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FIRE AND EXPLOSION PREVENTION IN OBJECTS OF POSSIBLE TERRORIST ATTACK

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Abstract: Nowadays there is an expansion of terrorism in the world, so there is a need for fight against it. Security services would particularly pay attention to prevention activities. Planting of explosive devices is one of the activities of terrorists where the harmful consequences of the blast wave with its pressure and heat on surroundings are used. This paper describes the preventive activities of security services. Those activities mean the fire and sabotage protection and possibility of using the risk theory. The risk theory deals with correlation between positions of different objects in space. The aim of these activities is to minimize the consequences on objects which are on the way of the blast and heat within a closed space (subways, market centers, etc.).

Keywords: explosion, fire after an explosion, closed space, prevention, risk theory, technical facilities.

1. Introduction

The aim of this paper relates to the impact of possible ways to reduce the risk of explosion and fire after an explosion. Thus under the term explosion we solely consider the chemical explosion as a form of decomposition of explosive substances with the consequence of pressure waves and heat waves. Given the fact that the planting of explosive devices is one of the aspects of the implementation of terrorist activities, minimizing the risk

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of explosion and fire as connected by cause and effect is of particular importance. Reduce of risks of explosions can be affected by the implementation of a whole range of activities, starting from the implementation of measures of anti-diversion protection, up to the consideration for the application of risk theory. The analysis of the problem of the appearance of fire after an explosion has the aim to determine the dependence on medium heat absorbed from the layout of objects of different material indoors and on the basis of the obtained analytical expression to determine the layout of objects for which the risk, of explosion with fire as a result, is minimal (Chow, 2005).

2. Planting explosive devices as a possible method of conducting a terrorist attack

There are a number of definitions for terrorism, although most authors agree on the next. Terrorism (Vujaklija, 1980) means the rule of intimidation and violence as a form of political struggle by the individual terror. As such it means the use of planned, organized and systematic violence of a non-governmental subject (minority group, organization, political party, etc.) or governmental subject with the aim to, primarily, cause collective fear or insecurity, anxiety or apathy within the environment from which the direct victim of the attack has originated. Besides that the mentioned subject is determined to use even worse physical force over the pre-selected or randomly selected victim, in order to commit murder, mutilation, abduction, physical or mental abuse, in order to achieve the projected political goal. The protagonist of terrorism uses this kind of violence in order to depreciate or to dethrone the current government, to spread its influence and power outside the home territory and to impose its will on state and society. That is an illegal and forbidden form of struggle for the resolution of political disputes since the terrorists seek to achieve their goals through non-parliamentary and violent forms of struggle. As such activity, terrorism was certainly envisaged as one of the most serious crimes in the criminal legislation. Terrorism is a very complex activity that involves complex actions through serious preparation, organization of terrorists' operations with strict conspiracy, as well as performance of the act. Terrorism as a phenomenon, although it is actually a threat to the survival of certain states, is a global threat to humanity because some forms of terrorist activities may have far-reaching consequences (Bolz, Dudonis & Shulz 2002).

The success of terrorist strategy and tactics depends, among other things, on means used for carrying out terrorist operations. Terrorists are usually equipped with certain types of conventional weapons that are otherwise used as the equipment of military and police forces. One of the forms of execution of terrorist attacks is setting the explosions. With the increase of terrorist activities in the world today the number of planted explosive devices is increasing as well.

Explosive lethal devices that are used for the performance of some terrorist operations are using the explosions effects on both the surface and the environment. Explosion (Bjelovuk, 2005) is a fast chemical reaction of decomposition of explosive substance, followed by sudden release of large amount of energy in a short time interval and the impact wave as its consequence that appears in the surrounding area. The process of an explosion spreads thanks to the compressed layers of explosives. Impact wave overtakes layer by layer until all explosive quantities fall apart. The sudden rise of pressure in the area of event is causing the huge destruction around the explosion spot. Characteristic for each explosion, as non-stationary process, is the exothermic and high process velocity, the creation of gases decomposition products and the ability to self-spread through the explosive substance. Brisant explosives which are commonly used for terrorist actions are TNT, PETN, hexogen, octagon, components A, B and C, and compositions type PBX, etc.

From the aspect of anti-diversion techniques the greatest attention should be paid to plastic explosives as easily deformable explosives, since with their use it is very easy to form the desired shape of the explosive charge. They are also commonly used for making improvised devices intended for sabotage actions.

The Figure 1. shows the scheme of creation of an explosion – the look of the explosive charge before an explosion and what happens after the initiation of the explosive charge by the blasting-cap. By initiating within the main charge an explosion occurs – decomposition of explosives in the gas products that are under great pressure, it creates an impact wave and the process of an explosion spreads spontaneously capturing the complete explosive charge (Jaramaz, 1997).

The explosion of lethal devices may have far-reaching consequences, depending on the place where it occurred. Effects of explosion on the environment are very different; all depending on the type and weight of explosives used, but one should not neglect the characteristics of the place where it occurred. As brisance of explosives is its ability to perform mechanical work, the brisant effect is manifested by breaking, tearing, penetrating and destructing of the material that surrounds, or it is in direct contact with, the explosives in the area of an explosion.

