Facade fire testing and flammability
What are we measuring and why?

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Introduction

- Fire engineer and research lead at Trigon Fire Safety in London
- Research presented here was completed at Imperial Hazelab in collaboration with ITB, sponsored by Berkeley Group
- All opinions are my own

What is combustibility?

Photo by Alexandre Jaquetoni

VS

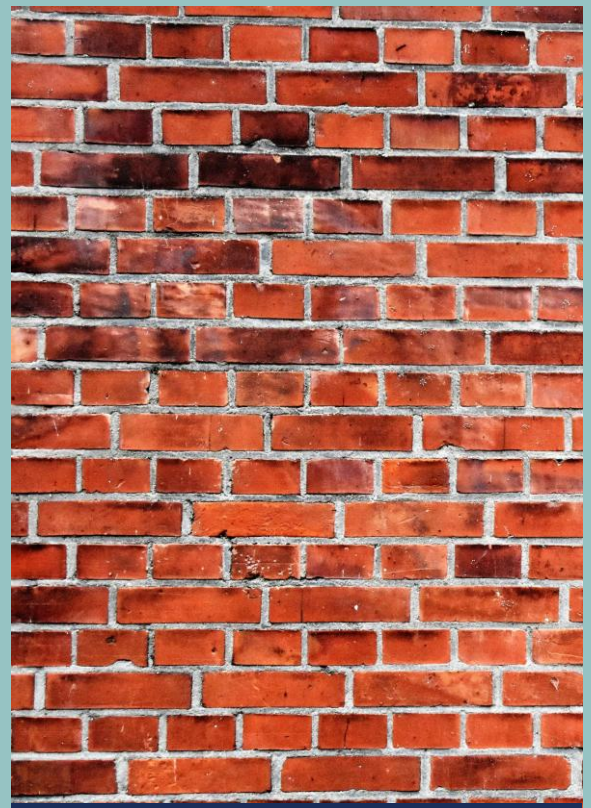

Photo by Waldemar

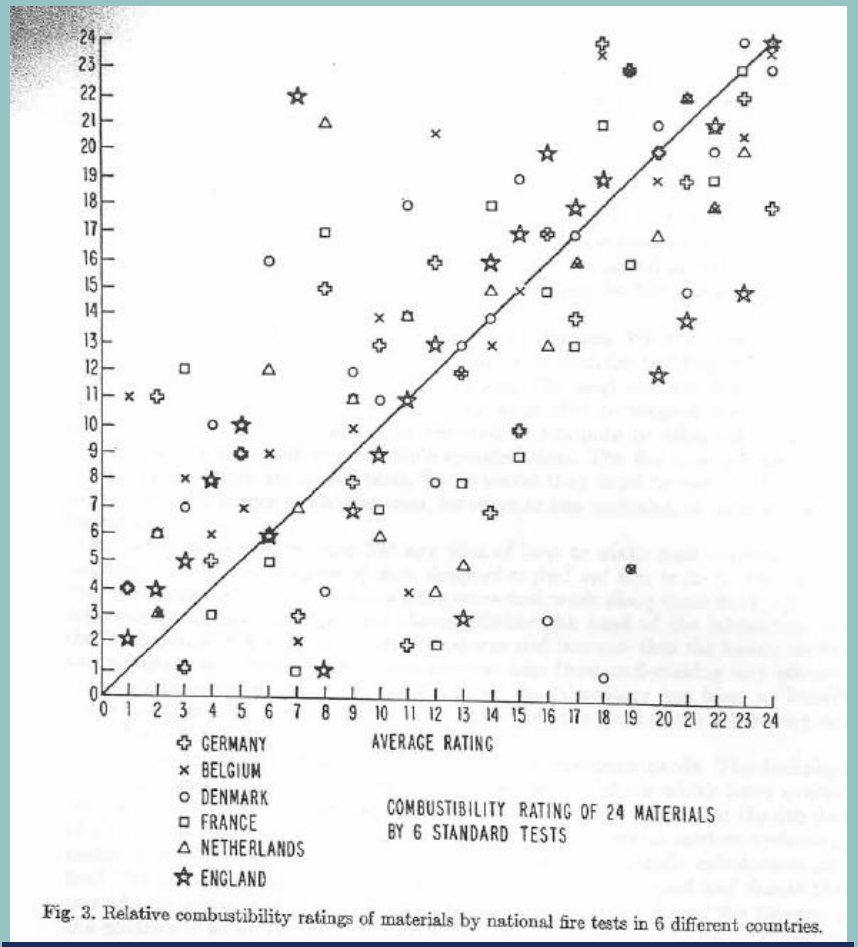

Fig. 3. Relative combustibility ratings of materials by national fire tests in 6 different countries.

Figure from H. Emmons, Fire Research Abroad, 1968

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What is combustibility?

