The influence of migration processes in gunpowder charge on the quality of mortar ammunition

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Abstract

The study describes the results of static, physicochemical and ballistic examination of double-based gunpowder charges, in order to establish the deviations from the demanded quality of mortar ammunition. The examinations were carried out on gunpowder samples used for laboration of mortar shells 60, 82 and 120 mm caliber and consisted of periodical measurements of the gunpowder mass loss, basic ballistic parameters, and compatibility testing of gunpowder and celluloid containers as well as chemical stability determination. The estimation of the gunpowder quality was performed by comparative analysis and the suggestions for more efficient production of it were given.

Keywords: mortar shells, gunpowder, nitroglycerine, migration, ballistite, ballistic stability, chemical stability.

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Up-to-date standards for ammunition are rather strict, considering the efficiency and the final effect. In order to obtain the desired quality and the minimal accident risk, the safe and reliable ammunition for the given time limit should be produced. Due to the variety of the ammunition components, it is necessary to constantly monitor the quality state, during storage and immediately before use.

Every ammunition component (electric, energetic, electronic, etc.) can harm the projected function of the round or make it unsafe for further use and keeping. The energetic components, gunpowder first of all, are susceptible to change with time and they influence the other components present [1–7]. In order to avoid the negative influence it is important to analyze the compatibility aspect of used materials with the aim of a product, considering the material aging. It is practically impossible to determine the ammunition duration by prediction of the process of components aging, so the material quality parameters have to be monitored often in order estimate the safety and efficiency of ammunition [2]. Determination of the ammunition components state is performed by various ballistic, physic-chemical and statistic examinations.

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Terms of production, storage and manipulation of ammunition and ammunition elements

Ammunition and its elements, such as gunpowder, are produced by the strict technological procedures and with a defined formal quality, for each product, in the Defense Industry of Serbia. The applied standards precisely define the sort and properties of the material for ammunition elements and also for packaging. The initial chemical composition and mass portions are defined for gunpowders, as well as the demands which have to be fulfilled in physicochemical and ballistic investigations.

The ammunition and ammunition elements storage, manipulation and transport are also defined by rules and instructions of the Ministry of Defense and the Serbian Army, and partly or completely in accordance with known international standards.

Degradation of ballistic characteristics of mortar ammunition

The decrease of the muzzle velocity of the laborated series of ammunition is noticed even in initial polygon testing, if the ammunition was stored for more than 6 months [3]. Based on experience and knowledge in the field, it is supposed that the first cause of this is the loss of ammunition mass induced by the evaporation of nitroglycerine and the degradation of nitrocellulose [8,9].

Nitroglycerine is a strong brisant explosive, colorless, oily, with high contents of nitrogen (18.5%), very sensitive to impact and heat. It is produced by the nitration of glycerin by sulphuric and nitric acid (both 96%), in a ratio 45–50% nitric and 50–55% sulphuric acid. Combined with nitrocellulose, it is used for the production of dibasic gunpowder charges. It forms weak bonds with nitrocellulose, so it is mobile and can easily penetrate to the gunpowder surface.

The physical and thermodynamic characteristics of nitroglycerin are given in Table 1.

Table 1. Physicochemical properties of nitroglycerin

Chemical formula	$C_3H_5(NO_3)_3$
Molecular mass	227,1 g/mol
Density	1,591 g/cm^3
Solubility	Slightly soluble in water, soluble in organic solvents
Sensitivity to friction and impact	Very high
Decomposition temperature	50–60 °C
Vaporization point	250 °C
Detonation point	218 °C

The "Krušik" Company (Valjevo, Serbia), which belongs to the group of the Defense Industry of Serbia is the ammunition manufacturer with long-term experience and worldly acknowledged results. "Milan Blagojević Industry" (Lucani, Serbia) is also a reliable long-term gunpowder and rocket fuel manufacturer. Their products are laborated into all sorts of conventional ammunition throughout the world.

The usual change of ballistic properties has caused the need for realization of complex testing in order to confirm the assumption or find another reason for degradation. Based on obtained results, it is necessary to take the specific steps to prevent the quality decrease.

