*Date: July 3rd 2018*
*Place: Ohrid, Macedonia*

# Knowledge FOr Resilient soCiEty

## CONSORTIUM MEETING

**NUZOP**
**Nacionalno Udruzenje Zastite Od Pozara**
**Serbian fire protection association**

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# Fire Safety of Facades
# – Comparative analysis of technical rules at WBC

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# Introduction / Background

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1st innovation of humanity

# Oldest threat

# What is fire?

Fire is uncontrolled combustion, characterized by heat release accompanied by smoke or/and flames, that can harm people and their health, environment and damage material and goods

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# Fires are faster …


**25 minutes**

**1950**

**3 minutes**

**TODAY**

Source: FSEU

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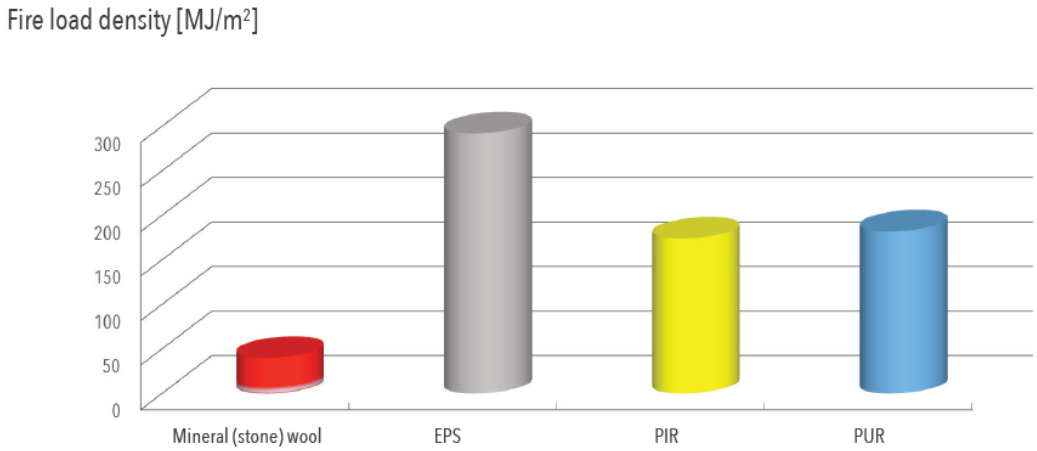
# … because …

- Buildings are changing
  - New materials
  - Modern technologies
  - Bigger and taller buildings
- Regulations are changing
  - EPBD and EED
    - Revised EPBD adopted on April 17th 2018 by EP: member states to address fire safety




Source: Fire protection of faced – guideline

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# Case in point

Fires involving façade systems in recent years

- In many of these fires the use of combustible materials caused rapid flashover and fire spread and intense smoke production

**Dijon 2010**
**7 dead**
**11 injured**

**Roubaix 2012**
**1 dead**
**250 evacuated**

**Dubai 2015**


**Duisburg 2016**
**3 dead**
**28 injured**

**London 2017**
**80 feared dead**

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# Dijon, France 2010 / Miskolc, Hungary 2009


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# Grozny City Towers, Russia 2013


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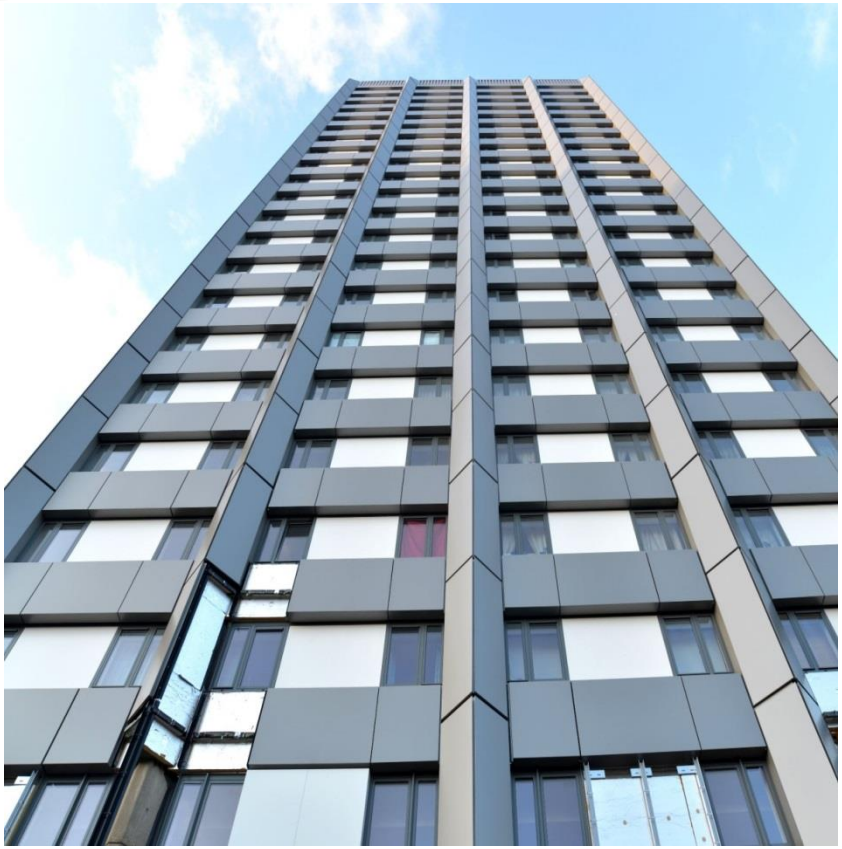
# London Grenfell Tower, UK 2017



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# Grenfell Tower – closer picture

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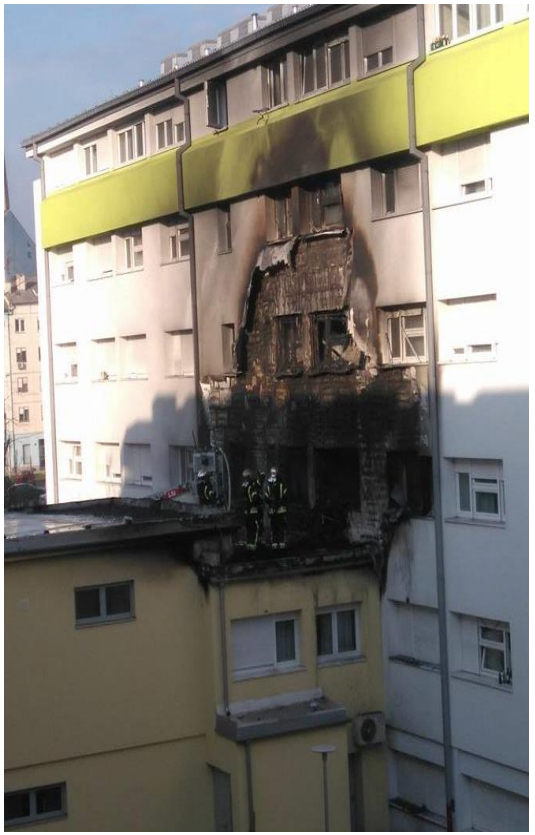
# Zagreb dorm, Croatia 2017



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Belgrade, Serbia 2016

PRETRAGA
Vatrogasci su pretraživali cijelu zgradu tražeći moguće žrtve trovanja

21 | 24SATA | NEWS | NEDJELJA 26. 10. 2014.

