Fire Scenarios Assessment

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Introduction

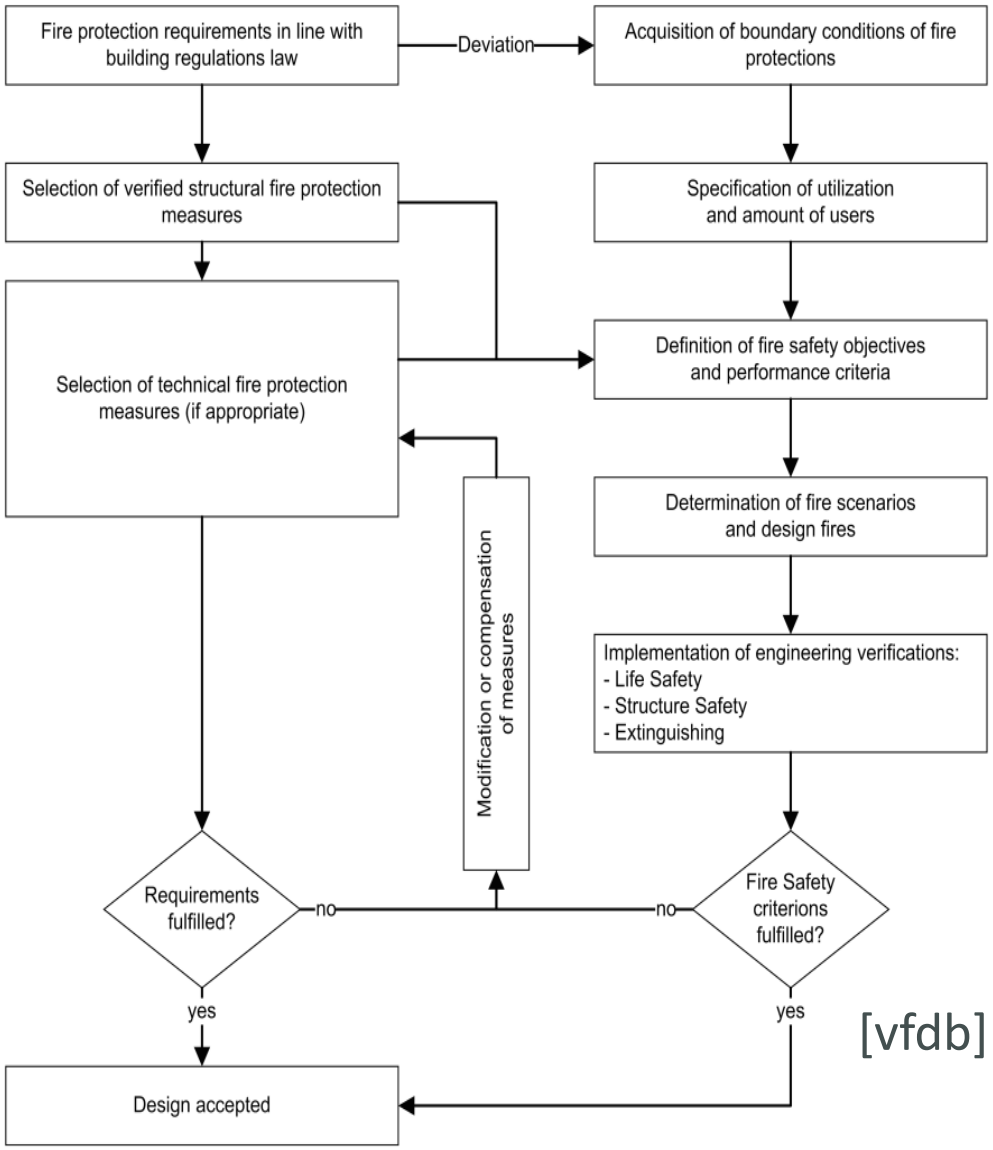
- Performance-based fire safety design is not explicitly embedded in German building codes
- Major knowledge is closely linked to prescriptive design approach

Germany

- 16 local building codes
- 16 local regulations for:
  - Assembly
  - Industrial buildings
  - High-rise buildings
  - Garage
  - Shop and mall
  - Electrical facilities

Performance based fire safety design in Germany

- Directive for industrial buildings in conjunction with DIN 18230 since1978
- German Fire Protection Association (GFPA): Guideline Fire Protection Engineering since 2005
- Engineering and/or expert judgement

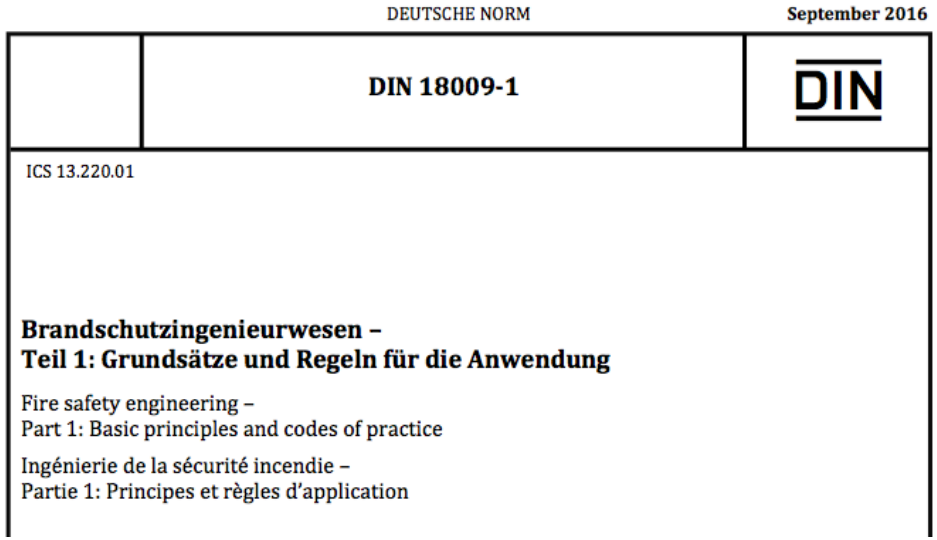


[vfdb]

Standardization activities in Germany

DIN working committee NA 005-52-21 AA
„Brandschutzingenieurverfahren“
(Fire safety engineering)

- DIN 18009 Part 1 (2016:09)
  Fire safety engineering:
  Basic principles and codes of practice
- DIN 18009 Part 2 (in progress)
  Fire safety engineering:
  Evacuation and life safety
- DIN 18009 Part 3 (in progress)
  Fire safety engineering:
  Fire scenarios