EXPERIMENTAL

Examination program, sample preparation of gunpowder, ammunition and package

The examination program, in accordance with the producer of gunpowder and mortar shells is created by The Military Technical Institute of the Ministry of Defense of the Republic of Serbia. The program contains of:

- Static examinations of increment charges from serially produced mines;
- Laboration of new increment charges for longer storage;
- Physicochemical examinations of etalons of gunpowder charges, gunpowder charges from stored mines and gunpowder charges that have already been stored for 3 and 6 months;
- Compatibility examinations for gunpowder and celluloid containers;
- Ballistic examinations of serial ammunition and the ammunition stored in original hermetically closed packages;
- The mortar stand vibration measurements on soft and hard surface;
- The measurements of pressure gunpowder gas in gunpowder chamber.

The ammunition, gunpowder samples and package preparation, as well as other static examination were carried out in the corresponding industrial plants in the republic of Serbia. The ballistic and vibration examinations were performed in the Technical Test Center, while the physicochemical examinations were carried out in The Military Technical Institute and the Technical Overhaul Works in Kragujevac, Serbia [3].

The examinations were carried out on gunpowder samples given in Table 2 [10–12].

For gunpowders A, B and D two samples of each of different age and of different laborated mass.

Table 3 displays the chemical composition of each sample.

All the gunpowder specimens are prepared in celluloid containers, which represent the primary packaging for additional gunpowder charges.

Mortar increment propellant container manufactured of foamed celluloid, which is composed of 50 to 84% nitrocellulose, having nitrogen content of from about 10.5 to about 13.5%, and about 15 to about 50% camphor. The burn rate of the foamed celluloid can be enhanced by the addition of energetic additives, such as energetic plasticizers. The containers are manufactured from celluloid nitrate sheet with a thickness of 0.13±0.02mm, totally combustible and leave a negligible residue.

Table 2. The examined gunpowder samples

Gunpowder sample properties	Sample label						
	A		B		C	D	
	A1	A2	B1	B2		D1	D2
Sort	NGB-051		EI-021		NGB-021	NGB-261	
Caliber of additional charge	60 mm		82 mm		82 mm	120 mm	
Age, years	25	0	16	0.5	4	5	2
Laboration mass, g	4.70	4.30	14.70	14.50	13.40	76.8	75.8

Table 3. The initial chemical composition of gunpowder samples (mass%)

Gunpowder label	Component	Value
A	Nitrocellulose	57.50±2.00
	Nitroglycerin	40.50±1.50
	Centralite 1	1.70±0.20
	Vaseline	0.30±0.20
	Graphite	max 0.20
	Volatile species	max 0.50
	Moisture	max 0.50
B	Nitrocellulose	max 84.75
	Nitroglycerin	15.00±2.00
	Diphenylamine	1.20±0.30
	Dibutilphtalate	max 1.5
	Graphite	max 0.30
	Volatile species and moisture	1.0±0.25
C	Nitrocellulose	57.50±2.00
	Nitroglycerin	40.50±1.50
	Centralite 1	1.70±0.20
	Vaseline	0.30±0.20
	Graphite	max 0.20
	Volatile species	max 0.50
	Moisture	max 0.50
D	Nitrocellulose	58.00±2.00
	Nitroglycerin	40.00±1.50
	Centralite 1	1.70±0.20
	Vaseline	0.30±0.20
	Graphite	max 0.20
	Volatile species	max 0.50
	Moisture	max 0.50

RESULTS AND DISCUSSION

Static examination

Under the assumption that the loss of the gunpowder mass occurs due to the migration processes of nitroglycerine into celluloid containers, cardboard packaging and the free space inside of it, it is planned to follow the mass loss of gunpowder charges placed in:

a) original cardboard packaging (serially produced ammunition);

b) hermetically closed metal boxes (temporary used metal containers designed for gunpowder charge of 155 mm ammunition);

c) hermetically closed polyvinyl packaging;

d) hermetically closed metal boxes with free space, equal in size to original cardboard packaging.

For serial ammunition, taken from two different warehouses, the mass measurements were performed for celluloid containers (increment charges), and the determination of mass loss by comparing with the gunpowder mass laborated for initial examinations.

There was a prominent difference between mass losses at additional charges of different age. Nitroglycerin present in newer gunpowder had no time to intensively migrate, while in older gunpowder there was a significant mass loss as a consequence of the ammunition age. The measuring the mass losses in ammunition of 82 mm caliber includes two different kinds of gunpowder, the extruder Impregnated (EI) gunpowder and the nitroglycerin (NGB) gunpowder, ballistite, of different age. Due to the lower contents of nitroglycerin in EI than in NGB gunpowder, the lower mass loss is expected in EI.

The percentage of mass loss after 2 years of storage and 5 years of storage pointed to the fact that the gradient of loss is greater in the initial period, and later diminished, in other words migration processes were later stabilized.

