ISO/TC 92/SC 4
Fire safety engineering

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WG1 Economic assessment of fire safety design as part of fire safety engineering

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Background: Please find enclosed a presentation made by Vladimir MOZER at the last SC4/WG 1 meeting held in Coimbra (Portugal) on 13th April 2015.

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Economic assessment of fire safety design as part of fire safety engineering

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ISO TC 92 / SC4 FSE – Coimbra meeting 13.4.2015

Objective and introduction

The aim of the proposed WI is to provide means of objective assessment of fire safety design economic implications.

What is the highest level of safety which can be achieved at a given level of costs.

Especially useful when multiple design alternatives are considered – avoid „cutting corners“ by spending funds efficiently.

Combination of fire safety engineering output – extent of fire at given level of fire protection (costs) vs extent of damage caused by the fire (loss).

Project background

Long-time topic of interest for all stakeholders.

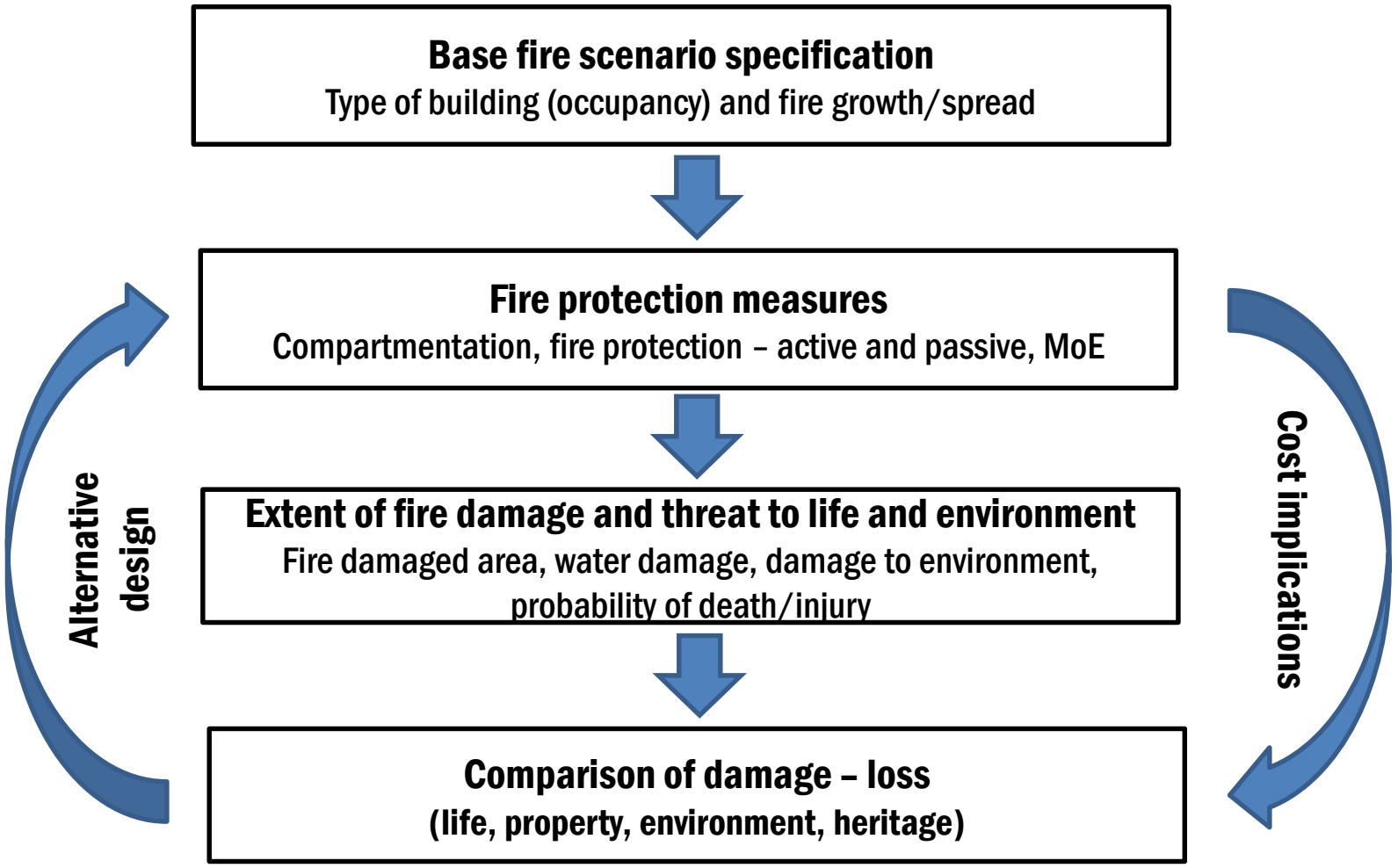
Numerous studies and publications (The value of fire protection in buildings, Economics of fire protection, etc.)