DEUTSCHE NORM September 2016

DIN 18009-1

DIN

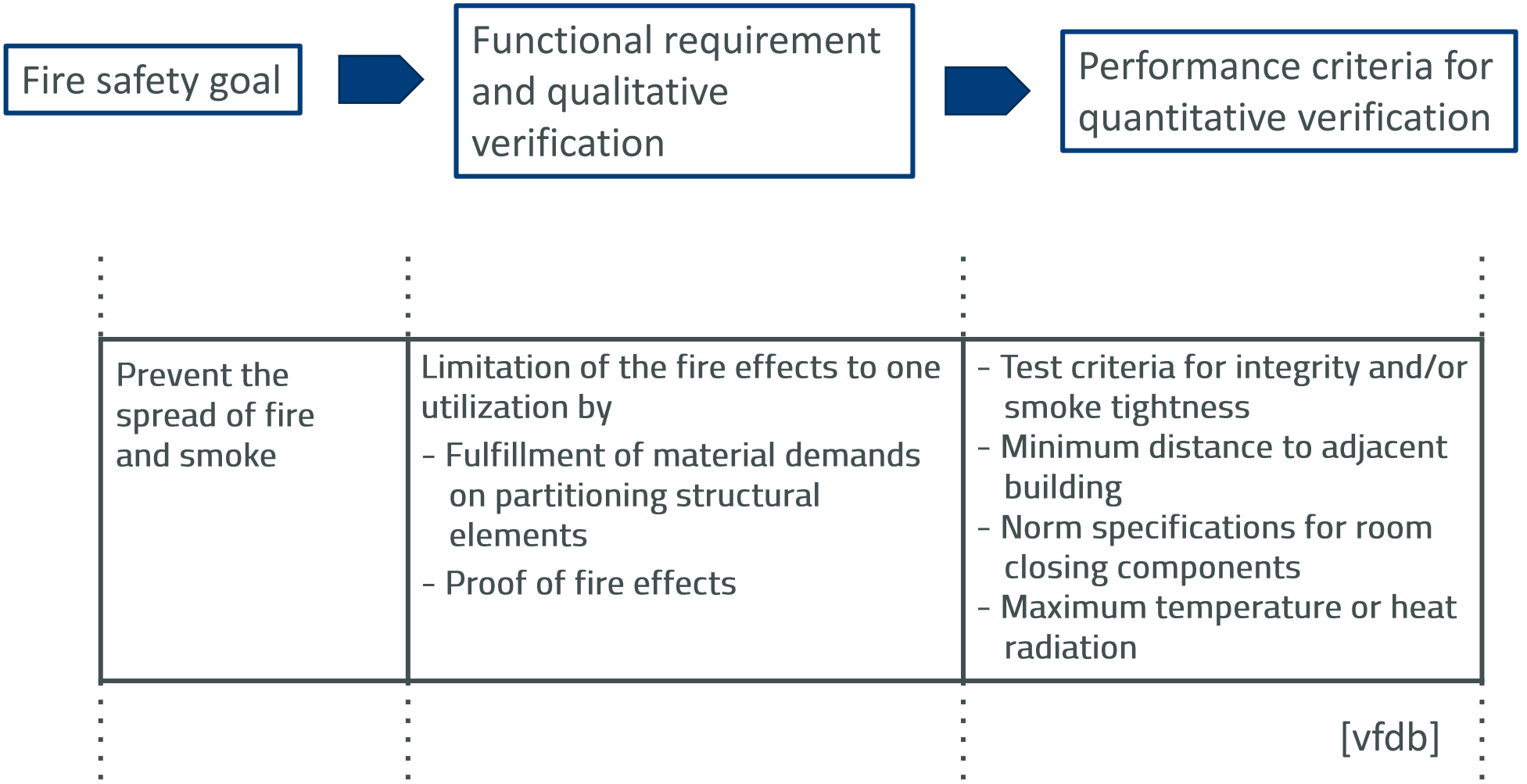
ICS 13.220.01

Brandschutzingenieurwesen –
Teil 1: Grundsätze und Regeln für die Anwendung

Fire safety engineering –
Part 1: Basic principles and codes of practice

Ingénierie de la sécurité incendie –
Partie 1: Principes et règles d'application

Performance criteria

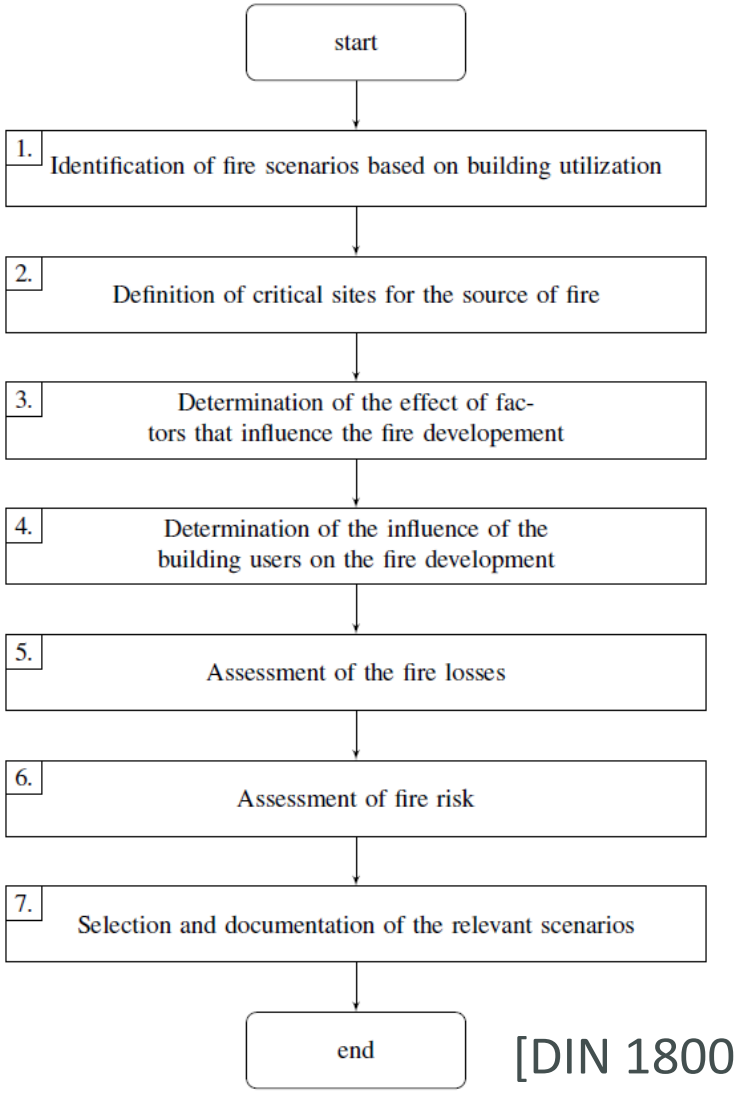


Performance criteria

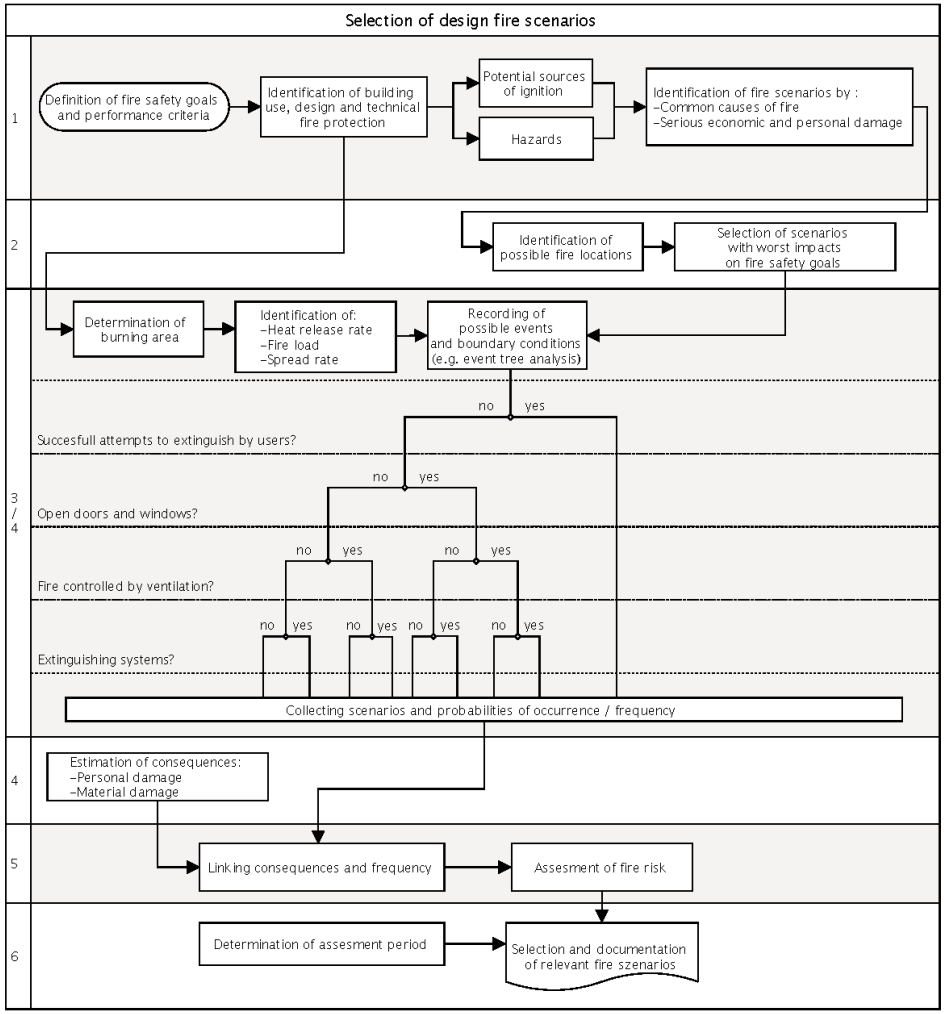
- Ensuring a safety level in accordance with building regulations
- Influencing variables must be selected based on sufficiently conservative assumptions or have to be varied within parameter studies

