and ceiling lining and panels, seat and toilet shrouds, toilet seats, trays and other tables, partitions, shelves, opaque windscreens, combustible signage, end caps, roof housings, articulation bellows, exterior shells, nonmetallic skirts, battery case material, and component boxes and covers[a,b,i–k]	ASTM E162	$I_s \le 35$
		ASTM E662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
	Thermal and acoustical insulation[a,b]	ASTM E162	$I_s \le 25$
		ASTM E662	D_s (4.0) ≤ 100
	HVAC ducting[a,b]	ASTM E162	$I_s \le 25$
		ASTM E662	D_s (4.0) ≤ 100
	Floor covering[b,k,l]	ASTM E648	CRF ≥ 5 kW/m^2
		ASTM E662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
	Light diffusers, windows, and transparent plastic windscreens[b,i]	ASTM E162	$I_s \le 100$
		ASTM E662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
	Adhesives and sealants[a,b]	ASTM E162	$I_s \le 35$
		ASTM E662	D_s (1.5) ≤ 100D_s (4.0) ≤ 200
Elastomers[a,b,i,j]	Window gaskets, door nosings, intercar diaphragms, seat cushion suspension diaphragms, and roof mats	ASTM C1166	Flame propagation ≤ 100 mm (4 in.)
		ASTM E662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
Wire and cable	All	See 8.6.7.1.1.1 through 8.6.7.1.3.	See 8.6.7.1.1.1 through 8.6.7.1.3.
Structural components[m]	Flooring,[n] other[o]	ASTM E119	Pass

Physics-Fire Physics
Vehicle Fire With Accelerant



Physics-Fire Physics
Vehicle Fire Without Accelerant



Physics Summary and Conclusion

- Large amounts of accelerant are necessary to vaporize sufficient fuel to cause a big fire.
- Materials used in transit vehicles are extremely fire resistant.
- An ultrafast growth rate is a reasonable design fire basis.

Physics Summary and Conclusion

- Small amounts of accelerant will not create sufficient fuel vaporization for flashover.
- Either
  - Flashover fire with ultrafast growth rate OR
  - Nonflashover fire that will self-extinguish
- Policy and Risk Assessment vs. Engineering
- Owner risk acceptance.

Fire Risk Acceptance-Policy

- Flashover Scenario
  - Highest levels of mitigation
  - Most systems designed to this criteria
- Nonflashover scenario
  - Lowest levels of mitigation
  - Security and/or on-board suppression
  - Significant facility requirements

Policy Summary and Conclusion

- Arson fire risk acceptance
  - Mitigations exceed benefit
  - Mitigations to be implemented
- Arson fire mitigations
  - Security
  - On-board suppression

Design Fire Scenario-Physics and Policy Summary and Conclusion

- Physics
  - Tests
  - Vehicle Construction
  - Fire physics
- Policy
  - Flashover scenario
  - Nonflashover scenario.

Questions?