UNIZA currently working on this project under a national grant scheme funding.

Approach – Keep it simple and compatible with existing fire engineering tools.

Creation of a set of fire engineering and economic assessment tools, i.e. no reinventing of the wheel.

Model framework description



WI Proposal: **Assessment of fire protection measures economic efficiency**

Example of application – property protection

Probability of fire starting (ignition):

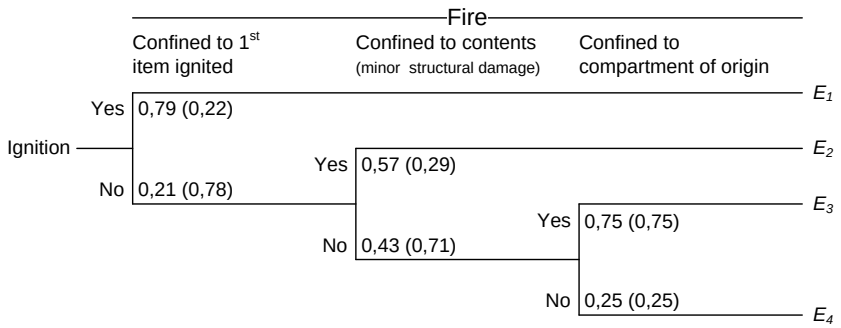
Industrial **– 0,096**

Office **– 0,052**

Shop **– 0,132**

From PD 7974-7

Event tree analysis diagram



values in brackets denote Unsprinklered scenario

Individual outcome probabilities

Fire scenario	Extent of damage	Outcome frequency	
		Sprinklered	Unsprinklered
Confined to 1st item E_1	max. 5m²	0,790	0,220
Confined to contents E_2	50% of compartment	0,120	0,226
Confined to compartment of origin E_3	100% of compartment	0,068	0,415
Spread beyond comparment of origin E_4	2x compartment area	0,023	0,139

WI Proposal: **Assessment of fire protection measures economic efficiency**

Example of application – property protection (based on most probable outcome)

Occupancy	Fire starting		E1		E2		E3		E4	
	P	0	P	0	P	0	P	0	P	0
Sprinklered										
Industrial	$9{,}6.10^{-2}$	10	**$7{,}5.10^{-2}$**	**13**	$1{,}1.10^{-2}$	87	$6{,}5.10^{-3}$	155	$2{,}2.10^{-3}$	464
Office	$5, 5.10^{-2}$	18	**$4{,}4.10^{-2}$**	**23**	$6{,}6.10^{-3}$	151	$3{,}7.10^{-3}$	268	$1{,}2.10^{-3}$	803
Shop	$1{,}3.10^{-1}$	8	**$1{,}0.10^{-1}$**	**10**	$1{,}6.10^{-2}$	63	$8{,}9.10^{-3}$	112	$3{,}0.10^{-3}$	336
Unsprinklered										
Industrial	$9{,}5.10^{-2}$	10	$2{,}1.10^{-2}$	48	$2{,}2.10^{-2}$	46	**$4{,}0.10^{-2}$**	**25**	$1{,}3.10^{-2}$	76
Office	$5{,}5.10^{-2}$	18	$1{,}2.10^{-2}$	82	$1{,}2.10^{-2}$	80	**$2{,}3.10^{-2}$**	**44**	$7{,}6.10^{-3}$	131
Shop	$1{,}3.10^{-1}$	8	$2{,}9.10^{-2}$	34	$3{,}0.10^{-2}$	33	**$5{,}5.10^{-2}$**	**18**	$1{,}8.10^{-2}$	55

Extent of damage

Fire scenario	Extent of damage
Confined to 1st item E_1	max. $5m^2$
Confined to contents E_2	50% of compartment ($500m^2$)
Confined to compartment of origin E_3	100% of compartment ($1000m^2$)
Spread beyond comparment of origin E_4	2x compartment area ($2000m^2$)

Buildings in Europe and America have an expected lifespan of 50-70 years.

