ETICS and fire safety
Basic principles and framework conditions

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Fire scenarios affecting a building's exterior walls

- Fire in a neighbouring building
- External fire in front of the building facade
- Fire inside the building with flames extending in front of the building facade

Statistically speaking the most frequent scenario
Design fire - "outside" a building

Approach:
This "statistical" assessment method represents fires from small-scale storage sites during relocations, collections of waste in usual quantities (several bins or a maximum of one waste collection container - 1,100 l), small-scale bulky waste collections or parked standard vehicles.

Fire characteristics
• Start of fire exposure: 3rd to 7th min.
• Full fire duration: approx. 15 min.
• Average flame heights: 4 to 5 metres
• Maximum flame heights: 6 to 7 metres
• Energy release in front of the building facade: 1.5 to 3.5 MW

Special features:
- Fire caused by human error/wrongdoing (vandalism, arson, negligence, etc.)
- Fire-load-controlled fire, i.e. the development of the fire over time is exclusively dependent on the flammable material
- Rapid exposure of facade to fire
- "Vandalism blazes" (fire bombs, etc.) are included
Design fire for a fire within the building (fire in a room located next to the building's facade with flames extending outside)

Approach:
This "statistical" assessment approach represents scenarios in which flames extend outside the building and in front of the exterior wall through an opening during a blazing fire (following the flash-over) in a neighbouring room. This is based on a room size of approximately 20 m² with an open window around 1/8 (2.5 m²) the size of the room. The room is located in a general purpose building (offices or flats, fire load density of approx. 600 MJ/m², moderate fire spread). The total energy released is estimated to be around 5 MW.

Fire characteristics:
- Start of fire exposure: 10 – 12 min. (flashover)
- Duration of full fire exposure in front of building facade: 10 to 15 min.
- Average flame length above window lintel: 3 metres
- Energy release in front of the building facade: 1.5 to 2.0 MW

Special features:
- The building facade's exposure to the fire is delayed. The flame's only extend outside the building after the flashover in the room.
- Ventilation controlled fire, i.e. intensity is dependent on the fresh air supply in the room.
Fire involving two motorbikes in front of the facade of a high-rise building

Fire in Hamburg-Billsted on 27 April 2012
- Two motorbikes burnt during the night in front of a glass porch
- *Fire spreads from outside to inside the building* (ground floor and first floor) via window openings
- Due to the heat effect, several windowpanes up to as high as the third floor shattered and smoke entered into the flats
- One person was seriously injured and 12 suffered minor injuries
- Non-combustible ETICS (mineral wool insulation and mineral-bound plaster system)
Flames leap from floor to floor

Non-combustible exterior wall without facade cladding (no ETICS)

The spreading of the flames from floor to floor takes place even if the exterior wall is completely non-combustible. This occurs via the window openings and the fire continues to advance upwards if not extinguished by the fire brigade!
Preventing the spread of fire in buildings with exterior wall openings situated on top of each other

1. Reduction of fire development in the room in which the blaze is located
   Comprehensive extinguishing systems (e.g. sprinklers)

2. Diversion of flames extending outside away from the building facade
   Back-set, "pyramidal" floor structure; overhanging, fire-resistant building components (> 1 m); aprons, ledges

3. Fire-resistant structuring of walls and shutters on all floors
   No openings, automatically controlled fire-resistant shutters for all exterior wall openings, partial sprinkler protection

4. Timely extinguishing of fire by the fire brigade
   Early identification of fire, rapid alarm times

Conclusion:
Building legislation in all European countries tolerates the floor-by-floor spreading of fire, as the lighting and ventilation of rooms frequented by people would otherwise not be possible!
The objective of building legislation in terms of fire protection on a building's exterior wall must be to prevent the rapid spreading of a fire across more than one (a maximum of two) floor above or below the location where the fire breaks out prior to the fire brigade extinguishing the blaze. It must be ensured that emergency workers are not placed in danger by extensive parts of the building's facade falling to the ground.
"Areas of conflict" of building regulations

Building regulations
Determination of time- and value-based framework conditions by social consensus

Safety
Profitability
Individual freedom
Preventive fire protection
Fire brigades
Height limits for the tackling of fires and rescue operations from outside

Technically speaking, the fire brigade can extinguish and open burning facade cladding up to around the 8th floor, while people can also be rescued via windows up to this height. However, this is not allowed on any floor higher than this.