For gunpowder charge of 120 mm caliber, the mass losses of etalon charges were also measured, 2 years after laboration.

The obtained mass loss of 1.25% in etalon charge is in accordance with the 1.10% mass loss of the same kind of gunpowder which comes from the ammunition stored for 2 years and 1.37% which comes from the

Table 4. The measured values of gunpowder mass (g) in additional charges and mass losses

Additional charge No.	Gunpowder sample						
	A		B		C	D	
	A1	A2	B1	B2		D1	D2
1.	4.40	4.26	14.63	14.47	12.80	75.75	74.98
2.	4.34	4.26	14.64	14.49	12.96	75.79	74.96
3.	4.39	4.27	14.64	14.47	12.88	75.70	74.99
4.	4.41	4.26	14.67	14.45	12.89	75.75	74.95
5.	4.32	4.26	14.65	14.48	12.92	75.79	74.97
6.	4.41	4.26	14.60	14.46	12.92	75.71	74.94
Medium value	4.38	4.26	14.64	14.47	12.90	75.75	74.97
Mass loss, g = $m_{\text{laboration gunpowder}} - m_{\text{gunpowder(mv)}}$	0.32	0.04	0.06	0.02	0.50	1.05	0.83
Mass loss, % = $100(m_{\text{laboration gunpowder}} - m_{\text{gunpowder(mv)}})/m_{\text{laboration gunpowder}}$	7.30	0.94	0.41	0.18	3.70	1.37	1.10

ammunition stored for 5 years (Table 4, D1 and D2 data).

By redirecting of gunpowder mass after 3 and 6 months of storage in different condition – original cardboard (a), hermetically closed metal (b), hermetically closed polyvinyl (c) and hermetically closed metal with free space (d), the migration part for all three destinations (container, box or free space) can be determined. This is calculated the following way:

$m_{\text{laboration gunpowder}} - m_{\text{gunpowder (a)}}$: mass of all migrated nitroglycerine;

$m_{\text{laboration gunpowder}} - m_{\text{gunpowder(c)}}$: mass of migrated nitroglycerine into celluloid containers;

$m_{\text{gunpowder(a)}} - m_{\text{gunpowder(b)}}$: mass of migrated nitroglycerine into cardboard box;

$m_{\text{gunpowder(c)}} - v_{\text{(b)}}$: mass of migrated nitroglycerine into free space of the cardboard box;

$m_{\text{laboration gunpowder}} - \text{v}_{\text{(d)}}$: mass of migrated nitroglycerine into free space of the hermetic box;

Table 5 displays the middle values of gunpowder mass in additional charges after storage, as well the mass loss in grams and percentage.

The results showed that, apart from the gunpowder age, the intensity of the nitroglycerin migration is also influenced by the packaging material porosity. Therefore, boxes made of cardboard and polyvinyl, which are porous materials facilitate the nitroglycerine migration considerably more than a hermetic metal box.

The mass loss in percentages for each storage quarter and for each migration destination is given in Table 6.

The more intensive migration process is in the initial period, especially for additional gunpowder charge in original packaging. The gunpowder mass loss is in fact nitroglycerine which migrated into celluloid shells, free space of the mortar box and into cardboard packaging. The given data showed that most nitroglycerin migrates into celluloid shells.

However, the measurements showed some facts which were not quite logical. The high percentage of nitroglycerin migration into celluloid shells for additional 82 mm charge is expected, but it is unclear why there occurred no migration of nitroglycerin in the free space of the mortar box. Furthermore, in the case of 120 mm caliber, the mass of nitroglycerin migrated into celluloid shells is greater than the mass that migrated both into celluloid shells and the free space of the mortar box, as well as of mass that migrated both into celluloid shells, the free space of the mortar box and into the packaging.

In spite of these unexplained observations, it is evident that, for any examined caliber, the migration processes are the most intensive at the initial storage period, and the nitroglycerin migrates most into celluloid shells.

Physicochemical examinations

Physicochemical examinations [13,14] included the compatibility of gunpowder and the corresponding celluloid containers, investigation of gunpowder stability, examinations of NGB-261 gunpowder prepared for laboration and after 2 years in celluloid containers and the examinations with the aim to determine the intensity of migration of nitroglycerin into a cardboard of the packaging box.

