Comparison of classification regarding different fire test scenarios

Prof. dr. ir. P. Vandevelde
General (1)

• Fire test scenarios address two fire phases:
  – early development (R2F)
  – fully developed fires (FR)

• Flash-over phase and extinction disregarded
General (2)

• What does science offer?

• What are the needs of regulators
  – in prescriptive regulations
  – in performance based codes

• How is this translated into regulations for sandwich panels
General (3)

Fire test scenario
→ fire test
   → classification
fits within a completer chain:
Fire scenario + design fire
→ fire test scenario
   → fire test
      → classification
Important to understand background of tests and classification: EC Study
EC study on R2F (1)

Identify:

• fundamental relevant physical parameters
• in frequently occurring real fires
• their combinations
• resulting in a choice of relevant fire scenarios
EC study on R2F (2)

Fundamental parameters are:

• direction of flame propagation
  – co-current (→ →), counter-current (→ ↔)

• horizontal surface up (H↑) or down (H↓) vertical surface (V)

• degree of feedback: low (L), medium (M), high (H)

• level of induced natural convection at flame front:
  low (L), high (H)

• severity of initial thermal attack:
  low (L), medium (M) high (H)
EC study on R2F (3)

• most real fires can be grouped into a limited number of frequently occurring FIRE SCENARIOS

• with similar combinations of the essential parameters for each group
EC study on R2F (4)

Outcome:

Definition of a series of relevant combinations of parameters into fire scenarios such as:
• fire developing in a small room
• fire developing in a large room
• fire extending from a room to a corridor
• fire spreading over large vertical surfaces
• fire extending within a shaft/conduit
Developments towards Euroclasses (1)

From fire scenarios
→ to large scale fire test scenarios:

• small room → room corner test (RC)
• room-corridor → room-corridor test (COR)
• large vertical surfaces → facade tests (FAC)
• shafts → vertical cable bundle test (CAB)
Developments towards Euroclasses (2)
Developments towards Euroclasses (3)

Room corner

Room corridor
## Developments towards Euroclasses (4)

<table>
<thead>
<tr>
<th>Direction of flame propagation</th>
<th>RC</th>
<th>COR</th>
<th>FAC</th>
<th>CAB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>V + H ↓</td>
<td>H ↑</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>Feedback</td>
<td>M</td>
<td>L</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Convection</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Thermal attack</td>
<td>M</td>
<td>H</td>
<td>L</td>
<td>M/H</td>
</tr>
</tbody>
</table>

Large rooms not considered separately
Developments towards Euroclasses (5)

• From large scale test scenarios to small/medium scale tests

• Followed by classification
Developments towards Euroclasses (6)

- Real Fire
  - ROOM CORNER
    - Intermediate scale (SBI, ...)
  - ROOM CORRIDOR
    - Intermediate scale (FRP, ...)
  - FACADE
    - Intermediate scale (Cable test, ...)
  - SHAFT
    - Other 'intermediate scale' tests
  - Other reference scenario
Developments towards Euroclasses (7)

EUROCLASSES
(Decision 94/611/EC, OJ L241, 16/9/94)

A - No contribution to fire
B - Very limited contribution to fire
C - Limited contribution to fire
D - Acceptable contribution to fire
E - Acceptable reaction to fire
F - No performance determined
Euroclasses (1)

- Euroclasses now apply for:
  - all construction products (other than), e.g. C-s1, d0
  - flooring: C_{fl}-s1
  - linear pipe thermal insulation: C_{l}-s1, d0
  - cables: C_{ca}-s1, d0, a2
Euroclasses (2)

Different scenarios = different product behaviour = different classification

3 scenarios

- Small flame
  - Ignition
  - Single Burning Item or Heat flux to floor or Cable Bundle
  - Contribution to fire development
  - Contribution to fire load

post-flashover
# Small flame scenario

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction products</td>
<td>EN ISO 11925-2 Exposure 15 or 30 s</td>
</tr>
<tr>
<td>Floorings (fl)</td>
<td>EN ISO 11925-2 Exposure 15 s</td>
</tr>
<tr>
<td>Linear pipe insulation (L)</td>
<td>EN ISO 11925-2 Exposure 15 or 30 s</td>
</tr>
<tr>
<td>Electric cables (ca)</td>
<td>EN 60332-1-2</td>
</tr>
</tbody>
</table>
Small flame

