

## **Effectiveness of “Fountain” Blast Inhibitors Estimated on the Basis of Analysis of their Practical Application by Law Enforcement Personal.**

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Statistic analysis shows that bombs and other blast devices are increasingly being used by terrorists. Complex of actions aimed to criminal blast prevention or, in case of the detonation to the damage effects suppression, shall be based on administrative security measures and special equipment used.

For suppressing blast, fragmentation and thermal effects law enforcement professionals use various blast blankets and blast containers [1]. Crucial requirement to blast inhibition devices is the safeness in application. It means -avoid contact with the explosive while covering it with the blast inhibition device, and avoid fragmentation resulted from the device in case of the detonation of the explosive covered by it. Some designs of blast blankets and liquid blast inhibitors meet these requirements.

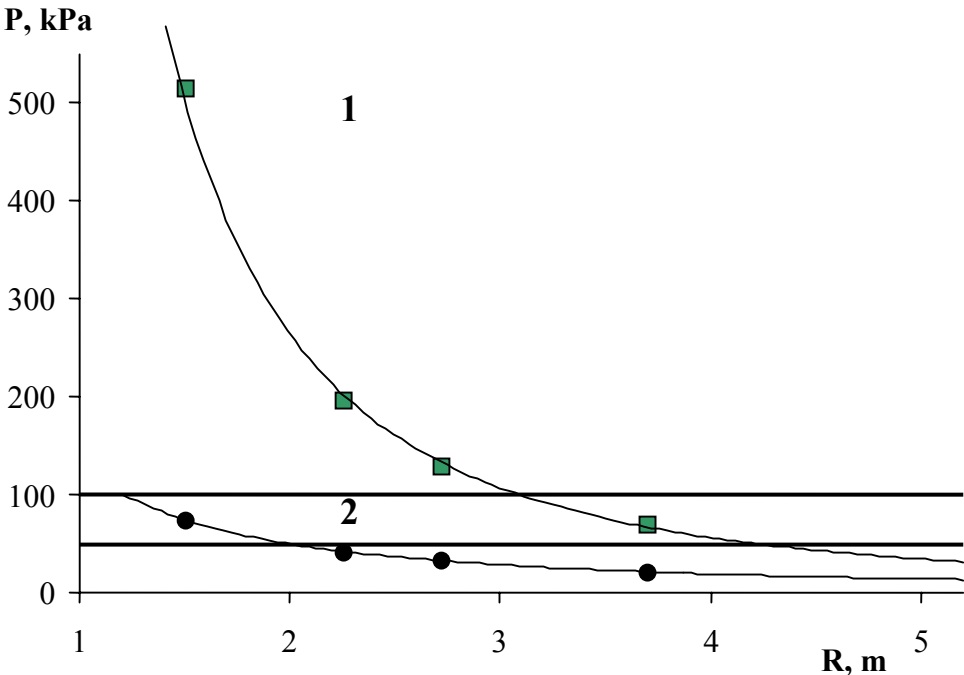
Liquid blast inhibitors “Fountain” designed by NPO SM have been produced since 1998 [2,3]. The product is available in several modifications designed to suppress blast effects resulted from blast devices of various sizes and containing 0.4 to 1kg explosive. Theoretical and experimental investigations aimed to updating and increasing effectiveness of the inhibitors have been constantly carried out along with their production [4-7].

Fountain blast inhibitors are handheld multi-camera elastic containers filled with a special gas-liquid mixture. The containers are equipped with fragment resistant screen made of aramid fiber. The principle of operation is based on initial attenuation of the blast wave while it is passing through the layer of two-phase liquid, this is followed by the blast energy dissipation and its transformation into the drop kinetic energy [8-10]. The two-phase liquid layer also suppresses the thermal blast effect, prevents burn injuries and fires, attenuates fragmentation. The fragment resistant screen provides additional protection.

Damage effects of a blast shock wave resulted from the detonation of a condensed explosive are determined by the shock wave overpressure and the shock wave impulse. Field testing shows that the application of the blast inhibition device reduces the shock wave impulse by 2-3 times and the shock wave overpressure – up to 10 times. The degree of the blast effect suppression increases as the distance to the epicenter decreases, that is the suppression effect is the highest in the most dangerous zone.

The blast shock wave overpressure values presented in fig. 1 have been obtained for various distances from the 0.8 kg TNT epicenter (with and without the inhibitor). Straight lines at 50 and 100 kPa correspond to the threshold of barotrauma –ear injury, and lung hemorrhage. The radius of

the dangerous area is 2-2.5 times less when the inhibitor is used.