Table 5. The measured values of gunpowder mass in additional charges after storage and mass losses

Storage location	Storage period, days	Gunpowder label	Medium value, g	Mass loss, g	Mass loss, %
Hermetic metal box	90	A2	4.245	0.055	1.279
	180		4.220	0.080	1.860
	90	C	13.287	0.113	0.843
	180		13.250	0.150	1.119
	90	D2	75.622	0.178	0.235
	180		75.590	0.219	0.277
Original cardboard box	90	A2	4.225	0.075	1.744
	180		4.218	0.082	1.907
	90	C	13.251	0.149	1.112
	180		13.231	0.169	1.261
	90	D2	75.590	0.210	0.277
	180		75.570	0.230	0.303
Hermetic polyvinyl packaging	90	A2	4.287	0.039	1.235
	180		4.246	0.054	1.256
	90	C	13.431	0.096	0.966
	180		13.249	0.151	1.127
	90	D2	75.576	0.224	0.296
	180		75.256	0.544	0.718

Table 6. The percentage mass loss in quarters due to the nitroglycerin migration into different destinations; –: measurement failed

Gunpowder label	Storage location	Mass loss in quarters, %		Mass loss into different parts of packaging, %		
		I	II	Celluloid containers	Free space of the mortar box	Packaging of the mortar box
A2	Hermetic metal box	68.8	31.2	65.8	31.7	2.5
	Original cardboard box	91.5	8.5			
C	Hermetic metal box	75.3	24.7	89.4	0	10.6
	Original cardboard box	88.2	11.8			
D2	Hermetic metal box	81.3	18.7	–	–	–
	Original cardboard box	91.3	8.7			

Compatibility of gunpowder and the corresponding celluloid containers

The investigation of compatibility of gunpowder NGB-051, NGB-021 and NGB-261 [10–12], and the corresponding celluloid container was performed in The Military Technical Institute. It was carried out by the microcalorimetric method with heating for 19 days at the temperature of 75 °C, on LKB 2277 microcalorimeter, Bio Activity Monitor. The method is based on measuring of the heat created by the chemical reaction or examined material (gunpowder and celluloid containers in this case) decomposition on constant temperature, as a function of time. The released heat, as a function of time, the mixture of energetic materials (gunpowder) and test material (celluloid container) is then divided by the referent value, obtained by heating the mentioned materials alone. Therefore the released energy for a mass unit is determined for gunpowder, celluloid container and their mix.

The relative compatibility (*D*) is calculated the following way:

$$D = \frac{2M}{E + C}$$

where *M* – released mixture energy, J/g, *E* – released energetic material energy, J/g and *C* – released test material energy, J/g.

If $D < 2$, it is a compatible mixture; for $2 < D < 3$ it is a moderately incompatible mixture; $D > 3$: it is an incompatible mixture.

Mixture of NGB-051/celluloid container, *D* value is 1.94, so it is considered a compatible mixture. However, the mixtures NGB-021/celluloid container and NGB-261/celluloid container are 2.59 and 2.15 respectively, and are considered moderately incompatible, so that some other method of compatibility determination should be applied.

By application of the ORIGIN 8.0 software package the diagrams from Figurures 1–3 were obtained.

Examination of gunpowder chemical stability

The microcalorimetric method has shown that all the gunpowder specimens are chemically stable, because they are compatible with the standard Stanag 4582 [13], in other words on the temperature of 75 °C in the period of 19 days (456 h) of heating, the released heat flow does not overflow the limit of 63.1 μW/g. This points to the fact that the noticed incompatibility is the consequence of the mutual interaction of energetic and test material and not of the chemical instability of the examined gunpowder.

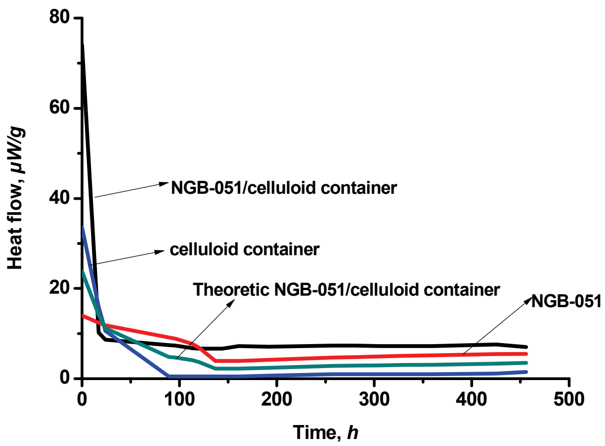

Figure 1. The curves of heat flow of specified components and the mixture NGB-051/celluloid container.

