REPORT

ASSESSMENT OF THE SIDE EFFECTS OF THE EXPLOSION ON THE ENVIRONMENT

OBJECT: ROZINO NEW SITE, MUNICIPALITY OF KARDZHAPI

Sofia, August 2020

COMPOSITION:

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(Dr. Eng. N. Georgiev)

КАМАРА НА ИНЖЕНЕРИТЕ В ИНВЕСТИЦИОННОТО ПРОЕКТИРАНЕ

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(Prof. Dr. Eng. I. Ivanov)

CONTENTS

1. GENERAL PROVISIONS

1.1. Basis for the development of this project

This project has been developed in accordance with the Agreement of 2020 between Tintyava Exploration AD and Dr. Eng. Nikolay Georgiev for **"Assessment of the side effects of technological blasting works on the environment and management of these effects within acceptable safety levels for the Rosino deposit, Ivaylovgrad municipality, Haskovo region**". The activities **presented in this report** represent an analysis, assessment and management **of the upcoming drilling and blasting activities at the Rosino deposit**.

The activities presented in this report represent an analysis, assessment and management of the upcoming drilling and blasting activities at the Rosino deposit. The following activities were carried out in fulfilment of the assignment:

Conducting experimental blasting at the Rosino deposit and control measurements to record their impact.

Analysis of the results of the control measurements and assessment of the impact on the relevant sites.

The main requirement when performing technological blasting operations in open-pit mining is to achieve maximum blasting effect, consisting of the following:

Complete removal of the rock mass (without thresholds and lifting of the horizon) with a conditioned grain size distribution of the blasted mine mass;

Control of the side effects of the explosion within the established safe levels for people and the environment.

1.2. SIDE EFFECTS OF THE EXPLOSION

The side effects of the explosion include:

- The explosive-seismic effect;
- Generation of a shock wave (SW) / noise;
- Scattering of individual rock fragments;
- Release of harmful gaseous products during detonation.

1.3. PURPOSE

The objective of this work is, based on the results obtained from measurements with specialised equipment during experimental explosions carried out on site and under similar conditions, to assess the side effects of the explosion on the environment and to make recommendations for the management of technological explosive works during the operation of the "Rozino" deposit in an open manner.

1.4. RELIEF AND GEOLOGICAL STRUCTURE OF THE " " "ROZINO" DEPOSIT

The Rosino deposit area is bordered to the south by the steep cliffs of the Tashlaka locality and is cut through by the Byala River and its tributaries. The average altitude in the deposit area is about 470 m above sea level in its northern part, decreasing to approximately 300 m above sea level in the south, where the terrain descends towards the Byala River.

Rozino is a low-sulphide epithermal gold deposit, composed mainly of Palaeogene sedimentary rocks - breccias and conglomerates. The mineralisation is mainly pyrite, disseminated, hydrothermal replacement and in the form of veins (with rare traces of non-ferrous metals) and arsenopyrite, which are associated with gold located at the contact of the sulphide mineralisation and, to a lesser extent, as free grains or encapsulated inclusions. The dominant direction of mineralisation distribution is northwest-southeast, parallel to the regional extension regime, with the local development of mineralisation controlled by the intersection of steep tectonic structures (parallel to the extensional faults) and the gentle contact between the sediments and the metamorphic basement.

During the exploration of the Rozino deposit, special attention was paid to the geological structure of the surrounding area.

The main mineralisation in the deposit is concentrated in the sediments of the Belorechsky Graben near the western border of the basin. Within the framework of the Palaeogene sedimentary basin, several superimposed high-metamorphic complexes, Mesozoic schists and aplitoid granites (Rozinski type) can be distinguished.

The sediments exposed on the surface are part of the Krumovgrad Group (undivided), the breccia conglomerate association (Podrumchenska Formation), and the coal-bearing sandy association (conglomerate-sandstone association).

2. METHODOLOGICAL APPROACH

The experimental blasting works and the measurement of the level of the side impact of the explosion using specialised equipment are based on:

2.1. STANDARDS AND BEST PRACTICES :

- Compliance with the requirements of the applicable regulatory documents in Bulgaria:
- *Law on Weapons, Ammunition, Explosives and Pyrotechnic Products*;
- *Regulation No. 9 of 12 February* 2010 on the maximum permissible vibration levels in residential premises – (*Regulation 9/12022010*);
- *Regulation No. 6 of 15 August* 2005 on the minimum requirements for ensuring the health and safety of workers exposed to risks related to noise exposure, issued by the Minister of Labour and Social Policy and the Minister of Health – (*Regulation 6/15082005*);
- *Regulation No. 6* of *26 June* 2006 on environmental noise indicators, taking into account the degree of discomfort during different parts of the day, the limit values of environmental noise indicators, methods for assessing noise indicator values and the harmful effects of noise on public health, issued by the Minister of Health and the Minister of Environment and Water – (*Regulation 6 /26062006*).
- *Regulations on occupational safety in explosive works* – 1997 (PBTVR)
- Methodologies and results underlying the development of "Project 2000 - 10, FUT - MLSP: "Updating the regulatory framework for explosive and seismic protection" [1].
- Requirements, recommendations and experience laid down in regulatory documents, standards and publications accepted as best practices in the field of blasting works worldwide [2,3,4,5,6].

2.2. METHODOLOGY FOR DETERMINING THE PARAMETERS OF THE SEISMIC EFFECT AND THE UBB ( )

The assessment of the explosive seismic impact and the UAV is based on the generally accepted methodology in global explosive practice (including that incorporated in the software application of specialised seismographs) [5,6] based on the relationship between the impact of the explosion (seismic effect/shock wave) and the amount of explosive material (EM) detonated and the distance to the protected objects, expressed as the so-called "equivalent distance", as follows:

- *Determination of "equivalent distance" (SD)*

1) The ratio of the distance from the explosion to the square or cube root of the mass of the charge is widely used in global explosive practice to establish and analyse the level of the sideways impact of the explosion, defined as the concept of
"*Equivalent distance*". It is based on the fact that the shock wave caused by the sudden increase in pressure of the gaseous products of the explosion creates stress that affects the rock mass, generating explosive-seismic vibrations in the destruction zone (the so-called "active explosive-seismic impact"), which provoke residual deformations in the massif (in the near zone), with elastic deformations (in the far zone) as the distance from the explosion site increases, and this impact of the explosion spreads and dissipates concentrically in all directions.

2) The actual value of the reduced distance depends on the units of measurement used in the equation,

$$\mathbf{SD = R / Q^{r}}, \qquad (1)$$

where:

R - distance and
Q - mass of the charge
r = (1/2 or 1/3) depending on whether a square or cube root is used. (To determine the reduced distance for UBB, a cube root of the charge mass value is used.)

3) To determine the relationship between the reduced distance and the mass velocity of the particles or for the UBB, a certain minimum amount of measured data is required in order to obtain a statistically valid expression showing this relationship, which is of the form:

$$\mathbf{P = H\,(SD)^{-ß}}, \qquad (2)$$

where:

P = **PPV** - peak particle velocity (maximum value of explosive seismic vibrations) or **P = P+** - overpressure at the shock wave front),
H – coefficient characterising the detonation conditions, representing the velocity (or air pressure) intersecting the axis, i.e. P, when SD = 1. ,
SD - reduced distance,
ß – power index characterising the attenuation of the explosive-seismic impact as a function of distance. It determines the slope of the curve, i.e. the negative exponent of the decay.

- *Algorithms*

1) Linear regression is used to find the equation of a straight line of the
the form:

$$y = a + bx,$$

where:

the slope **b** is calculated from the expression,

$$b = \{\Sigma(x_i * y_i - n * x * y)\} / \{ \Sigma(x_i - n * x^2)\}$$

a is calculated from the expression,

$$a = y - b * x$$ The

correlation coefficient **r** is obtained by the expression

$$r = \{ \Sigma(x_i * y_i - n * x * y)\} / [\{\Sigma(x_i^2 - n * x^2)\} \{ \Sigma(y_i^2 - n * y^2)\}]^{1/2}$$

and the standard deviation is estimated by

$$s = [\{(\Sigma(y_i^2 - n * y^2) - \Sigma(x_i * y_i - n * x * y)^2 / \Sigma(x_i^2 - n * x^2)\} / n]^{1/2}$$

In the equations above, **n** is the number of points (or PPV events, SD pairs) x_i and y_i are the i-th variable in the set i = 1 to n, and **x** and **y** are the mean values or each of the variables in the given set.

2) The confidence line is based on Chebyshev's rule - with normal distribution, approximately 68% of the data lies within one standard deviation of the mean value, while 95% of the data lies within two standard deviations. In order to achieve a high degree of reliability, the dependence established for a 95% range is used to calculate/predict the level of impact.

These two impact indicators (seismic effect and UVV) are monitored by measuring them with specialised equipment and comparing the values obtained with the applicable standards.

The management of maintaining the levels of seismic effect and UVV generation within the permissible standards for blasting operations is carried out by:

Determining the mass of the explosive charge detonated in a delay interval during the design of the PVR, based on the determined relationship between the impact and the distance to the protected object;

Monitoring and periodic measurements of these impacts with specialised equipment, analysis of the results and, if necessary, updating and correction of the parameters of the PVR.

Measurements of the impact of UVW are also used to assess the impact of noise from explosive works, given that noise represents UVW with a speed below 343 m/s and is a consequence of its attenuation with distance from the site of the explosion.

3. RESULTS FROM MEASUREMENTS WITH SPECIALISED EQUIPMENT

3.1. NECESSARY PARAMETERS FOR ASSESSMENT

Explosive seismic impact:

- Maximum vibration velocity (PPV), mm/s;
- Vibration frequency, Hz;

- Maximum acceleration, g;
- Maximum displacement, mm

Shock wave:

- Overpressure at the wave front, Pa or dB;
- Frequency, Hz.

3.2. SPECIALISED EQUIPMENT USED

In accordance with the requirements of Article 3 of Annex No. 7 to Article 141 of the PBTWR, the seismic dimensioning of blasting works shall be carried out on the basis of experimental studies using specialised equipment. To measure the level of impact of the seismic effect and the UBB of the explosion, the most widely used and best practice in the field of blasting in the EU and worldwide is the use of specialised seismographs equipped with geophones to record the seismic impact and microphones to measure the pressure of the shock wave from the explosion.

The registration of the lateral impact from the experimental blasting operations at the Rozino deposit was carried out with an autonomous INFRA system from the Swedish company SIGICOM. The INFRA system kit includes:

- Two C22 sensors for surface seismic impact, recording and transmitting the measured values in real time;
- One Logger Mini-1000 recorder equipped with S10 sensors for UVB, S50 sensors for noise and V12D sensors for deep seismic impact.

The authors declare in the report that all loggers and sensors were checked and calibrated by the manufacturer in March 2020, for which they received the relevant protocols.

3.3. SITES

Natura 2000 sites (Annex No. 3):

In accordance with the requirements of environmental protection experts, the predicted levels of side effects of blasting operations should be determined in two zones of potential impact at a distance from the design contour of the Rozino mine, with the following conditional names:

- Ecozone 1-Natura 2000 – Zone of potential impact - R= 600 m.
- Ecozone 2-Natura 2000 – Zone of potential impact - R= 800 m.

Yuren Dere (habitat of various bird species):

- Distance from the outer contour of the Rosino mine - R= 650 m.
- Average slope gradient: ~ 7^{O} ;

R. Byala Reka

- Distance from the outer contour of the Rozino mine - R= 1050 m.
- Slope inclination: ~11^{O} ;

Rozino village:

- Distance from the outer contour of the Rosino mine - R= 1200 m.

- Slope inclination: ~2^{O} ;

Water collection station:

- Distance from the outer contour of the Rozino mine - R= 705 m.
- Slope inclination: ~3^{O} ;

3.4. MAIN PARAMETERS OF THE EXPERIMENTAL BLASTING WORKS [7]

The experimental blasting works were carried out as follows:

Drilling works: 12 pieces on 3 blast fields of 4 blast boreholes each with a length of 6 m and a diameter of 102 mm – parameters that are set out in the conceptual design for the exploitation of the Rozino deposit. The explosive charge is distributed in the same way in all three fields – 2 boreholes with a mass of 30 kg in each and 2 boreholes with 22.5 kg in each (Appendix 2);

Preparatory and adjustment activities ensuring sufficient reliability and precision of the equipment and sensor technology when used in the upcoming real VR. In order to ensure the adaptation of all elements of the measuring equipment to the specific working conditions, a training simulation of spontaneous and deliberate activation of the sensors was carried out with registration and recording of values (background), certifying the accuracy and flawless operation of the measuring elements.

Charging works: In accordance with the developed methodology and the Explosives Passport, the following Explosives were loaded;

Explosives – Cartridged emulsion explosives "Hydromite" were used, totalling 307.5 kg, which were initiated in each borehole with a detonator consisting of 1 cast booster 0.450 kg and 1 non-electric borehole detonator.

SV – 12 non-electric detonators from the long-period (LP) series with a length of 7.8 m, providing a 1-second delay between individual charges, respectively LP 1000 – 3 pcs.; LP 2000 – 3 pcs.; LP 3000 – 3 pcs. and LP 4000 – 3 pcs. The surface detonation network was implemented by 12 surface connectors with a waveguide length of 7.8 m and a delay of 0 ms.

