The Calculation of Fire Risk as a Way of Prevention Using the Euroalarm Method

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Fire, as a process of uncontrolled burning and very often as a process with tragic epilogue in the sense of human lives and material properties demands very detail and serious approach. One of the most important tasks in the fire controlling and fire elimination is a prevention. There are different ways of prevention related to fire. One of them is an evaluation and calculation of a fire risk. In many countries, related to their rules, regulations and laws, the calculation of fire risk, for some types of objects, presents the law obligation. Related to accessible information, the first fire risk procedures dated from sixties from the last century. Today, there are more methods for calculation of fire risk, with their advantages and disadvantages. This paper was written to present the importance and meaning of fire risk evaluation and calculation and to present the example of fire risk calculation with Euroalarm method.

Key Words: *fire, risk, method, prevention*

1. INTRODUCTION

There are many occurrences in human`s life that can have tragic consequences. One of such occurrences is fire. The experience showed that the best way of fight against such occurrences, also and fire, present prediction. One of the very effective ways of prediction is the calculation and evaluation of fire risk. In many countries, the calculation and evaluation of the fire risk presents the law obligation. For an example, in Serbia, related to the Law of fire protection, objects are divided into different categories. These categories depend on the endanger degree from fire. Related to this endanger degree, for every object from the first and the second category of endanger from fire, the evaluation of risk from fire must be realised. There are many different procedures and methods today in whole world for fire risk analyse [4].

Related to historical facts, the first group of procedures for fire risk evaluation dated from sixties years of the last century (more precisely, from 1961-1968). This group of procedures based on researches of Max Gretener, researcher from Switzerland. He has defined the procedure for fire risk evaluation related to realised and accessible information and also defined references for preventive precautions realisation. Later, this procedure was modified on several ways and related to that, there were procedures with different names (SIA 81, TRVB 100, Euroalarm procedure, Frame etc.).

The second group of developed procedures aimed to evaluate the resistance of structural construction from fire, and these procedures were standardised in 1964. in the form of standard DIN 18.230 (related to industrial objects).

The new versions of this standard have been released in 1988. and 2010, with some extensions. For example, this standard was modified in Serbia in 2012 in the form of SRPS-EN1991-1-2:2012 and this presented modified procedure [1].

Today, there are several different fire risk methods in use for some concrete object. The differences between these methods are in number and type of factors that were included into risk definition, in the date of use (some of them are very old), in they origin (who developed this methods) and similar.

This paper was written to show the importance of fire risk calculation and evacuation, to present the example of fire risk calculation with Euroalarm method, to note the advantages and disadvantages of this and other methods.

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2. EUROALARM METHOD

The Euroalarm method presents the simplest and the most frequently used method for fire risk calculation. Related to this method, the fire risk consists of object destruction risk and object contents destruction risk. These facts require inclusion of parameters into calculation which are relevant for both noted factors. In the case that object purport the presence of technological process, the fire endanger degree is different for different phases of technological process. This implicates the presence of systems for fore detection and systems for automatic extinguishing beside standard mobile equipment for fire extinguishing. The reason for presence of automatic systems for fire detection and fire extinguishing related to the dimension of fire risk for object construction and related to object contents fire risk. The main advantage of this method is the simplicity while the main disadvantage of this method is that this method enables advantage for material properties risk over human`s life [2].

3. THE FIRE RISK OF THE OBJECT

This dimension is marked as R_0 and it is calculated related to next equation:

$$R_0 = (P_oC)+P_kBLS/ WR_i \tag{1}$$

In the equation (1), P_0 presents the fire load coefficient of the object contents; C presents the flammability coefficient of object contents; P_k presents the fire load coefficient of incorporated materials into object construction; B presents the coefficient of dimension and position of fire sector; L presents the coefficient of time of fire extinguishing beginning; S presents the coefficient of fire sector width; W presents resistance the coefficient on fire resistance related to object construction and R_i presents the fire risk reduction coefficient.

Table 1. The fire load coefficient of the object contents P_0 (figure source: Blagojević, M. Fire protection systems designing)

Danger degree	MJ/m²	kg of wood/m²	P_0
1	0-251	0-15	1.0
2	252-502	16-30	1.2
3	503-1004	31-60	1.4
4	1005-2009	61-120	1.6
5	2010-4019	121-240	2.0
6	4020-8038	241-480	2.4
7	8039-16007	481-960	2.8
8	16079-32154	961-1920	3.4
9	32155-64309	1921-3840	3.9
10	64310	>3841	4.0

The fire load coefficient of the object contents, marked as P_0 is related to equipment in object, installations in object, furniture in object, stored materials and similar. The calculation method for this dimension purports the transformation of heat values of all combustible materials in the object into heat values of wood in MJ/m² related to table 1.

