ISSN 2518-170X (Online)
ISSN 2224-5278 (Print)

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ
«ХАЛЫҚ» ЖҚ

ХАБАРЛАРЫ

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»
ЧФ «Халық»

NEWS

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF
KAZAKHSTAN
«Halyk» Private Foundation

SERIES
OF GEOLOGY AND TECHNICAL SCIENCES

6 (462)

NOVEMBER – DECEMBER 2023

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

Clarivate
Analytics

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

ЧФ «ХАЛЫҚ»

В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект Ozgeris powered by Halyk Fund – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz.

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

С уважением,
Благотворительный Фонд «Халык»!

«ҚР ҰҒА» РҚБ Хабарлары. Геология және техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Меншіктеуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).

Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *геология, мұнай және газды өңдеудің химиялық технологиялары, мұнай химиясы, металдарды алу және олардың қосындыларының технологиясы.*

Мерзімділігі: жылына 6 рет.

Тиражы: 300 дана.

Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

«Известия РОО «НАН РК». Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.

Тематическая направленность: *геология, химические технологии переработки нефти и газа, нефтехимия, технологии извлечения металлов и их соеденений.*

Периодичность: 6 раз в год.

Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).
The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.
Thematic scope: *geology, chemical technologies for oil and gas processing, petrochemistry, technologies for extracting metals and their connections.*
Periodicity: 6 times a year.
Circulation: 300 copies.
Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19
http://www.geolog-technical.kz/index.php/en/

NEWS of the National Academy of Sciences of the Republic of Kazakhstan
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224–5278
Volume 6. Number 462 (2023), 50–69
https://doi.org/10.32014/2023.2518-170X.349

UDC 622.235

© S.Zh. Galiyev[1], F.Ya. Umarov, U.F. Nasirov*, Sh.Sh. Zairov, A.U. Fathiddinov, 2023
National Branch Research Technological University "MISIS" in the city of Almalyk, Almalyk, Uzbekistan.
E-mail: unasirov@yandex.ru

SAFETY SYSTEM AT FACTORIES PRODUCING EMULSION EXPLOSIVE COMPOSITIONS IN THE REPUBLIC OF UZBEKISTAN AND RECOMMENDATIONS FOR ENSURING SAFE CONDITIONS FOR BLASTING WORK

Galiyev S.Zh. — doctor of Technical Sciences, professor, corresponding member of the National Academy of Sciences of the Republic of Kazakhstan. *Branch of RSE NC CPMC MIIR RK Institute of Mining Engineering named after D.A. Kunaev,* Almaty, Kazakhstan
Umarov Farkhodbek Yarkulovich — Doctor of Technical Sciences, Professor, director of the branch of the National Research Technological University "MISIS" in the city Almalyk, Republic of Uzbekistan
E-mail: farkhodbek.umarov@yandex.ru;
Nasirov Utkir Fatidinovich — Doctor of Technical Sciences, Professor, Deputy Director for Research and Innovation of the National Branch Research Technological University "MISIS" in the city of Almalyk, Republic of Uzbekistan
E-mail: *unasirov@yandex.ru;*
Zairov Sherzod Sharipovich — Doctor of Technical Sciences, Professor, Head of the Sector of Scientific Research, Innovation and Training of Scientific and Pedagogical Personnel branch of the National Research Technological University "MISIS" in the city of Almalyk, Republic of Uzbekistan
E-mail: sher-z@mail.ru, https://orcid.org/0000-0002-1513-5683;
Fatkhiddinov Asliddinjon Utkir ugli — PhD, Associate Professor of the Department of Mining, Almalyk branch of Tashkent State Technical University, Republic of Uzbekistan
E-mail: *unasirov@yandex.ru*