Explosive actions: According to the Methodology, the boreholes were grouped into 3 separate groups, each consisting of 4 boreholes, two of which had a charge length of 4 m (30 kg of explosives) and two had a length of 3 m (22.5 kg of explosives). Each group was detonated separately with group control, achieving a delay between the individual charges of not less than 1000 ms. Each group of boreholes was initiated remotely using the "IGNUS" system for remote initiation of non-electric explosive networks.

3.5. EFFECT

Of the registered impacts presented in the above-mentioned report, the following results are of interest for the purposes of this report:

1. *Registered seismic impact* (seismic wave propagation velocity) above the set threshold value for triggering the equipment (0.5 mm/s) (Fig. 1):

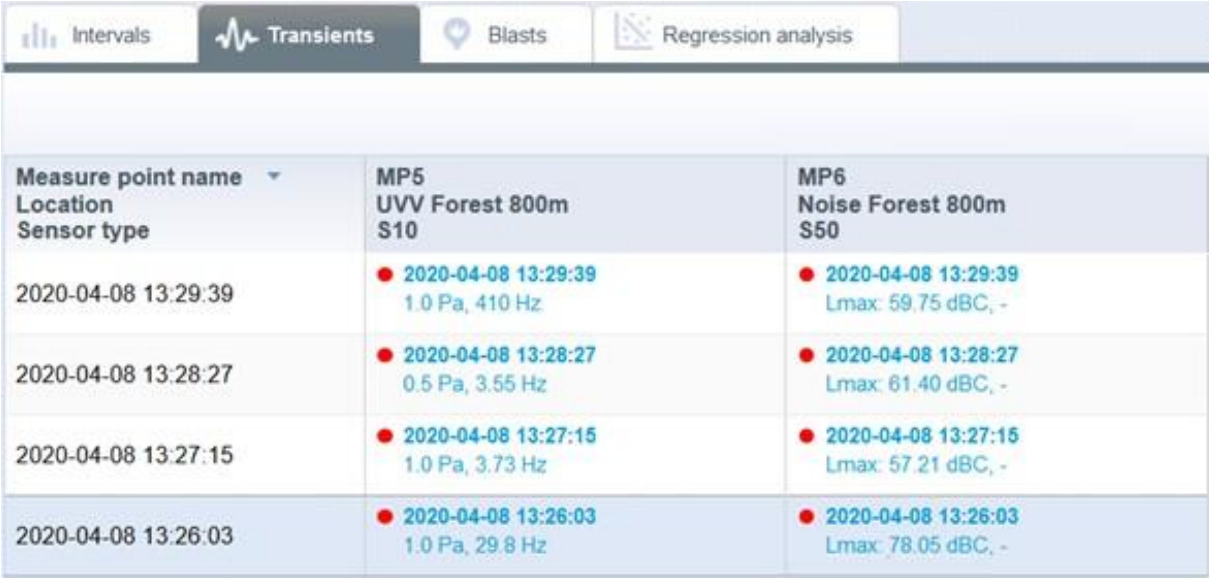
Mass of the charge in a delay interval (in order of detonation): 30 kg, 30 kg, 22.5 kg, 22.5 kg (Appendix 2);

- Distance from the explosion to the geophone: 400 m;
- Recorded maximum vibration velocity in the three components and their corresponding frequency: L-0.530 mm/s, 85.3 Hz; V-0.085 mm/s, 58.5 Hz; T-0.280, 70.6 Hz (L-longitudinal, V-vertical, T-transverse).

Figure 1. Registered results from measuring the explosive seismic impact with specialised equipment on 8 April 2020.

1. *Shock wave* (SW) / noise:

The sensors recorded 4 consecutive peak levels corresponding to 4 consecutive explosions from the experimental blasts located at a distance of 800 m from the explosion (Fig. 2).

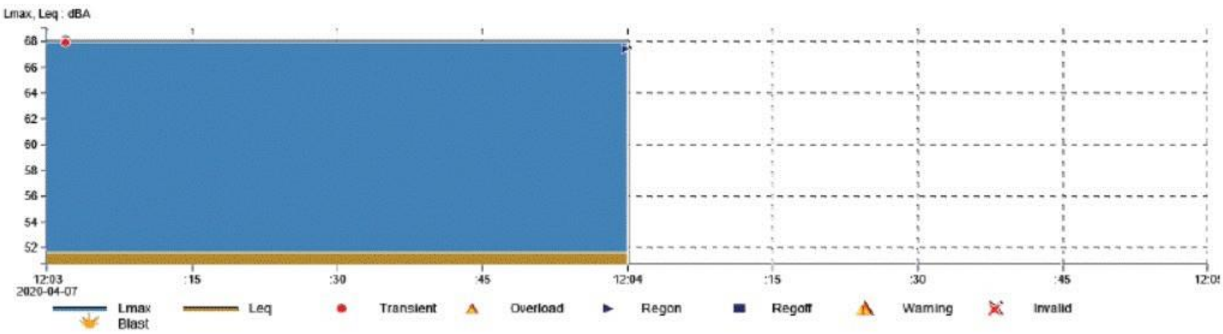


Measure point name Location Sensor type	MP5 UVV Forest 800m S10	MP6 Noise Forest 800m S50
2020-04-08 13:29:39	2020-04-08 13:29:39 1.0 Pa, 410 Hz	2020-04-08 13:29:39 Lmax: 59.75 dBC, -
2020-04-08 13:28:27	2020-04-08 13:28:27 0.5 Pa, 3.55 Hz	2020-04-08 13:28:27 Lmax: 61.40 dBC, -
2020-04-08 13:27:15	2020-04-08 13:27:15 1.0 Pa, 3.73 Hz	2020-04-08 13:27:15 Lmax: 57.21 dBC, -
2020-04-08 13:26:03	2020-04-08 13:26:03 1.0 Pa, 29.8 Hz	2020-04-08 13:26:03 Lmax: 78.05 dBC, -

Figure 2. Recorded results from measuring the impact of the shock wave and noise with specialised equipment

The same measurements also recorded the background noise from wind gusts before the experimental detonation (Fig. 3).

Max Lmax: 68.0 dBA, Leq: 51.70 dBA, Lcustom:



X-span 2020-04-07 12:03:00 - 2020-04-07 12:05:00

Y-span Lmax, Leq : dBA: 50.70 - 69.0, Lcustom: 0.0 - 1.0

	Lmax	Leq	Lcustom
Max	68.0 dBA	51.70 dBA	-
Date	2020-04-07	2020-04-07	-
Time	12:04:00	12:04:00	-

Results recorded from measuring background noise before the explosion.

According to the report [7], the measurement of UVB/noise was performed in the presence of noticeable wind gusts, which were recorded by the equipment, while compromising the recording of the impact of noise from the explosion at some of the measurement points.

The recorded impact of the UAV and noise from the blasting works is lower than the measured background noise recorded on the day before and during the experimental blasting [7] (Appendix 2).

4. BLAST-SEISMIC IMPACT

4.1. REQUIREMENTS

The permissible maximum values of explosive seismic impact in technological industrial blasting are regulated in the following areas:

1. Protection of building structures and facilities

The maximum permissible explosive-seismic impact for a single explosion, determined in accordance with the requirements of Article 1 of Annex No. 7 "Instructions for determining safe distances during blasting operations" to Article 141 of the PBTWR, is the vibration velocity (V) in the rock mass at the base of the protected facility not to exceed:

V = 30 mm/s.

In the case of repeated technological blasting, the requirement of Art. 1 is not applicable, according to Art. 2 of the same Annex No. 7. In this case, according to Article 3 of Annex No. 7, "...the seismic dimensioning of the parameters of the blasting works shall be carried out on the basis of experimental studies with specialised equipment."

The regulatory framework in Bulgaria does not explicitly specify permissible levels of explosive seismic impact on building structures and facilities when performing technological blasting operations. For this purpose, the requirements of recognised EU standards are applied. The most widely used standard in Europe and beyond is the German standard DIN 4150 [2,3,4,6] (Table 2).

Table No. 1

GERMAN STANDARD DIN 4150 FOR EXPLOSIVE SEISMIC IMPACT			
Permissible vibration velocity, mm/s			
Type of buildings and facilities	Frequency		
	<10 Hz	10-50Hz	50-100 Hz
Industrial	20	20	40
Residential	5	5	15
Highly sensitive (historical monuments, nuclear power plants, optical facilities, etc.)	3	3	8

This standard also forms the basis for the assessment of explosive seismic impact, which is the subject of this report.

Annex 4 presents other international standards for permissible explosive seismic impact. Most of them have similar standards.

2. Protecting human health and comfort

The natural human instinct for self-preservation allows us to perceive vibrations as a possible warning sign of danger. Table 2 presents average data on human sensitivity to vibrations.

Table No. 2

Level of human perception of vibrations	Vibration speed mm/s
Imperceptible	0.1
Perception threshold	0.15
Barely noticeable	0.35
Noticeable	1
Easily noticeable	2.2
Too noticeable	6.00

According to the requirements of Regulation 9/12022010, the maximum permissible vibrations that do not disturb human comfort are:

V = 1.07 mm/s – during the day (from 07:00 to 23:00) and

V = 0.6 mm/s – at night (from 23:00 to 07:00).

Technological blasting in open-pit ore mining in Bulgaria is usually performed once a day during daylight hours. This is a result of the requirement of Article 184, paragraph 1 of the PBTWR: "It is prohibited to carry out blasting works on the earth's surface when visibility at the blasting site and the danger zone is reduced (in case of blizzard, thick fog, etc.)."

For additional information, Annex 5 provides the impact levels of other sources of vibration.

4.2. DETERMINATION OF THE EXPLOSION-SEISMIC IMPACT

Unlike natural earthquakes, in man-made earthquakes caused by explosions, the relationship between the total energy released and the portion of it used to generate seismic waves is well known.

When designing and implementing a blasting plan, it is particularly important to find the most acceptable option that minimises the side effects of the explosion so that they do not exceed the permissible limits and, at the same time, ensures the maximum effect of the explosive destruction of the rock mass in accordance with the expected parameters, such as: achieving the specified grain size distribution of the broken rock mass, minimal displacement of the blasted material, minimal losses and depletion of the ore, etc.

The main factors for controlling the side effects of blasting operations are as follows:

- Knowledge and compliance with the physical, mechanical and structural characteristics of the rock mass – the necessary balance for effective combination of the interaction between "rock resistance to destruction and explosive energy";
- Determination of the effective length of the blast;
- Choosing a suitable inert material for the charge, ensuring maximum use of the explosive energy to destroy the rock mass and minimising its side effects;
- Application of techniques to minimise the side effects of the explosion,

such as:

- increasing the length of the blast;
- reducing the charge mass (smaller diameter boreholes, spaced

charges);

- application of appropriate blasting schemes (directing the front of destruction and the direction of movement of the blasted rock mass, minimising the charge mass in a delay interval, etc.);
- use of protective coatings.

The use of modern detonation systems allows each charge to be detonated with a separate/independent delay interval. This provides a double effect: on the one hand, the effect of millisecond (short-delay) sequential detonation of the charges is used for better fragmentation of the rebounded mass, and on the other hand - minimal explosive-seismic stress on the environment by dispersing the energy of the explosion, by initiating the minimum possible mass of explosives in a delay interval.

It should be noted that with the development of the mine below the level of the upper boundary contour, the impact of UVW and noise will be further limited by the barrier function of the non-working boards.

In practice, the control of the explosive-seismic parameters (explosive mass in the interval T<~4ms) in the "Active explosive-seismic impact" zone is achieved through:

- the construction of the charge
- performing contour blasting (at a distance of about 20 m from the non-working steps)
- the connection scheme of the boreholes in the blast field and the delay interval.

With the development of deep mining, working conditions are changing. In this regard, periodic control measurements are carried out with specialised equipment, updating the mathematical dependencies determining the levels of side effects of blasting works in the near and far zones of influence and, if necessary, adjusting the parameters of the PVR and taking any additional control measures.