Photo by Alexandre Jaquetoni

VS

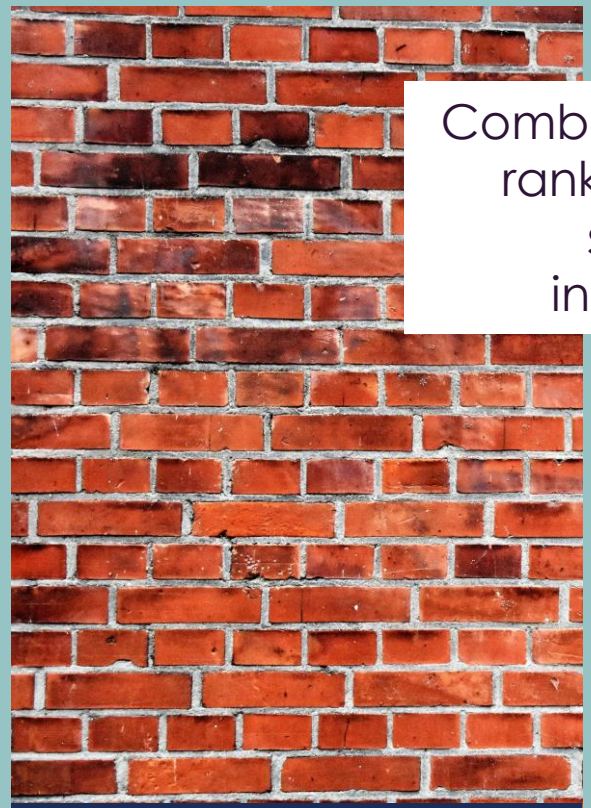

Photo by Waldemar

Combustibility rank from a specific institution

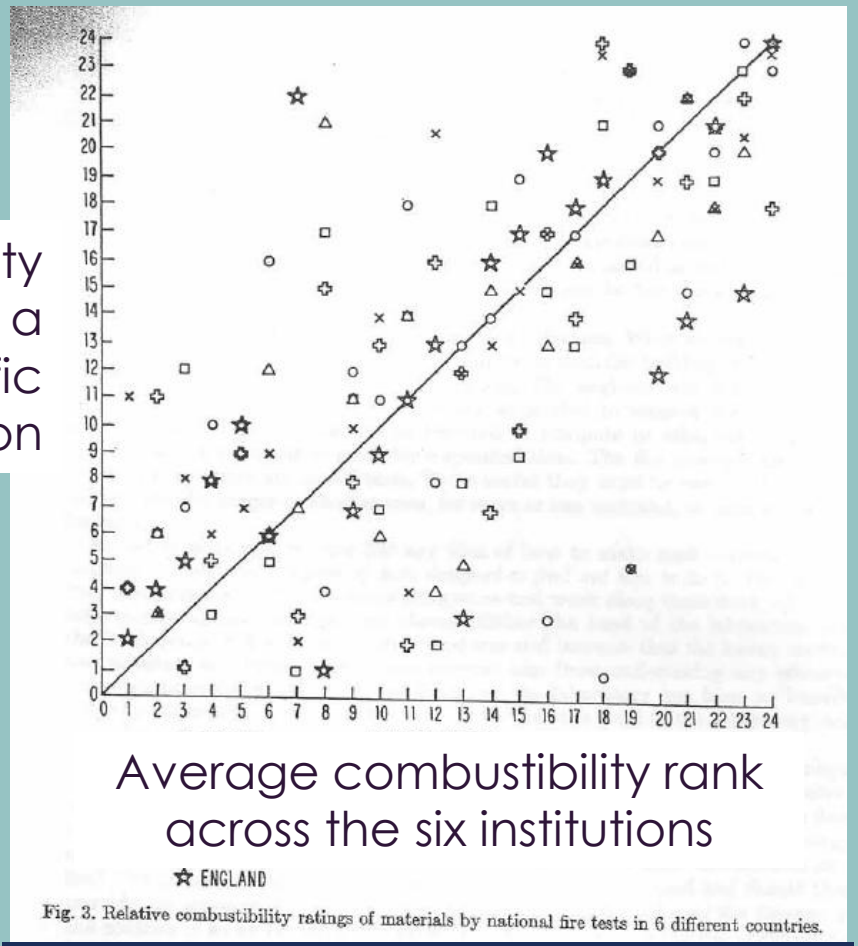

Fig. 3. Relative combustibility ratings of materials by national fire tests in 6 different countries.

Average combustibility rank across the six institutions

Figure from H. Emmons, Fire Research Abroad, 1968

Standardized testing

Photo by Alexandre Jaquetoni

1 European Standard

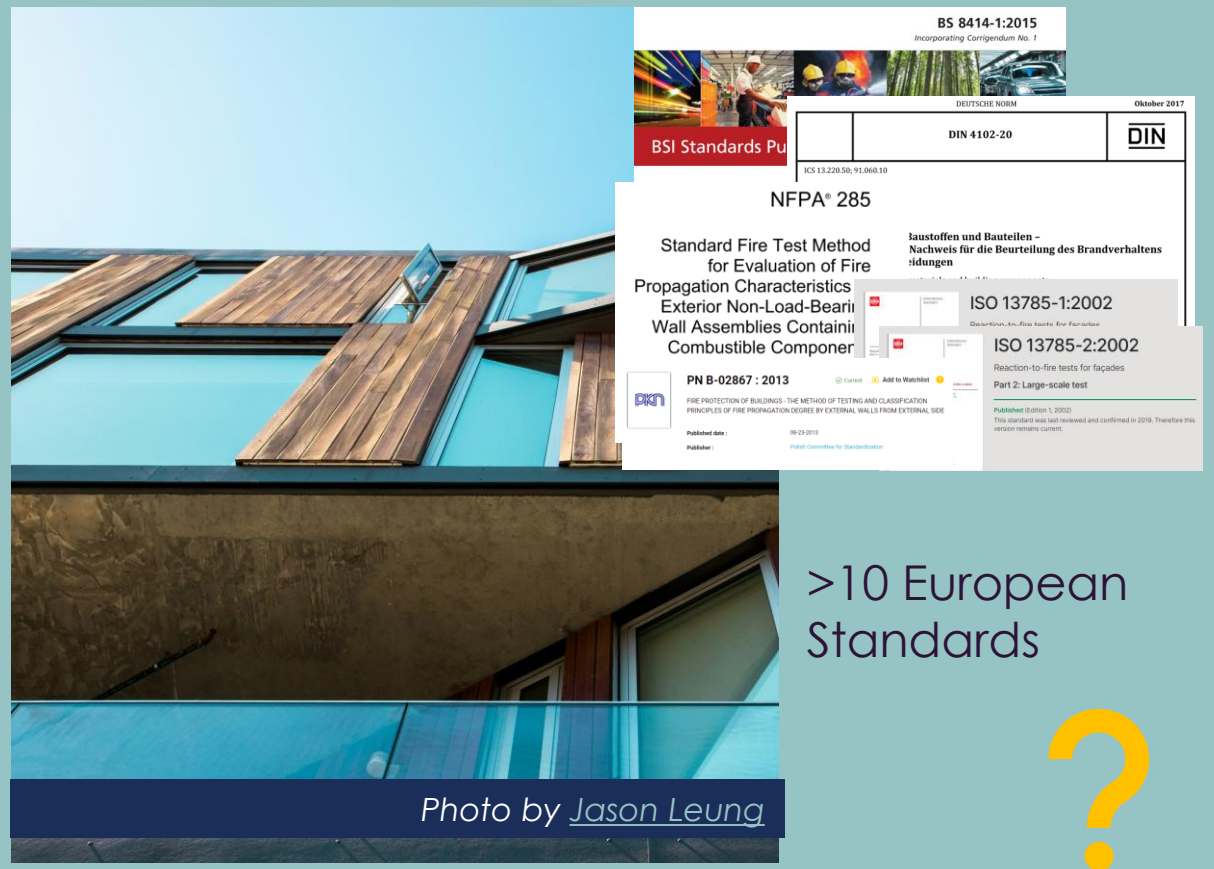

Photo by Jason Leung

>10 European Standards

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What do facade tests measure?