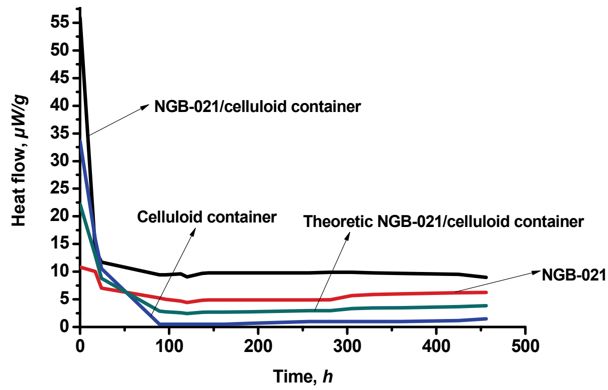

Figure 2. The curves of heat flow of specified components and the mixture NGB-021/celluloid container.

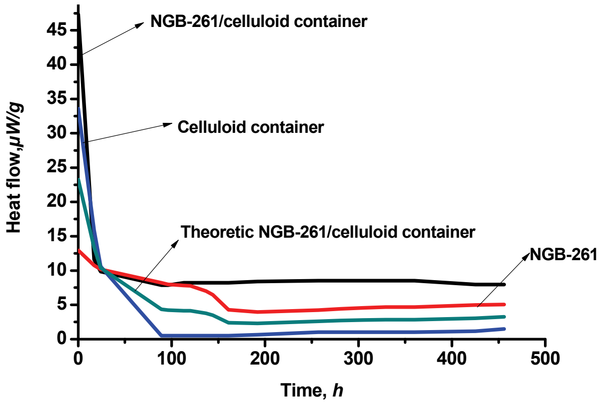

Figure 3. The curves of heat flow of specified components and the mixture NGB-261/celluloid container.

Physicochemical investigations of gunpowder NGB-261

The gunpowder NGB-261, often used for the laboration of increment charges of mortar ammunition, is convenient for the examination of physicochemical characteristics of the ammunition during storage, especially as this type of gunpowder was laborated into etalon gunpowder charges. From the moment of laboration, the gunpowder charges were stored for 2 years. The results of the physic-chemical of this gunpowder in the laboration moment and after 2 years of storage, obtained in the laboratory of the gunpowder manufacturer, showed that the gunpowder is, even after 2 years, in agreement with the demands of the standard SORS 1224/94 [11], considering chemical composition physicochemical properties and chemical stability. Considering the demanded contents of nitroglycerine, the deviation is noticed – instead of the demanded value of 40.00±1.50 mass%, the one obtained was 37.49 mass%. The decrease of the heat potential was also noticed (demanded value was 4899±84 J/g, and the obtained value was 4723 J/g). The presence of camphor was registered in gunpowder, and it is the component of the celluloid container (0.5 mass%) which proves that, during storage, there were not only the migration processes of nitroglycerine, but also of the mentioned plasticizer into the gunpowder mass.

Even after a short period of storage, the percentage of nitroglycerine, considering ins migration propertied, is not high enough for the criteria of the production and laboration of gunpowder.

Physicochemical examinations of gunpowder, containers and packaging

The examination of nitroglycerine content in celluloid containers and packaging was performed in Technical Overhaul Works in Kragujevac, Serbia, by the method of liquid chromatography on the Waters Alliance 2695/2996 chromatograph. The obtained results come from a large number of gunpowder samples and packaging elements.

The examined packaging elements are of older age, while the celluloid containers come from etalon charges, stored for 2 years. The mass loss of nitroglycerine in gunpowder was established to be 3.82 g. Nitroglycerine was found in all materials which were in contact with gunpowder, however in small concentrations, 0.47% of the starting mass. The missing quantity of nitroglycerine was found to be partly in the free space of the packaging box and partly the consequence of nitroglycerine decomposition, which is exactly a cause of ballistic properties degradation during storage. Based on performed examinations, it became certain that the packaging is not the reason for ballistic degradation of gunpowder charges.

Ballistic examinations, mortar stand vibration measurements and the gunpowder gas pressure measurements

Regardless of the significance of static and physicchemical examinations for the estimation of the migration gunpowder properties, the real overview of their influence on the ammunition quality during storage can be made only after the ballistic examinations. They were carried out in The Technical Test Center, according to the established program. It is planned to measure the muzzle velocity (v_0) and the maximal pressure of the gunpowder gas (P_m), by firing the mortar ammunition of caliber 120 mm. Apart from that, the vibration measurements of the mortar stand were also carried out, in order to determine the influence of the surface on the ballistic properties degradation. The results are displayed in Table 7.