In terms of the number of measurements, the results recorded in the above-mentioned report fully satisfy the requirements for measurements with specialised equipment. For the purposes of expert analysis, these results allow the measured explosive seismic impact for the conditions at the Rozino deposit to be compared with the dependence (3) derived from the processing of results from measurements of the seismic impact of the explosion, carried out with specialised equipment under similar conditions in Bulgaria (diameter of the explosive boreholes d=76-102 mm and height of the working step H< 6.5 m), recorded for the period 2018-2019 (Fig. 4):

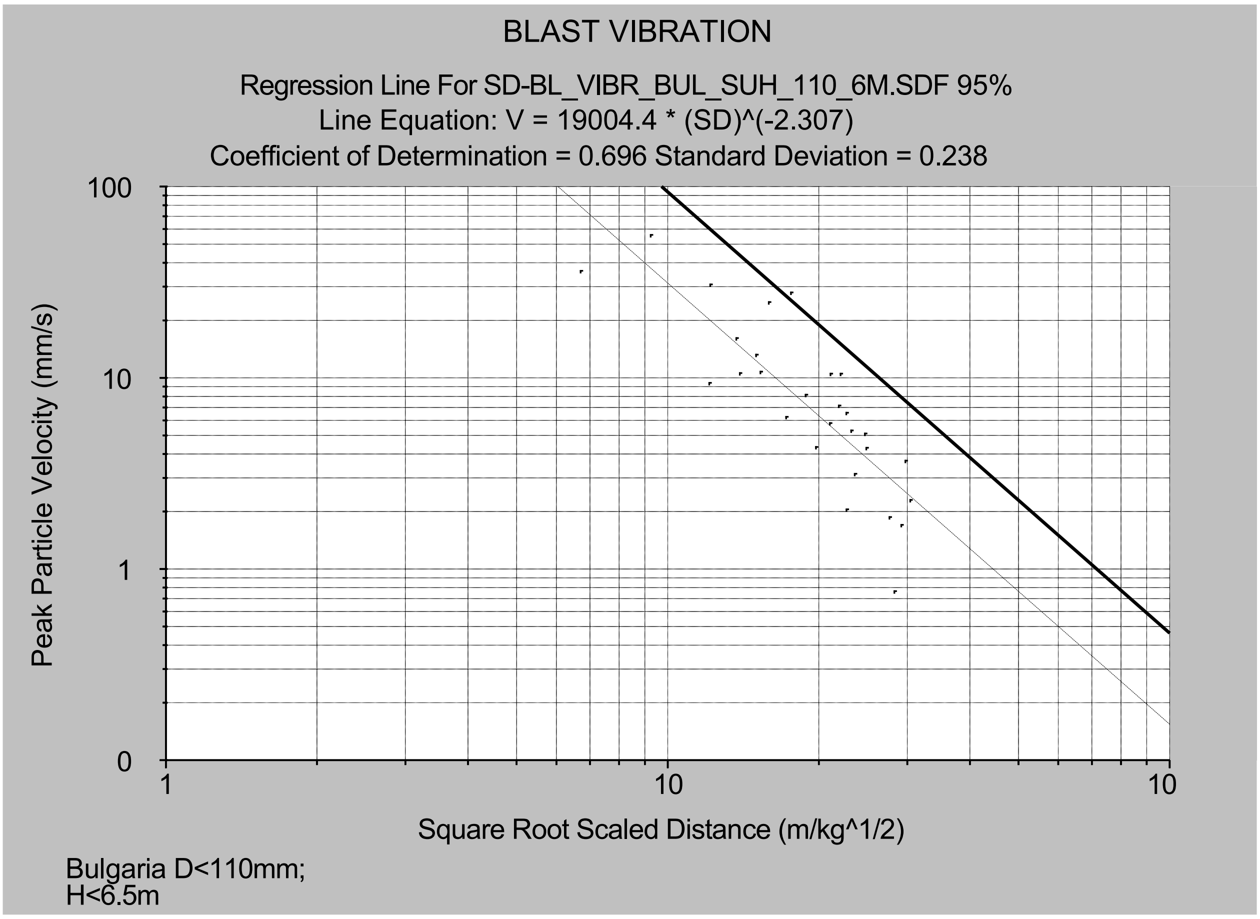


Figure 4. Results from measurements of the seismic effect of the explosion in Bulgaria with a charge diameter D<110 mm and a length of the explosive boreholes L_c< 6.5m

The established mathematical relationship between the vibration velocity and the distance and mass of the explosive charge is as follows:

$$\textbf{PPV} = 19004.4 \left(\frac{R}{\sqrt{Q}}\right)^{-2.307} \textbf{ mm/s} \qquad (3)$$

where: R - distance from the explosion site to the protected object, m Q - mass of the explosive charge detonated in a single delay interval, kg.

Fig. 5 shows the recorded maximum value of the seismic impact from the control blasts carried out on 08.04.2020, added to the graph with the data from the measurement results under similar conditions in Bulgaria (Fig. 1). The same graph also shows its predicted value, determined by the above-mentioned dependence (3) with the same parameters (R=400 m and Q=30 kg) (Fig. 5 – data enclosed by a dotted contour).

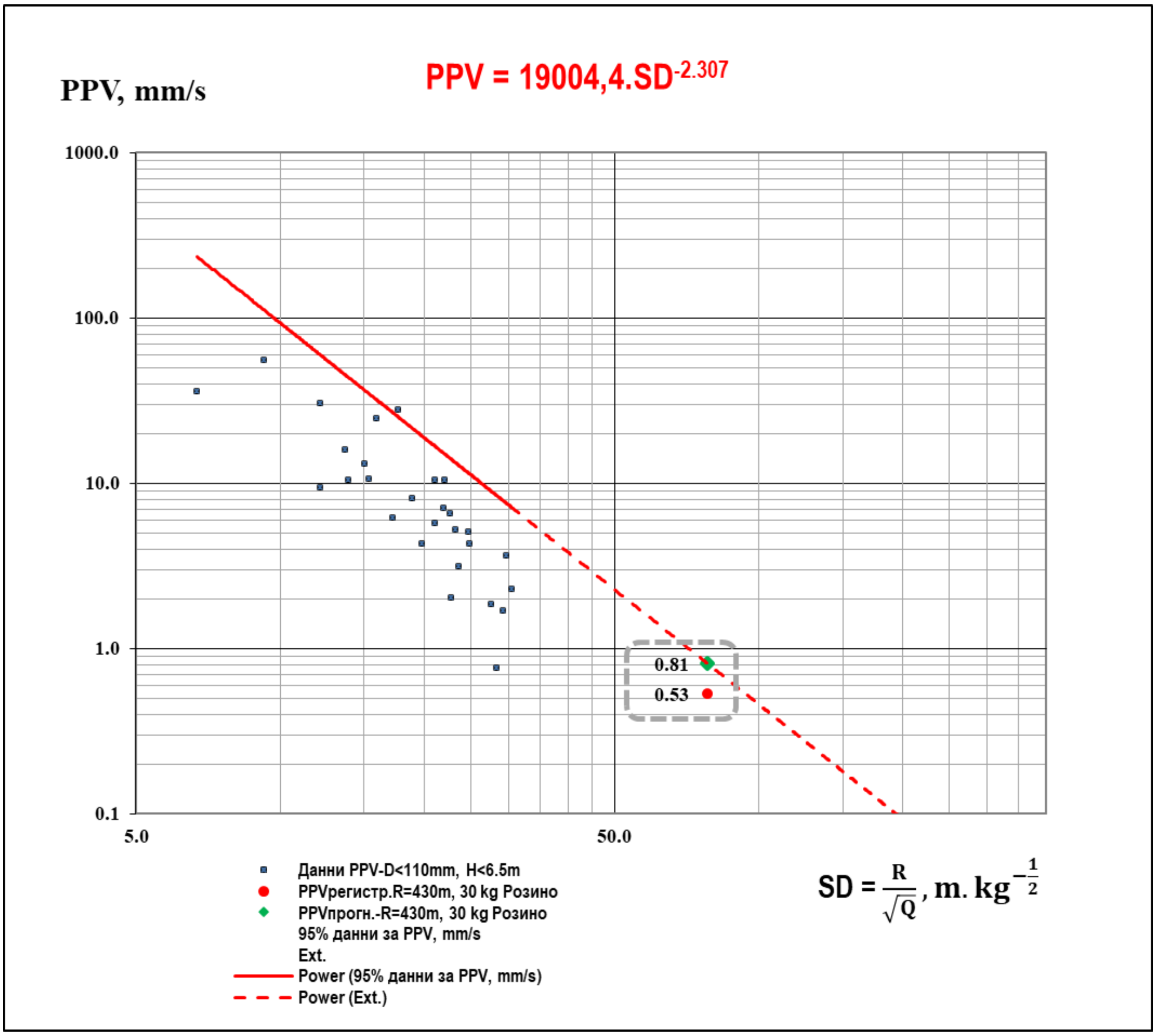


Figure 5. Location of the measured maximum vibration velocity from the control blasts carried out in the Rosino deposit area (PPVregistered) and its calculated forecast value (PPVforecast) according to formula (3).

The calculated forecast value according to the derived dependence is in the upper limits of the data range, which represents the forecast in the most severe possible impacts for the cases studied. The exact seismic dimensioning of the blasting works is carried out when preparing the project for drilling and blasting works.

The contractor for the drilling and blasting activities (DBA) prepares a DBA Project and Passport for each individual blasting, which is submitted for approval to the COS service at the regional office of the Ministry of Interior. The specified safe charge weight is mandatory when preparing the Project and Passport for each individual blasting operation. The blasting itself is carried out in the presence of the aforementioned service.

The investor may not carry out any detonation that does not comply with the specified safe charge weight in terms of the seismic impact on the quarry area.

In other words, the legislator has provided for a strict control mechanism with a view to protecting the working environment, the environment and the life and health of local communities.

The relationship between the total energy released and the portion of it used to generate seismic waves is determined by the formula:

$LgEc = 1.2LgE – 6.6$, where:

Es - the seismic energy released; E - the

total energy of the explosion.

When detonating a mass of 14 kg of explosives in a single delay stage, $E = 5.85 \times 10^{14}$ and $Ec = 1.32 \times 10^{11}$.

The Richter magnitude M

$= \underline{LgEc – 11.8/1.5}$

$M < 1$

The relative deformation during dynamic loading and unloading of the terrain caused by seismic waves, according to wave dynamics, is determined by the formula:

$\varepsilon = V/ \; Cp$

ε - relative deformation during dynamic loading and unloading of the terrain; V – displacement

velocity,

Sr – propagation velocity of longitudinal elastic waves, which according to the "Guide for the Design of Buildings and Facilities in Earthquake-Prone Areas", is defined as 1000 m/s as the most unfavourable.

ASSESSMENT OF THE IMPACT OF THE EXPLOSION ON GROUNDWATER AND WATER SUPPLY SOURCES IN NEARBY POPULATED AREAS

To determine the explosive seismic impact on groundwater and water supply sources, the calculated values of relative acceleration (g) and displacement coefficient (u) are commensurate with the seismicity coefficient for the area Ks=0.1, and all other results are one order of magnitude lower.

The results obtained give reason to conclude that, provided the recommended maximum mass of explosives in a delay interval is observed, the vibration velocity at depth is not expected to exceed a level that would have a seismic impact on groundwater and water supply sources, and **the implementation of the investment project will not have a negative impact on drinking water sources**.

In conclusion, it can be summarised that in the process of conducting mining and extraction activities accompanied by periodic PVRs, taking into account the high water density, low water abundance, low filtration coefficient and hydraulic conductivity, and anisotropy of the PWT with code BG3G000PtPg049, a negligible to slight impact on the quality of groundwater and water supply sources should be expected.

The planned blasting method does not have a dangerous impact on buildings and facilities.

The results obtained give reason to conclude that, provided the recommended maximum mass of explosives in a delay interval is observed, the vibration velocity at depth is not expected to exceed , which would have a seismic

impact on groundwater and water supply sources, and the implementation of the IP will not cause a negative impact on drinking water sources that are not directly affected by the extraction works.

5. IMPACT OF SHOCK WAVES AND NOISE

5.1. GENERAL PROVISIONS

When explosives are detonated to break up rock formations during open-pit mining, part of the energy released during the explosion is transferred to the air, generating a shock wave front (SWF) travelling at a speed of over 600 m/s. As it moves away from the site of the explosion, its speed decreases and, after reaching 343 m/s, this SAW becomes a sound wave.

The maximum permissible values of the impact of the shock wave/noise in technological industrial explosions are regulated in the following areas:

1. *Protection of building structures and facilities*
2. *Protection of human health and comfort*

The impact of UAVs on buildings and other building structures (collectively referred to as "facility") depends on:

- The duration of the impact of the UAV when it reaches the object
- The location of the object relative to the front of the UAV – frontal or parallel to its propagation.
- The reaction of the object depending on its construction.

In buildings located at a great distance from the explosion source, the most vulnerable parts – glazed windows – can withstand high values of the positive phase of overpressure, but can be destroyed by lower values of the negative phase of overpressure.

With a constant "distance" factor ($\bar{r} = \frac{R}{\sqrt[3]{\#\$}}$ m $kg^{-\frac{1}{3}}$), the value of the excess pressure at the front of the blast wave depends on the current meteorological conditions (relative pressure, temperature, cloud cover, humidity, wind direction and strength). For specific conditions, it is mandatory to take these factors into account when carrying out blasting operations.

The criteria accepted in global blasting practice for the safe impact of blasting on building structures are:

$P_+ \leq$ 0.4 kPa (146 dB) - complete preservation of the integrity of the structure;

$P_+ \leq$ 0.7 kPa (150.88 dB) - partial damage (up to 1%) to the integrity of the glazed parts of buildings;

$P_+ \leq$ 7.0 kPa (170.88 dB) - damage to part of the building structure, mainly 100% destruction of the glazed parts;

$R_+ \leq$ 30.0 kPa (183.52 dB) – risk level for the human auditory organ;

The frequency (f) generated by the UAV has a decisive influence on the human organism. According to recent studies, when it resonates with the internal frequencies of certain human organs, it affects the psyche of more sensitive individuals. It has been established that in industrial explosions, the carrier frequency ranges from 0.1 to 100 Hz. At long distances (outside the protected area), it is in the range of 1-10 Hz, which is not perceived by the human auditory system. At f > 20 Hz, the UAV reproduces a sound that can be heard at long distances and affects people. The internationally accepted "noise" limit, at which the frequency generated by the UAV is not perceived by a normal human organism, is f ≤ 20 Hz [8].

