Risk Asse s sment as a Tool to Protect Historical Buildings

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1. Introduction

Some of the characteristics of today‘s world are that residential and industrial areas merge each other, production lines and products become increasingly complex and new technological systems are often used in older buildings. All these activities create new hazards and typically large numbers of people and/or high economical and cultural values are threatened by these hazards.

It is important to understand that acceptable level of safety and elimination of losses are not guaranteed only by meeting code regulations, proper quality control and good insurance coverage. This is because codes typically enforce only minimum safety requirements. In addition, proper quality control may not be sufficient because it would not reveal design errors built into a high-quality product or piece of machinery. And finally, good insurance coverage cannot protect anyone from suffering any losses because certain losses cannot be quantified and insured.

2. Risk Engineering

Due to increased need to avoid or reduce losses, professional engineers with experience in industry developed first hazard analysis methodologies in 1950‘s. In these methodologies, every hazard is usually expressed as an unknown function (loss potential) of its occurrence probability and severity of its consequences, and such function is called *risk*.

The discipline to study risks is called *risk engineering*, which can be defined as a systematic use of engineering knowledge, experience and know-how for optimum protection of human life, environment, property and economic interests. Main goal of risk engineering is to reduce all types of losses through risk management. The typical attributes of risk engineering are:

- interdisciplinary approach to problem solving
- use of knowledge from science (chemistry, biochemistry, physics, biology ...)
- use of knowledge from engineering (material, civil, mechanical, electrical ...)
- a risk engineer should be able to communicate with non-technical colleagues

Main tasks of risk engineering are accomplished by four different activities of a risk engineer:

1) Risk Assessment, during which questions such as “What can happen?” or “What is the probability that it happens?” or ”What are the consequences?” are asked.
2) Risk Reductions - Recommendations to manage risk are proposed.
3) Loss Investigations – Learning from real past events.
4) Supporting functions – Documentation, maintenance of a risk data bank, library, and training for other engineers.

3. Risk Management

In order to manage risks, it is essential to understand what basic *types of risk* one can deal with. These types are introduced in Table 1.

Table 1. Anatomy of Risks

Risk Order	Effect	Quantification of Resulting Loss
1st order	Direct damage	Repair and cleanup cost
2nd order	Loss of use	Reimbursable loss
3rd order	Loss of image Loss of trust	Non-reimbursable loss
4th order	Loss of permit	Direct and indirect non-reimbursable loss (unacceptable to people and society)

Once the risk is quantified through hazard analysis it can be managed, typically we aim to lower it. Basic ways to lower risk, as can be seen in Figure 1, are:

- ELIMINATION – using different process, method, material ...
- REDUCTION – improve protection systems, install fire barriers ...
- TRANSFER – on insurance company

It is important to remind, that retained risk should be well known and controlled.