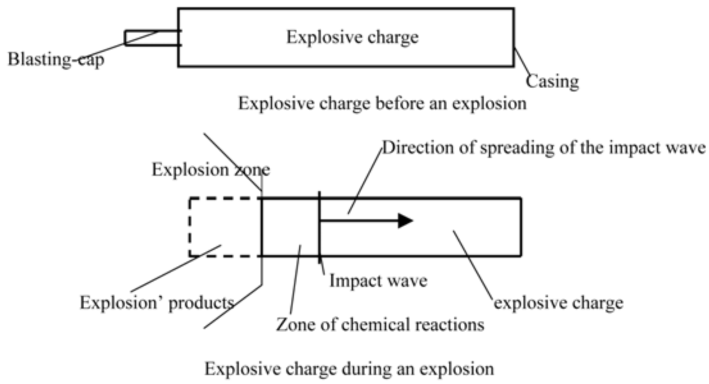


Figure 1 − *Scheme of creation of an explosion*

The explosion of lethal devices usually leaves traces of brisant and demolition effects on the surface and in the surrounding in the form of craters, holes or other visible damage of different shapes and sizes, blast injuries and deaths are the result if live persons were present at an explosion site. Since an explosion effect is unthinkable without the release of the large amounts of heat, the thermal effect of an explosion on the environment is of great significance. At an explosion site, flammable gases, which are the products of an explosion, and the surrounding air, are heated up to high temperatures. This energy can cause the appearance of secondary fires within the area of an explosion, and they could increase damages and complicate the process of an investigation. Duration and intensity of the heat are greatly affecting the potential damage and injuries from an explosion, and there are traces of thermal effects in the form of melting, fire and burns. Fire often occurs as a result of an explosion.

Terrorists use the formational, improvised or combined explosive lethal devices. For the execution of sabotage – terrorist actions the formational devices are the most appropriate, but the improvised explosive devices are used as well. Explosive devices consist of a body-casing which is mandatory part of some device (devices can be made from pure brisant explosive with initiating mechanism), ignition – initiation part and the explosive charge that is made out of military or commercial explosives. Many terrorist entities give great importance to the improvised devices for the use of physical violence. From the aspect of anti-diversion technique, the particularly interesting groups of improvised explosive devices are those that are passively waiting for the objective and that can be activated in different ways, depending on the desired effects on the target and the available elements. Improvisation can be done in different ways, although it is usually performed within the sphere of initiation

– i.e. the ignition part (fuse, detonators, electro-detonator caps and explosives cannot be improvised). Improvised explosive devices are usually planted in items for daily use. Explosion may occur when the item changes position, when there are changes in pressure or temperature, in the cases of increased speed, in the cases when an electric circuit is made, when there are appearances of light or sound signals, etc., depending on the situation, the level of knowledge, training and inspiration of the person who has made the device and in accordance with planned operations on the object of an attack. Here the creativity in the development and use of devices from the most primitive to the most sophisticated can be noticed. For this purpose, a variety of explosive devices are made, set to desired location, and through the time mechanism (time ignitions), remote control, and recently through the use of mobile phones, those devices are activated to attack the victim, i.e. kill or physically injure the victim and with that to cause fear within wider population. Improvised explosive devices may contain a few grams of brisant explosives placed in a suitcase, purse, book, calendar, gift package, letter, pen, umbrella, electric household appliances, hair drier, etc., up to several kilograms of explosives placed in a car, truck, train, trash cans, toilette water basin, etc.

3. Prevention of explosions and fire after explosions

Objects that may be the targets of terrorist attacks are airports, railway stations, bus stations, subways, shopping centers, stadiums, cinemas and theatre halls, sports halls and other sports facilities and all places for massive gatherings of people. Places of massive gathering of people are particularly interesting for terrorist activities because of greater probability of murder and inflicting injuries to victims and greater spread of fear and panic among people (Jovanov, 2000). Since today more perfidious forms of threats to the security of persons and property are used, it is necessary to pay special attention to the follow-up of the latest technological achievements, acquisition of sophisticated equipment and modernization of training in the use of these means. In addition to technical resources, the use of specially trained dogs capable of the detection of explosives is becoming more and more actual (Stojanović, 1988).

3.1. Technical resources in the prevention of explosions and fire after explosions

From the aspect of preventive actions against explosions and fire as their possible consequences, it is especially important to use the measures of anti-diversion protection, i.e. use of technical resources. Anti-diversion measures of protection include, among other things, the use of different devices for the detection of formational and improvised mine-explosive devices - various types of metal detectors, detectors of various types of chemical explosive substances, mine detectors, search mirrors, X-ray devices, etc., with the aim of technical reconnaissance and provision of additional control within the buildings' protection system. One of the devices for the detection of explosives, whose use in the world today is very wide, is the so called *Itemizer* that simultaneously detects positive and negative ions, in that way allowing the detection of explosives. Also, the handheld explosives' detector, so called *Mobile Trace* is in use. These devices are basically spectrometers and they are enabling accurate and reliable detection of explosives (Yinon, 2003).

We should not neglect the use of cameras with different spectral scopes in order to make it possible to notice the appearance of fire and smoke, and consequently to have the time to react. Regarding the prevention of explosions at the airports, especially from the possible effects of car bombs, the existence of the concrete wall would certainly prevent the spread of explosions to the interior of airport facilities (Klikovac, 1993). Since terrorists are sometimes very perfidious when it comes to improvisation and the smuggling of explosives, useful idea is for the manufacturers of explosives to oblige in a specific way and to mark the explosives. In the case when explosive devices are found, it is very important to implement security measures for the safe transport with the use of self-propelled robot vehicles.