$$R \cdot \gamma_R \geq A \cdot \gamma_A$$

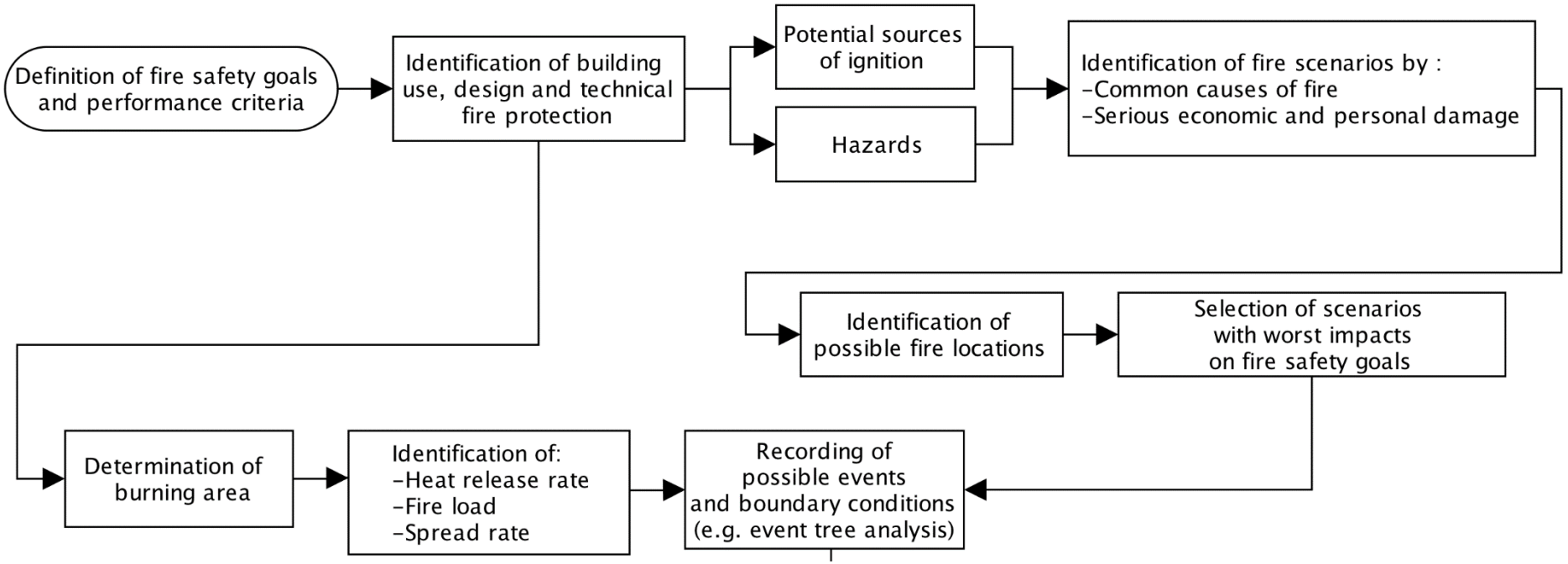
Selection of design fire scenarios



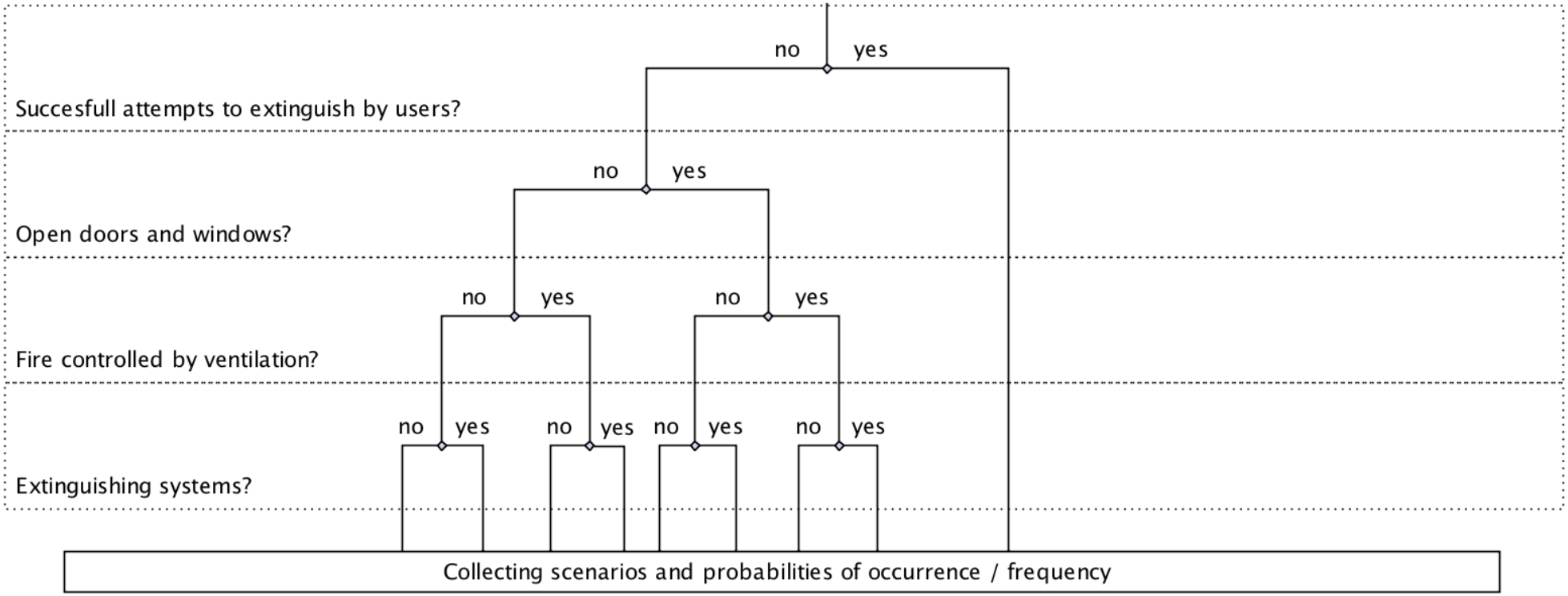
[DIN 18009-1]