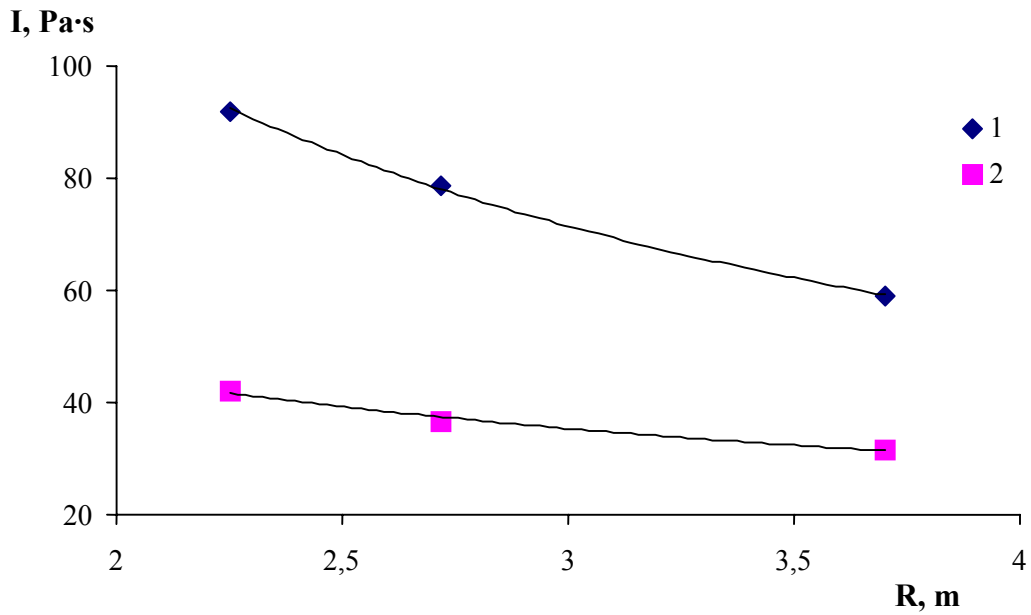
**Fig.1 – The blast shock wave pressure resulted from the detonation of the ‘open’ 0.8 kg TNT charge (1) and the detonation of the same charge covered with the inhibitor. Straight lines at 50 and 100 kPa correspond to the threshold of barotrauma –ear injury, and lung hemorrhage and indicate the dangerous zone.**

The example of the blast wave compression at the detonation of 1 kg TNT covered with the inhibitor is given in fig. 2.

Empirical dependence found allows evaluating the shock wave damage effect resulted from the detonation of open and covered 1 kg TNT charges. The most accurate way of the evaluation is constructing nomographs in P-I coordinates.

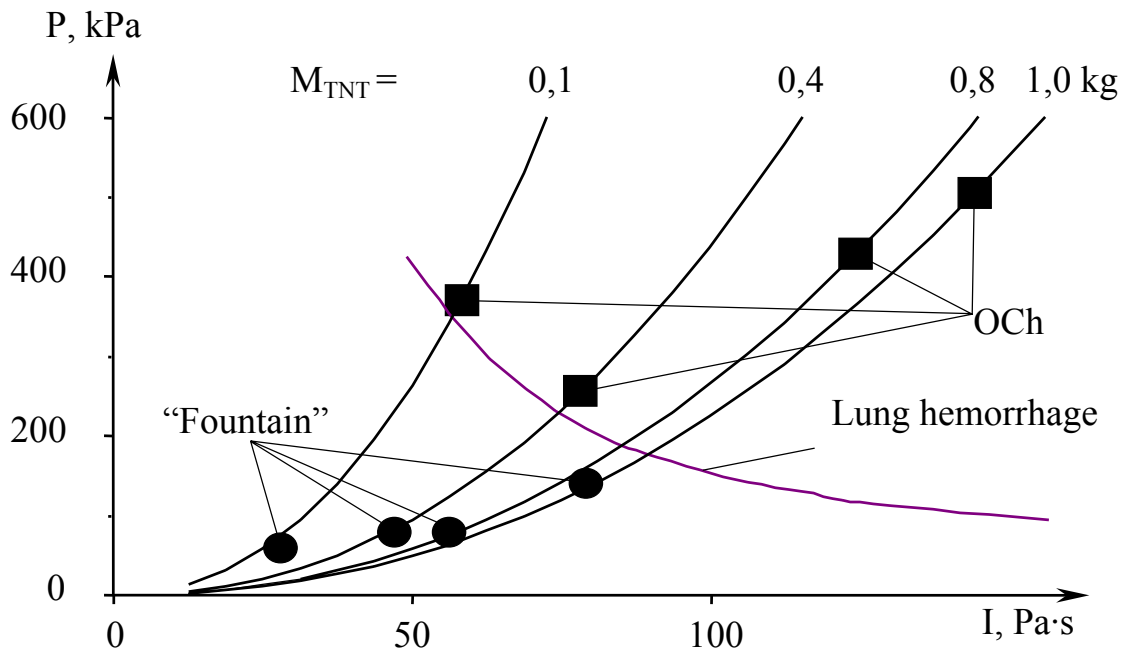
Nomograph for the blast shock wave evaluation constructed on the basis of experimentally obtained pressure dependencies (the front shock wave and the compression phase) of the distance and the weight of the open TNT charge is presented in fig.1.