3.2. Risk theory in the prevention of explosion and fire after it

The goal of this part of paper is to analyze the expansion of thermal wave after an explosion in a closed space and to determine the dependence of the average absorbed thermal energy from the layout of objects made of various materials in it (Babrauskas & Grayson, 1992). The layout of objects in closed space with minimum risk of fire after an explosion has to be determined from analytical equation (Cote, 2003). Semi-empirical formulas for energy absorption will be used in order to achieve this and the mean value of absorbed energy will be determined by the method of Markov graphs (Markov, 1971). The objects in the premises will be made of blocks, which a certain number of Markov cells can correspond to. Within such an approach, one Markov cell will be represented by a bloc having the shortest length, and the numbers of Markov cells per blocs will be determined as a quotient of the length of a given bloc and minimum bloc length (Norris, 1997).

3.2.1. Stationary Markov probabilities in one-dimensional chain

Linear Markov graph is represented in the following manner (Figure 2):

$$\boxed{p_0} \underset{\mu}{\overset{\lambda}{\rightleftarrows}} \boxed{p_1} \underset{\mu}{\overset{\lambda}{\rightleftarrows}} \boxed{p_2} \underset{\mu}{\overset{\lambda}{\rightleftarrows}} \cdots\cdots \boxed{p_{k-1}} \underset{\mu}{\overset{\lambda}{\rightleftarrows}} \boxed{p_k} \underset{\mu}{\overset{\lambda}{\rightleftarrows}} \boxed{p_{k+1}} \underset{\mu}{\overset{\lambda}{\rightleftarrows}} \cdots\cdots$$

Figure 2. – *One-dimensional chain of Markov cells*

Certain p_n probability corresponds to each cell. Probabilities change over time, where λ frequency corresponds to probability decrease and μ frequency corresponds to probability increase. Probabilities must be positively definite and their sum must be equal (Markov, 1971).

$$\sum_{n=0}^{N} p_n = 1, \quad n = 0,1,2,\cdots,N_1 + N_2 + \cdots + N_{B-1} \tag{3.1}$$

Changes of probability over time are "read" from Markov graph and the system of differential equations for probabilities is as follows:

$$\begin{aligned} \dot{p}_0 &= \mu p_1 - \lambda p_0 \equiv u_0 \\ \dot{p}_1 &= -\lambda p_1 + \mu p_2 - \mu p_1 + \lambda p_0 = u_1 - u_0 \\ &\vdots \\ \dot{p}_k &= -\lambda p_k + \mu p_{k+1} - \mu p_k + \lambda p_{k-1} = u_k - u_{k-1} \\ &\vdots \end{aligned} \tag{3.2}$$

The system tends towards stationary condition over time, which means that after a long enough period of time has elapsed the changes of probabilities over time can be taken as very small so that they become equal to zero:

$$\dot{p}_0 = \dot{p}_1 = \dot{p}_2 = \cdots = \dot{p}_k \cdots = 0 \tag{3.3}$$

Considering the introduced marks, we obtain that: $u_0 = 0, u_1 = 0, \cdots, u_k = 0$. This means that:

$$p = \frac{\lambda}{\mu} p_o \text{, that is } p_{k+1} = \frac{\lambda}{\mu} p_k \tag{3.4}$$

If we introduce that $\frac{\lambda}{\mu} = \omega$ then:

$$
\begin{aligned}
&p_1 = \omega p_0 \\
&p_2 = \omega p_1 = \omega^2 p_0 \\
&\vdots \\
&p_k = \omega^k p_0 \\
&\vdots
\end{aligned}
\tag{3.5}
$$

As based on (3.1)

$$p_0 \sum_{k=0}^{N} \omega^k = 1 \quad \text{and} \quad \sum_{k=0}^{N} \omega^k = \frac{1-\omega^{N+1}}{1-\omega}, \tag{3.6}$$

it follows that: $p_0 = \frac{1-\omega}{1-\omega^{N+1}}$, that is $p_k = \frac{1-\omega}{1-\omega^{N+1}} \omega^k$ the final expression for probabilities is:

$$p_n = \frac{1-\omega}{1-\omega^{N+1}} \omega^n \tag{3.7}$$

3.2.2. Mean absorbed heat energy in the premise

We shall analyse the mean heat energy through the premise that contains B blocs. If heat flux spreads from the left to the right, then the first bloc will be the first on the left while the index rises to the other blocs. We shall assume that:

- the first bloc includes N_1 cell and the bloc material has α_1 absorption coefficient,
- the second bloc has N_2 cells, and the coefficient of its material absorption is α_2, and finally
- B^{th} bloc has N_B cells and the coefficient of its material is α_B.