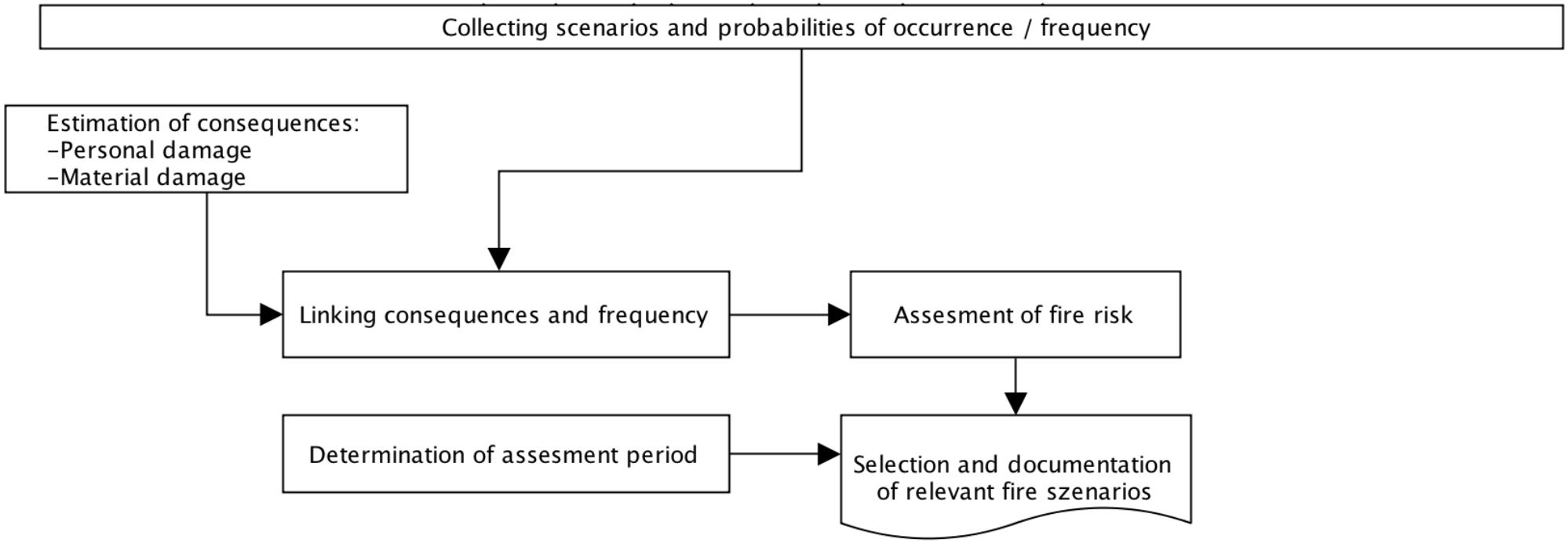
Workflow Part 1 - 3



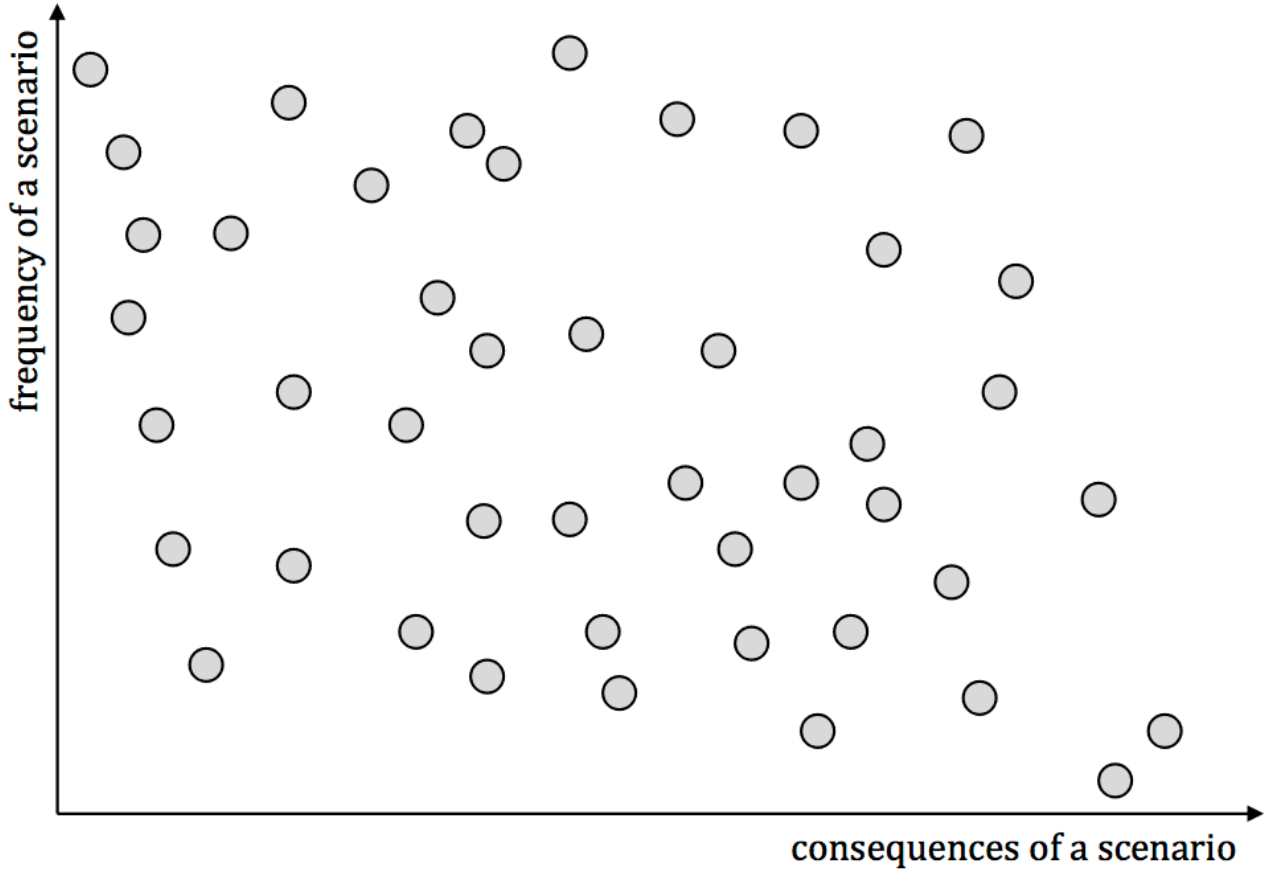
Workflow Part 3-4



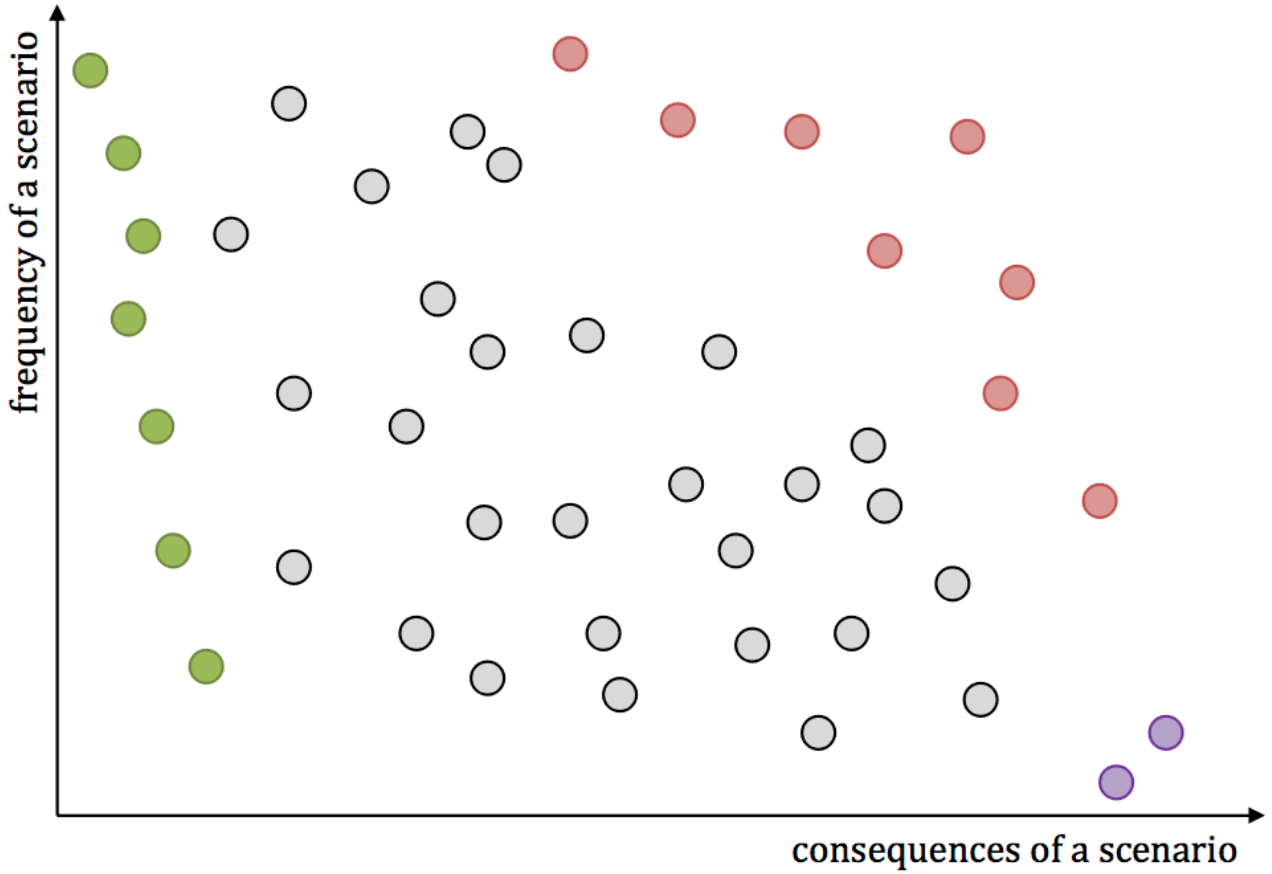
Workflow Part 4-6



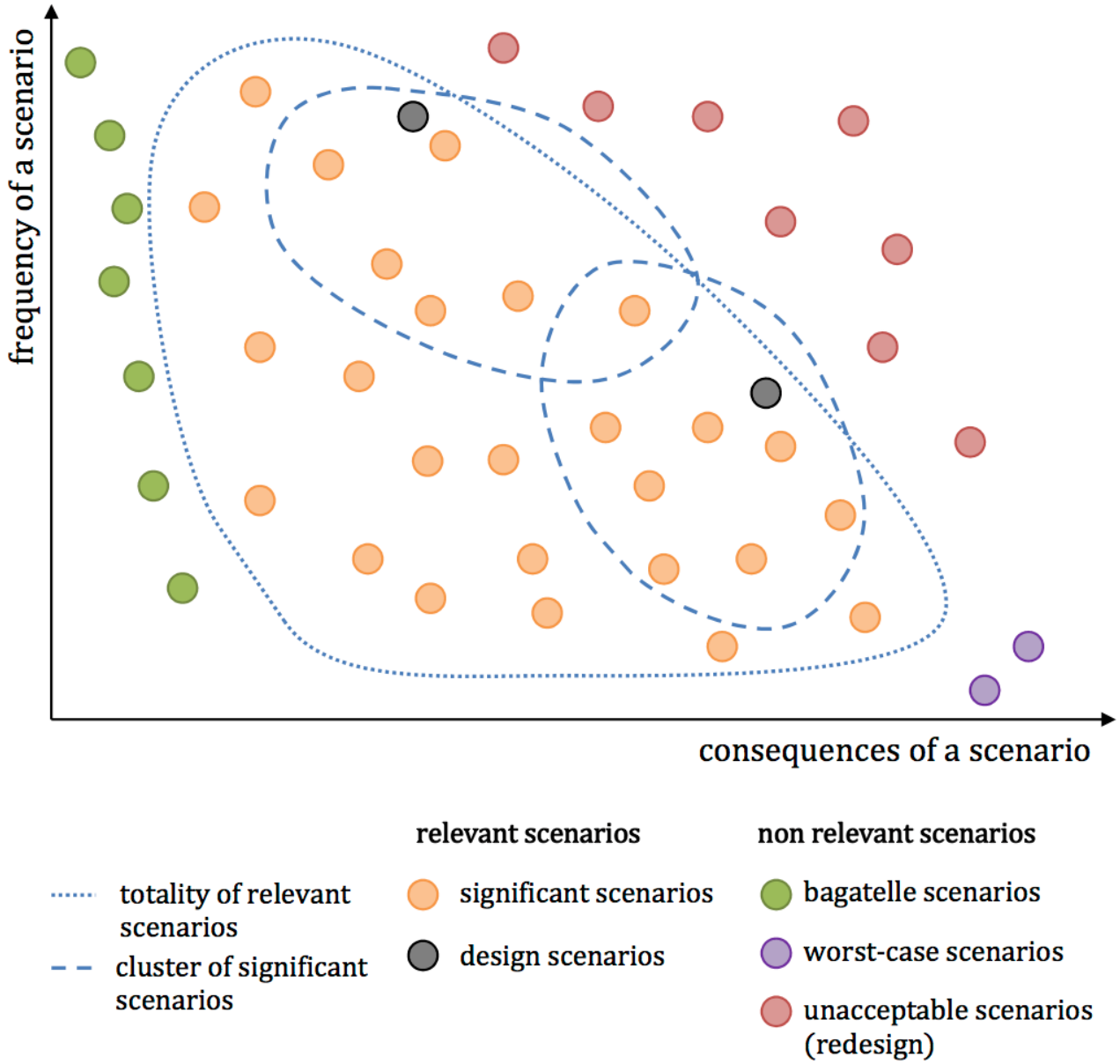
Scenario based design



Scenario based design – bagatelle and worst case scenarios