- Ignition
- Falling burning droplets/particles
Euroclasses (3)
Different scenarios = different product behaviour = different classification

3 scenarios
- Small flame
- Ignition
- Single Burning Item or Heat flux to floor or Cable Bundle
- Contribution to fire development
- post-flashover
- Contribution to fire load
## Contribution to fire load

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction products</td>
<td>EN ISO 1182</td>
</tr>
<tr>
<td></td>
<td>EN ISO 1716</td>
</tr>
<tr>
<td>Floorings (fl)</td>
<td>EN ISO 1182</td>
</tr>
<tr>
<td></td>
<td>EN ISO 1716</td>
</tr>
<tr>
<td>Linear pipe insulation (L)</td>
<td>EN ISO 1182</td>
</tr>
<tr>
<td></td>
<td>EN ISO 1716</td>
</tr>
<tr>
<td>Electric cables (ca)</td>
<td>EN ISO 1716</td>
</tr>
</tbody>
</table>
Calorimeter

EN ISO 1716
Non combustibility test

EN ISO 1182
Euroclasses (4)

Different scenarios = different product behaviour = different classification

3 scenarios

- Small flame
- Ignition

- Single Burning Item or Heat flux to floor or Cable Bundle
- Contribution to fire development

- post-flashover
- Contribution to fire load
## Contribution to fire development

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction products</td>
<td>EN 13823</td>
</tr>
<tr>
<td>Floorings (fl)</td>
<td>EN ISO 9239-1</td>
</tr>
<tr>
<td>Linear pipe insulation (L)</td>
<td>EN 13823</td>
</tr>
<tr>
<td>Electric cables (ca)</td>
<td>prEN 50399-2-1/2</td>
</tr>
</tbody>
</table>
SBI: Single Burning Item
Radiant Flooring Panel
Cable tester: prEN 50399
Real Fire

ROOM CORNER
- Intermediate scale (SBI, ...)

ROOM CORRIDOR
- Intermediate scale (FRP, ...)

FACADE
- Intermediate scale (Cable test, ...)

SHAFT
- Other 'intermediate scale' tests

Classification

Other reference scenario

Other R & D tests
Particular considerations for sandwich panels

Subjects of sandwich panel debate:

• Assumed lack of correlation between:
  real fires and classification
  real fires and small room = room corner
  room corner and SBI

• Influence of down scaling fire test scenarios:
  – Large room and small room to ‘room corner’
  – Room corner to SBI
Particular considerations for sandwich panels

Aspects of concern: thermal deformation

• Bending proportional to square of length and width
• Deformation opens joints between panels
• Determines evacuation pattern of decomposition gasses
• Consequence: importance of joint type, joint protection, mutual fixing, flashing
Particular considerations for sandwich panels

Aspects of concern: geometry (1)

• Representativity of location of ignition source
  – Probability of location in direct contact
    large room: ceiling exposure by hot gasses
    small room: ceiling and (direct?) wall exposure
    SBI: only direct wall exposure

• Consequence: potentially inadapted evaluation
Particular considerations for sandwich panels

Aspects of concern: geometry (2)

- Influence of room volume:
  Accumulation of decomposition gasses and heat build-up
  large room: slow
  small room: faster
  SBI: no build-up
  difference between two types of RC: ISO 9705 versus ISO 13784-1

- Consequence: change of determining classification parameter from one fire test scenario to another
Particular considerations for sandwich panels

Aspects of concern: thermal attack (1)

• Influence of thermal attack in different fire test scenarios:
  Large rooms:
  – direct contact of initial source with panels less likely
  – slow heating of room, decomposition delayed
  – large area attacked simultaneously
  Small rooms:
  – direct attack more likely
  – faster heating of room
  – first local attack, later large area
  SBI:
  – only direct local attack
• Consequence: strong influence of fire test scenario
Particular considerations for sandwich panels

Aspects of concern: thermal attack (2)

• Feedback:
  Large room: very small till flash-over
  Small room: very high
  SBI: medium (corner)

• Consequence: strong influence of fire test scenario
Appeal procedure: Guidance Paper G

When?