# Kaos u Beogradu: Nakon svađe ukućana gorjela četiri stana u neboderu

**Vlasnica stana u Novom Beogradu primila je beskućnika u svoj dom na četvrtom katu nebodera.**

Između njih dvoje jučer ujutro izbila je žestoka svađa nakon koje je beskućnik razbio staklo na ulaznim vratima u zgradu, a potom i ogledalo u liftu. Vidjevši to stanari su pozvali policiju, a 40 minuta poslije u stanu gdje se odvijala svađa izbio je požar. Vlasnica stana u tom trenutku nije bila kod kuće jer je, kako prenosi srpski Blic, nakon svađe skoknula do kladionice. Na teren je izašlo pet vatrogasnih vozila, a član vatrogasne brigade Beograd Slaviša Karadžić rekao je da se požar proširio na još tri stana. Ozlijeđena je studentica koja živi u unajmljenom stanu na sedmom katu te jedna žena i dijete.

**Nasreću**, vatrogasci su požar brzo ugasili, a kažu da je cijela vertikala nebodera bila puna dima. Troje ljudi prevezeno je u bolnicu zbog trovanja ugljičnim monoksidom. Vatrogasci su pretraživali sve stanove na okolnim katovima i provjeravali ima li unutra ljudi sa simptomima trovanja. (jsč)

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# Skopje EVN, Macedonia 2016


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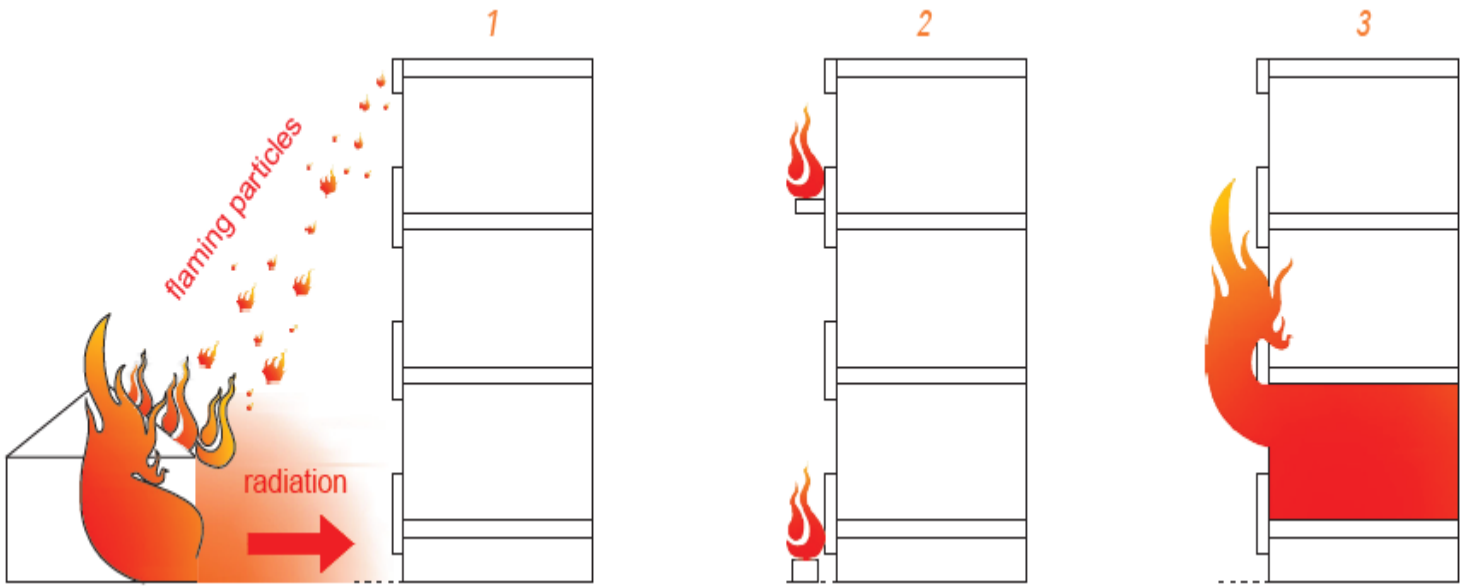
# Mechanisms of fire spread over facades

3 possible scenarios




Source: Fire protection of faced – guideline

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# Why focus on facades?

- The facades of buildings are changing
  - From the well known stone based exteriors to composite systems comprising insulation and an outer shell
  - These systems are excellent solutions to bring both insulation and architectural features to facades
- Regulations don’t follow Innovations
  - Many European countries have been struggling to keep their regulations and codes up to speed with new innovative materials
  - In addition there is little training and accreditation or supervision for this specialist work leaving too much room for error
- Fires make changes in Regulations
  - In recent years we have seen several façade fires in Europe and across the globe which have highlighted new risks that we hadn’t seen in the past
  - As a result of these fires many countries have tightened their regulations for facades specifically

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# Facades

- Definition
  - Façade is an elegant component of the building envelope that helps to define the unique architectural aesthetics of the building and it also has the critical role related to energy performance of a building
- Type of facades
  - ETICS (External Thermal Insulation Composite System)
  - Ventilated
  - Non-ventilated
- Function (as a part of building envelope)
  - Weather barrier against the environmental factors for air and water infiltration
  - Provides comfort and safety
    - Thermal comfort / energy saving
    - Sound comfort / protection from outside noise
    - Fire protection

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# Fire protection requirements for facades

**The objective** of fire regulation requirements for buildings in terms of fire protection of exterior wall is **to prevent the rapid spreading of a fire** (both horizontally but more important vertically) across more than one (a maximum of two) floor above or below the place where the fire breaks out prior to the fire brigade extinguishing the fire.

It must be ensured that **firefighters** are **not in danger** by extensive parts **of the building's facade falling** to the ground.