Abstract. When developing rocks using drilling and blasting operations (DBO), serious problems arise in terms of technological provision of safe conditions. This article outlines the experience of performing a significant amount, analysis of the theory and practice of blasting operations at the quarries of Almalyk and Navoi mining and metallurgical plants, which allowed to establish the insufficiency of theoretical and practical research on the development of safety system for blasting, management of the magnitude of the striking factor, contributing to damage reduction. Consistently disclosed the results of the study of the degree of technological risk at the plants for the production of emulsion explosive compositions, set out the authors developed classification of dangerous events in the operation of the plant of emulsion explosives with the presentation of a set of appropriate measures to prevent them. This work recommends a comprehensive safety system for the operation of an emulsion explosives (EME) plant, which allows for the safe production of EME at the plant while reducing the existing risk level of the plant from 6.5 points to 4.0 points. Safe conditions for blasting in deep quarries were recommended in terms of the introduction of radio control of explosions, the development of a predictive assessment of blasting operations near mining equipment and utilities in terms of the damaging effect of pieces of blasted rock, which made it possible to increase the safety and efficiency of blasting operations in deep quarries.

Keywords: quarry, blasting operations, emulsion explosives, integrated security system, industrial safety, control of the magnitude of the damaging factor of the explosion, scattering of rock pieces, rock blasting method, negative impact of the explosion on the environment

© С.Ж. Галиев, Ф.Я. Умаров, У.Ф. Насиров*, Ш.Ш. Заиров, А.У. Фатхиддинов, 2023

Алмалық қаласындағы «МИСИС» ұлттық зерттеу технологиялық университеті.
Алмалық, Өзбекстан.
E-mail: unasirov@yandex.ru

ӨЗБЕКСТАН РЕСПУБЛИКАСЫНДАҒЫ ЭМУЛЬСИЯЛЫҚ ЖАРЫЛУШЫ ҚҰРАМДАРДЫ ӨНДІРЕТІН ЗАВОДТАРДАҒЫ ҚАУІПСІЗДІК ЖҮЙЕСІ ЖӘНЕ ЖАРЫЛУ ЖҰМЫСЫНЫҢ ҚАУІПСІЗ ЖАҒДАЙЛАРЫН ҚАМТАМАСЫЗ ЕТУ БОЙЫНША ҰСЫНЫСТАР.

Галиев С.Ж. — техникалық ғылымдарының докторы, Қазақстан Ұлттық ғылым академиясының корреспондент мүшесі. Қазақстан Республикасының минералдық шикізатты кешенді қайта өңдеу жөніндегі ұлттық орталығының филиалы Д.А. Қонаев атындағы тау-кен ісі институты Almaty, Kazakhstan
E-mail: seitgaligaliyev@mail.ru;

Умаров Фарходбек Яркулович — т.ғ.д., профессор, Өзбекстан Республикасы, Алмалық қаласы, Алмалық қаласындағы «МИСИС» Ұлттық ғылыми-зерттеу технологиялық университеті филиалының директоры
Scopus ID 55827283800; E-mail: farkhodbek.umarov@yandex.ru;

Насиров Уткир Фатидинович — т.ғ.д., профессор, Өзбекстан Республикасы, Алмалық қаласы, Алмалық қаласындағы «МИСИС» Ұлттық зерттеу технологиялық университеті филиалы директорының ғылыми-зерттеу және инновациялар жөніндегі орынбасары
Scopus ID 56527108100; E-mail: unasirov@yandex.ru;

Заиров Шерзод Шарипович — т.ғ.д., профессор, «МИСИС» Ұлттық ғылыми-зерттеу технологиялық университетінің Алмалық қаласындағы, Өзбекстан Республикасы, Алмалық қаласындағы филиалының ғылыми зерттеулер, инновациялар және ғылыми-педагогикалық кадрларды даярлау секторының меңгерушісі
E-mail: sher-z@mail.ru, https://orcid.org/0000-0002-1513-5683;

Фатхиддинов Аслиддинжон Уткир угли — актерлік Ташкент мемлекеттік техникалық университетінің Алмалық филиалы тау-кен ісі кафедрасының доценті, Өзбекстан Республикасы, Алмалық қаласы
E-mail unasirov@yandex.ru.

