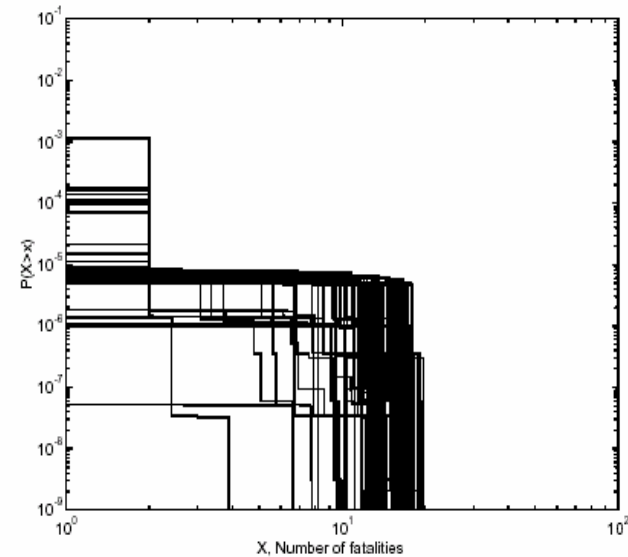
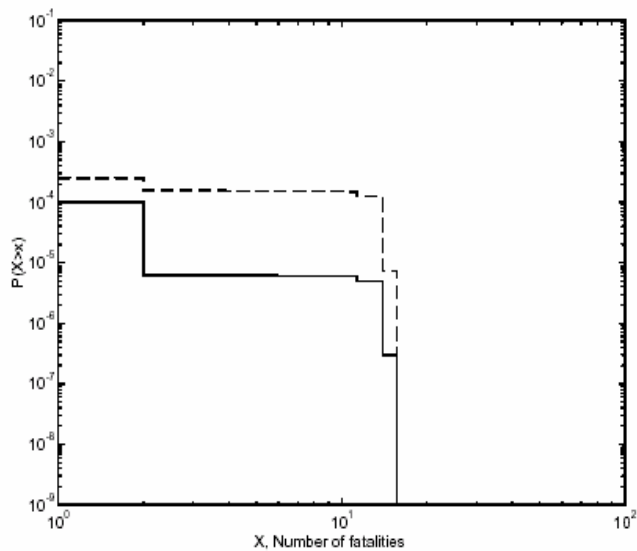


Risikoanalyser ved funktionsbaserede brandkrav



Fredrik Nystedt
Tekn. Lic., Brandingenjör

- Fire safety design aspects
- Verifying building safety
- Quantitative risk analysis
- Danish building fire risk
- Promoting Fire QRA
- Notes on probabilities and consequences
- Interpreting the design fire

Fire safety design aspects

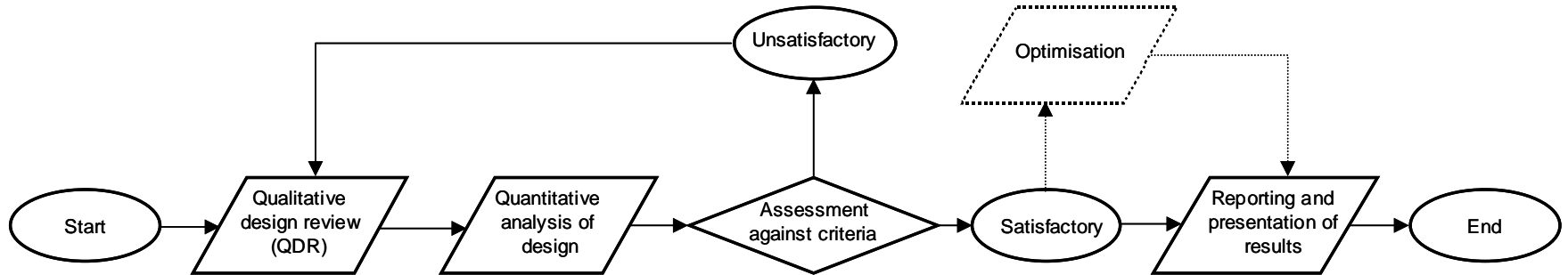
- Fire regulations are developed by tradition and "trial ´n error"
- Today´s architecture is not traditional



