Optimization of drilling and blasting technology in the gypsum mine Glubokoye to reduce the share of boulders and fines

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Approved

MASTER THESIS

To attain the degree of Master of mining

Submitted by

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Dedicated to my beloved parents Ievgen Liubymtsev and Tatiana Liubymtseva

Declaration

I hereby declare that I completed this work without any improper help from a third party and without using any aids other than those cited. All ideas derived directly or indirectly from other sources are identified as such.

I did not seek the help of a professional doctorate-consultant. This thesis has not previously been submitted to another examination authority in the same or similar form in Germany or abroad.

Abstract

The current stage of blasting operations in Russia is characterized by a high rate of development and production of new types explosives and initiating devices. In this context improving the technology of mass explosions in the quarries is an important task.

The idea of the work is improving the energy efficiency of explosives and achieves the required quality of rock crushing. Increased explosive fragmentation of rock can be achieved by increasing the fugacity and brisance provided a rational volume concentration of energy in the rock mass explosion. To implement the necessary quality rock crushing author proposed to use explosives based on ammonium nitrate using turbulence promoter and modernized packaging explosive of cartridges.

However, to achieve the most efficient technology of blasting is an urgent question of constructing storage of explosive materials. In view of this, the authors developed a model project of powder storage with its feasibility study.

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Abbreviations

TNT – trinitrotoluene

CNaR - Construction Norms and Rules

GOST – USSR Standard-Setting Authority

RSS - Radiation Safety Standards

SNiP - Construction Norms

AN - ammonium nitrate

PAN – porous ammonium nitrate

OJSC – open join stock company

TS – Technical Specification (Russian low)

LLC – Limited Liability Company

ST – shock tube

CJSC – Closed Join Stock Company

UESR – Unified Explosive Safety Regulation

MMP - mobile mixing plant

General characteristics of the work

<u>Relevance of the work.</u> The current stage of blasting operations in Russia is characterized by a high rate of development and production of new types explosives and initiating devices. In this context improving the technology of mass explosions in the quarries is an important task. For companies the leading blasting operations come to the fore issues of the economy, environment and the quality of the rock mass crushing. Competitive market conditions and safety requirements of blasting driving organizations to move from the use of expensive environmentally harmful TNT explosives to use the simplest type of explosive ammonium nitrate - diesel fuel without loss of quality rock crushing. The desire to increase safety and reduce the cost of production of mass explosions encourages enterprises to use a fundamentally new systems of initiation, which offers domestic and foreign industry. In this context improving the technology of mass explosions in the quarries is an important task.

<u>Purpose</u> - optimization of drilling and blasting technology in the gypsum mine Glubokoye to reduce the share of boulders and fines.

<u>The idea of the work</u> - improving the energy efficiency of explosives and achieves the required quality of rock crushing. Increased explosive fragmentation of rock can be achieved by increasing the fugacity and brisance provided a rational volume concentration of energy in the rock mass explosion. In view of the complex geological features of the deposit there is a need to construction of storage facilities of explosives this will provide blasting operations with the best quality.

<u>Objectives:</u>

- to justify the use of the type explosives;

- to develop rational design of an explosive charge;

- to develop a model project for build of powder storage;

- to conduct a feasibility study of the project.

<u>Key points:</u>

- Use the simplest explosive compositions instead of powerful containing TNT explosives in blasting rocks determined using explosives based on a modified porous ammonium nitrate with high detonation velocity comparable with the velocity of detonation reference TNT explosives.

- Improving the quality of blasting with the use of packaged explosives reduced diameter for loading the water-flooded wells is achieved by increasing the energy of the explosion when used in the construction of borehole charges a turbulence detonation product.

- The use of the polymer shell with double tucked topknot inside allow to explode flooded parts of wells and increase the velocity of detonation.

Scientific novelty:

- Identified the conditions for the effective application of basic explosives based on a modified porous ammonium nitrate with high detonation velocity.

- Identified the conditions for the effective use of packaged explosives of reduced diameter in watered wells is to increase the energy of the explosion by the inclusion in the explosive charge the turbulence promoter.

- To increase the velocity of detonation between cartridges granular explosives suggested the use of dual polymer shell tucked topknot inside.

- Calculated the parameter of charging wells for Glubokoe deposits.

Practical significance:

- For the purpose blasting operations with the best quality has been developed a model project to build powder storage based on laws in Russia.

- Has been accomplished a feasibility study of the project for the construction of the warehouse.

Personal contribution of the author:

- development and justification of rational technology of mass explosions;

- ensuring cost-effectiveness and safety of blasting operations;

- development of a method for calculating the value of explosive charges;

- analyzing and summarizing the results of experimental industrial explosions;

- development a model project to build powder storage.

Amount of work: Master's thesis consists of an introduction, four chapters and conclusion of 117 pages, including 22 tables, 15 figures and references with 30 names.

Chapter One: Geological and industrial characteristics of the deposit

1.1 Overview of the deposit

Gypsum deposit Glubokoe is located in the Kholmogorsky district of Arkhangelsk region at 8 km north-west of the station Glubokoe - New railway line Arkhangelsk - Karpogory, on the watershed Chuga and Poser and 10 km south of the river Pinega.

Distance to Arkhangelsk by rail - 125 km. 10 km south-east of the deposit is located the village Svetly. Highway roads in the area of the field is not present. Village Svetly associated with the Archangel dirt roads.

The geographical coordinates of the field: $64^0\ 07^/ - 64^0\ 08^/$ north latitude and $42^0\ 38^/ - 42^0\ 41^/$ east longitude.

In the northern and eastern part of the deposit is Chugsky landscape reserve of regional importance, with the resolution of Arkhangelsk Oblast Administration in November 1996

Administratively the field is located within the boundaries of the municipality "Kholmogorsky District, Arkhangelsk Region" on the lands of forest Kuzomenskogo Kholmogorsky forestry.

8 km to the southeast of the deposit is located the village Svetly with a population of 2,000 people who work in the logging industry. Gypsum deposit Glubokoe is located in the Arkhangelsk region Kholmogorsky area south of the river Pinegi near the station Glubokoe - new railway line Arkhangelsk-Karpogory.

Passes through the village of the power line voltage of 110 kV. Water to the village is from lakes Svetly and Izbnoe.

The industrial zone of the village is connected with the station Glubokoe - new railway line normal track.

Village Glubokoe linked to the regional center of Arkhangelsk and Kholmogory improved dirt road.

The climate is temperate continental humid with long cold winters and short cool summers. The average annual temperature is about $0\ ^oC$.

Frosts reach $30\text{-}35^0$ (rarely $45\text{-}48^o$ C). In December and January are often strong blizzards and snowstorms. Steady snow cover is formed at the beginning of November. In March the snow cover reaches 50-60 cm. The snow cover lasts 160 days a year. The depth of soil freezing from 0.32 m to 1.8 m, the average - 0.56 m. The thickness of the ice at the end of winter in the rivers of 0.5-0.6 m and 1.0 m on the lakes. Small lakes and rivers freeze to the bottom. The average summer temperature is $13 \div 17^o$ C.

The largest river Pinega flows along the northern boundary of the field 10 km away.

In 0.25-0.5 km west of the deposit flows r. Pozera (left tributary of the river Pinegi), which refers to the small rivers. Banks are steep height of 10-20 m. The width of the buffer zone of the river 100 m.

1.2 The geological structure of the deposit

Gypsum deposit Glubokoe is located within Kuloisko-Pinezhsky gypsum-bearing area and is confined to the thickness of sedimentary formations Sotkinskoy Formation (P1 sot) Samarsky layer (P1 s) lower Permian performing the northern flank of the Moscow syncline and is composed of gypsum interbedded with dolomite, anhydrite and clays.

In its genesis manifestation of the Glubokoe refers to a type of sedimentary deposits and has seams shape with relatively sustained thickness and quality of minerals. From the north and east of the deposit is restricted security zone Chugskogo reserve in the west - the protected zone of the river Poser, from the south and south-west - the overseas with sharp increase a thickness of Quaternary sediments.

The length of the considered site is 2,3 km. The width varies from 0,6-0,8km to 1,4km and decreases in the direction from north to south. Lower bound estimation of reserves is a horizon with an altitude + 52 m. In the case where the thickness of the underlying gypsum anhydrite lie above this mark, the lower limit of the useful thickness passes through contact gypsum with anhydrite.

Gypsum thickness is represented by three main structural varieties of gypsum: cryptocrystalline, crystalline and porphyroblastic.

Cryptocrystalline gypsum characterized by fine-grained, less grained structure massive structure. Solid has monomineral composition with dense massive construction. Usually white, often - weakly cavernous. Perhaps the presence of dolomite (~ 15-20%) in the form of fine-grained aggregate clusters dirty-gray color, which develops the basic of fine fiber gypsum rock, forming a mottled, speckled stringer-less isolation. Also among the fine-grained aggregates of fine crystals of gypsum are marked size of 0.3-0.4 mm and less colorless mineral in the form of columns, needles and poorly decorated xenomorphic anhydrite grains.

Crystalline gypsum are characterized by uneven-grained, medium-grained structure, geteroblastic, plate-like structures. Characterized by prismatic lamellar form with a sufficiently clear outline of the crystallographic structure of fibrous and granular. Rocks consist of an aggregate of crystals of gypsum plate, less are columnar-prismatic forms of development; crystal structure is fine-fibered, less is grainy, has white color and light gray, sometimes translucent. Texture has massive form or spotted. Spotting is due to the presence of aggregates larger gypsum crystals in comparison with those that make up the bulk of the gray and dark gray dolomite often

mixed with substances characterized by the presence of small columnar crystals of anhydrite as inclusions in large grains of gypsum (sites poikilitic structures). Anhydrite in addition to small inclusions in gypsum forms threadlike veins intermittent nature consisting of small elongated needle-like crystals. Against the background of large crystals of gypsum allocated small separation point consisting of fine-grained, fine particulate matter dolomitic material. Crystalline gypsum occurring in the upper part of the section is usually porous and saccharoidal. It's clogged by a small fraction of iron and clay. Thickness of the crust of weathering is 0,4-0,7m.

Among the group of crystalline gypsum highlights the group cataclastic, schistose rocks with obvious signs of tectonic development. Rock consists of modular clusters plate, prismatic crystals of gypsum with a clear linear orientation and allotriomorphic grains that have no clear crystallographic constraints. Size of individual crystals of gypsum varies 3-5mm in some cases up to 7-8mm.

Porphyroblastic gypsum characterized by clearly defined porphyritic structure. Saturation of porphyritic rock gypsum crystals vary from 10-15% and in some cases as high as 35-40%. Varieties of gypsum between white and pink color characterized by presence in gypsum of large crystals of fine crystalline or microcrystalline groundmass. Porphyritic allocation of gypsum has sizes from 2mm up to 15-20mm. They often form small aggregates or irregular star-shaped and comprise from 10-20% to 30-40% by weight of the main species. These rocks are often cavernous. Cavities are usually associated with porphyry secretions of gypsum. Structure is Porphyroblastic with cryptocrystalline, fine-grained, mid-grained ground origin and with elements of poikilitic structures. Massive texture has elements of the linear orientation of plate and prismatic minerals. The structure is fine-fibered and fine-grained. In large gypsum crystals observed numerous small crystals of anhydrite predominantly acicular habit.

Clear pattern in the spread of the varieties of gypsum in area and in depth is not observed. Among the varieties of gypsum is dominated cryptocrystalline.

The maximal capacity of the uncovered gypsum strata within the considered site is 16,9m, minimal thickness is 3,8m. Thickness variation caused by the uneven of the roof and floor of gypsum strata. The absolute mark of the roof of gypsum thickness over most of the range from 58,1m to 64,2m, absolute marks of floor - from 51,6 to 54,9m. The average thickness of gypsum (in the circuit calculation of reserves) is 7,6m to 2,4m with fluctuations up to 11,0m.

The chemical composition of gypsum is quite stable. Weighted average content of $CaSO_4 \times 2H_2O$ is 88.83%.

Stratum of gypsum is heterogeneous in composition and contains lenticular intercalations of dolomite to 3-5%, clay - up to 15-17%, at least - anhydrite, iron hydroxides to 1%. In individual cases met the lens of fine sand capacity of 1.1 m.

The layers of dolomite usually observed in the crystalline gypsum. Their thickness is usually 0,3-0,7m and reaches 1,2-1,3m in the central part of the site. The upper contact dolomite with the host rock is gradual but precise. Gypsum on contact with dolomite contains light brown, grayish substance include nest-kind dolomite vein. Inclusion content increases as it approaches to the contact with gypsum. Rock thus gets spotted appearance. Lower contact is abrupt. Gypsum in the contact zone is fractured and often ferruginous.

In most cases under dolomites lie maroon and bright (green, blue, red) calcareous, heavy clay, often containing fragments of dolomite and gypsum. Thickness of clay layers is 0,3-1,4m. In the central part of the site thickness of clay and dolomite reaches 2,4-2,6m. There are separate the clay from and dolomite. Usually in the form of thin layers 0,1-0,2m capacity, less 0,5-2,3m.

Lenticular interlayers of anhydrite are usually seen in cryptocrystalline varieties of gypsum. Their thickness is 0,2-0,6m. Lenticular intercalations of marl has thickness 0,03-0,4 m were found in the central part of the site.

Stratum of gypsum is largely uneven by karst. On the surface there is a small superficial and deep karst formed due to the collapse of underground cavities. Deep Karst usually covered and developed by 60% of the territory. The greatest development it has in the south of the site and in the most northern part. Deep karst presented as craters round, oval, rarely is sink hole and irregularly shaped. The diameter of the wells is 20-60 m, depth ranges from 4 m to 6.7 m. Sink hole funnel reach out to 150-350 m. Slopes range from 40-50^0 to 70-80^0. In most steep sides of craters often observed outputs of gypsum. The funnels are dry. The average extent of karst on the site is 29% with fluctuations from 9% to 43%.

During drilling in the range of considered site revealed the presence of internal karst. Thickness of the karst ranges from 0,1-0,4 m to 2,4-2,5 m.

There are both filled karst cavities and unfilled. Large karst cavities are usually filled partially. Most often karst cavities filled with fragments of clay mixed of fragments of gypsum. Sometimes the fragments are cemented by clay. Rock that fills the karst takes the form of "breccia". The presence of filled karst cavities leads to degrade the quality of the useful thickness of gypsum.

Maximal thickness of unfilled caverns reaches 1,0-1,2 m.

Small surface karst which forming a cirque surface are occupies 40% of the territory and distributed in the northern and partly in the central part of the site, where gypsum come to the surface. The depth of the surface karst is 1,5-2,0 m. The territory occupied by karst is breakdowns of the upright blocks of gypsum up to 2x3x4 m. Overburden rocks are almost absent. Gypsum is covered only the soil-plant-bed with thickness of 0.2-0.3 m, sometimes in depressions remained sandy loam with thickness of 0.5-0.7 m and loam with thickness of 1-2 m.

The gypsum from the surface is less dense than the inside it is affected by weathering processes to a depth of 5-15 cm. The extent of karst area is spread to a depth of 2 m is 80-90%.

Along with small craters in the field there is developed a deep karst but to a much lesser extent. General stretch of karst is in the south-west to north-east along the azimuth 50-55^0. The length of the valley is about 700 m, width - 50-70 m, depth - 6.9 m. The slopes have varying steepness (from 40 0 to 80^0) composed of gypsum and covered by soil and vegetation layer. The bottom of the valley is filled with Quaternary sediments.

In accordance with the condition the cirque formation (to a depth of 2 m) is attributed to the rock overburden. The extent of karst for the rest of the useful thickness is taken to be 29%, as well as for the development of deep karst area.

Quaternary sediments within the site are represented by lacustrine-glacial clay, loam and sandy loam. On the field they are unevenly distributed. Within the territory of surface karst the Quaternary sediments are represented mainly by soil and vegetation layer with thickness 0,2-0,3m. In the lower parts there are loam and sandy loam with thickness to 0,5-1,0m and local distribution. To the north and south of the field capacity of Quaternary deposits is increased rather abruptly. So in the central part of the site on the border with the surface area of karst the thickness of Quaternary sediments is reaches 6,0-7,4m. In the rest of the site capacity of Quaternary sediments is 2,4-5,2 m in the northern part and 3,5-9,5 m in the southern part of the site. Here Quaternary deposits are mainly represented by dense brown loams or gray, brown clay containing rare gravel, pebbles and boulders unit. In the upper part of the section lies sandy loam with thickness 0.2-0.4 m, occasionally - 1.0 m. In unconsolidated Quaternary sediments are occur lenticular interlayers of dolomites with capacity 0.6 m.

Classification of rocks in deposit Glubokoe by fortress and fracture is shown in Table 1.1.

Table 1.1 Classification of rocks

Name of rock	Classification				
	Hardness			Rock fracturing	
	By SNiP	By prof. M.M. Protodyakonov		According to the classification by Interdepartmental Commission on explosives	
	group	category	Hardness coeff.	category	fracturing degree
Gypsum	V	VI	2 - 3	III	medium fractured (large-block)

Development of quarry for 2012 is executed within the block C1-1-A2 which is located in the south-east corner of the field of Glubokoe. During mining operations at 2008-2012 years in the useful thickness revealed the presence of three layers of red-brown clay with low-plasticity and semi-solid consistency. Clay interlayers are sub-horizontal bedding and extend over the entire area of these blocks.

The first (upper) interlayer of clay is lies beneath the crust of weathering of gypsum, while its absence underlies the Quaternary sediments. Interlayer thickness is ranges from 0,5 m to 2,3 m. The absolute mark of the roof is 60-64 m. The second (middle) interlayer clay is lies at 2-6 m below the ground and has thickness from 0,2 to 0,8 m. The third (lower) interlayer of clay has average thickness 0.5 m ayd located at 2-4 m below the second. In the reports of prospecting work which carried out in the field these interlayers are specified in the form of lenses or attributed to aggregates internal karst formations.

For mining operations in 2013 was selected a north direction along the eastern boundary of the block C1-1-A2.

1.3 The hydrogeological conditions of the deposit

Hydrogeological conditions of the site are determined by its physical and geographical location. They are confined to the useful thickness of gypsum karst deposits of sotkinskaya Formation of the lower Permian and its location on the watershed Poser and Chuga rivers.

Hydrogeological conditions of field were studied relatively details in 1986. Been measured groundwater levels in wells, pumping from two wells and monitoring observations.

Hydrogeological conditions of deposit development are characterized by extremely unrestrained groundwater level.

Single stable aquifer associated with the basis of discharge is below the base of gypsum thickness (lower abs. depth mark 40 m). Occurring to different hypsometric levels of groundwater it is associated with the local "hanging" aquifers confined to local systems of cracks and caverns. They can provide a significant (up to 20-30 m^3/h) but short-lived (due to limited availability) breakouts water into the quarry.

River Poser is not a basis of groundwater discharge.

Basis of groundwater discharge is most likely connected with an underground river known in these places with manifestation of which on the surface is probably located within the site of karst valley.

In located at the northeast corner of the field of large sinkholes filled with water the water level is at around 37 m. Apparently this is the level of a continuous aquifer associated with the basis of discharge.

Despite the sharp fluctuations in groundwater levels there is a certain pattern in their distribution. The highest levels (above abs. mark + 55m) are found in the southern and north-eastern parts of the site. The lowest levels (lower abs. mark + 50m) are observed in the middle part of the site and forming two sink hole tabs submeridional strike. One is under the karst valley and other in the south. In most of the area groundwater level is within the absolute elevations from +50m to +55m.

Monolithic gypsum has very low water conductivity (filtration coefficient is a few thousandths of a meter per day). Flooded pit is due to constant water inflow of groundwater will be 0.4 - 0.5 m^3/h during the first years of operation and 5 m^3/h at the end of field development.

The main inflow of water into the quarry will be from precipitation. The average annual number of which is 0.7 m^3/h of quarry hectare. In extreme conditions during periods of heavy rain and snowmelt intense it can reach 7 - 12 m^3/h of quarry hectare. A substantial portion of the water will be filtered through the cracks in the bottom of ponor and career to the underlying aquifer associated with the basis of discharge.

Groundwater gypsum-bearing strata are largely mineralized.

Waste dump water will be mainly formed by precipitation. Their mineralization is considerably lower than in the groundwater.

1.4 Qualitative characterization of minerals

Assessment of the quality of minerals and gets out of it products are manufactured in accordance with the requirements of the following standards:

GOST 4013-82 "gypsum and anhydrite stone for the production of binding materials";

GOST 30108-94 "Building materials and products. Determination of specific effective activity of natural radionuclides ".

According to the results of laboratory analyzes established suitability of gypsum production for binding materials and as an additive in cement.

In accordance with the Radiation Safety Standards (RSS-99) and Sanitary Norms (SN 2.6.1.758-99) the rocks of useful stratum are assigned to the 1st class building materials and can be used in all types of construction work without restrictions.

1.4.1 Quality of rocks

Quality of raw materials is determined by petrographic characteristics of rocks, radiative properties, physical and mechanical characteristics, true average density, water absorption and dry strength.

Petrographic characteristics of rock strata is established on geological documentation of wells, mining, natural outcrops with the petrographic analysis of 34 thin sections and the results of the prospecting hole samples studying. All structural varieties of gypsum rocks are characterized by identical gypsum content. Therefore, belong to a single technological species.

Indicators the quality of original rock for the production of gypsum deposits Glubokoe shown in (Table 1.2) were used to calculate the approved balance sheet reserves and definition of operational losses and dilution.

Table 1.2 Quality of rocks

№	The name of indicators	quality indicators (average)
1	Interlayers overburden capacity of 1m,% dolomite clay anhydrite aleurolite Clay as filler of karst cavities	2 2,2 0,7 0,3 0,5
2	True density, g / cm^3	2,47
3	The average density, g / cm^3	2,17
4	Water absorption,%	5,5
5	Natural moisture,%	3,9
6	Mechanical compressive strength in the dry state, MPa	22,5
7	Gypsum content,%	88,6

All structural varieties of gypsum rocks are characterized by identical gypsum content, therefore belong to a single technological species.

Thickness of the gypsum contains interlayers of rough. Interlayers of barren rock have capacity 1,5-3,4 m and assigned to the internal stripping. They are not ubiquitous and are found in the northern part of the site which shows as anhydrite. In the central part of the area they are represented by dolomite and clay. The capacity of interlayers waste rock of 1m or less are included in the useful thickness.

Quality of useful rocks thickness are measured according to GOST 4013-82 "gypsum and anhydrite stone for the production binding materials."

From taken samples were assigned to 1 grade 33 samples (24%) to 2 grade - 74 samples (53%), to grade 3 - 26 samples (18%), to grade 4 - 7 samples (5%).

1.4.2 Radiation and hygienic assessment of minerals

In the assessment process were selected 3 samples in different parts of the site for radiation and hygienic evaluation of rocks. The obtained data indicate that the effective specific activity of

natural radionuclides in useful rocks of stratum is less than 15 Bq/kg. In accordance with the Radiation Safety Standards (RSS-99), SN 2.6.1.758-99 and GOST 30108-94 "Building materials and products. Determination of specific effective activity of natural radionuclides" the useful rocks stratum field Glubokoe refers to building materials of 1 class. As their effective specific activity does not exceed 370 Bq / kg and can be used in all types of construction works without restrictions.

Chapter Two: Justification of the explosive choice

At present the Russian State Technical Supervision approved for use more than 100 kinds of explosives with different energy and detonation characteristics. However, the type of explosives used in most cases is taken without regard to the explosive properties of the rock mass and the desired degree of fragmentation. As a result in quarries the specific consumption of explosives has increased significantly with high oversize output 10-15%.

In recent years there are wide use of conversion and produced on the field explosives. For these explosives there are not established the sound of use and optimal parameters of drilling and blasting operations in specific mining conditions. This is leading to unsatisfactory results of the explosion and the rise in the cost of drilling and blasting.

Improving the quality of blast rock crushing without an increase in the specific consumption of explosives is associated with an increased efficiency of the explosive fragmentation which depends on the characteristics of used explosives and blasting conditions.

Therefore, the problem of rational justification conditions of use industrial explosives in accordance with their energy and detonation characteristics, properties of the explosive of array for required quality of explosive fragmentation and costs of drilling and blasting is relevant.

Currently on the market a large number of new types explosives and initiation systems are proposed by domestic and foreign industry. For this purpose these researches were performed.

2.1 Blasting of not flooded wells

In dry wells of quarries which produce building materials is mainly used TNT-contained Grammonite 79/21. Replacement of Grammonite 79/21 by mixture of simple composition explosive (Granulit UP-1, igdanit) while maintaining the well spacing results in an increased yield oversize. And as a result lead to increase the cost of stone crushing due to the weakness of the simplest explosives compared with TNT-contained.

One of the simplest ways to increase the capacity of explosive materials is the use of explosives based on porous ammonium nitrate (Granulites M, RP-1, RP-2, NM-1). Comparative tests have shown that the quality of the preparation of the rock mass explosive is comparable to that obtained when using Grammonite 79/21.

The task for achieving high quality of rock mass crushing using granulite UP-1 has found the solution using the technology of turbulence promoter. Using promoter heat the deflagration granulite UP-1 is increased by about a third, making fugacity heat at 15% more than in the Grammonite 79/21.

2.2 Blasting of watered wells

Problem of defining waterproof and cheap enough explosives for blasting of watered wells is the most difficult and important task. Currently the largest mining companies in the quarries with aquifers are mainly used emulsion explosives. Their use are remains the most inexpensive way of solving the problem of explosion watered wells. Large careers are oriented to the construction and operation of manufacturing items waterproof emulsion explosives (poremite and granemite).

