Performance based fire safety

Dealing with uncertainties

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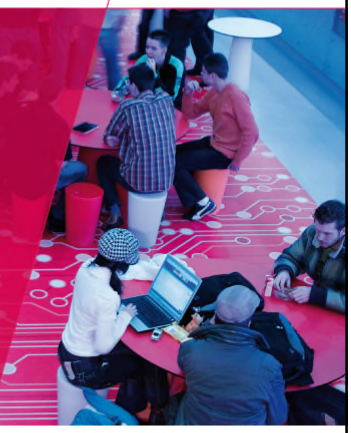

Nieman

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Where innovation starts

Objectives of fire safety

Public objectives (building act):

Preventing victims of fire

- Building users, assistance, …

Preventing fire damage to third parties

- Neighbouring plots

Private objectives:

Sustainability, flexibility,
Damage control,
Business continuity,
…

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Objectives and LOD's

Risk objectives (building code):

- Safe environment (neighbouring plots)
- Safe building (structure) → LOD
- Safe compartmentation (max. spread of fire and smoke) → LOD
- Safe escape routes (building occupants)
- Safe attack routes (suppression and assistance)

Are fire safe buildings possible without escape routes?

Rule based vs. Risk based

Safe Escape Routes

Objective:

A route for building users to reach a safe haven without health-damage

Rule based:

Walking-distances, flow/storagecapacities of escaperoutes, number and safetylevel of escaperoutes, number of building occupants, etc….

Risk based:

The failureprobability and failureconsequences of the objective

Rule based vs. Risk based

Safe Escape Routes

Rule based:

Independent from boundary conditions

Not realistic

Risk based:

Taking into account boundary conditions and uncertainties (stochastic conditions)

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Rule based vs. Risk based

Safe Compartmentation

Objective:

Limiting spread of fire

Rule based:

Fire resistance (EIW) of separation contructions

Risk based:

The failureprobability and failureconsequences of the objective

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Rule based vs. Risk based

Safe Compartmentation

Example:
Supermarket 1.000 m2

Objective:
AST > RST

- AST depends on fire resistance of separation construction
- RST depends on thermal load by a natural fire

[min. SFC]

Safe Compartmentation

AST:

- Assessment criterion:
  - Thermal load standard fire curve
  - Fire resistance 60 min. EIW (classification: EN 13501-2)

RST:

- Assessment criterion:
  - Thermal load natural fire curve
  - **Stochastic boundary conditions→ reliability?**

AST > RST

Supermarket, 1000 m²

Supermarket, simplified model
1,000 m² floor area
5 m height

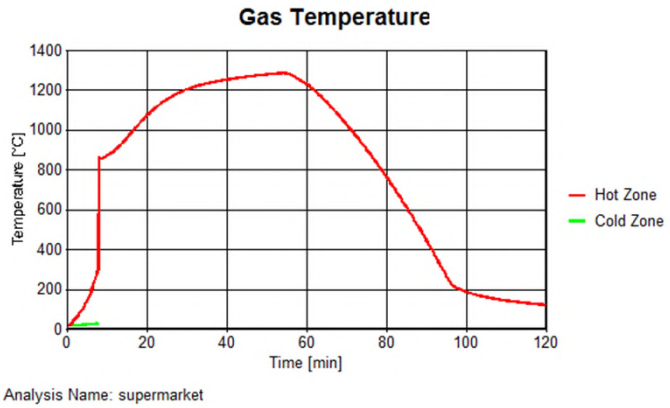
Supermarket, boundary conditions

Mean conditions for RST (natural fire calculations):

- Uniform distribution of fuel (NEN-EN 1991-1-2/NB):
  - Fire load 900 MJ/m²
  - RHR = 500 kW/m² (medium)
  - Time constant tc = 150 s (fast)
  - Plume = Heskestad
  - Stoichiometric constant r = 1,27 (cellulose fuel)
  - Combustion model (external flaming / extended combustion)