- Fire safety could be designed by...
 - Prescriptive methods
 - Analytical methods (prescribed for some buildings)
- Code compliance should be shown
 - Comparative criteria
 - Absolute criteria

- When beyond normal limits...
 - Treatment of reliability and uncertainty
 - Risk analysis (e.g. QRA)
- Acceptable risk?
 - Quantitative measures
 - Qualitative measures
 - Everything operates - no critical exposure
 - Number of safety barriers
 - Switch-over analysis
 - What will cause consequence?

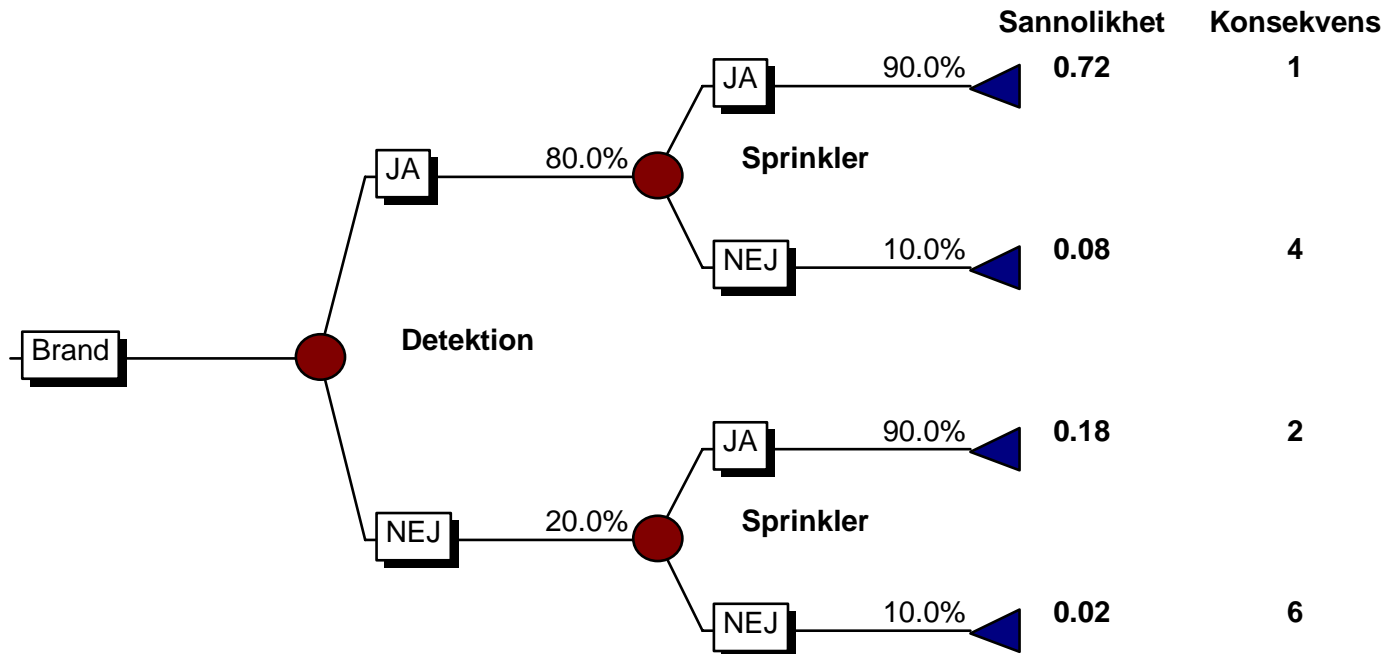
Standardised procedure



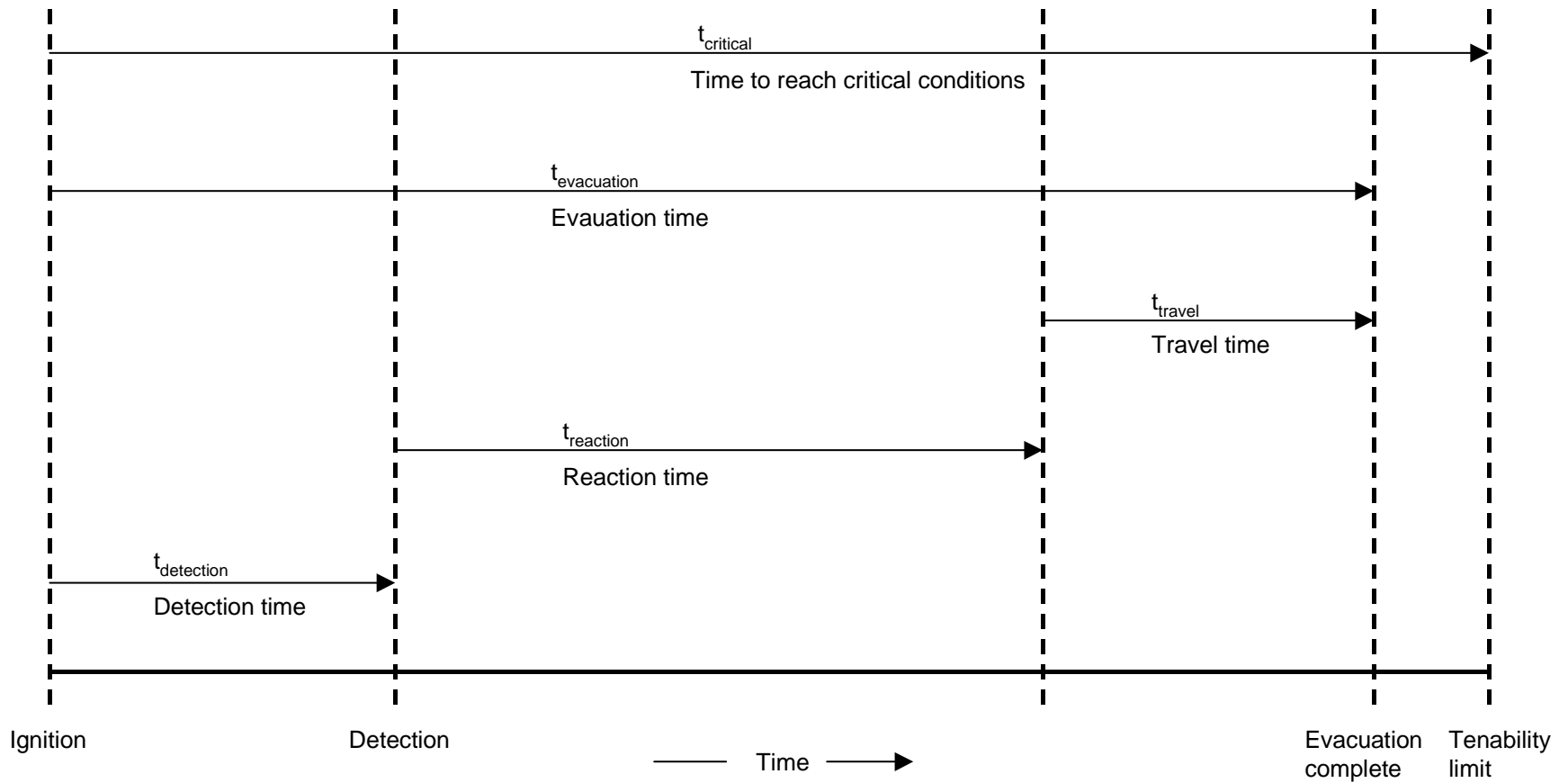
- **First, a qualitative design review**
 - Characterize building & occupants
 - Define safety objectives and trial design solutions
 - Identify fire hazards and design scenarios
- **Then, a QRA**
 - Selection of events
 - Event tree design
 - Quantification of fire development
 - Assessment of damage
 - Calculation of risk measures and risk evaluation