• Reference scenario not appropriate for products in certain intended uses
• Classifications inappropriate
• Only if factors are significantly different
• And regulatory authorities cannot adapt regulations

Initiative

• Member states, CEN/CENELEC, EOTA, FSG or European Industry Federations
Resistance to fire (1)

• Temperature exposure evaluation depends on:
  – fire load
  – ventilation
  – thermal characteristics (kpc) of walls/floors/ceilings
Resistance to fire (2)

• Severity of thermal attack expressed by:
  – speed of temperature increase
  – maximum temperature
  – duration of fully developed fire
  – rate of cooling after ‘extinction’

• Load

• Mechanical boundary conditions
Resistance to fire (3)

• Criteria: R, E, I, W

• Is behaviour of steel sheets sufficiently covered by R and/or E?

• How to deal with influence of bending and dilatation when extending application to larger sizes than tested
Resistance to fire (4)

- Standard tests offer:
  - temperature exposure:
    - ISO 834 standard curve
    - Hydrocarbon curve (2)
    - RW tunnel curve
    - Constant temperature curves
    - No cooling phase included
Resistance to fire (5)

• Load:
  – only primary forces applied walls, columns, floors, beams
  – no fire induced effects (thermal dilatation)

• Boundary conditions:
  – simply supported (isostatic)
  – exceptionally partially restrained (columns)
  – Limited span (4 m), height (3 m)
Resistance to fire (6)

Special tests/calculation can offer use of:

• Parametric temperature curves
• Particular mechanical load conditions
• Particular boundary conditions including or not fire induced load changes
• Extension to larger sizes than tested
• Procedures specified in Eurocodes
• Ongoing research
The need of regulators

Prescriptive regulations

• Based on two-phase model
  1. Starting fire develops to flashover: R2F
     • early starting fire
     • small fire source
  2. Fully developed fire: FR
     • ISO 834 curve
     • HC, tunnel and similar
• Oversimplified
• Not always adequate
  Usually too high requirement
  Sometimes insufficient
The need of regulators

Performance based regulations

• More efficient, appropriate approach
• More complex, difficult
• Applied in UK, Sweden
• Gains slowly recognition in MS
• Often ‘allowed’ as alternative way to demonstrate safety level
• Requires performance based design
• Requires product information from other tests (ISO/TR 17252)
The need of regulators

Performance based design (2)

Series of ISO TC 92/SC 4 standards ISO/TR 13387/X

1: The application of fire performance concepts to design objectives
2: Design fire scenarios and design fires
3: Assessment and verification of mathematical fire models
4: Initiation and development of fire and generation of fire effluent
5: Movement of fire effluent
6: Structural response and fire spread beyond the enclosure of origin
7: Detection, activation and suppression
8: Life safety: occupant behavior, location and condition
The need of regulators

Performance based design (3)

ISO TC 92/SC 4 standards - Based on Risk analysis

• Select relevant fire scenarios + design fires
• Predict fire development (deterministic/probabilistic)
• Calculate/evaluate risk
• Apply safety coefficients
The need of regulators

Performance based design (4)

- R2F
  Product characteristics
e.g. HRR from cone calorimeter tests
  Use modelling/CFD

- FR
  Parametric fire curves
  Product characteristics (steel, concrete etc.) as specified in Eurocode standards
  Consequence for classification!!!
Particular requirements
sandwich panels
in national regulations
Particular requirements for sandwich panels

• Enquiry by the EC through the SCC on national regulations applicable to sandwich panels (2006) (63rd SCC meeting)

• Answers collected in doc. ‘Construct 06/763rev1’ dd 09/10/2006
Particular requirements for sandwich panels

• Conclusion of the EC
  ‘Having examined the issue, the Commission concluded that there are no regulatory needs justifying the development of a large scale testing for sandwich panels’