Although the obtained ballistic parameters values are within the limits of the product quality rule 6699/11 (v_0 = 322±3 m/s; r_{V0} = 1,5 m/s; P_m = 940 bar), the examination results pointed to the fact that there had occurred a certain degree of degradation, in other words of the decrease of ballistic properties. This annotation calls for the consideration of the quality of the ammunition estimation criteria. Although it is known that, for the ballistite gunpowder, the degradation due to the nitroglycerine migration cannot be avoided, the quantitative intensity of it is not presented neither in literature nor in official documents. However, the allowed degree of the ballistic loss can be quite precisely defined because, no matter how long the storage period is, the ballistic properties have to be in the product quality regulatory range. It was determined that, if the deviation from the required standard is less than a half of the allowed values, the ammunition is considered reliable even after the proper period of storage. This condition in fulfilled in all examined types of ammunition in this study.

Table 7. The results of ballistic examinations for the 120 mm ammunition

No.	Subject of ballistic examinations	Muzzle velocity, v_0 / m/s	Dispersal of muzzle velocity, r_{v0}	Gunpowder gas pressure, P_m / bar	Notice
1.	Etalon increment charge	320.6	0.51	782	Gunpowder label NGB-261 MBL 1234
2.	Etalon increment charge 2 years after laboration	319.8	0.49	767	
3.	Gunpowder from the original manufacturer's can (hard surface)	321.5	0.82	789	
4.	Gunpowder from the original manufacturer's can (soft surface)	317.3	0.92	789	
5.	Gunpowder from the original packaging, after 6 months storage	320.6	0.85	778	
6.	Gunpowder from the hermetic packaging, after 6 months storage	320.0	0.80	776	
7.	Gunpowder from the 120 mm ammunition, serial production, 6 years old	323.5	0.41	797	Gunpowder label NGB-261 MBL 0927
8.	Gunpowder from the 120 mm ammunition, serial production, 21 years old	321.8	0.82	828	Gunpowder label NGB-261 MBL 9409

The results of each ammunition type examination point to following characteristics:

- Regarding the ballistic properties, serially produced ammunition of older age is of high quality.
- Ballistic loss due to migration of nitroglycerine into packaging is not noticed.
- Higher values of the velocity for the ammunition laborated by gunpowder from the original cans immediately before the examinations are expected, considering that no nitroglycerine migration was possible.

The gunpowder used for firing on the soft surface, like sand, gave the value of muzzle velocity (v_0) lower than regulatory for 4.2 m/s. This is an important data, as the exact value of degradation of the ballistic performance of a mortar ammunition on different surfaces was never determined before. Namely, while firing on a softer surface, the ground absorbs a part of energy of the projectile, which is clearly noticeable by the vibrations of the mortar stand, prominent when firing from the soft surface. The energy loss can be so strong that the ballistic properties decrease under the limit of allowed values. Test firing on the hard surface (soil) showed that v_0 was 321.5 m/s and on the soft surface (sand) 317.3 m/s. Figures 4 and 5 show the recording of the mortar M74 stand vibrations, while firing equal 120 mm mines, on different surfaces.

Using the internal pressure gauges the pressure curves were recorded, during gunpowder ignition and burning in the chamber. They display the regular inside-ballistic process, contributing to the conclusion that the conceptual solution for a gunpowder charge cannot be the cause of ballistic properties deviations.

CONCLUSIONS

When the mortar ammunition with the ballistite gunpowder charges is used, the nitroglycerine migration from the gunpowder mass occurs during storage, mostly into celluloid containers and less into cardboard packaging. Apart from the nitroglycerine migration the plasticizer also migrates from the containers into the gunpowder mass. Both processes lead to the decrease of ballistic properties of the ammunition, however it does not harm the quality regulatory determined by the product quality rule. No omission was found, neither with the producer of gunpowder, nor of ammunition, which would lead to quality decrease during storage.