- Construct the event tree
 - Considered events relates to both human response and performance of fire protection systems
- Fire development and evacuation calculations for each sub scenario
 - Computerized models like CFAST, FDS and Simulex could be used

The event tree

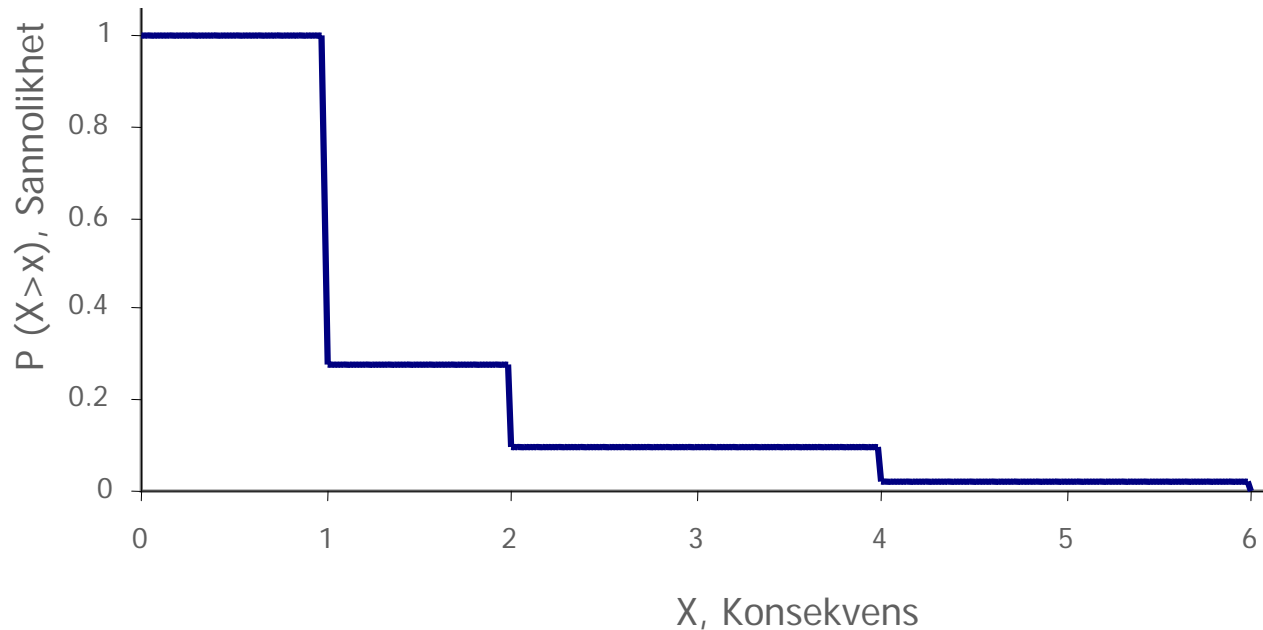