The impact of shock waves on the environment during industrial blasting (built structures and humans) is most accurately described by Nitro Consult [9].

For industrial technological outdoor blasting with optimal parameters for effective destruction of the rock mass, the predicted value of overpressure at the shock wave front is determined by the expression:

$$P+=0.2*(200/(\frac{R}{\sqrt[3]{Q}})), \text{ kPa} \qquad (4)$$

Below are the limit values for the levels of impact on humans (Table 3) and on construction sites (Table 4) in a protected area [8].

Table No. 3

Levels	Impact on humans: sensation, aggravating factors and reaction	Pa	dB(C)
Level I	Similar to distant thunder. Awakening of sensitive people	20	12
Level II	Loud thunderous sound: Surprising reaction; awakening of sleeping people	50	128
Level III	Similar to a fist hitting a table. Rattling of glass, movement of unsecured objects on shelves. Fear reaction; waking sleeping people;	100	134
Level IV	Strong impact; Clearly audible with background noise; rattling of glass; vibrations of weak structures. Fear reflex; Animals look around and react	200	140
Level V	Very loud noise. Windows rattle; buildings vibrate. Fear among more people.	500	148
Comparison	Maximum value recommended by NC, accepted as sound load	250	142

Table No. 4

Impact on building structures and facilities	Level

	Ra	dB(C)
Poorly secured objects fall and move on shelves	10	134
Cracks in the ceiling; wallpaper and poorly executed plasterwork may fall off.	15	138
Damage to windows	25	142
Cracking of paint and wallpaper on light walls Plaster cracking from wooden walls Plaster falling in strips Items on walls and shelves may fall	 350	 145 148
Recommended value from Nitro Consult	25	142

Within the meaning of the Environmental Noise Protection Act: "*Environmental noise is unwanted or harmful external sound caused by human activity*, including noise emitted by motor vehicles, railways, water and air transport, industrial installations and facilities, including the categories of industrial activities listed in Annex 4 to Article 117(1) of the Environmental Protection Act, and local sources of noise, including mechanical and electronic sound equipment."

1. Types of noise according to frequency [10]:

- low frequency – from 16 to 350 Hz;
- medium frequency – from 350 to 800 Hz;
- High frequency – from 800 to 20,000 Hz.

Waves with a frequency higher than the upper limit of human hearing – above 20,000 Hz – are called *ultrasound*. Some animals such as dogs (up to 45 kHz), dolphins (up to 150 kHz) and bats (up to 110 kHz) have a higher limit than the human ear and can hear ultrasound.

Waves with a frequency below 17-20 Hz are called *infrasound*, with the lower limit of infrasound waves not being definitively determined. Sources of infrasound include turbulent atmospheric and wind movements, electrical charges in the atmosphere, waterfalls, sea waves, explosions, cannon fire, and jet aircraft. In the Earth's crust, these are shocks and vibrations from a wide variety of sources – volcanic phenomena, earthquakes, explosions [11].

2. Depending on the duration of exposure, noise can be [10]:

- *Constant* noise, whose level changes by less than 5 dB over time during individual work operations;
- Non-constant/variable noise, where the noise level changes by more than 5 dB during different work operations. It can be:
  - Intermittent noise, when its level drops suddenly for short intervals and repeatedly to the ambient level;
  - *Fluctuating* noise, when its level varies continuously;
  - *Impulse noise* – perceived as separate beats and consisting of one or more pulses of sound energy, with the duration of each pulse being less than 1s.

Basic noise characteristics of:

- *constant* noise is the noise level in dB(A);
- *variable* noise is the equivalent noise level in dB(A);
- *imp*ulse noise is the peak sound pressure level in dB(C).

Table 5 shows the impact of noise on human health [12].

Table No. 5

Impact of noise on human health		
Noise, dB(A)	Impact on humans	
0	Noise perception limits	No effect on health
10	Very quiet noise	No effect on humans
30	Quiet noise	Slight effect on humans
5	Moderately loud noise	Hinders communication, stresses the psyche
75	Very loud noise	Impossible to work, affects the hearing apparatus
10	Unpleasant loud noise	Damages hearing, causes mental disorders, damages a number of other organs
120	Painfully loud noise	Hearing loss

For comparison in assessing the impact of noise, Table 6 shows the noise levels from various sources in people's social lives [13].

Table

Noise levels at:	dB(A)	≈dB(C) 31.5Hz*
Whisper	10	47
Quiet conversation between two people	40	80
Ordinary conversation in a group	60	10
Telephone conversation	75	115
Loud speech	80	120
Automatic washing machine	80	120
Car transport	75	115
Vacuum cleaner	75	115
**Minimum frequency values in the calculator [14]*		

There are four characteristics of noise that have a traumatic effect on the human body [15]. These are: intensity, spectrum, rhythm and duration. The sound level that causes damage starts at 80dB(A). As far as the spectrum of noise is concerned, high-frequency tones are the most harmful. Noise with a continuous rhythm is more dangerous than intermittent noise, and the duration of exposure to acoustic trauma is an important factor in the occurrence of hearing damage. For example, exposure to noise of 115 dB(A) for 15 minutes represents a critical threshold for gradual hearing loss. For 95 dB(A), the critical threshold is four hours, and for 100 dB(A), it is two hours. To prevent damage to the inner ear, the duration of exposure to noise must be reduced as the intensity of the noise increases, and this rule is mandatory for everyone who works in high-noise environments. According to [17], a person can be exposed to different noise levels without any impact on their health, as shown in Table 7.

Table 7

Noise level, dB(A)	Exposure time,
85	8 hours
8	4 hours
91	2 hours
94	1 hour
97	30 min
100	15 min
103	7.5 min
106	3.8 min
109	1.9 min.
112	57 sec.
115	28.5 sec.
118	14.3 sec.
121	7.1 sec.
124	3.6 sec.
127	1.8 sec
130	0.9 sec.

A worker is considered to be at risk if his or her daily exposure to noise or peak exposure to noise exceeds the lower exposure action values [16], according to Regulation 6/15022006.

Due to the fact that the impact of noise on birds and animals has not yet been well studied [18]. The data presented in Table 3 - Level IV - "...*Animals look around and* react", corresponding to the exposure limit value for 8 hours of work according to Regulation 6/1502006 ($L_{ex,8h}$ = 87dB(A) and peak sound pressure $_{Ppeak}$ = 200 Pa, corresponding to 140 dB(C)).

5.2. REGULATORY REQUIREMENTS

1. In accordance with Annex No. 7 to Article 141 – PBTVR, the minimum permissible safe distance for the action of UVB is:

- For buildings - R = **63 ÷ 156** m, according to Art. 5 of Annex No. 7: at (Km = 20 ÷ 50 - no damage) and a charge mass of 30 kg.
- For people - R = **94 ÷ 140** m, according to Art. 10 of Appendix No. 7 (at 2 and 3 times the increase in the calculated distance according to formula 7, according to the recommendations in the appendix).

2. According to Regulation 6/15082005:

a) Exposure limit values for 8-hour work:

- $_{Lex,8h}$ **= 87dB(A)** and peak sound pressure $_{Ppeak}$ **= 200Pa**, corresponding to **140dB(C**).

Exposure limit values are used in risk assessment, especially when appropriate personal protective equipment (PPE) for hearing protection needs to be recommended, as in this case the actual exposure of workers is calculated taking into account the noise reduction provided by the PPE used for hearing protection.

b) Upper exposure action values:

- $_{Lex,8h}$ **= 85 dB(A)** and peak sound pressure $_{Ppeak}$ **= 140 Pa**, corresponding to **137 dB(C)**.

c) Lower exposure values for action

- $_{Lex,8h}$ **= 80 dB(A)** and peak sound pressure $_{Ppeak}$ **= 112 Pa**, corresponding to **135 dB(C)**.

When applying exposure values for taking action, the effect of using PPE for hearing protection is not taken into account.
the effect of using PPE for hearing protection is taken into account.

3. According to Nitro Consult recommendations, the maximum exposure level is **142 dB** [9].

4. According to Regulation 6/26062006 (Table 8)

Due to the fact that the side effects of explosions (blast waves, flying rock fragments and toxic gases) are extremely dangerous to human life and health, as well as to measuring equipment, measuring the impact of blast waves from explosive works and noise in real conditions requires that this be done at a safe distance from the source of its generation (for example, according to Article 143 of the PBTWR, the radius of the danger zone for people is at least 300 m for charges in boreholes with a diameter of up to 110 mm, which is significantly greater than 7.5 m). The noise from blasting operations is classified as "impulse noise", and its level is measured by the peak overpressure in dB(C). Measuring this type of noise in dB(A) is not recommended.

Table No. 8

Territories and planning zones in urbanised territories and outside them		Equivalent noise level in dB(A)		
		day	evening	night
1		2	3	4
1	Residential areas and territories	55	50	45
2	Mixed central urban areas	60	55	50
3	Areas exposed to heavy traffic	60	55	5
4	Areas exposed to rail and tram traffic	65	60	5
5	Areas affected by aircraft noise	65	65	55

Areas and planning zones in urbanised areas and outside them		Equivalent noise level in dB(A)		
		day	evening	night
6	Production and storage areas and zones	70	70	70
7	Areas for public and individual recreation	45	40	35
8	Areas for medical facilities	45	35	35
9	Areas for scientific research and educational activities	45	40	35
10	Quiet areas outside urbanised territories	40	35	35
Note	The limit value for the maximum noise level when an aircraft flies over a given area is 85 dB(A).			

Under these conditions, it is impossible to measure the impact of UVV, i.e. the noise from explosive works, in accordance with Annex No. 3a to Regulation 6/26062006 - "Assessment of noise from local and industrial sources" for determining the equivalent noise level (LAeq(7.5)) of the source by measuring at a distance of 7.5 m from it. In this regard, measurements of the impact of the shock wave/noise from blasting operations are carried out using a methodology applied as best international practice in the field of blasting operations, as described in section 2.2 "Methodology for determining the parameters of the seismic effect and shock wave".

5.3. DETERMINATION OF THE IMPACT OF THE SHOCK WAVE/NOISE FROM NOISE

As with the determination of the explosive-seismic impact, in terms of the number of measurements, the results recorded for the impact of UVF/noise from the above-mentioned report [7] are not sufficient to derive the necessary mathematical relationship, but as control measurements they fully satisfy the requirements for performing measurements with specialised equipment. For the purposes of expert analysis, these results allow the measured impact of the UAV to be established for the conditions at the

"Rozino" with the derived relationship (5), obtained from the processing of results from measurements of the seismic impact of the explosion, carried out with specialised equipment under similar conditions in Bulgaria (diameter of the blast holes d=76-102 mm and height of the working step H< 6.5 m) (Fig. 6).

The established mathematical dependence of the overpressure of the UBB on the distance and mass of the explosive charge is as follows:

$$P+ = 3059.1\left(\frac{R}{\sqrt[3]{Q}}\right)^{-1.151}, Pa \qquad (5)$$

where: R - distance from the explosion site to the protected object, m

Q – mass of the explosive charge detonated in a single delay interval, kg.

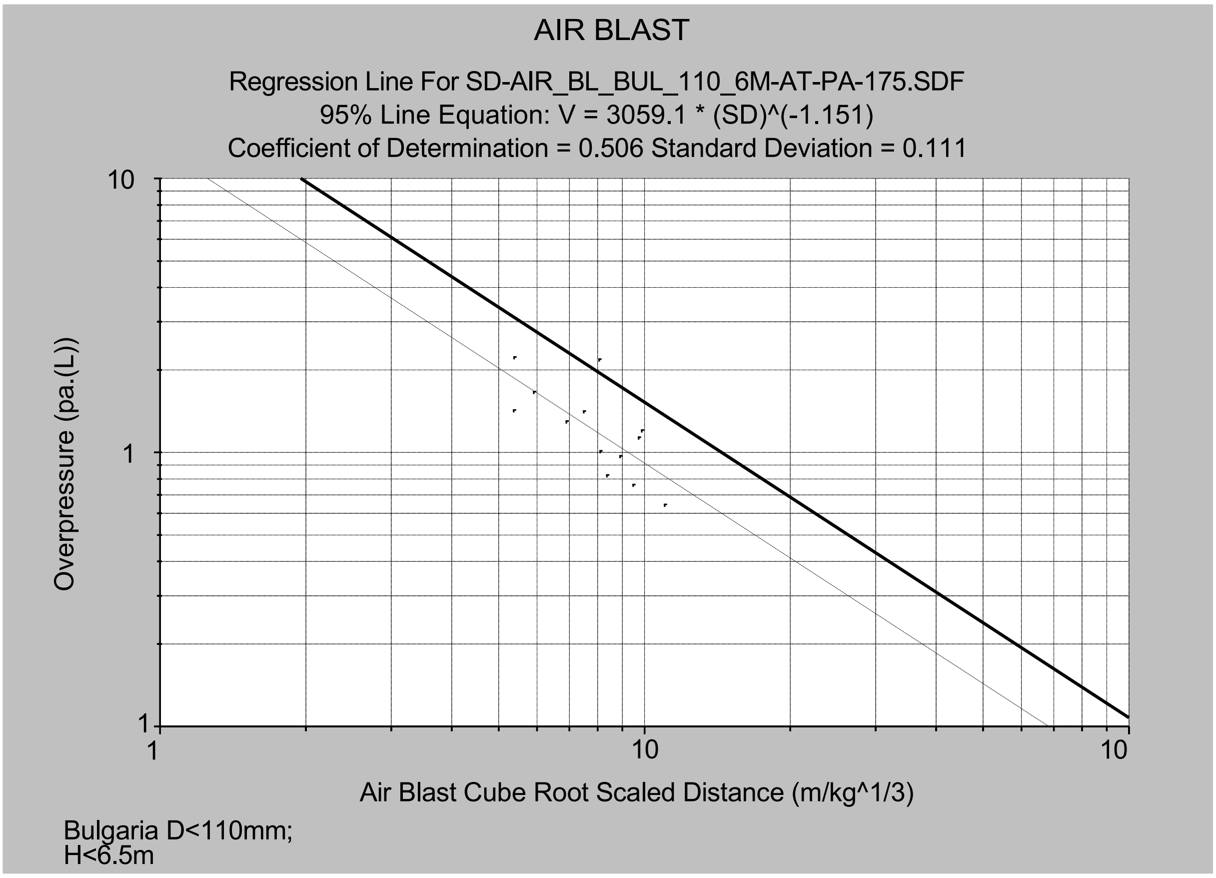


Figure 6. Results of measurements of the air blast velocity (Pa) of the explosion in Bulgaria with a charge diameter D<110 mm and a length of the explosive boreholes Lc< 6.5m