- Extent of flame spread
- Self-extinguishment
- Debris from facade
- Presence of smouldering
- "**Flammability** characteristics"*

Photo from author's own experiments

*From NFPA 285, 2012

What is flammability?*

- Ease of ignition
- Rate of flame spread
- Rate of fire growth (HRR)
- Production of harmful products

Photo by Patrick Hendry

*From C. Lautenberger et al., Understanding Material Flammability, 2006

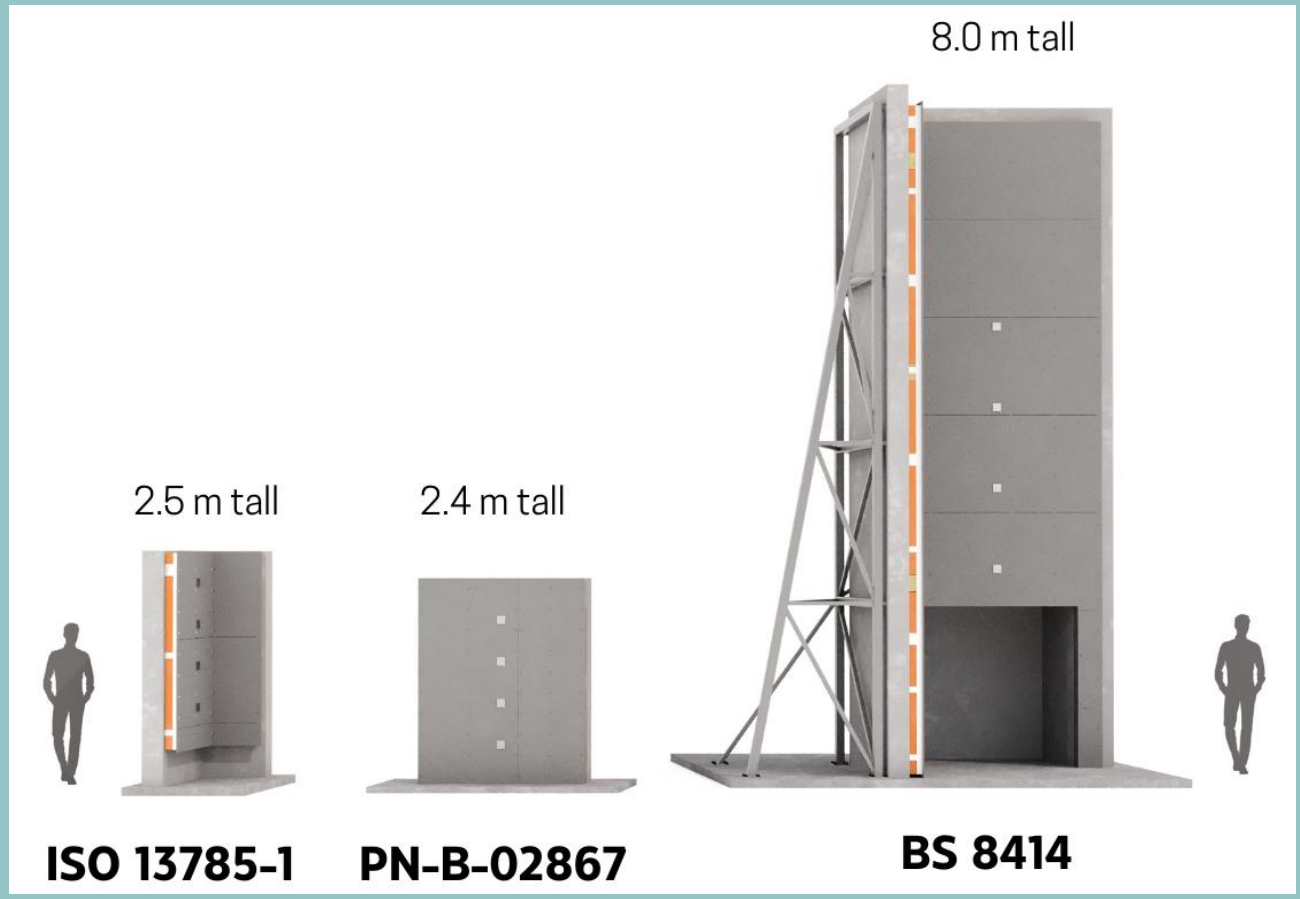
What is flammability?

- Flammability depends on both **internal** properties and **external** heating / flow conditions
- For **system** flammability it also depends on **interactions** between components

Photo by Patrick Hendry

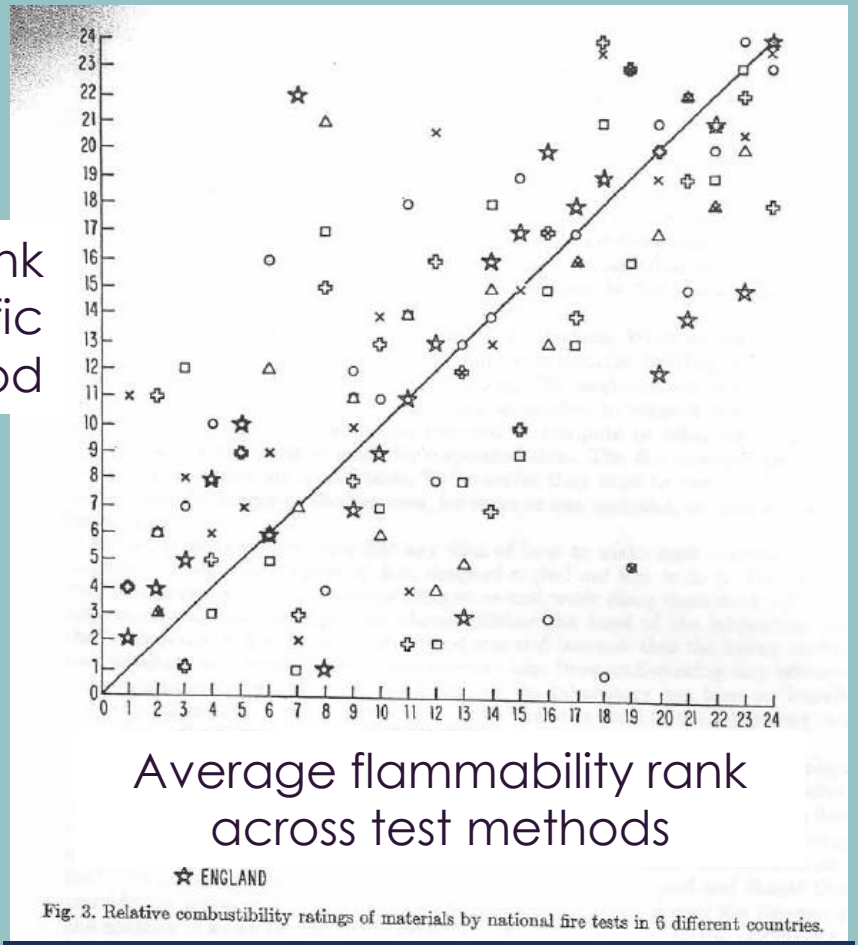
Differences in facade tests

- Geometry:
  - Corners
  - Size
  - Openings
- Ignition source:
  - Fuel type + amount
  - Location
  - Wind



How consistent are different test methods?