The lines present values of the blast waves at the detonation of 0.1 and 1 kg TNT open charges. The squares corresponds to the blast wave values recorded at 0.8m (for 0.1 kg charge) and at 1.5 m (for all the rest charges) from the epicenter of open TNT charges. The circles indicate the blast wave values obtained for the similar charges detonated under the inhibitors.



**Fig.2 - The shock wave impulse at 1-kg TNT detonation: 1 – ‘open’ charge, 2- charge covered with the inhibitor**

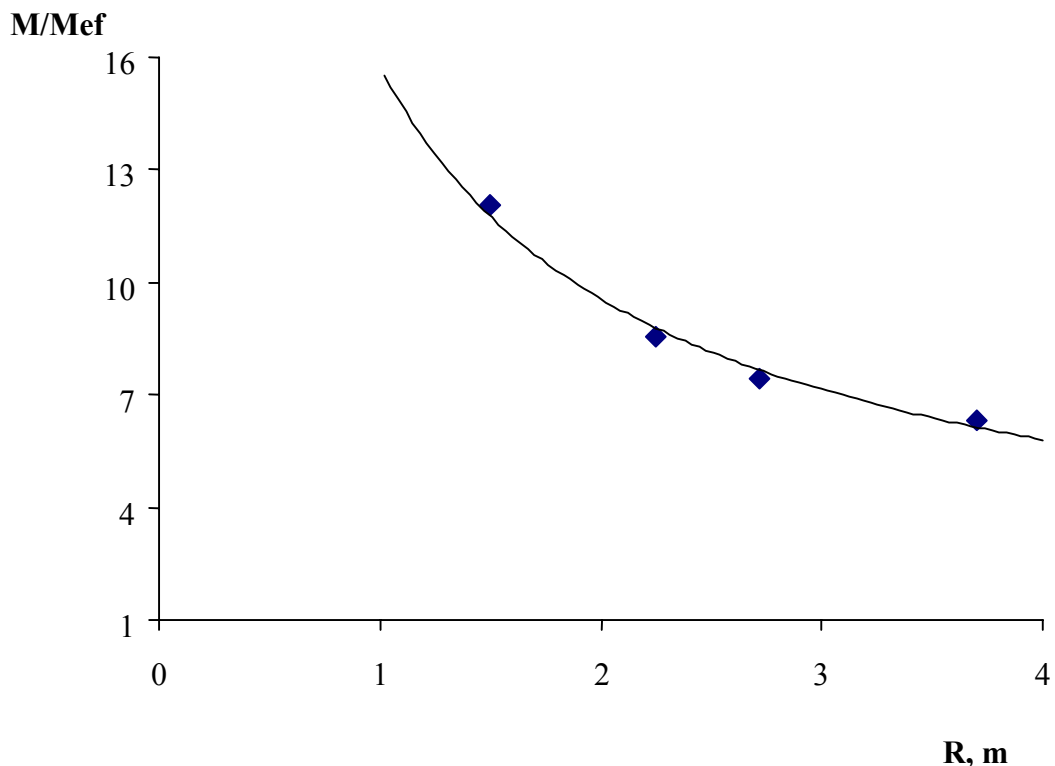
Fig 3 shows that at the same distance the blast effect resulted from the given open charge and causing lung hemorrhages can be reduced to the safe values in case of using the inhibitors.



