Application
of Fire Engineering

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Background FSE

- Fire safety engineering presents a framework for the long-term future of fire safety standards. Includes a new set of standards that will support performance-based national fire safety regulations that are being discussed, developed and implemented world-wide. Such standards will be essential for a variety of current custom and pre-engineered projects designed either solely by performance-based methods, or more likely, by a blend of performance-based and prescriptive methods. There are additional needs for standardisation in areas such as the relation between fire safety design and the construction process, fire safety management, fire safety training/education and even regulation.

Introduction FSE

- Fire safety engineering (FSE) is the professional discipline that uses a formal set of procedures and engineering methods in support of existing or planned performance-based national fire safety requirements world-wide. In addition to these purely performance-based requirements, it is becoming very common for fire safety engineering to supplement prescriptive requirements by being applied to specific design aspects of a project.

Introduction FSE

- Many standardised fire test methods give information on the performance of a material or assembly '*in the test*', which may or may not be related to the most likely real fire scenarios. These test methods are valuable for ranking materials or assemblies under standard fire exposure conditions and play an important role in prescriptive regulations, but they are not automatically suitable for supporting performance-based design.

Introduction FSE

- Material or assembly ranking is useful and necessary for quality assurance purposes, but relative 'success' in a ranking test does not reflect performance in the “real world,” where many fire scenarios are possible. Nor does a ranking test allow a comparative assessment of performance among alternative (e.g. active versus passive) fire protection strategies. The difficulty is that, in general, neither exposure conditions nor performance are adequately quantified at present to allow extrapolation to be possible from a *test environment* to different *real world* conditions.

Long-term strategy for a framework of fire safety standards

- Because of the need for a new breed of standards to support performance-based fire safety requirements, future fire safety standards are proposed to follow two parallel "tracks" that will reflect the dual needs both of prescriptive requirements and performance-based requirements. These two tracks will contain, respectively

  - Standards that support prescriptive regulations
  - Standards that support performance-based requirements

Overview of performance-based fire safety design

- Due to the randomness of fire and variations in building and occupant characteristics, it is difficult to set up a general step-by-step performance-based fire safety design that could apply to all buildings.
- Therefore, every building should be evaluated according to its specific geometric features, its use and its occupancy. However when performing a performance-based fire safety design, there are four generic steps that should be followed.
  - 1. Identification of performance objectives and requirements.
  - 2. Establishment of performance criteria.
  - 3. Quantification process.
  - 4. Presentation of design documentation to the Authority having jurisdiction for approval.

The types of analysis procedure to consider include

- Simple calculation
- Computer-based deterministic analysis
- Probabilistic studies
- Experimental methods