Flammability rank from a specific test method



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?

Does flammability vary more between different facade build-ups (**internal properties** and **interactions**) or between different test standards (**external conditions**)?

Choice of facades

More fuel

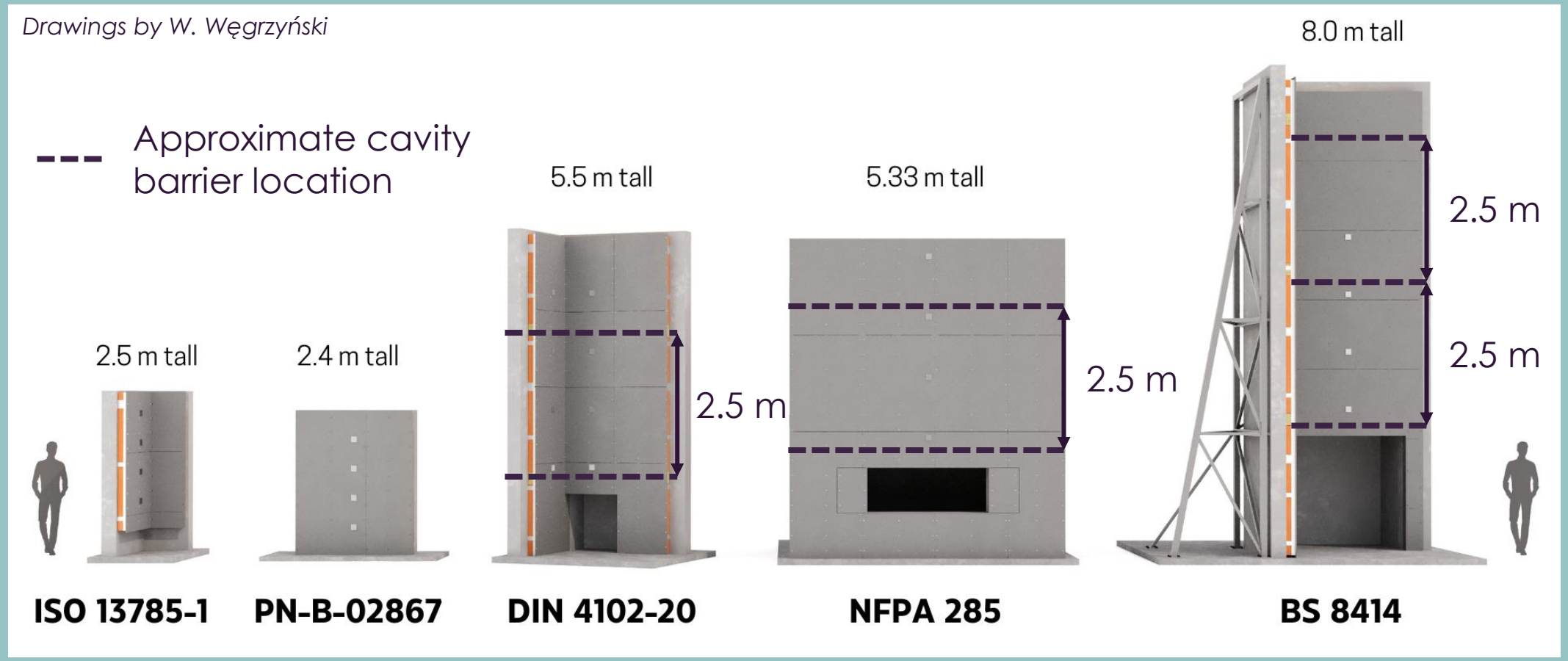
Facade type	Outer layer	Insulation
ETICS	Render	Mineral wool
ETICS	Render	EPS
Rainscreen	Cement board	Phenolic foam
Rainscreen	HPL	Mineral wool
Rainscreen	HPL	Phenolic foam