The described situation can be represented by Figure 3:

$I_0 \rightarrow$	α_1	α_2	α_3	……	α_k	……	α_B
	$n = 0$	$n = N_1$	$n = N_1 + N_2$		$n = N_1 + N_2 + \cdots + N_{k-1}$		$n = N_1 + N_2 + \cdots + N_{B-1}$

Figure 3 – *One-dimensional arrangement of blocs made of various materials*

Total N number of Markov cells in the premise here is: $N = N_1 + N_2 + N_3 + \cdots + N_k + \cdots + N_B$

Index n that counts cells in Markov chain and takes values is: $n = 0, 1, 2, \cdots, N_1 + N_2 + \cdots + N_{B-1}$

According to a semi-empirical formula for thermal energy absorption, the energy which leaves the system at cell n is represented by the following formula:

$$I_n = I_0 e^{-\alpha n} \tag{3.8}$$

Mean thermal energy leaving the system at cell n is represented by the following formula:

$$\langle I_n \rangle = \sum_{n=0}^{N} I_n p_n \tag{3.9}$$

After we replace (3.7) and (3.8) in (3.9), we have:

$$\langle I_n \rangle = I_0 \frac{1-\omega}{1-\omega^{N+1}} \frac{1-(\omega e^{\alpha})^n}{1-\omega e^{\alpha}} \tag{3.10}$$

In order to determine the mean thermal energy leaving the premise, the energies leaving each bloc must be added since the bloc absorptions are different. Using the formula (3.10), we come to the general expression for mean thermal energy leaving the premise:

$$\frac{\langle I_n \rangle}{I_0} = \frac{1-\omega}{1-\omega^{N+1}} \left\{ \frac{1-\left(\omega e^{-\alpha_1}\right)^{N_1}}{1-\omega e^{-\alpha_1}} + \left(\omega e^{-\alpha_2}\right)^{N_1} \frac{1-\left(\omega e^{-\alpha_2}\right)^{N_2}}{1-\omega e^{-\alpha_2}} + \left(\omega e^{-\alpha_3}\right)^{N_1+N_2} \frac{1-\left(\omega e^{-\alpha_3}\right)^{N_3}}{1-\omega e^{-\alpha_3}} + \cdots \right. \tag{3.11}$$
$$\left. + \left(\omega e^{-\alpha_k}\right)^{N_1+N_2+\cdots+N_{k-1}} \frac{1-\left(\omega e^{-\alpha_k}\right)^{N_k}}{1-\omega e^{-\alpha_k}} + \cdots + \left(\omega e^{-\alpha_B}\right)^{N_1+N_2+\cdots+N_{B-1}} \frac{1-\left(\omega e^{-\alpha_B}\right)^{N_B}}{1-\omega e^{-\alpha_B}} \right\}$$

The incident energy I_0, is sum of absorbed energy A and transmitted energy I_n , i.e. I_0 =A+I_n . Meaning this equality (the "meaning" denotes finding of mathematical expectation :$\langle F \rangle = \sum_{i=1}^{n} F_i p_i$, here p_i is the probability of appearance the value F_i) and taking into account that $\langle I_0 \rangle = I_0$, we obtained $I_0 = \langle A \rangle + \langle I_n \rangle$. In order to go over to the relative values, we divided the late equality with I_0 and obtained that:

$$\frac{\langle A \rangle}{I_0} = 1 - \frac{\langle I_n \rangle}{I_0} \tag{3.12}$$

where $\frac{\langle A \rangle}{I_0}$ is relative mean energy absorbed by the system, and $\frac{\langle I_n \rangle}{I_0}$ is relative mean value of thermal energy transmitted by the system. If the arrangement of blocs in the premise is changed, the last formula is re-arranged according to the new layout. It turns out that $\frac{\langle I_n \rangle}{I_0}$ value changes for another bloc layout (in relation to the stated one).

In order to have a better view onto how the system transmits (absorbs) energy, we shall analyse the general formula (3.11) for some extreme cases.

- If $\omega \to 0$, it means that $\lambda \ll \mu$ in boundary case is $\omega = 0$, therefore it follows from (3.11) that

$$\frac{\langle I \rangle}{I_0} = 1 \tag{3.13}$$

which means that the system transmits all energy penetrating into it.

- Contrariwise, when $\lambda \gg \mu$, i.e. when $\omega \to \infty$ it follows from (3.11) that:

$$\lim_{\omega \to \infty} \frac{\langle I \rangle}{I_0} = e^{-N\alpha_B} \tag{3.14}$$

Based on the obtained result (3.14), it can be concluded that transmitted energy depends on the coefficient of absorption of the last bloc material α_B, i.e. on the bloc situated farthest from the place of energy penetrating the system.

For the most frequent cases in practice the input and output frequencies are equal, unless the relation $\frac{\lambda}{\mu}$ is artificially influenced on, which means that $\omega = 1$.

In this case the general formula (3.11) is of the following form:

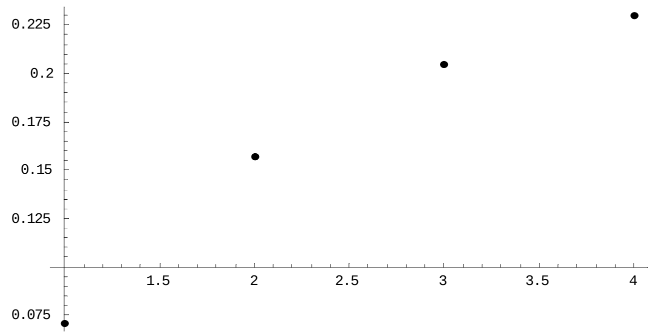
$$\lim_{\omega\to 1}\frac{\langle I_n\rangle}{I_0}=\frac{1}{N+1}\left\{\frac{1-\left(e^{-\alpha_1}\right)^{N_1}}{1-e^{-\alpha_1}}+\left(e^{-\alpha_2}\right)^{N_1}\frac{1-\left(e^{-\alpha_2}\right)^{N_2}}{1-e^{-\alpha_2}}+\left(e^{-\alpha_3}\right)^{N_1+N_2}\frac{1-\left(e^{-\alpha_3}\right)^{N_3}}{1-e^{-\alpha_3}}+\cdots\right.$$
$$\left.+\left(e^{-\alpha_k}\right)^{N_1+N_2+\cdots+N_{k-1}}\frac{1-\left(e^{-\alpha_k}\right)^{N_k}}{1-e^{-\alpha_k}}+\cdots+\left(e^{-\alpha_B}\right)^{N_1+N_2+\cdots+N_{B-1}}\frac{1-\left(e^{-\alpha_B}\right)^{N_B}}{1-e^{-\alpha_B}}\right\} \quad (3.15)$$

3.2.3. Analysis of the situation most frequent in practice

Because of the practical importance of cases with equal input and output frequencies ($\lambda=\mu$), we shall present the results for the absorbed energy in an 8 m long premise with one object, 1 m long, and for a 16 m long premise with 1 m long object. Coefficient of absorption of air in these cases is α_2 =0.05, and for the material the object is made of the coefficient of absorption is α_1 = 0.5. Considering the described situation and general formula (3.15), the following values of absorbed heat energy for certain positions of objects in premises are obtained, which are presented by Tables and Graphs (a-f):

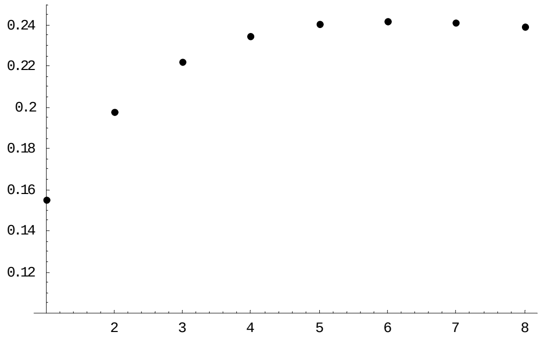
a) 4 m long premise

k	**1**	**2**	**3**	**4**
<A>/ I_0	0.0708063	0.156981	0.205046	0.230201



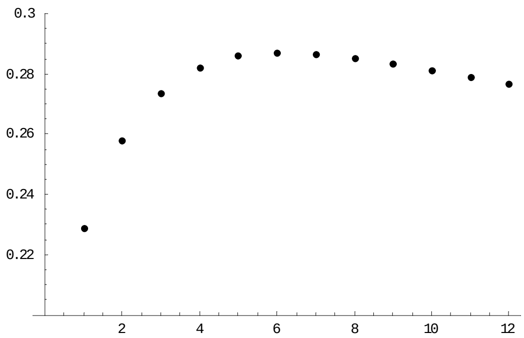
b) 8 m long premise

k	1	2	3	4	5	6	7	8
$\frac{\langle A \rangle}{I_0}$	0.155023	0.19811	0.222143	0.234721	0.240448	0.242113	0.241402	0.239335



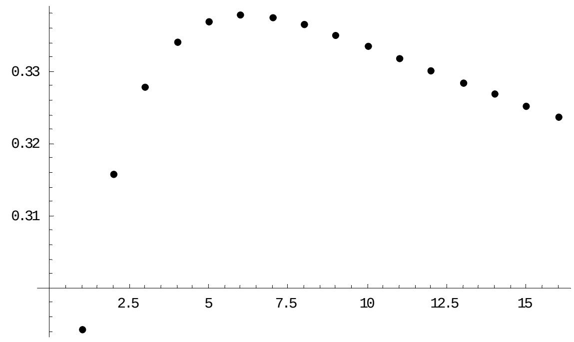
c) 12 m long premise

k	1	2	3	4	5	6
<A>/ I_0	0.229063	0.257788	0.27381	0.282195	0.286013	0.287123
k	**7**	**8**	**9**	**10**	**11**	**12**
<A>/ I_0	0.286649	0.285271	0.283397	0.281273	0.279046	0.276802



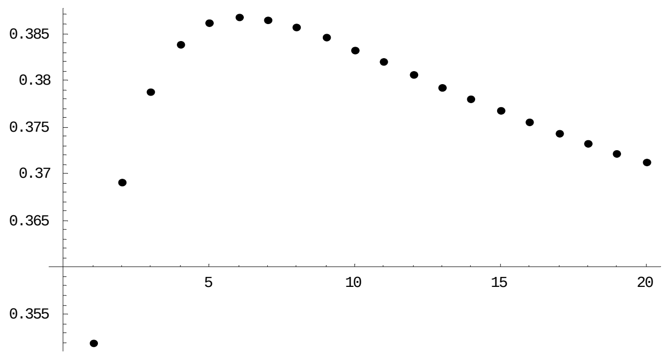
d) 16 m long premise

k	1	2	3	4	5	6
<A>/I_0	0.294309	0.315853	0.327869	0.334158	0.337022	0.337854
k	**7**	**8**	**9**	**10**	**11**	**12**
<A>/I_0	0.337499	0.336465	0.33506	0.333467	0.331796	0.330113
k	**13**	**14**	**15**	**16**		
<A>/I_0	0.328455	0.326843	0.325289	0.323798		