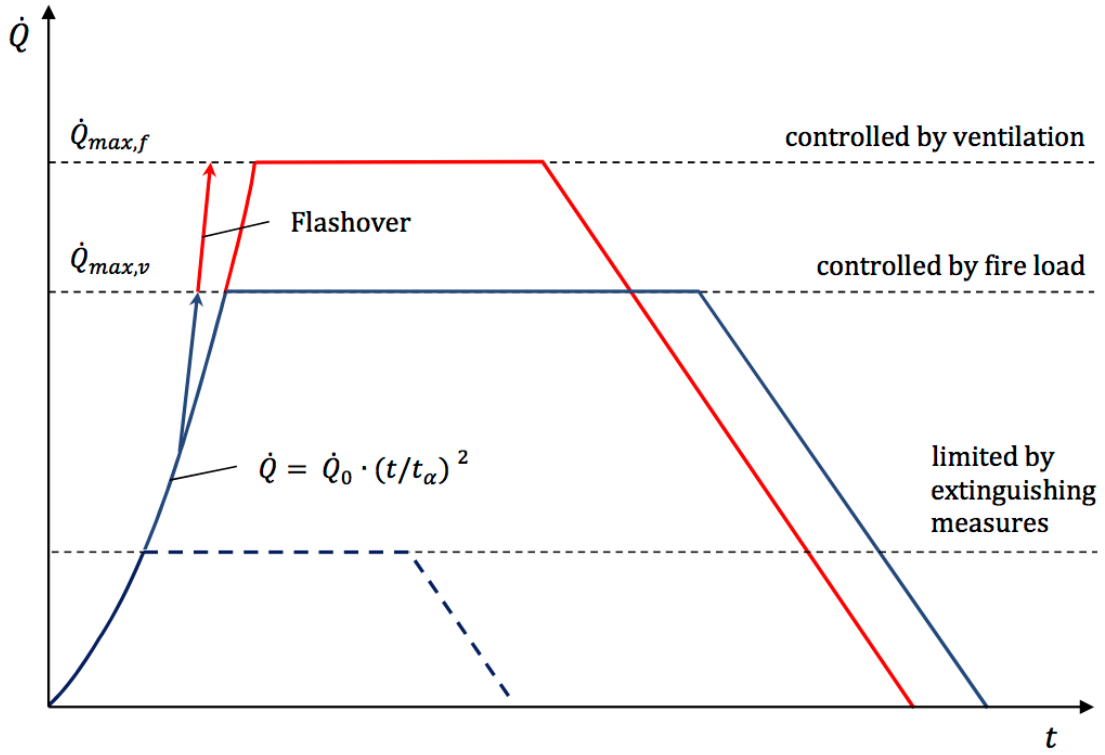
Scenario based design – selection of relevant scenarios



Fire modeling – design fire

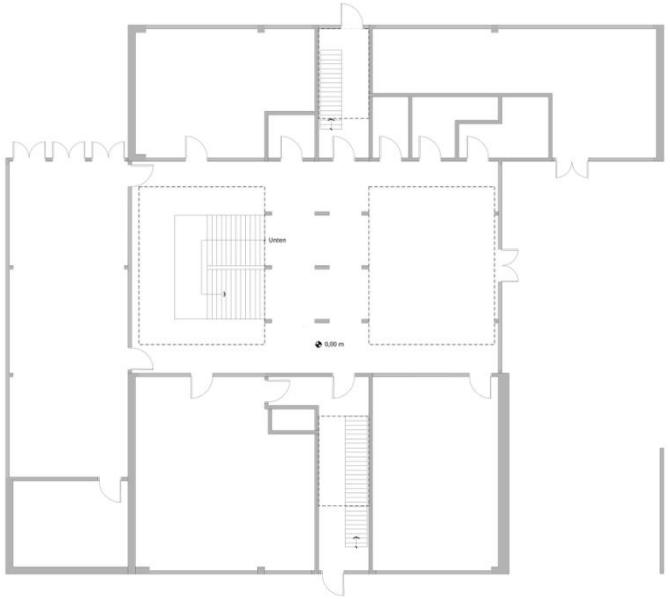
Design fire is characterized by:

- Maximum fire surface
- Fire load density
- Heat release rate