Time-line comparison

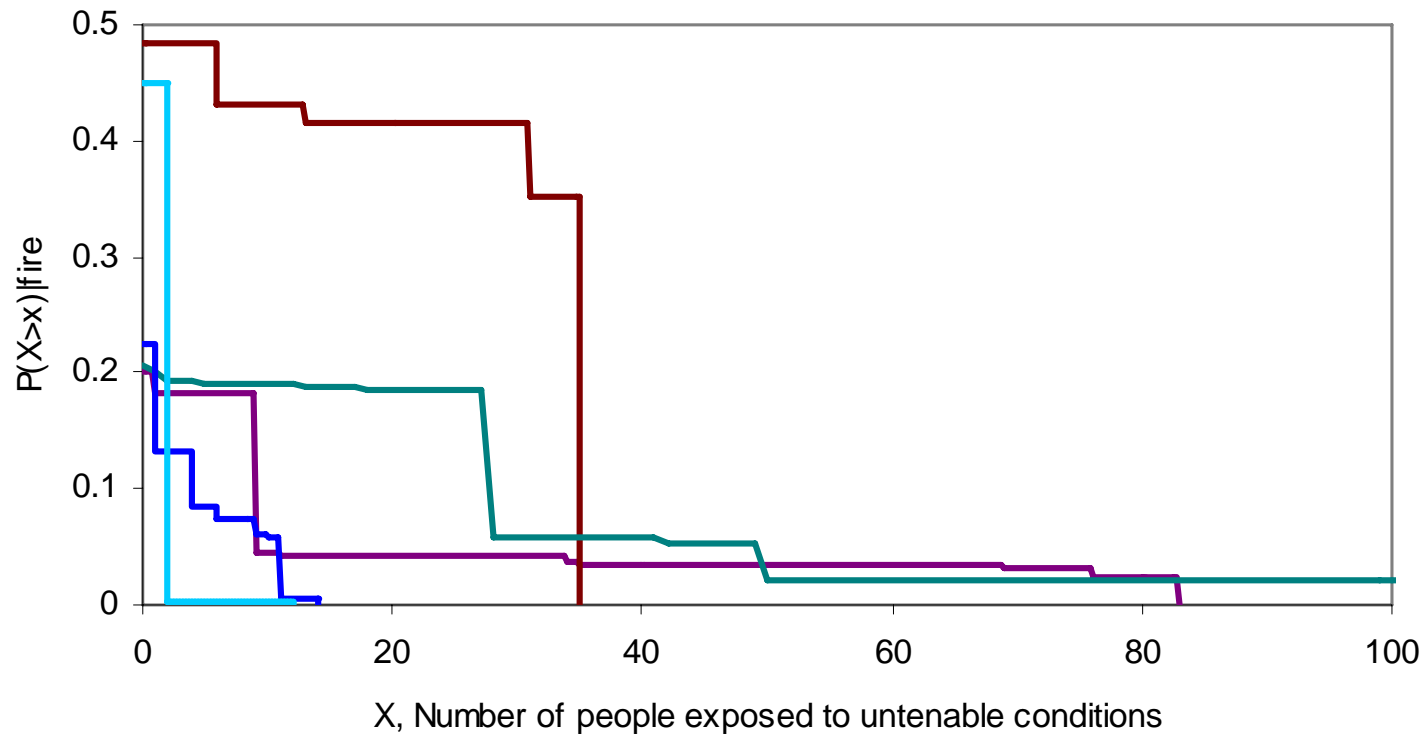


Risk measures

Consequence	Probability	CDF	CCDF
0	0	0	1.00
1	0.72	0.72	0.28
2	0.18	0.90	0.10
4	0.08	0.98	0.02
6	0.02	1.00	0.00



- Analysing five code compliant buildings of different types resulted in...



Danish fire risk (assessed)