- External separation constructions:
  - Adiabatic
  - Entrance facade open

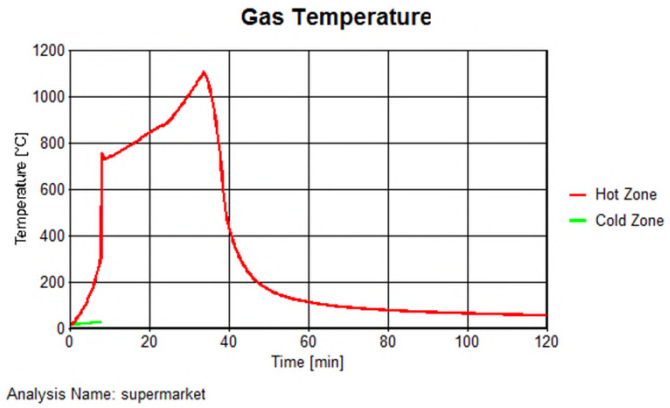
Supermarket, RST



Analysis Name: supermarket

Post flashover: ventilation controlled, extended combustion

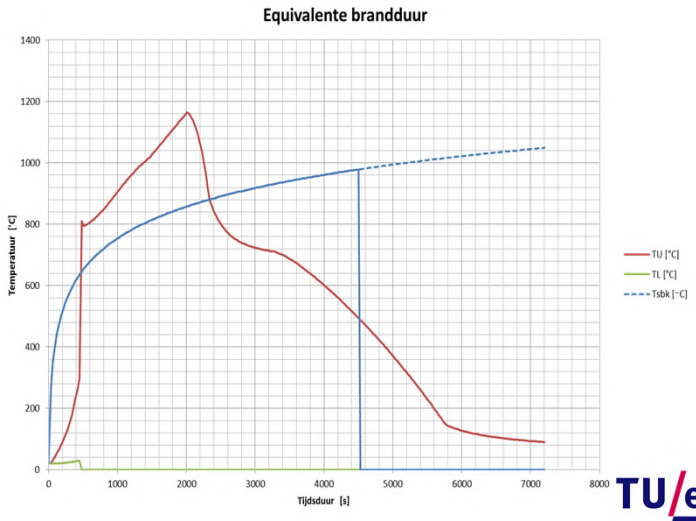
Supermarket, RST



Analysis Name: supermarket

Post flashover: ventilation controlled, external flaming

Supermarket, RST



Supermarket, RST and AST

- **AST :** **60 min SFC**
- **RST :** **70.5 min SFC**

- **AST-RST =** **-10.5 min**

Safe compartmentation?

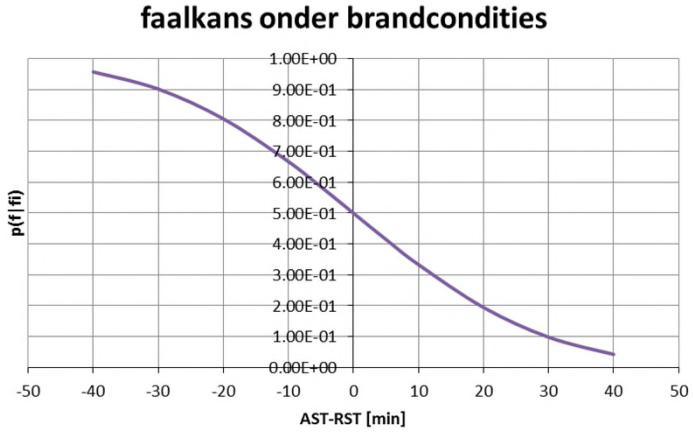
Failure probability analysis

Take into account uncertainty of boundary conditions (stochastic parameters):

- **Fire Load (MJ/m^2)**
- **RHR (kW/m^2)**
- **Time constant (s)**
- **Height of fire source (m)**
- **Openings (m^2)**

Most important parameter?

Failure probability analysis



AST: 60 min SFC, RST: 70.5 min SFC → failure probability: 67.5 %

Improving safe compartmentation

Improving passive fire control:

Increase fire resistance → 90 min → 120 min

Active fire control: sprinkler system

Source reduction → improving AST

Active smoke control: smoke outlet system

Increasing smokelayer buffering → improving AST

Improving safe compartmentation

Manual suppression/cooling by fire brigade

Inside compartment (offensive)

Outside compartment (defensive)

Related problems separation constructions

Adjoining constructions

Flanking heat transport

Smoke resistance

Convective transport

Overpressure in case of developing fire in compartment

Risk of evacuation blocking

Master students needed!

safety of large compartments
safety of large carparks
safety of buildings without evacuation
safety of highrise buildings

reliability of load bearing elements
reliability of separation constructions
reliability of active preventive measures
reliability of suppression by fire brigade

modelling of fire and fire experiments

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