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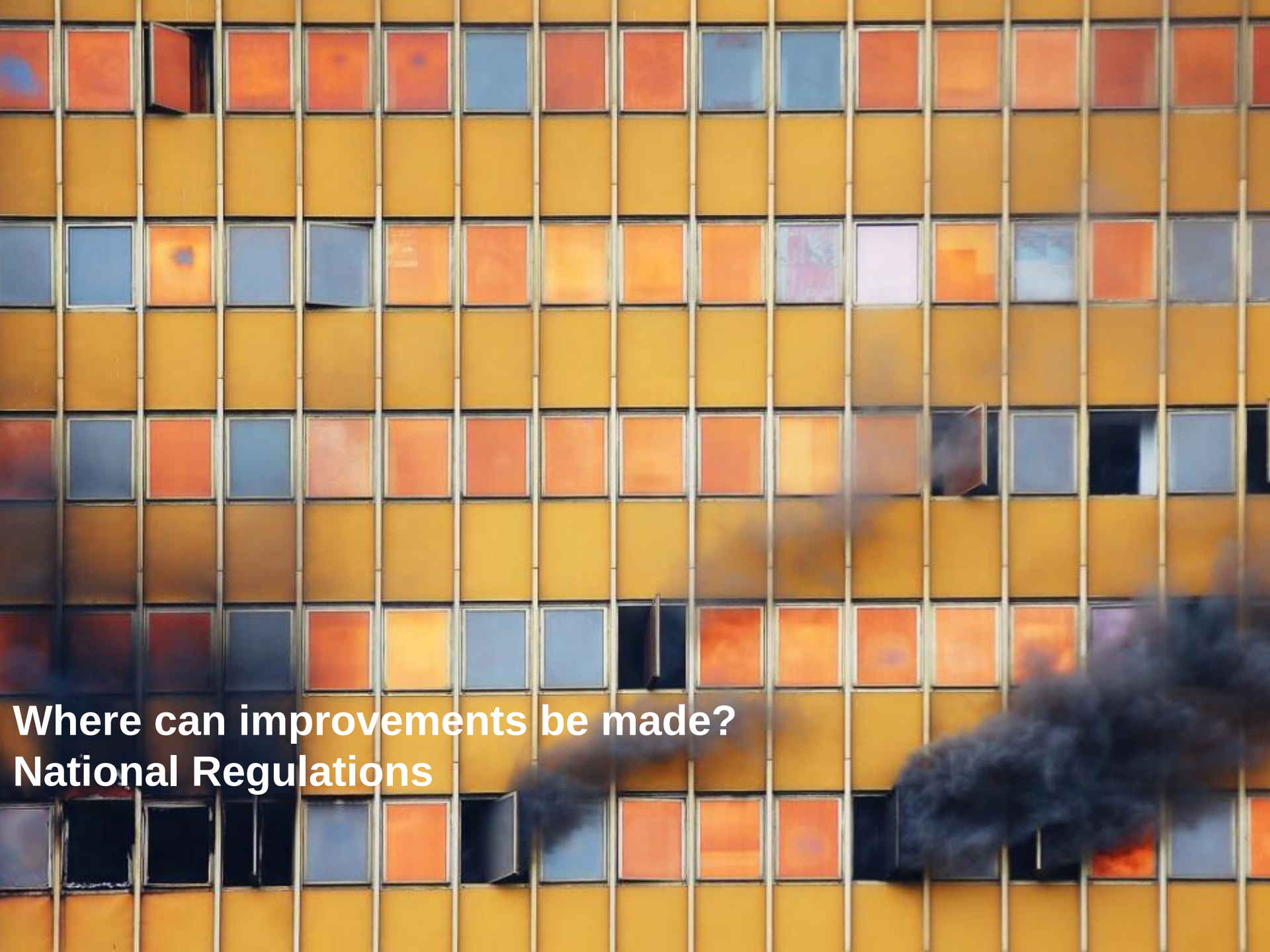

## Where can improvements be made?
## National Regulations

# Reaction to fire classification

## EN 135010-1

| Requirements for homogeneous building products [a] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Class** | **EN ISO 11925-2 (s)** | **EN 13823** | | | **EN ISO 1716** | | **EN ISO 1182** | | |
| | | **FIGRA (W/s)** | **LFS** | **THR $_{600s}$ (MJ)** | **PCS (MJ/kg)** | | **$\Delta T$ (°C)** | **$\Delta m$ (%)** | **$t_f$ (s)** |
| **A1** | | | | | 2,0 | and | ≤ 30 | ≤ 50 | ≤ 0 |
| **A2** | 30 (60 s, <150 mm) | ≤ 120 | yes | ≤ 7,5 | 3,0 | or | ≤ 50 | ≤ 50 | ≤ 20 |
| **B** | | | | | | | | | |
| **C** | | ≤ 250 | | ≤ 15 | | | | | |
| **D** | | ≤ 750 | | | | | | | |
| **E** | 15 (20 s, <150 mm) | | | | | | | | |
| **F** | No performance criteria | | | | | | | | |

[a] valid for non-homogeneous building products class E, D, C and B

**FIGRA – FIre Growth RAte**
**LFS – Lateral Flame Spread**
**PCS – gross caloric potential**
**THR$_{600s}$ – total heat release at 600 s**

**$\Delta T$ – temperature rise**
**$\Delta m$ – mass loss**
**$t_f$ – duration of sustained flaming**

# Additional classification

EN 135010-1

| Smoke production | | |
|---|---|---|
| **Class** | **SMOGRA ($m^2/s^2$)** | **TSP ($m^2$)** |
| **s1** | ≤ 30 | ≤ 50 |
| **s2** | ≤ 180 | 200 |
| **s3** | No performance is declared or do not comply with the s1 and s2 criteria | |
| **Building elements class A2, B, C i D gets additional classification** | | |

| Flaming droplets and/or particles | |
|---|---|
| **Class** | **According to EN 13823** |
| **d0** | No flaming droplets/particles occur within 600s |
| **d1** | No flaming droplets/particles, persisting longer than 10s, occur within 600 s |
| **d2** | No performance is declared or do not comply with the s1 and s2 criteria or the paper ignites according to EN ISO 11925-2 |
| **Building elements class A2, B, C i D gets additional classification** | |

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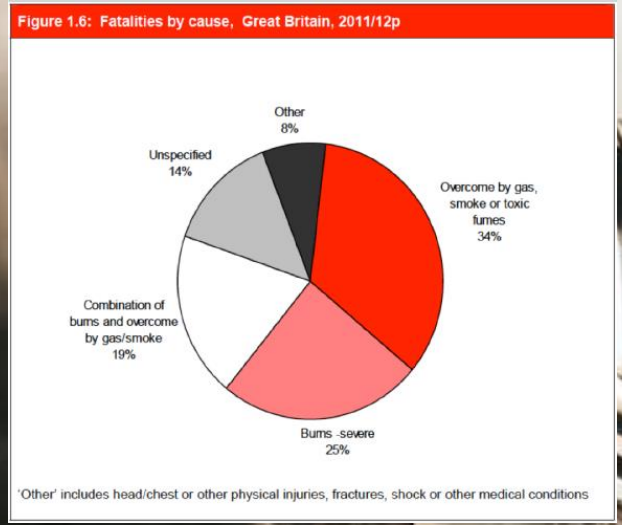
# Smoke toxicity

What about smoke toxicity?

- Cause of fatalities
  - Content of carbon monoxide, CO2 and other toxic gases:
    - Halogen flame retardants increase toxicity
    - Toxicity depends on materials and conditions of fire propagation
- Reduced visibility
- Fear, shock, panic
- How to quantify
  - Smoke toxicity classes: t1, t1, t3 ?

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# Elements for comparative analyses of regulation requirements for facades

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# Starting points

- Building category
- Type of facades
- Regulation requirements based on protection against fire spread along the facades:
  - Reaction to fire requirements of the materials on façade which influence the speed of fire spread on the envelope of a building
  - The existence of cavities in a façade (which are part of façade systems, e.g. ventilated facades)
  - Openings on a façade (windows, doors etc.)