In the case that the determination of some combustible materials presents the problem than data about dimension of fire load for some technical processes can be used for approximately calculation. Examples for some technological processes are presented in table 2.

Table 2. The dimension of fire load and danger class for some types of technological processes (figure source: Blagojević, M. Fire protection systems designing)

Technological process	MJ/m²	Danger class
Metal varnishing	251	I
Furniture varnishing shop	167	I
Chemical cleaning	251	I
Glue production	1256	I
Paint shop in car industry	544	II
Furniture paint shop	419	II
Plastic materials welding	670	III
Parquetry production	1674	III
Blanket production	502	III
Sunblind production	754	IV
Skin treatment	419	IV
Electro apparatus production	562	IV

The flammability coefficient of object contents marked as C can be determined with danger classes showed in table 2 and it is presented in table 3.

Table 3. The flammability coefficient of object contents (figure source: Erić, M. Anti-fire and prevenive technical protection)

Danger class	VI	V	IV	III	II	I
Flammability coefficient C	1.0	1.0	1.0	1.2	1.4	1.6

The fire load coefficient of incorporated materials into object construction P_k presents dimension determined as heat value of all materials in MJ/m² related to table 4. It means that all fire load of all materials into object are transferred to standard of wood value.

Table 4. The fire load coefficient of incorporated materials into object construction (figure source: Erić, M. Anti-fire and preventive technical protection)

MJ/m^2	P_k
0-419	0
435-837	0.2
845-1675	0.4
1691-4187	0.6
4203-8373	0.8

The coefficient of dimension and position of fire sector *B* can be determined related to table 5 and it depends from object characteristics in the sense of fire sector area, room`s height, the numbers of floors generally and the number of floors in the basement.

Table 5. The coefficient of dimension and position of fire sector (figure source: Erić, M. Anti-fire and preventive technical protection)

Object`s characteristics	*B*
Fire sector up to 1500 m^2 Room`s height up to 10 m Up to three floors at the most	1.0
Fire sector from 1500 m^2 to 3000 m^2 Room`s height from 10 m to 25 m Four to eight floors One floor in the basement	1.3
Fire sector from 3000 m^2 to 10000 m^2 Room`s height over 25 m More than eight floors More than two floors in the basement	1.6
Fire sector over 10000 m^2	2.0

The coefficient of time of fire extinguishing beginning *L* depends from several different factors: fire unit type and equipment, the distance of the endangered object from fire unit, traffic conditions (traffic state, presence of obstacles, potential conditions) etc. and it can be determined related to table 6.

Table 6. The coefficient of dimension and position of fire sector (figure source: Erić, M. Anti-fire and preventive technical protection)

	Time from the extinguishing beginning [minutes]	**10**	**10-20**	**20-30**	**30**
	Range [km]	**1**	**1-6**	**6-11**	**11**
Fire unit type	Professional industrial unit	1.0	1.1	1.3	1.5
	Voluntary industrial unit	1.1	1.2	1.4	1.6
	Territorial professional unit	1.0	1.1	1.2	1.4
	Territorial voluntary unit with permanent duty	1.1	1.2	1.3	1.5
	Territorial voluntary unit without permanent duty	1.3	1.4	1.6	1.8

The coefficient of fire sector width S depends from the fire sector width and it can be determined related to table 7.

Table 7. The coefficient of fire sector width (figure source: Erić, M. Anti-fire and preventive technical protection)

The smallest length of the fire sector [m]	*S* [m]
Up to 20	1.0
20-40	1.1
40-60	1.2
Over 60	1.3

The coefficient on fire resistance related to object construction *W* depends from constructive characteristics of the object and it can be determined related to table 8.

Table 8. The coefficient on fire resistance related to object construction (figure source: Blagojević, M. Fire protection systems designing)

Fire resistance [minutes]	kg of wood/m^3	MJ/m^3	*W*
Up to 30			1.0
30	37	619	1.3
60	60	1004	1.5
90	80	1339	1.6
120	115	1925	1.8
180	155	2595	1.9
240	180	3014	2.0

This fire risk reduction coefficient is presented in table 9 (Blagojević, 2018), (Erić, 2003).