In some European countries (e.g. Germany), the use of flammable building materials above the "high-rise building limit" is forbidden. In other countries (e.g. the UK), the use of flammable building materials is permitted if special test certification is obtained (extreme fire load).
Conclusions

1. The physics of fire are the same all over the world, including in Europe
2. The same applies to possible fire locations (fire scenario)
3. The only possible differences between the individual member states are:
   a) the building design,
   b) the used building products and the construction kits for the facade cladding,
   c) the national fire protection requirements, the safety level and
d) the testing methods used for determining performance.
"Who knows the nation, who the name..."
Differentiation of facades in terms of fire protection

• Separating exterior wall
  Fire resistance requirements
  Room partition (E), temperature increase (I)
  stability (R)
  Load bearing and non-bearing
  Curtain walls pursuant to EN 13830
  Examination also across two floors pursuant to EN 1364-4,
  including spread of fire

• Facade cladding (ETICS or VC)
  Building material requirements ("reaction to fire")
  Flammability, spread of fire, non-combustibility
  No fire resistance requirements
  Classification: EN 13501-1
Facade cladding comprises a system of physically linked building materials. It is mounted on a separating exterior wall (load-bearing or non-bearing) for design reasons and serves to improve the physical construction properties of a building (weather protection and thermal insulation).
European building material test procedure pursuant to EN 13501-1

Non-combustible building materials (furnace and calorimeter)

Determination of energy release under extreme conditions at 750 °C

Determination of the calorific value(s) of components (supplementary to SBI)

Limiting the potential energy release of products as a material property.
European building material test procedure pursuant to EN 13501-1

Combustible building materials (fire box and SBI)

**Fire box**

**Fire scenario:**
Exposure via a small defined flame (match, lighter, etc.)

**Test set-up:**
- Flat sample: Height 0.19 m (0.23), width 0.09 m
- "Pre-mixed" gas burner: approx. 0.1 kW, duration 15 min.
- Flame height: 2 cm (0.02 m)

**Protection objective:**
Flammability and flame propagation must be limited within a certain time period

**Problem:** The test specimen is too small to reproduce all of the relevant construction features of a facade cladding system.

**SBI test stand**

**Fire scenario:**
Individually burning object in the corner of a room

**Test set-up:**
- Corner positioning: Height 1.5 m, width 1.5 m (1 m + 0.5 m)
- "Non-pre-mixed" gas burner: approx. 30 kW, duration 20 min.
- Flame height: 0.8 – 1.2 m (pulsating)

**Protection objective:**
No exceeding of defined energy release threshold values within a finite time frame, no direct visual statements on the spreading of the fire
Natural fire tests for buildings (research)

- Back-ventilated cladding (4 tests)
- ETICS with EPS (4 tests)
- Timber cladding (5 tests)
International overview of facade testing procedures

Harmonised approach to real-scale fire performance of facade claddings in EU is still absent. External wall claddings and their components are evaluated for reaction to fire as standalone products and assemblies to EN 13501-1 in a room fire scenario; fire resistance requirements to EN 13501-2 may comprise external wall claddings as part of the structure; and spread of fire along facades is currently not part of this harmonised system at all. Consequently European member states, which presently regulate for this characteristic, have to rely on national test methods.