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# Building key factors

- Building height
  - The higher the building, the higher the risk
  - Limited means of escape (often only one escape route!)
  - Limited means of fire fighting (only from the inside)
  - Typical for residential buildings

Conclusion: Stricter rules for high building; “High building” definition varies from country to country

- Building type
  - Based on the usage (e.g. public, commercial buildings)
  - The more people in the area, the higher the risk
  - The more vulnerable / disabled occupants, the higher the risk

Conclusion: Stricter rules for schools, hospitals, nursery homes, retail, cinemas, theaters, etc…

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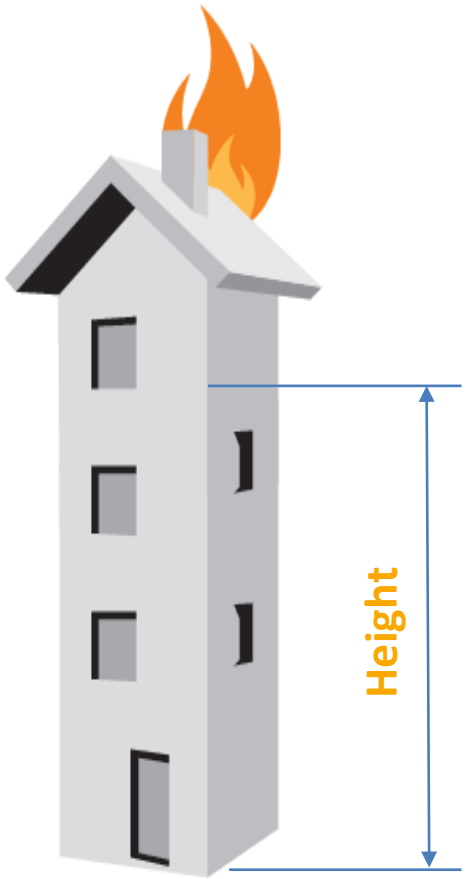
# Building split per category

- Important for defining fire safety requirements
  - Not to have only requirements based on the building height like in most countries
- To take in consideration all aspects
  - Height
  - Floor area
  - Number of people
  - Usage of building / type of occupants
  - …

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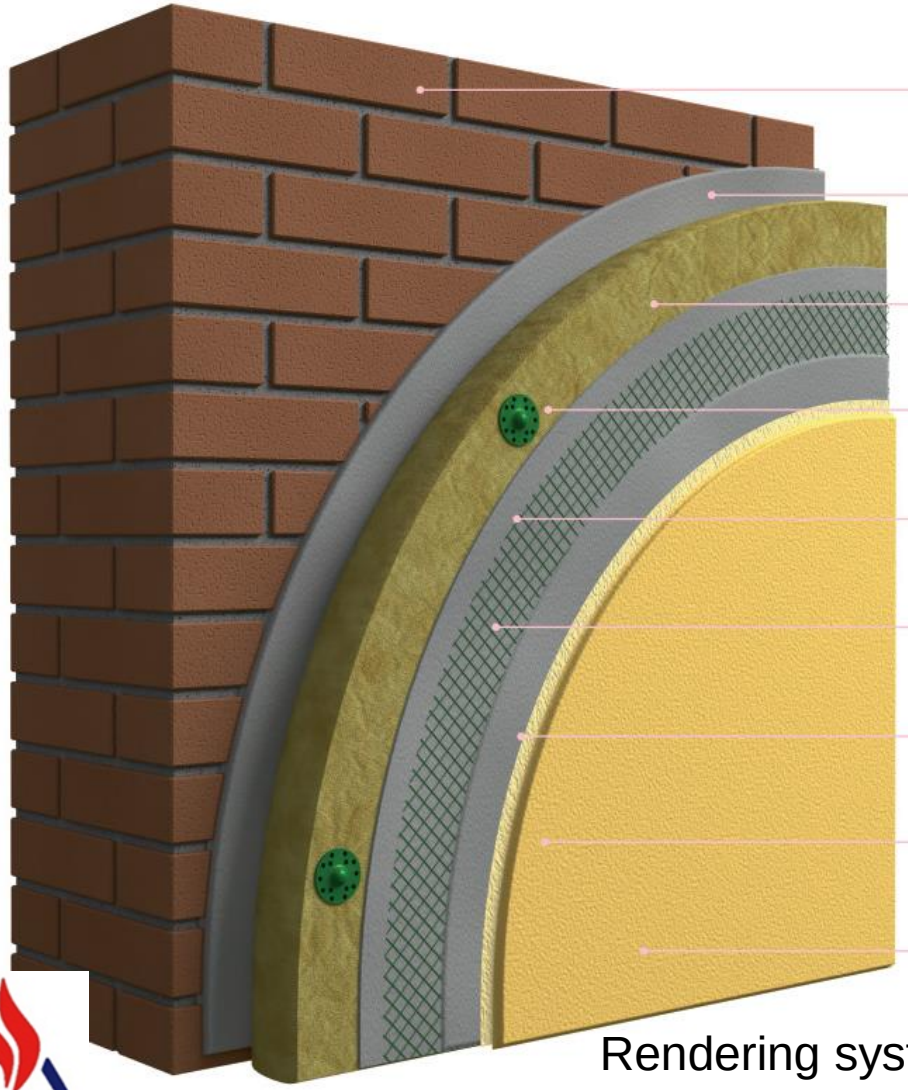
# Type of façade - ETICS



- Wall substrate
- Adhesive
- Thermo insulation material: Rock Mineral Wool or EPS
- Mechanical fixing device - anchor
- Base coat
- Reinforcement - glass fiber mesh
- Base coat
- Key coat
- Finishing coat – decorative layer

Rendering system

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# Reaction to fire

Thermo insulation material vs ETICS system

- Thermo insulation material most commonly used
  - Rock mineral wool (RMW): A1
  - Expended polystyrene (EPS): E

- ETICS (acrylic finishing layer – worst case scenario)
  - With RMW: A2-s1,do
  - With EPS: B-s2,d0

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# Regulation requirement overview for ETICS based on height

- Insulation reaction to fire requirements
  - In some countries, based on ETICS reaction to fire requirements (RS, CRO, MAC)
  - In some countries, refers mainly to residential buildings (RS, CRO, MAC), in some to all types of buildings

| Building height | RS | MAC | BG | HR | SI | CZ | SK | | RO | | DE | FR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | New + Reno | New + Res | New + Reno | New + Reno | New + Reno | New + Reno | New | Reno | New | Reno | New + Reno | New + Reno |
| 50 | A2 | A2 | C | A2 | A2 | A2 | A2 | A2 | A2 | A2 | A2 | A2 |
| 28 | A2 | A2 | C | A2 | A2 | A2 | A2 | A2 | A2 | A2 | A2 | 20cm barrier |
| 25 | A2 | A2 | 20cm barrier* | A2 | A2 | A2 | A2 | A2 | No req. | 30cm barrier | A2 | 20cm barrier |
| 22 | A2 | A2 | 20cm barrier* | A2 | A2 | A2 | A2 | 20cm barrier | No req. | 30cm barrier | A2 | 20cm barrier |
| 15 | A2 | A2 | 20cm barrier* | 30cm barrier** | 20cm barrier | 90cm barrier | 90cm barrier | 20cm barrier | No req. | 30cm barrier | 20cm barrier* | 20cm barrier |
| 11 | 100cm barrier | A2 | 20cm barrier* | 30cm barrier** | 20cm barrier | 90cm barrier | No req. | 20cm barrier | No req. | 30cm barrier | 20cm barrier* | 20cm barrier |
| 7 | 100cm barrier | 50cm barrier* | 20cm barrier* | No requirements | No requirements | 90cm barrier | No req. | 20cm barrier | No req. | 30cm barrier | 20cm barrier* | 20cm barrier |