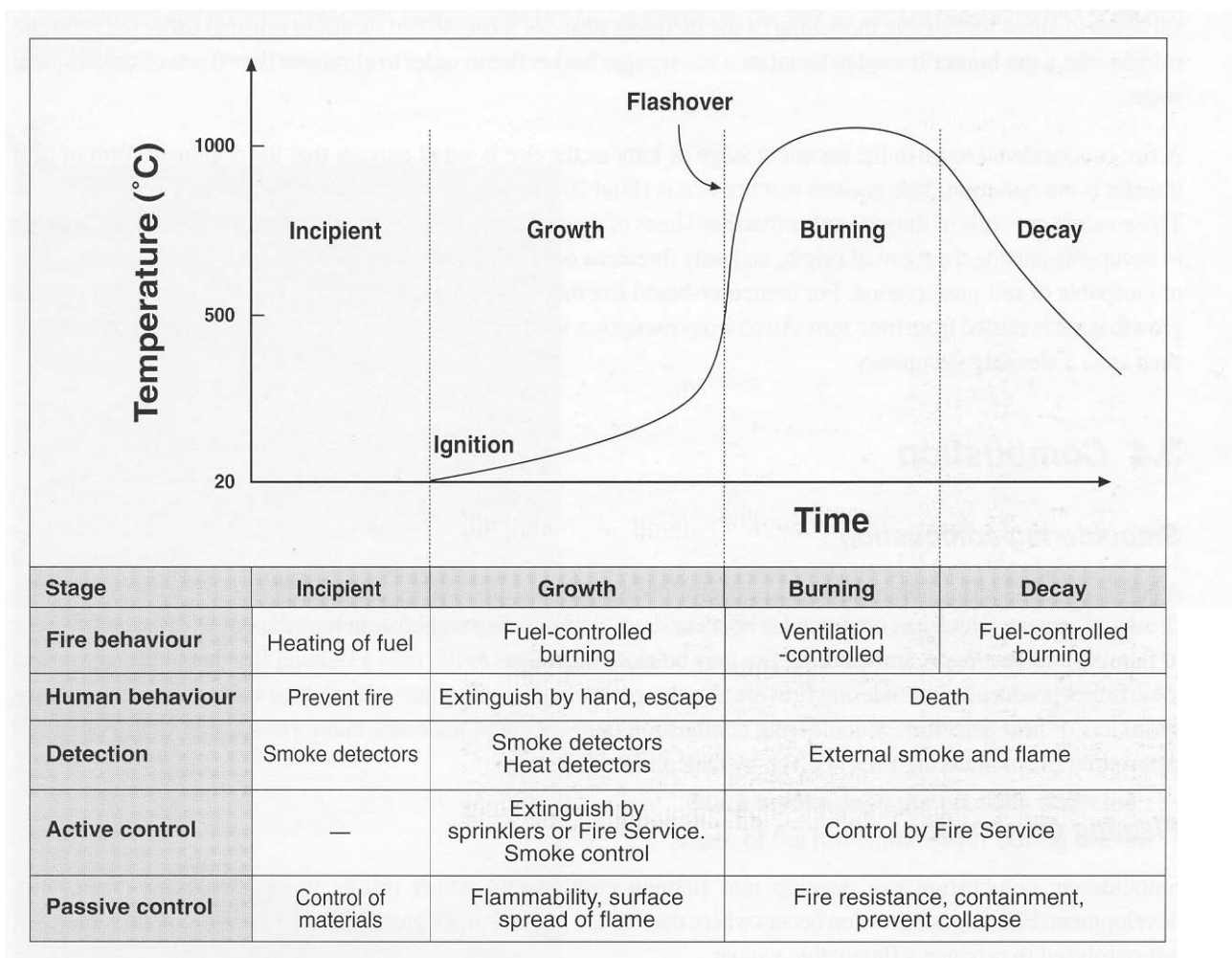
Building	Fire safety measure	Individual risk	Average risk	Maximum consequence
Elderly home 14 occupants	Br 95	0,23	1,2	14
	No smoke alarm	0,34	2,0	14
	Sprinkler system	0,08	0,5	14
Elderly home (dormitory) 82 occupants	Br95	0,45	0,9	12
	No sprinkler system	0,45	1,4	12
Hotel with restaurant 647 occupants	Br95	0,20	9,1	236
	Smoke and escape alarm	0,17	5,8	128
	Sprinkler system	0,16	5,6	236
School 365 occupants	Br95	0,20	4,3	83
	Manual escape alarm	0,18	2,8	83
	Smoke and escape alarm	0,07	1,5	83
	Sprinkler system	0,02	0,8	83
Office building 160 occupants	Br95	0,48	14,8	35
	Manual escape alarm	0,44	13,8	35
	Smoke and escape alarm	0,43	10,7	35
	Sprinkler system	0,15	3,5	35

- QRA is a must in performance-based building design
- QRA is needed to show code compliance
 - Treats reliability, variability and uncertainty
 - Extensive information on fire safety gathered
 - Identifies strengths and weaknesses
- Risk-informed decision making

- Analysis based on:
 - Absolute measure of risk?
 - Risk given that a growing fire occurs?
- Successful operation of safety measures
 - What does a 95% probability of sprinkler activation mean?

