FIRE EXPERT

Interreg SLOVENIJA – AVSTRIJA
Evropska unija | Evropski sklad za regionalni razvoj

Experimental methods in fire research and product certification

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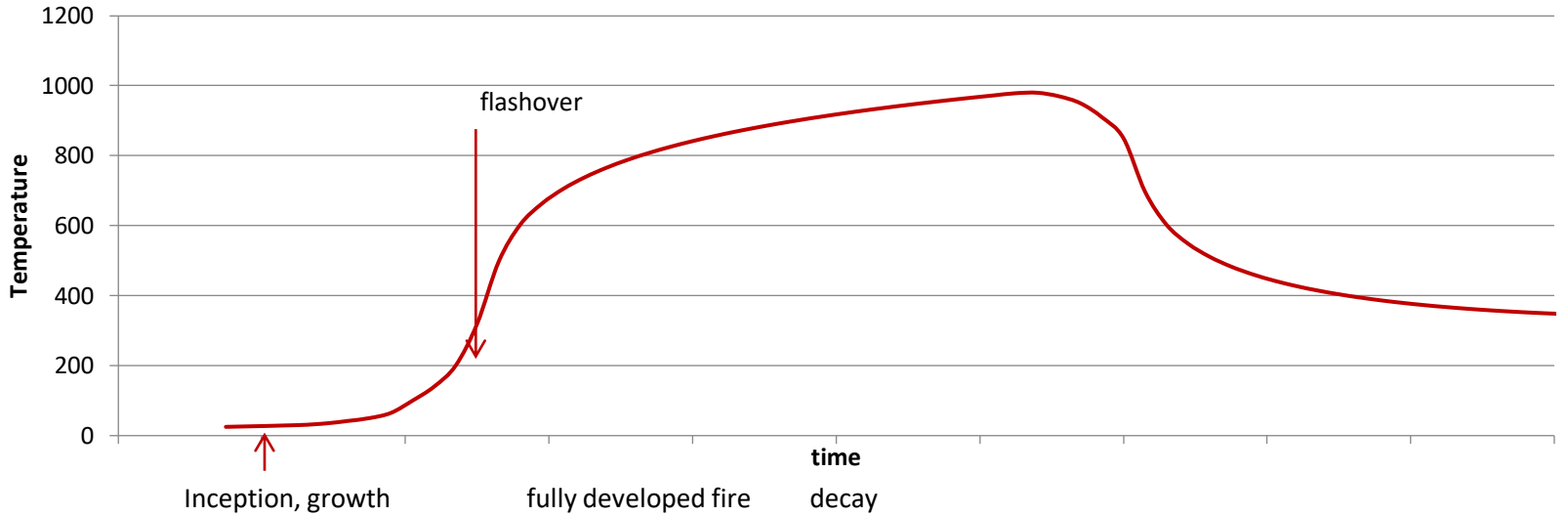
SZPV

ZDRUŽENJE ZA BETON SLOVENIJE ZBS

Fire as a phenomenon

- Fire is basically oxidation of fuel
  - Normally fuel is decomposed, creating flammable gases
- Three major factors, controlling fire dynamics
  - Fuel
  - Temperature to support reaction
  - Oxygen

Fire



Stage	growth	Fully developed	decay
Characteristic	Fuel controlled	Ventilation controlled	Fuel controlled
People	evacuation	death	---
Detection	sensors	visual detection	---
Active control	extinguishers, sprinklers, firefighters	firefighters	
Passive control	Reaction to fire of materials in the room of origin	Fire resistance between the rooms	