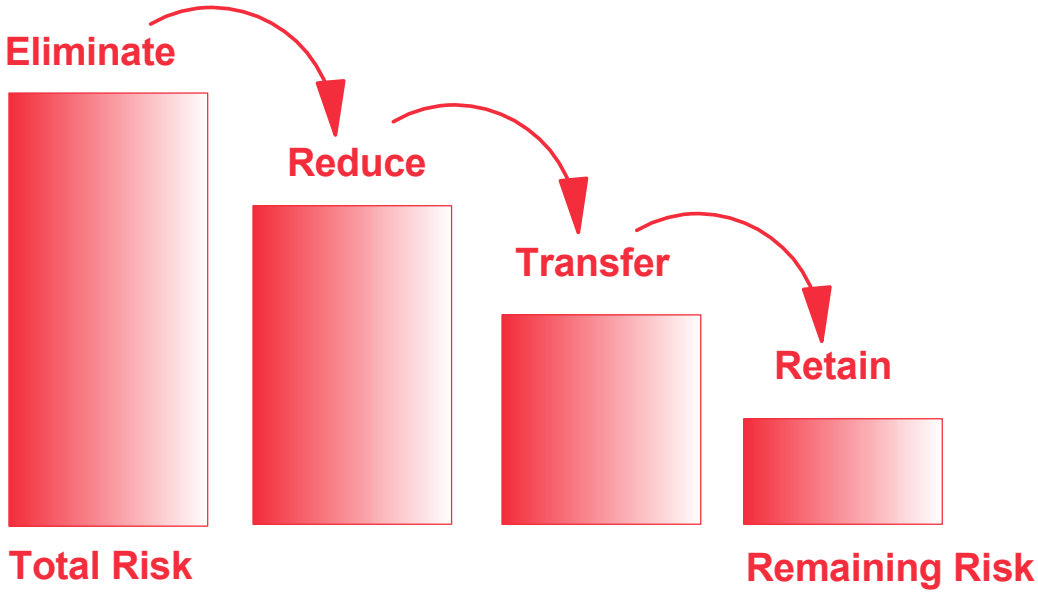

Figure 1. Basic Ways to Lower Risk

One of the important concepts used in risk engineering is the concept of *system safety*. System safety is a systematic, forward-looking identification and control of risks throughout the life cycle of a system. It is based on a Before-the-fact philosophy rather than on After-the-fact action. Basic idea behind this concept is that an acceptable safety level is built into the system prior to its production and operation. In such a way, most of potential accident causes are designed out from the system while it is still on drawing board. Adopting the system safety concept ensures minimum investments to safety for a given level of safety.

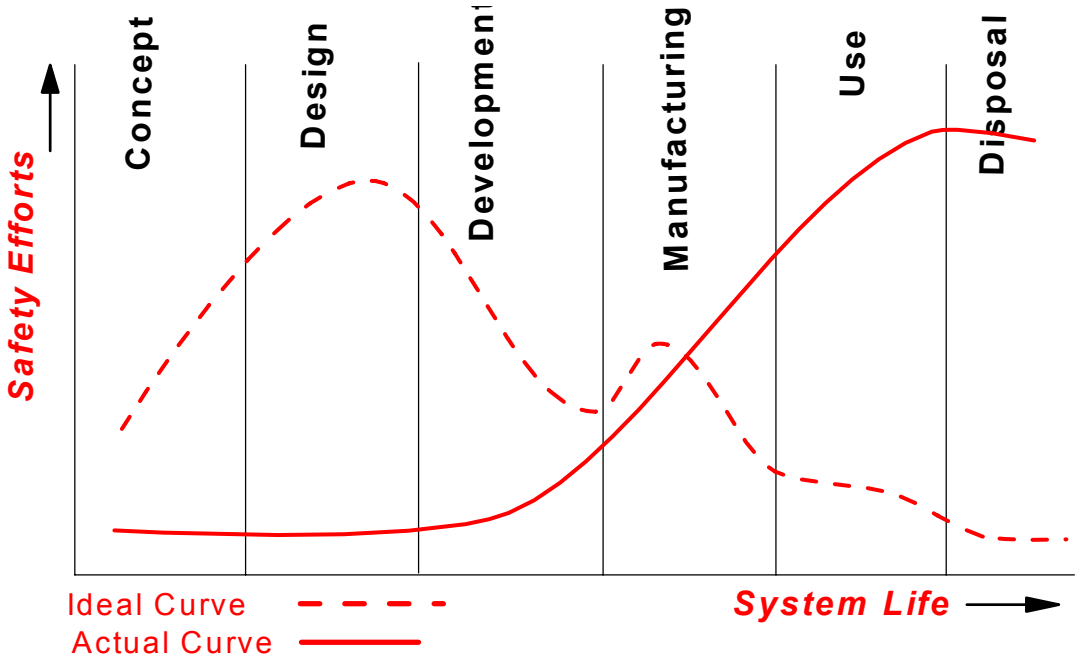

Figure 2. Safety Efforts during System Life Cycle

4. Fire statistics for historical buildings

Fire is often one of the most threatening hazards and therefore, it is justifiable to study it in detail. From the statistics of the Fire Rescue Service of the Czech Republic, the following was observed:

- a total of 180 fires on historical buildings occurred in the Czech Republic between 1992 and 2001
- 1 person killed, 10 people injured due to these fires
- a total loss on property: was CZK 67 million (not including loss on heritage)
- number of fires peaked in 1995 – 27 fires occurred during that year

Causes of largest fires in 1999 – 2001 were as follows:

1999: - Wodden stairs in Moravská Třebová – arson
- Catholic church in Uherské Hradiště – ignition from hot surface of a light bulb
- Catholic presbytery in Telč – ignition from incense
- Historical museum in Slavkov – igntion of roof from defective chimney

2000: - Church in Svárov near Kladno – ignited from open flame of unattended candle
- Presbytery in Olbramkostel near Znojmo – cause unknown
- Castle Loket near Sokolov – self-ignition of paints in a box
- Church at Nižší Hrádek near Prague – from open flame of unattended candle
- Church in Chotýšany near Prague – unattended burning candle on the altar

2001 (first half of the year only): Presbytery in Mrákotín near Jihlava – ignition of combustible material from unattended local electric heater in sacristy