Аннотация. Бұрғылау-жару жұмыстарын (БЖЖ) пайдалана отырып тау жыныстарын игеру кезінде қауіпсіз жағдайларды технологиялық қамтамасыз ету тұрғысынан күрделі мәселелер туындайды. Бұл бапта айтарлықтай көлемді орындау тәжірибесі, жарылыс жұмыстарын жүргізу кезінде қауіпсіздік жүйесін әзірлеу, залалды азайтуға ықпал ететін зақымдау факторының шамасын басқару бойынша теориялық және практикалық зерттеулерді жүргізудің жеткіліксіздігін анықтауға мүмкіндік берген Алмалық және Навои тау-кен металлургия комбинаттарының карьерлерінде жарылыс жұмыстарын жүргізу теориясы мен практикасын талдау баяндалған. Эмульсиялық жарылғыш құрамдар өндіретін зауыттарда технологиялық тәуекел дәрежесін зерттеу нәтижелері жүйелі түрде ашылады, олардың алдын алу бойынша тиісті іс-шаралар кешенін ұсына отырып, эмульсиялық жарылғыш заттар зауытын пайдалану кезінде қауіпті оқиғалардың авторлар әзірлеген жіктемесі баяндалады. Бұл жұмыс эмульсиялық жарылғыш заттар (ЭЖЗ) зауытының жұмысы үшін қауіпсіздіктің кешенді жүйесін ұсынады, бұл зауыттың қауіпті деңгейін 6,5 баллдан 4,0 баллға дейін төмендете отырып, зауытта эмульсиялық жарылғыш заттарды қауіпсіз өндіруге мүмкіндік береді. Жарылыстарды радиобақылауды енгізу, жарылған тау жыныстары бөліктерінің зақымдаушы әсері тұрғысынан тау-кен жабдықтары мен инженерлік желілердің жанындағы жарылыс жұмыстарын болжамды бағалауды әзірлеу тұрғысынан терең карьерлерде жару жұмыстарын жүргізудің қауіпсіз жағдайлары ұсынылды, бұл мүмкіндік берді. терең карьерлердегі жару жұмыстарының қауіпсіздігі мен тиімділігін арттыру.

Түйін сөздер: карьер, жару жұмыстары, эмульсиялық жарылғыш заттар, кешенді қауіпсіздік жүйесі, өнеркәсіптік қауіпсіздік, жарылыстың зақымдаушы факторының шамасын бақылау, тау жыныстарының шашырауы, тау жыныстарын жару әдісі, жарылыстың қоршаған ортаға кері әсері

© С.Ж. Галиев, Ф.Я. Умаров, У.Ф. Насиров*, Ш.Ш. Заиров, А.У. Фатхиддинов, 2023

Филиал Национального исследовательского технологического университета «МИСИС» в г. Алмалык, Алмалык, Узбекистан.

E-mail: *unasirov@yandex.ru*

СИСТЕМА БЕЗОПАСНОСТИ НА ЗАВОДАХ ПО ПРОИЗВОДСТВУ ЭМУЛЬСИОННЫХ ВЗРЫВЧАТЫХ СОСТАВОВ В РЕСПУБЛИКЕ УЗБЕКИСТАН И РЕКОМЕНДАЦИИ ПО ОБЕСПЕЧЕНИЮ БЕЗОПАСНЫХ УСЛОВИЙ ВЕДЕНИЯ ВЗРЫВНЫХ РАБОТ

Галиев С. Ж. — доктор технических наук, профессор, член-корреспондент Национальной академии наук Республики Казахстан, филиал Национального центра по комплексной переработке минерального сырья Республики Казахстан, «Институт горного дела им. Д.А. Кунаева» Алматы, Казахстан

E-mail: *seitgaligaliyev@mail.ru*;

Умаров Фарходбек Яркулович — доктор технических наук, профессор, директор филиала