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Fuel

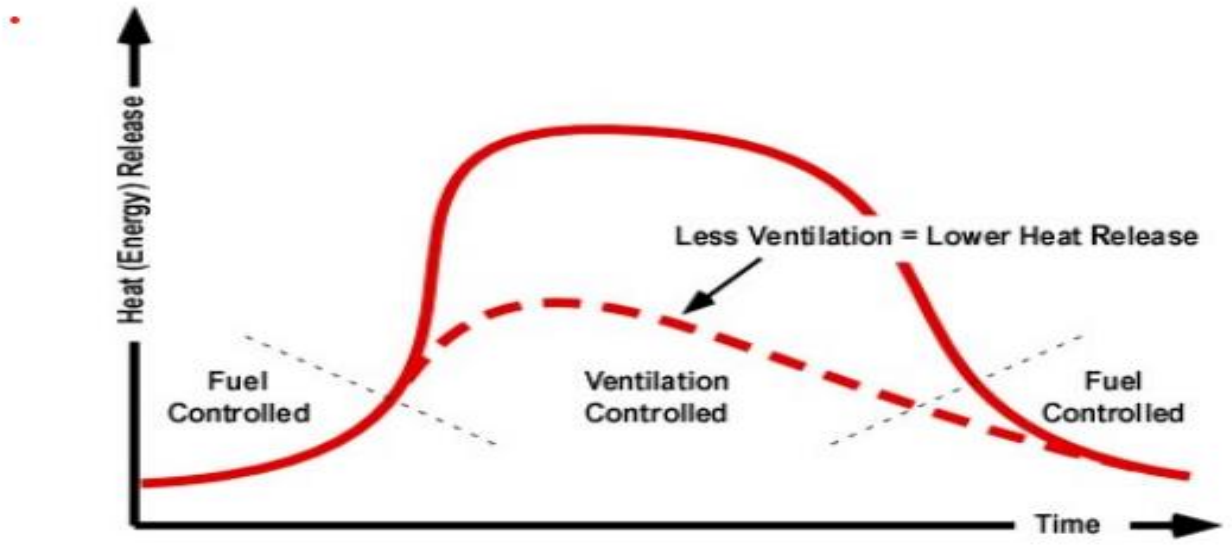
- Organic materials
- Different energy stored per unit of mass
  - Plastics 40 MJ/kg
  - Wood 17 MJ/kg
- Different temperatures of fuel to sustain burning
  - e.g. wood 120°C – 180°C with external starting to ignite flammable gases, 400°C without external starting

Temperature

- Temperature is needed to support processes
- Mainly the surface fuel temperature rises due to radiative heat flux
  - Incident heat flux may be as large as 150 kW/m^2
- In fire if is often easier to predict heat flux than temperature
  - Incident heat flux depends on number of factors, dominated by (average) surface temperature of the surroundings
  - Emissivity in solids and soot in fire is close to 1, emissivity of gases is rather different
  - Important factor is also view-factor
  - Also absorption (water, CO_2) and even secondary radiation may take place
  - Conclusion: heat transfer in fire is rather complex

Oxygen

- Oxygen is available in air, nominally 20,95%
- In fully developed fire oxygen availability is reduced, down to roughly 5%
- Oxygen deprivation may cause injuries, but it is not most decisive affect on humans



http://cfbt-us.com/pdfs/FBIandFireDevelopment.pdf

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Fire stages (ISO 19706)

Note:

- Oxygen governs progress between stages
- V_{CO}/V_{CO2} highest in smouldering
- Highest heat flux post flashover
- Most casualties in fire are due to suffocation / toxic gases, not due to temperature load or oxygen deprivation

Fire stage	Heat (kW m^{-2})	Max Temp (°C)		Oxygen (%)		Equivalence ratio (ϕ)	V_{CO}/V_{CO_2}	Combustion efficiency (%)
		Fuel	Smoke	In	Out			
Non-flaming								
1a. Self sustained smouldering	n.a.	450–800	25–85	20	0–20	–	0.1–1	50–90
1b. Oxidative, external radiation	–	300–600		20	20	–		
1c. Anaerobic external radiation	–	100–500		0	0	–		
Well ventilated flaming								
2. Well ventilated flaming	0–60	350–650	50–500	~20	0–20	<1	<0.05	>95
Under ventilated Flaming								
3a. Low vent. room fire	0–30	300–600	50–500	15–20	5–10	>1	0.2–0.4	70–80
3b. Post flashover	50–150	350–650	>600	<15	<5	>1	0.1–0.4	70–90