However, this method cannot be sufficiently efficient for relatively small organizations. Because they cannot afford to build expensive plants to produce emulsion explosives and acquisition of appropriate pump trucks for delivery to the unit and feed emulsion explosives in the hole. For them the list is limited mostly by expensive Granulatol, Grammonite 30/70, cartridged explosive. Due to the fact that the aquifer of deposit Glubokoe is below that absolute level of the mine development this method does not fully comply with the technical and economic requirements.

An alternative to the use of explosives in industry of non-metal enterprises can serve a cartridged not waterproof explosives relatively smaller hole diameter for blasting of not watered well. These include a commercially available Grammonite P21 (79% AN and 21% TNT). Given the relative cheapness of Grammonite P21 the solution of solving the problem of explosion watered horizons has a great future. Also the use Granulite UP-1 (simplest three-component explosive) in which to increase the holding capacity on surfaces the granules dense of ammonium nitrate oil (GOST 2-85) is used carbon powder. Or used in the field of Glubokoe granulite RP-1.

2.3 Granular explosives

Granulite UP-1 (simplest three-component explosive) in which to increase the holding capacity on surfaces the granules dense of ammonium nitrate oil (GOST 2-85) is used carbon powder. Granulite UP-1 is characterized by:

- Relatively low cost;

- The possibility of complete mechanization of the production and the loading of blast holes;

- Sufficient power of blasting;

- Physical stability to charge wells after drilling them in a few days.

The main disadvantages of granulite UP-1 are:

- Low water resistance;

- Insufficient pressure for blasting of hard blasted rock;

- A large number of toxic gases emissions.

To reduce the cost of blasting operations and improve the quality of blasted rock mass are constantly improved blasting parameters. Including conducted tests of new types of industrial explosives and own production allowed for use by Rostekhnadzor.

World experience of production and consumption of simple explosives indicates that the explosive which is incorporated into the porous ammonium nitrate is very effective in blasting rocks of varying strength and difficulties blasting. Porous ammonium nitrate has a high retention in relation to liquid petroleum products. This allows to make a simple explosives with stable composition.

Currently in Russian market appeared the enterprises producing porous ammonium nitrate for the production of explosives. The quality is not inferior to foreign analogues.

Use of porous ammonium nitrate in the production of explosives allows to obtain homogeneous composition mixture which is in explosion form a small amount of toxic gases. At 6% of the liquid phase of oil the specific energy of the explosion rises to 30-38 J/kg for mixtures with zero oxygen balance.

In 2003 at stage of preparation no TNT explosives were mastered the production of explosives based on porous ammonium nitrate - granulite RP-1, which differs from granulite UP-1 simple component composition.

Granulite RP-1 is designed for dry blasting and dry parts of flooded wells in rocks with factor of a fortress up to 15 on a scale of Professor Protodjakonov M.M.

According to the work of the Arslanov K.R. and Angelica G.K. "Analysis of the use of explosives in modern production", a comparison was made of exploded blocks (shape and dimensions collapsed, the average linear size of a piece of rock, performance excavators) charged using Granulit UP-1, Granulit RP-1and Grammonit 79/21. The efficiency of Granulit RP-1 was higher than that of Granulit UP-1 and almost equivalent performance of Grammonit 79/21.

The maximum size of a piece of rock 1,2-1,5 m. The average linear size of a piece of rock 0,28-0,37 m.

On all blocks of the sites charged using Granulit RP-1 the excavators have passed on the project marks the horizon or below them without any difficulty in excavation. Specific consumption for blasted blocks by Granulit RP-1 was reduced by an average of 12.5% compared with the blocks exploded using Granulit UP-1.

With increasing depth of cut at mining are increases airing after the production of mass explosion, during which are idle of mining equipment. During the negative temperature of air the duration of ventilation reaches sometimes 3 or more hours. In this regard one of the advantages

of using as a Granulit RP-1 or Sibirit-1200 (1000) is small amount of toxic gases generated by the explosion.

Using Sibirit 1200 (1000) and Granulit RP-1 with higher energy performance compared with Granulit UP-1 is allowed to expand the grid wells, increase the height of the column charge, reduce specific consumption, reduce the amount of drilling and increase the yield of the blasted rock mass. At the same time the use of granulite RP-1 which has a lower density charging than the granulite UP-1 is allowed to refuse from dispersed explosive charge and improve the crushing at top of bench.

According to the research outlined in the thesis of Grishin A.N. "Improving the technology of mass explosions in the quarries of building materials" can make the following analysis.

Rate technical and economic efficiency transition to cartriged explosives is possible if to answer several questions. The most important ones - what is real capacity of the wells and what is the overlap factor of the initial charge of water level during the charging?

To answer these questions on the OJSC "Novosibirskvzryvprom" was built a stand simulating the well diameter of 220 mm on a scale of 1: 1 on which was conducted tests of packaged explosives.

The following parameters were recorded: the mass of charge m, the height of the column of charge H, the height of the water column h, capacity of wells $P = m/H$, raising the maximum level of the water column due to its displacement during charging h_{max}, overlap factor k.

During the charging of watered wells using Hexonit P-1 (its parameters are denoted by the subscript "1") is immersed in water due to the relatively high density, while Grammonit P21-180 (parameters with index "2") - due to the penetration of water into the cartridge through the holes in polyethylene sheath.

This difference is due to scheduling change h (m) and H (m) (Fig. 2.1) and the values P and k of given explosives. Tests have shown that the capacity of Geksonita P1,R1 is 31.25 kg / m (for comparison charging of the wells using Granulatol such diameter P_{TNT} = 38 kg / m). Capacity Grammonit P21-180 P2 is 27.7 kg / m, i.e. 10-12% smaller than P1 despite the same diameter of cartridges.
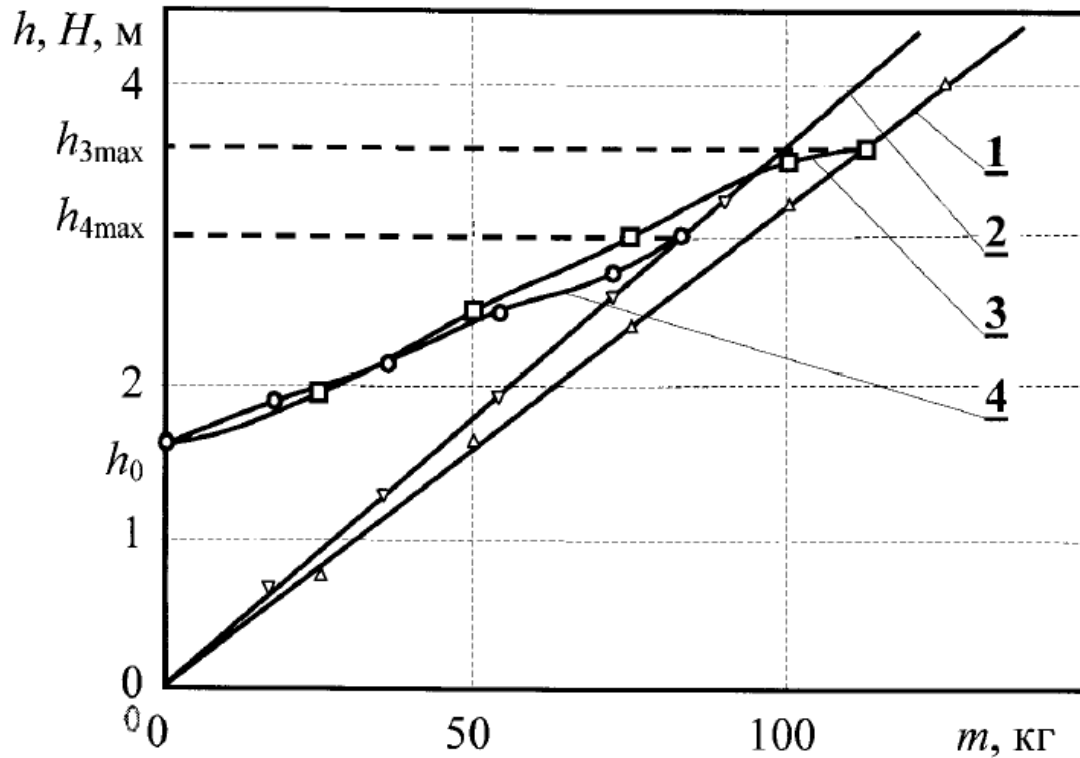
Fig. 2.1 Comparison of raising the water level *h* (lines 3 and 4) from the entry-level h_0 = 1,6 m at charging the bench holes with a diameter of 220 mm using Geksonit P-1 (line 1 H (m)) and Grammonit P21-180 (line 2).

Overlap factor k for Geksonit P-1 - *k1* = 2,25, for Grammonit P21-180 - *k2* = 1,87.

In cost expression the efficiency of blasting depends on three factors: the price of explosives *C*, as well as the values of *P* and *k*. Fig. 2.2 shows the dependence of the coefficient of water cut h_0/H_{max} dimensionless costs blasting *CP* when charging of 1 m borehole leading by combined charge height H_{max}:

$$CP = \frac{C_w P_w h_0 k + C_d P_d (H_{max} - h_0 k)}{C_{TNT} P_{TNT} H_{max}} \qquad (1)$$

where the subscripts *w* and *d* relate to explosives which is being charged watering and dry well, respectively; C_{TNT} - selling cost of 1 kg Granulatol (prices are taken as of 01.01.06). $C_{TNT} P_{TNT}$ product is the value of the Granulatol charge placed in 1 m of borehole. Relative price C_w/C_{TNT} of waterproof explosives: Grammonit 30/70 is 0.764; Grammonit P21 is 0.435; Geksonit N-1 is 0.432. For charging the dry part of the well accepted Granulit UP-1 with the ratio of C_d/C_{TNT} = 0,315.
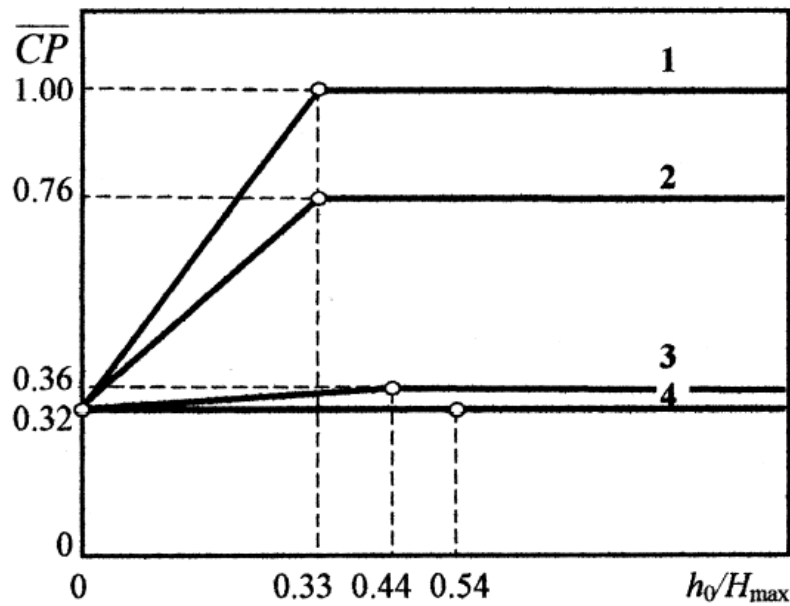
Fig. 2.2 The dimensionless value of explosives with charging of 1 m borehole by combined charge of the relative water content of wells: 1 - Granulotol; 2 - Grammonit 30/70; 3 - Hexonit P-1; 4 - Grammonit P21-180

Fig. 2.2 and the expression (1) shows that at $h_0 = 0$ (dry hole) CP corresponds to the continuous coring charge of not waterproof Granulit UP-1. With increasing h_0 between $0 < h_0/H_{max} < 1/k$ CP the costs increase linearly at a charge of 1 m borehole as in the numerator of (4) increasing the share of relatively expensive waterproof explosives. When $h_0/H_{max} \geq 1/k$ (i.e. $h_{max} \geq H_{max}$) the well is charged by continuous coring charge waterproof explosive, so that CP remains constant.

Fig. 2.2 implies that the charging using Granulotol (line 1) or Grammonit 30/70 (line 2) is not economically feasible, that was to be expected. It was established that the charging of watered well by cartridged explosives in value close (line 3) or equivalent (line 4) charging of dry wells using Granulit UP-1. This means that at 100% utilization of Grammonit P21 can not control the water cut of wells and discard from combined charges by using this explosives in any hydrogeological setting.

Bench testing and industrial environments with variable initial value h_0 are revealed that on units with water content of wells up to 100% (i.e. before $h_0 \cong H_h$, where H_h - well depth) the use of cartridged explosives with permeable shell is advisable only if the conditions of continuous charging

$$H_k - h_0 k_2 \geq 3 \text{м} \qquad (2)$$

This is due to the slow filling of water into each cartridge when it is not loaded more then 2-3 cartridges, injected into the wellbore with a height close to 3 meters. Due to failure (2) will

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unproductive increase the time of wells charging (conducted in accordance with the timing from 2-3s to 30-40s per cartridge at $h_0 = H_h$) due to disruptions caused by the necessity of forced flooding of cartridges improvised means.

Measurements carried out on the stand that the cartridge of Grammonit P21-180 mass of 18 kg, being immersed in the watered well Ø 220 mm after shrinkage takes 0.58 m of its length. In this regard, design of the calculated mass explosion capacity of water-flooded wells should take RP21 = 31 kg explosive per meter. Knowing the heat of explosion Q and capacity by weight of the explosive P is not difficult to determine the capacity of the energy:

$$U = PQ \qquad\qquad (3)$$

Thus, the capacity of Ø 220 mm wells by weight of Granulotol explosive when charging a bulk density of 1000 kg/m^3 is R_{TNT} = 38 kg/m. Knowing this heat of explosion (Q_{TNT} = 4.1 MJ/kg), by the formula (3) can define its "energy capacity." In this case U_{TNT} = 156 MJ/m.

Charging using Grammonit P21-180 (Q = 4,31 MJ/kg) in accordance with (2) provides UP21 = 134 MJ/m, which is less than charging using Granulotol at about 14%. Therefore, to increase the heat of the explosion in charge included the vortex generator 4 of detonation products (Fig. 2.3).
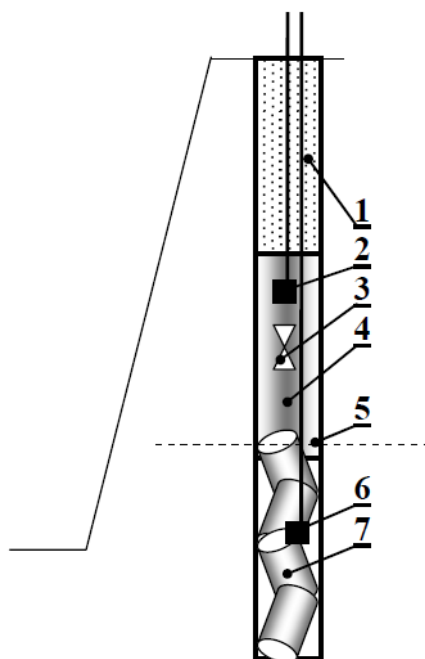
Fig. 2.3. construction of a combined charge using turbulence promoter:
1 - tamping,
2 - upper intermediate detonator with downhole deceleration 450 ms,
3 - vortex generator,
4 - Granulit UP-1 in the dry part of the well,
5 - the water level in the well,
6 - backup boosters with downhole deceleration 500 ms,
7 - Grammonit P21-180 (or P21-160) in the water-flooded part of the well

In accordance with the turbulence promoter technology the bottom (reverse) initiating charge was replaced by the upper (direct) initiation. In order to eliminate threat of kerving the upper (main) intermediate downhole detonator 2 is 450 ms deceleration, whereas the lower detonator 6 has an intermediate retardation of 500 ms and plays the role of a substitute.

Found that in turbulence promoter of a specific consumption of explosives q, adopted in the sample project, must be multiplied by a reduction factor $e_T < 1$:

$$e_T = 0{,}73 + \frac{0{,}02D^2}{Q} \qquad (4)$$

For Grammonit P21 ratio $e_{T(P21)} = 0.78$. Thus, the energy capacity of wells charged using Grammonit P21-180 using turbulence promoter was:

$$U_{T(\Pi 21)} = \frac{U_{\Pi 21}}{e_{T(\Pi 21)}} \qquad (5)$$

From the (3) - (5) is derived the formula for calculating energy capacity of well using turbulence promoter, which has the form

$$U_T = \frac{PQ^2}{0{,}73Q + 0{,}02D^2}, \text{ J/m} \qquad (6)$$

In this example the $U_{T(P21)} = 134/0.78 = 172$ MJ/m. This value is 10% higher than the values of U_{TNT} for Granulotol.

These estimates were confirmed in practice. Blasting of limestone without changing the standard grid drilling showed "the effect of overcharging" manifested in improved separation and a slight positive crushed rock than previously achieved by using of Granulotol. Blasting of diabase using cartridged explosives of this type led to the conclusion that the required quality of loosening can be obtained only by application of vortex generator.

Reduced capacity of watered wells by using cartridges Grammonit P21, the use of explosives with zero oxygen balance with minimal use of TNT, as well as improving combustion efficiency of explosive using turbulence promoter will increase the environmental safety of mass explosions on the earth's surface.

2.4 Application of simple explosives

The precise ere results of a study of use the simple explosives on quarries of building materials.

OJSC "Novosibirskvzryvprom" before 2003 in not watered blocks used mainly Grammonit 79/21. The transition to the use of twice cheaper Granulit UP-1 prevented unacceptably low quality of loosening array at constant parameters of well spacing and specific consumption of explosives.

The task of achieving high quality crushing by cheap Granulit UP-1 has found the solution using the technology of vortex generator. On the limestone quarry OJSC "Iskitimcement" the

block volume of 59 thousand m^3 was divided into two approximately equal parts. Wells on the control part of the unit were charged using Grammonit 79/21 (32802 kg) for the experimental part - Granulit UP-1 (20,960 kg). Wellhead at 6-6.5 m filled by material from dropping out. The distance between the holes in a row and between the rows of holes is 6 m. The wells are staggered. The actual specific consumption of explosive was 0,91 kg/m^3. The turbulence promoter of Granulit UP-1 was carried out with the direct initiation of charges. The second intermediate detonator was placed in the bottom of the wells for duplication in the event of failure of the first (Fig. 2.4, b). For control of the unit was used reverse initiation. Second intermediate detonator was set by the wellhead for duplication in the event of failure of the first (Fig. 2.4, a).
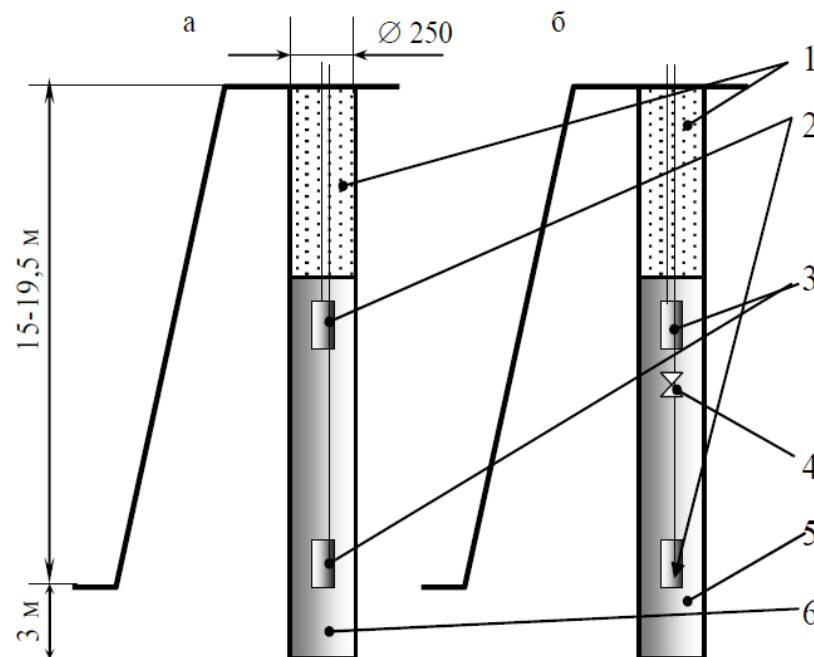
Fig. 2.4 Construction of the charges (a, b):
1 - stemming, 2 - intermediate detonator (deceleration downhole time 500 ms), 3 - intermediate detonator (deceleration downhole time 450 ms), 4 - vortex generator, 5 - Granulit UP-1, 6 - Grammonit 79/21

According to the results of the explosion found that an experimental part of the block where was an increased gap between the collapse of the blasted rock mass from slope of the bench and the best crushing with increased output fines. In this case the collapse remained a compact form. It was found that the transition to the use of Granulit UP-1 with turbulence promoter in hole charges for not watered blocks will provide significant economic benefit.

In case of using vortex generator there is question arose about the possibility of applying this technology in combined hole charges (Fig. 2.5). In this case the lower part of the charge 6 consists of waterproof explosive (Granipor BP-1 with detonation velocity in the water filled

condition D = 5300 m/s, in anhydrous - 3600 m/s). The upper part 4 of the charge is a simple explosive (granulite UP-1, D = 2900 m / s).
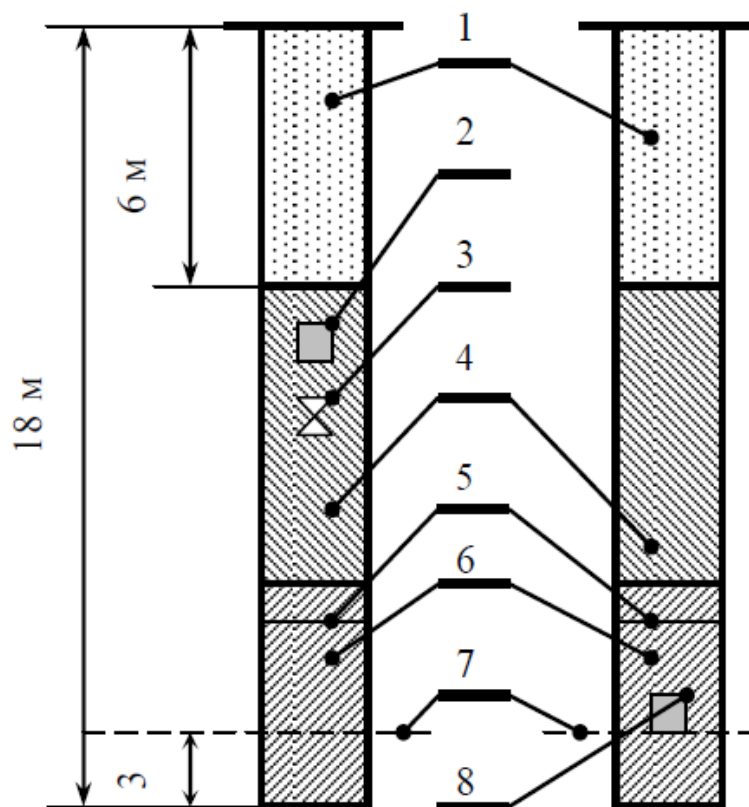
Fig. 2.5. Construction of charges for experimental wells using vortex generator (left) and model (right): (1 - stemming, 2 - position of the intermediate detonator for direct initiation which provided turbulence, 3 - vortex generator of detonation products, 4 - Granulit UP-1, 5 - water level in well, 6 - Granipor BP-1, 7 - horizon of bench bottom (70 m), 8 - typical intermediate position in the reverse detonator initiation)

The task was that turbulence promoter necessarily involves direct (top) initiation of charge from the intermediate detonator 2, in this case from the low-speed granulite UP-1 4 to high-speed Granipor BP-1 in anhydrous state 6, located above the water level 5, and followed by anhydrous BP-1 (D = 3600 m / sec) at water content (D = 5300 m / s). At the same time, usually in combined detonation charge is always transmitted from more detonation velocity of explosive to the less detonation velocity. In this case from waterproof Granipor 6 with water filled in state to the bottom of the charge - is not waterproof Granulit 4 in the upper part of the charge.

It is believed that the mass velocity of matter at the shock front of the detonation wave $u_c=0,44D$ and mass velocity of detonation products at Jouget $u_d = 0,25D$. It is known that in the construction of the capsule detonator and electric detonator primary explosives, denotes the index «I» (mercury fulminate, lead azide or teneres) have significantly lower rates of detonation

(D_I = 5200-5400 m / s) compared with secondary explosives, possessing index «II», (tetryl D_{II} = 7200 m/s; pentaerythitrol tetranitrate, hexogen D_{II} = 8200-8300 m/s), which does not interfere with their work. These initiating explosive detonators primers used the condition of transmission of detonation from the primary to the secondary explosive:

$$u_{c(1)} \geq u_{d(II)} \ (7)$$

$$(0{,}44 \bullet 5200 > 0{,}25 \bullet 8300)$$

where $u_{c(I)}$ - the mass velocity substance at the shock front of the detonation wave at low speed explosives; $u_{d(II)}$ - the mass velocity of detonation products at Jouget from high explosives.

The question as to whether the transfer is carried out in a similar way between the detonation granular explosive mixtures in the well, the study claimed. It has been suggested that one of the transmission conditions on the industrial explosive detonation with less detonation velocity D_I to explosive with higher speed D_{II} is also inequality (7).

To check the validity of condition (7) for industrial mixed explosives and determine whether the transmission of explosives detonation with low value D_I to waterproof with high explosives D_{II} ($D_{II} > D_I$) at OJSC "Novosibirskvzryvprom" was conducted pilot massive explosion in conditions of OJSC "Iskitimcement" hor. +90 m. Construction of the charges shown in Fig. 2.5.