$$U = 0.37\ \mathrm{W/m^2K}$$

Choice of facades

Drawings by W. Węgrzyński

Choice of facades



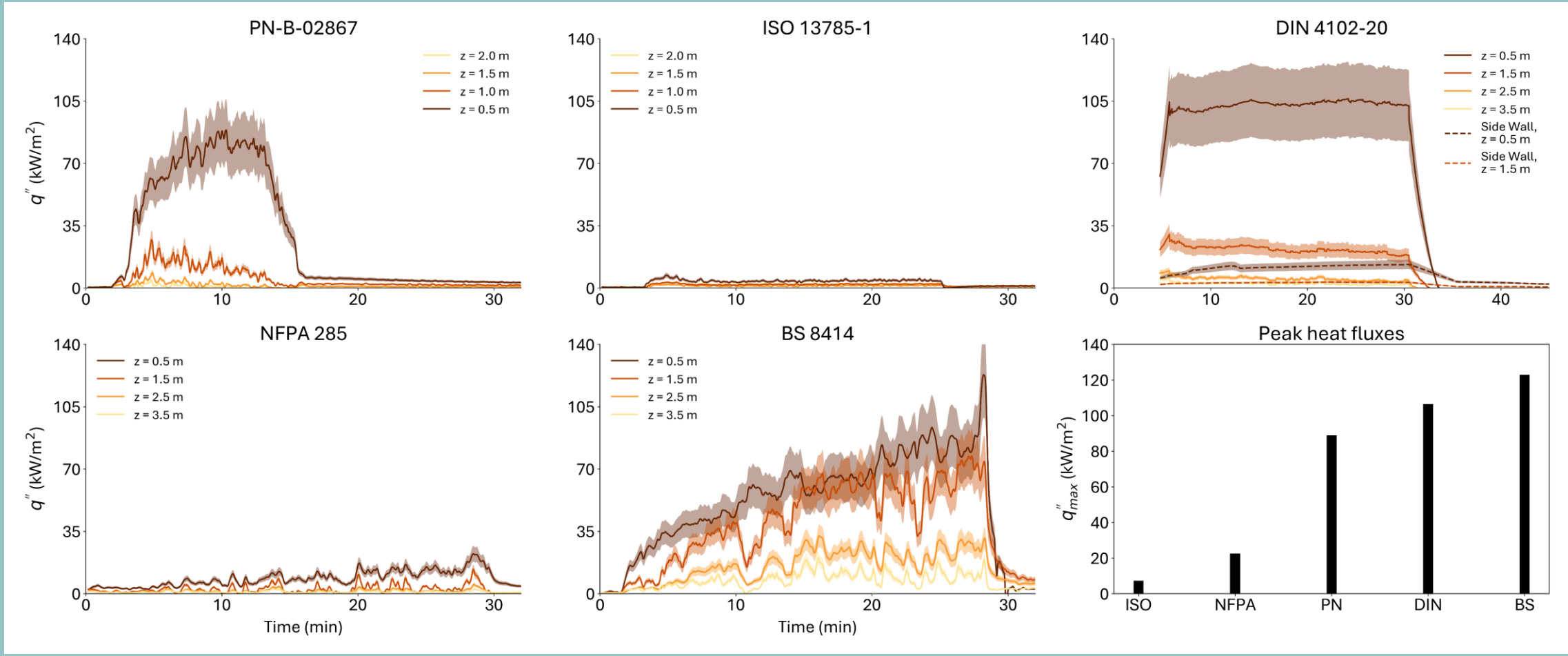
Choice of instrumentation

- Cameras
- Thermocouples
- Plate thermometers

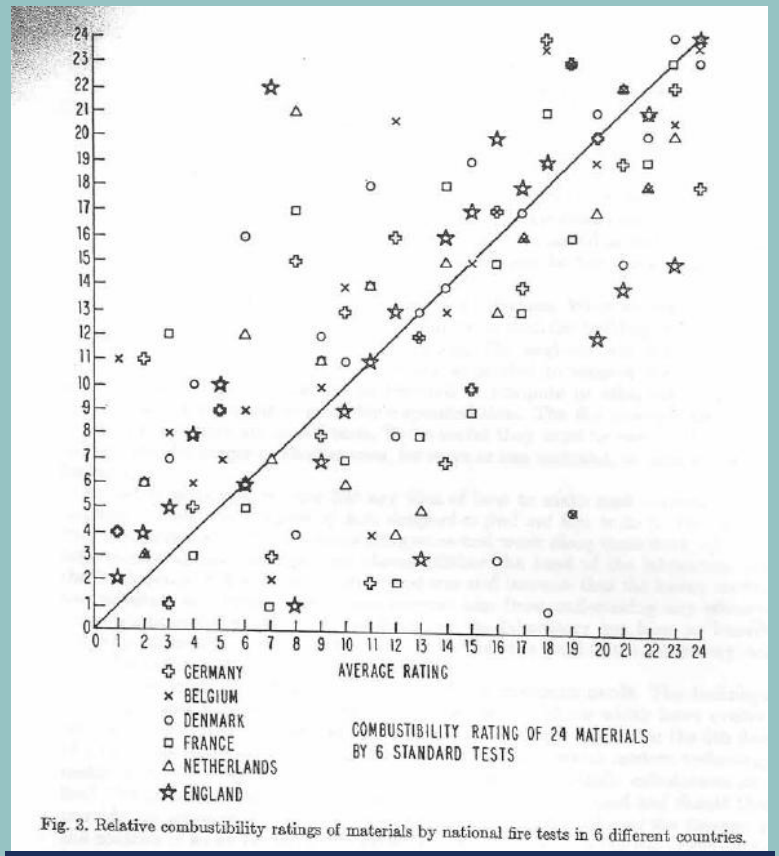
Choice of instrumentation

- Heat flux from ignition source, q''
- Average flame spread rate, S
- Average reconstructed heat release rate, Q

Heat flux from ignition source, q''



Measuring consistency



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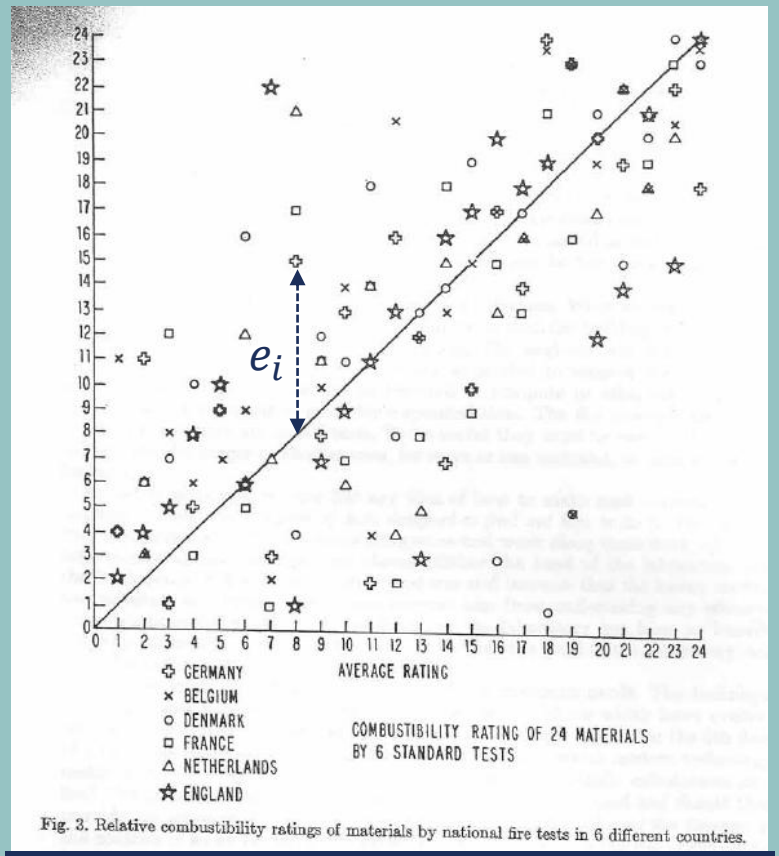
Measuring consistency