Passive control of fire

- Reaction to fire
  - Better the reaction to fire of exposed surfaces (structures) the slowest fire growth rate
  - If surfaces are non-combustible the contribution to fire growth is low – no flashover
- Fire resistance
  - The room of fire origin is lost, protecting spread to other sectors
  - In principle it is possible to build fire resistant structures that withstand fire for very long time (e.g. 4 hours), but
  - Usually such structures are not needed or designed

Fire properties and the market access

Construction products must comply to legislation

- Harmonized
  - Most products, but
  - Important products, e.g. fire doors, fire glazing, are still not harmonized
- Non-harmonized
  - National rules

- Sometimes additional rules for installation apply

Harmonized technical specifications (hTS)

- Developed based on the EC mandate
- Harmonized once they are published in the OJ
  - Currently there is a stall in harmonization
- Harmonized technical specifications are:
  - Harmonized standards (e.g. EN 14509, EN 12101-2, EN 1856-1, EN 13241,… special standard for fire doors and gates - EN 16034)
    - https://ec.europa.eu/docsroom/documents/38863/attachments/1/translations/en/renditions/native
  - European assessment documents (EADs)
    - Found at www.eota.eu

AVCP system

- Defined in hTS
- Multiple choices
  - AVCP 1:
    - RtF A1/A2, B, C if there is possibility to influence RtF during production
    - FR in some (most) products, such as fire doors, NSHE, MSHE, Ducts,… In some case (e.g. sandwich panels acc. To EN 14509 multiple choices exist)
  - AVCP 3:
    - RtF A1/A2, B,C (if not in AVCP 1) D, E
    - Rare in FR
  - AVCP 4:
    - RtF e.g. materials of CWFT (classified without further testing)
- For some products Commission decisions define “default” RtF class

Manufacturer – what to do

- If AVCP 1 applies: contact Notified certification body (e.g. ZAG). They will perform / define sampling and ask Fire laboratory to do the testing
- If AVCP 3 applies: sample products yourself (make sure you have an appropriate record), find a notified laboratory (e.g. ZAG) and submit the product to the test
- If AVCP 4 applies: do the sampling and the testing (select any laboratory as long as testing is correct)

Specialty in fire - classification

- EN 13501-1,-2,-3,-4,-5
- Based on test or tests and possibly “extended field of application” rules the classification reports summarize results in a (relatively) clear range of products and the valid class, e.g.:
  - B-s2,d0 (example for reaction to fire according to EN 13501-1), or
  - EI_2 30 – C0 (example for fire door, according to EN 13501-2)

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IMO

- Maritime testing is to an extent similar to construction products, classification is rather different
- Testing / classification according to FTP Code 2010

TESTING at ZAG

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Construction	Standard
Reaction to fire	SIST EN 13823, SIST EN ISO 1182, SIST EN ISO 11925-2, SIST EN ISO 1716, SIST EN ISO 9239-1
Fire resistance	SIST EN 13381-1, SIST EN 13381-4, SIST EN 13381-6, SIST EN 13381-8, SIST EN 1364-1, SIST EN 1364-2, SIST EN 1364-3, SIST EN 1364-4, SIST EN 1365-2, SIST EN 1365-3, SIST EN 1365-4, SIST EN 1366-1, SIST EN 1366-10, SIST EN 1366-2, SIST EN 1366-3, SIST EN 1366-4, SIST EN 1366-5, SIST EN 1366-6, SIST EN 1366-7, SIST EN 1366-8, SIST EN 1366-9, SIST EN 14135, SIST EN 1634-1, SIST EN 13381-2, SIST EN 13381-3, SIST EN 13381-5, SIST EN 13381-7
External fire performance	SIST-TS CEN/TS 1187

IMO	FTP Code
Part 1	Non-combustability test
Part 2	Smoke and toxicity test
Part 3	Test for 'A', 'B' and 'F' class divisions
Part 8	Test for upholstered furniture
Part 19	Test for bedding components
Part 11	Test for fire-resisting divisions of high-speed craft