* - every second floor

** - every second floor + additional
requirements for vertical and horizontal barriers

Note: requirements for non-combustible insulation materials for whole facade surface based on building height are different from country to country (from 11m to 50m) but experience from recent fires like Grefell (UK) shows that fire fighters are not able to effectively fight the fire when you go above 5th floor (+/- 15m). In general the trend is to decrease usage of non-combustible insulation materials above 15m - one step toward that is usage of wide fire barriers.

# Serbia – ETICS regulation requirements

- Based on the height and type of building
- Based on reaction to fire of ETICS or system components

| **Building category** | **A** Temporary buildings, area < 40m2 | **B** Res up to 4 units, area < 400m2 | **V1** Res up to 15m, ind.build. | **V2** Res 15 – 22m, public buil. (schools, hospitals, … < 500 people) | **G** Res >22m, public buil. (schools, hospitals, … > 500 people) |
|---|---|---|---|---|---|
| *Reaction to fire of the system* | D-s2,d2 | C-s2,d2 | B-s2,d1 | A2-s1,d1 | A2-s1,d1 |
| *Reaction to fire of system component* | | | | | |
| - Finishing layer | B-s2,d1 | B-s2,d1 | B-s2,d1 | B-s1,d1 | A2-s1,d1 |
| - Thermo insulation layer | D-s2,d2 | C-s2,d2 | B-s2,d2 | A2-s1,d1 | A1 |

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# Macedonia – ETICS regulation requirements

- Based on the height and type of building
- Based on reaction to fire of ETICS or system components

| **Building category** | **A1** Temporary buildings, area < 40m2 | **A2, B1, B2** Height < 7m, up to 3 floors, area < 400m2 or no limit, < 300 people | **V** Height < 11m, up to 4 floors, area < 400m2, < 300 people | **G** Height < 22m, public buil. (schools, hospitals, … > 300 people) | **D** Height > 22m, |
|---|---|---|---|---|---|
| *Reaction to fire of the system* | D-s2,d2 | C-s2,d2 | B-s2,d1 | A2-s1,d1 | A2-s1,d1 |
| *Reaction to fire of system component* | | | | | |
| - Finishing layer | B-s2,d1 | B-s2,d1 | A2-s2,d1 | A2-s1,d1 | A2-s1,d1 |
| - Thermo insulation layer | E-s2,d2 | E-s2,d2 | B-s2,d2 | A2-s1,d1 | A1 |

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# ETICS – fire barriers

- Additional requirement needed when it's not used non-combustible thermo insulation material, reaction to fire class A1 or A2
  - Fire barriers, made of thermo insulation material reaction to fire A1

- Horizontal fire barriers – possible options:
  - Above every window
  - Ceiling level (every or every second)
    - Width may vary from country to country (from 20cm to 100cm)
  - Combination above two
- Vertical barriers:
  - Specific requirements vary from country to country, mainly connected with borders of fire sector / segments

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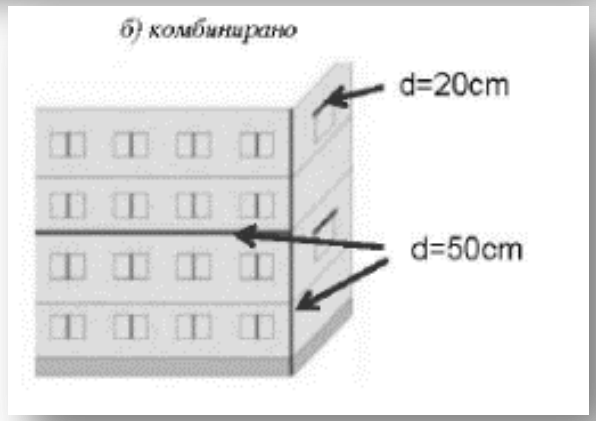
# ETICS – fire barriers

- Examples



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Source: Regulation Serbia and Macedonia

# ETICS – fire barriers

- View from the building site

Source: Fire protection of faced – guideline

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# Fire safety of ETICS
# Full scale test, Zagreb 2014

# Test main objectives

- To provide deeper understanding of the fire performance of ETICS systems with combustible insulation materials
- To investigate whether and how the fire barriers constructed above openings influence fire performance of ETICS systems with combustible insulation materials
- But there were also some other findings