Overview of test methods evaluating fire performance of facade claddings in fire spread scenarios

<table>
<thead>
<tr>
<th>Standard</th>
<th>BS 8414-1</th>
<th>LEPIR II</th>
<th>MSZ 14800-6</th>
<th>SP FIRE 105</th>
<th>DIN E 4103-20</th>
<th>PN-90/B-02867</th>
<th>ISO 13785-2</th>
<th>ISO 13785-1</th>
<th>GOST 31235</th>
<th>NFPA 285</th>
<th>NFPA 268</th>
<th>CAN/ULC-S134</th>
<th>CAN/ULC-S114</th>
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<tbody>
<tr>
<td>Country</td>
<td>UK</td>
<td>F</td>
<td>H</td>
<td>S</td>
<td>A</td>
<td>D</td>
<td>PL</td>
<td>none</td>
<td>CZ</td>
<td>USA</td>
<td>USA</td>
<td>CAN</td>
<td>CAN</td>
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<tr>
<td>Fire exposure</td>
<td>Wood crib, peak heat 3.5 MW, 4500 MJ</td>
<td>600 kg wood crib</td>
<td>650 kg wood crib/10 kg Diesel oil 3.0 MW</td>
<td>60 l heptane</td>
<td>25 kg wood / 320 kW propane</td>
<td>25 kg wood / 320 kW propane</td>
<td>20 kg wood crib + wind towards the wall (2 m/s)</td>
<td>Propane set by calibration</td>
<td>Propane 100 kW</td>
<td>Soft wood 700 MJ/m²</td>
<td>Gas burner</td>
<td>Radiant panel 12.5 kW/m²</td>
<td></td>
</tr>
<tr>
<td>Max. heat flux on surface</td>
<td>70 kW/m² at 1 m height</td>
<td>Not specified</td>
<td>Not specified</td>
<td>15 or 80 kW/m²</td>
<td>Not specified</td>
<td>70-95 kW/m² at 1 m height</td>
<td>Not specified</td>
<td>55 kW/m² at 0.6 m height</td>
<td>Not specified</td>
<td>12.5 kW/m² at 2 m height</td>
<td>38-40 kW/m² at 0.6-1.2 m height</td>
<td>12.5 kW/m²</td>
<td>45 kW/m² at 0.5 m height</td>
</tr>
<tr>
<td>Max. temperature on surface</td>
<td>600°C / 20 min</td>
<td>Average 500°C / peak 800°C</td>
<td>600°C / 0.5 m high / 50 min</td>
<td>450°C / 12 min</td>
<td>Not specified</td>
<td>Not specified</td>
<td>800°C peak</td>
<td>Min. 800°C</td>
<td>Max. 150°C at 0.5 m height</td>
<td>750°C at lintel</td>
<td>712°C at 0.9 m height</td>
<td>Not specified</td>
<td>Approx. 415°C</td>
</tr>
<tr>
<td>Test duration</td>
<td>30 min</td>
<td>Min. 30 min</td>
<td>45 min</td>
<td>Min. 12 min</td>
<td>30 min</td>
<td>21 min gas, 30 min wood</td>
<td>30 min</td>
<td>23-27 min</td>
<td>30 min</td>
<td>35 min</td>
<td>30+10 min</td>
<td>20 min</td>
<td>Min. 15 min</td>
</tr>
<tr>
<td>Test specimen</td>
<td>Corner 2.5 m x 8.0 m + 1.5 m x 8.0 m</td>
<td>Flat wall 5.0 m x 7.0 m</td>
<td>Flat wall 6.0 m x 6.7 m</td>
<td>Flat wall 4.0 m x 6.7 m</td>
<td>Corner 3.0 m x 6.0 m + 1.5 m x 6.0 m</td>
<td>Corner 3.0 m x 6.0 m + 2.0 m x 5.2 m</td>
<td>Flat wall 2.3 m high</td>
<td>Corner 3.0 m x 5.7 m + 1.2 m x 5.7 m</td>
<td>Corner 1.2 m x 2.4 m + 0.6 m x 2.4 m</td>
<td>Flat wall 3.0 m x 5.1 m</td>
<td>Flat wall 4.1 m x 5.3 m</td>
<td>Flat wall 1.2 m x 2.4 m</td>
<td>Flat wall 10 m high</td>
</tr>
<tr>
<td>Substrate</td>
<td>Masonry or light frame</td>
<td>Any</td>
<td>Masonry</td>
<td>Aerated concrete</td>
<td>Aerated concrete</td>
<td>Aerated concrete</td>
<td>Masonry</td>
<td>Any</td>
<td>12 mm Ca-Si board</td>
<td>Masonry, concrete</td>
<td>150 mm th. floor slabs</td>
<td>Steel tube</td>
<td>Concrete</td>
</tr>
<tr>
<td>Criteria’</td>
<td>Temp. limits</td>
<td>Flame on 2nd floor</td>
<td>Temp. rise, fire spread, falling parts</td>
<td>Flames 2 floors above, falling parts</td>
<td>Temp. rise, fire spread, falling parts</td>
<td>Temp. rise, fire spread, falling parts</td>
<td>Temp. limits, Burning particles</td>
<td>Not included</td>
<td>Not included</td>
<td>Not included</td>
<td>Flame spread, temp. rise</td>
<td>Ignition</td>
<td>Vertical flame spread, heat flux</td>
</tr>
</tbody>
</table>