- Today's measure is in conflict with decision makers risk aversion
- Which measure of consequence should be used?
 - Untenable conditions
 - Number of wounded or dead
- Zone models vs CFD-models
 - A single measure from zone models
 - Where to measure in a CFD-model

Interpretation of the design fire



A Quantified Fire Risk DESIGN METHOD

By Fredrik Olsson

The available risk analysis tools possess a variety of different methods. These methods are non-unique, flexible and could therefore be divided into the following well-established categories of descriptive methods, semi-quantitative methods and quantitative methods.

OVERVIEW OF RISK ANALYSIS METHODS

Qualitative methods are either based on an individual case where a well-defined hazard is evaluated and the solution is the best safety strategy in kind. Design engineers and engineers performing an other task can make minor adjustments in existing, accepted solutions in risk or other areas of different safety measures of a building. The performance reference used in the methods to estimate and compare solutions for one or two worst cases. The use of performance methods thus only normally begins in the design process of buildings. In accepted design methods

In the historical, national and other methods, the best strategy and a risk and indicate different preventive safety measures. In Sweden, such methods are developed for facilities such as a hotel, see for example the project "In the case of fire in a newly designed risk analysis is used to study both the overall level of risk and not remember the design solutions. The method of evaluation is based on a measurement of distant risk with some form of design criteria.

THE PRELIMINARY DESIGN PROCESS

In Sweden, the fire safety design process method includes the possibility of "Start to design" method and a performance-based design method. The performance-based design method and a risk analysis methodology is supported the design process. A design building solution is developed and was based on certain technical parameters. The fire safety objectives are defined as a "level" that a statistically limited safety is achieved. Risk-based methods can be used for this purpose. Figure 1 outlines the design process.

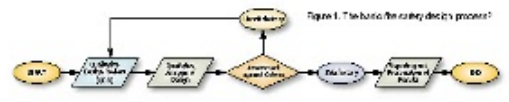


Figure 1. The basic fire safety design process?

© 2006 WUZ

Tolerable Fire Risk Criteria for Hospitals

Fredrik Olsson

Department of Fire Safety Engineering
Lund University, Sweden

Brandteknik
Lunds tekniska högskola
Lunds universitet
Report 3101, Lund 1999

Quantifying the Safety Level in the Danish Building Fire Regulations

Fredrik Nystedt Oresund Safety Advisers AB P.O. Box 82 SE-201 20 Malmö SWEDEN fredrik@oresundsafety.se	Tomas Rantatalo Fire Safety Nordic AB Orkestergatan 55 SE-371 49 Karlskrona SWEDEN tomas.rantatalo@firesafety.nu	Charlotte Micheelsen By- og Boligministeriet Slotholmsgade 1 DK-1216 København DENMARK chm@bm.dk
---	---	---

ABSTRACT

The paper presents results from a Danish study where the safety level in case of fire for number of buildings have been examined. The analyses were made with the aim of trying establish acceptance criteria to be used in risk-informed building design. An event tree based quantitative risk analysis method was used. It was not possible to give recommendations national acceptance criteria. The main reason for this conclusion is that the reliability and risk analysis methodology could be questioned. Without standardized input data a calibrated calculation methods it is most likely that the assessed safety level will be vary with great magnitude between different engineers. A comparison with acceptance criteria would there be unfair. Risk analysis is however recommended to be used as a decision tool when designing fire safety in high-risk buildings and in buildings where the traditional code compliant solutions are not applicable.

INTRODUCING PERFORMANCE-BASED CODES IN DENMARK

In 1998, Denmark initiated a transition towards performance based building regulations in field of fire safety. One of the main prerequisites for the work was that the transition should not result in a lowered safety level than what is accepted today. No matter if a prescriptive solution is adopted or analytical methods are used, the society demands that the achieved safety level should be the same. It was suggested that risk analysis should be used to identify the safety level. Risk analysis should also be used by engineers to show that the building complies with the acceptable safety level. Essential questions that arise early in the work outlined below.

- Is there enough knowledge and experience with risk analysis in the field of building fire safety engineering?
- Are the suggested methods transparent enough to be used by different engineers and satisfactory comparable results?
- Which is an acceptable level of safety and is available input data satisfactory?

■ Available at www.wuz.se