- Fire spread rate

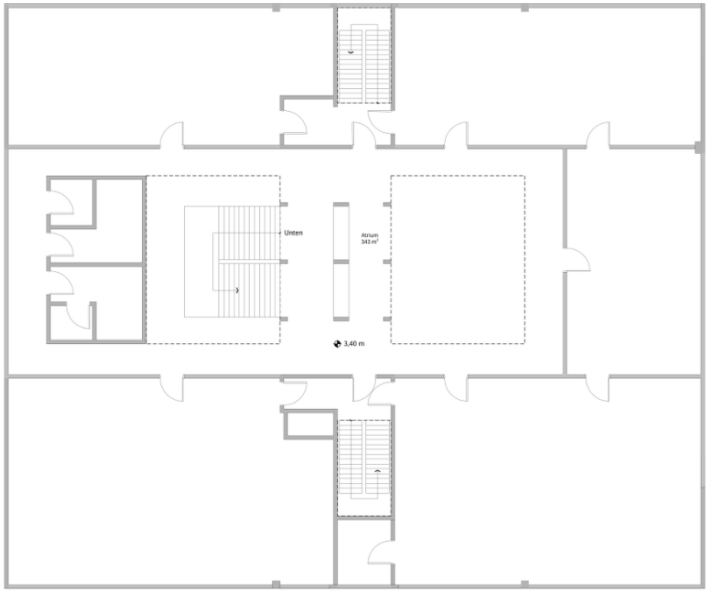


Application example

- Three-storey building
- Differently used areas:
- Ground floor:
  - Lobby
  - Restaurant
  - Offices
- 1st/2nd floor:
  - Offices
  - Meeting/conference
- Two independent stairwells
- Atrium with open stairs