As the low-speed explosive was taken Granulit UP-1 (D_I = 2900 m/s, $u_{2(I)}$ = 1280 m/s) and as high explosives was taken dry Granipor BP-1 (D_{II} = 3600 m/s, $u_{1(II)}$ = 900 m/s). Then the transfer was carried out from low-speed Granipor BP-1 (D_I = 3600 m/s, $u_{1(I)}$ = 1585 m/s) to the high speed watered (D_{II} = 5300 m/s, $u_{1(II)}$ = 1325 m/s). Condition (7) is performed in the one and in the other case. The essence of the experiment was to assess the condition (7) into the transmission of detonation from Granulit UP-1 to the dry Granipor BP-1. And then from the dry to watered Granipor BP-1. As a control parameter has performed the actual mark of bench bottom compared with the design project.

The charges were placed in the wells with a diameter of 250 mm. The height of the water column was at a level from 1 to 3 m.

It was found that at the reaming of bench bottom site in experimental wells using vortex generator system ranged from hor. 90.0 to the hor. 90.3 m. This is corresponds to the usual range of random variation in the control of the site.

On this basis concluded that in all experimental wells the transfer detonation occurred smoothly on full height the column of the combined charge. The results indicate that under the

condition (7) the transmission of detonation from low speed to high speed explosives is carried out in a stable regime for industrial explosives.

Subsequent of turbulence promoter with combined charges on the water-bearing blocks and lack of failures confirmed the correctness of the assessment results.

Before the start of production and application of Granulit M - explosive (such as ammonium nitrate and diesel) on the basis of porous ammonium nitrate there were a number of questions that needed to be answered. One of the issues are relating to the quality of porous ammonium nitrate, and as a consequence, to the actual explosive performance of Granulit M. The aim of this study was to determine the characteristics of explosive Granulit M which was made on the basis of the modified porous ammonium nitrate manufactured by OJSC "Azot" (Berezniki) with respecting of TS 2143- 029-00203795-2005.

To answer these questions were conducted research in two ways.

Produced a detonation velocity measurement in wells with Granulit M d = 220 mm and d = 110 mm. As a result were obtained values: 4048.7 m/s in a well d = 220 mm (Fig. 2.6) and 3403.6 m/s in a well d = 110 mm (Fig. 2.7).
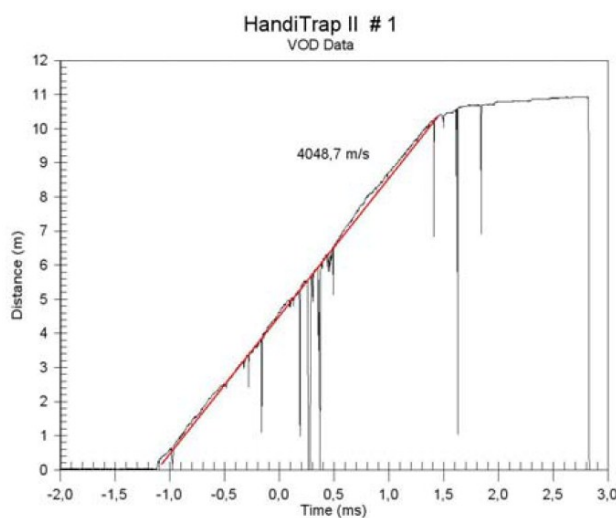
Fig. 2.6. Detonation velocity in the borehole with Granulit M (d= 220 mm)
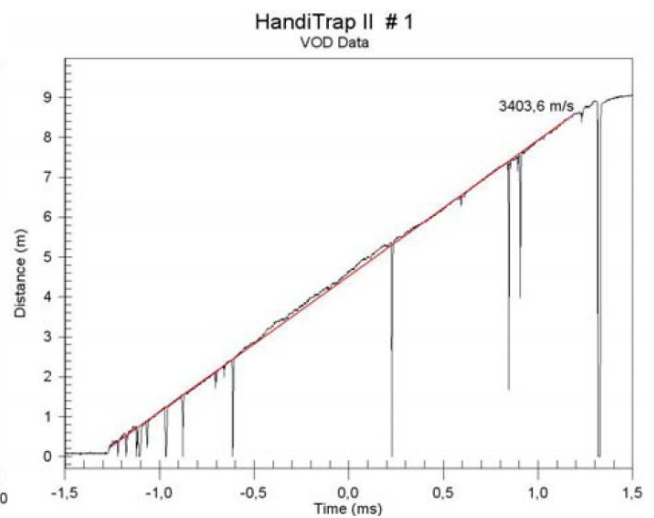
Fig. 2.7 Detonation velocity in the borehole with Granulit M (d = 110 mm)

Detonation velocity of Granulit M at these diameters is close to the detonation velocity of Grammonit 79/21. It has been found that the Granules M produced on the basis of the modified PAN is detonates at high velocity and can be used for blasting of hard rock in wells with big and small diameters.

In another case, investigations were directed to establishing of grading coarsensess in blasted rock mass using Granulit M and comparison with a grading coarsenses of blasted rock mass using Grammonit 79/21 (Fig. 2.8). For this purpose was produced a series of holes blasting with a diameter of 170 mm, which was drilled out by high-production pneumatic impact tool manufactured in Atlas Copco. Part of the wells was charged using Grammonit 79/21 and other part using Granulit M.
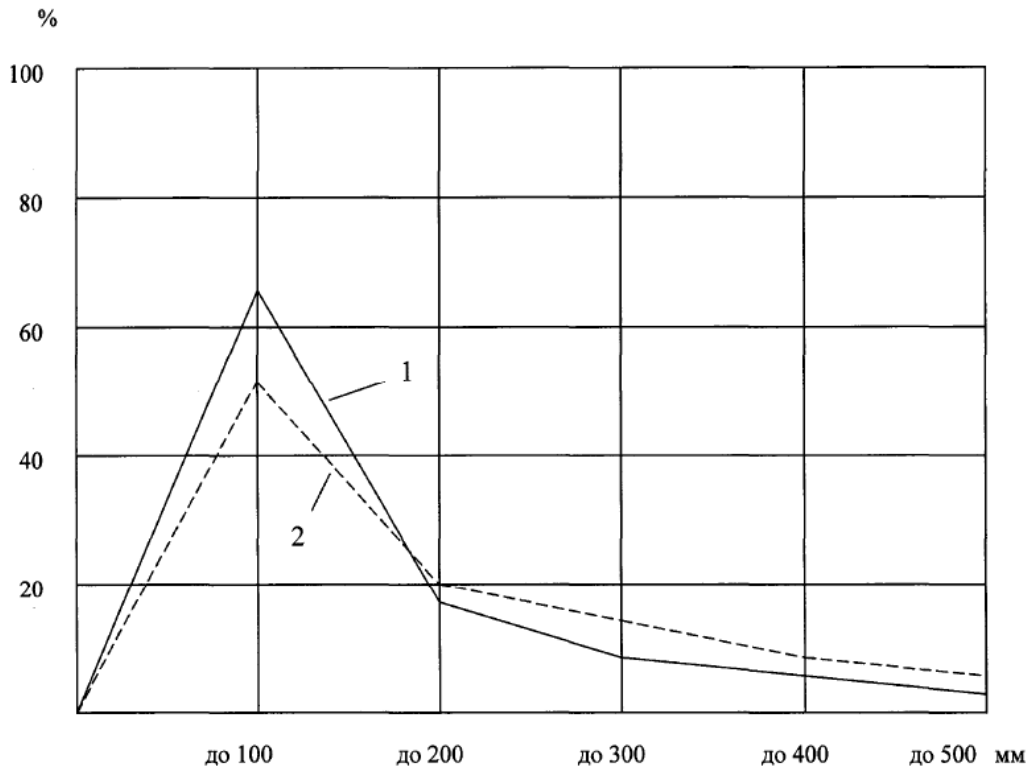
Fig. 2.8 Grain size distribution of blasted rock mass on Shipunovsky limestone quarry (1 - using Grammonit 79/21, 2 - using the Granulit M)

As can be seen from graphs the rock crushing using Granulit M has identical fragmentation in the case of Grammonit 79/21.

2.5 Waterproof shell polymer

The invention relates to the construction of a borehole charge and can be used in the mining industry in the breaking of rocks in dry and flooded conditions.

The essence of a utility model:

- Borehole charge consists of an explosive cartridges, which are the two shell polyamide sleeves are inserted into each other;

- The lower ends of each sleeve are assembled inside a "tuft" and clipped;

- The upper end of the inner polyamide sleeve assembled in "tuft" and clipped above the placement of explosives;

- Node clamp filled under the outer polyamide shell, the upper end of which is above the level of accommodation inner clipped polyamide shell;

- Then inserted in a plastic bag or a plastic sleeve with sealed lower end, a length equal to the height of the cartridge.

And also live primer as a patron of powdered ammonium nitrate explosive. Sensitive to the start pulse and capable of detonating cord to initiate detonation of explosive cartridges in a two-layer polyamide shell. The ends of which sealed in the manner described above, with the cartridge fixed on surface perpendicular to its axis of the detonating cord in the form of several turns of the helix.

The diameters of the cartridges and the explosive live primer are equal and smaller than the diameter of the well. Borehole explosive charge smoothly and operates reliably at crushing rocks in dry, pre-drained and partially flooded wells (Fig. 2.9)
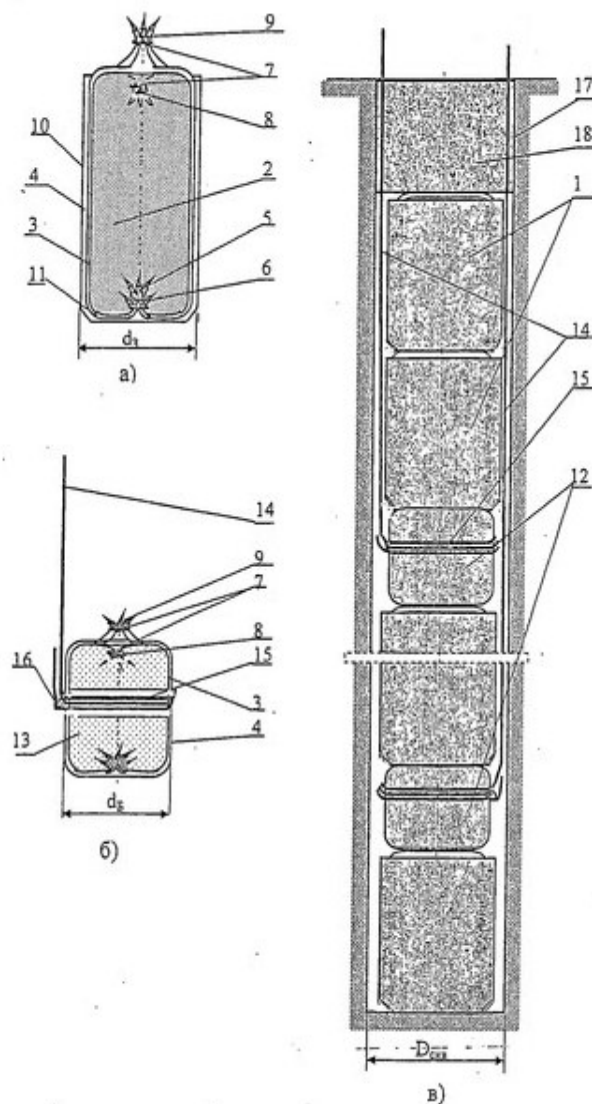
Fig. 2.9 Borehole charge of cartridged explosives in a polymer shell
a) - type cartridge explosives; b) - kind of live primer; a) - the kind borehole charge.

(1 - a cartridge explosives; 2 - explosive, 3 - inner polyamide sleeve, 4 - polyamide outer sleeve, 5 - "tuft" lower end of the inner sleeve polyamide 6 - "tuft" lower end of the outer sleeve polyamide, 7 - metal clip 8 - "tuft" upper end of the inner sleeve polyamide, 9 - "tuft" upper end of the outer sleeve polyamide, 10 - a plastic bag or a plastic sleeve, 11 - the lower end of the plastic bag or plastic sleeves, 12 - live primer 13 - powdered explosive of live primer, 14 - detonating cord, 15 - the spiral turns of detonating cord, 16 - knot tying detonating cord, 17 - well, 18 - inert stemming well, d_3 - the diameter of the cartridge explosive, d_6 - diameter of cartridge-live primer, D_{ckb} - the diameter of the hole.)

The invention relates to the construction of borehole charge and can be used in the mining industry in the breaking of rocks in dry and flooded conditions.

Development of rational structures explosive charges associated with the need to improve the efficiency of blasting using cheap ammonium nitrate explosives, with a wide range of detonation and energy characteristics. The main disadvantage of ammonium nitrate explosives is the reduction or complete loss of detonation characteristics of the high solubility of ammonium nitrate in charging of the flooded well and caking due to moisture in the ammonium nitrate during transportation and storage of explosives.

To ensure continuity of explosive detonation and its performance are widely used methods of waterproofing charges using water impermeable polymeric bags.

The closest of the known technical solutions to the claimed utility model is a hole charges, made in waterproof plastic sleeve with sealed end face. Which is placed in a pre-dried borehole (diameter greater than the diameter of the polymeric sleeve) of the cartridges ammonium nitrate explosive in waterproof plastic shell (diameter smaller than the diameter of the polymeric sleeve). The main disadvantage of this design is the charge restriction of its use because of the difficulty lowering and placing the polymer sleeve in deep wells.

The technical problem has been solved by the development of borehole explosive charge placed in a polymer sleeve explosive the cartridges in a polymeric shell. Initiating and stemming of inert material in which the shell of the explosive cartridge are two nylon sleeves that are inserted into each other, the lower ends of each sleeve are assembled inside a "tuft" and clipped. The upper end of the inner sleeve assembled in polyamide "tuft" and clipped above the placement of explosives. Node clamp filled with polyamide under the outer shell. The upper end is above the level of accommodation clipped internal polyamide membranes, then inserted in a plastic bag or a plastic sleeve with sealed lower end, a length equal to the height of the cartridge. One or more cartridges as live primer are powdered with ammonium nitrate explosive. The initiating pulse sensitive and capable of detonating cord to initiate the detonation of the explosive cartridges in a two-layer structure described above. Polyamide sheath with cartridge fixed on surface perpendicular to its axis of the detonating cord in the form of several turns of the helix. Diameter of explosive charge is less than live primer borehole diameter.

For manufacturing explosive shells and live primer cartridges used polyamide tube of the multilayer film. The film thickness of the polyethylene sleeve is taken not less than 150 microns. Explosive cartridges are made of an explosive on the basis of a porous or dense granular ammonium nitrate or milled ammonium nitrate. The live primer cartridges are made from powder explosive on the basis of milled ammonium nitrate.

A distinctive feature of the claimed charge is:

- Equal diameter explosive and live primer;

- Unification of cladding material and the method of sealing membranes cartridged explosive and live primer;

- Placing the explosive cartridge in double polyamide shell further in a plastic bag or a plastic sleeve with sealed lower end and equal length to the height of cartridge.

The technical result can only be achieved in combination of distinguishing features of the utility model.

A smaller but equal diameter of cartridged explosive and cartridged live primer relative to the diameter of borehole and provides free movement and adjustment of hole forming with continuous column charge of explosive. Intimate contact of explosive cartridge in a three-layer polymer shell and live primer cartridges in a two-layer polyamide shell is achieved by the proposed seal method the ends of the two polyamide membranes, thereby providing a pulse detonation transfer between cartridges and completeness of borehole detonation of an explosive charge.

Summary of the utility model is illustrated in Fig 2.9. Proposed borehole explosive charge is a continuous column consisting of cartridges (1) and ammonium nitrate explosive (2). On the basis of the granular (solid, porous) or milled ammonium nitrate in a three-layer polymer shell consisting of two polyamide sleeves (3, 4) of equal diameters, inserted one into the other. The lower ends of each are assembled inside a "tuft" (5, 6) and sealed metal clip (7). The upper end of the inner polyamide sleeve (3) after filling it with explosives (2) assembled in "tuft" (8). Sealed metal clip (7) is above the placement of explosive. Node clamp tucked under the outer polyamide sleeve, which is going to end in "tuft" (9). And clipped using metal clip (7) above the level of hosting an internal polyamide sleeve. For clipping used pneumatic machines that provide reliable attachment to "tuft" the polymer sleeves metal clips and sealing the ends of the cartridge from the penetration downhole water to the polymer shell. Cartridge in a two-layer polyamide sleeve mounted in a plastic bag or a plastic sleeve (10) with a film thickness of not less than 150 microns. With lower sealed end (11) of length is substantially equal to the height of explosive cartridge in the polyamide sheath. Live primer (12) is a cartridge of powdered ammonium nitrate explosive (13) responsive to the start pulse of the detonating cord (14) and able to initiate the

detonation of packaged explosive (2) in two polyamide sleeves. Sealing (sealing upper and lower ends) of which is carried out as described above. On the surface of the holder perpendicular to its axis fixed detonating cord (14) in the form of several turns of the helix (15), the ends of the detonating cord tied in a knot (16). The ends of the detonating cord from the live primer removed from the well and connected to the network of superficial explosive with detonating cord. Diameter of cartridged explosive (d_3) and cartridged live primer (d_6) are equal and smaller than the diameter of the well ($D_{CKB.}$).

Cartridges and of explosive live primer can be made in the field of blasting or import from the manufacturers of explosives.

Procedure for the manufacture of cartridges, explosive and live primer.

Take two nylon sleeves (3, 4) of equal diameters. The lower ends of each sleeve are collected in "tuft", clips metal clip or clips on the inside sleeve and outside sleeve turned inside out. And then inserted into each other, the inner sleeve is filled with explosives (2) or (13). The upper end of the inner polyamide sleeve (3) is collected in "tuft" (8), clips metal clip (7) above the placement of explosives, and tucked under the "tuft" (9) of the outer polyamide sleeve (4), which is clipped metal clip (7) above the clamp polyamide inner sleeve (3). In the manufacture of explosive cartridges polyamide membrane is then inserted into a plastic bag or in a plastic sleeve (10) with the sealed lower end (11) with a diameter close to the diameter and height of polyamide membranes substantially equal to the height cartridge. In the manufacture of cartridge for the live primer the polyethylene sheath is not used.

The order of making live primer:

Live primer is made in the field of blasting before loading the wells. On the shell cartridge live primer detonating cord (14) is secured by strapping it several turns (15) perpendicular to the axis cartridge, its ends tied in a knot (16), one end of the detonating cord is derived from the well to the surface.

The procedure for forming a column borehole charge:

Depending on the diameter and depth of the well (17), the height of the column borehole charge selected dimensions and mass characteristics of cartridges, types of explosives to fill the shell cartridges, calculated the optimal number of explosive cartridges and live primer needed for wells charging. Then the column is formed by lowering borehole charge in sequence of explosive cartridges (1) and live primer (12). Produce stemming of the upper part of the hole uncharged inert material (18). Undermining of borehole charge is carried by a conventional method.

Due to the proposed method of sealing the ends of explosive cartridges and live primer cartridges are reached close contact with each other, which ensures reliable transmission of the pulse detonation and complete detonation of the charge column.

Overclamping of internal polyamide sleeve above the level of the explosive and polyamide outer sleeve above the clamp polyamide inner sleeve are creates a compensation amount in the inner and outer polyamide membranes. Thereby it's preventing their collision with gaps between cartridges in a free fall into the well. Due to the waterproof material shell cartridges ammonium nitrate of explosive is not in contact with the well water in the process of loading and finding cartridges with explosive in flooded wells before they explode. This ensures consistency of component composition, energy characteristics, explosive detonation and charge based on it. With the loading of explosive the cartridges having a diameter smaller than the diameter of the well are freely moving in the well under the action of its own weight. Additional plastic shell protects the polyamide shells which is filled by not waterproof ammonium nitrate explosive from rupture in contact with uneven walls cartridges well, thus ensuring consistency of the component composition of the explosive. In case of hit the cartridge explosive on the bottom of the well the outer polyethylene sheath with free upper not clipped end is retain their integrity and protects against break polyamide membranes made with a compensation amount, so ammonium nitrate explosive is not in contact with water during charging the flooded wells.

2.6. Vortex generator

Turbulator of downhole products such as "Turbos" TU 7288-002-10887323-95 (hereinafter - the "turbulator") is designed to improve the actual utilization of the potential energy of the charges of core industrial types explosives by increasing the speed of the secondary chemical reactions burnt out in the well after the passage detonation until the breakthrough of detonation products on the free surface.

Increasing the speed of the secondary chemical reactions explosives afterburning is achieved by creating in the well via turbulator vortex flows in the detonation products after passage of the detonation wave. The vortex flow is intense mixing (forced convection) of detonation products, which increases the rate of chemical reactions of decomposition products of incomplete burn-explosives remaining in the detonation products after passage of the detonation wave.

Blasting borehole explosive charges with afterburning of detonation products in the vortex flow in the well before their breakthrough on the free surface is termed vortex generator and intended to:

- Reduce the specific consumption of explosives and increase the yield of the rock mass with a meter of blast hole in the production of massive explosions at loosening;

- To improve the quality preparation of explosive rock mass, improve elaboration floor bench and improve the stability of the slope bench;

- To increase the discharge rate of the rock mass in the dump blast energy in the conduct of explosives relief.

Application of turbulence promoter on mining companies will lead to reduce the need of explosives and volumes of drilling, reduce the cost of secondary crushing, increase the productivity of excavators and mining safety.

2.6.1 The unit turbulator

Vortex generator is a metal plate 2 x 20 x 180 mm (preferably) or 1.5 x 20 x 170 mm (length coring charges less than 5 m), twisted fusiform full revolution through 360 °. For ease of use with a life primer T-400 and others the turbulator can have an extra hole and recess (Fig. 2.10).
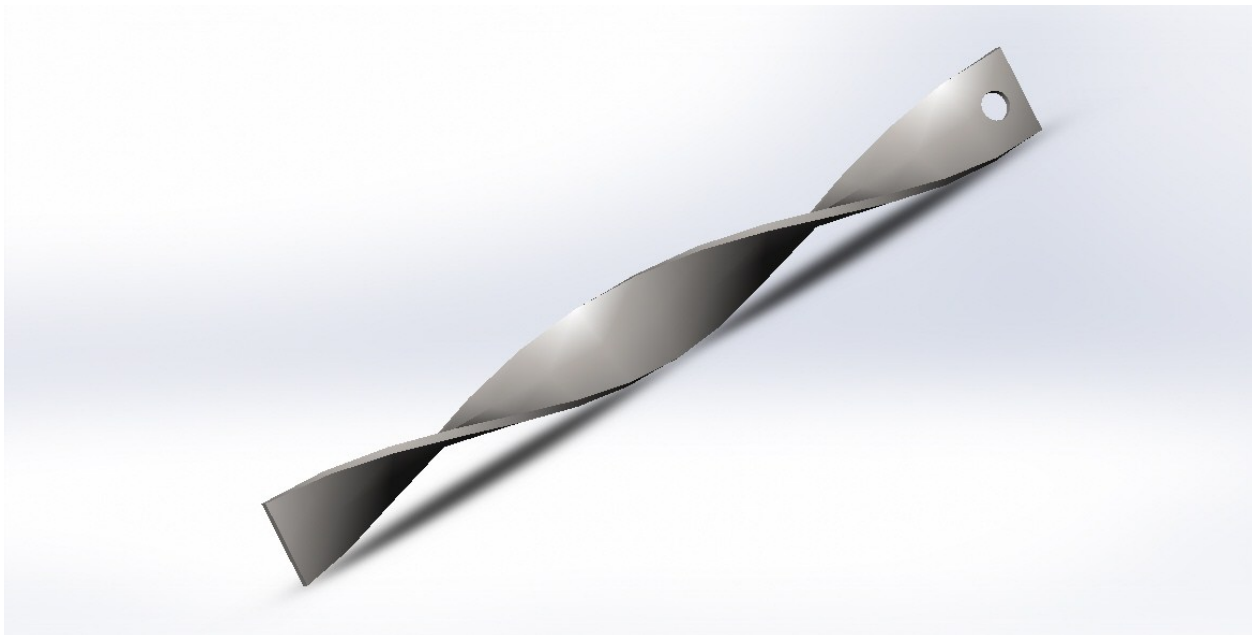
Fig. 2.10 Vortex generator of detonation products

Average consumption of the turbulators is 1 pc/blasting hole.

The hole charges turbulator must be completely immersed in the explosive and is on the side of the life primer, where it is necessary to increase the efficiency of the explosion. Axis turbulator should focus as much as possible parallel to the axis of the well (ie vertical wells - vertically), providing the highest attainable removing it from the wall of the well.

2.6.2 Distribution zone of turbulence in the well.

When designing the structure of the charge should be borne in mind that turbo mode (high-efficiency) will work only that side of the downhole explosive charge, which is located along the detonation of turbulator. For example, if the turbulator is located under life primer the mode of

turbulence work the lower part of the column charge located under the turbulator. If the turbulator located above life primer, the mode of turbulence work the upper part of the column charge located above the turbulator. That side of the downhole charge, which is located between the turbulator and life primer as well as on the side of the life primer will operate in a conventional explosion.

2.6.3 Principle of operation turbulator

At operation life primer in the well there is a charge detonation wave that moves toward the turbulator runs along it, and continues to further movement of the column charge.

Vortex generator actuated extending along detonation wave. The pressure on the front of the detonation wave is transmitted to the cavity of turbulator which can be decomposed into components P_x and P_y. The component creates a turbulator P_x torque about its longitudinal axis. Component P_y is pushing turbulator forward well. As a result, after passing turbulator detonation wave begins high speed rotational-translational movement along the borehole. The rotational speed of turbulator is about 103 r/s. The speed of translational movement along the borehole is order of 102 m/s. Moving in gas-dispersed aria of detonation products the rotating turbulator creates around itself vortex flows, which can be divided into two components: an axisymmetric vortex flow that occurs in the well due to the rotation around the axis of turbulator; longitudinal vortex flow due to the fact that the turbulator works like a mini-turbine is injected gases ahead of him and the generator during its movement a zone of compression (high pressure), and behind the area of depression (low pressure). The gases from the compression zone are flocks to the area of depression along the walls of the well, forming a longitudinal vortex flows.