In order to weaken the intensity of the nitroglycerine migration and therefore the loss of the gunpowder mass, the laboration of the additional gunpowder charge should be done using gunpowders with lower initial content of nitroglycerine. Apart from the production of EI gunpowder it is necessary to develop production of new gunpowder types without nitroglycerine. That way the problems that cause the deterioration of the ammunition quality will be prevented in the present temperature conditions during storage and use. The results of the initial researches of the world famous gunpowder and ammunition producers point to the more and more probable use of gunpowder of low sensibility (ECL – extruded composite low sensitivity), which contains nitroamine instead of nitroglycerine (hexogen – RDX or octogen – HMX) [15]. In comparison to the ballistite or EI gunpowder, in the case of these new types, there is no change during sto-

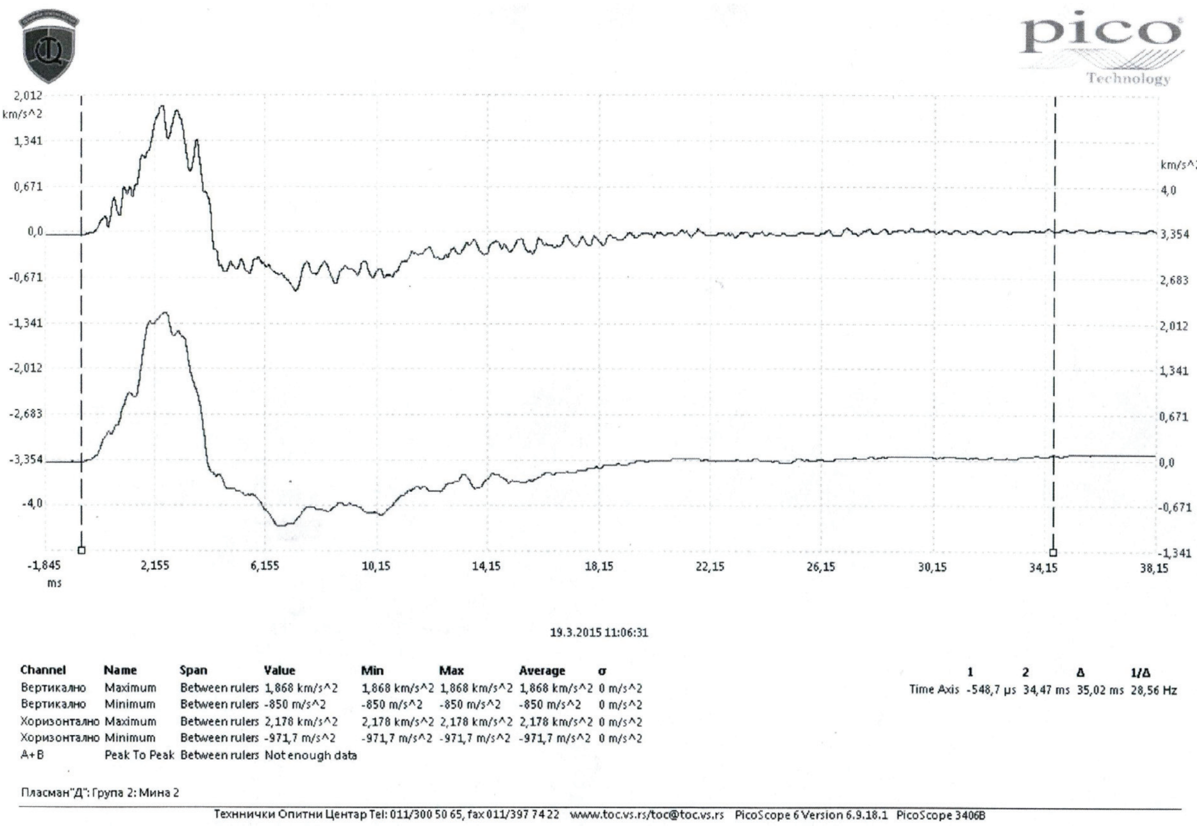

Figure 4. Vibrations of the mortar stand while firing on hard surface.