Ground floor



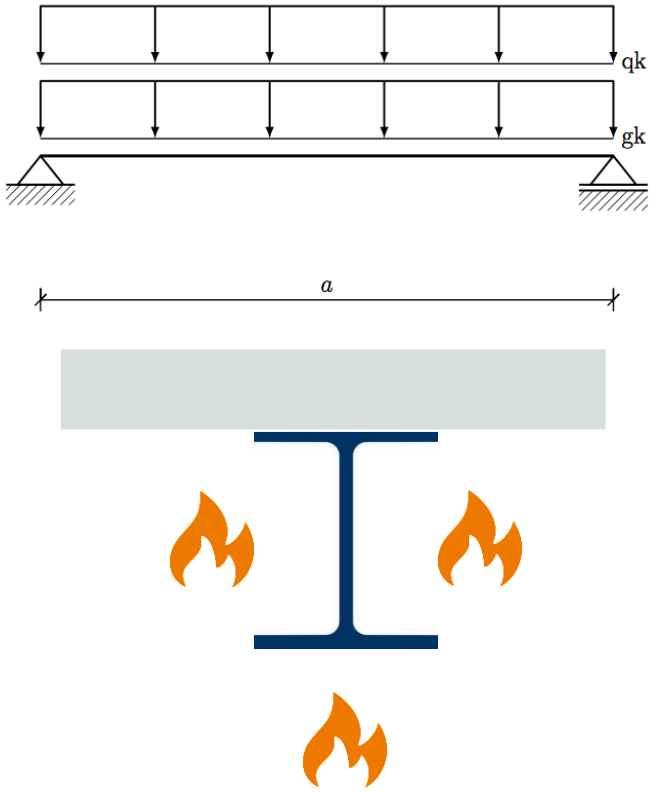
1st/2nd floor

Project scope and goals

Fire safety goals can be derived from the requirements of MBO:

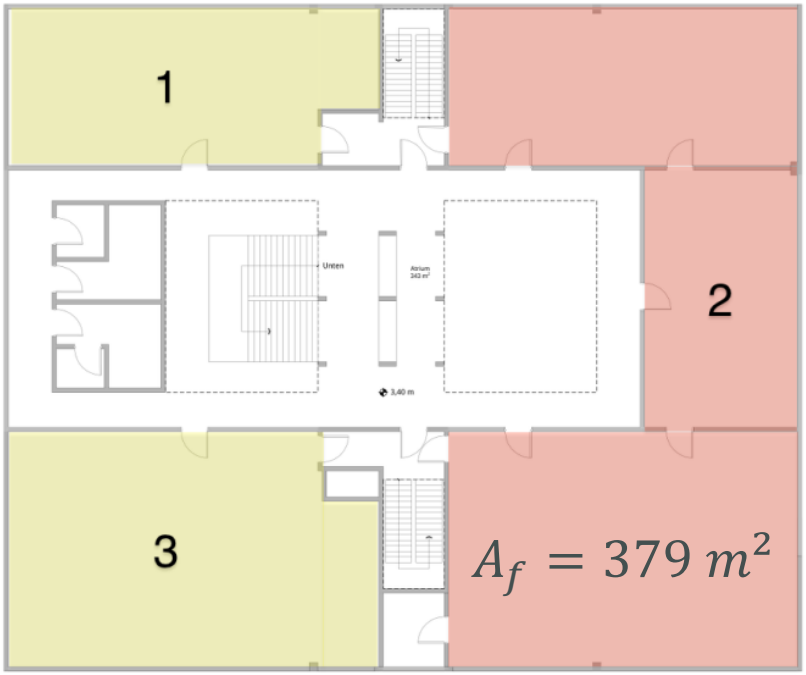
- Prevent the fire from starting
- Prevent the spread of fire and smoke
- Enabling of escape and rescue
- Enabling of effective firefighting measures

R 90 can not be guaranteed without further evidence



Exploration of fire scenarios

- Defective electrical equipment and misbehavior of persons can be identified as possible causes of fire
- Fire scenarios which result in a high thermal load of the roof structure should be considered



Design fire and safety concept

Annual probability of occurrence for an initial fire in an utilization unit	p_1	6.2×10^{-3}
Probability of the failure of firefighting measures by users	$p_{2,1}$	0.5
Probability of the failure of firefighting measures by the fire brigade	$p_{2,2}$	0.2
Probability of the failure of firefighting measures by an automatic extinguishing system	p_3	1.0
Permissible failure probability	p_f	1.3×10^{-5}

Probability of occurrence of a destructive fire in a utilization unit (1 year)