Table 9. The fire risk reduction coefficient (figure source: Erić, M. Anti-fire and preventive technical protection)

The risk evaluation	Conditions relevant for risk evaluation	R_i
The highest	High flammability of material with bigger storage distance Fast fire spreading is expected Existence of several sources of ignition in the technological process or storage	1.0
Normal	Not high flammability of material with distance in storage that enables manipulation Normal fire spreading is expected Existence of normal sources of ignition in the technological process or storage	1.3
Less than normal	Smaller flammability of material with partial storage (25-50%) of flammable stuff in non-combustible packing	1.6
Inappreciable	Small ignition probability with material stored in metal or plate chests so as high density of storage Very slow fire spreading is expected	2.0

Related to all noted dimensions, the maximal fire risk can be calculated. This maximal fire risk purports very fast fire spreading with release of complete fire load. It is important to note that such scenario is not possible in reality, so as valid dimension the fire risk reduction coefficient can be defined, related to combustible material type, the way of material storage, some ambient conditions, combustion speed and other factors.

4. FIRE RISK OF OBJECT`S CONTENT

The fire risk of the object contents presents the dimension related to danger for humans, equipment, furniture, storage stuff etc. It is marked as R_s and it can be calculated related to equation 2.

$$R_s = HDF \tag{2}$$

The values in the equation 2 present: *H*-danger coefficient related to humans; *D*- danger coefficient related to property and *F*- smoke action coefficient. *H* danger coefficient related to humans depends from evacuation possibilities from some particular object and it is presented in table 10. *D* danger coefficient related to property depends from complete value inside one fire sector, so as the possibility of the procurement of the destroyed equipment and it is presented in the table 11. *F* smoke action coefficient related on the occurrence of bigger smoke quantities and it is presented in the table 12.

Table 10. The danger coefficient related to humans (figure source: Erić, M. Anti-fire and preventive technical protection)

Endanger degree	*H*
No danger for humans	1.0
There is some existence of danger for humans, but they can save themselves	2.0
There is some existence of danger for humans, but with considerably hard evacuation	3.0

Table 11. The danger coefficient related to property (figure source: Erić, M. Anti-fire and preventive technical protection)

Values concertation	*D*
Object contents does not present great value	1.0
Object contents does present great value and it is prone to destruction	2.0
Great destruction and irreparable loss	3.0

Table 12. The smoke action coefficient (figure source: Erić, M. Anti-fire and preventive technical protection)

Conditions that lead to smoke inhalation	F
There is no danger from smoke inhalation and corrosion	1.0
There is no danger from smoke inhalation and corrosion; more than 20 % of weight of all combustible materials cause smoke or emission of toxic materials	1.5
More than 50 % of weight of all combustible materials cause smoke or emission of toxic materials; also, more than 20 % of weight of all combustible materials are consist of materials that release very corrosive gasses	2.0

With the calculation of R0 and Rs, the way of fire protection based on risk evaluation can be realised, as it is presented on diagram on figure 1. Values for R0 are presented on ordinate on figure 1 while the values for Rs, are presented on abscissa on figure 1. Related to values realised and showed on diagram, it is possible to determinate fire risk in the section of values presented on abscissa and ordinate. The evaluation of potential realised fire risk is presented on table 13 [2], [3].

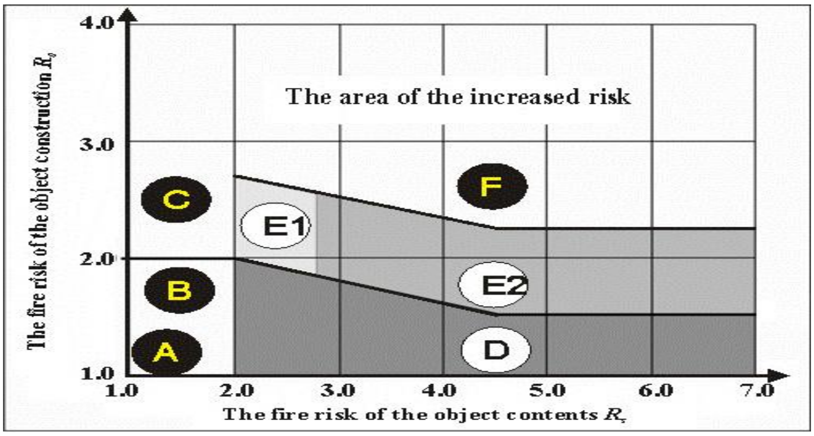

Figure 1 - Fire protection way diagram based on risk evaluation

Table 13. Risk evaluation related to realised results for R_0 and R_s

Mark	Description
A	Small risk, preventive measurements are enough
B	There is no need for automatic systems for fire extinguishing and detection
C	Automatic system for fire extinguishing is needed, but without system for fire detection
D	System for fire detection is needed, while installed fire extinguishing system is not needed
E	Double protection is recommended with systems for fire extinguishing and fire protection (E_1-extinguishing device is needed, E_2-detection device is needed)
F	Installation of systems for fire detection and fire extinguishing is mandatory

5. CONCRETE EXAMPLE FOR RISK ESTIMATION BY USE OF EUROALARM METHOD

For presentation of risk evaluation with Euroalarm method, the furniture factory, blanket production and skin treatment were taken as a theoretical example. Related to potential facts and comparation with existing objects, values for needed dimensions were adopted as it is presented in table 14, so as calculated values for risk evaluation. Calculation was realised related to noted equations. Related to realised results showed in table 14, risk evaluation can be determined as it is presented on figure 2. For every noted example, realised points with numbers are presented with different colour-for furniture factory, red colour was used; for blanket production, orange colour was used and for skin treatment, purple colour was used.