The vortex flow there is an active mixing of detonation products. It is well known that intensive mixing of the components of chemical reactions can enhance chemical reaction rates several orders of magnitude. When vortex flow generated in the conditions for the most complete exothermic chemical conversions of reactive components contained in the detonation products directly in the well before the explosive gases burst out to the surface. Giving off heat increases the overall heat of combustion of industrial explosives in the well and is spent on useful work on the destruction of the array.

Work turbulator affects several factors that improve the actual utilization of the potential energy of the explosive, namely:

- It is known that the explosive in the detonation wave is not completely burned, and the detonation products contain components that are capable of chemical reactions to generate heat (exothermic decomposition products of incomplete burn). However, such a conventional

explosion afterburning reaction proceed relatively slowly, so that the detonation products are released into the atmosphere before the components contained in them have time to react;

- Detonation products, unlike the products of complete decomposition of explosives contain a large number of polyatomic molecules, that is are less important to the polytropic index. It is not difficult to calculate, for example, that the initial and final temperature of the explosion $T_j = 4500 °$ K and $T_g = 900 °$ K, respectively, due to changes to the polytropic index = 1.15 (detonation products) to a = 1.20 (of turbulence products, i.e., the complete decomposition of explosives), the actual utilization of the potential energy of explosives.

The work of turbulator makes a positive effect on the redistribution of the pressure of the gaseous products of the explosion in the well:

- In direct charge of the initiation of rotating turbulator pumps gases deep into the well, creating a counter-flow of gases, seeking to escape to the surface through the wellhead, i.e. increases the impact of the explosion products on destroying the array. Ahead of working turbulator formed compression zone;

- Creating a hole concentric vortex flow leads to a reduction of gas pressure in the central vortex (near the borehole axis) and the increased pressure on the periphery of the vortex, i.e. on the borehole wall. Stirring gas-dispersion of detonation products in the solid-explosives vortex flow can cause a secondary detonation of gas-dispersed product in a well.

2.6.4 Installing the turbulator into the well

Receptions installation turbulator well depend on the type of life primer and schemes initiation charge.

The turbo explosives of dry vertical wells.

When used in life primer such as T-400 (TG-400) and direct initiation of the charge applied turbulator having on one side an opening for detonating cord.

Install turbulator comprises the following steps:

1) make a life primer in the usual manner;

2) On one end of a cord to put turbulator;

3) Thread the end of the detonating cord in the opening between the filaments detonating cord and sword to form a loop of 100 mm.

4) Pulling up the strings detonating cord. Vortex generator should hang freely under the sword on the loop detonating cord. Vortex generator tightly to the life primerr does not pull tight and not secured (Fig. 2.11).

Fig. 2.11 Setting the turbulator of detonation products.
1 - intermediate detonator;
2 - Vortex generator of detonation products;
3 - position before turbulator on the well.

As well turbulator should take the vertical position by life primer in accordance with the design of the charge shown above.

For proper installation of turbulator into the well it is necessary to perform the following operations:

5) Lower the life primer with turbulator in the hole to the explosive charge. This turbulator will be on the charge and will be in the rest position.

6) Pulling detonating cord 50 cm up, pick up the slack and raise life primer of charge. This turbulator hang freely on the loop detonating cord under fife primer, i.e. will work upright.

7) While holding the detonating cord continue filling of explosives in the hole (at least one bag explosive). In this life primer will plunge into turbulator and explosives and ready to work.

8) To carry out the stemming of wells in the usual manner.

When blasting with an air gap life primer with turbulator shall be loaded in charge of at least 1 meter from the top of the column charge. Otherwise turbulator with the expanding gases in the free space will be thrown at the wellhead and is not going to work. Direct initiation of the charge is the main most effective scheme at initiation turbo explosive. This turbulator is moving deeper into the wells, pumps gas from the mouth towards the bottom of the hole.

When blasting watered wells charging technology is used to initiate the reverse charge militants from sticks of TNT. In this case, use of turbulence turbulator having an opening on one side and a recess on the other side. Thus turbulator can be straight or have a curved tail. Vortex generator with a curved tail creates a powerful vortex flows in the well, but quickly loses speed rotary-translational-relative motion. Its use in the reverse initiation most preferred.

Installation turbulator at the opposite initiating charge comprises the following steps:

1) Before the start of production of one of the life primer thread the yarn through the hole detonating cord turbulator.

2) make a life primer in the usual manner.

3) Install the turbulator to a distance of 100 mm from the life primer, empty thread detonating cord according plane turbulator and threaded through the lateral recess.

4) Lower the life primer on the charge in the ordinary course and recharge the wells.

In this operating the turbulator is takes position according to the structure of the charge. Reverse initiating charge to the location of the turbulator life primer should only be used when high water cut wells in homogeneous explosive charge, and the combined explosive charge. When combined charge is required to produce a stemming of the wellhead.

As noted above, the use of oppositely-directed initiation charge does not give a positive effect inherent turbo explosion and is not recommended for use.

Turbo explosive using cartridget explosives.

Direct charge to the initiation of life primer from the socket diameter should be applied in vertical or inclined wells. The design of turbulator in the most simple case, since it contains no holes and recesses.

Install turbulator comprises the following steps:

1) To produce a cartridge-life primer, while detonating cord hinges placed on one side of the cartridge.

2) At the opposite end of the hinge detonating cord cartridge shooter knife make an incision cartridge shell width of 20 mm.

3) Enter through the incision in the life primer turbulator. Notching close with adhesive tape.

4) Lower the cartridge into the well-life primer turbulator down to make refilling the well.

Further operations are performed in the usual manner.

When blasting deep wells (double ledges, non-transport system development, etc.) to prevent the detonation damping instrumental in the middle part of the well-placed additional life primer with turbulator. In this case, turbo explosion initiated in two ways: first from the cartridge with turbulator-life primer, and then at the approach of a detonation wave to the cartridge helpful life primer into operation a second turbulator.

In deep wells turbulators be applied to the plate thickness of 2 mm.

If strong rocks occur in the lower part of the block and covered with soft rock, the explosive should be applied only in the lower part of the column charge, intersecting layers of hard rocks. Otherwise, for weak rocks advancing blowby occurs at the free surface bench and

application of turbulence not lead to a positive effect. When applied to the bottom of turbulence bench at the top of the column charge should be used to initiate the counter-directional charge.

Do not install the turbulator at the wellhead or tamping.

It is forbidden to enter into the hole turbulator cast or pressed explosives, as well as customize the turbulator close to the life primer.

After the end of the introduction of the life primer in the wells is necessary to remove unused tabulators outside the explosive unit.

2.6.5 The choice of the coefficient relative performance of turbo explosive

Experience has shown that applied explosives have a coefficient of relative performance e_0, the turbo explosive this figure designated is greater than the initial value e_0 more than 30%, i.e a> 1.3 e_0.

In practice, however, together with the task of saving explosives (reducing specific consumption) and to increase the yield of the rock mass from 1 meter blast holes faces challenges to improve the quality of the rock mass blasting preparation and elaboration floor bench. Therefore, in order to address these challenges is recommended to tamping wellheads in the project lay in the propagation of turbulence the entire column charge is $e_0 = 1.3$.

If the turbulator design charge recessed in the 2-nd quarter of the column charge, the mode of turbulence works only part of the charge, this is located below the turbulator. It should take the average estimated value is $e_m = 1.23 \ e_0$.

If the turbulator is recessed in the third quarter of the column charge, then $e_m = 1.15 \ e_0$.

2.6.6 Turbo explosive in dry blocks

Selection of specific parameters drilling block at turbo explosion depends on the blasting presence stemming wellheads and schemes blasting charges.

Turbo exlosion is very sensitive to the conditions of blasting for the following reasons. In conventional explosion the detonation velocity is greater than the speed of known main cracks in the array. Products detonation under normal explosion has the potential supply of purely mechanical energy expended on the destruction of the array (the piston action of the explosion). Premature breakthrough of detonation products into the atmosphere by developing a system of large main cracks only is leads to some deterioration in both the quality of the crushing weight of blasted rock from the top of bench, and the quality of elaboration due to bench of the irrational loss of mechanical energy of detonation products.

Turbo explosive detonation products should be regarded as containing, along with manual also reserve potential chemical energy. However, the rate of conversion of chemical energy into

mechanical energy (heat) is determined by speed at turbulator hole. The velocity of the turbulator on the order of magnitude is smaller than the velocity of propagation of a detonation wave and is commensurate with the speed of development of the main crack. Turbo explosive premature expiration of detonation products from the wells is essentially a loss of components of chemical reactions necessary for the implementation of turbulence that leads to the cessation process. This is unacceptable, since explosives reduced the specific consumption per turboeffekt.

Known effective means of preventing the rapid development of large main cracks and premature breakthrough of detonation products into the atmosphere is blowing on a retaining wall of a width not less than one excavator stope. Blasting on the retaining wall is the preferred condition tubulence promoter.

2.6.7 Turbo explosive of flooded wells

When blasting watered wells under the terms of manufacturability is forced to apply reverse charging scheme initiation charge. In this case, the location of the turbulator relative life primer depends on the specific problem to be solved turbo explosion.

On the steep seams main task is to study quality floor ledge prevention rapids. In this case, turbulator should be placed under life primer, in the lower quarter of the column charge and apply derating factor of specific consumption of explosives $q_T = q_0 / 1.15$.

Options mesh well chosen depending on the orientation of the CPR line and stretch recovery.

If along with the study of floor task of improving bench of crushing the blasted rock mass, it is recommended to use the well with two turbulator arrangement of one of them over the militants, the other - a life primer. In this case, $q_T = q_0 / 1.23$, tamping required wellhead.

If a gentle dip the lower part of bench is composed of soft rock, it is sufficient to use a turbulator located above the life primer, while $q_T = q_0 / 1.15$ with a mandatory stemming wellheads.

2.6.8 The value of stemming wellheads at turbo explosive

An important factor in the premature detonation of breakthrough products in the atmosphere is the presence of stemming the wellhead. If use a conventional explosion detonation at high speeds reduces the effect of the presence or in the blast hole stemming preparation of the rock mass, when the tamping turbo explosive plays a special role in the application of any type of explosives. At the same time the use of dispersed charge (air gap) and replace the locking tamping explosive charge is equivalent to turbo explosive blasting without tamping.

The reason is that the blasting without tamping during direct initiation, after the initiation of the explosive charge militants in space wellhead rushing streams expanding of detonation products. They entrain the working turbulator and throw it out of the well to the surface. Turbo explosive in this case does not occur. The charge detonation is in normal mode. Therefore, when blasting is going without tamping during direct initiation charge the turbulator should be placed in a recessed charge (at least 1 m).

Chapter Three: Conditions of mining operations

To optimize drilling and blasting at the mine Glubokoe has done a great job. There are used a lot of different explosives - emulsion explosives, as well as the patronage explosives with different chemical composition – TNT based and without TNT based on porous ammonium nitrate. Were used different types of drilling grid of 2.0 * 2.0 * 4.5 to 4.0. Various methods of blasting grid with different time of delay.

Exploitation of deposit Glubokoe is being by open way. The field is developed by one quarry face, thickness of which is adopted in accordance with the geological conditions of mining. The height of the quarry bench varies from 2.0 to 11.0 m. To the calculation of average height adopted quarry face - 7.0 m.

Thickness of the gypsum is heterogeneous in composition and contains lenticular interbeds intermediate stripping presented by dolomite, clay, sand. In areas where is the pre-operational exploration will reveal bands of intermediate stripping there is working out of useful sequences will be selective manner.

Development of the field is carried out in accordance with the mining conditions for the development of the transport system with the placement of overburden in internal and external piles. Overburden removed by a bulldozer without loosening. Mining operations are carried out on the same horizon. Supply of exploded minerals from the bottom of the quarry to the crusher header bin (screening and crushing unit) is produced hydraulic excavator Volvo BLC 460. The maximum linear dimension of a piece of rock - 700mm. A method of cutting oversized pieces after the explosion is mechanical by hydraulic hammer in two shifts (60 shifts per month). Bench Height – H_b = 7,0m (from 2.0 to 11,0m.). The angle of repose is 75°. The annual volume of exploded rocks in the dense body is 300-400 thousand m^3.

As a working body on a removable hydraulic excavators domestic and foreign production, and other hydroficated machines (trucks, cranes, etc.) corresponding to the mass and capacity, used hydraulic hammers Delta F-50, subject to the requirements of the hydraulic circuit. Delta F-50 is used on excavators weighing from 45 to 80 tons. Hammer used in construction work requiring maximum power and performance: for crushing oversized, destruction of buildings, as well as in the development of primary rocky soils. Performance of hydraulic breakers according to passport data is up to 100 m^3 per hour.

According to the standard project of doing blasting operations in the field Glubokoe by contractor LLC NTF "VZRYVTEHNOLOGIYA" the oversize output is up to 15%. This figure is associated with complex geological conditions - the presence of a large empty karst, karst represented clay, loam, sandy loam (42%). Part of the explosive force was adopted internal karst.

According to the above data it is possible to conclude that no qualitative blasting operations on the example of the unit volume of 40,000 m3:

1. The actual yield of oversize (15 percent) of the total amount will be 40,000 * 0.15 = 6 thousand m^3.

2. According to technical certificate on the hammer taken from the field Glubokoe from the surveyor the performance is equal 250 m^3 per shift (although this figure is somewhat understated, according to the official website of the technique and the actual work in the field).

3. The required number of shifts to split oversized 6000/250 = 24 shifts. As stated above the quarry hammer works in 2 shifts per day, or 60 per month.

4. Hence the conclusion - a large amount of time and energy costs is to refine the line floor from the previous explosion testing of pillars (which according to the masters of the field are occurs quite often). Otherwise there is no need to hammer usage in two shifts.

And as a result of blasting operations are not conducted at the highest quality. On the example of the explosion №181 held contractor LLC NTF "VZRYVTEHNOLOGIYA" observed expressed acknowledgment of the problem (Fig. 3.1). By visual inspection not worked floor has dimensions 7x5x1 m. Scraping not worked part of gypsum require a lot of resources and time spent. The charge in not worked part was laid (Fig. 3.2). The reason, apparently, was the presence of karst represented by clay, which acted as the depreciation charge for the explosive power (Figure 3.1). Provide for possible occurrence of this problem is impossible in conditions of blasting large blocks. Because geology of the deposit is not monotonous.

The most striking example of the difficulties of blasting is conducted by an explosion № 137,139 contractor SOBR. By visual inspection failures in the explosion was not, however, 2,1 thousand M^3 of rock mass has not been worked out.

Another example is the completion of the base of bench to the explosive unit № 183. In this case were taken about two shifts for the complete removal of all the pillars to the absolute level of 52 m.

The presences of such technical subtleties which can be solved directly on the field are lead to the need for additional work shift at the hammer. The solution to this problem is to improve the quality of blasting through the use of cheap explosives based on simple porous ammonium nitrate with turbo explosion technology described in the previous chapter. That will lead to a possible reduction of unit labor on the night shift.

Fig. 3.1 Explosion of block №181 in the field Glubokoe

Fig. 3.2 Out of boulders on the block №181 field Glubokoe

For loosening of rocks as the main method adopted vertical borehole charges with multiple rows of their location and short-delay firing. Drilling of wells are made using machine Titon 300 with diameter of holes is 127mm. The wells are staggered or drilled on a square grid.

Due to the economic feasibility of blasting operations are carried out once a month on the agreed schedule, based on the needs of the mining, crushing and screening production in the rock

mass at the actual readiness for blasting blocks of drilled wells. In accordance with the model project doing of volume blasting the rock mass have to exceed 30000 m^3. In consequence of that is difficult to control the quality of the conduct blasting operations with maximum efficiency. This meant not only the complex geological conditions of the deposit. Also in the autumn and spring there is the problem with transporting of the explosives using car transport due to climatic conditions. To solve this problem in winter blasting operations are conducted with a large margin of the rock mass. What causes a number of additional issues related to the quality of blasting, such as:

- Appears slightly from the previous line of separation of the exploded block;

- Mountain range explodes worse with each successive block due to lack of space for output.

3.1 Design parameters of drilling and blasting operations

As the main industrial explosive for borehole charges in the quarry is used flowing granular ammonium nitrate explosives Granulit RP-1 (TS 7276-028-11692478-2002). Which in turn is a good option because of the analysis held in the previous chapter. Explosive Granulit RP is made on the basis of porous ammonium nitrate at a stationary point of production explosives, located on the territory of enclosed warehouse Consumables LLC NTF "VZRYVTEHNOLOGIYA" and delivered to the job site by special vehicles. The cost of transportation services of explosives is not included in the calculation of blasting operations in career field and cost 9 rubles/m^3.

The main explosion and technical characteristics of Granulit RP are given in Table 3.1.

Table 3.1 Explosion and technical characteristics of the Granulit RP

Indicator name	Standard		
	Granulit RP-1	Granulit RP-2	Granulit RP-2
Estimated			
The heat of the explosion, kJ/kg (kcal/kg)	3800 (907)		
The volume of gaseous explosion products, L/kg	980-990		
The volume of toxic gases (CO), l/kg	45		
Oxygen balance,%	Минус 0,35		
Experimental			
Bulk density, g/cm3	(0,7–0,8)/(0,8-0,9)*	0,8–0,9	0,8–0,9
Critical detonation diameter of open charge, mm	(70–80)/(30-50)*	80–90	60-70

The detonation velocity of the open charge with diameter of 100 mm at a bulk density, km/sec	(2,9-3,0)/(3,3-3,4)*	2,8–3,0	3,0–3,3
Impact sensitivity in accordance with GOST 4545-88: - Unit 2, explosion frequency,%	0		
- Unit 2, the lower limit, mm	500		
Friction sensitivity on the device K-44-SH according to GOST R 50835-95, the lower limit, MPa (kgf/cm^2)	More 300 (3000)		
The minimum ignition energy of aerosols, J	More 1		
Sensitivity to the primary means of initiation: to electrical exploder ED-8J	Not sensitive / sensitive *	Not sensitive	Not sensitive enough
- to bunch of 2 threads detonating cord length of 10 cm with the density of sample explosive 12 g/m	Not sensitive / sensitive *	Not sensitive	Not sensitive enough
The coefficient of relative performance by the explosion crater (reference - ammonite №6ZHV)	(1,05-1,1)/(1,0-1,05)*	1,1-1,15	1,0-1,05
* The numerator values for granular formulation, the denominator for powder.			

Explosive fragmentation of rock in the quarry is done by vertical borehole charges. Borehole diameter $d = 127$ mm drilled of machine tools «Titon 300". Well on the benches arranged in several rows, depending on the required volume of blasted rock mass and the width of the work sites. Breaking is carried out on a fully matched excavator face from the previous mass explosions.

In vertical stacking of charges the main borehole blasting parameters are: the hole diameter (d), the line along the floor of the bench resistance (W) for the first row of wells, the distance between the charges in the row (a), the distance between the rows of charges (b), the length of overdrill (L_o), the length of the charge (L_c) stemming length (l_{st}), the specific consumption of explosives (q), the interval between adjacent delay charges (charges groups) (t_d) and the weight of the charge in the well (Q).

To calculate the parameters of hole blasting charges in the project there are following fixed input data in accordance with the terms of reference and in fact the prevailing operating conditions at the quarry:

- Diameter of the wells - $d = 0,127$ m;

- A group of rocks SNiP = V;

- Density of rocks – $\rho_r = 2.17$ t/m3;

- The working angle of repose the bench $\alpha_b = 750$;

- Coefficient of loosening blasted rock mass – K_L = 1.42;

- Resistance line at the floor of the bench - W = 3,5 m;.

- Distance between the holes in a row - a = 3,5 m. (H = from 2.0 to 11,0m) ;

- Distance between the rows of holes - b = 3,5 m. (H = from 2,0 to 11,0m) ;

- Depth overdrill wells below the base of the bench: L_o = 1 m.

- The length of tamping the bench: L_{st} = 20 x d m. (Optimum crushing), but with the explosion of the dispersal charge to reduce the length of the stemming have to be decreased to value of 10 charge diameters for further crushing.

The accepted value of the resistance along the floor of the bench W should not exceed the value of the maximum permissible resistance at the floor of the bench W_{pr} surmounted in the first row of a single charge of core holes without forming rapids and overpriced floor the bench: $W \le W_{pr}$.

The limit value of toe condition are overcome in the first row of a single charge of core holes without forming rapids and overpriced floor, calculated as follows:

$$W_{pr} = \sqrt{\frac{P}{K}(\sin \alpha + \sin \beta)} \text{ , m,} \qquad (3.1)$$

where: α, β - the angles defined by the length of the borehole charge located in overdrill L_o and above the floor of the bench L_o, according to the scheme shown in Figure 3.3;

P - linear density (capacity) of explosive in a borehole kg/m;

K - estimated specific consumption of explosive concentrated charge crushing (loosening) actions kg/m3.
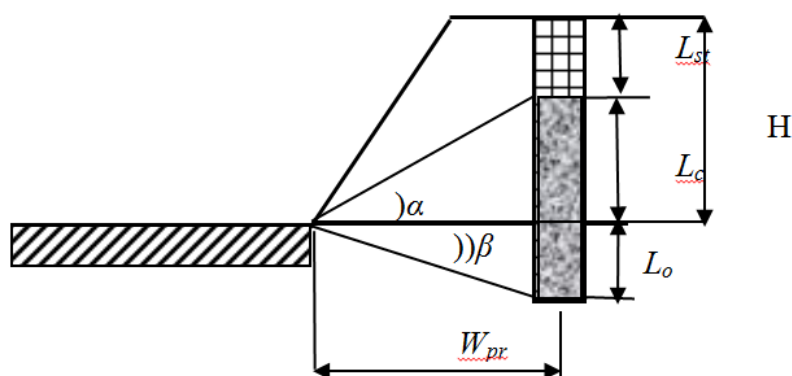

Fig. 3.3 Design model of borehole charge

Design model of borehole charge to determine the length limit toe condition (W). For calculate W of formula (3.1) using a nomograms. Resistance the toe condition W does not exceed the limit value of toe condition: $W \le W_{pr}$

Capacity explosive in a well taken: for dry wells $P = 8.5$ kg/m at $d_h = 110$ mm and $P = 11$ kg/m at $d_h = 127$ mm for loose explosive Granulit RP based on granular porous ammonium nitrate with a density of charging wells t/m³. Explosion and technical characteristics are appropriate to most effective explosive fragmentation developed rocks. For charging flooded wells used cartridged explosive Granulit RP in the polyamide shell whith diameter $d = 90$ mm and $d = 110$ mm. Explosive cartridges have a density $\rho = 0,8$ g/cm³. Capacity of explosive cartridge P = 5.7 kg/m and P = 8,5 kg/m. The height of the water in the well is taken in the range from 0.5 to 3.0m.

Estimated specific consumption of explosive concentrated crushing (loosening) action to Granulit RP is determined by the formula [1]:

$$K = K_\kappa K_{ee} K_p^2, \text{ kg/m}^3, \qquad (3.2)$$

where K_c - estimated specific consumption charge largest camouflet, kg/m3. For species with F = 3 for ammonite №6ZHV value $K_c = 0.4$ kg / m3. [1].

K_e - the coefficient of efficiency relative to a reference explosive (Ammonit №6ZHV). For Granulit RP K_e value is determined by the specific heat of the explosion Granulit RP ($U_e = 900$kkal / kg) and ammonite №6ZHV ($U_e = 1030$kkal / kg) - $K_e = 1030/900 = 1.14$.

K_l - coefficient of loosening the blasted rock mass. $K_l = 1.42$.

Estimated specific consumption of concentrated charge accept K = 0.65 kg/m³.

The length of the floor charge of the bench:

$$l_e = H - l_{st}, \text{ m} \qquad (3.3)$$

The length of the column explosive charges in the well:

$$l_c = l_o + l_e, \text{ m} \qquad (3.4)$$

Charge mass in the well:

$$Q = P \, l_c, \text{ kg} \qquad (3.5)$$

where P - linear density (capacity) explosive in the well kg/m.

Specific consumption of explosives on the basic of blasting rock hole charges determined by the conditions of production of blasting on the grid actually worked well locations for height benches is developed by the formula:

$$q = \frac{P \cdot l_c}{S_g \cdot H} \text{ kg/m}^3 \qquad (3.6)$$

where l_c - the length of the charge, m;

S_g - area of grids borehole, m^2;

H - height of the bench, m.

Output of blasted rock mass is calculated by the formulas:

- From one well:

$$\rho = a \times b \times H, \text{ m}^3 \qquad (3.7)$$

- from unit of borehole length:

$$\rho_b = \frac{a \times b \times H}{L}, \text{ m}^3/\text{m} \qquad (3.8)$$

Basic design values of the geometric parameters of borehole explosive charges for the most common bench height are given in Table. 3.2.

Table 3.2 Geometrical parameters of borehole explosive charges

Bench №	H,m	a,m	$в$,m	L,m	L_{st}, m	L_c, м	L_{ov}, м	W, m	W_{pr}, m	Q, кг	q, kg/m^3	ρ, м^3	ρ_c,m^3
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 d_b= 110mm	2,0	2,5	2,5	3,0	1,5	1,5	1,0	2,5	2,5	8,5	0,68	12,5	6,25
	5,0	3,0	3,0	6,0	2,0	4,0	1,0	3,3	3,3	23,0	0,51	45	7,5
	7,0	3,5	3,5	8,0	2,0	5,0	1,0	3,5	3,5	42,5	0,49	85,7	10,7
	9,0	3,5	3,5	10,5	2,0	8,5	1,5	3,5	3,7	72,5	0,65	110,2	10,5
	11,0	4,0	4,0	12,5	2,0	10,5	1,5	4,0	4,0	89,0	0,50	176,0	14,0
1 d_b= 125mm	2,0	3,0	3,0	3,0	1,5	1,5	1,0	3,0	3,0	12,7	0,7	18,0	6,0
	5,0	3,5	3,5	6,0	2,0	4,0	1,0	3,5	3,8	34,0	0,55	61,25	10,2
	7,0	4,0	4,0	8,0	2,0	5,0	1,0	4,0	4,0	55,0	0,49	112,0	14,0
	9,0	4,0	4,0	10,5	2,0	8,5	1,5	4,2	4,2	85,0	0,59	144,0	13,7
	11,0	4,0	4,0	12,5	2,0	10,5	1,5	4,4	4,4	105,0	0,60	176,0	14,1

Depending on the requirements to the quality of the crushing rock mass in the production of blasting, the values of the geometric parameters of grids holes (A x B) are adopted in Table 2 and may be changed within ± 0,5 m (a = mW, m, where m = 0,8 ÷ 1,4).