**Fig. 3 - P-I graph for open and covered TNT charges (0.1 – 1.0 kg)**

Data obtained experimentally for  $R=0.8\text{m}$  ( $M_{\text{TNT}} = 0.1 \text{ kg}$ ) and  $R=1.5 \text{ m}$  ( $M_{\text{TNT}} = 0.4; 0.8; 1.0 \text{ kg}$ ): squares indicate data obtained for the open charges and circles point data obtained for the covered charges.

Based on the comparisons of the nomographs in P-I coordinates constructed for the detonations of the open and covered TNT charges, the coefficient of liquid inhibitor effectiveness has been calculated. At first, the distance at which a certain injury occurs (in particular, threshold for lung injuries) was determined experimentally for covered charges of M-weight. Then the weight of an open charge ( $M_{\text{ef}}$ ) resulting to the same injury at the same distance was calculated.  $M/M_{\text{ef}}$  is taken as the coefficient of liquid inhibitor effectiveness. An example of  $M/M_{\text{ef}}$  – dependence of the distance from 0.8 kg TNT epicenter is given in fig. 4. The diagram shows that the liquid inhibitor attenuates the blast damage effect more than 10 times. The effectiveness is growing sharply in the most dangerous zone, within 1m from the epicenter the damage effect is 16 times less.



**Fig. 4 – Coefficient of liquid inhibitor effectiveness at the detonation of 0,8 kg TNT charge**

The experimental data obtained in the testing show that the number of fragments decreases by 7 – 20 times, depending on a type of the inhibitor used. Besides, the inhibitor reduces the height of the fragment scattering zone, which also diminishes the risk of vital organ injuries.

High-frequency camera recorded the formation of a fireball at the detonation of the open charge. At the detonation of the charge covered by “Fountain” inhibitor the fireball does not

transgress the inhibitor's container [11]. Apart from the fact that the fireball diameter grows smaller, application of the Fountain inhibitor reduces the risk of ignition, as the liquid filling the elastic envelope is spattering away.

Comparing blast effects caused by the detonation of an open charge to the blast effects resulted from the detonation of a charge covered with the inhibitor Fountain, we can note: the thermal blast effect is limited by the volume of the inhibitor's container; the area of fragmentation decreases by 200 times; the area of the blast damage effect is 8 times less; the effectiveness of the blast shock wave is 16 times less.

"Fountain" blast inhibitors are patented, certified and assigned by the Russian Ministry of the Interior Affairs and the Ministry of Defense.

Statistic analysis of the criminal usage of explosives in Russia shows that 'Fountains' blast inhibitors may be widely used. Most of the blast devices contain less than 1-kg high-energy charge and are found before the detonation. This statistic may be completed with the enormous number of suspicious objects found in populous areas. Whilst the objects may occur to be not dangerous, the situation nevertheless requires actions on evacuation, cordoning off the area and calling mine clearing specialists.

By now in Russia law enforcement and military bodies, financial institutions, railway stations and airports are equipped with more than 1000 pieces of "Fountains".

The blast Inhibitors "Fountains" have been applied many times in practice for mine clearance, neutralizing grenades and other blast devices. The effectiveness of the inhibitor is proved by positive responses received from Moscow, St. Petersburg and Leningrad region Riot Squads, deputy chief of the Ministry Interior Main Headquarter, chiefs of the Headquarters of St. Petersburg and Leningrad region, Moscow Metro Security and many others.

The aspects of "Fountain" inhibitor usage, mentioned in the above responses can be gathered into several interacting groups. Firstly, to save lives, which is the main idea of the inhibitor.

The fact that the inhibitor is easy in operation, stressed out in most responses, contributes to the security. Due to the compact design 'Fountain' is always ready to be used, convenient in transportation and use.

The most dangerous period is the period between the time of finding a suspicious object and the time of arrival the mine clearing specialists. The object can detonate any second. When using 'Fountain' blast inhibitor, we reduce this period up to the moment of covering the object with it.

The product has been successfully applied many times by law enforcement professionals called to the places of blast emergency. Application of "Fountain" devices does not require special training.

Secondly, all the users have reported that “Fountains” save money, time and efforts on evacuation and cording off a dangerous area. Due to significant reduction of the cording off area, it is easier to control it and fewer personnel are necessary for it. Besides, people from and adjacent offices and building are not to be evacuated and can continue normal activity.

Thirdly, all the users have mentioned a psychological factor. It has been reported that the application of “Fountains” encourages the personnel responsible for evacuation and cording off actions. People feel more confident and safe, which helps to avoid panic.

“Special Materials” is continuing the work on enhancing effectiveness and operation characteristics of blast inhibition devices, as well as on developing complex techniques of their application for opposing criminal blasts.

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