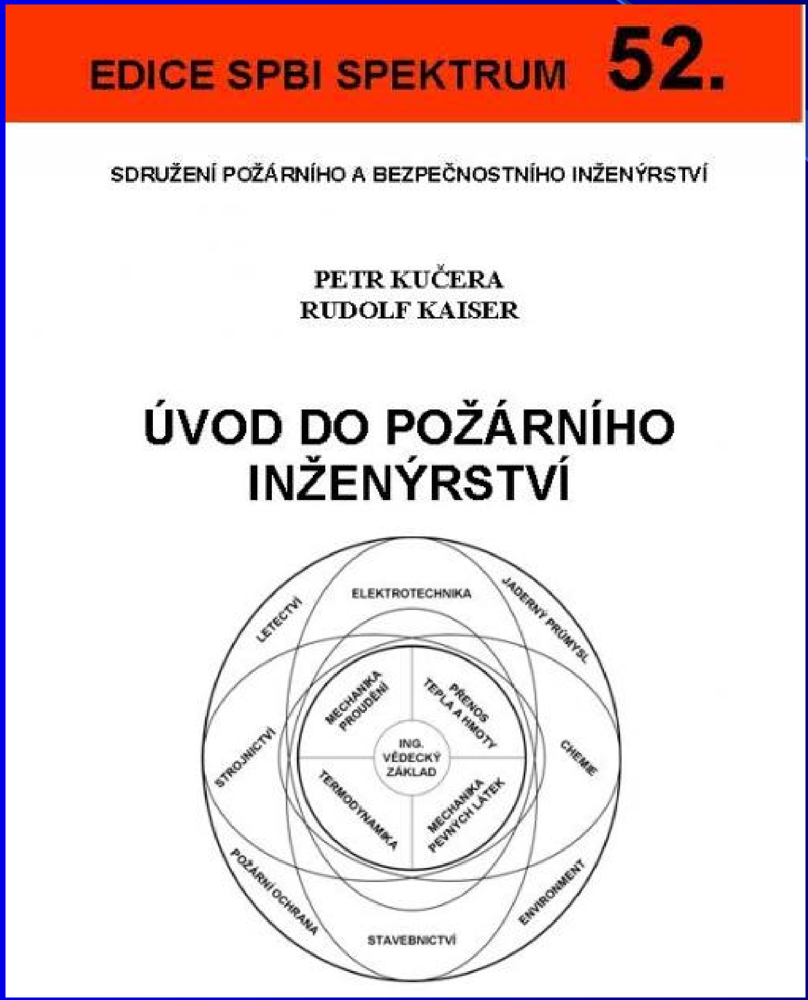
Fire safety objectives and requirements

- The following describe objectives and requirements, for consideration by the design team, in the following areas:
- fire outbreak and development;
- spread of fire and smoke;
- means of notification and evacuation;
- fire resistance and structural stability;
- emergency response operations;
- economic and social impacts;
- environmental protection.

Legislature in the Czech Republic

- Change law No. 133/1985 Sb., about fire protection, subsequently amended.
- In the year 2006 facilitation use FSE. That was the first move legislature for usage FSE.
- The new law enables to the appointed FSE to criticise construction not only according to FSE procedures.

First publication introduction to the FSE in the Czech Republic



Philosophy of document preparation in the CR

- Prepared philosophy will represent philosophical engineering progress for assesment of fire scenarios and design fires. Starting source of text material for this document will be international standard ISO/TR 13387 - 2 *Fire engineering - part 2: Design fire scenarios and design fire*.
- Submitted engineering process will be related to the constructions, that are for reasons of its range, position, way of usage or by other characteristics considered as risky and demand usage of special evaluative methods. For analysis of common constructions will be used fundamental norms of fire safety constructions.

Philosophy of document preparation in CR

- The objective of fire engineering methods is proposition of building and technical system measures that will lead to achievement of acceptable exposure (measure of risk).
- The document containes the general principles of process for assesment of design fire scenarios and design fire, without detailed specifications of methods for assesment of input values or parameters. Being usable are considered methods from tested sources with sufficient measure of veracity.

Philosophy of document preparation in CR

- In document supplements will be concluded some from input data usable at application of present engineering progress. These data will constitute characteristic fragment of usable data (e.g . choice statistical data, experimentally given characteristics).
- From principle of used methods of fire engineering for constructions results that it will be applied by specialists with appropriate qualification. For these specialists is not serviceable, in some cases perhaps not even possible, these methods of evaluation specify in detail.

Identification of fire scenarios

- **Step 1 — Location of fire**

  -Select locations in the building that produce the most adverse fire scenarios

- **Step 2 — Type of fire**

  -From fire incident statistics appropriate for the building and occupancy under consideration identify: the most likely types of fire scenarios and the most likely high consequence design fire scenarios

- **Step 3 — Potential fire hazards**

  -Identify other critical high consequence scenarios for consideration

Identification of fire scenarios

- **Step 4 — Systems and features impacting on fire**

  -Identify building and fire safety systems that are likely to have a significant impact on the course of the fire or development of untenable conditions.

- **Step 5 — People response**

  -Identify occupant characteristic and response features that could have a significant impact on the course of the fire

Identification of fire scenarios

- **Step 6 — Event tree**

  -Construct an event tree that represents the possible states of the factors that have been identified as significant. A path through this tree represents a fire scenario for consideration.

- **Step 7 — Consideration of probability**

  -Estimate the probability of occurrence of each event using available reliability data and/or engineering judgement

Identification of fire scenarios

- **Step 8 — Consideration of consequence**

  -Estimate the consequence of each scenario using engineering judgement

- **Step 9 — Risk ranking**

  -Rank the scenarios in order of risk by the probability of occurrence of the scenario

- **Step 10 — Final selection and documentation**

  -Select the highest ranked fire scenarios for quantitative analysis. These will become the design fire.