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Mean absolute error (MAE):

$$MAE = \frac{\sum_{i=1}^{n} |e_i|}{n}$$

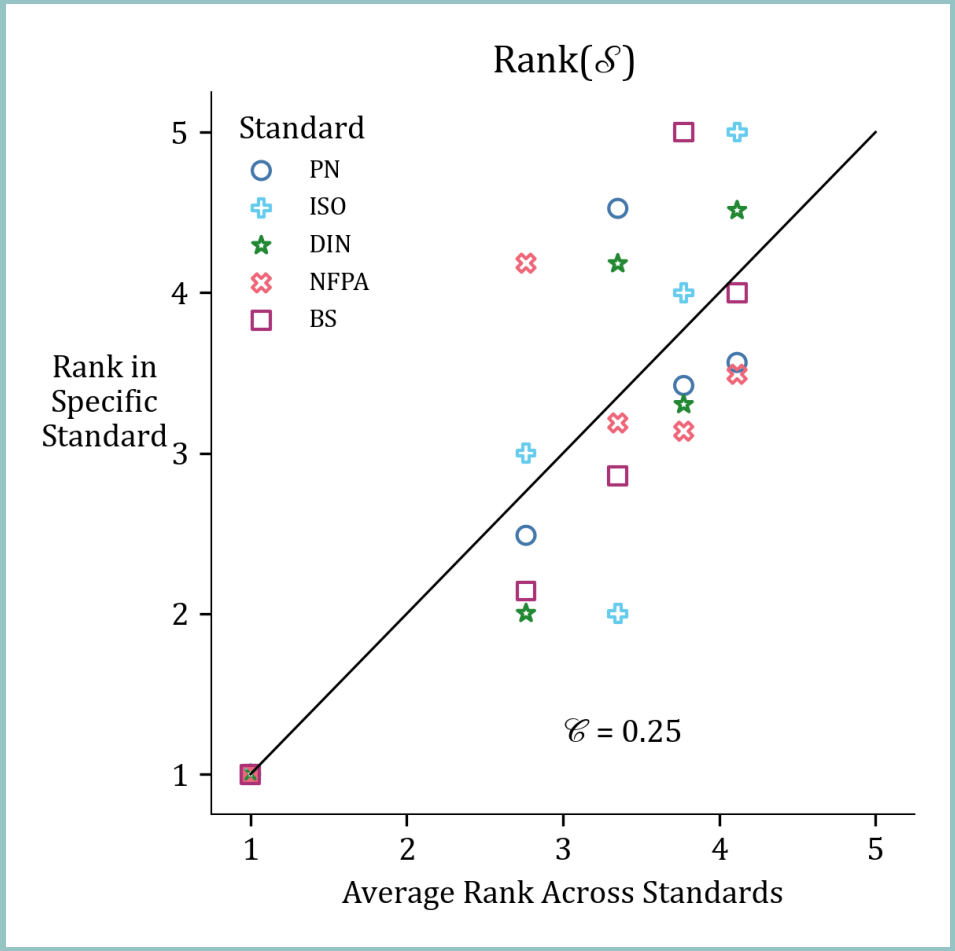
Consistency:

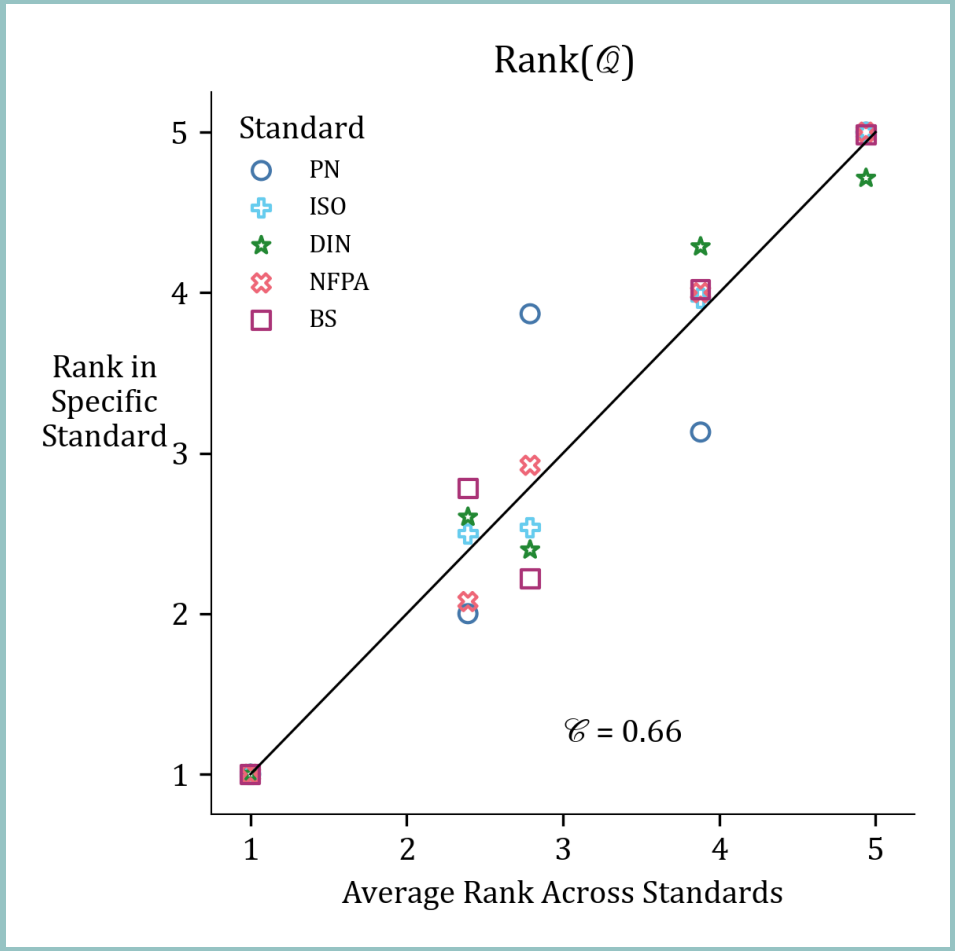
$$c_{\text{metric}} = 1 - \frac{MAE_{\text{metric}}}{MAE_{\text{max}}}$$