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# Test results - visual

0:30 min

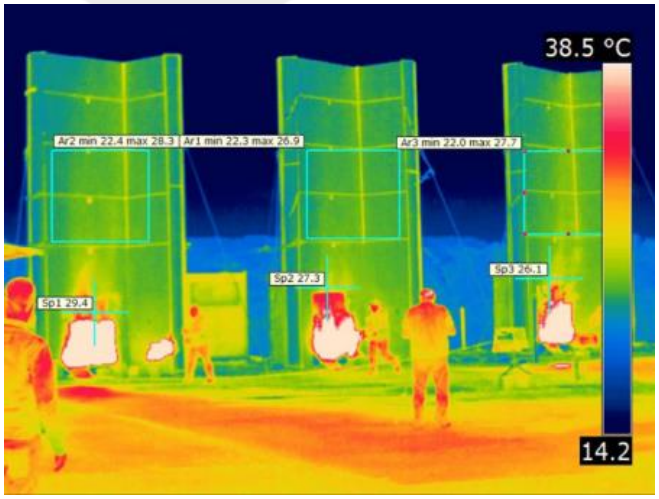

19 min

15 min

28 min

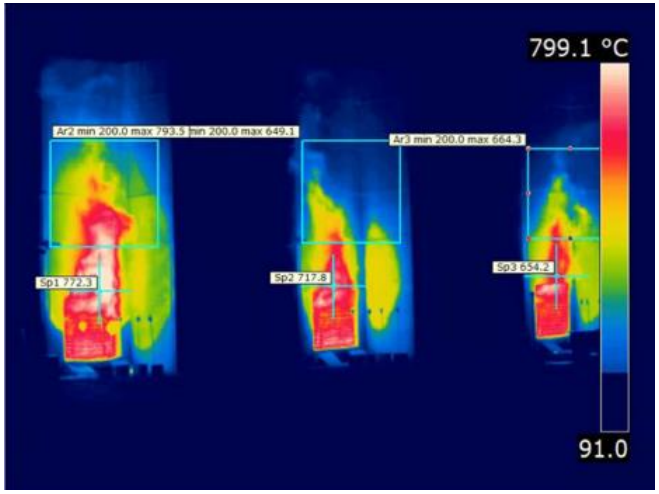
Source: Press release

# Test results - thermographic



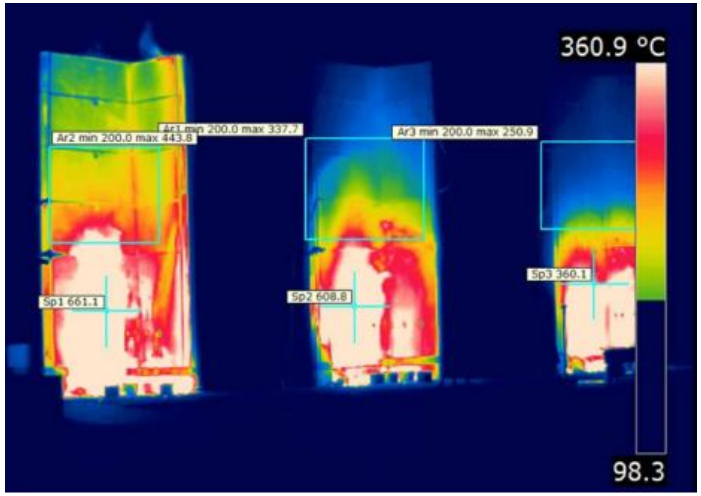

0:30 min

- T1: ETICS with EPS (B-s2,d0)
- T2: ETICS with EPS + RMW barrier 20cm above opening
- T3: ETCS with RMW (A2-s1,d0)




15 min

33 min




Source: Press release

# Test results - visual

40 min

Source: Press release

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# Test results - conclusions

- ETICS with EPS (T1)
  - EPS burned completely, melted under the render
  - Fastest fire spread, both vertically and horizontally, accompanied with significantly more smoke production

- ETICS with EPS + RMW fire barrier 20cm (T2)
  - Fire barrier, didn't prevent fire from spread
  - EPS melted (partially) and pooled on top of the fire barrier
  - Melted EPS drip out as burning droplets after the render cracked
    - Fire barrier delays cracking of the render
  - Fire barrier delayed the smoke production (still significant), burning droplets and smoldering

Source: University of Zagreb, Faculty of Civil Engineering

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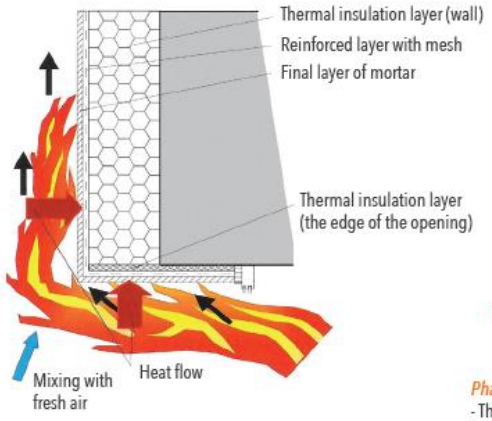
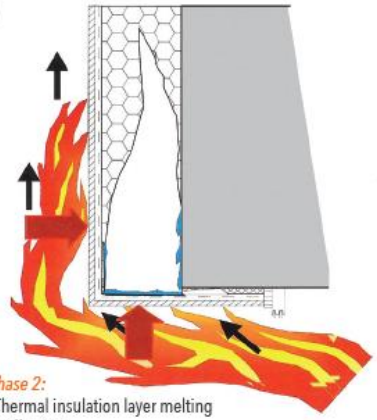
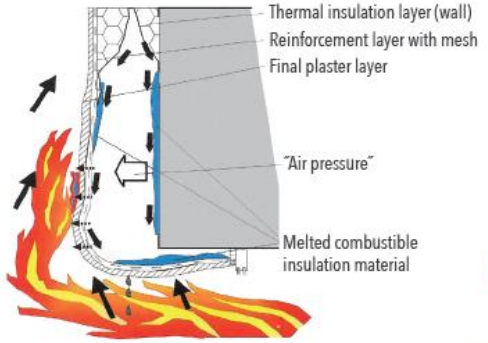
# Development of fire across a façade due to combustible thermal insulation material



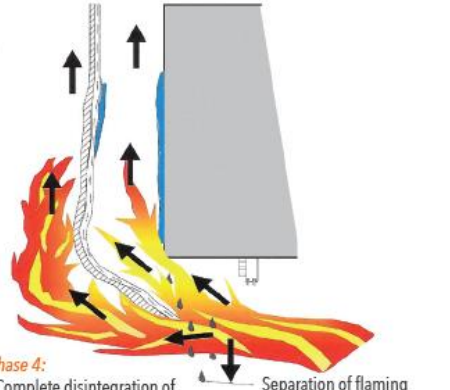

*Phase 1:*
Thermal effect on a façade from the bottom and front side into the ETCS system.



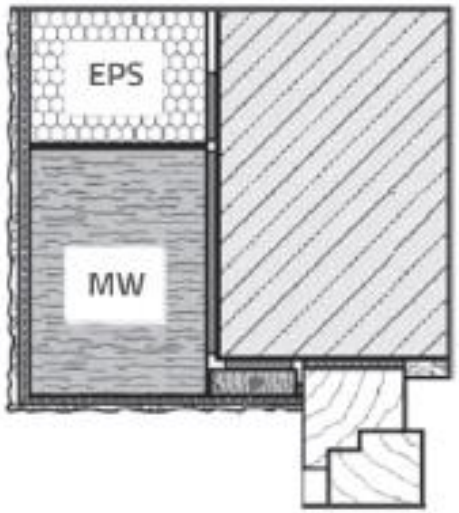
*Phase 2:*
- Thermal insulation layer melting
- Hollowing
- Accumulation of melted material on the external wall
- Accumulation of melted insulation layer along the upper edge




*Phase 3:*
- Occurrence of compressive stresses behind the outer plaster layer (due to hot air and pyrolytic gases)
- Release of pyrolytic gases through plaster
- Burnout of organic plaster
- Bending and cracking of the outer layer of plaster
- Disintegration of the ETICS system along the edge of the opening under the weight of the dissolved substance
- Occurence of flaming droplets




*Phase 4:*
- Complete disintegration of the ETICS system at the edge of the opening
- Penetration of flame behind the plaster
- Burnout of the system on the inside and external sides
- Flaming droplets falling




Source: Fire protection of faced – guideline

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# Final conclusions

- ETICS with RMW
  - The most favorable overall fire performance was demonstrated

- ETICS with EPS + RMW fire barrier
  - Cannot be considered as fire safe as systems with non-combustible insulations and hence are not suitable for all building types (limited safety)
  - Therefore not be used on buildings such as high rise buildings and buildings where occupants need additional time to escape such as hospitals, schools and nursing homes

Source: University of Zagreb, Faculty of Civil Engineering

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# Some other findings

- SBI test does not represent and cannot fully describe real fire performance of a full scale system, i.e. the entire building and its façade
  - EN 13823 (SBI test): B-s2,d0 (ETICS with EPS reaction to fire)
  - BS 8414-1 (full scale test): burning droplets occurred at the ETICS with EPS (T1 and T2)
- In order to sustain repeatability of the testing procedure, fire source needs to be carefully defined and it is necessary that environmental factors (such as wind and ambient temperature) are controlled and within certain limits