Example of selected scenarios

- Analysed building
- Type of building — **Administration building**
- Period under consideration — year 2007
- Territorial range — Moravskoslezsky region
- Number of fires — 8
- Total loss — 5 338 000, - Kc
- Causes of fires:

technical fault	2	0, - Kc
negligence	2	12 000, - Kc
arson	3	426 000, - Kc
chimneys	1	4 900 000, - Kc

Example of selected scenarios

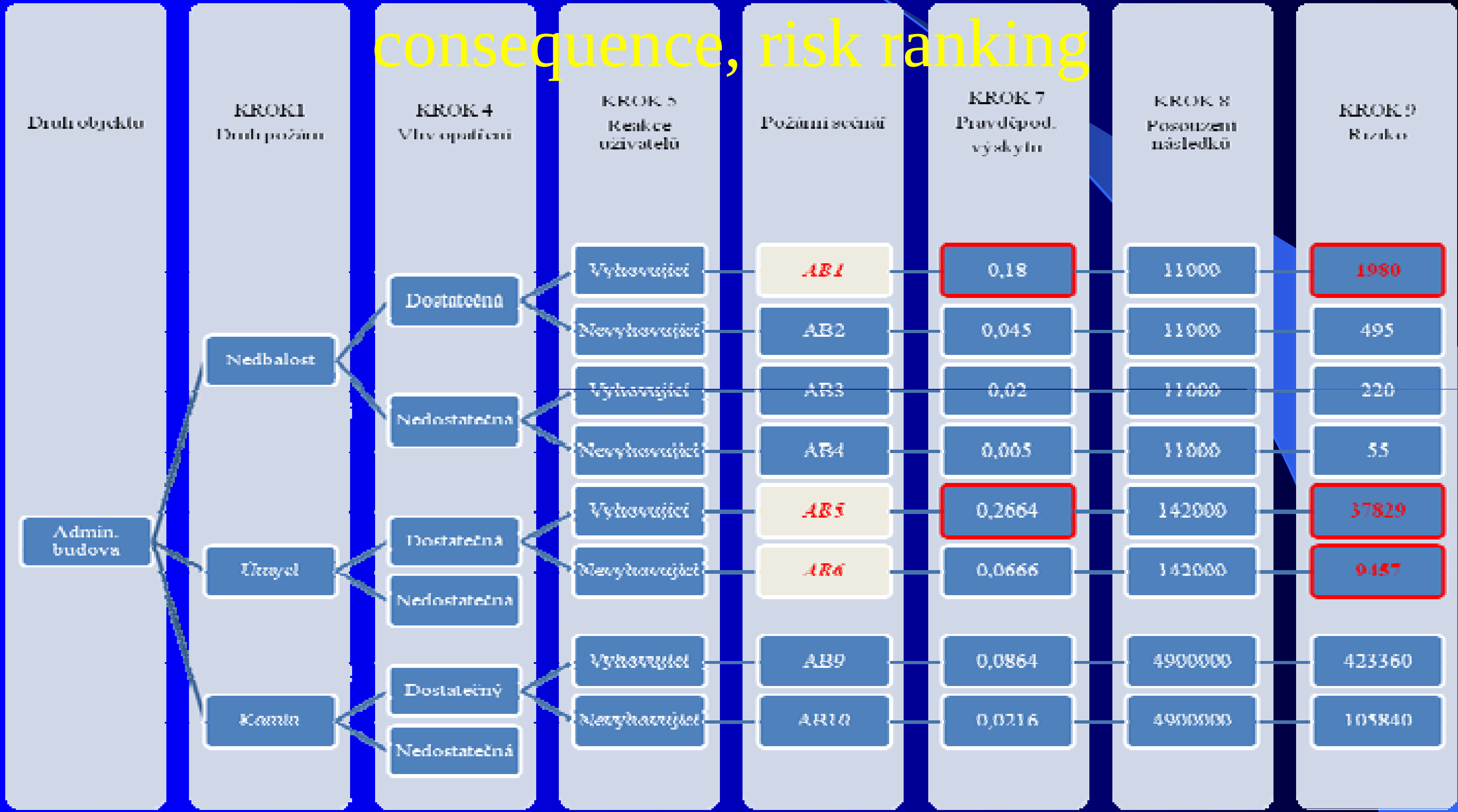
- Step1 input data - statistics (percentage expression of specific fire causes compared to total number of fires for given object)
- Step4 input data - characteristics specific building (in the present case is building new, according with codex, it is assumed decent maintenance); expertness compiler
- Step5 input data - from universal basics (in the present case it will contain mostly staff, they have skills, they are trained); expertness compiler