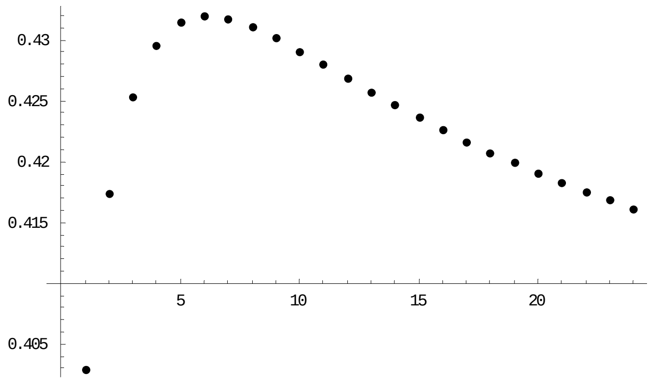
e) 20 m long premise

k	1	2	3	4	5	6
<A>/I_0	0.351945	0.36918	0.378793	0.383824	0.386115	0.386781
k	**7**	**8**	**9**	**10**	**11**	**12**
<A>/I_0	0.386496	0.385669	0.384545	0.383271	0.381934	0.380588
k	**13**	**14**	**15**	**16**	**17**	**18**
<A>/I_0	0.379261	0.377972	0.376728	0.375535	0.374394	0.373305
k	**19**	**20**				
<A>/I_0	0.372267	0.371278				



f) 24 m long premise

k	1	2	3	4	5	6
<A>/I0	0.402982	0.417345	0.425355	0.429548	0.431457	0.432012
k	**7**	**8**	**9**	**10**	**11**	**12**
<A>/I0	0.431775	0.431086	0.430149	0.429087	0.427973	0.426851
k	**13**	**14**	**15**	**16**	**17**	**18**
<A>/I0	0.425746	0.424671	0.423635	0.422641	0.42169	0.420783
k	**19**	**20**	**21**	**22**	**23**	**24**
<A>/I0	0.419917	0.419093	0.418308	0.417562	0.416851	0.416175



Based on the above Tables and Graphs (a-f), it can be concluded that the absorbed energy varies considerably with the change of position where the object is. It is interesting that the maximum absorption appears when the object is at the 6th meter from the wall affected by heat flux. From the point of view of fire hazard, this object position corresponds to the maximum hazard and such a position should be avoided. Minimum absorption values are obtained when the object is placed directly behind the wall affected by heat energy flux. The absorption is also very low when the object is placed quite closely to the opposite wall of the premise. In addition to this, the analysis shows what could have been expected, which is that the bigger the premise is the higher quantity of heat energy is absorbed.

3.2.4. Analytic simulation of histograms obtained for ω =1

The obtained Tables and Graphs (a-f) show important information concerning which position of the object corresponds to minimum fire hazard and based on this information the position of objects corresponding to low fire hazard can be determined before the construction of the premise. The inconveniency of using these Tables and histograms obtained is that it is rather hard or sometimes even impossible to find out thermo-dynamic characteristics of premises which depend on absorbed thermal energy. This is why in this paragraph we shall look for functions of continuous variable *x*, which is the measure of positions within the premise simulated by the obtained histograms in an optimum manner.

Continuous approximation will be determined by means of histograms for premises of the following lengths: 8 m, 10 m, 12 m, 14 m and 16m. Based on the obtained continuous curves, we shall determine the dependence of quantity of absorbed heat and maximum absorption value on the premise length. Based on the obtained histograms, it can be concluded that the function is of the following form:

$$A(x) = C - e^{-\left(bx - ax^{L+1}\right)}, \quad -1 \langle L \langle 1 \qquad (3.16.)$$

i.e., $A(x) = \frac{\langle A \rangle}{I_0}$, simulates the obtained histograms in the best manner. Coefficients *a, b, C, L* will be determined by fitting of curve *A(x)*. By means of the data from histograms, three equations for determining the said parameters will be taken at points x = 1, x = N+1, x = x $_{M=6}$, where x_M is marked as abscissa of the maximum. The fourth equation will be taken for the current point of histogram *k*, which takes all values except 1, x_M, N+1. The system of four equations will be calculated for every *k* and the values of parameters a_k, b_k, C_k, L_k will be obtained. Arithmetic means of these values will be taken as parameters of *A(x)* curve.