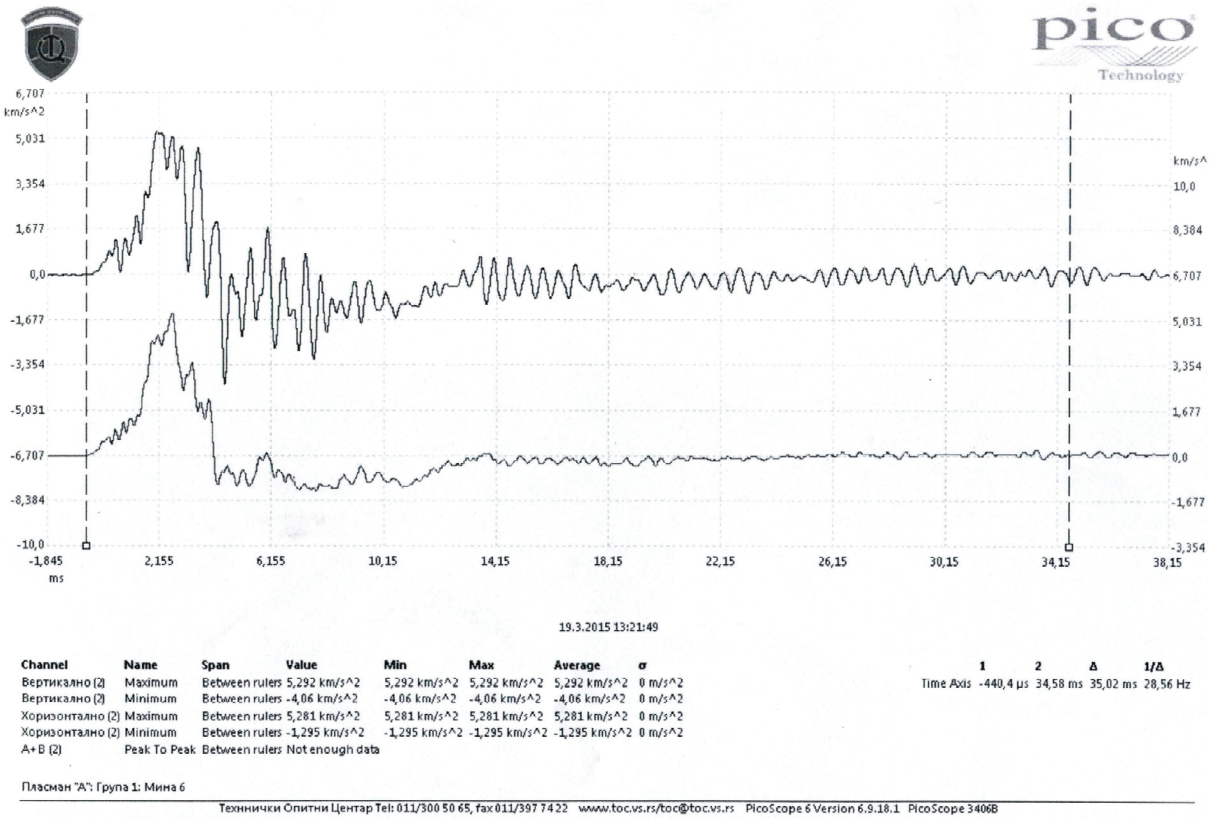

Figure 5. Vibrations of the mortar stand while firing on soft surface.

rage, no change of the muzzle velocity and the thermical, chemical and ballistic stability is very favorable.

During the laboration of the increment charges, when the mass of the ballistite gunpowder is determined, it is necessary to correct the mass because of the nitroglycerine migration, in order to save the regulatory ammunition properties. The mass correction is empirically determined – 0.5 g for a shell of 120 mm caliber, 0.3 g for a shell of 82 mm caliber and 0.15 g for a shell of a60 mm caliber.

As it is proved that the surface sort (hard or soft) influences the mortar ballistic properties it is recommended that the manufacturers pay attention to the procedure of ammunition delivery to the final users. The determination of the gunpowder charge and firing ammunition afterwards has to be done on an adequate surface (soil, sand, etc.) which corresponds to the conditions the final user needs.

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IZVOD

UTICAJ MIGRACIONIH PROCESA U BARUTNOM PUNJENJU NA KVALITET MINOBACAČKE MUNICIJE

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U radu su prikazani rezultati statičkih, fizičko–hemijskih i balističkih ispitivanja dvobaznih barutnih punjenja, radi utvrđivanja odstupanja od zahtevanog kvaliteta minobacačke municije. Ispitivanja su vršena na uzorcima baruta kojima se laborišu dopunska barutna punjenja minobacačkih mina kalibra 60, 82 i 120mm. Ispitivanja su obuhvatila periodična merenja gubitka barutne mase i osnovnih balističkih parametara, ispitivanje kompatibilnosti baruta i celuloidnih školjki, te utvrđivanje hemijske stabilnosti tretiranih baruta. Komparativnom analizom izvršena je ocena kvaliteta proizvedenog baruta i municije, te dati predlozi za efikasnu i kvalitetnu proizvodnju barutnih punjenja i municije.

Ključne reči: Mine • Baruti • Nitroglicerin • Migracija • Balistiti • Balistička stabilnost • Hemijska stabilnost