Fire resistance testing

- Horizontal and vertical test samples
- Load bearing and non-loadbearing
- Linear, flat and 3D samples
- REI t – basic classes
- Additional properties
- Basic standards:
  - EN 1363 series (general)
  - EN 1364 series (non loadbearing)
  - EN 1365 series (loadbearing)
  - EN 1366 series
  - EN 1634 (fire doors / gates)
  - EN 12101series
  - EN 1856-1,-2
  - EN 13381 series…

Vertical partitions

EN 1364-1

- Temperature on the unexposed side
- Heat flux, radiated
- Flame, openings

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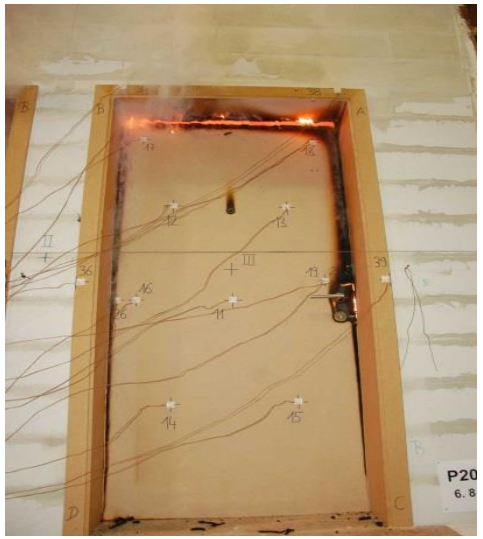
Doors and windows

EN 1634-1

- Temperature on the unexposed side
- Flame, openings



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Horizontal structures

EN 1365-2

- Temperature on the unexposed side
- Loadbearing capacity
  - Maximum deformation
  - Rate of deformation
- Integrity (Flame, openings)

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Protection of loadbearing elements

Series EN 13381

- Thickness uniformity
- Temperature on the steel structure member (EN 13381-8)
- Very sensitive in installation conditions. Issue: durability???




Ducts, SHE (smoke and heat extraction)

EN 1366-1, EN 1366-8, EN 1366-9

- Temperature on the unexposed side
- Leakage
- Mechanical stability
- Flame, openings

Natural SHE

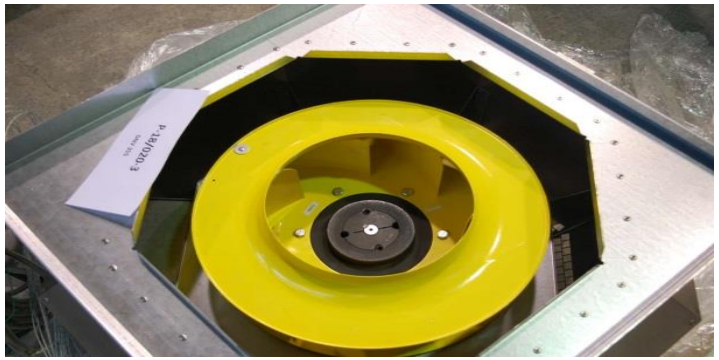
EN 12101-2

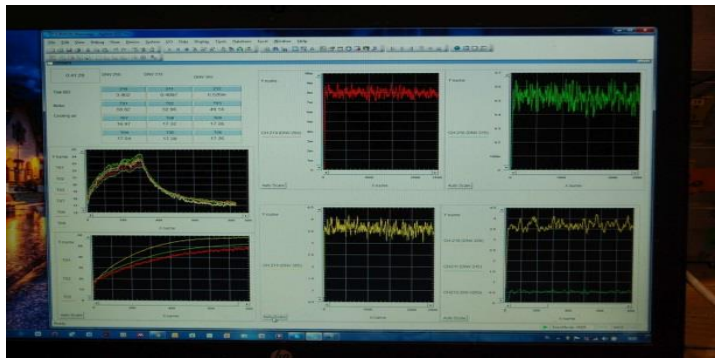
- Functionality – opening after 5 minutes
- Flame, openings size
- Droplets