The system of equations for fitting is as follows:

$$\begin{aligned} A(1) &= C - e^{-(b-a)} \\ A(6) &= C - e^{-\left(bq_m - aq_m^{L+1}\right)} \\ A(8) &= C - e^{-\left(bM - aM^{L+1}\right)} \\ A(k) &= C - e^{-\left(bk - ak^{L+1}\right)} \end{aligned} \qquad (3.17)$$

The values on the left are read from the histograms. More convenient system for numeric calculation of parameters a_k, b_k, C_k, L_k is obtained by computing the system equations (4.2) with logarithms:

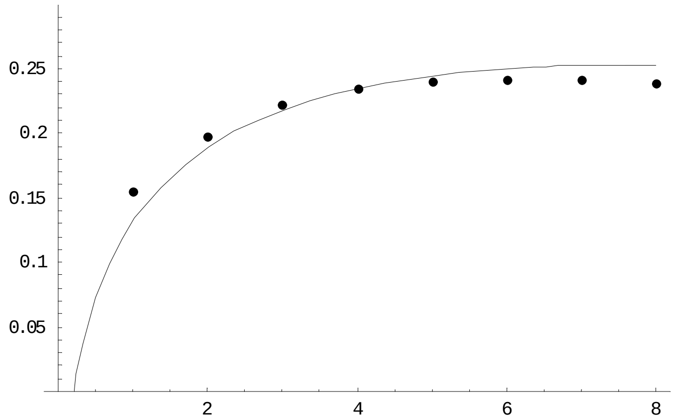
$$\begin{aligned} a - b &= \ln\left[b - A(1)\right] \\ aq_m^{L+1} - bq_m &= \ln\left[C - A(6)\right] \\ aM^{L+1} - bM &= \ln\left[b - A(8)\right] \\ ak^{L+1} - bk &= \ln\left[b - A(k)\right] \end{aligned} \qquad (3.18)$$

Arithmetic means are determined for parameters determined in the described manner and they are inserted in the formula (3.16). We shall here compare the continuous curve and the corresponding histogram for premises 8 m and 16 m long.

- The following expressions are obtained for M=8 histogram:

$\overline{a} = -0.610912$; $\overline{b} = -0.0515033$; $\overline{C} = 0.704008$; $\overline{L} = -0.672408$

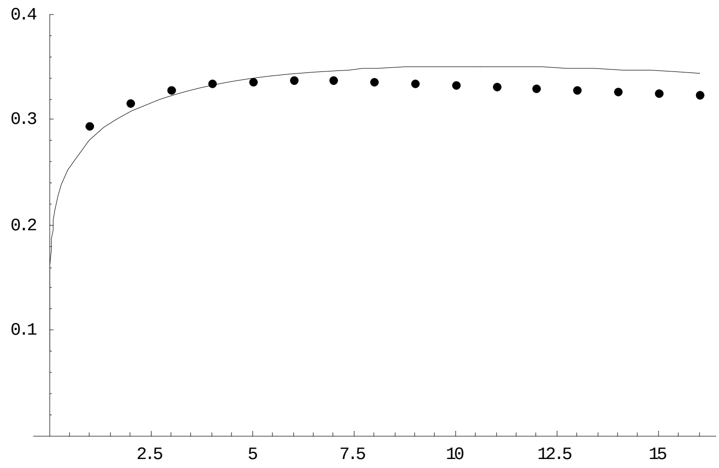
$$A(x) = 0.704008 - e^{0.0515033x - 0.610912x^{1-0.672408}} \tag{3.19}$$



- The following expressions are obtained for M=16 histogram:

$\overline{a} = -0.242375$; $\overline{b} = -0.0099849$; $\overline{C} = 1.07329$; $\overline{L} = -0.756501$

$$A(x) = 1.07329 - e^{0.0099849x - 0.242375x^{1-0.756501}} \tag{3.20}$$



As it can be seen, simulation function corresponds well to the histogram, so this form of simulation can be used for calculations of systems we are interested in. As it has already been said, the biggest practical interest is for the dependence of absorbed energy on the premise length and maximum value of absorbed energy. In order to determine dependence of absorbed energy on the premise length, $\int_0^M dxA(x)$ integrals are numerically calculated, where M is the premise length. These dependences may also be presented by the function of $A_{TOT}(M)$ form. The stated dependence will also be determined by fitting.

Since all *A(x)* curves have the same abscissa of maximum absorption, A_{MAX} maximum ordinate is determined by the replacement of this abscissa in the obtained continuous curves, (3.16).

It has already been underlined that the quantity of absorbed energy increases together with the increase of premise length. Due to its practical importance, this fact requires special analysis. We shall observe the premises 8 m, 10 m, 12 m, 14 m, 16 m, 18 m, 20 m, 22 m and 24 m long, and for each of the cases we shall determine *A(x)* functions. By means of these functions we shall determine the values of total energy absorbed by the premise as:

$$P(M) = \int_0^M dxA(x) \tag{3.21}$$

The found values are given in Table 3:

Table 3

M	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**
$\int_0^M dxA(x)$	1.64	2.49	3.29	4.25	5.34	6.75	7.83	8.97	10.33

Based on this table, it can be concluded that by the increase of M length the extract $\frac{dP}{dM}$ becomes constant, so the simulation curve *P(M)* will be searched in the form:

$$P(M) = uM + vM^{\frac{1}{4}} \tag{3.22}$$

The value stated in the table will be used to determine *u* and *v* coefficients of analytical curve (3.22).