Table 14. Adopted values for needed dimensions for risk evaluation calculation and calculated values for noted examples

.	Furniture factory			Blanket production			Skin treatment		
	Dimensions	Values	$R_{0/}$ R_s	Dimensions	Values	$R_{0/}$ R_s	Dimensions	Values	$R_{0/}$ R_s
R_0	P_0	4	2.68	P_0	2	1.35	P_0	1	1.06
	C	1.4		C	1.2		C	0.2	
	P_k	0.4		P_k	0.2		P_k	1	
	B	1		B	1		B	1.8	
	L	1.3		L	1.6		L	1.3	
	S	1.3		S	1.3		S	1.5	
	W	1.8		W	1.6		W	1.3	
	R_i	1.3		R_i	1.3		R_i	2	
R_s	H	2	6	H	2	4	H	2	4
	D	2		D	2		D	1	
	F	1.5		F	1		F	1	

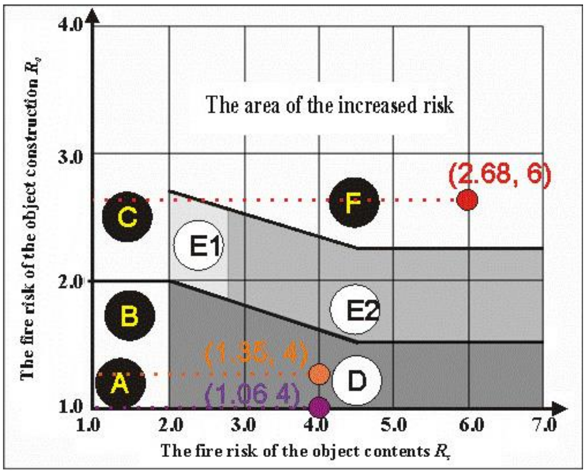

Figure 2 - Fire protection way diagram based on risk evaluation with realised values for noted

Realised results for noted examples showed that the first example-furniture factory, related to used values needed the installation of system for fire detection and fire extinguishing system. The second and the third noted example, blanket production and skin treatment, needed only system for fire detection. By using of this method, it is possible to get risk evaluation for different objects. In this paper, because of paper limitation, only some object with their fire load and danger class as examples are presented in table 2.

6. CONCLUSION

It is very important that noted method Euroalarm for risk evaluation has a large number of disadvantages, regardless of the fact that its use is required, for example, in Serbia. As the main disadvantage, the advantage of property evaluation over human lives was noted. Also, by use of this method, many objects with low fire risk are recommended to install fire detection system. Of course, it will not be bad in the sense of safety and security, but if the fact that authors of this method are the producers of fire equipment that should be installed take into account, many questions can be asked. Noted method can also give relatively good results of risk evaluation for residential and business objects, so as TRVB 100 method. But, for risk evaluation of objects with a lot of human inside, these methods are not good because of the noted main disadvantage. However, this paper was written to show the use of Euroalarm method and risk evaluation in hypothetic cases of furniture factory, blanket production and skin treatment.

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REZIME

PRORAČUN RIZIKA OD POŽARA KAO NAČIN PREVENTIVE KORIŠĆENJEM EUROALARM METODA

Požar kao proces nekontrolisanog i veoma često, kao proces sa tragičnim epilogom u smislu ljudskih života i materijalnih vrednosti, zahteva veoma detaljan i ozbiljan pristup. Jedan od najvažnijih zadataka u kontrolisanju požara i eliminaciji požara je prevencija. Postoje različiti načini prevencije požara. Jedan od njih je evaluacija i proračun rizika od požara. U mnogim zemljama, prema njihovim pravilima, regulativama i zakonima, proračun rizika od požara za neke vrste objekata predstavlja zakonsku obavezu. Prema dostupnim informacijama, prvi postupci za procenu rizika od požara datiraju iz šezdesetih godina prošlog veka. Danas, postoji više metoda za proračun rizika od požara, sa svojim prednostima i manama.Ovaj rad je napisan da pokaže važnost i značaj procene i proračuna rizika od požara i da predstavi primer proračuna rizika od požara metodom Euroalarm.

Ključne reči: *požar, rizik, metod, prevencija*