Mechanical SHE

EN 12101-3

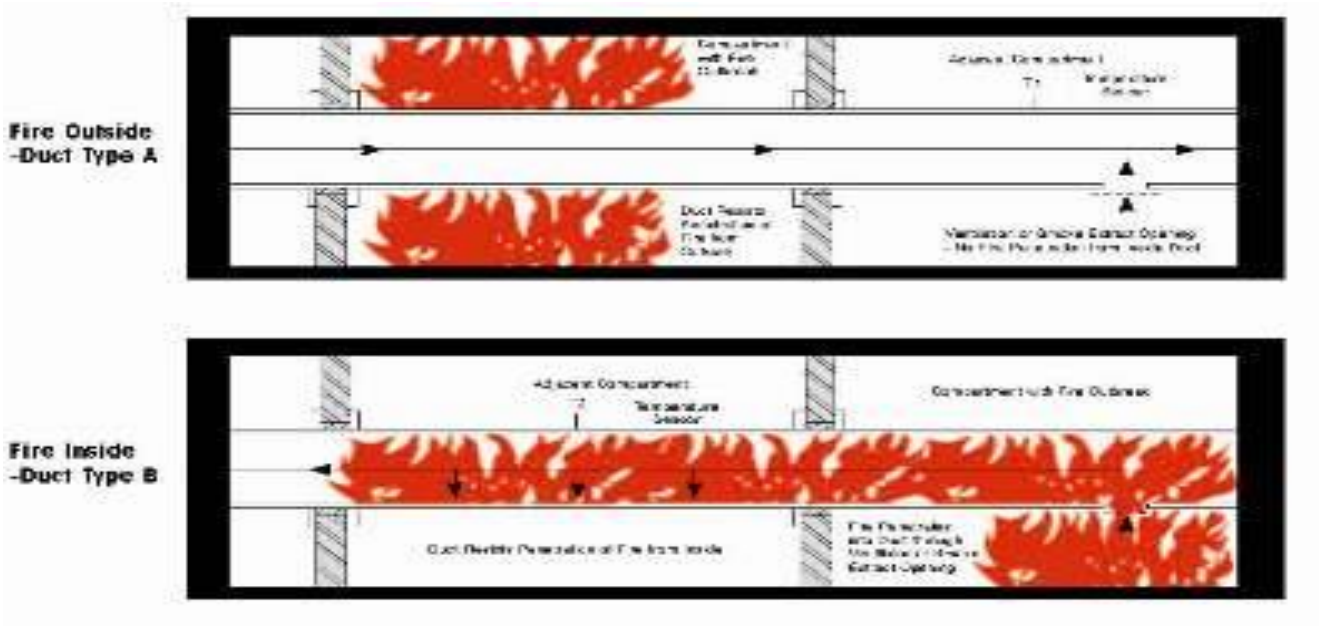
- Functionality (sustaining airflow throughout fire)





Ducts

- Horizontal, vertical
- Rigid, flexible structure penetrated
- Duct type A and B



http://www.fireprotection.co.uk/news/archive/fire_rated_ductwork_and_bs9999_explained/

Reaction to fire

- Euroclasses
  - Main classes: A1, A2, B, C, D, E, (F)
  - Additional parameters: d, s
  - No parameter for toxicity of gases
- Meaning
  - A1/A2 – non-combustible: no contribution or negligible contribution to fire
  - B, C – combustible: limited / acceptable contribution to fire
  - D, E – medium / high contribution to fire
  - F – does not meet requirements for classes A1/A2-E, flammable

Non-combustibility and PCS value

EN ISO 1182

- Temperature rise
- Flaming
- Mass loss

EN ISO 1716

- PCS value

SBI test

EN 13823

- Classes A2-D
- Fire growth rate (FIGRA)
- Total heat release (THR)
- Lateral flame spread (LFS)
- Smoke growth rate (SMOGRA)
- Total smoke production (TSP)
- Flaming droplets/particles