The minimum permissible under the terms of the security making a hole in the front row (placing the drilling rig at the top of the bench abroad prism caving) for pick up from the

previous explosion face, the resistance line at the base of the bench (WB) is calculated as follows:

$$W_b = b_b + H \, ctg \, \alpha_b, \text{ m} \tag{3.9}$$

where b_b - allowed a safe distance from the top edge of the bench to the drilling rig, m;

αb - the bench slope angle to the horizon in the steady state ($\alpha_b = 75^o$).

When matched to the breaking of face:

$b_b = 0{,}05 \times F \times H$ with $F \times N{\geq}40$,

$b_b = 2$, with $F \times N{\leq}40$,

where F - a group of rocks to SNiP.

W_b calculation is performed for gypsum F = 2-3.

The calculated values W_b for various benches heights in accordance with the estimated length of the resistance line at the floor of the bench W are shown in Table. 3.3.

Table 3.3 The calculated of values W_b

Bench №	H, m	B_b, m	W_b, m	W, m
1	2	3	4	5
1 d_b=110mm	2,0	2,0	2,5	2,5
	5,0	2,0	3,3	3,3
	7,0	2,0	3,5	3,5
	9,0	2,0	4,4	3,5
	11,0	2,0	4,9	4,0
1 d_b=127mm	2,0	2,0	2,5	3,0
	5,0	2,0	3,3	3,5
	7,0	2,0	3,5	4,0
	9,0	2,0	4,4	4,2
	11,0	2,0	4,9	4,4

The optimum time (interval) of delay between downhole explosive charges determined by the formulas:

- Between the hole charges in the rows:

$$t_h = \frac{5 \times K_l \times De \times \rho_d \times W}{f}, \text{ ms} \tag{3.10}$$

- Between the rows of hole charges:

$$t_r = t_h \sqrt{1 + (b/a)^2}, \text{ ms} \tag{3.11}$$

where K_l - coefficient of loosening the blasted rock mass;

D_e - downhole velocity of detonation of the explosive charge, km / s. For Granulit RP - De = 3.0 km / s.

ρ_d - density of blasted rock, t/m^3 (ρ_d = 2.17 t / m3);

W - resistance on the sole of the ledge, m;

f - coefficient of the fortress by MM Protodyakonov (f = 2-3);

b - the distance between the rows of charge m;

a - the distance between the charges in row m.

To avoid failure as a result of undercutting shock tube in wells scheduled time delay when the short delay charge shall be verified by the formula:

t ≤ 1.1 a/d, ms.

where a - the minimum distance between adjacent hole charges exploding in different groups deceleration m.

Estimated time delay will be rounded down to the nearest nominal value means of time delay.

The calculated values and accepted means of initiation delay intervals based on the presence of the actual deceleration denominations are given in Table. 3.4.

Table 3.4 Values intervals of delay

№ of bench	K_l	W, m	a, m	b, m	The calculated values		Accepted intervals of delay, ms
					t_h, ms	t_r, ms	t_h, ms
2	3	4	5	6	7	8	9
1	1,42	3,5	3,5	3,5	29	41	25

The total width of the collapse in the blasted rock mass is determined by the width of the stope drilling entirely A and maximum ejection rocks from the lower edge of the bench B$_e$ in accordance with the following formulas:

$$B = A + B_e, \text{ m} \tag{3.12}$$

$$A = W + b\ (N - 1), \text{ m} \tag{3.13}$$

$$B_e = 3{,}5\,H\ \sqrt[4]{F}\ \sqrt[3]{q/H}\ , \text{ m} \tag{3.14}$$

where N - number of rows exploded wells;

q - the specific consumption of explosives, kg/m^3.

The calculated values for the width of the collapse, average height of the bench and various amounts exploded on the bench hole charges are given in Table. 3.5.

Table 3.5 Calculated values of the collapse width

	N	A, m	B_e, m	B, m
1	2	3	4	5
H = 5,0 m	10	30,3	10,5	40,8
H = 7,0 m	10	35,0	13,1	48,1
H = 9,0 m	10	35,0	17,0	52,0
H = 11,0 m	10	40,0	17,8	57,8

The maximum height of the collapse rock mass in the explosion hole charges on selected bench is calculated as follows:

$$H_c = H \sqrt[4]{N/Hq} \text{ , m} \qquad (3.15)$$

The calculated values for the height of the collapse benches of various heights H and the number of rows exploded wells are shown in Table 3.6.

Table 3.6. The calculated values of the collapse height

№ Bench	H, m.	q kg/m³	H_c, m				
			N=6	N=7	N=8	N=9	N=10
1	5,0	0,51	6,2	6,4	6,6	7,8	7,0
	7,0	0,49	8,0	8,3	8,6	8,9	9,2
	9,0	0,65	9,0	9,4	9,7	10,0	10,3
	11,0	0,50	11,2	11,6	12,0	12,4	12,8

To ensure safety of excavation the height collapse of blasted rock mass H_c shall not exceed the height of the excavator digging N_e.

3.2 Industrial safety in the performing of blasting

The radius of the danger zone by outburst of rock pieces during blasting of hole charges (r_o).

The outburst distance $(r_o$, m) dangerous for people during blasting calculated on the crushing action and is determined by the formula:

$$r_o = 1250 \times \eta_f \times \sqrt{\frac{f}{1+\eta_{st}} \cdot \frac{d}{a}} \qquad (3.16)$$

where η_f - the filling factor of borehole explosive column is equal to the length of the charge in the well (L_c) to the depth of the hole (L);

η_{st} - filling factor of stemming borehole, equal to the ratio of length tamping (l_{st}) to the mean free of charge from the upper part of the hole (l_h). For full tamping = 1.0.

f - the fortress coefficient of rocks on a scale prof. MM Protodjakonova. For mining rocks = 3;

d - diameter of the blasting borehole, $d = 0,9$ (cartridged explosive) and $d = 0,11$m (loose explosive)

a - the distance between the wells in row m.

Found by calculation according to the formula (3.16) r_o distance is rounded up to the value R_o multiplicity of 50 m.

Table. 3.7 shows the calculated parameters for maximum hole charges and radii expansion r_o and R_o.

Table 3.7 Maximum parameters of borehole charges

Bench	d, m	f, m	η_{st}	a, m	η_f	r_o, m	r_o, m
1	2	3	4	5	6	7	8
H = 2,0 m	0,90	3	1,0	2,5	0,5	375	400
H = 7,0 m	0,11	3	1,0	3,0	0,75	220	250

As the danger outburst zone for people during blasting of hole charges explosives has the largest resulting value: $R_o = 400$ m.

The radius of the danger zone on seismic action explosion (r_s)

The arbitrary blasting (N) groups explosive charges with a total mass (Q) with time of delay between explosions groups charge no less than 20 ms, is definition of a safe distance by the formula:

$$r_s = \frac{K_s \times K_b \times \alpha}{\sqrt[4]{N}} \times \sqrt[3]{Q}, \text{м} \qquad (3.17)$$

where K_s - coefficient depending on the properties of the soil at the base of the protected building (structure), adopted by 12.0;

K_b - coefficient depending on the type of building (structure) and the nature of development, is assumed to be 1.5;

α - coefficient depending on the conditions of blasting is assumed to be 1.0;

N - number of groups on the deceleration (when the maximum number of wells in each group).

Explosions in the career are multiple characters, so the resulting value r_s is doubles. However, if all the recommendations proposed in this diploma project will take place the r_s value will remain unchanged. In view of not block technology blasting.

According to this formula was calculated maximum permissible mass of the charge in the group (kg per 1 step of delay), depending on the distance to the protected object.

The results of the calculation are given in Table 3.8.

Table 3.8 Calculation of the maximum permissible mass of charge

The number of charged groups	Distance to the protected object								
	400	450	500	550	600	650	700	750	800
1	2	3	4	5	6	7	8	9	10
2	486,6	692,9	950,4	1265,0	1642,4	2088,1	2608,0	3207,8	3893,0
3	439,7	626,1	858,8	1143,1	1484,1	1886,8	2356,6	2898,5	3517,8
4	409,2	582,6	799,2	1063,8	1381,1	1755,9	2193,1	2697,4	3273,6
5	387,0	551,0	755,9	1006,1	1306,1	1660,6	2074,1	2551,0	3096,0
6	369,8	526,5	722,2	961,2	1247,9	1586,6	1981,7	2437,4	2958,1
7	355,8	506,6	694,9	924,9	1200,8	1526,7	1906,8	2345,2	2846,2
8	344,1	489,9	672,1	894,5	1161,3	1476,5	1844,2	2268,2	2752,8
9	334,1	475,7	652,6	868,6	1127,6	1433,7	1790,6	2202,4	2672,9
10	325,4	463,4	635,6	846,0	1098,3	1396,4	1744,1	2145,2	2603,4

The radius of the danger zone by the action of shock air wave on the glazing.

To calculate the radius of the danger zone by the action on the shock air wave for glazing (r_w) during blasting of hole charges with $l_c < 12d$ equivalent weight is determined by the charge (Q_e) by the formula:

$$Q_e = P \times d \times K_s \times N \text{ ,kg} \qquad (3.18)$$

where *P* - explosives downhole capacity, kg / m;

d - diameter of borehole, m;

K_s - coefficient depending on the ratio of length to diameter of stemming well;

N - number of wells in a group.

To calculate the radius of the danger zone by the action on the shock air wave for glazing (r_w) during blasting of hole charges with $l_c > 12d$ equivalent weight is determined by the charge (Q_e) by the formula:

$$Q_e = 12 \times P \times d \times K_s \times N \text{, kg} \qquad (3.19)$$

where P - explosives downhole capacity, kg / m;

d - diameter of borehole, m;

K_s - coefficient depending on the ratio of length to diameter of stemming well;

N - number of wells in a group.

When $Q_e < 2$ kg a safe distance by the action on the shock air wave for glazing (r_w) during blasting hole charges determined by the formula:

$$r_w = 63 \times K_T \times K_t \times \sqrt[3]{Q_e^2} \text{, m} \qquad (3.20)$$

where Q_e - the equivalent weight, kg

K_t - coefficient taking into account the air temperature. At negative temperature $K_t = 1.5$.

K_T - coefficient taking into account the interval of delay between groups of charges. When delay range from 20 to 30 ms. K_T value = 1.5.

With $2 \text{ kg} \leq Q_e \leq 1000$ kg a safe distance by the action on the shock air wave for glazing (r_w) during blasting hole charges determined by the formula:

$$r_w = 65 \times K_T \times K_t \times \sqrt{Q_e} \text{, m} \qquad (3.21)$$

where Q_e - the equivalent weight, kg

K_t - coefficient taking into account the air temperature. At negative temperature $K_t = 1.5$.

In all cases the values of the equivalent weight of the explosive charge is added to the total mass of explosives detonating cord surface network Q_{ST} (shock tube).

Table. 3.9 shows the calculated parameters for maximum hole charges radii of the danger zone by the action of shock air wave during blasting block type hole charges for glazing.

Table 3.9 radii of the danger zone by the action of shock air wave

Level	Type of explosive	$P,$ kg/m	$L_{st},$ m	$d,$ m	K_s	N	Q_e+ Q_{ST} kg	K_T	r_w+ m	r_w- m
1	2	3	4	5	6	7	8	9	10	11
1	loose	8,5	-	0,11	0,002	25	6,7	1,5	252	378
	cartridged	5,7	-	0,11	0,002	25	4,9	1,5	215	323

r_w^+ - the radius of the danger zone by the action on the shock air wave for glazing with a positive air temperature

r_w^- - the radius of the danger zone by the action on the shock air wave for glazing at subzero temperatures

Comparing the data for calculating the maximum permissible mass of the charge in the group on seismic effects of the explosion and by the action of shock air wave, it can be noted that the seismic effect of explosions imposes far more restrictive than the shock air wave.

To exclude the effects of the seismic mass explosions on protected objects the maximum permissible mass of the charge in the group (by 1 step delay) for a given number of groups and determine the distance to the protected object should not exceed the values given in Table. 3.8.

In determining the parameters of blasting, in order to reduce the psychological impact of repeated mass explosions, should be the maximum possible for technical reasons the number of groups of charges with the lowest possible weight of the charge in the group (by 1 step delay).

The radius of the danger zone by outburst into individual pieces of rock for the mechanisms assumed equal to $R_m = 200$ m.

Blasting hole charges only provided from outside the danger zone.

Finally radii danger zones during blasting operations are made for the people - $R_b = 400$ m.

Within a radius of dangerous zones adopted by the action of an explosion (seismic, shock air wave), protected objects - buildings and structures are absent.

3.3 Organization of blasting performing

3.3.1 General organization of work

Blasting is carried out in accordance with the "Guidelines for the safe conduct of mass explosions downhole explosive charges on the ground", performed by LLC NTF "Vzryvtehnologiya" and CJSC "Morozovka." Compliance with the instructions agreed with the territorial authority Rostehnadzor are mandatory for contractors and customers.

Mode of blasting is once a month on schedule. In the construction of a warehouse on territory of field Glubokoe the blasting may exercise if necessary. This will lead to a higher

quality of crushing rock. However, is possible to carry out equivalent explosion using technology of turbulence promoter with explosives on the basis of solid ammonium nitrate.

Preparing and conducting mass explosions hole charges set out the following work organization:

In accordance with the required volume of the rock mass component of the project drilling unit to be approved by the technical leaders of the organization producing drilling - Arkhangelsk branch of "KNAUF GIPS KOLPINO" and agreed with the producer organizations blasting - LLC NTF "Vzryvtehnologiya" and CJSC "Morozovka."

Surveying Service Customer produces a breakdown of the first row of wells in the area pegs, which indicates the number of borehole and the height of the bench in this location.

Resistance line on the sole (W) measured at pick up the ledge of the actual bottom edge, with unpicked - from the last row of wells previously bombed. The value of overdrilling W is determinate the distance between the holes in a row and between the rows of wells should be taken according to the types of projects.

In characteristic points of the top platform the bench surveying service customers also exhibited pegs labeled height of the ledge.

One copy of an approved project for drilling (mine survey with remote terrain mouths of the first row of wells to table height the bench and W for each of them, and the distance between the holes in the rows and between the rows, and values overdrilling) issued mining drilling machine and head blasting. One copy is kept by the project surveyor.

Massive explosions on earth surface produced by the project, consisting of:

a) technical calculation with the layout of the wells;

b) parameter table blasting;

c) the regulations of mass explosion;

d) the place of production scheme works with applied boundary danger zone, it posts the safety and location of explosive station.

The project is a massive explosion made on the basis and in accordance with the types of projects blasting.

The head of blasting parameters have to make table of blasting, which sets out the design and actual values and calculated values of the charges. During loading the table entered the actual values of the charges and stemming.

Table parameters of blasting signed by the chief operating decision blasting designated and order of the head contractors.

The head of blasting makes "The schedule of mass explosion".

Schedule of mass explosion is approved technical manager of the Customer and the chief operating decision blasting contractor. These same leaders after a preliminary examination of the career and the necessary approvals are claim as a whole "Project mass explosion" and appoint a "routine" or a separate Order of Executive Director of mass explosion.

Responsible manager organizes mass explosion is familiarize engineers and staff with documentation on the explosion, procedure for the preparation and conduct and necessary security measures.

3.3.2 Safety precautions during performing of drilling operations

All workers Customer employed in drilling operations should be trained and have the rights to produce of relevant works.

Each worker prior to the outfit and should receive instruction in occupational safety and health, as well as to ensure a safe work place, in good condition drilling rig, safety devices, the availability of tools, appliances, personal protective equipment needed for the job.

Maintenance and operation of drilling rigs, accommodation and movement of their on-site must be carried out in accordance with approved instructions for the type of equipment and types of work. Move the machine from a drilled well to the new site via the shortest possible distance. This machine is set so that its longitudinal axis is perpendicular to the upper the bench brow. The scheme of movement of the machine should avoid hitting the machine on a drilled well.

3.3.3 Preparing and conducting a mass explosion

Based on the approved project and the daily a mass explosion is determined by the head of the blasting is required amount of explosive and personnel necessary for the production of a mass explosion, as well as personnel for the protection of explosive at the job site and guard posts danger zone.

Number prescription for mass explosion explosive must match the actual availability of wells.

Staff contractors working on blasting is provided office space and facilities for recreation and delivered to the quarry gypsum deposits Glubokoe well in advance of vehicles designed to transport people. Using same vehicles the staff is delivered workers to the place of work.

In the application of industrial explosives compatibility group «D» on the prepared block set an exclusion zone within which prohibited people is not related to the loader. The dimensions of the restricted area to ensure safe working conditions during charging is assumed equal to $R_r =$ 20 m from the nearest charge. It extends both on the jobsite the bench on which are charging below and above staggered starting horizontally from the nearest charges.

The second and subsequent rows of holes are marked on the basis of these parameters in the Project of mass explosion.

After the end of the block is made drilling off mine survey of wells drilled, measured their depths and the plan is the actual location of the wells. On the plan is displayed as the actual position of the lower and upper edge of the bench and their elevations. The drilled off block is transmitted by the Customer to the Contractor under the act, designed in accordance with the instructions for the safe conduct of massive explosions. During the drilling of the first row of wells is necessary that the machine tracks were perpendicular to face, and at least 2 m from the edge of the bench outside the prism caving.

After drilling each well of mouth within a radius of 0.7 m must be free of foreign objects, stones, drill cuttings, and closed inventory plugs. Control over the production of safe drilling operations and to prepare them for charging of implementing engineering and technical personnel of the Customer.

Outside the exclusion zone are displayed drills, career trucks, excavators and other equipment in accordance with the approved routine of a mass explosion.

Abroad exclusion zone within the danger zone only is allowed maximum limit routine a mass explosion among people.

The explosive materials delivered to the place of work must be in special machines.

In all cases, explosives and initiating system during storage at places of works (special purpose vehicle) must be placed separately, at a distance of eliminating the transmission of detonation.

The explosive materials for the production of a mass explosion of blasthole charges before charging are stored in special machines in the field works in the restricted area under protection in accordance with the UESR (pp. 38, 41 Chapter I).

Finding persons who are not associated with blasting, in places explosive storage is not allowed.

Explosive materials must be kept under constant guard. Protection of explosive carried out an armed paramilitary guard (at least 2 people.).

Before charging ere specified target location for stacking bags of explosives (directly from the mouth of each well) for loading transported and place for the manufacture of militants scheme bringing up the explosive.

Explosives are placed in rechargeable wells in the number and names defined in the calculation of the production design a mass explosion.

During charging the means of initiation and explosives are being monitored shooter appointed responsible for charging wells.

Before loading the explosive borehole the block is thoroughly measured and is recorded the depth of each well and level of water therein.

Flooded borehole are charged with patronize Granulit RP waterproofing in polymeric membranes to ensure its full water resistance. (Notification of Changes 11692478.2-2011 AI "Explosive industrial substances Granulit RP. TS 7276-028-11692478-2002" agreed by Rostehnadzor letter from 12.07.2011y. № 07-03-04 / 2159)

Depending on the level of water content and water flow in wells, as well as its degree of pollution and sanding, the patronized Granulit RP in waterproofing membranes can be charged with or without preliminary dewatering of water wells.

With the charging wells waterproof cartridged explosive Granulit RP without dewatering to protect the polymer shell cartridges explosives from their possible mechanical damage in the course of work on the charging of wells to be blasted, there is additionally applied external shell of thick polyethylene film thickness 150-200 microns in which the explosives cartridges are placed.

In wells with polluted water and sanding should be carried dewatering using electric submersible centrifugal pumps with an external diameter not exceeding 90 mm, with a maximum pressure of not less than 30 m, driven by mobile power supply AC 220 V (petrol or diesel generator) placed outside the chargeable unit. After full and partial reduction using a submersible pump the water column in the well is made it waterproof loading cartridged Granulit RP waterproofing in polymeric membranes, provided the requirements of RD 13-522-02 and TS 7276-028-11692478-2002 during of loading flooded wells.

Is determined in advance the required amount of stemming material, place its production and warehousing. Last chosen so that it does not interfere with work performance when charging provides the ability to perform stemming of at least cost and in the shortest time. In the winter and rainy being are taken to loosening stemming material.

Blasting of hole charges is made using detonating cord DSHE-12 in the surface and downhole networks. As retarders used pyrotechnic relay RP-2 with nominal delay t_d = 25 ms crashed into the surface network of shock tube.

Initiation of boosters downhole explosive charges is performed using detonating cord DSHE-12. The design of borehole charges is shown in the previous chapter.

In the present thesis project to improve the quality of crushing the rock mass is proposed to use vortex generator. Installation techniques of vortex generator into the well depend on the type of live primer and schemes initiation charge. In direct initiation charge applies the vortex, having on one side a hole under shock tube. Installation vortex generator comprises the following steps

- At one end of a shock tube stick to put on vortex generator;

- Fill the end of shock tube in the gap between the turbulence promoter and shock tube threads to form a loop of 100 mm;

- Tighten up the strings of shock tube to loop;

- In well vortex generator should take an upright position.

Direct initiation charge is the main most effective scheme initiation during turbulence blasting. In this case, vortex generator moves deeper into the well pumps gas from the mouth towards the bottom of the hole.

Surface is mounted an explosive network after loading and stemming wells. Explosive network is mounted on the assembly schemes explosive network.

For the installation of electroexplosive network is used main cable VP1x0,8 to check - lattice network portable direct current P-3043, to initiate charges - capacitor blasting machine KPM - 3U or other devices approved for blasting.

Accommodation charge in wells, its mass and column length explosives are controlled during the process of loading. The actual weight of the charge wells after completion of the loading head blasting is entered into the table correction calculation. Consumption of explosive on a mass explosion must be confirmed by signature of the head blasting in order - the permit.

In the preparation of a series of a mass explosion hole charges when charging is takes a long time (more than a work shift) is allowed the loading without derivation of people and mechanisms from the danger zone, provided:

a) the use explosives compatibility group "D";

b) the prohibition of access to places of charging personnel, machinery and equipment, not associated with production of blasting with the establishment of the exclusion zone and the designation of its boundaries at the surface flags notices;

c) the production of all the works on loading and blasting is performed under the direct supervision of a person technical supervision and linking them in time with the other work performed within the danger zone with very limited working there staff;

d) all of the electrical cables, contact and other overhead wires that are in the danger zone must be disconnected at the time of assembly electroexplosive network. When using a special secure electrodetonators power outage is not performed.

On a power outage before explosion the Power Engineer is appropriate entry in the journal blackouts and regulations about holding a mass explosion.

Danger zone in the performing of massive explosions is introduced during blasting using detonating cord - before joining pyrotechnic relay or electric detonators.

Construction of the danger zone boundaries on the ground is performed in accordance with situational plan labeled them with the necessary warning labels, barriers on the roads leading to

the danger zone of blasting signal mast, the device glades on the border of the danger zone for visibility between adjacent posts.

By the beginning of work on the accession of pyrotechnic relay or electric detonators to the danger zone is introduced, established by this project and outputs the people not associated with production of blasting outside the danger zone, as well as the alignment posts cordon danger zone.

Communication between manager of blasting and guards carried out by means portable radios having a radius of not less than 2 km ..

In accordance with the established routine of a mass explosion is determined responsible for the protection of dangerous and restricted area and the persons appointed to the posts of protection from the personal and qualified workers.

Guard of danger zone is carries by qualified personnel.

After cordoning off the danger zone the staff is performed installation of explosive network.

After installation of explosive network responsible manager are checks a mass of explosion assembly network design diagrams switching reliability of nodes and connections of installed correctly moderators. The detected defects must be eliminated.

Responsible manager of the explosion, received notice of those responsible for the loading and preparing to explode the block for the protection of the danger zone and to stand posts, and for the withdrawal of people from the danger zone, having familiarized with the completed table blasting parameters of and make sure to follow the activities listed in regulations about holding a mass explosion, including after obtaining the necessary written information from the Customer's representatives, is gives an indication of the filing of the combat signal and blasting charges.

Sound signals are directed by the manager of blasting or his designee technical supervision in the following order:

THE FIRST SIGNAL - a warning (one long beep) is served before entering the danger zone, in which all people are not occupied by loading and blasting are removes by person of technical supervision outside the danger zone, and at places of possible entry into the danger zone exhibited guard posts.

THE SECOND SIGNAL - battlelike - (two long signal), this signal on command by manager of blasting is made an explosion.

THE THIRD SIGNAL - stand-down (three short beeps), submitted after inspection of the explosion and marks the end of blasting. Guards (Signalist) protection (cordon) danger zone after the signal "stand-down" are leaving their

posts and going to the head of blasting to sign in a special surrender guard posts.

Methods of feeding and signal assignment while blasting should be brought to the attention of the employees of the Customer and other interested businesses.

Protection of the danger zone is provided and the filing of "warning signal until the alarm "stand-down".

During blasting with the use of electric detonators the output of explosive operator from the shelter to the scene for inspect the results of the explosion in the absence of failures is allowed after displacement blasted rock, full airing, but not earlier than 5 minutes, and only after disconnecting from the network electroexplosive current source circuit and its circuit.