a) Additional criteria may be contained in other standards or regulations.
b) Temperature rise, vertical and/or horizontal flame spread, burning droplets and particles, falling parts of certain size or mass.
c) Proposed values (under revision)

Presented by Rockwool International at the first European Facade Conference at CSTB held in November 2014 in Paris

The overview of test procedures mentioned is useful. The description, however, includes some mistakes!
Basic principles for facade tests - CIB W 14 "workshop facades"

Initial development of harmonised international and European testing approaches for facades under the leadership of the Leipzig Fire Testing Authority in 1988.

"Curtain walls"
- Fully developed fire on facades with windows
- The test specimen is the separating exterior wall itself
- Two floors, height in excess of 5 metres
- All sources of fire which could generate a blazing fire are possible
- Investigation of fire spread on the building component:
  - via the windows
  - via the "ceiling gap"
  - via gaps and channels in the facade itself
- Proof of the stability of the facade construction:
  facade does not collapse, no significant parts fall down and no "internal" spreading of the fire

Facade surface – cladding
- Scaled fire on facades without windows, fire load thus in the chamber directly behind the facade (no room heating)
- A test in front of the area and/or a test in the corner
- Test specimen is the cladding on a non-combustible, massive exterior wall
- Two floors, height in excess of 5 metres
- Fire load: 50 kg wooden crib in each case
- Proof of fire spread via the facade cladding
Facade tests

Natural fire testing
Realistic re-creation of the fire situation to be investigated in an original building (e.g. demolition building) with the practice-oriented installation of the facade (geometrics of load-bearing walls, curtain walls, facade cladding, etc.) Always a one-time, difficult to repeat fire event

Testing procedure

Curtain walls
(in addition to fire resistance)

Behaviour of non-bearing exterior walls

LEPIR II (F), BS 8414-2 (UK), MSZ 14800-6 (H), SP 105 (S)

Test fire in room behind facade

ISO 13785 – part 2, GOST 31251 (UA), NFPA 285 (USA), CAN/ULC 134 (CAN)

Cladding
(in addition to building materials)

Facade cladding, surfaces, etc., building material

Test fire in opening behind facade

European EOTA testing procedure

Scaled fire load
(up to high-rise building limit)

ÖNORM 3800-5 (A), ad hoc test (CH), DIN E 4102-20 (G), PN-90/B 02867 (PL)

Extreme blazing fire
(above the high-rise building limit)

BS 8414 – 1 (UK), SP 105 (S)

• Simulation of fire load via various test fires such as wooden cribs, pool fires, gas burners.
• Interpretation of test results shaped by national building legislation
**Background**

- Beginning of discussions at a European level with the introduction of EN 13501-1 (SBI)
- EU draft mandate completed in 2004
- In 2005, the EU decided to stop the work in CEN (EGF 388 (Construct 05/691))
- Agreement between the Commission and EOTA that EOTA should develop a testing method for facade cladding (Construct 05/716rev.1) on the basis of the earlier mandate.
- The first meeting of a facade group in EOTA took place in 2007 following a 2-year pause
- In April 2013, EOTA presented the "Draft Technical Report 073, version Jan. 11 2013, amended April 18". This was followed by a new discussion phase of two years 2002 – 2014 (12 years of expert work!!!!!)