For the purposes of this report, the data from the measurements in Bulgaria (Fig. 6) have been converted to dB(C) using an online converter [13] and are presented graphically in Fig. 7, with the mathematical formula taking the following form:

$$\mathbf{P+ = 175.3 \left(\frac{R}{\sqrt[3]{Q}}\right)^{-0.087}, Pa} \qquad (6)$$

The maximum values of the impact of the UAV from the control explosions (section 3.6 of this report) conducted on 08.04.2020 have been added to the graph with the data from the measurement results under similar conditions in Bulgaria (Fig. 7 – data enclosed by a dotted contour). The same graph also shows their predicted values, determined according to the above-mentioned dependence (6) for a charge mass of 30 kg (corresponding to that in the experimental on-site blasts) and a distance of 600 m and 800 m, respectively.

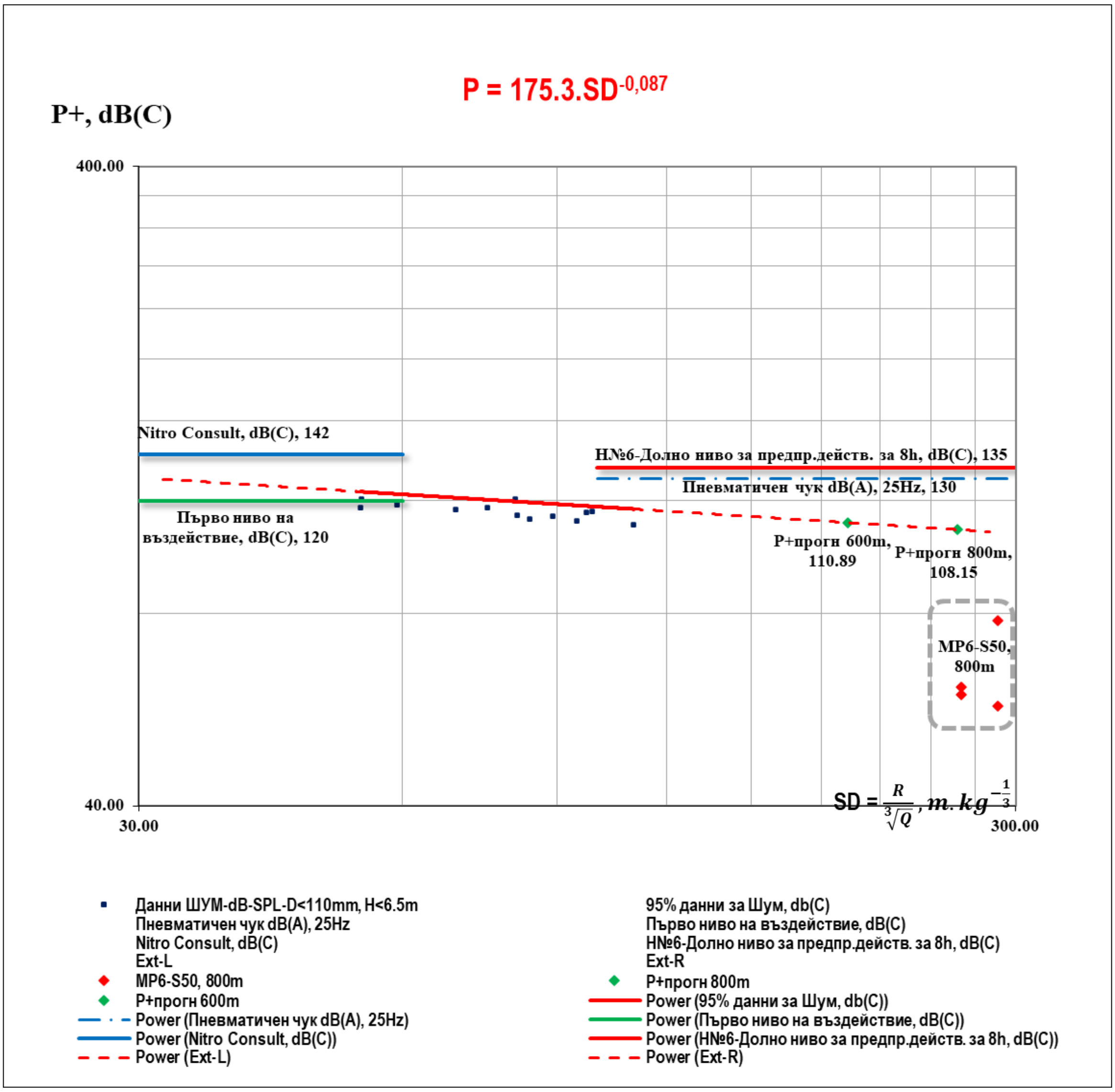


Figure 7. Results of measurements of the UVV/noise of the explosion in Bulgaria at a charge diameter d<110 mm and a length of the explosive boreholes Lc< 6.5m, converted to dB(C). The results enclosed by a dotted contour were recorded in the Rosino deposit area during the experimental blasting on 8 April 2020.

The calculated forecast values according to the derived dependence are at the upper limits of the data range, which represents the forecast of the most severe possible impacts for the cases studied.

6. SPREAD OF SINGLE ROCK

6.1.

The maximum scattering distance of individual rock fragments at a constant diameter of the borehole charge is determined by taking into account:

- The structure of the rock mass in the area in front of the first row of boreholes;

- The actual resistance line for the first row of borehole charges, taking into account the deviation of the borehole depending on its length;
- The length of the pile;
- The quality of the pile (type and grain size composition)
- Presence of rock fragments near the mouth of the boreholes

6.2. E REQUIREMENTS

The calculated minimum permissible distance for people in case of scattered rock fragments in accordance with Article 11 of Annex No. 7 to Article 141 of the PBTWR, in case of technological drilling explosions (d ≤ 110 mm) is determined by the expression:

$$\mathbf{Rp} = 1250.\mathbf{r}_{зар}.\sqrt{\frac{f}{1+\mathbf{r}_{заб}}.\frac{d_c}{a}} = 320,\mathbf{m} \qquad (6)$$

where: r_{zar} is a coefficient that takes into account the length of

the charge f is the Protodyakonov strength coefficient;

$r_{зар}$ - coefficient taking into account the length of the charge

from BB; $r_{заб}$ - coefficient taking into account the length of the

drive;

a - distance between boreholes in a row, m.

When carrying out blasting works on steep slopes and when the upper line of the blasting section is higher than the others by more than 30 m, the radius of the danger zone shall be determined in accordance with Article 15 of the above-mentioned Appendix No. 7, depending on the angle of inclination or the elevation of the explosion site relative to the level of the protected zone. The safe distance (R) is as follows:

- Down the slope in a westerly direction - **R = 360 m.**
- Down the slope in a southerly direction - **R = 380 m.**
- On the slope in an eastward direction - **R = 400 m.**

7. RADIUS OF THE PROTECTED AREA, DANGEROUS DUE TO THE EFFECT OF THE EXPLOSION

The radius of the area protected from the dangerous effects of blasting operations is the maximum of those determined by various factors, namely:

1. Impact of blasting works on people - **R = 94 ÷ 140** m,
2. By the spread of rock fragments
   - On flat terrain - **R = 320 m**
   - When blasting towards a slope - **R = 400 m**
3. According to Art. 143 of the PBTWR, for technological blasting of borehole charges (d ≤ 110 mm)
   - The safe distance for people cannot be less than - **R = 300 m**,
   - And when detonating towards a slope, the safe distance for people is - **R = 450 m**.

Given that the terrain where the deposit is located is hilly, the radius of the protected area is assumed to be no less than R = 450 m (Appendix 1).

8. ASSESSMENT OF THE SIDE EFFECTS OF THE BLAST

The designated zones in which the maximum permissible levels of side effects of technological blasting operations during the exploitation of the Rosino deposit should not be exceeded are at a distance (R) from the outer contour of the Rosino project mine, as follows:

- Detachment zone ....R=450 m
- Eco zone 1 - H-2000 .... R=600 m
- Eco zone 2 - H-2000 .... R=800 m
- Water collector ....R=705 m
- Yuren Dere (Contour of protected area for bird habitats) .... R= 650 m
- Rozino village... R=1200 m

Performance of technological blasting works during the exploitation of the deposit "Rozino" envisages blasting the rock mass with explosives placed in blast holes with a diameter ranging from 76 to 102 mm. The main explosive to be used is expected to be an ammonium nitrate-fuel oil (ANFO) explosive mixture and/or emulsion explosives. Given the type and condition of the rock mass, the parameters of the blasting plan have been determined for three different zones, as follows: Oxidised, Transitional and Fresh Rocks, for ore and waste rock, respectively (Table 9). The drill charges for breaking the ore in the "Fresh rock" zone have the largest explosive mass.

Table No. 9

ROCK	TYPE OF	ZONES	OKISNA			TRANSITIONAL			FRESH SCALES		
		PARAMETERS OF P.B.R.									
		D probe, mm	76	89	102	76	89	102	76	89	102
ORES	ANFO	LNS charge, m	2.8	3.3	3.7	2.6	3.1	3.5	2.4	2.8	3.2
		Density BB, kg/m3	800	800	800	800	800	800	800	800	800
		Mass BB per 1 m	3.6	5	6.5	3.6	5.0	6.5	3.6	5.0	6.5
		Length of probe, m	5.4	5.5	5.6	5.4	5.9	6.1	5.7	5.8	5.9
		Length of the beam, m	1.9	2.2	2.5	1.8	2.1	2.4	1.6	1.9	2.1
		Length of the rod	3.5	3.3	3.0	3.6	3.8	3.7	4.1	4.0	3.8
		Mass BB in probe, kg	12.8	16.3	19.7	13	19.0	23.9	**15.0**	**19.7**	**24.8**
	EMULSION V.V.	LNS charge, m	3	3.5	4.0	2.8	3.3	3.7	2.5	2.9	3.3
		Density BB, kg/m3	1060	1060	1060	1060	1060	1060	1060	1060	1060
		Mass BB per 1 m	4.8	6.6	8.7	4.8	6.6	8.7	4.8	6.6	8.7
		Length of probe, m	5.4	6.0	6.2	5.4	6.0	6.1	5.4	5.9	6.0
		Length of the barrier, m	2.0	2.4	2.7	1.9	2.2	2.5	1.9	2.0	2.3
		Length of roll	3.4	3.7	3.5	3.5	3.8	3.6	3.5	3.9	3.7
		Mass BB in probe, kg	16.6	24.3	30.2	17	24.8	31.0	**17**	**25.7**	**32.3**
STERILE	ANFO	LNS charge, m	2.8	3.3	3.7	2.6	3.1	3.5	2.6	3.1	3.5
		Density BB, kg/m3	800	800	800	800	800	800	800	800	800
		Mass BB per 1 m	3.6	5	6.5	3.6	5.0	6.5	3.6	5.0	6.5
		Length of probe, m	5.4	6.0	6.1	5.4	5.9	6.1	5.4	5.9	6.1
		Length of the beam, m	1.9	2.2	2.5	1.8	2.1	2.4	1.8	2.1	2.4
		Length of the rod	3.5	3.8	3.6	3.6	3.8	3.7	3.6	3.8	3.7
		Mass BB in probe, kg	12.8	18.7	23.4	13	19	23.9	13	19	23.9
	EMULSION V.V.	LNS charge, m	3	3.5	4.0	2.8	3.3	3.7	2.8	3.3	3.7
		Density BB, kg/m3	1060	1060	1060	1060	1060	1060	1060	1060	1060
		Mass BB per 1 m	4.8	6.6	8.7	4.8	6.6	8.7	4.8	6.6	8.7
		Length of probe, m	5.4	6.0	6.2	5.4	6.0	6.1	5.4	6.0	6.1
		Length of the barrier, m	2.0	2.4	2.7	1.9	2.2	2.5	1.9	2.2	2.5
		Length of roll	3.4	3.7	3.5	3.5	3.8	3.6	3.5	3.8	3.6
		Mass BB in probe, kg	16.6	24.3	30.2	17	24.8	31.0	17	24.8	31

Using the derived dependencies for seismic effect, UBB and noise, the predicted impact levels of single borehole charges with maximum explosive mass (for ore in the "Fresh Rocks" zone) were calculated depending on the distances to the protected areas (Table 10). For comparison, the same table also shows the maximum permissible levels according to the accepted Bulgarian and international standards.