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SBI test

Small flame

EN ISO 11925-2

- 15 or 30 seconds exposure
- Flame height
- Droplets

Roofs

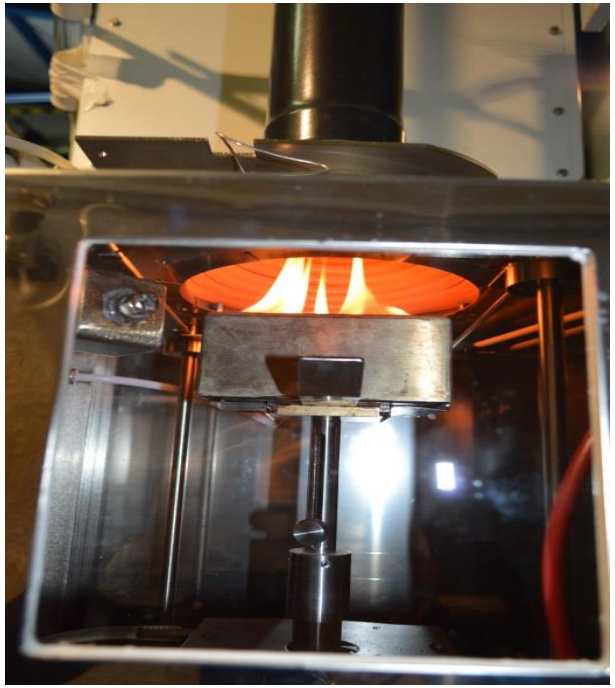
ENV 1187, test 1

- Damage
- Flame spread

Other tests…

- Chimneys
- Special testing (fire suppression systems)
- Electric cables
- IMO testing (International Maritime Organization)
  - Structures
  - Materials

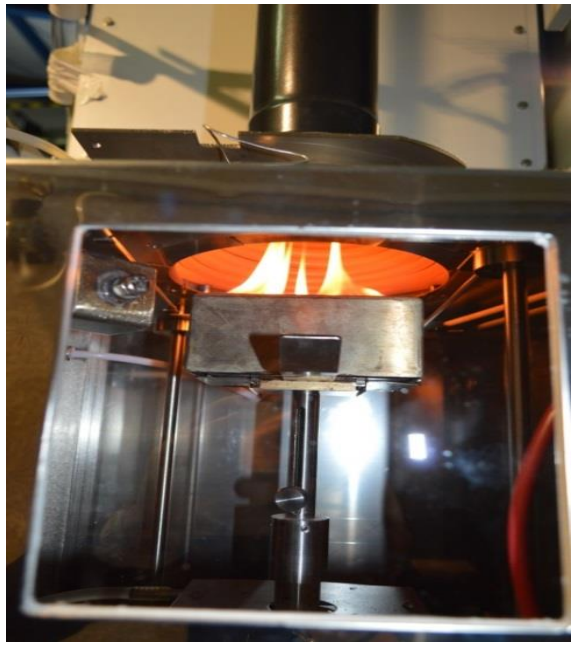
Research in fire



Cone calorimeter

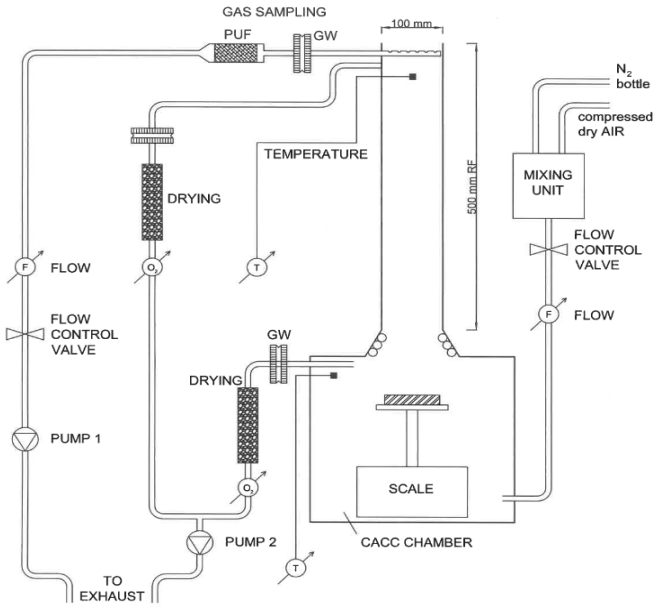
- Research tool
- Assess combustion dynamics
- Firesim software
- Connection to FTIR
- FED calculation