The procedure of fitting is the following: for every pair of the closest points *u* and *v* values are determined, and their arithmetic means are taken as coefficients in the curve (3.22). The found values per pairs of points are as follows:

$$\begin{bmatrix} u = 0.490523. \\ v = -1.35819 \end{bmatrix}, \begin{bmatrix} u = 0.445916 \\ v = -1.10734 \end{bmatrix}, \begin{bmatrix} u = 0.54349 \\ v = -1.73644 \end{bmatrix}, \begin{bmatrix} u = 0.620251 \\ v = -2.29201 \end{bmatrix},$$

$$\begin{bmatrix} u = 0.821639 \\ v = -3.90311 \end{bmatrix}, \begin{bmatrix} u = 0.592166 \\ v = -1.89778 \end{bmatrix}, \begin{bmatrix} u = 0.62672 \\ v = -2.22458 \end{bmatrix}, \begin{bmatrix} u = 0.76688 \\ v = -3.64835 \end{bmatrix} \quad (3.23)$$

Here we have 8 *u* values and 8 *v* values. Their arithmetic means are:

$$\overline{u} = 0.613448$$
$$\overline{v} = -2.27098 \quad (3.24)$$

Therefore, the shape of continuous curve is as follows:

$$P(M) = 0.613448M - 2.27098M^{\frac{1}{4}} \quad (3.25)$$

The continuous curve (3.25) and histogram made of values given in the second row of Table III are compared on Figure 4.

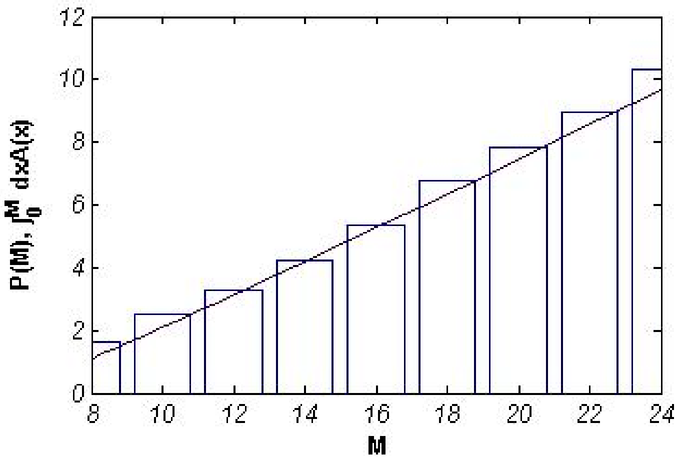


Figure 4 – *Absorbed energy depending on the premise length.*

As it can be seen the correspondence is very good, so the curve (3.25) may be used for the estimate of absorbed energy by the premises of any length. These estimates are necessary since based on them the reduction of fire hazard can be made. The fact that fire hazard can be estimated by means of simulation curve (3.26) for the premise of any length represents the best illustration required for its determination.

4. Conclusion

As the explosion is one of the modes of terrorists` activities, the detection of explosives is an important area for its prevention. The prevention of explosion is in constant observation and direct control of the entrances of objects – targets of terrorists, application of the modern technical devices (cameras with different scopes of wave length, metal detectors and explosive detectors, X-ray scanners, etc.). The constant vigilance of counterterrorist teams is implied. It is important to realize lifetime education of members of security services. Also, if an explosive device is found, safe transport and its extermination at special range are important.

The risk analyses carried out in this paper have resulted in the fact that the mean absorbed thermal energy of a premise is depending on the layout of objects in it. The simplest example which refers to absorption in length showed that:

−Maximum risk from fire (as consequence of an explosion) in closed space with length of 8 m is on the sixth meter distance from the wall on which flux of thermal energy precipitates

−Minimum fire hazard in closed space is when the object is directly behind the wall on which flux of thermal energy precipitates. The important information concerning which position of the object corresponds to minimum fire hazard is shown in Tables and Graphs (a-f). Based on this information, the position of objects corresponding to low fire hazard can be determined before the construction of the tract.

In order to estimate relevant thermodynamic characteristics of the premise, which depend on the energy absorption, we simulated the histograms by the functions of continual variables.

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PREVENCIJA EKSPLOZIJA I POŽARA U OBJEKTIMA MOGUĆIH TERORISTIČKIH NAPADA

Rezime

Danas je u svetu očigledna ekspanzija terorizma, te se javlja potreba za razmatranjem različitih vidova borbe protiv svih njegovih pojavnih oblika. Naročitu pažnju treba pokloniti preventivnom delovanju bezbednosnih subjekata. Podmetanje eksplozivnih naprava je jedna od terorističkih aktivnosti, koja koristi štetne posledice dejstva eksplozivnog talasa u vidu pritiska i toplote na okolinu. U ovom radu je dat pregled preventivnih aktivnosti bezbednosnih subjekata, s ciljem borbe protiv terorizma. Te preventivne aktivnosti podrazumevaju protivdiverzionu zaštitu – pregledi, otkrivanje, delaboracija i uništavanje, kao i razmatranje mogućnosti primene teorije rizika, a u vezi s prostornim rasporedom predmeta u objektima. Minimiziranje rizika od eksplozija i požara, koji su uzročno-posledično povezani, od naročitog je značaja. Takođe je dat pregled tehničkih sredstava koja se mogu koristiti u preventivnim pregledima i za detekciju eksploziva. Analiziran je i problem minimizacije rizika od požara nakon eksplozije nalaženjem optimalnog rasporeda predmeta u prostorijama različitih dužina. Cilj tih aktivnosti je ublažavanje posledica na objekte koji se nalaze na putu dejstva eksplozivnog i toplotnog talasa u nekom zatvorenom prostoru (metroi, tržni centri i sl.). Takođe je uvedena i kontinualna simulacija zavisnosti apsorbovane energije od dužine prostorije.