In the corrective calculation results of the fixed a mass explosion (the collapse of the parameters, the presence of stabbing, crushing quality), in the presence of failures is being done to eliminate them.

The admission of people in careers and to the scene after the event can be resolved directly responsible leader of blasting only after they will be found together with the demolitions that work at the site of the explosion is safe. Admission is carried out in accordance with the procedure adopted by the Company approved the chief operating decision blasting together with technical manager of the Customer.

The results of the mass explosions are subject to a systematic analysis of the company. In this case, decisions are made to clarify the parameters and further improvement of drilling and blasting, by making appropriate additions to the types of projects.

In order to ensure safety in the performing of blasting the staff of career is notified customer, and the system takes the following (measures) alerts:

- On the border of the danger zone of blasting and on the roads leading to the quarry, on poles are hung out warning signs indicating the time of blasting, the designation signals fed electric siren in the performing of blasting.

3.4 Prevention, detection and elimination of failed charges

During performing of massive explosions downhole explosive charges necessary to take measures exclude the possibility of failure. Under the refusal to accept full or partial absence of the detonation of the explosive charge or group of charges after a blast in the network initiating pulse. In all cases, the charges can not be blown up because of a technical nature, they are treated as failures.

The preparation and manufacture of blasting must to be comply with the requirements to prevent failures, their timely detection and elimination in a safe manner prescribed " Unified

Explosive Safety Regulation " (UESR 13-407-01) and the "Regulations for the prevention, detection and elimination of failed charges explosives on earth surface and underground workings (RD 13-522-02), approved by Rostekhnadzor.

Warning signs of a failed charge are:

- Presence in exploded (broken) rocks faces the places residues of explosives (explosives, detonating cord segments, a pyrotechnic fuse, electric detonators and wires, and others);

- The presence of unruptured explosion array of bench in the area of the well or borehole;

- Type face (the face site), similar to the unexploded pillar;

- Difficulty of excavation (loading) of the rock mass compared to neighboring areas has already worked, etc.

Probability of failure (the lower limit between failures) for the production of mass explosions hole charges in the investigation of reasons caused by the effect of unavoidable hidden defects applicable industrial products and devices (electric and non-electric detonators, detonating cords and waveguides, connectors, explosive devices, and others.) in compliance with the design of blasting technology is adopted on the basis of the possibility of occurrence of one failure per 500 exploded borehole explosive charges.

Upon detection of latent failures during the excavation, loading operation must be stopped and the place of works caused by the blasting head or his deputy.

Worker, a failure is detected, should put a warning sign with the word "failure" and immediately notify the head of blasting. In places failures is forbidden conduct any activities not related to their liquidation. Those working in the area of failure should be warned about this.

When it detects a fault alarm sounds "stand-down" is dependent on the method of liquidation and the time needed for this. If possible, the elimination of repeated failure blasting, collection, and then the destruction of explosive and so on, the signal "stand-down" is served at the end of all work and personal inspection of the scene of the explosion head blasting, otherwise the signal is "stand-down" and carry out the necessary package of measures to Elimination of failure.

Work related to the elimination of failures, should be conducted under supervision of blasting or designated of technical supervision. Depending on the nature of the failure and its causes the head of blasting is develop "The daily production work on liquidation of failed charges", coordinates it with the technical head of the Customer. Staff working on the Elimination of failures, should be familiar with the "regulations" under the signature.

Choice of a way liquidation of failed charges is made in view the specific conditions (method of blasting, such as explosives, blasting method, situational conditions, revealed the reasons for refusal). Technology elimination of failures (repeated blasting, blasting with

additional charges, dismantling rock excavator, leaching, etc.) must be carried out in accordance with the "Regulations for the prevention, detection and elimination of failed explosive charges in the performing of blasting on the earth surface.

For the elimination of failure method which is not listed in UESR and instructions of special project are approves by technical manager.

Each rejection charge (or suspected failure), including the detected later in the shipment of the rock mass, subject to registration in the Register of failures in blasting operations in the form prescribed by the Regulations.

3.5 Quality control of blasting

Quality blasting controlled at all stages of the production process, drilling, loading and blasting holes. Control shall be the following parameters of blasting operation:

- Resistance to the floor of the bench - W;
- The distance between the holes and rows of holes - a, b;
- Depth overdrilling - L_n;
- Mass of the charge - Q;
- The length of stemming - l_{st}.

Quality of the individual operations for the preparation of the explosion is estimated deviation of the actual values of monitored parameters established by the project table design parameters of massive explosion.

The quality of the explosion is determined by the study of clean floor and oversize output. The presence of thresholds and overpriced soles the bench is not allowed.

Accounting for deviations from the set of monitored parameters that determine the level of assessment as the preparatory work is made according to Table. 3.10.

Table 3.10 quality of preparatory works

preparatory work	Control parameters	indication	Unit of measure	Permission level of deviation (limits) $P_{в}$
				$d = 115$ мм
drilling of wells	Resistance on the floore	W	m	± 0,3
	The distance between the rows and boreholes	a, b	m	± 0,3
	Depth of overdrilling	l_o	m	+ 0,5; - 0,1
Charging of wells	Weight of charge	Q	%	± 10
stemming of wells	The length of stemming	L_{st}	m	± 0,5

where P_b - the maximum deviation of the parameter at which work is considered reject.

All identified during monitoring violations of production technology works should be removed prior to subsequent operations (works).

Chapter Four: Warehouse for explosive storage

4.1 Overview

The main reasons for the construction of a warehouse:

- Improving the quality of conducting blasting operations due to the possibility of reducing the size of the explosive unit, and as a consequence a better separation of the rock mass and its loosening;

- Full control over the line of separation in view of reducing the size of the explosive unit;

- The possibility of blasting at any time of year, regardless of climatic conditions in the region;

- Possibility of local (selective) explosion in cases that it necessary;

- Reduction of the specific consumption of explosives per m^3 (average consumption according to the passports - 0.7, which is too much for loosening gypsum), and as a result a decrease in the cost of loosening of the rock mass.

- Significant savings on the transportation explosives;

- Getting more income because of the possibility of cooperation with neighboring mining companies in the area to provide the blasting as a contractor;

- Getting more income because of the possibility of cooperation with neighboring mining companies in the area of transportation explosives from producer.

- Ability to establish its own production explosives in agreement with the neighboring mining companies that will considerably reduce the cost of loosening of the rock mass.

The project of explosive materials storage is surface container type, located near v. Svetly, Kholmogorsky District, Arkhangelsk Region.

The project was designed to store explosive and issue for their further use in the field of gypsum Glubokoe. The project took into account compliance with the requirements of Unified Explosive Safety Regulation, as well as compliance with Safe Operation explosive warehouse in industrial safety of hazardous production facilities.

Used in the design of standard elements of surface warehouses, developed by experts of the Institute LLC NTF "Vzryvtehnologiya" and other specialized organizations.

Out of stock will be stored following explosive materials:

- ammonium nitrate explosives- up to 50 tons;

- including: Granules RP in bags;

- detonating cord – up to70 thousand m;

- pyrotechnic relay;

- electrodetonators;

- waterproofing polymeric membrane (AMIFLEX T-100) – up to 50 thousand m

- wire VP (wire for explosion);

- clips;

- and other materials.

Note: Storage of ammonium nitrate according to GOST 2-85 in bags on the stock explosive instead of ammonium nitrate explosives in sacks allowed in the same amount and parameters.

In accordance with the submitted drawings, nomenclature and calculations described below the consumables stock explosives and the means of initiation will be stored on the surface of a pre-planned in permanently mounted container platforms, consisting of specialized closed containers type 1 SS weight gross - 20.0 tons and 1A gross weight - 40.0 tons GOST 18477-79*, including:

- container platform with explosives №1 (four containers of type 1A) - storage of up to 50 tons explosives (ammonium nitrate explosives in sacks Granulit RP-1, detonating cord, impermeable polymeric shell or perhaps another explosive);

- container platform with the initiating system № 2 (2 container type 1CC) - storage of electric detonators, pyrotechnic relay RP-2, VP wires, clips, as well as possible storage vortex generator of detonation products, or other materials and means of initiating system in the performance contracting services.

Projected surface active storage explosive container type with capacity up to 50 tons explosives is intended for storage of industrial explosives, detonating cord compatibility group D, granular ammonium nitrate according to GOST 2-85, means of initiation and issuing them to the object blasting.

All explosive arriving at the warehouse are input control.

Maximum design of loading consumables warehouse explosive is up to 50 tons of explosives, given the explosives ammonium nitrate, and the means of initiation.

Explosive storage location is shown in application, the sheet 1.

4.2 The general plan of the warehouse with explosive.

The area between the pad and a supply warehouse explosive nearest objects where possible occasional residence of the population is a surface covered with forests and could change the effect of the shock air wave at emergency explosions.

Platform territory of storage, including the exclusion zone, has the shape of an irregular pentagon and occupies an area of 41720 m2 available for land leases 54,000 m2.

Fenced area warehouse (irregular pentagon with sides of $95.6 \times 52.1 \times 68.7 \times 80.7 \times 118.1$) is enclosed by fencing on wooden pillars with a diameter of 100 mm. and barbed wire of

10 threads, a minimum height of 2.0 m. On the part of the driveway gate in the fence is installed gate for vehicles. On the part of the driveway gate in the fence are installed for vehicles and gate. The length of the fence on the perimeter is 415.2 m. The fence is installed at a distance of at least 40 m from the nearest places explosive storage (container platforms with explosive) according p.26.5 "Unified Explosive Safety Regulation (PB 13-407-01). Section X. Requirements for construction and operation of warehouses with explosives".

At a distance of not less than 50 meters from the fence warehouse established an exclusion zone, equipped perimeter notices on metal poster height of 1 m. 50 m with warning labels "exclusion zone".

Surface active storage explosive container type (hereinafter - warehouse) is a subdivision of the Arkhangelsk branch of LLC "KNAUF GIPS KOLPINO."

In storage explosive there is reception of explosives, stock and release for blasting.

At territory of storage explosive within fences are located:

- Container platform with explosives number 1 - up to 50 tons of explosives, consisting of 4 containers of type 1A (storage of explosives, detonating cord and polymeric shell);

- Container platform with the means of initiation number 2 - storage of electric detonators, pyrotechnic relay RP-2, VP wires, clips, as well as possible storage vortex generator of detonation products and other materials and means in the performance contracting services, consisting of 2-type containers 1CC;

- Preparation and issuance of building explosive (mobile building of the "trailer");

- Panels for fire-fighting equipment.

In the restricted area warehouse are:

- Support with lights to illuminate the perimeter of territory of storage explosive.

For the restricted 50-meter warehouse area in the danger zone are located:

- Guardhouse (mobile building of the "trailer");

- WC on two points;

- Backup diesel power substation.

The territory of the warehouse entrance has a car Gates equipped for the passage of personnel and access road train paths for unloading explosive. Are designed access railways and roads for the shipment loading explosive.

The warehouse territory explosive to prevent flooding areas paved with gravel height of 0.5 m.

The general plan is shown in the application, sheet 2.

Outside the exclusion zone storage explosive, at a distance of 380m. from the fence warehouse explosive is an outdoor test site and the destruction of explosive.

4.3 Architectural and construction solutions

To store explosive uses specially modified stationary mounted universal large container type 1CC nominal load capacity of 20.0 tons and 1A nominal load capacity - 40.0 tons (GOST 18477-79 *) installed on pre-planned areas. Total storage of explosives in stock in the amount of up to 50 tons of explosives and means of initiation nomenclature and number of the above, in the territory of the warehouse are arranged two container platforms.

4.3.1 Container platform with explosive №1 (four containers of type 1A)

Storage of explosives, detonating cord and polymer shell (ammonium nitrate explosives, detonating cord) in an amount of up to 50 tons of explosives in the warehouse is provided on the container site with explosives №1.

Platform is designed to accommodate four standardized, large-purpose 40-foot containers 1A with length of 10.5 m and a width of 12.2 m and planned surface paved with gravel height of 0.5 m.

Containers are installed on a platform in a single row across the width. Container base construction site and arrangement of containers on it is shown in the application, the sheet 3.

Explosives on the container site will be stored in specially converted large-universal 40-foot containers of type 1A.

To comply with UESR requirements to storage sites the explosive containers shall be equipped:

- Device for ventilation, to elements which are vents and vent outlet.

- Vents size 0,2 × 0,2 m, is arranged in the lower part of the door leaf or the bottom of the front side wall of the container and vent outlet size of 0,2 × 0,2 m - in the ceiling at the rear of the container.

To avoid the possibility of getting through these devices precipitation inside the container, over vents is arranged visor with sides, and above outlet - an umbrella.

- Boardwalk on the floor of the container board thickness of 40 mm (for the storage explosive) for placement of bags, boxes, and other places with explosives.

- Additional devices (loops) for locking the outer container door locks.

All wooden structures in each container (flooring, pallets) must be treated with flame retardant.

Calculation of the capacity of one 40-foot container when placing ammonium nitrate explosives in bags:

Internal dimensions of 40-foot container in terms of 12.0 × 2.3 m. Height - 2.35.

Ammonium nitrate explosive comes from manufacturers in bags with dimensions of 0.8 × 0.4 × 0.2 m. (Length - width - height). Weight of explosives in one bag - 40.0 kg.

The distance between the stack and the wall of the container - 0.2 m;

The width of the passage between the stack and the wall of the container - 0.95 m;

Stack height - 2.0 m.

Under the scheme stacking bags with explosive define that in the same row (layer) on the pallet length 11.2 m is placed 42 bags (per pallet length 0.8 m - 3 bags). When laying bags of explosives in the 10 series, the capacity explosive in a single container will be 420 bags. Capacity of one container will be 420 × 40 = 16800 kg.

To accommodate the explosive ammonium nitrate are need three containers 1A. Ammonium nitrate explosive will be stored in containers №1, №2, №3 on site with explosive in a quantity with a maximum capacity of this type of 50 tons explosive.

Diagram layout ammonium nitrate explosive in sacks in the container 1A is shown in the application, sheet 4.

Placed in containers 1A the ammonium nitrate according to GOST 2-85 in bags is follow the same parameters as when placing ammonia-nitrate explosive in sacks.

Calculation of the capacity of one 40-foot container when placing detonating cord and polymer shell (Amiflex T-100):

Internal dimensions of 40-foot container in terms of 12.0 × 2.3 m.

The distance between the stack and the wall of the container - 0.2 m;

The width of the passage between the stack and the wall of the container - 0.93 m;

Stack height - 1.82 m.

To count the number of boxes of detonating cord is taken their dimensions 0.62 × 0.25 × 0.4 m (length - width - height). Capacity of the box with detonating cord is 500 m. To store 140 boxes of detonating cord there is sufficiently small space.

Accordingly, the container №4 will be stored detonating cord 70 th. m and polymer shell Amiflex T-100 - 50 th. m.

To prevent collapse of the stack explosive consisting of boxes after three rows of boxes laid adjustment veneers.

On this basis, the total capacity of the container yard №1 with explosive is equivalent to 50 tons of the explosive charge, including; ammonium nitrate explosive in bags, 70,000 meters detonating cord and 50,000 meters polymeric shell for explosive.

4. 3.2. Container yard №2 with means of initiation (two containers of type 1 SS)

Designed for storage means of initiation:

- electric detonators

- Pyrotechnic relay RP-2,

- Wire VP

- Clips

- Store vortex generator of detonation products

- Or other materials and means of initiation in case of contracted services

Storage will be implemented in large-purpose 20-ton containers.

Storage of means of initiation in stock is provided on the container site №2.

Container yard №2 (length 6.4 m and a width of 5.4 m) consists of 2 standardized, large-purpose 20-ton containers.

The base of construction container yard as follows:

On the planned surface location of the warehouse explosive on detrital paved base thickness of 0.5 m are installed containers.

Containers are installed on site in a row across the width (in the series there are two container 1SS). Container base construction site and arrangement of containers on it is shown in the application, the sheet 5.

To comply with the UESR requirements to storage sites explosive containers shall be equipped:

- Device for ventilation, to elements which are vents and vent outlet.

- Vents size 0,2 × 0,2 m is arranged in the lower part of the door leaf or the bottom of the front side wall of the container and vent outlet size of 0,2 × 0,2 m - in the ceiling at the rear of the container. To avoid the possibility of getting through these devices precipitation inside the container, over vents is arranged visor with sides, and above outlet - an umbrella.

- Boardwalk on the floor of the container board thickness of 40 mm to accommodate the boxes, and other places with the means of initiation;

- Additional devices (loops) for locking the outer container door;

All wooden structures in each container (flooring, shelves) should be treated with flame retardant.

4.3.3 Building for the preparation and issuance of the explosive

Building for the preparation and issuance of the explosive is equipped on the basis of mobile building of the "trailer" and has a rectangular shape. The building is located at the entrance gate to the warehouse explosive at a distance of 29.0 m from the container yard with explosives №1 and 28.4 m from the container yard with means of initiation №2. Size of the building in terms of 2,5 × 6 m. Building height 2.6 m. Windows are plastic. The outer metal door

has width of 0.8 m and a height of 2.0 m. Floor - 18 mm plywood, linoleum fireproof. Walls, partitions, ceiling - MDF 5-6 mm. Wiring - with copper conductors in cable ducts, lighting incandescent lamps in protective dome with 6 outlets. Heating is electric radiators oil explosion-proof 6 kW. The package also includes building a fire extinguisher, medicine cabinet, plastic bucket.

The windows of the building preparation and issuance of explosive are equipped with metal bars from the corner with the faces of 45 × 45 mm. and rod Ø 15 mm. The cell size is 150 × 150 mm. In each crossing bars welded together.

The front door to the room is metal, opening outwards. Dimensions of doorways 0.8 × 2.0m.

The room has the following equipment: front of the door on the opposite wall mounted shelf unit length 2.4 m width 0.6 m and a height of 1.7 m to accommodate issued means of initiation. For the issuance of means of initiation is placed table SL-1 near the window. Opposite it is set a special table SL-2 for marking and checking resistance electric detonators. The design of the table should include securing devices for marking and determination of resistance to electric detonators.

Additionally, each room is set on two fire extinguishers OU-10, with a capacity of 10 liters.

During the determining the resistance of electric detonators, detonators placed in a protective device (cut metal pipe with a diameter of 100 mm, inside lined with felt, 5 mm thick). Safety device are pre-tested for durability and reliability of protection by undermining it at the site of electric detonators.

In order to prevent accumulation of static electricity and Markers "channel security" must be grounded. The grounding resistance should be less than 100 ohms.

The design of the building and the main parameters for the preparation and issuance of explosive is shown in the application, sheet 6. Layout of premises and equipment in the building preparation and issuance of explosive is shown in the application, sheet 7.

4.3.4 Guardhouse (trailer mobile building)

For a restricted area warehouse in the region of the entrance road to the warehouse and highways is located the guardhouse.

As a guardhouse is used trailer mobile building.

Dimensions of guardhouse in terms of 3 × 6.15 m., Height - 2.84 m. (Cantilever). Windows are plastic 860 × 800 mm with double glazing and shutters. The outer is metal door with width of 0.8 m and a height of 2.0 m. Floor is 18 mm plywood, linoleum fireproof. Walls,

partitions, ceiling are MDF 5-6 mm. Wiring - with copper conductors in cable ducts, lighting incandescent lamps in protective dome with 6 outlets. Heating is electric. Oil radiators are explosion-proof 6 kW. In the guard-room there are two rooms:

- Room for gun recharging;

- Room for guard post.

On the side of the guardhouse and roofed enclosure for backup power is set mobile power type AWH-30.

At the guardhouse is installed metal pole with energy-saving lamp power of 200 watts.

4.3.5. Lavatory

Pit latrines by 2 points is located outside the restricted area of the warehouse guardroom.

Lavatory is made of wooden structures. Dimensions (length × width × height) 2100 × 1200 × 2050.

Alternatively, the model can be installed prefabricated composting toilets, plastic tank waste.

4.3.6 Metal cabinet for firefighting equipment

Metal cabinet for firefighting equipment has a rectangular shape. The cabinet is installed on the sand and gravel pad height of 0.5 m.

The cabinet for fire-fighting equipment are placed (buckets - 6 pcs., hooks - 3 pcs., crowbars - 3 pcs., shovels - 6 pcs.).

In view of the delivery to the warehouse of explosives, granulated ammonium nitrate, electric detonators, detonating cord in cardboard boxes and paper bags, non-refundable, device storage space for containers are not provided. Used containers, as release have to immediately taken out of the warehouse and utilized.

4.3.7 Fire water

The fire water for storage of explosive materials in the container yard №1 with explosives from two end sides, about container yard with means of initiation №2 and near building of preparation and issuance of explosive are installed barrels of water with volume of 100 liters (filling in the summer), and box with a capacity of 0.5 m^3 and fire shield with sand.

Due to the fact that the warehouse is not equipped with an internal fire line and automatic fire extinguishing based on p. 21 of Annex 3 of the Rules of fire safety in Russia 01-03 to accommodate the primary means of fire, non-mechanized tools and fire equipment at the

warehouse explosive must be equipped with fire boards. To extinguish fires, Class A (A2) in the premises of category B is fire shield type SCHP-A.

Fire board type SCHP-A is equipped with composed of: scrap - 1 pc., gaff - 1 pc., bucket - 2 pcs., spade - 1 pc., shovel - 1 pc., fire extinguishers: GP-10 - 2 pcs .

4.4 Engineering equipment, networks and systems
4.4.1 Heating

Heating is provided for the guardhouse and building of preparing and issuing the explosive. Heating is electric (electric oil heaters in a protective casing).

4.4.2 Water supply

Due to the remoteness of location the warehouse from water supply systems for filling fire water tanks (barrel), as well as for other household needs will be delivered in the vessels from the nearest source. Drinking water is bottled in plastic bottles capacity 19l and delivered from the village Svetly.

4.4.3 Sewage

At the warehouse is not envisaged construction of the storm and fecal sewage. Near the trailer is installed toilet room on 2 points with raking. To prevent erosion of the warehouse in the spring and autumn periods, the warehouse area are slept sand and gravel ground thickness of 0.5 m above the existing ground surface.

4.4.4 Power supply

Power supply is provided for warehouse 6 kV transmission line through the pole-top transformer 40/6 / 0.4 kV.

Power supply of storage provided in accordance with the Rules for Electrical Installation (The seventh edition of UESR (PB 13-407-01).

Pole-top transformer is mast outdoor transformer substation. The high voltage bushing is air, conclusions lines 0.4 kV - cable.

Due to the fact that the work technology warehouse release of explosive is made only during daylight hours, the electricity of storage explosive (containers 1SS and 1A) is not provided (p.26.21 Unified Explosive Safety Regulation).

Power supply of temporary active storage explosive refers to the consumers I category. As a source of backup power is installed diesel electric power station provides backup needs for storage explosive.

Voltage from pole-top transformer 40/6 / 0.4 kV for power transmission lines fed into the building guard, building preparation and issuance of the explosive and the electric lighting on the perimeter. The building guard is used electricity for lighting and cooking. For illumination area and perimeter warehouse explosive are installed wooden supports with lamps rated at 250 watts.

4.4.5 Fencing of storage explosive

The warehouse territory is enclosed by the fence of wooden poles which provided for mounting the 10 strands of barbed wire, height 2.0 m, in which from part of the driveway are installed gate for vehicles and it can be locked with locks. Automotive design and wicket gates are shown in the application, the sheet 8. The design of the warehouse unit fence is shown in the application, sheet 9. These structures are shown as standard in the construction of these facilities. There is possible a replacement from wooden structures to metal, while maintaining the general parameters and dimensions of the equipment.

Fencing is set at a distance at least 40 m from the nearest places of explosive storage, according p.26.5 "Unified Explosive Safety Regulation (PB 13-407-01). Section X. Requirements for construction and operation of warehouses of explosives".

At a distance of 50 m from the fence warehouse is installed an exclusion zone around the perimeter equipped notices on metal poster height of 1 m and 50 m with warning labels "EXCLUSION ZONE".

4.5 Industrial Safety during storage of explosive materials

The stock explosive must ensure compliance with the requirements of "Unified Explosive Safety Regulation" (PB 13-407-01) on the inner and outer safe distance from the explosive storage.

4.5.1. Determination of the safety distance for the transfer of detonation.

Taking into account the development of measures to prevent emergencies in stock explosive and quantification of hazardous substances involved in a hypothetical accident is necessary to determine the safety distances for the transfer of detonation.

Distance r_D, excluding the possibility of transmission of detonation from the explosion at the surface of one object with explosives - the active charge to another such object - passive charge determined by the formula (19) p. 6 Chapter VIII, Table 9 UESR.

$$r_D = K_D \times \sqrt[3]{Q} \times \sqrt[4]{b},$$

where:

- r_D - a safe distance from the center of the active to the passive charge, m;

- K_D - coefficient whose value depends on the type of explosives and explosion conditions (taken from Table 9 to Nos. 6 and 7 of Chapter VIII of the UESR), containers for storing explosive which is not diked;

- Q - weight of the active charge, kg;

- b - the smallest linear dimension of the passive charge, according to the order of placement: the width of the stack (TNT blocks, detonating cord) - $b = 0,8$ m .; maximum width of the rack with the SI - $b = 0,7$ m.

4.5.2 Safety distance for shock air wave action on buildings and structures

According to the p 5.1.2 (b) Chapter VIII of the UESR, in the general case when calculating a safe distance from the warehouses to the settlements, road and railways, major waterways, factories, warehouses, explosives and flammable materials and structures of national importance is adopted the third degree of damage. For completeness the effects of accidental explosion at a warehouse are presents the calculation of the radii of zones in which has highest possible degree of damage.