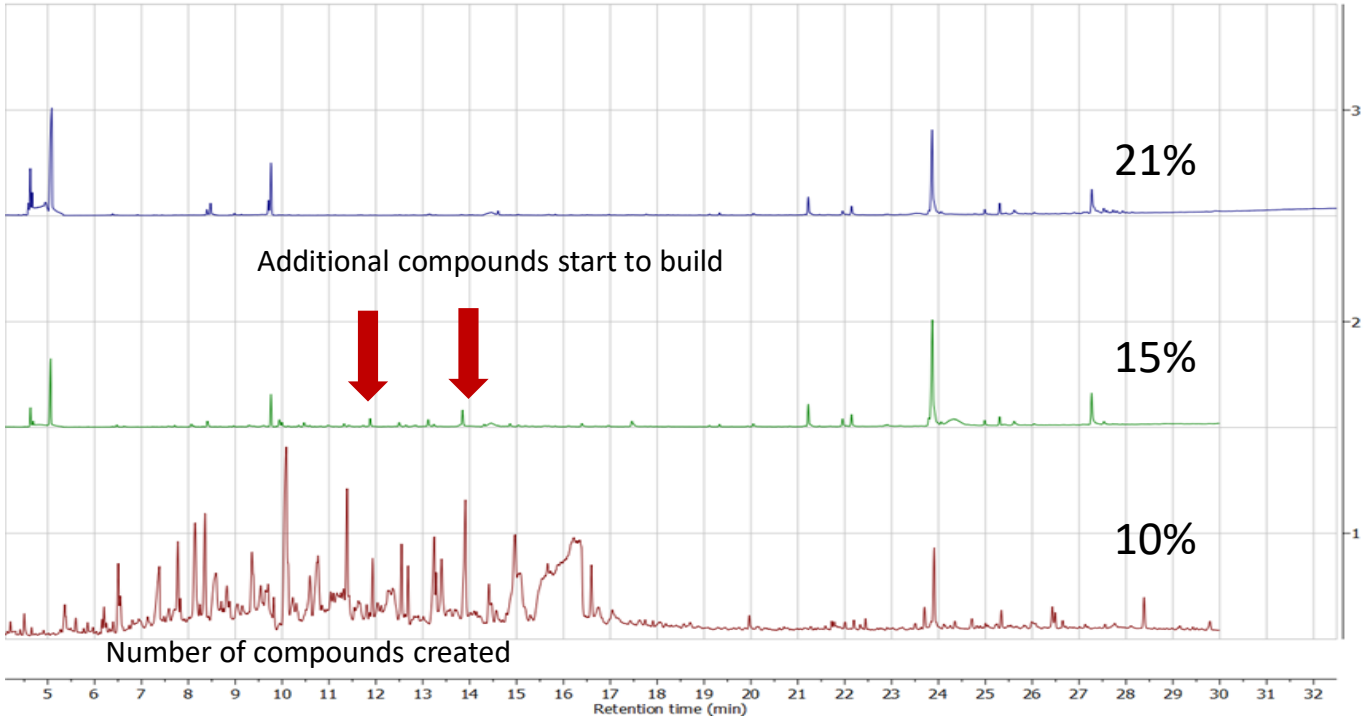
“Modified – controlled atmosphere CC”



- Possibility of tracking oxygen concentration along the fire effluents path (using paramagnetic sensors)
- 3 continuous channels, up to 12 tracked sampling lines