Appropriate large-scale testing of façade systems is needed in order to fully understand their behavior in fire

Source: University of Zagreb, Faculty of Civil Engineering

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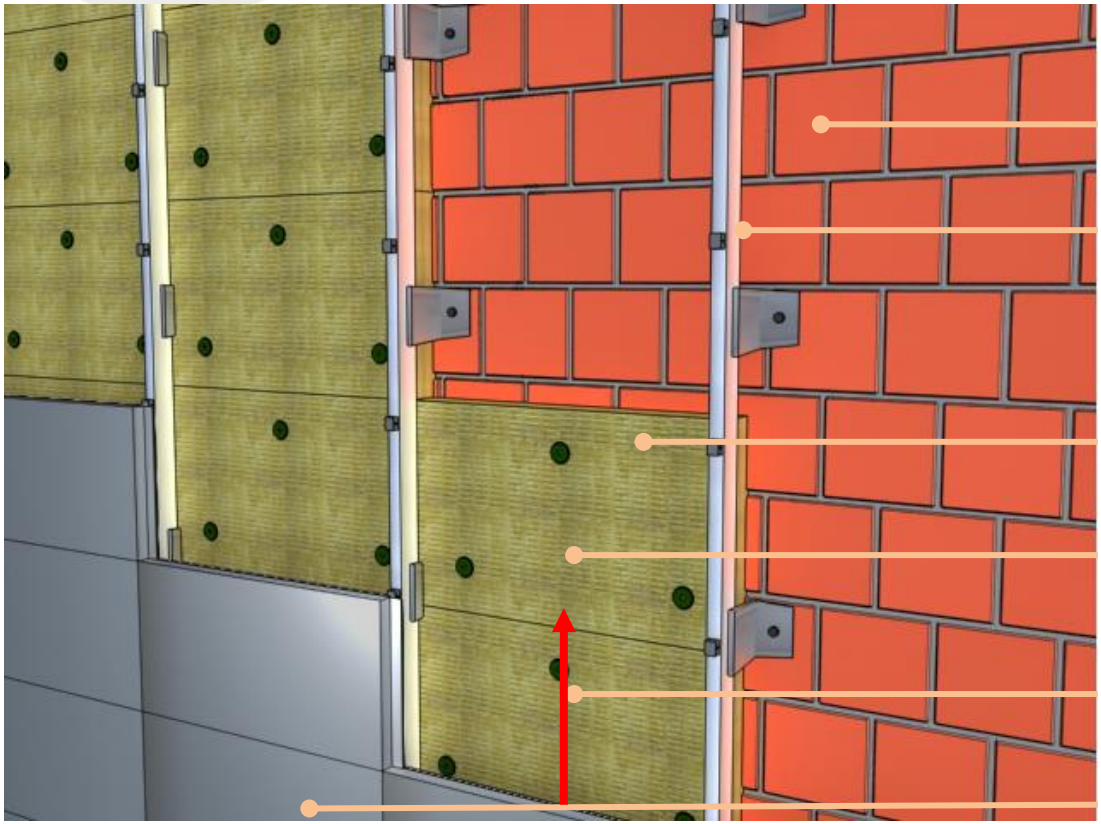
# Type of façade - ventilated



- Wall substrate
- Supporting structure for finishing layer
- Thermo insulation material
- (Rainscreen foil)
- Layer for ventilation (air gap)
- Finishing layer

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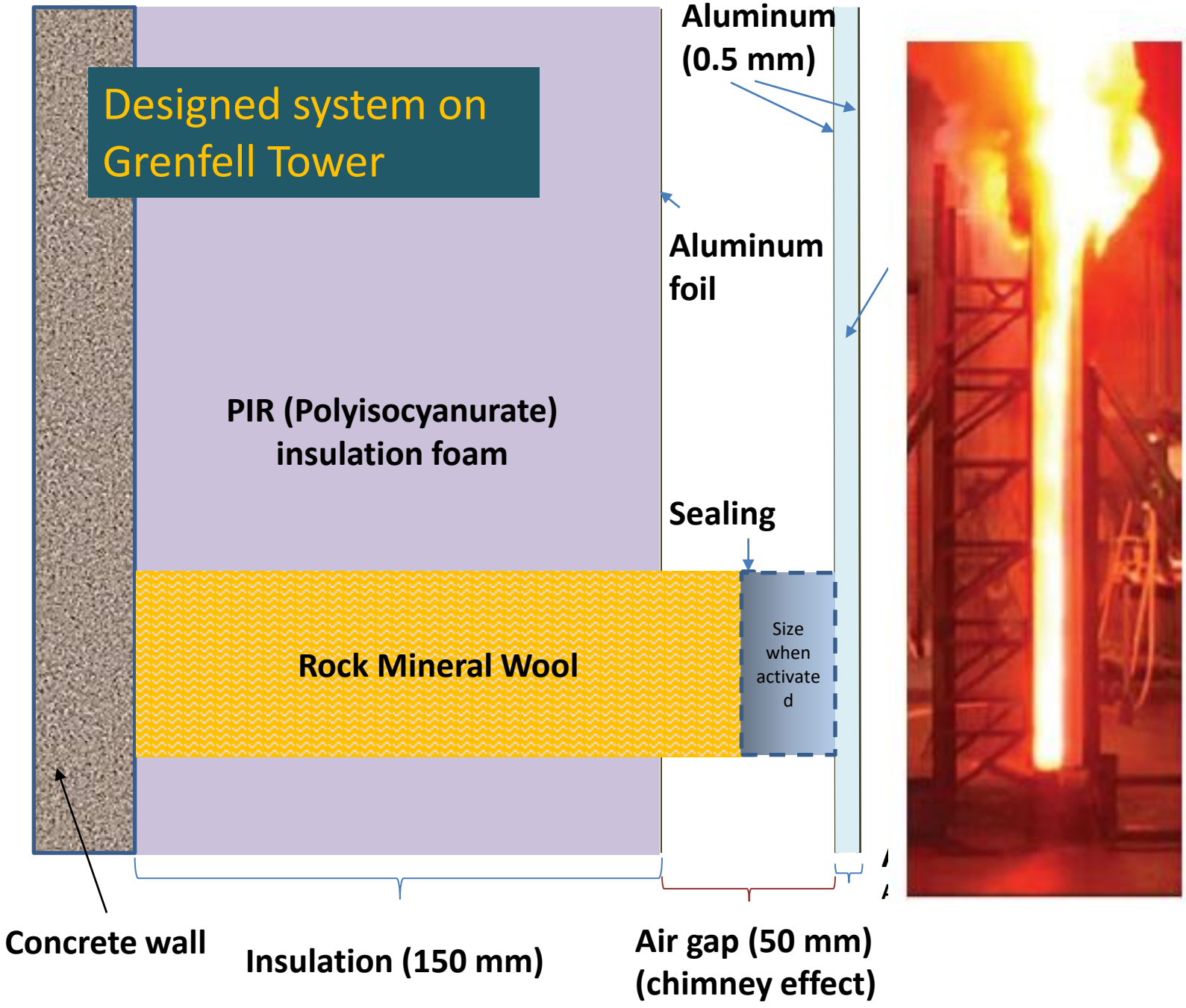
Designed system on Grenfell Tower
Aluminum (0.5 mm)
Aluminum foil
PIR (Polyisocyanurate) insulation foam
Sealing
Rock Mineral Wool
Size when activate d
Concrete wall
Insulation (150 mm)
Air gap (50 mm) (chimney effect)