Container platforms with consumable store explosive the explosive is openly located, not diked. Permissible distances by the action of the shock air wave from the storage of explosive materials to a variety objects is calculated as shown in Table 8 (in p. 5.1.7, 5.1.8 Chapter VIII) of Annex 1 " Unified Explosive Safety Regulation".

In view of the calculations presented in p. 4.5.1 of this project, in the accident total will participate, the maximum stock explosive, stored in warehouse with amount of 50.0 tons.

Safe distance by the action of the shock air wave in case of emergency explosion is calculated by the formula:

$$r_v = 30 \ Q^{1/3}, \text{ m. at Q} > 10 \text{ ton}$$

At emergency explosion of total maximum stock the explosive stored on a temporary active storage container type, the range of shock air wave will be (at $Q = 50.0$ tons explosive):

$$r_v = 30 \times 50000^{1/3} = 1105 \text{ m.}$$

Thus, from the calculations show that objects with a constant presence of people is not subject to the range of a shock air wave.

Thus, all the places of permanent residence and episodic people not subject into the danger zone by the action of the shock air wave an emergency explosion total maximum stock the explosive stored in a warehouse in an amount of 50.0 tons.

Distance, the current safety shock air wave per person is determined according to p.5.2. Chapter VIII of the UESR.

The total maximum stock of explosive stored on a temporary active storage:

$$r_{min} = 15 \cdot \sqrt[3]{Q} \text{ , m.}$$

$$r_{min} = 15 \cdot \sqrt[3]{50000} = 553 \text{ , m.}$$

where Q - weight of explosives, kg.

Lethal radius zone for the person in the explosion of large explosive charges (Q ≥ 300 kg) is:

$$r_{lh} = 2,7 \cdot \sqrt[3]{Q} \text{ , m.}$$

$$r_{lh} = 2,7 \cdot \sqrt[3]{50000} = 99 \text{ , m.}$$

Safety distance on the effects of shock air wave in case of emergency explosion the explosive stored in the warehouse will be: r_v = 1105 m. The protected objects according to resulting distance, including residential settlements and other objects of the third degree of damage within UESR" (PB 13 407-01) are absent.

4.6 Lightning protection and grounding

Lightning protection of warehouse is performed in accordance with Chapter XI of the UESR "Instructions for the design, device, and operation of lightning for warehouses"

4.6.1 Calculation of lightning for container yard with explosives №1

Lightning protection of in each vault and container yard with explosives are secures by double lightning rod, pipe design on extensions height of 16.0 m.

Lightning is centrally located at short sides of container area at 6.0 m distance from the walls of the containers (the UESR in accordance with TS, depending on the impulse earthing resistance).

Parameters of lightning protection zones calculated by the formula Chapter XI the UESR "Instructions for the design, construction and operation of lightning for warehouses with explosive"

$$h_0 = 0{,}85h; \qquad (4.1)$$

$$r_0 = (1{,}1 - 0{,}002h)h; \quad (4.2)$$

$$r_x = (1{,}1 - 0{,}002h) \times \left(h - \frac{h_x}{0{,}85}\right); \qquad (4.3)$$

$$h_d = h_0 - (0{,}17 + 3 \cdot 10^{-4}h) \times (L - h); \qquad (4.4)$$

$$r_{dx} = r_0 \frac{h_d - h_x}{h_d}. \qquad (4.5)$$

where:

L - distance between the lightning rods;

h - height of the lightning rod;

h_0 - the height of the top of the lightning rod protection zone;

r_0 - radius protection zone of lightning rod at ground level;

r_x - zone radius protection of lightning rod at the height of the protected structures;

h_x - the height of the protected structures;

h_d - height of the protection zone dual lightning rod;

r_{dx} - radius protection zone of dual lightning rod at the height of the protected structure.

Lightning protection arrangement shown in the application, the sheet 10.

The calculated parameters of protection zones dual lightning rod for protection equipment at the container yard №1 are presented in Table 4.1.

Table 4.1 dual protection zone of lightning rod for container yard №1

Storage explosive	L, m	h, m	h, m	r_0,m	r_x, m	h_x, м	h_d, м	r_{dx}, m
Container yard №1	27.6	16.0	13,6	17,1	13,7	2,7	11,1	12,9

4.6.2 Calculation of lightning for container yard with means of initiation №2

Lightning protection from the primary effects of lightning to container yard with means of initiation №2 is executed with freestanding lightning rod tube design on extensions height 13.0 m, which is located at the end face of the lower container at a distance of 4.0 m from it.

Parameters of lightning protection zones is also calculated by the formula Chapter XI the UESR "Instructions for the design, construction and operation of lightning for warehouses with explosive":

$$h_0 = 0{,}85h; \qquad (4.6)$$

$$r_0 = (1{,}1 - 0{,}002h)h; \qquad (4.7)$$

$$r_x = (1{,}1 - 0{,}002h)\left(h - \frac{h_x}{0{,}85}\right). \qquad (4.8)$$

where:

h - height of the lightning rod;

h_0 - the height of the top of the lightning rod protection zone;

r_0 - radius protection zone of lightning rod at ground level;

r_x - zone radius protection of lightning rod at the height of the protected structures;

h_x - the height of the protected structures;

The calculated parameters of a single zone protection lightning rod for equipment at the container yard with means of initiation №2 are presented in Table 4.2.

Table 4.2 protection zone of a single lightning rod for container yard №2

Name of the storage explosive	h, m	h_0, m	r_0, m	r_x, m	h_x, m
Container yard №2	13,0	11,05	13,96	10,68	2,59

4.6.3 Calculation of the lightning protection for building preparation and issuance of the explosive

Lightning protection from the primary effects of lightning for building preparation and issuance of the explosive is performed by a single lightning rod with height of 10.0 m, located at a distance of 4.0 m (or perform a calculation in accordance with paragraph 6.3, Chapter XI of the UESR) from the back of the front wall of the building.

Parameters protection zones of a single lightning rod as well are calculated by the formulas within Chapter XI the UESR "Instructions for the design, construction and operation of lightning for warehouses with explosive".

The calculated parameters of single zone of protection lightning rod for building preparation and issuance of the explosive are shown in Table 4.3.

Table 4.3 protective zone of a single lightning rod for the building with explosive.

Name of the storage explosive	h, m	h_0, m	r_0, m	r_x, m	h_x, m
Building for preparation and issuance of the explosive	10,0	8,5	10,8	7,6	2,59

Supports of lightning conductors are made from metal pipes. Metal poles are protected against corrosion staining surfaces. Staining of the contact surfaces in the joints is not allowed. The upper end of the support attached to the welding lightning arrester d ≥ 12mm. extending above the support at 1.0 m. Lightning is connected to earth and the current lead is attached to the support straps. Metal supports lightning rod are installed in the ground to a depth of 3 meters.

Sectional area conductor of steel lightning rod should be at least 100 mm^2. The length of the conductor project adopted by 1.0 m. Lightning is protected from corrosion by galvanizing or coated with tin.

Each lightning rod has an individual combined three earthing rod, made from parts of a length 3.0 m, a cross section of 50×50×3 mm and are arranged in a row. Tubes are connected to the metal strip 40×4 mm with depth 0.8 m. The distance between the corners is 6.0 m.

The design of earthing is made in accordance with the requirements of the Unified Explosive Safety Regulation (p. 8.2.4, Chapter XI «the UESR).

4.6.4 Protection from secondary effects of lightning

Protection from secondary impacts of lightning for containers with explosive and buildings of preparation and issuance of the explosive will be performed using the electrodes for connecting the metal frame canopy and container grounding protection against secondary effects of lightning.

Grounding is arranged of the steel strip section 40×4 mm, laid on the perimeter of each container at a distance 0.5 - 1.0 m from the foundation at a depth 0.8 m from the ground. To reduce the resistance of current spreading is hammered segments of angular steel section 50×50×5 m in length 3.0.

Construction of earth electrodes from the secondary effects of lightning takes a similar as lightning conductors of earth electrodes from direct lightning strikes. Inhibitors are protect against direct impacts and secondary effects of lightning and must be separated from each other at least 7 meters.

Shells of lighting, lighting boxes and starting equipment as well as brackets for fixtures shells and armor of cables should be grounded.

4.7. Fire-fighting measures

To extinguish fires around the container yard with explosives №1, with means of initiation №2 and buildings for preparation and issuance of the explosive are placed by staffed firefighting equipment shields (SCHP, type-A, Class A). Nomenclature of fire-fighting equipment must be agreed with the local authority legally. In addition, there are a number of them with shield and 1

box of sand (size 0,7×0,55×0,55 m) and in the summer time is set for one barrel of water capacity of 100 liters.

In the guardroom are four additional extinguishers. To protect the floor from fire around the warehouse, destruction of vegetation is plowed strip with width of 5.0 m. Within the restricted area is cut down trees and bushes. Around each container at a distance of 5.0 m is removed the sod.

In the guardroom is posted instructions of the procedure for fire-fighting equipment and their use. Warehouse personnel should be familiar with the instructions on signature.

On the territory of the warehouse and the exclusion zone are removed trees and shrubs, dry grass, twigs and other flammable objects.

In a metal cabinet for fire-fighting equipment must be kept fighting equipment according to the following nomenclature:

- Crowbars - 2 pcs;
- Shovel - 4 pcs;
- Axes - 2 pcs;
- Bucket - 3 pcs;
- Hooks - 3 pcs.

4.8 Security, alarm and communication

Security of explosive storage is carried out by armed guard.

To protect the warehouse is organized two posts. During business hours the one post at the road gate, the second in the guard room. Location of guardhouse is providing the necessary overview of the warehouse, the exclusion zone and vehicle entrances to the warehouse and guardhouse.

Pass on the territory of the warehouse and back is carried out in accordance with a discharge mode.

Between the guardroom and posts link is provided radio stations.

The personnel of the guard should be armed with firearms.

4.9. Project of testing ground for explosive and its destruction

4.9.1. General information

Test and destruction of dilapidated and not satisfying explosive materials for technical requirements and GOST are provided on the open range, located outside of exclusion zone storage explosive, at a distance of 380 m from the fence warehouse.

The general plan is shown in the application, sheet 11.

Parameters of polygon: length 40.0 m; width of 30.0 m.

The landfill is slept with soil, sand. For fenced the perimeter from entrance to warehouse are installed car gate (on the principle of fences and gates store).

Polygon surface must be flat with a slope of 0.001% for the drainage of surface water and covered with a pillow of plastic or loose soil with a minimum thickness of 20 cm.

The landfill are arranged at facilities such: aria for destruction the explosive; hole for the destruction of the explosive with low detonation ability; armored pit to destroy detonators; pyrotechnic time relay (RP-8); storage containers for explosive; a place of destruction for containers; storage with sand (volume V=3 m^3). Scheme of testing ground for the destruction of the explosive is shown in the application, sheet 12.

Pit for the destruction the explosive with a reduced ability of the detonation should have a flat bottom, covered with a pillow of plastic or loose soil with a minimum thickness of 20 cm. Before the the explosive pit should be cleaned from snow, water. The dimensions of the hole: depth - not less than 0.6 m; length and width - not less than 2.5 m.

Armored pit for the destruction of electro detonators must be box-shaped from metal sheets thickness of not less than 10 mm, size is not less than 1.0×1.0×1.0 m. During the destruction with the top of the pit is should be closed with solid wooden shield made of boards with a minimum thickness 50 mm and sprinkle a layer of sand thickness not less than 0.2 m.

Place of short-term storage with explosives is protected from destruction sites of explosive by defensive shaft from the ground without coarse inclusions conical height of 2.5 m. The configuration of the protective shaft should be such to completely cover the place of short-term storage explosives from the site to place of destruction explosive.

The destruction shall be carried out after the completion of the destruction explosive.

4.9.2 Requirements for the production of works destruction explosive

The destruction of the explosive, including not meeting the requirements of standards and specifications, must be carried out by written order of head blasting organization, burning according to standards, specifications, manufacturer's instructions the explosive.

For each destructed explosive must be an act within indicating the number and name of the destruction explosive materials, causes of destruction. Act is made in 2 copies intended the warehouse and accounting organization.

Place to destroy the explosive is equipped according to this project, approved by the head of the company and must be defined danger zone.

The destruction of the explosive must be performed under the supervision of warehouse manager or persons of technical supervision appointed by head of the organization.

Destruction blasting should be carried out with the help of benign explosive: cartridged explosives must be destroyed in batches. Detonators, detonating cord and pyrotechnic relay - in any package buried into the ground or in other ways that exclude spread unexploded products.

Subject to destruction by burning way is entitled an explosive that cannot be blasted. Do not dispose of combustion detonators and products with them.

Secure distance of combustion the explosive shall be calculated with the corresponding number of blasting explosives.

Burning the explosive are only permitted in dry weather in the amounts set by management (instructions) on the application.

Explosives and Detonating cord are burned separately, and allowed to burn at the stake at a time not more than 20 kg.

Cartridges explosive combustion are arranged in a single layer so that they do not touch.

Do not dispose of the explosive in their containers, before burning explosives make sure they do not contain means of initiation. Unusable boxes, paper bags, etc., including traces of fluid, after inspection and cleaning of explosives and initiating devices must be burned separately from them.

To ignite the fire with the explosive must downwind run track of flammable material of at least 5 m. After igniting the shooter must immediately withdraw from the danger area.

Ignition can be carried out after all the preparatory work and the withdrawal of people in a safe place.

Fire should be such that it is not necessary to enclose the combustible material in the combustion of the explosive.

Inspection of the burning is prohibited until the complete cessation of burning fire with the explosive;

At the end of the destruction of the explosive the staff respective operations, including the head of the works are obliged to ensure of complete destruction articles with explosives.

4.9.3 Identification and protection of the danger zone

The dimensions of the danger zone during the works for the destruction of the explosive are installed according to the maximum weight of explosives and based on the weight of benign the explosive which exploded at a time. The weight of the charge does not exceed 20 kg.

The current safety distance on the explosion shock air wave for human in external charge is determined by the formula:

$r_{saf} = 3 \times 15 \times \sqrt[3]{Q}$, m with the requirements of p. 5.2 of Chapter VIII UESR

Taking into account the maximum mass of exploded explosives and destroyed no more than 20.0 kg the danger zone by the action of shock air wave will be (subject to blasting in the pit):

$$r_{\min} = 3 \times 15 \times \sqrt[3]{20} = 122 \text{ м.}$$

Nearest building with personnel (guardhouse of warehouse) is located 220 meters from the fence of the landfill site, which ensures the safety for staff staying during the work on testing and destruction of the explosive.

On the border of danger zone calculated with rounding (R = 150.0 m), on the ground is necessary to install warning signs with an inscription: "PASSAGE IS PROHIBITED", "DANGER! EXPLOSION.".

Protection of the danger zone is carried out according to the requirements of the UESR by posts of the danger zone at the border, for the time necessary to destroy the explosive.

The number of posts is set by supervisor responsible for the destruction of the explosive.

Determination of current safety distances at air shock waves for glazing with outer blasting charges.

A safety distance r_e on the effects of shock air wave is given by:

$r_B = 65 \times Q^{1/2}$, m, with 2<Q<1000 kg with the requirements of p. 5.1.9 Chapter VIII UESR

Guardroom of warehouse is located at 220m from fencing landfill.

The maximum weight of explosives destroyed is calculated:

220 = 1/2x65xQ$^{1/2}$ kg. Q = 45kg. At positive temperatures.

220 =1/2x65x1,5 x Q$^{1/2}$kg. Q = 20кгkg. At negative temperature.

The maximum weight of destroyed explosives or means of initiation with the weight of benign at one time shall not exceed 20 kg.

Before working for the destruction of explosive should be done supply signals according to p. 12, Chapter IV of UESR.

Work to destroy explosive must be in accordance with the requirements of UESR and the requirements of sections of this project for the destruction the landfill and testing of explosive materials.

4.9.4 Requirements UESR during the test of explosive

Quality Control explosive is carried out:

- During entering the warehouse (input control).

- During storage prior to the expiration of the warranty period;

- During storage at the end of the warranty period;

All explosive regardless of the period of storage should be tested in the event doubt in their purity by visual inspection or unsatisfactory results in blasting operations.

Issuance of explosive from a warehouse for tests carried out in accordance with the requirements of the "Instructions of store, transport, use and registration of explosive materials" and " Unified Explosive Safety Regulation ".

Consumption of explosive issued tests has to be written in the book (Form 2 and Form 1) in the prescribed manner.

Issuance of explosive beyond the warranty period of storage for use in blasting operations is allowed only if the positive results of their tests.

The results of quality control explosive (inspection and test) shall be made by an act of the Form 2a and entered in a special journal on Form 1 UESR.

Results of unsatisfactory quality test explosive to the expiration of their warranty shelf life of claim report, copies of which have to be sent to the factory and Rostehnadzor. Rejected lots of explosive should be destroyed.

The total amount of simultaneously exploded at the site in one time must not exceed 20.0 kg, up to 1,000 electric detonators, detonating cord is no more than 500 m.

Explosive test must be carried out in accordance with the requirements of p. 9 Unified Explosive Safety Regulation according to standards specifications (factory instructions, guidelines on the application) to the appropriate explosive materials in the manner prescribed by management.

Test of explosive arriving at the warehouse is made by the commission under the supervision of a person technical.

The commission is determined by the order of the enterprise.

Stock of consumables is produced an external examination of the explosive and check all electric detonators resistance.

4.10 Sanitary protection zone of warehouse

Sanitary protection zone storage of explosive materials is determined according to SNiP 2.2.1 / 2.1.1.1200-03 the Amendments №1 (SNiP 2.2.1 / 2.1.1.2361-08), p. 4.1.1., Class I - and is 1000 m.

4.11 Arrangements for personnel actions in case of fire

In the event of a natural disaster, the fires in the area adjacent to the area of the warehouse and the establishment in these areas by the administration of emergency situation in which the risk of fire at the warehouse and the impossibility of establishing its liquidation in-house, by the fire departments of the State Fire Supervision Department of Russia in the Arkhangelsk Region, manager organizes the immediate removal of all explosives that are in stock at nearby stores own vehicles and dedicated district administration in full compliance with the requirements of UESR.

In exceptional cases, when the fire situation does not allow to export explosive to other stores due to the distance of transportation, lack of a sufficient number of vehicles, explosive must be stored at a safe distance from fire source with the organization of their protection. Choosing a place in advance of the head portion is produced in consultation with local authorities and representative of the Office of the Ministry of Emergency Situations of Russia in the Arkhangelsk region.

In the event of a flammable situation, temporary workers consumable warehouse Arkhangelsk branch of "KNAUF GIPS KOLPINO" or in their absence, security staff must immediately notify by telephone on the head of the company in accordance with the list of officials (lists with phone numbers should be in the workplace warehouse manager explosive in the guardhouse):

- After reports of a fire before arrival the leaders and temporary workers consumable warehouse Arkhangelsk branch "KNAUF GIPS KOLPINO", and in their absence the person protection have to use fire-fighting equipment and fire-fighting primary means, which are in stock explosive and also take measures to eliminate fires in the warehouse.

- To prevent the transfer of fires on the territory warehouse, the area around containers and the path of the fire watered is covered with sand or snow.

- If it is impossible to cope with the seat of the fire on their own and there are conditions under which the possibility of penetration of fire in a container with explosives and means of initiation, the head of blasting or warehouse manager should command the departure of its employees (including security) from the danger zone on a pre-specified paths and over a distance of 0.5 km. Head of section must familiarize the personnel with safety actions during emergency and protection of the area to pinpoint the safe zone on escape routes in emergencies. The results of instruction shall be entered in a book of instruction under the signature. Evacuation plan must be in the guard-room and warehouse at conspicuous place.

- In the case of finding the victims staff or armed guard their evacuated at first using available tools.

4.12 explosives of own production

In the Arkhangelsk region not far from the field Glubokoe as well are working other mining companies. In the village Savinskiy, Plesetsk District, works JSC "Savinskiy cementniy zavod" Every year, the company conducts blasting in order to loosen the rock mass in the amount of 200 thousand m^3 using outsourcing services. Blasting operations are carried out by the same contractors that the field Glubokoe. The "Lukoil" is launched mining and processing plant (GOK) capacity of 4.5 million tons of ore per year in diamond mine named Vladimir Grib in the Arkhangelsk region. Blasting operations are scheduled to hold contractors in the amount of up to 500 thousand m^3 per year.

In view of possible cooperation in the organization and conduct blasting operations as a contractor in this thesis project is proposed the idea to establish the production of explosives.

A suitable example for the production was proposed by management of HC "Jakutugol" - invited to develop skilled local project to replace regular explosives to explosives of own production, packed into sack tare (or cartridges).

In order to reduce the cost of drilling and blasting, improve safety during transportation explosives from manufacturers, improving working conditions of staff has examined several options for packing of explosives own production.

1st option is to create wrapping production on the existing process plant point production of granular explosives, as part of the project which has capacity for bagging produced by explosives in the bags. However, with the new regulations this installation was not meet the requirements of industrial safety and this option has not reached the stage of feasibility study.

2nd option was considered after receipt of the offer from NTF "Vzryvtehnologiya", which has developed and gained approval for the use of Rostekhnadzor (conducting preliminary tests) mobile mixing plant (MMP) for the production of industrial explosives.

Project under consideration is carried out in an efficient production and aimed at reducing costs.

MMP is an installation composed of a two assembly process modules, one of which - the mixing is designed to accommodate the hardware components mixing, the second - receiving - for receiving, dispensing and packing of the finished explosives.

MMP is located within the complex structures of the base explosive storage and stationary points of production industrial explosives from a safe distance, calculated under the terms of the transmission of detonation. This arrangement is simplifies the transport scheme of movement of ammonium nitrate on the territory warehouse explosives and finished product warehouse on the base the explosive. The modular design of MMP provides its portability and low operating costs. Specifications are given in Table 4.4.

For the implementation of the project (the acquisition of mobile mixer) is needed funds of 4.5 mln. Ruble. (Table. 4.5).

To determine the changes in the activity of the enterprise, which would entail commissioning MMP considered 2 options (calculated at according prices of 2014).

Table 4.4 Technical characteristics of MMP

Name of parameter	Value
Productivity, kg/h	1000
Base of mobile mixing plant	Two universal container ICC
Overall dimensions in operating position, mm, not more: length width height	6050 2438 5180
The volume of the hopper, dm^3	250
The storage bin volume, dm^3	180
Motor: type performance Power, kW Rotational speed, rev/min	АИМ-М80В4 Explosion-proof 1,5 1395
Gross vehicle weight, kg, not more	5200

Table 4.5 Breakdown of the necessary financial resources for the implementation of the project

Name	Sum, ths. Rub.
The cost of equipment (installation MMT)	3813,56
delivery of the equipment	205,1
installation	381
Total excluding VAT	4399,66
Total with VAT	5191,6

The first option is the production of explosives using MMP for their own needs. It is planned to replace the 1000 tonnes of Granulit RP.

For the calculation of the economic efficiency of MMP, the following inputs:

- The performance of MMP - 166 t per month, or 2,000 tons per year at one-shift 8-hour operation, the maximum capacity can reach 3000 t per year;

- Power consumption is not more than 15 kW/h;

- The staff - loader (3 people), mixing apparatchik (1 person);

Operating mode MMP (eight-hour single-shift) is selected based on the mode of operation of the base explosive warehouse, which will be produced by explosives stored.

The increase of the number of loaders in the area for the production explosives due to personnel serving MMP and to an increase in the number of loading and unloading operations as ammonium nitrate of finished products. The existing circuit includes only operations with explosives.

The second option is production of explosives on the MMP for own use and for the implementation of the consumer. Given that the maximum capacity of the plant at the existing mode of operation is 2000 t per year can be realized Granulite RP or other explosive for outside customers.

Potential consumers of the product may be CJSC "Savinskiy Cementny Zavod" and "Lukoil". This will reduce the potential risk during transportation of regular explosives by railway transportation.

Chapter five: Feasibility Study

5.1 General information

The annual costs of Arkhangelsk branch LLC "Knauf Gips Kolpino" to perform blasting operations by contractor service are taken as the basis of feasibility study and for the construction of a warehouse to provide explosives for gypsum quarry Glubokoye. These annual costs include blasting working cost in the place of deposit in an amount equal to 32 rubles per м^3 and transportation costs of explosive materials from the storage location to the quarry in an amount equal to 9 rubles per м^3. Average annual productive capacity of the quarry is 350 thousand м^3. Calculation of the annual cost of blasting operations performance by contractor service is the following:

$$P_{year} = (P_{bl} + P_{tr})\ V_{year}$$

Where: P_{bl} - blasting working cost

P_{tr} - transportation costs of explosive materials

V_{year} - amount of the annual quarry performance

In such a way, the total annual cost of blasting should not exceed P_{year} = 14.35 million rubles.

To calculate the profitability of the project is taken straight-line method of depreciation - the most common way. In this method of depreciation is charged in equal installments over the life cycle. For calculation shall be the initial cost, the sum of all costs incurred in connection with the acquisition of the object. The depreciation period linear method takes - 10 years.

The cost of doing blasting in mine Glubokoe involving outsourcing forces for a period of 10 years takes 143.5 million Rubles.

Mineral reserves of categories B, C1 and C2 (prospected and extrapolated reserves) with capacity of 22.6 million tons (10.4 millionм^3) are taken as projected to open pit mining. Since the beginning of quarry operation, the following amount was worked out:

- 2009-393 thousand tons;
- 2010-520 thousand tons;
- 2011-652 thousand tons;
- 2012-719 thousand tons;
- 2013-735 thousand tons;
- 2014-685 thousand tons;

Total amount of the waste gypsum is 3.7 million tons (1.7 million м^3) of gypsum stone. Besides the fact of time necessary for the construction of a warehouse and necessary operations, preparation of documents and so forth was taken into account – 2 years. In such a way it is

necessary to add the plan for 2015 and 2016 to the waste gypsum capacity – 1.6 million tons (0.73 million м³).The total cost of blasting on the deposit will be calculated as follows:

$$P_{total} = (P_{bl} + P_{tr})\ V_{reserve}$$

Where: P_{bl} – blasting working cost

P_{tr} - transportation costs of explosive materials

$V_{reserve}$ –reserve deposits for 2015

The total investment of the project to conduct blasting operations, taking into account the entire life of the quarry and the depreciation of investments should not exceed $P_{total=}$ 320 million rubles.