0 when maximally inconsistent

1 when all points fall on the diagonal line

Consistency depends on the metric used





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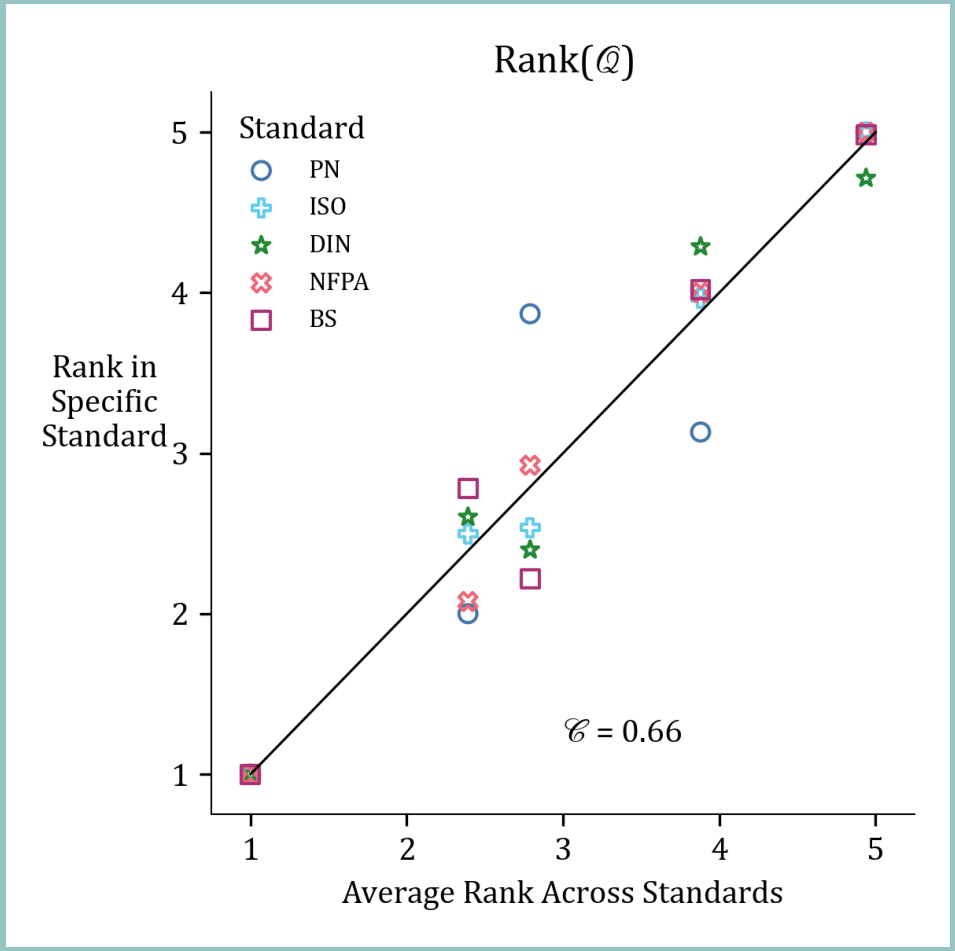
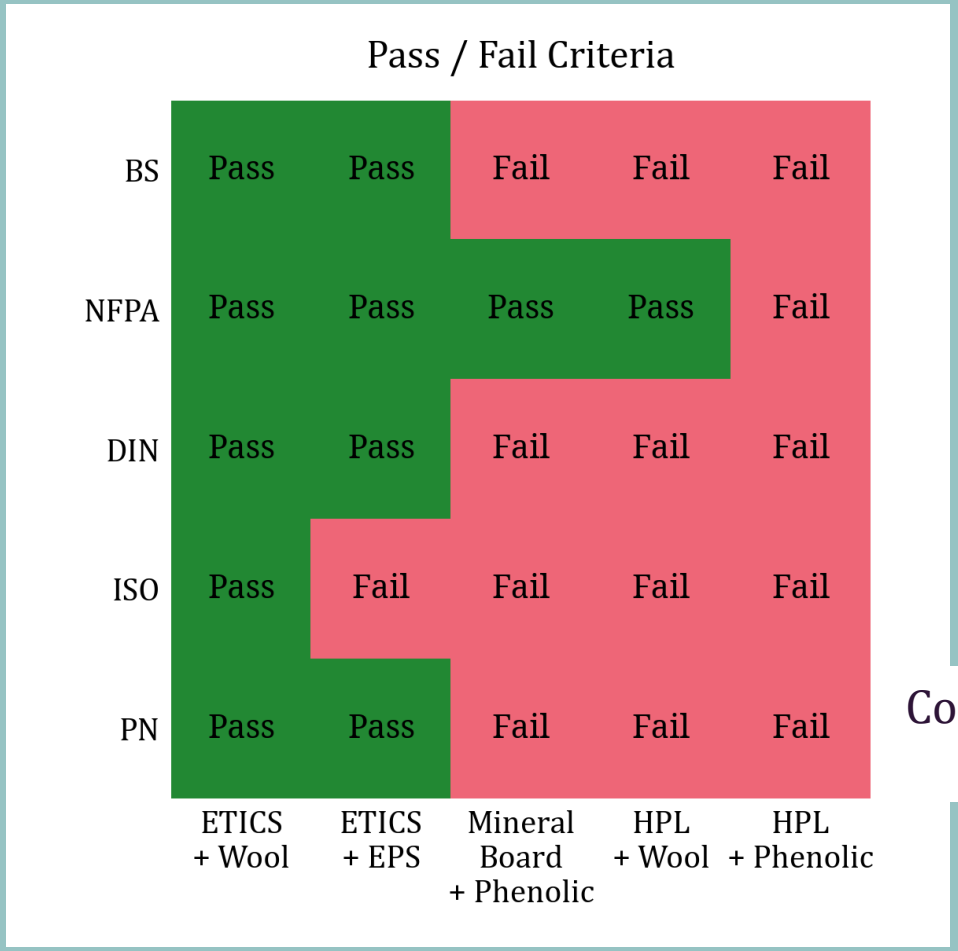
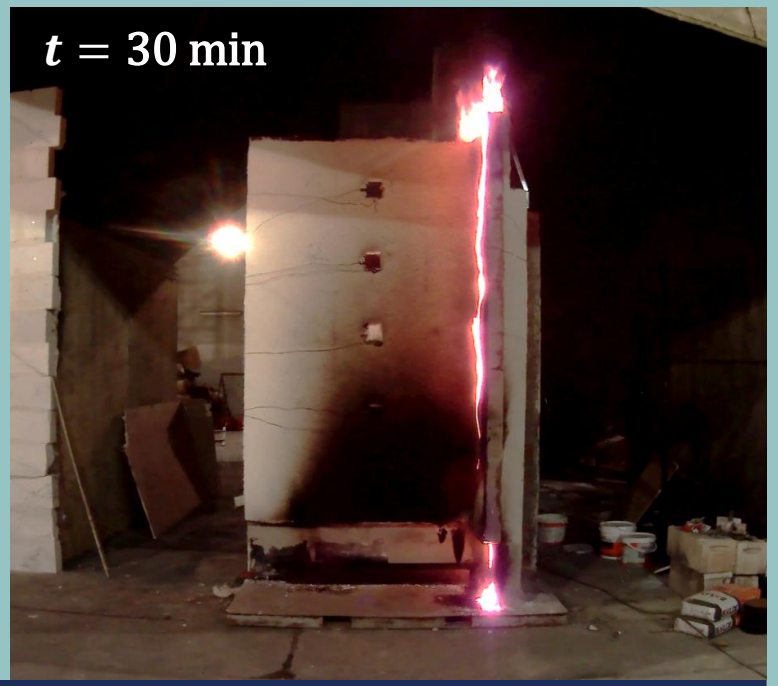
Consistency vs pass/fail criteria