• This conclusion is confirmed during the 64th SCC meeting

• The conclusion refers to Guidance paper G and enumerates the steps required to enable changing the Commission Decision 2000/147/EC establishing the reference scenario
<table>
<thead>
<tr>
<th>Country</th>
<th>National provisions regarding sandwich panels imposing test methods different from the SBI</th>
<th>National provisions NOT regarding sandwich panels BUT APPLICABLE TO THEM and imposing test methods different from the SBI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>NO</td>
<td>YES - Not notified</td>
</tr>
<tr>
<td>Czech Rep.</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Denmark</td>
<td>YES - Notification No. 97/0527/DK</td>
<td>YES - Notification No. 97/0527/DK</td>
</tr>
<tr>
<td>Germany</td>
<td>YES - Notification No. 05/424/D</td>
<td>YES - Not notified</td>
</tr>
<tr>
<td>Estonia</td>
<td>NO ANSWER</td>
<td>NO ANSWER</td>
</tr>
<tr>
<td>Greece</td>
<td>NO</td>
<td>YES - Notification No. 1987/0133/GR</td>
</tr>
<tr>
<td>Spain</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>France</td>
<td>NO</td>
<td>YES - Notification No. 2004/0124/F</td>
</tr>
<tr>
<td>Ireland</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Italy</td>
<td>NO</td>
<td>YES - Notification No. 2001/0044/I</td>
</tr>
<tr>
<td>Cyprus</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Latvia</td>
<td>NO ANSWER</td>
<td>NO ANSWER</td>
</tr>
<tr>
<td>Lithuania</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Luxemburg</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Hungary</td>
<td>NO ANSWER</td>
<td>NO ANSWER</td>
</tr>
<tr>
<td>Malta</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Netherlands</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Austria</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Poland</td>
<td>YES - Not notified</td>
<td>YES - Not notified</td>
</tr>
<tr>
<td>Portugal</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Slovenia</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Slovak Rep.</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Finland</td>
<td>NO</td>
<td>YES - Not notified</td>
</tr>
<tr>
<td>Sweden</td>
<td>NO</td>
<td>YES - Notification No. 2005/0592/S and 2000/48/S</td>
</tr>
<tr>
<td>UK</td>
<td>NO</td>
<td>YES - Notification No. 2005/0382/UK</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>NO ANSWER</td>
<td>NO ANSWER</td>
</tr>
<tr>
<td>Romania</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Turkey</td>
<td>NO ANSWER</td>
<td>NO ANSWER</td>
</tr>
</tbody>
</table>
Particular requirements for sandwich panels

Denmark
No specific requirements for sandwich panels. General requirements include covering class K_{10}. Requirements for insulating materials.

Germany
No specific requirements. Insulating materials have to satisfy ‘continuous glowing combustion’ test.
Particular requirements for sandwich panels

France
Opportunity to apply FSE approach for combustible insulating materials.

Poland
Class E for the core insulation

Finland
All requirements expressed in terms of Euroclasses + covering class K1.
Particular requirements for sandwich panels

Sweden

‘If testing according to NT FIRE 004 (now replaced by SBI if CE-marking is possible) gives doubtful results or results hard to interpret, testing shall be made in full scale according to NT FIRE 030 or ISO 9705’
Particular requirements for sandwich panels

UK

Euroclasses are applied.
Supplemented by factors such as:
Fixing systems, jointing, finishing details etc.

Market strongly influenced by insurers.
UK: Market ruled by requirements of insurers

Requires LPS 1181 test

• Panels fixed as in practice and on a real scale.
• Significant heat source challenges the joints. >1000°C.

• Assesses:
  ▪ security of fixing
  ▪ fire penetration
  ▪ contribution of core material
  ▪ effect of radiation
  ▪ smoke and flashover
  ▪ surface spread of flame
UK: Market ruled by requirements of insurers

• No LPCB approvals with fire resistance for EPS and PUR panels.

• Approvals for some PIR, phenolic, and Mineral Wool core materials.

• The level of approval for fire resistance is critical. So are the fixing details!