M-CACC / CC – fire effluents under different conditions





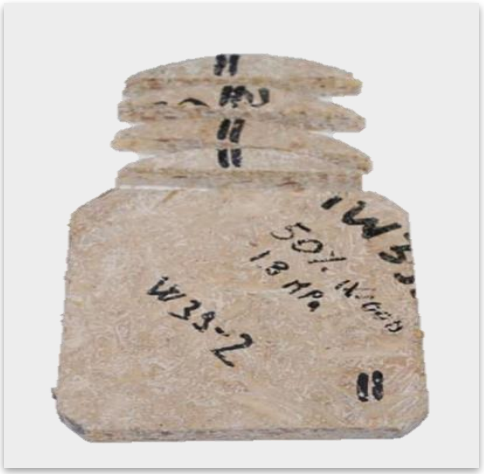
- Importance: prior to flash-over relatively low number of compounds. Key compounds for toxicity: CO in HCN
- After flash-over many compounds are created, some having (significant) contribution to chronic toxicity.

M-CACC - towards toxicity and ecotoxicity

- Testing on isopods and plants
- Steps towards assessment of ecotoxicity
  - Very few available papers so far

Wood

- Behaviour of modified wood
  - Mineralization of wood
  - Thermal modification
  - Composites (e.g. for 3D printing)



Wood

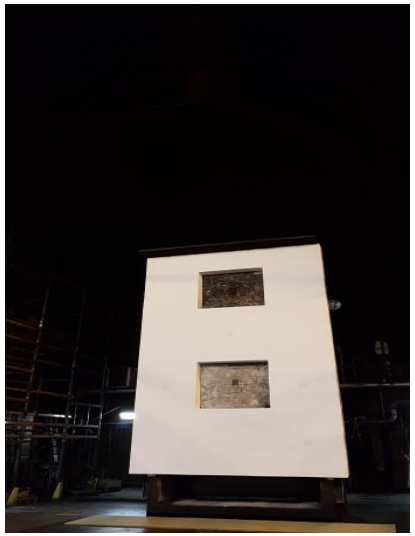
- Structural research
- Burning rate / charring rate
- Ambition: transfer small scale test results to large scale data

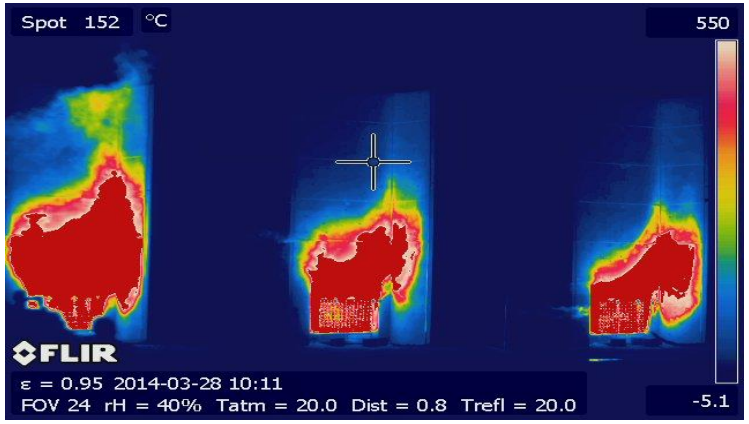
Large scale testing

Facades

- **Details**
- Temperature
- Heat flux

Modular buildings





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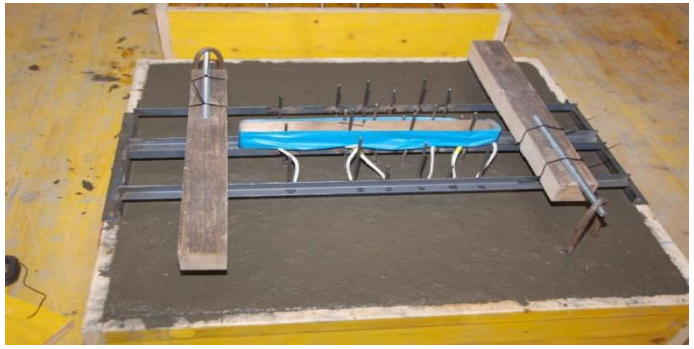
Spalling (concrete)

- Test according to EN 1363-1
- Embedded thermocouples
- Acoustic emission



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THANK YOU FOR YOUR ATTENTION

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