Example of selected scenarios

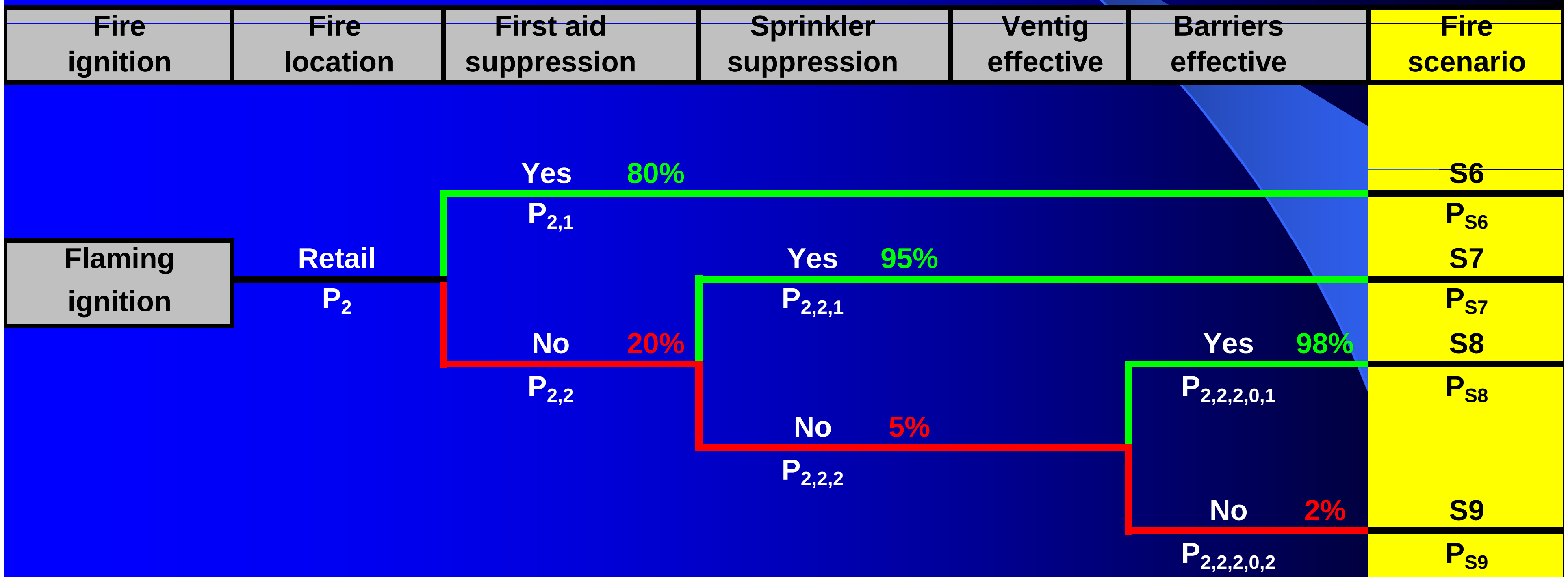
- Step7 mathematical formulation of probability occurrence
- Step8 input data - statistics (losses refered to given building and fire cause)
- Step9 mathematical formulation of hazard

- ***Chosen fire scenarios AB1, AB5 and AB6.***

Type building, type fire, systems impacting on fire, ocupant responze, design fire scenario, consideration of probability, consideration of consequence, risk ranking



Next example
400 people, retail



Consideration of probability

- $P_{S6}=P_2xP_{2,1}=0,6x0,8=0,48$
- $P_{S7}=P_2xP_{2,2}xP_{2,2,1}=0,6x0,2x0,95=0,114$
- $P_{S8}=P_2xP_{2,2}xP_{2,2,2}xP_{2,2,2,1}=0,6x0,2x0,05x98=0,004\ 8$
- $P_{S9}=P_2xP_{2,2}xP_{2,2,2}xP_{2,2,2,2}=0,6x0,2x0,05x0,2=0,001\ 2$

Consideration of consequences

- C_{S6}=0
- C_{S7}=0,005x400=2
- C_{S8}=0,5x400=200
- C_{S9}=0,25x2 000+0,5x400=700

Risk ranking of scenarios

Fire scenario	Probability	Consequence	Risk	Rank
S6	0,48	0(low)	0(low)	3
S7	0,114	2	0,228	2
S8	0,004 8	200	0,96	1
S9	0,001 2	700	0,84	1

For fires originating in the retail area

- Scenarios S8 and S9 have about the same risk and entail large consequences. The design should be undertaken to address these potentially large-loss fires. Perhaps two design fire scenarios could be considered.
- One in which the fire grows until sprinklers activate.This would assure design of an adequate sprinkler system.
- One in which the fire grows without sprinkler activation and flashover is achieved.This would assure design of adequate barriers.

Summary and conclusions

- Finally, the success of adopting performance codes will depend on the availability of calculation systems to support the user in trying to meet code objectives and the availability of training programs to educate the user on how to apply these systems.
- This introduction will also require a higher level of expertise and knowledge.

Thank You! Questions?

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