WI Proposal: **Assessment of fire protection measures economic efficiency**

Example of application – property protection (based on most probable outcome)

Likely total and yearly loss for most probable fire outcomes

Occupancy	Value density*	Likely damage	Likely loss	Occurence interval	Loss per year
	[EUR/m²]	[m²]	[EUR]	[y]	[EUR/y]
Sprinklered					
Industrial	300	5	1500	13	115
Office	100	5	500	23	22
Shop	200	5	1000	10	100
Unsprinklered					
Industrial	300	1000	300000	25	12000
Office	100	1000	100000	44	2272
Shop	200	1000	200000	18	11100

*Fabricated values – for demonstration only

Assessed against costs
of fire protection per year
*Sprinkler system 2000 Eur/year

Example of application – property protection (based on weighed mean of outcomes)

$$S_d = \sum_{i=1}^{n} \frac{F_{Ei} . S_{d,Ei}}{O_{Ei}}$$

Where:

S_d - expected fire damaged area per year for selected level of fire protection [$m^2.year^{-1}$]

F_{Ei} - outcome probability frequency for *i*-th outcome scenario E_i (Table on Slide 5) [-]

$S_{d, Ei}$ - expected fire damaged area for *i*-th outcome scenario E_i(Table on Slide 5) [m^2]

Occupancy	$\frac{F_{Ei} . S_{d,Ei}}{O_{Ei}}$				S_d
	E1	E2	E3	E4	[$m^2.year^{-1}$]
Sprinklered					
Industrial	$3{,}04.10^{-1}$	$6{,}90.10^{-1}$	$4{,}39.10^{-1}$	$9{,}91.10^{-2}$	**1,53**
Office	$1{,}72.10^{-1}$	$3{,}97.10^{-1}$	$2{,}54.10^{-1}$	$5{,}73.10^{-2}$	**0,88**
Shop	$3{,}95.10^{-1}$	$9{,}52.\ 10^{-1}$	$6{,}07.10^{-1}$	$1{,}37.10^{-1}$	**2,09**
Unsprinklered					
Industrial	$2{,}29.10^{-2}$	$2{,}46.10^{+0}$	$1{,}66.10^{+1}$	$3{,}66.10^{+0}$	**22,7**
Office	$1{,}34.10^{-2}$	$1{,}41.10^{+0}$	$9{,}43.10^{+0}$	$2{,}12.10^{+0}$	**13,0**
Shop	$3{,}24.10^{-2}$	$3{,}42.10^{+0}$	$2{,}31.10^{+1}$	$5{,}05.10^{+0}$	**31,6**

Assessed against costs
of fire protection per year
*Sprinkler system 2000 Eur/year

Comparison of expected yearly fire loss

Occupancy	Value density*	Expected yearly fire damage based on scenario [$m^{-2}.year^{-1}$]		Expected yearly fire loss b on scenario [$€.year^{-1}$]	
	[$€.m^{-2}$]	most likely	weighed mean	most likely	weighed me
Sprinklered					
Industrial	300	0,39	1,53	117	459
Office	100	0,22	0,88	22	88
Shop	200	0,5	2,09	100	418
Unsprinklered					
Industrial	300	40,0	22,7	12000	6810
Office	100	22,7	13,0	2270	1300
Shop	200	55,6	31,6	11120	6320

*Fabricated values – for demonstration only

Conclusion

The question of financial implications of fire protection in building design remains a very important one.
If no legal requirements exist and there is lack of financial substantiation, the stakeholder is very likely do decline an inclusion of a fire protection system in the building design.
On the other hand if sufficient and convincing evidence is provided that a particular system brings financial benefits in the form of significant potential loss reduction, the fire protection system should be included even if no legal requirement exists.
This is particularly true when Fire safety engineering is used in the design process.

Thank you for your attention!

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