# General recommendations (1)

- Fire barriers required
  - Protection from fire spread across ventilated façades is a complex issue because there is no generally accepted prevention principle of fire spread which can be applied to all systems of ventilated façades
  - The protection is achieved by installing fire barriers, as system components, which will limit the fire spread through the ventilation space by separations or by reducing the free cross-section
  - This barriers in classified façade systems are installed according to the manufacturer's instructions, and in systems with individual components according to the accepted regulations in technical practice

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# General recommendations (2)

- Non-combustible insulation materials
  - Due to the problem of fire spread across the cavities in ventilated façades and the systems which are generally not tested, recommendation is to use insulation materials reaction to fire class A1 or A2-s1,do

Source: Fire protection of faced – guideline

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# Ongoing EU activities

- Study one the need to regulate on smoke toxicity
- Study on developing a European approach to the fire assessment of facades
- Member States Roundtable on fire safety in buildings supported by the Slovak presidency in 2016
- New Fire Information Exchange Platform supported by the Estonian presidency in 2017

Source: FSEU

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# Fire Safety Strategy & the Fire Information Exchange Platform


1st meeting of the Fire Information Exchange Platform (FIEP) on 16 October 2017:

- 25 Member States present
- 25 stakeholders
- 2 FSEU presentations
- Estonian Presidency supported
- Slovakia presented conclusions of 1st Member States Roundtable
- 5 work streams identified:
  - Data
  - Fire prevention
  - Lessons learned
  - New products
  - Fire Safety Engineering

Source: FSEU

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# Critical steps to get to fire safe buildings

- Regulation set-up
- Education on all levels
- Monitoring that regulation requirements are really and correctly implemented

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# And who we are

- Serbian fire protection association established with an aim to improve and develop the fire protection system in Serbia
- Main tasks
  - **Connecting** all relevant people on the topic of fire safety (institutions, professionals, individuals, companies and others)
  - **Supporting** initiatives and activities in the area of fire protection which shall ensure long-lasting sustainable fire safe environment for the entire society
  - **Education** in order to facilitate fire prevention through professional work and joint efforts to improve fire protection system for the benefit of us all

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# References


- Fire Safe Europe (FSEU) web site and documents
- Fire protection of faced – guideline, University of Zagreb, Faculty of Civil Engineering 2017
- University of Zagreb, Faculty of Civil Engineering (FCE), fire test Zagreb study works
- Press release fire test Zagreb 2014, FSEU, HUZOP, FCE
- Regulation on technical requirements of fire safety of external walls of buildings (Serbia, number 59/2016 and 36/2017)
- Regulation of fire protection measures and explosions (Macedonia, number 99 from 3.8.2017)



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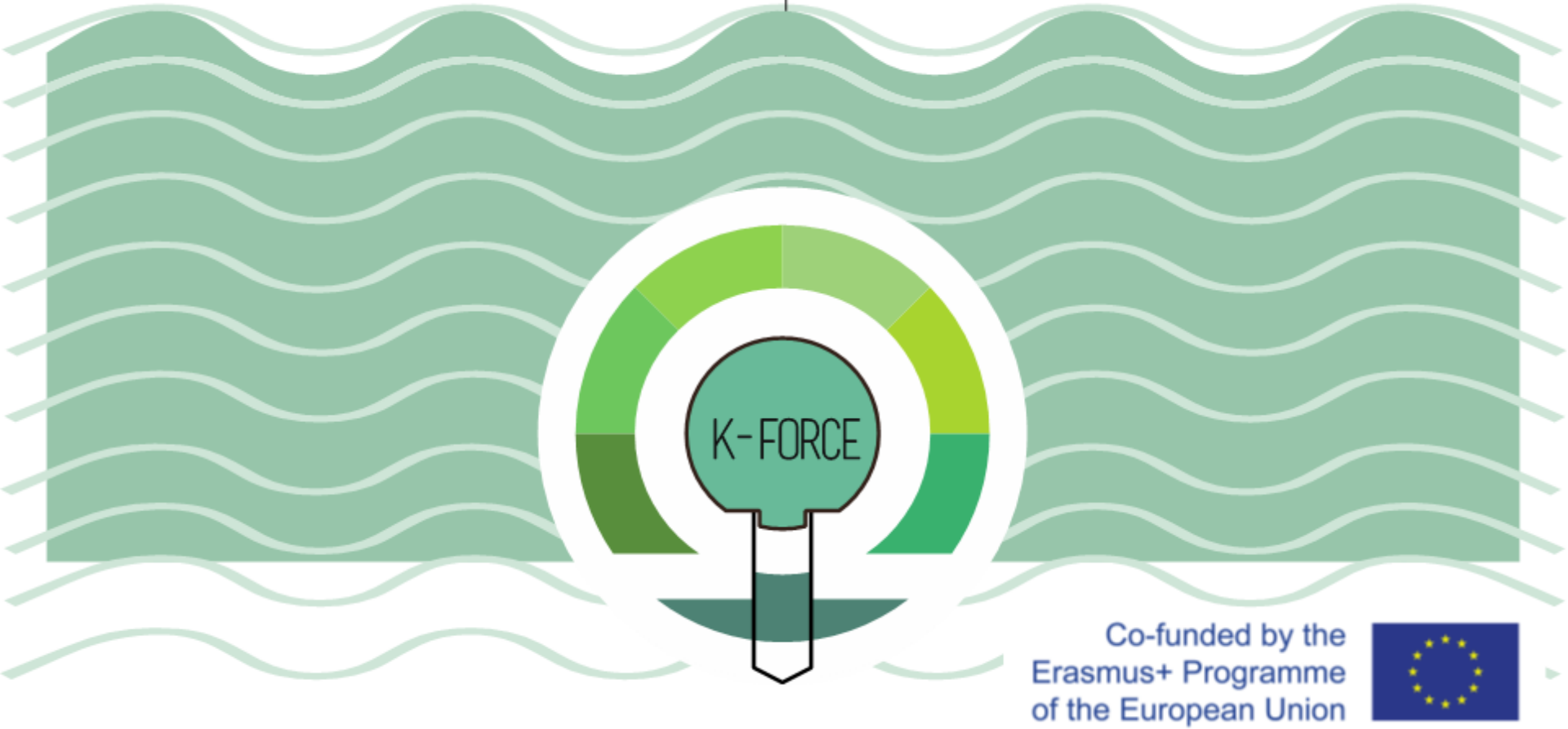


Thank you for your attention

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*+381 63 10 88 982*

**K**nowledge **FO**r **R**esilient so**C**i**E**ty

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