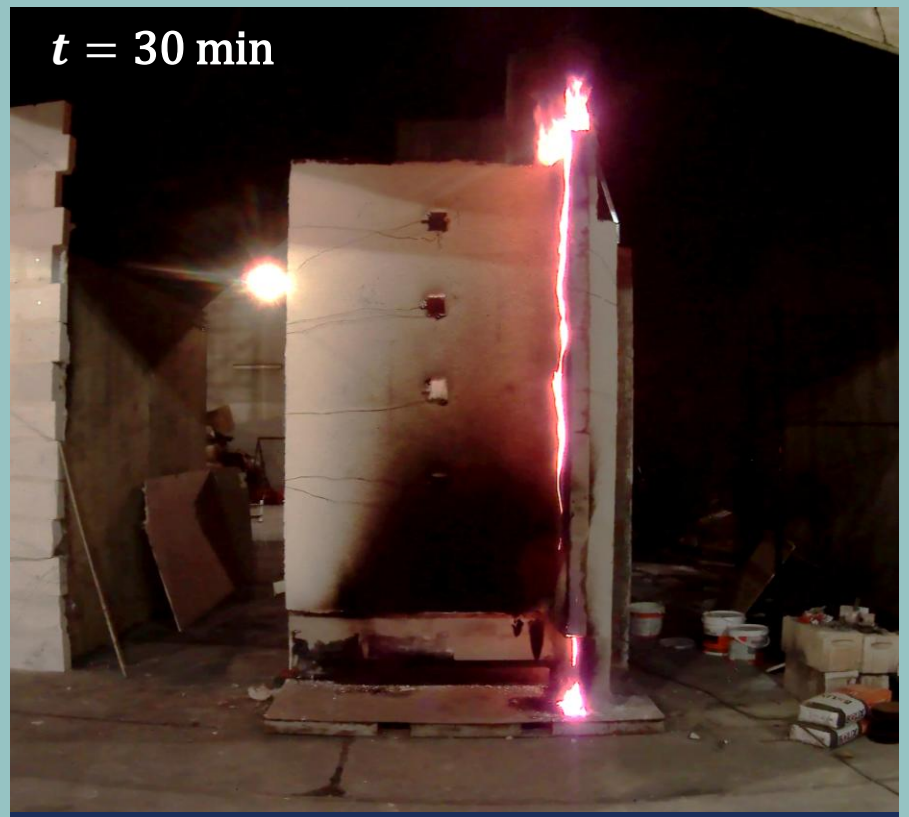
Consistency = 0.5

Beyond metrics

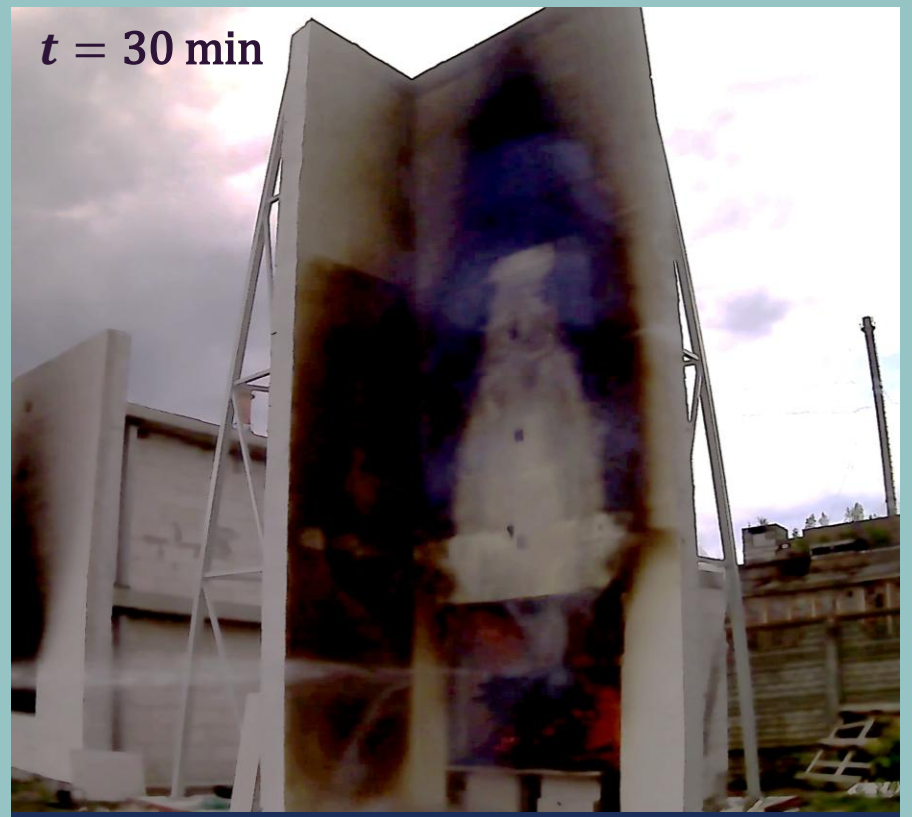


ISO 13785-1

Beyond metrics



ISO 13785-1



BS 8414

Summary

- Consistency between different standards depends on your choice of metric (0.25 for flame spread rate vs 0.66 for heat release rate)
- Pass/fail criteria for each test do not increase consistency (a consistency of 0.50 vs 0.66 for heat release rate).
- Some behavior cannot be easily captured by any single metric.
- Raises the question: What do we expect from these tests?

What do we expect from these tests?

- To rank relative flammability of facades?
  - Based on these experiments, expensive tests may not be necessary.
  - Need to agree on how to measure flammability.
- A guarantee that a facade has an acceptable level of risk?
  - Dependent on the context in which the facade is used.
  - Need to move beyond binary classification.
  - How are we sure that we have tested a “reasonable worst-case”?
- For a competent person to extrapolate from?
  - Need to agree on how to extrapolate.
  - Need to agree on what performance-based objectives to use.

Thank you for listening!

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References and further reading

[1] M. Bonner et al., Flammability of facades across scales and international standards, Proceedings from the 4th International Symposium on Fire Safety of Facades, 10–12 June 2024.

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