Table No. 10

ROCK		TYPE OF	PROTECTED AREAS	Distance	PPV/P+=H.SD$^{-\beta}$								
					H	PPV	β	H	P	β	H	P	β
					19004.4	mm/s	-2.307	3059.1	Pa	-1.151	175.3	dB (C)	-0.087
				R, m	76	89	102	76	89	102	76	89	102
Ruda	Fresh rocks	ANFO	Breakaway zone	450	0.33	0.45	0.59	7.6	8.4	9.2	116	117	118
			Eco zone 1 - H-2000	600	0.17	0.23	0.30	5.4	6.0	6.6	113	114	116
			Yuren Dere	650	0.14	0.19	0.25	4.9	5.5	6.0	112	114	115
			Water collector	705	0.12	0.16	0.21	4.5	5	5.5	111	113	114
			Eco zone 2 - H-2000	800	0.09	0.12	0.16	3.9	4.3	4.7	110	112	113
			Belya River	1050	0.05	0.06	0.08	2.8	3.2	3.5	108	109	110
			Rozino village	1200	0.03	0.05	0.06	2.4	2.7	3	106	108	109
		EMULSION V.V.	Detachment zone	450	0.38	0.61	0.79	7.9	9.3	10.1	117	119	120
			Eco zone 1 - H-2000	600	0.20	0.31	0.41	5.7	6.7	7.3	114	116	117
			Yuren Dere	650	0.16	0.26	0.3	5.2	6.1	6.6	113	115	116
			Water collector	705	0.13	0.22	0.28	4.7	5.5	6	112	114	115
			Eco zone 2 - H-2000	800	0.10	0.16	0.21	4.1	4.8	5.2	111	113	114
			Belya River	1050	0.05	0.09	0.11	3.	3.5	3.8	108	110	111
			Rozino village	1200	0.04	0.06	0.08	2.6	3	3.3	107	109	110
REGULATORY REQUIREMENT			DIN 4150-Residential buildings	mm/s		5.0			-			-	
			DIN 4150-Highly sensitive structures	mm/s		3.00			-			-	
			Regulation 9/12022010 - Day	mm/s		1.07			-			-	
			Level I of impact on humans (Table 3)	Pa		-			20			-	
				dB(C)		-			-			120	
			Regulation 6/Regulation 6/15082005-Lower exposure values for taking action	Pa		-			112			-	
				dB(C)		-			-			135	

Appendix No. 3 also provides nomograms for determining the charge mass depending on the distance and level of seismic effect and the blast radius of the explosion for the diameters of the crown for drilling explosive boreholes: 76, 89 and 102 mm.

As can be seen from the results in Table 10, when each drill charge is detonated with a separate delay interval, the lateral impact of the explosion is as follows:

- **The calculated values of the explosive seismic impact for all three charge diameters (of the explosive boreholes) are significantly lower than the permissible standards for all factors: for people, buildings and facilities, including the requirements for comfort.**
- **The determined levels of impact of the UBB, also for the three planned diameters of the charges, when each charge is detonated with a separate delay interval, are significantly lower than the normative ones, according to Regulation 6/15082005 and Level I of impact on humans.**
- **The noise impact values in dB(C) are below the lower exposure value for action to be taken, regulated by Ordinance 6/15082005, and do not exceed Level I of human impact. Only in the exclusion zone (the area protected from the effects of the explosion - R=450m) does the calculated impact value equal Level I of human impact (Table 3).**

9. CONCLUSION

8.1. CONCLUSIONS

The selected system for the development of the Rozino deposit, according to the conceptual design: low working steps (5 m), resp. short boreholes (~6 m) with a relatively small diameter (76-102 mm), is one of the most environmentally friendly technologies for the extraction of minerals using explosive rock breaking. The use of modern systems for initiating explosives charges complements the possibilities for effective management of the side effects of the explosion.

Measurements taken using specialised equipment during experimental blasting in the Rosino deposit area [7] show that the seismic impact of the explosion is lower than the maximum permissible standards, including the standard for ensuring comfort in protected areas, in accordance with Regulation 9/12022010.

The values of the recorded results from the measurement of the impact of UVV/noise at a distance of 800 m from the site of the experimental explosion carried out within the boundaries of the Rosino deposit are significantly lower than the maximum permissible standards of the regulatory framework in force in Bulgaria for safe impact and the restrictions adopted in global explosive practice.

The impact of the noise from the blasting operations was lower than the background noise levels recorded on the previous day and on the day of the experimental blasting operations [7]. According to those present at the explosion, the sensation at a distance of 600 m and 800 m was like "distant thunder".

The values recorded from the measurement of the lateral impact of the explosion in the Rosino deposit area are consistent with the results obtained from studies conducted in Bulgaria under similar mining, natural and technological conditions. This allows the mathematical formulas derived from these studies to be used to calculate the explosive seismic impact and the impact of the UAV for the conditions at the Rosino deposit, depending on the distance to the protected object and the mass of the explosive charge detonated at a delay interval.

The following conclusions can be drawn from the assessment of the impact of blasting operations on people and the environment:

The PVR technology envisaged for the development of **the Rozino** deposit **complies with the standards for safe impact on people and buildings when applying drill-and-blast rock breaking for all three diameters of the explosive boreholes (76, 89 and 102 mm) when detonating each drill charge with a separate (independent) delay interval.**

Given the location of the deposit in the Natura 2000 area, the PVR technology should be applied with the minimum possible side impact of blasting on the environment. Within the specified parameters of the PVR (Table 9), the blasting technology with the lowest levels of side effects is that using charges with a diameter of 76 mm. If there are no other aggravating conditions

for the PVR technology, it is recommended to work with a diameter of the explosive boreholes d=76 mm.

The results obtained show that, when the specified technological parameters are observed during blasting, the predicted levels of seismic impact at various distances outside the mine contour are:

Below the requirements of Article 1 of Annex No. 7 "Instructions for determining safe distances for blasting operations" to Article 141 of the PBTWR;

Below the maximum permissible vibrations according to the requirements of Regulation 9/12022010 on the maximum permissible vibrations that do not disturb human comfort;

The calculated values of the explosive seismic impact are significantly lower than the permissible standards: for people, buildings and facilities, including the requirements for comfort.

<u>Assessment of the side impact of the explosion on groundwater and water supply sources in nearby settlements</u>

The results obtained give reason to conclude that, if the recommended maximum mass of explosive material in a delay interval is observed, the vibration velocity at depth is not expected to exceed the level that would have a seismic impact on groundwater and water supply sources.

In the course of mining activities accompanied by periodic blasting, taking into account the high water tightness, low water abundance, low filtration coefficient and hydraulic conductivity, and anisotropy of PWT with code BG3G000PtPg049, a negligible to slight impact on the quality of groundwater and water supply sources should be expected.

<u>Assessment of the impact of shock waves/noise</u>

The results obtained from the explosion show that with regard to workers:

With the correct length and quality of the pile, in accordance with Regulation 6/15082005 and Level I of impact on humans, when detonating a charge with a maximum explosive mass of up to 30 kg in a single delay interval, no exceedance of the safety standards for shock waves and noise is expected.

The calculated values of the impact of UV/noise are below the lower exposure value for action to be taken, regulated by Ordinance 6/15082005 (< 112 Pa / < 137 dBC) and lower than Level I of impact on humans (< 20 Pa / < 120 dBC) .

The results obtained from the explosion show that, in terms of the environment, including in the most severe case of blasting works in terms of the side impact of the explosion – with a borehole diameter of 102 mm and a charge weight of 28.8 kg, they show that:

The exposure time to the noise generated by technological blasting works, on the scale of mineral extraction in our country, is in the order of 1-

2 s, with safe exposure to such impact being more than 8 hours and noise levels having no impact on human health and comfort; they are in accordance with Annex No. 7 to Article 141 of the PBTWR for the minimum permissible safe distance.

In addition to all of the above, in order not to disturb the comfort of people living near open-pit mines and quarries, the most commonly used approach is to consult with the public in the area on the most appropriate/acceptable time to carry out the technological blasting works.

6.4. Assessment of rock fragment dispersion

It is recommended that, in the case of explosive drilling at a distance of less than 300 m from a populated area, protective geotextiles be used as a preventive measure to avoid rock fragments flying and posing a risk to the population and the environment.

8.2. MANAGEMENT OF THE SIDE EFFECTS OF THE EXPLOSION

When designing and implementing the PVR, it is particularly important to find the most acceptable option that minimises the side effects of the explosion does not exceed the permissible standards and at the same time ensures maximum effect from the explosive destruction of the rock mass, in accordance with the expected parameters, such as: achieving the specified grain size distribution of the broken rock mass, minimal displacement of the blasted material, minimal losses and depletion of the ore, etc.

The main factors for controlling the side effects of blasting are as follows:

- Knowledge and compliance with the physical, mechanical and structural characteristics of the rock mass – the necessary balance for effective combination of the "rock resistance to destruction - explosive energy" process;
- Determination of the effective length of the blast;
- Choosing a suitable inert material for the charge, ensuring maximum use of the explosive energy to destroy the rock mass and minimising its side effects. In this case, the priorities are UVB and noise;
- Application of techniques to minimise the side effects of the explosion, such as:
  - increasing the length of the blast,
  - reducing the charge mass (smaller diameter boreholes, spaced charges);
  - application of appropriate blasting schemes (directing the front of destruction and the direction of movement of the blasted rock mass, minimising the charge mass in a delay interval, etc.);
  - use of protective coatings.

The use of modern detonation systems allows each charge to be detonated with a separate/independent delay interval. This provides a double effect: on the one hand, the effect of millisecond (short-delay) sequential detonation of the charges is used for better fragmentation of the rebounded mass, and on the other hand, minimal explosive-seismic stress on the environment by dispersing the energy of the explosion, initiating the minimum possible mass of explosives in a delay interval.

It should be noted that with the development of the mine below the upper contour, the impact of UVW and noise will be further limited by the barrier function of the non-working boards.

In the case of open-pit mining of minerals near urban areas, the blasting time is agreed with the local community in order to avoid the surprise effect and to establish the most acceptable time for blasting operations with a view to reducing the unpleasant effect on the comfort of local residents – most often this is during daylight hours within the working day.

8.3. ADDITIONAL RECOMMENDATIONS

With the development of deep mining, working conditions are changing. In this regard, periodic control measurements with specialised equipment, updating of mathematical dependencies determining the levels of impact and, if necessary, correction of the parameters of the PVR are recommended.

It is recommended that measurements and expert analysis of the explosive-seismic impact be carried out in order to take measures in the design and implementation of technological blasting works to protect the stability of the non-working and working steps with the development of the mine at depth.

For all facilities within the mining complex that fall within the hazardous zone of impact of blasting operations, the design and implementation of technological PVRs shall be carried out in accordance with the requirements of Chapter Six of the PBTIR: "Special Blasting Operations".