5. Fire Risk Assessment

There are a large number of methodologies to assess fire risk. In this paper, the methodology used in Zürich Insurance to assess industrial fire risk is introduced. It is also shown how this methodology can be used to assess fire risk of historical buildings. A total of four areas are considered in the assessment of fire risk according to Zürich methodology. These include:

1) *Protection*
2) *Construction, Access, Location*
3) *Risk Management and Commitment*
4) *Loss Trend Probability*

Each of these areas gets its partial grading: Poor (1 point), Fair (2 points), Good (3 points), Excellent (4 points), and each area has the same weight in overall grading. This means that the overall grade is a summation of all partial gradings. Following this scheme, overall grading can reach:

4 to 5 points, that is overall grading Poor

6 to 9 points, that is overall grading Fair

10 to 13 points, that is overall grading Good

14 to 16 points, that is overall grading Excellent

The main risk attributes, which should be considered during the assessment, are given below:

Area 1: Protection

- Exposures – distance, activities
- Processes / Activities – fire risk (fire load, ignition sources, oxidants)
- Automatic fire extinguishing – coverage, adequacy, reliability, inspection
- Fire detection and alarms – type of detectors, coverage, testing
- Watchman service (in relation to arson) – regular rounds, cameras, alarms, fences
- Manual fire fighting – hydrants, extinguishers, training
- Fire venting – coverage, reliability, testing
- Fire brigade response (private and public) – arrival time, number, training
- Sources of external fire water – capacity, reliability.

Area 2: Construction, Access, Location

- Site layout – buildings and equipment divided to fire areas
- Dimensions of buildings, year of construction, number of floors
- Compliance with building codes (VdS, NFPA, Euro codes, local codes…)
- Construction – fire resistance (duration), insulations, concealed spaces
- Fire division – walls & door with proper resistance, fire cut-offs, ductwork
- Smoke controls – smoke barriers, venting
- Maintenance of buildings
- Roads on site – dimensions, maintenance

- Potential fire fighting complications
- Potential evacuation complications.

Area 3: Risk Management, Commitment

- Fixed electrical systems – appropriate for hazard, maintenance, revisions
- Electrical equipment – heaters, battery chargers, portable appliances
- Utilities – heating, air conditioning, water
- Preventive maintenance and repairs – buildings, utilities, machinery
- Contractors and other occupants – permit system, other requirements
- Hot works – assessment of risk, written permits, after work control
- Smoking control – defined areas, regulations
- Housekeeping - waste management, pollution control
- Emergency response – written plans (fire fighting, natural disasters ...)
- Emergency drills – fire fighting, evacuation
- Certificates – quality, environment.

Area 4: Loss Trend Probability

- Control of potential loss sources
- Inspection and testing of potential loss sources
- Congestion of high hazard processes
- Possibility of interaction with other risks
- Subjective opinion of the assessing risk engineer.

Application of Zürich methodology to fire risk assessment of historical buildings

Historical buildings have number of specifics. For example, the concept of system safety, widely used in assessment of industrial risk, can hardly be applied in the area of historical buildings, because here we are dealing with a system built mostly long time before first attempts to perform any risk assessments. According to the local Czech statistics, the losses result mostly from area of Risk Management, but other areas also have weaknesses, especially Protection and Construction.

Based on the risk assessment and on the overall grading obtained for a site, the following examples of recommendations, specific for historical buildings, can be given:

- reduce sources of ignition in the buildings (open flames of candles, etc.)
- discourage users who increase risk (restaurants, kitchens ...)
- replace old electrical installations - fixed on wood, overloading, moisture, inspections
- perform regular sweeping of chimneys, proper lightning protection
- dual (automatic extinguishment plus smoke detector) systems should be used to protect precious items of cultural heritage, such as paintings, wood works, icons …
- install fire detectors (signal connected to fire brigade alarm response center)
- monitoring systems sensitive to unwanted intrusions (in relation to arson) should be used
- use of fire-retardant materials during reconstructions and
- use of fire-resistive paints (regularly renewed)
- build special heritage features in fire-response plan

- maintain access roads - sometimes on a hill or in remote area
- water supplies should be identified and assessed if adequate to the fire risk
- water sources should be plotted to the fire-response plan.

6. Conclusions

Basic terminology and activities used in risk engineering were mentioned in the first part of this paper. This was followed by a summary of main tools to manage risk. A methodology to assess industrial fire risk used by Zürich Insurance was introduced and explained. It was concluded that this Zürich methodology can be used to assess fire risk of industrial buildings. An example series of risk reduction recommendations applicable specifically to historical buildings was given in the end of the paper.