Design study includes:

1. Capital investments:

- Construction of warehouse for explosives;

- Construction of access railroad;

- Construction of approach automotive road;

- Purchase of special vehicles for explosives transportation from the warehouse to the quarry;

- Course for receiving the qualification of blaster for drill runners;

- 10 % of unexpected expenses.

2. Operating costs for providing and maintenance of blasting:

- Explosives purchase

- Transportation of explosives from manufacturer to warehouse of temporary dislocation

- Paramilitary twenty-four-hour security services of the warehouse

5.2 Capital investments

5.2.1 Warehouse for explosives

Due to the large difference in price between the new containers and trailer-type containers previously used, it makes sense to purchase the second type. The average price on the Russian market for container of type 1A (modified as a warehouse) is 240 thousand rubles, for container of type 1SS (modified as a warehouse) – 180 thousand rubles. Trailer-type building of preparation and issuance of explosives (modified) has the average price 300 thousand rubles, trailer-type guardhouse (modified) – 320 thousand rubles, container of type UKK-1 – 45 thousand rubles. The data are taken according to the pricelist of "Konteynerlizing" company.

Analysis of all necessary expenses for the warehouse construction is tabulated in the table 5.1.All costs are taken to the cost of transportation.

Table 5.1 Capital investments for warehouse of explosives

Item	Amount	Unit price, thousand rubles	Company	Web site
Container of type 1A	4	240	«Konteynerlizing»	http://www.contlease.ru/
Container of type 1SS	2	180	«Konteynerlizing»	http://www.contlease.ru/
Building of preparation and issuance of explosives	1	300	«Konteynerlizing»	http://www.contlease.ru/
Container of type USS-3 for fire-fighting equipment	1	45	«Konteynerlizing»	http://www.contlease.ru/
Guardhouse	1	320	«Konteynerlizing»	http://www.contlease.ru/
Restroom	1	20	«Ecoservice-plus»	http://www.ecomarka.ru/
Gates	1	80	«Alyumarket»	http://www.alumarket.ru/
Lightning discharger	4	160	LLC «Stroj Invest Komplekt»	http://flagma.ru/
Fire extinguishing panel	4	30	Avangard-Ekb	http://ekb.pulscen.ru/
Site fence of warehouse (415 meters)	1	996	MetallPromKontinent	http://chel.pulscen.ru/
Light tower of territory perimeter	9	200	LLC «Tekhsnab»	http://flagma.ru/
Traffic-control barrier	1	25	Optima service	http://www.optimaservis.su/
Means of energy and heating	-	1600		http://www.pulscen.ru/
Fittings	-	2300		http://www.pulscen.ru/
Deforestation	-	500		
Sand and gravel playground	1	1500		http://www.pulscen.ru/
Prohibiting signs	12	6		http://www.pulscen.ru/
Compensation of outsourcing forces	-	1400		

The total investments for the construction of a warehouse for explosives of container type are up to about 13 million rubles.

5.2.2 Construction of access railroad

The ballast layer for railway tracks is arranged in loose and highly conductive water materials. It must ensure the sustainability of the way and have elastic properties. The gravel is used as ballast, as a cushion is used dropouts from the field Glubokoe.

Figure 5.1 displays cross section ballast prism. Top macadam ballast in the sleepers of wood must be at least 3 cm below its upper layer, and for concrete sleepers - on the same level with the top of the formation of the middle part. Fig. 5.1 shows the ballast with a pillow of dropouts.
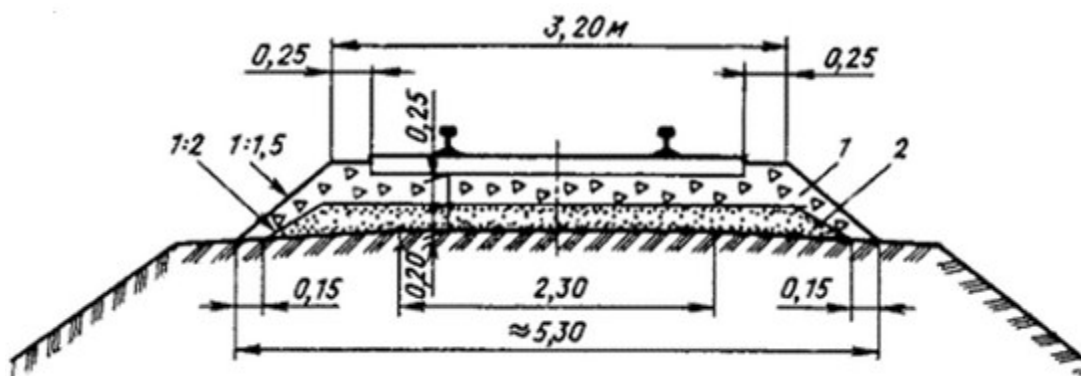
Figure 5.1 Cross-section ballast prism
1- gravel; 2 - dropouts

The cost of construction of railways calculated on the basis of services provided the LLC "Bi-Tavr" (table 5.2).

Main specialization of the LLC "Bi-Tavr" is construction and repair of all types of main lines, railway sidings, constructional works, the device subgrade, as well as delivery of materials for the of the permanent way.

The company carries out a full range of services in the following areas:
- designing of railway tracks;
- construction of railway tracks;
- laying of railway tracks;
- reconstruction and modernization of ways;
- service of tracks;
- overhaul and maintenance of railways.

All types of construction works are carried out with the usage of own materials, own machines and mechanisms, with high quality and on time. The company performs works with high quality and will make the delivery of the object to structures of JSC "Russian Railways".

The list of the main services includes:

- preliminary examination (at the stage of land selecting) for the technical possibility of joining sidings and evaluation of the estimated cost of construction;

- receipt and approval of design specifications in braches of the JSC "Russian Railways" and in the Federal Railway Transport Agency, by the owners of utilities, local and federal authorities;

- engineering surveys, develop options gridiron, preparation of preliminary estimates for construction;

- designing of railways, artificial structures, utilities, coordination of projects;

- construction of railway and put into operation;

- reduction of railway track ballast by gravel and sand;

- installation and repair of railway crossings and driveways;

- laying and construction of turnouts and dead crossings of all types;

- technical inspection and examination of the state of the railway line, issuing opinion letters;

- overhaul, average repair, rehabilitation of access railway performed by using the new or used materials - in consultation with the client, the cost of work is determined by the cost sheet;

- implementation of materials supply for the permanent way: timber sleeper impregnated, sleepers made of concrete (new and used); crossing sleepers for turnouts – wood, impregnated, turnouts; rails, bonding of the permanent way.

To perform the work the company has:

- necessary licenses;

- qualified professionals;

- building machineries;

- devices of small-scale mechanization.

Technical equipment enables to perform construction, repair or reconstruction of the railway line reliable, with high quality and warranty.

To calculate the cost of the railway line from the station to the village "Svetly" to the warehouse of explosives distance in 912 meters was taken, including a straight section in 837 meters and the radius of curvature in 75 meters (Table.5.2). The calculation was made by using a calculator of the company LLC «Bi-Tavr» on the website http://bitavr.ru. Prices are taken to the cost of transportation.

Table.5.2 The cost of railway construction

Cost of track material	7211750 rubles
Cost of the ballast	1760000 rubles

Cost of construction of the railway track	**11000150 rubles**
Cost of materials	791400 rubles
Cost of turnouts	330000 rubles
Cost of turnouts construction	**1121400 rubles**
Total cost of the project	**22214700 rubles**

5.2.3 Construction of approach automotive road

Focusing on the amount of road traffic the category II-B was accepted. According to SNiP 2.05.07-91* «Industrial transport» the following main technical standards in the design were adopted:

- design speed– 40 km/h

- grading width – 7,5 m

- bridge roadway breadth – 3,5 m

- shoulder width – 1,5 m

The general direction of the projected area of the road – north-east. The total length of the planned road section is 695 m. The road does not cross any settlements.

According to the necessary in parts and materials for the construction of a highway project the following is used:

- borrow soil of the quarry "Glubokoye" is used for the construction of subgrade and device underlayment, as well as devices for road pavement;

- rushed stone for road pavement is delivered from the quarry «Ostrechkovo»;

- concrete products for pipes delivered from Arkhangelsk plant of building structures and materials (concrete goods)

The main volume of works is performed by the own efforts, by the employers of the Arkhangelsk branch of the LLC "Knauf Gips Kolpino". Relying on the fact that the construction of the main road from the village "Svetly" to the deposit of Knauf company costed out in 12 million rubles per kilometer. With the use of outsourcing and the width of the carriageway of 7.5 m. Currently having a high material and technical basis, the cost of the project is estimated at 3,5 million rubles on the intended length and width of the roadway. The cost of deforestation is taken separately in Table 5.1.

5.2.4 Special vehicles

Trucks are depreciation groups depending on their load capacity and type. Most of them belongs to the 3rd - 5th depreciation groups. Let us assume in the calculations and depreciation group 3 amortization period - 5 years.

At working 0.7 million tons of gypsum annually the field's reserves will last for 25 years. Thus, for the entire period of the mine have the need to buy 5 cars. Operating costs for the use of a vehicle covered by the profit from the sale after the amortization period.

According to the rules of safety in transport of explosives by road (PB 13-78-94 Gosgortechnadzor Russia approved by Resolution of November 8, 1994 N 57) the car is must comply with the technical parameters described below.

"6.1. Explosive can be transported by specialized cars for general purpose and adapted for this purpose, working with liquid or gaseous fuels.

6.4. Explosive, except detonators and black powder may be transported on trailers. At the same time transportation explosive on single-axle trailers and trailers that do not have a solid connection and brakes is prohibited. Is permits transportation of explosive in specialized wagons - trailers, completed with special cars.

6.5. Metal parts of the body (bottom and sides) of vehicles and trailers carrying explosive must be covered with a continuous deck not readily flammable prevent sparking. Wood used for the manufacture of flooring is must to be infiltrate fireproof structure recommended by a specialized expert organization for the safety of operations.

6.6. Motor vehicle carrying the explosive has to work normally.

6.7. Fuel tank (except for gas cylinders) must be equipped with a metal shield of the front and rear walls, from the bottom installed steel mesh with a mesh size 10 x 10 mm (perforated plate); distance from the fuel tank to the boards and nets must be at least 20 mm.

The fuel tank should be removed from the engine, electrical wires and drain pipes, so that in the event of fuel leakage is directly poured on the ground.

6.8. Electrical equipment for vehicles carrying of explosive must meet the following requirements:

- rated voltage must not exceed 24;

- circuits shall be protected against over-current fuses prefabrication and disconnect switch, actuated from the cab;

- electrical wiring must have a reliable insulation, eliminating the short circuit, securely attached and placed in such a model, that it can not be damaged by the impact and friction of parts of the vehicle, and be protected from exposure to heat of the exhaust system;

- wiring must be made of wires with seamless top shell, does not corrode.

6.9. Vehicles must be equipped with rear-view mirrors on both sides. The driver and the person accompanying the goods are required to monitor the condition of the cargo and take immediate steps to eliminate faults occurring in transit.

6.10. The vehicle with bodywork type "wagon" carrying explosive must be completely closed, durable, does not have slots, interior wiring and separated from the driver's cab interval of not less than 150 mm. Wood used for the construction of the body is necessary to infiltrate fireproof structure (see. P. 6.5). For internal coating materials should be used that do not cause sparks. It is forbidden to use the materials to form dangerous compounds with the shipment.

Van door should be located on the right side of the vehicle. Allowed the unit door in the back of the van in case provided equipment alarm connected to the cabin of the car and is triggered when the door is opened. The door should be locked in the internal lock and have a device that prevents its opening in case the lock disengaged. For indoor lighting have to be used lamp cover which must be installed in the upper part of the front wall of the body from the outside wiring, laid in a protective casing.

6.11. If the coverage of public bodies for vehicles intended for the carriage of explosive, there is used readily flammable, waterproof, well stretched and covers the sides of the body is not less than 200 mm. The fabric should be fixed on special hooks and loops that are installed on all sides of the body.

6.12. Technical condition and equipment of vehicles carrying explosive must meet the requirements of the rules and guidelines for their technical operation, taking into account the need to protect the environment.

6.13. Each vehicle designed to carry the explosive is completed:

- A red flag attached on the left side of the cockpit;

- Chock of a size suited to the type of vehicle;

- Three fire extinguishers with a capacity of not less than 5 liters each;

- Readily flammable waterproof fabric;

- A set of tools for small (emergency) repair of the vehicle;

- Flashing red lamp or warning triangle;

- Two signs "No entry";

- First-aid kit;

- A set of snow chains. The need for staffing snow chains vehicles with two or more driving axles determined by the technical head of the company to be shipping explosive.

In the case of transport of pyrotechnic compositions and articles the vehicle is equipped with a shovel and a stock dry sand in an amount not less than 50 kg. "

According to paragraph 8.3. PB 13-78-94

When transporting explosive on the same vehicle is responsible for the transportation of a person may simultaneously perform the functions of protection. In the case of transportation of explosive on two or more vehicles stands guard on a mandatory basis. At the same time

responsible for the transportation of a person must be on the front car and face protection - at last. The first and last cars should be between a reliable radio communications.

When transporting explosive column drivers of motor vehicles, which are not accompanying the goods or face protection are required to sign for the adoption of explosive to the transport document of arbitrary shape, which is located in the responsible person.

An example of a vehicle for transportation explosive materials on the chassis serve Kamaz 65115-1095-97 selling company "Automaster." (Figure 5.2)

Fig. 5. 2 Vehicle for the transportation of explosive materials

Vehicles for transportation of explosive materials EX / III is designed for the transport of explosives, such as explosives, gunpowder, fireworks, ammunition construction, industrial charges, ammo shooting and other dangerous goods, materials and substances.

The car meets all requirements for transport safety in accordance with the requirements of POGAT. (Table. 5.3)

Table 5. 3. Characteristics of special vehicles

№	Product name and modifications	Number of pieces
1.	Base unit KAMAZ-65115. Wheel arrangement 6x4. Speed limiting device till 90 km/h, the digital tachometer, system GLONASS are set.	1
	Box body for transportation of explosives: - external van size: 6000x2500x1950 мм; - outer skin of the van – clad metal; - van is painted white; - PZHZH-200 – 50 mm; - upholstery – plywood 10 мм., flame retardant; - floor – flooring, fluted aluminum shouldered; - ring securing cargo on the floor - 8 pieces.;	1

	- doors: side single, splitdoor equipped with a retractable ladder; - storage compartment and equipment hatch outside of the van door;	
3	Exhaust	1
4	Fuel tanks protection	1
5	Setting the switch to open the electrical circuit in the cab and in the vicinity of the battery	1
6	Ground pin with wire 6м	1
7	Grounding chain	1
8	Set of tools for minor repairs of transport	1
9	The rear doors are equipped with alarm connected to the cab driver and are triggered when the doors are opened	1
10	Interior room light is protected by casing, all wiring and signaling ceiling back door is in a protection shell, with insulated electrical wiring in the aluminum casing	4
11	Flashing indicator of orange color	2
12	Frames for danger signs	2
13	Fire extinguisher OP-6	3
14	Installation of filters from ignition of wheels	2
15	Installation of fire extinguishers type "Buran" in a motor compartment	1
16	Extinguishing system "Doping-2", which has an independent power supply from the regular battery and driving from the driver's cab	6
17	Rear safety bar	1
18	Box for sand	1
19	First-aid box «Fest»	1
20	Highway emergency warning triangle	2
21	Shutdown alarm	2
22	Sign «Road Up»	2
23	Tow cable	1
24	Folding shovel	2
25	Wheel blocks	1
26	Flame-retardant waterproof fabric	1

The cost of one piece of equipment with value added tax – 0% is 2 855 000 rubles.

Time of equipment manufacture is 25-30 workdays.

Payment terms: advanced payment 50%, the rest 50% upon notification of the car readiness.

Performer,

Sales manager   Suvorov Vasily

Mobil phone 8-920-011-45-15,

407253112v@gmail.com

5.2.5 Employee training and education

To ensure timely delivery of blasting on the deposit "Glubokoye" presence of the master-blaster on two watches in necessary. During one of the experts' vacation time blasting will be conducted only in one watch. To achieve the desired quality of blasting working at the quarry

drillers best suit for the position of blasters. Costs of training for two employees are 300 thousand rubles. This number includes saved salary in an amount of 35 thousand rubles, 50 percent of travel expenses, cost of living in a hotel or in a rented apartment, tuition fees. Training time – 2 months.

Optional training program is provided for receiving of Blaster's uniform certificate in the Moscow State Mining University for the specialty "Blasting work".

Direction:

Mining and Geology

Target audience:

Engineers and technicians of mining companies who do not have mining education Higher education, secondary vocational education

Duration:

240 hours

Cost:

28 thousand rubles

Annotation:

Mining. Systems of open mining: transport, materials, power source, measuring instruments. Blasting technology. Quality control and destruction of explosives. Workflow management for blasters. Safety and environment. Preparation of blasters (with production or management rights) for production in open mining

Document issued after the graduation*:*

Standard-issue certificate

5.3 Operating costs

5.3.1 Explosives purchase

During negotiations with the contracting organization LLC Research and Technic Company "Vzryvtechnologiya" (Moscow, tax identification number 7719044698) prices for the purchase of explosives for for gypsum quarry "Glubokoye" of Arkhangelsk branch of the LLC "Knauf Gips Kolpino" (Primary State Registration Number 1057810222392) were negotiated. The price is 27 rubles per 1 kg, providing the ensure loosening of the rock mass - 40 thousand $м^3$ on the deposit "Glubokoye" and with explosive ratio 0.5 kg/$м^3$. The price of which includes:

- blaster agent – Granulit RP

- instantaneous fuse DSHE-12

- pyrotechnic relay RPE-2

- electric detonator ED-8ZH

- amiphlex T-100

- clips

- sticky tape with logo

- wire VP-0.8

While maintaining the same specific consumption, value of annual loosening of the rock mass will be:

$$P_{year} = V_{year} \cdot q \cdot P$$

Where: V_{year} – amount of the annual quarry performance

q – specific consumption of explosives

P – price of 1 kg of explosives

Annual investment in the purchase of explosives is 4.7 million rubles.

To calculate depreciation for a period of 10 years, the costs will amount to 47 million Rubles.

The funds that are necessary for the explosives purchase for the entire life period of the quarry "Glubokoye" will be:

$$P_{total} = V_{total} \cdot q \cdot P$$

Where: V_{total} – total reserves of the deposit

The total cost of the explosive purchase with the entire life of the quarry will be 108 million rubles.

During negotiations with the contractor private limited company "Morozovka" (Leningrad region, tax identification number 4703067775) estimated price for explosives purchase was discussed in the amount of 28-29 rubles per 1 kg under the same conditions described above.

5.3.2 Transportation of explosives

The transportation cost of explosives by rail is measured by the track foreman of Russian Railways with the use of calculator of provided services of Public Limited Company "Russian Railways".

Annual production of gypsum is 350 thousand м^3. Taking into account specific consumption of explosives – 0.7, necessary amount of explosives will be 245 thousand tons. Since the warehouse capacity is 50 tons, 5 trips should be made. Taking into account loading gage of explosives, 2 covered railroad cars are necessary for transportation of 50 tons. In such a

way, the number of railroad cars running is 10. According to the price list for the transportation, the annual cost will be 0.47 million rubles.

Stock of the quarry for 2016 is 8 million м^3. Amount of explosives required for loosening of the rock mass - 5.6 million tons (120 railcars). The total cost of transport is 5.7 million rubles.

According to legislation of Russian Federation paramilitary security services are needed for explosives transportation. The average daily cost of such service in private security companies is 6 thousand rubles. The average delivery time is- 5 days. Number of trips per year is 5 times. In such a way, annual cost on paramilitary security services is 150 thousand rubles.

The total number of flights for the entire life period of the quarry is 120 times. Thus, the cost of the paramilitary security services is 3.6 million rubles.

The total cost of transporting of explosives will be 9.3 million rubles.

Table 5.4 Payment for transportation

Shipping fee on the price list №10-01	
Payment for transportation	
Total accrued	46759,86 rubels
including VAT	7132,86 rubels
tariff	39627,00 rubels
VAT	7132,86 rubels
in total	46759,86 rubels
internal transportation	
shipment	01 carload
distance	1372 km
For information on sending	
departure date	14.09.2014
date of issue	14.09.2014
dispatch station	291302 GLUBOKOE-NOVOE
road departure	28 СЕВЕРНАЯ
station of destination	060209 MOSKAU-TOVARNAYA
road destination	01 OTYABRSKAYA
speed	Freight
delivery period	21.09.2014
Information about loads	
weight	68000 kg
code	433070 ammonium nitrate
class	2
Information about the car / container	
Rhode car	20 covered
Number of axes	4
Carrying capacity of wagon	69 t
Wagon tare weight	220 c

car accessory	own
Country-owner car	Russia
index oversize	20
calculated weight	69000 kg
Number calculation scheme	8
rate	12544,04

5.3.3 Paramilitary twenty-four-hour security services of the warehouse

When the current annual production of gypsum is constant, quarry operation will last for 25 years. According to negotiations with private security firms for the deposit Glubokoye average price is 3 million rubles per year. Calculated on the amortization period - 30 million rubles.

5.4 Result of the feasibility study

Total amount of the capital and operating costs are shown in the table 5.5.

Table 5.5 General costs for construction of the warehouse for explosives

1. Capital investments:	Price (rubles)
- Construction of warehouse for explosives	13 million
- Construction of access railroad	23 million
- Construction of approach automotive road	3,5 million
- Purchase of special vehicles for explosives transportation from the warehouse to the quarry	5,6million
- Course for receiving the qualification of blaster for drill runners	0,3 million
- 10 % of unexpected expenses	4,4 million
Total of the section	*50 million*
2. Operating costs:	
- Explosives purchase	47 million
- Transportation of explosives from manufacturer to warehouse of temporary dislocation	9,3 million
- Paramilitary twenty-four-hour security services of the warehouse	30 million
Total of the section	*83,2 million*
Total	**133,2 million**

The total amount required for the conduct of blasting contractors for a period of 10 years will be about 143.5 million Rubles.

According to the analysis given above, the amount of investments for the construction of a warehouse with the capital and operating costs will be about 133.2 million Rubles. To calculate

the depreciation of the value of the fixed assets accepted. The rate of depreciation for a period of 10 years of use will be calculated as follows:

Normal A = 100% / 10 = 10%

Annual A = 133,200,000 * 10% / 100% = 13,320,000 rubles.

Monthly A = 13,320,000/12 = 1,110,000 rubles.

Annual costs for blasting operation with involving forces of outsourcing and in-house for amortization period of 10 years are equal to 14.35 million rubles and 13.32 million rubles, respectively. Thus, the annual cost of blasting operations will be reduced by 7.2% in the most pessimistic estimate. In fact, this figure will be much higher due to the possibility of cooperation with neighboring mining companies in the delivery explosives, blasting as contractors, the possible joint production of explosives.

Thus, the feasibility study has shown that the project will save the company about 7.2% of the costs for conducting blasting operations at the most pessimistic assessment on the depreciation period of 10 years. And will provide of high quality blasting.

Conclusions

Key findings, conclusions and recommendations are as follows:

1. In order to ensure the rational blasting on the mine Glubokoe is the appropriate use of explosives based on simple ammonium nitrate that will provide high quality of crushing the rock mass and cost-effectiveness.

2. Based on bench testing of packaged explosives isolated or permeable membranes are allowed to establish that the lowest rate of capacity watered wells and overlap factor explosive charge entry-level waters have cartridged explosives relatively smaller diameter compare to wells with permeable membrane. On cost parameters are identical to cheap simplest explosives used for dry wells.

3. Based on hole charges calculation method consisting of various types cartridges of explosives based on ammonium nitrate with increasing high-explosive blast of heat and use significantly less charge relatively to well diameter followed vortex generator are opens up the possibility of solving the problem of effective and safe loosening of the rock mass. Increasing the speed of the secondary chemical afterburn reactions is achieved by providing in the borehole the flow vortex turbulator products after the detonation of wave transmission. In vortex is intense mixing (forced convection) of detonation products, which increases the rate of chemical reactions afterburning products of incomplete decomposition explosives, remaining in the detonation products after passage of the detonation wave.

4. As a result of the proposed method sealing the ends of cartridges explosives and live primer are reached close contact with each other, which ensures reliable transmission of the pulse detonation and complete detonation of the charge.

5. In view of not monotonous field geology is actual to reduce in volume of the blasting. Which is impossible to achieve with outsourcing performance of crushing due to feasibility study. Thus, there is a question about building a warehouse.

6. Quite often is produced loosening of the rock mass by explosion where possible is disassemble by excavating machines or use selective loading wells to work out only on the floor. These can only be achieved in the manufacture of blasting operations on own.

7. Construction of a warehouse explosive will improve the quality of blasting by changing the size of the explosive array.

8. Acquisition of mobile mixing plant will reduce the cost of production blasting. Potential consumers of the product may be CJSC "Savinskiy Cementny Zavod" and "Lukoil". This will reduce the potential risk during transportation of regular explosives by railway transportation.

9. In the presence of consumer products among the mining companies of the Arkhangelsk region may receive additional profit from its sale. Implementation of this project is relevant to the mining companies.

10. The feasibility study has shown that the project will save the company about 7.2% of the costs for conducting blasting operations at the most pessimistic assessment on the depreciation period of 10 years. And will provide of high quality blasting.

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