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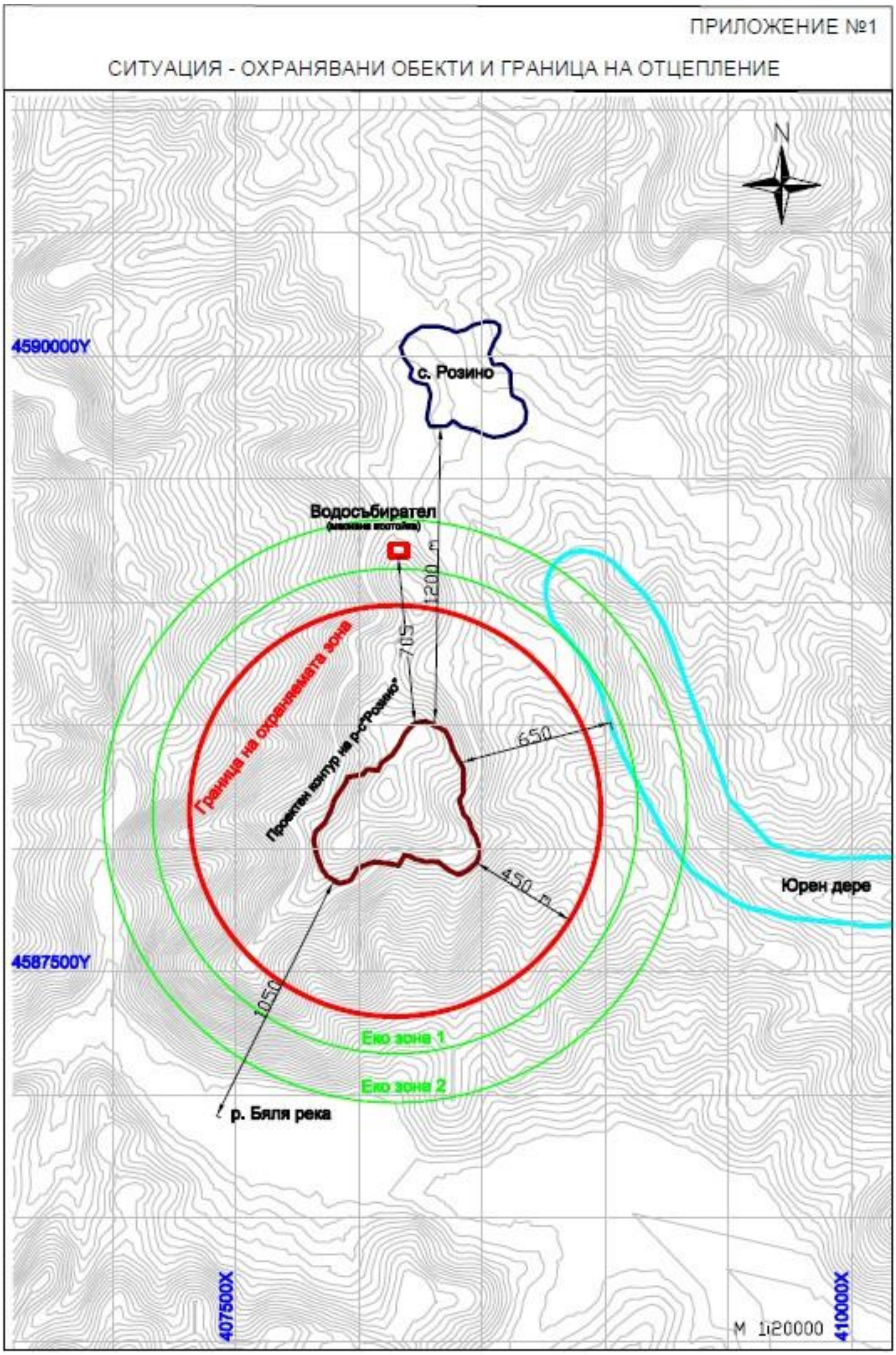
11. Annexes



ПРИЛОЖЕНИЕ №1
СИТУАЦИЯ - ОХРАНЯВАНИ ОБЕКТИ И ГРАНИЦА НА ОТЦЕПЛЕНИЕ
N
4590000Y
с. Розино
Водосъбирател
1200 m
705
Граница на охраняемата зона
Проектен контур на р-с"Розино"
650
450 m
Юрен дере
4587500Y
1050
Еко зона 1
Еко зона 2
р. Бяла река
407500X
410000X
M 1:20000

ANNEX No. 2

Blasting works in the Rosino study area [7]

„ГЕОМАКС БЪЛГАРИЯ"ООД
гр.Варна
ул.Никола Козлев № 28-Д-26,
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GEOMAX Bulgaria

Взривни работи на площ за проучване „Розино" 08.04.2020г.

1. Взривни работи поле 1
   4 сондажа свързани с 4 повърхностни конектора с дължина 7,8метра и закъснение 0ms
   - 1-ви сондаж Lсонд.=6m; Lзаряд=4м.; Lзаб. = 2м.; неелектрически детонатор със закъснение 1000ms и дължина 7,8 метра = 1бр.; лят бустер 0,450кг. = 1бр.; ВВ хидромайт = 30кг.
   - 2-ри сондаж Lсонд.=6m; Lзаряд=4м.; Lзаб. = 2м.; неелектрически детонатор със закъснение 2000ms и дължина 7,8 метра = 1бр.; лят бустер 0,450кг. = 1бр.; ВВ хидромайт = 30кг.
   - 3-ти сондаж Lсонд.=6m; Lзаряд=3м.; Lзаб. = 3м.; неелектрически детонатор със закъснение 3000ms и дължина 7,8 метра = 1бр.; лят бустер 0,450кг. = 1бр.; ВВ хидромайт = 22,5кг.
   - 4-ти сондаж Lсонд.=6m; Lзаряд=3м.; Lзаб. = 3м.; неелектрически детонатор със закъснение 4000ms и дължина 7,8 метра = 1бр.; лят бустер 0,450кг. = 1бр.; ВВ хидромайт = 22,5кг.

2. Взривни работи поле 2
   4 сондажа свързани с 4 повърхностни конектора с дължина 7,8метра и закъснение 0ms
   - 1-ви сондаж Lсонд.=6m; Lзаряд=4м.; Lзаб. = 2м.; неелектрически детонатор със закъснение 1000ms и дължина 7,8 метра = 1бр.; лят бустер 0,450кг. = 1бр.; ВВ хидромайт = 30кг.
   - 2-ри сондаж Lсонд.=6m; Lзаряд=4м.; Lзаб. = 2м.; неелектрически детонатор със закъснение 2000ms и дължина 7,8 метра = 1бр.; лят бустер 0,450кг. = 1бр.; ВВ хидромайт = 30кг.
   - 3-ти сондаж Lсонд.=6m; Lзаряд=3м.; Lзаб. = 3м.; неелектрически детонатор със закъснение 3000ms и дължина 7,8 метра = 1бр.; лят бустер 0,450кг. = 1бр.; ВВ хидромайт = 22,5кг.
   - 4-ти сондаж Lсонд.=6m; Lзаряд=3м.; Lзаб. = 3м.; неелектрически детонатор със закъснение 4000ms и дължина 7,8 метра = 1бр.; лят бустер 0,450кг. = 1бр.; ВВ хидромайт = 22,5кг.

3. Взривни работи поле 3
   4 сондажа свързани с 4 повърхностни конектора с дължина 7,8метра и закъснение 0ms
   - 1-ви сондаж Lсонд.=6m; Lзаряд=4м.; Lзаб. = 2м.; неелектрически детонатор със закъснение 1000ms и дължина 7,8 метра = 1бр.; лят бустер 0,450кг. = 1бр.; ВВ хидромайт = 30кг.
   - 2-ри сондаж Lсонд.=6m; Lзаряд=4м.; Lзаб. = 2м.; неелектрически детонатор със закъснение 2000ms и дължина 7,8 метра = 1бр.; лят бустер 0,450кг. = 1бр.; ВВ хидромайт = 30кг.
   - 3-ти сондаж Lсонд.=5m; Lзаряд=2,2м.; Lзаб. = 2,8м.; неелектрически детонатор със закъснение 3000ms и дължина 7,8 метра = 2бр.; лят бустер 0,450кг. = 2бр.; ВВ хидромайт = 15 кг.
   - 4-ти сондаж Lсонд.=6m; Lзаряд=3м.; Lзаб. = 3м.; неелектрически детонатор със закъснение 4000ms и дължина 7,8 метра = 1бр.; лят бустер 0,450кг. = 1бр.; ВВ хидромайт = 22,5кг.

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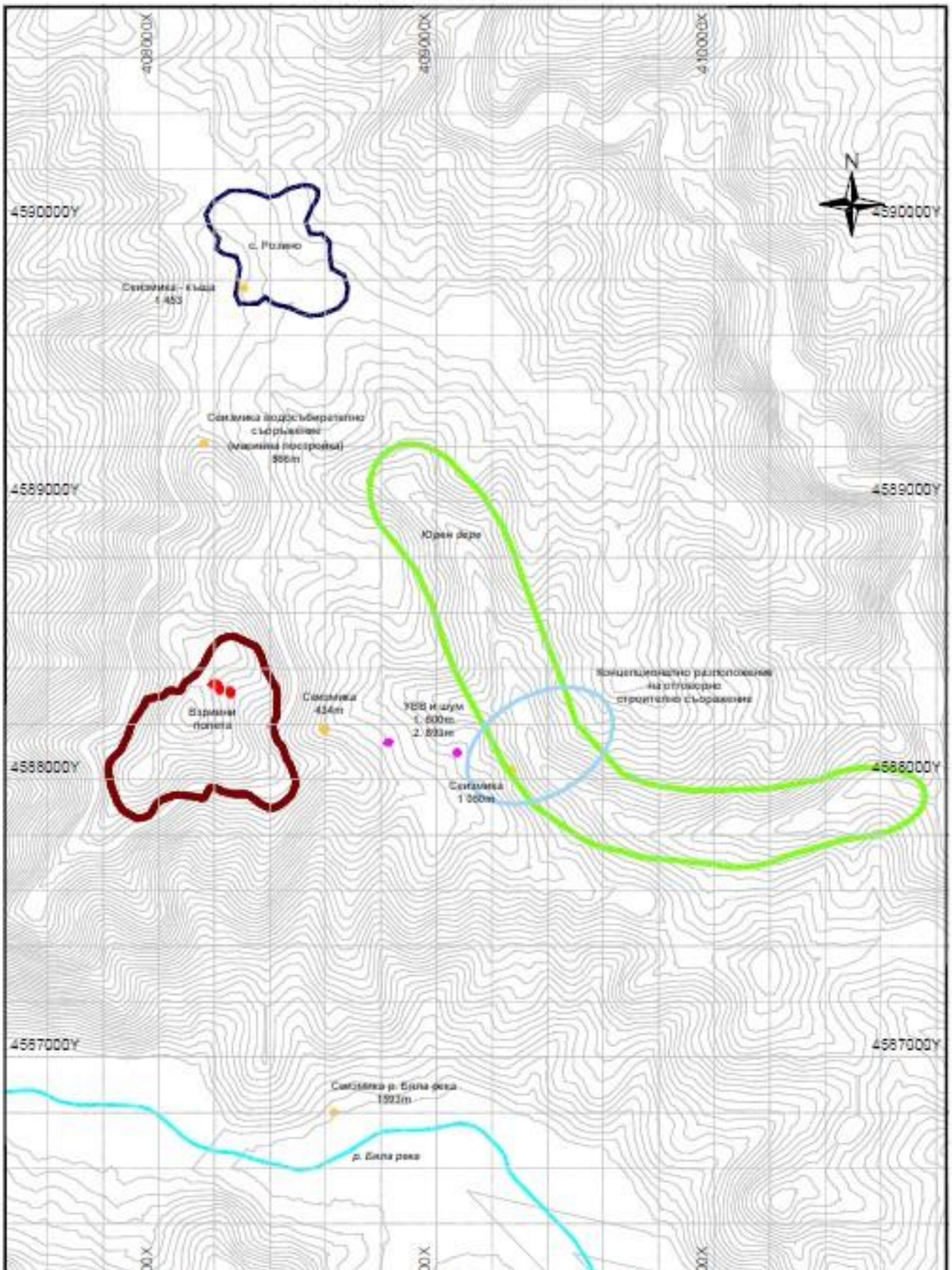
СИТУАЦИЯ – РАПОЛОЖЕНИЕ НА СЕНЗОРИТЕ ПРИ ЕКСПЕРИМЕНТАЛНОТО ВЗРИВЯВАНЕ ПРОВЕДЕНО НА 08.04.2020г.



М 1:20000

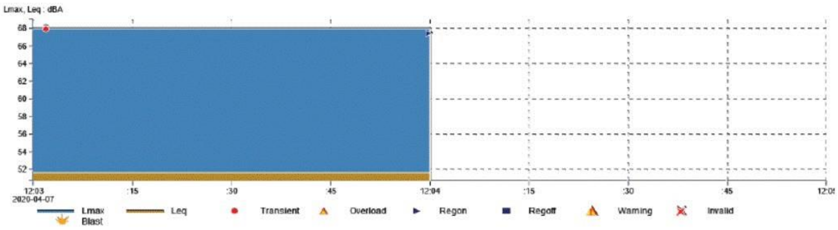
REGISTERED MEASUREMENT OF BACKGROUND NOISE BEFORE EXPERIMENTAL BLASTING IN THE ROSINO DEPOSIT AREA

Sigicom

Interval report

Page 1 of 1

Project	Tintyava OVOS
Project maintainer	Stanislav Nikolov
Customer	Logo Group
Customer contact	Hristo Stoev (+359888375715)
Time frame	2020-04-07 12:03 - 2020-04-07 12:05 (Europe/Sofia)
Measure point	MP3
Location	Noise Forest 600m
Sensor type	S50
Serial no.	12619
Master(s) serial no.	7873
Latest calibration	2020-03-27
Standard	Lmax + Leq 20-95 dBA Fast
Unit	dBA
Quantity	Sound Pres.Level, Eqv.Sound Pres.L
Interval time	2 min
Max	Lmax: 68.0 dBA, Leq: 51.70 dBA, Lcustom:

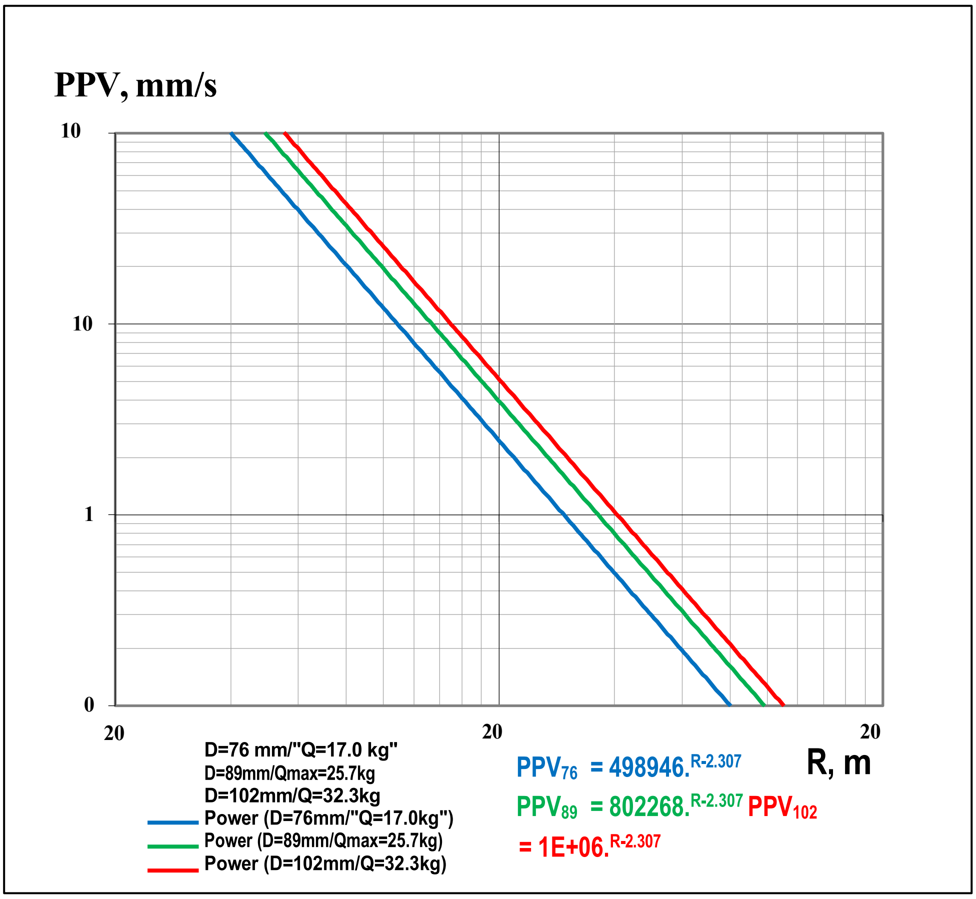


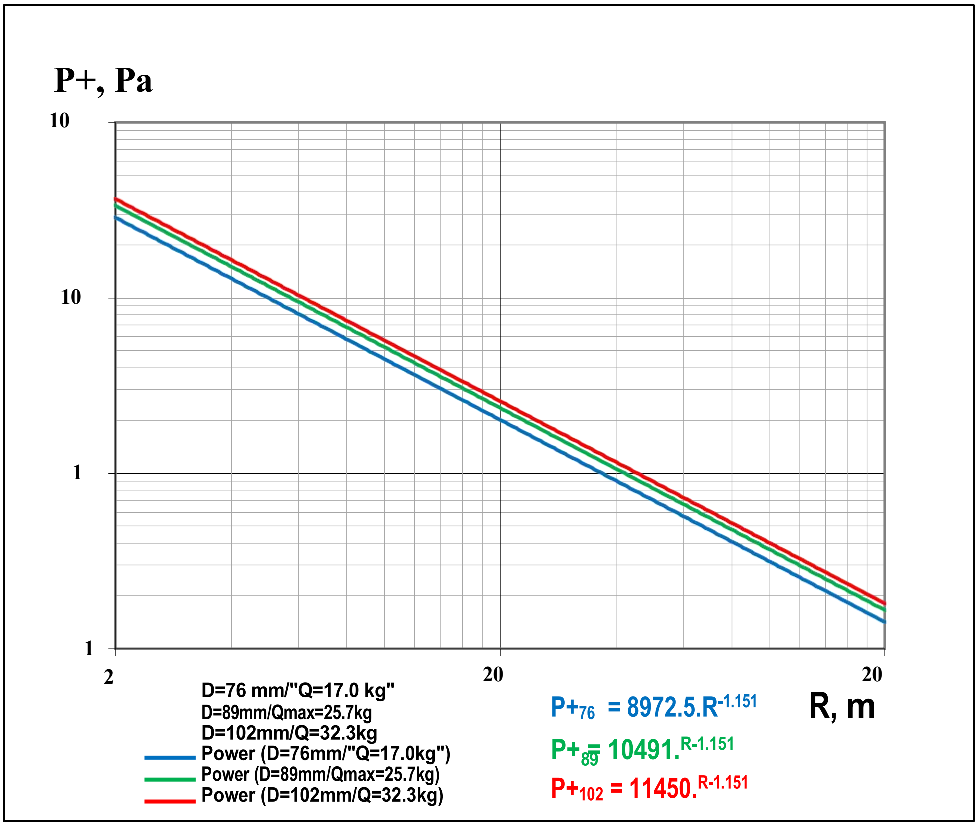
X-span	2020-04-07 12:03:00 - 2020-04-07 12:05:00
Y-span	Lmax, Leq : dBA: 50.70 - 69.0, Lcustom: 0.0 - 1.0

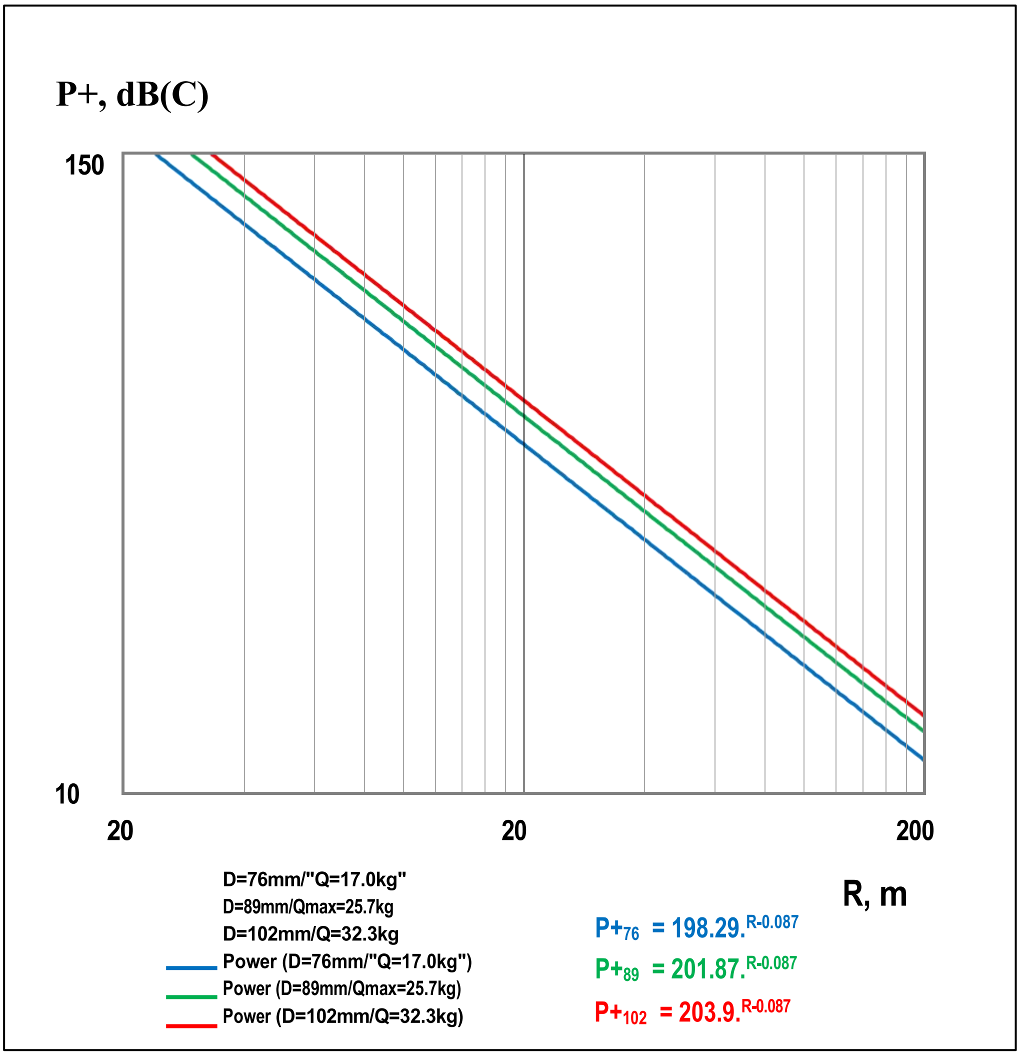
	Lmax	Leq	Lcustom
Max	68.0 dBA	51.70 dBA	-
Date	2020-04-07	2020-04-07	-
Time	12:04:00	12:04:00	-

Created by Stanislav Nikolov on 2020-04-14 20:11 EEST +0300

REGISTERED NOISE LEVEL IN MP6 (800 m) FROM THE WIND BURST IMMEDIATELY BEFORE THE EXPERIMENTAL BLASTING IN THE ROZINO DEPOSIT AREA


PPV, mm/s
10
10
1
0
20
20
20
D=76 mm/"Q=17.0 kg"
D=89mm/Qmax=25.7kg
D=102mm/Q=32.3kg
Power (D=76mm/"Q=17.0kg")
Power (D=89mm/Qmax=25.7kg)
Power (D=102mm/Q=32.3kg)
PPV76 = 498946.R-2.307
PPV89 = 802268.R-2.307
PPV102 = 1E+06.R-2.307
R, m


P+, Pa
10
10
1
1
2
20
20
D=76 mm/"Q=17.0 kg"
D=89mm/Qmax=25.7kg
D=102mm/Q=32.3kg
Power (D=76mm/"Q=17.0kg")
Power (D=89mm/Qmax=25.7kg)
Power (D=102mm/Q=32.3kg)
P+76 = 8972.5.R-1.151
P+89 = 10491.R-1.151
P+102 = 11450.R-1.151
R, m



P+, dB(C)
150
10
20
20
200
R, m
D=76mm/"Q=17.0kg"
D=89mm/Qmax=25.7kg
D=102mm/Q=32.3kg
Power (D=76mm/"Q=17.0kg")
Power (D=89mm/Qmax=25.7kg)
Power (D=102mm/Q=32.3kg)
P+76 = 198.29.R-0.087
P+89 = 201.87.R-0.087
P+102 = 203.9.R-0.087

APPENDIX No. 4

INTERNATIONAL STANDARDS FOR PERMISSIBLE EXPLOSIVE AND SEISMIC IMPACT

German standard DIN 4150

Type of construction	Maximum vibration velocity in mm/s		
	<10Hz	10Hz to 50Hz	50Hz to 100Hz
Industrial buildings	20	20	40
Residential buildings	5	5	15
Historical and cultural sites	3	3	8

French standard (87/70558)

Type of construction	Maximum vibration speed in mm/s		
	4Hz to 8Hz	8Hz to 30Hz	30Hz to 100Hz
Resistant	8	12	15
Sensitive structures	6	9	12
Very sensitive	4	6	9

Swedish standard (SS 460 48 66) – based on the conditions of the earth mass:

Ground base	Vibration velocity in mm/s
Unbound layers of sandy moraine, gravel, clay	18
Bonded layers of shale, soft limestone	35
Granites, gneisses, hard limestones, diabase	70

The Swedish standard is unique in that it regulates the determination of the permissible vibration velocity for a specific building structure, taking into account the type of ground, a number of construction factors and the location of the site in relation to the source of the explosive seismic impact. In this case, it is possible for the necessary restrictions not to be reduced to a single fixed standard.

Indian Standard (IS)

Type of building	Dominant excitation frequency, Hz		
	<8Hz	8Hz to 25Hz	> 25Hz
Residential buildings/structures (brick and cement)	5	10	15
Industrial buildings (reinforced concrete, metal structures)	10	20	25
Unique historical and highly sensitive structures	2	5	10
Temporary residential buildings/structures (bricks and cement)	10	15	25
Temporary industrial buildings (reinforced concrete, metal)	15	25	30

Australian Standard (AS2187.2)

Level	Standard No.	Vibration speed (mm/s)
Human perception threshold	-	0.5
Total environmental limit	-	5.0
Maximum permissible for residential buildings	AS2187.2	10.0
Industrial limit	AS2187.2	25.0
Minimum disturbance level	-	50

ANNEX No. 5

Other sources of vibration	Vibration rate mm/s	Distance m
Vibration rollers	**1.5**	**25**
Hydraulic impactor	**4.5**	**5**
	1.3	**10**
	0.4	**20**
	0.1	**50**
Tamping machine	**20**	**5**
	2	**15**
	0.3	**30**
Bulldozer	**2**	**5**
	0.2	**2**
Truck, flatbed	**up to 0.2**	**10-20**
Truck, private road	**up to 2**	**10-21**

Sound power for different sources		
3sound in the world of humans	**dB(A)**	**3sound in nature**
rocket engine	180	
rocket launch	17	
The threshold beyond which sound breaks the eardrum is called		
turbojet engine	160	
aircraft during take-off, at 50 metres	150	volcanic eruption
rock singer screaming into a microphone	140	
pneumatic hammer, machine gun	130	thunder
Threshold beyond which the sound is harmful		
ship engine room, concrete breaking, trumpet	12	
train in close proximity, underground, chainsaw, excavator	110	
music in a disco, helicopter	10	
truck with diesel engine	90	elephant
busy street, factory	80	
vacuum cleaner, typewriter	70	
normal speech	60	rooster
business office, refrigerator	50	goose, duck, rain
library	40	bird chirping
human whisper	30	city park
empty studio	20	rustling of tree leaves
wall clock	10	mouse