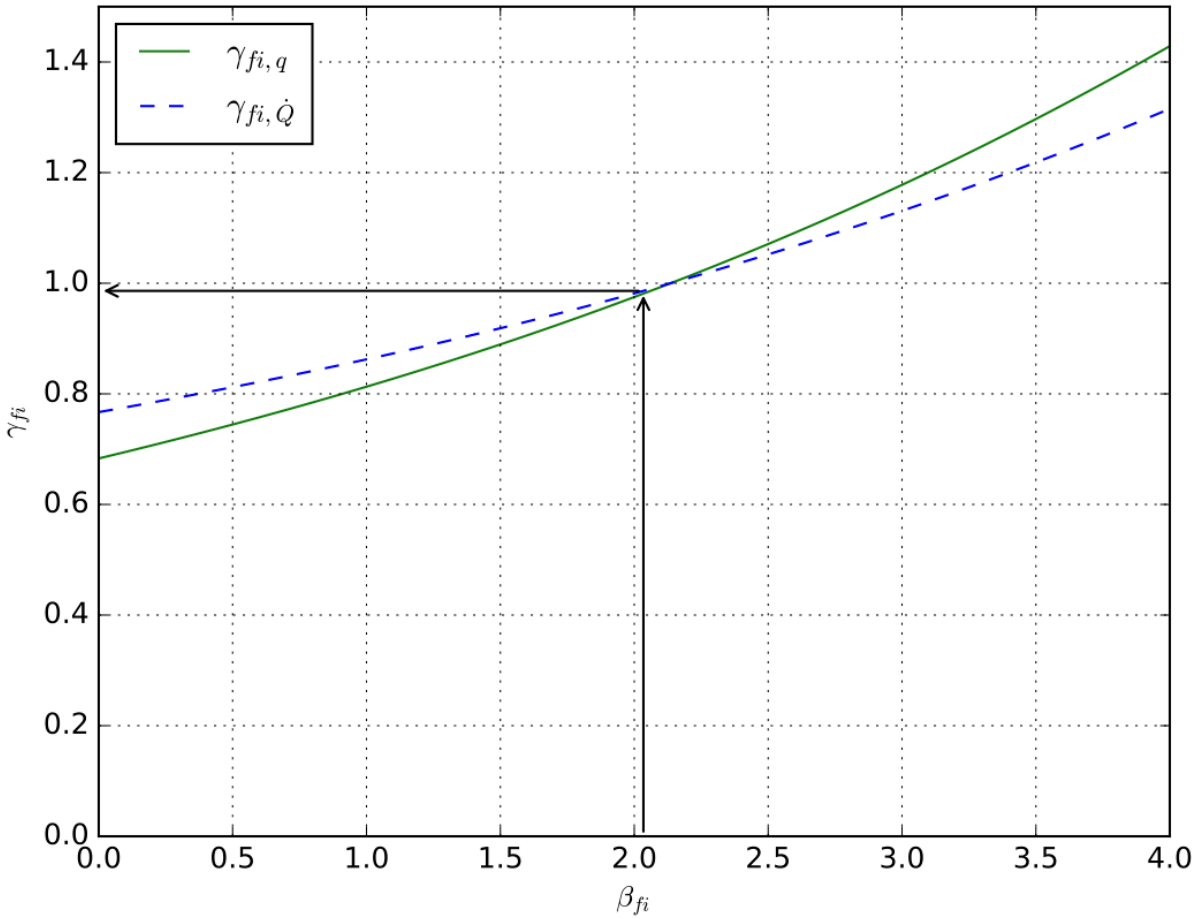
$$p_{fi} = p_1 \cdot p_{2,1} \cdot p_{2,2} \cdot p_3 = 6.2 \cdot 10^{-3} \cdot 0.5 \cdot 0.2 \cdot 1 = 6.2 \cdot 10^{-4}$$

Conditional failure probability in case of fire and linked reliability index

$$p_{f,fi} = \frac{p_f}{p_{fi}} = \frac{1.3 \cdot 10^{-5}}{6.2 \cdot 10^{-4}} = 2.097 \cdot 10^{-2}$$

$$\beta_{fi} = -\phi^{-1}(p_{f,fi}) = -\phi^{-1}(2.097 \cdot 10^{-2}) = 2.034$$

Design fire and safety concept



$$\gamma_{fi,\dot{Q}} = 0.986$$

$$\gamma_{fi,q} = 0.981$$

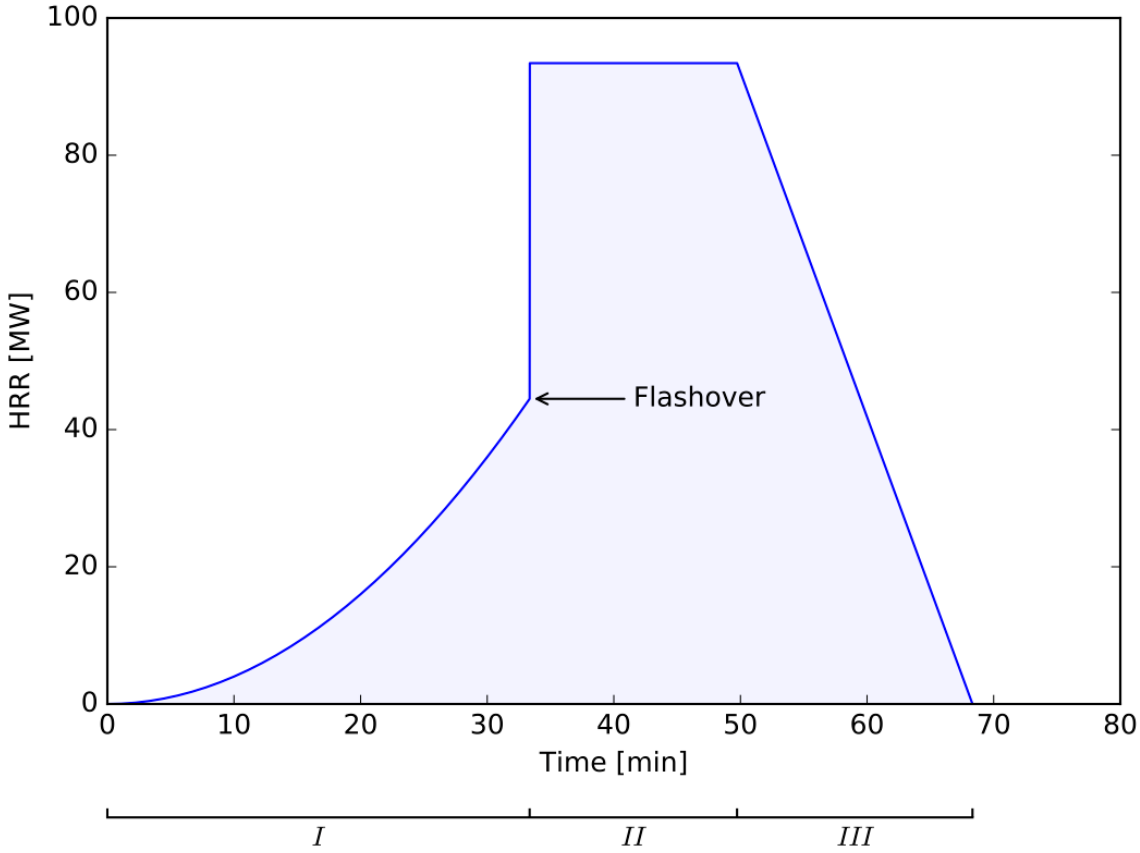
$$\gamma_{fi} = \frac{1 - V \cdot 0.78 \cdot [0.5772 + ln(-ln(\phi(\alpha \cdot \beta_{fi})))]}{1 - V \cdot 0.78 \cdot [0.5772 + ln(-ln(0.9))]}$$

Design fire and safety concept

Input parameters as 90% quantile

$$q_{fk} = 584\ MJ/m^2$$

$$RHR_f = 0.25\ MW/m^2$$



Design values of fire load density and heat release rate:

$$q_{f,d} = \chi \cdot q_{f,k} \cdot \gamma_{fi,\dot{Q}} = 0.8 \cdot 584\ MJ/m^2 \cdot 0.981 = 458.3\ MJ/m^2$$

$$\dot{Q}_{max,d} = A_f \cdot RHR_f \cdot \gamma_{fi,\dot{Q}} = 379m^2 \cdot 0.25\ MW/m^2 \cdot 0.986 = 93.42\ MW$$

Conclusion and outlook

- Working steps by DIN 18009-1 can only be regarded as indications for a performance-based design
- Boundary conditions should cover all conceivable fire events
- Decision whether or not an fire safety goal is fulfilled by a computational evidence is with the approving authority
- Equivalence of computational evidence with descriptive specifications would be desirable

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Sachverständige, Berater, Gutachter

Questions ?