The discussion is now starting again, the result is not yet clear....
• Original fire testing procedure for non-bearing exterior wall cladding systems which are installed on the exterior surface of a building (facade) either with or without insulation

• Testing method for determining the technical fire protection performance (fire spread, contribution to fire and mechanical behaviour) of exterior wall cladding systems

• The testing procedure provides no information on the fire-resistance behaviour of an exterior wall cladding system, as there are no building law requirements in this regard

• The fire load represents a room fire following the flashover stage, with flames extending in front of the facade through windows, and a fire from an external fire source (e.g. a waste collection container) close to the facade with flame exposure

• Against the backdrop of the different building law requirements as regards facade cladding in the individual member states, a single test scenario (room fire with flames extending outside) is used as a basis but with two different exposure levels
Performance characteristics

- Spread of fire (internally and on the surface of the facade cladding system)
- Maximum flame heights
- Temperature-time behaviour
- Progressive smouldering
- Mechanical behaviour such as flaming droplets, falling parts from the facade, failure or collapse of the facade cladding system
- Fire damage to the facade cladding system across all layers
Large Scale Fire Performance Testing of External Wall Cladding Systems

Large-scale test (cladding system test)

One-fire scenario: flames spread out via an opening

Reaction to fire (material test)

Exposure level one

30 kW

320 – 380 kW

SBI

Exposure level two

3000 – 3500 kW

Average-height buildings

High-rise buildings
Large Scale Fire Performance Testing of External Wall Cladding Systems

- One fire scenario: Flames extend out of an opening
- One test stand: for both exposure levels
From a fire protection perspective, an external thermal insulation composite system comprises an – often combustible – insulating material which is mounted on a non-combustible/fire-resistant wall (using glue or mechanically) and fully covered with an effectively non-combustible plaster layer.
Stability of the plaster layer of the ETICS when exposed to fire

**Test approach**
- Thermal exposure only for the plaster layer of an ETICS with the full fire curve for fire resistance in accordance with EN 13501-2 over 60 minutes
- Dispersion-based, reinforced plaster with a low thickness (2 mm sub-layer and 2 mm final coat, total of 4 mm) and high proportion of organic components (approx. 10% by weight, dry)

**Results**
- No flames on the side facing away from the fire
- No burn-through, physical room barrier ⇒ E 60 as per EN 13501-2 (50 x 50 cm) ⇒ E 30 as per EN 13501-2 (100 x 100 cm)
- Maximum temperature on the inside 15 min. 400 °C, 60 min. 500 °C

The reinforced plaster layer of an ETICS acts as a fire curtain for the insulation located behind it even at its minimum thickness of 4 mm!!
Basic fire protection measures

Room fire protection zone + Base protection zone = Facade protection zone

Measures incorporate room fires!
Possible fire protection measures for ETICS with EPS

"Protection again falling material" above every exterior wall opening

(Prevention of fire occurring in the insulation layer)

Possible alternative solutions

Special training required for shading units and forward-set windows

Circumferential "fire barrier"

(secure restriction of a fire in the insulation layer of every second floor)

Acceptance of floor-by-floor spread of fire through local burning in the same way as for flames jumping from window to window on a massive, non-combustible wall, but no progressive burning of the ETICS

No training for special details for shading units and forward-set windows
Thank you for your attention!

A "professional pyromaniac" will now attempt to answer your questions!