Национального исследовательского технологического университета «МИСИС» в городе Алмалык, Республика Узбекистан
E-mail: *farkhodbek.umarov@yandex.ru*. Scopus ID 55827283800;
Насиров Уткир Фатидинович — доктор технических наук, профессор, заместитель директора по научной работе и инновациям филиала Национального исследовательского технологического университета «МИСИС» в городе Алмалык, Республика Узбекистан
E-mail: *unasirov@yandex.ru.* Scopus ID 56527108100;
Заиров Шерзод Шарипович — доктор технических наук, профессор, начальник сектора научных исследований, инноваций и подготовки научно-педагогических кадров филиала Национального исследовательского технологического университета «МИСИС» в городе Алмалык, Республика Узбекистан
E-mail: *sher-z@mail.ru,* https://orcid.org/0000-0002-1513-5683;
Фатхиддинов Аслиддинжон Уткир угли — и.о. доцента кафедры «Горное дело» Алмалыкского филиала Ташкентского государственного технического университета, г. Алмалык, Республика Узбекистан
E-mail *unasirov@yandex.ru*.

Аннотация. При разработке горных пород с применением буровзрывных работ (БВР) возникают серьезные проблемы технологического обеспечения безопасных условий. В данной статье изложен опыт выполнения значительного объема, анализа теории и практики ведения взрывных работ на карьерах Алмалыкского и Навоийского горно-металлургических комбинатов, который позволил установить недостаточность проведения теоретических и практических исследований по разработке системы безопасности при ведении взрывных работ, управлению величиной поражающего фактора, способствующих уменьшению ущерба. Последовательно раскрыты результаты исследования степени технологического риска на заводах по производству эмульсионных взрывчатых составов, изложена разработанная авторами классификация опасных событий при эксплуатации завода эмульсионных взрывчатых веществ с представлением комплекса соответствующих мероприятий по их предотвращению. В данной работе рекомендована комплексная система безопасности эксплуатации завода эмульсионных взрывчатых веществ (ЭВВ), позволяющая обеспечить безопасное производство ЭВВ на заводе при снижении существующего уровня риска завода с 6,5 балла до 4,0 баллов. Рекомендованы безопасные условия взрывных работ в глубоких карьерах в части внедрения радиоуправления взрывом, разработки прогнозной оценки ведения взрывных работ вблизи горного оборудования и инженерных коммуникаций в части поражающего действия кусков взорванной породы, которые позволили повысить безопасность и эффективность взрывных работ в условиях глубоких карьеров.

Ключевые слова: карьер, взрывные работы, эмульсионные взрывчатые вещества, комплексная система безопасности, промышленная безопасность, управление величиной поражающего фактора взрыва, разброс кусков горных пород, метод взрывания горных пород, отрицательное влияние взрыва на окружающую среду

Introduction

For the foreseeable period of time, blasting remains the most common means of destroying rocky and semi-rocky rocks, despite their negative impact due to volley emissions of dust and gases, from which a dust and gas cloud is formed, rising to a height of up to 800 m and spreading in the direction of the wind for tens kilometers, which depresses flora and fauna and can lead to a decrease in the ability of fertile soil to self-purify. There is also significant harm from the impact of volley emissions of dust and gases on people. Therefore, the task arises of a gradual transition in open-pit mining, first to environmentally friendly, and then to environmental blasting technologies. At the same time, the assessment of the effectiveness and reliability of such technologies should be based on the balance of economic and environmental interests of the enterprise, which in the "mining production — environment" system is achieved by minimizing the costs of implementing technological solutions and environmental damage in specific mining conditions. From a technical point of view, the task comes down to optimizing blasting technology and environmental protection methods.

A significant contribution to the development of the scientific and technical foundations of drilling and blasting operations in quarries of the Republic of Uzbekistan was made by I.P. Bibik, N.I. Kuchersky, O.N. Malgin, Yu.D. Norov, Yu.E. Petrosov, B.R. Raimzhanov, V.R. Rakhimov, S.K. Rubtsov, N.P. Snitka, V.N. Sytenkov, P.A. Shemetov and etc.

Despite the significant amount of research performed (Baron et al., 1972; Bibik et al., 2008; Khakimov et al., 2021; Kechersky, 2007; Kutuzov et al., 1988; Malgin et al., 2003; Norov et al., 2011, 2011, 2016; Petrosov et al., 2017; Raimzhanov et al., 2001; Rakhimov et al., 2013; Tosltov et al., 1999; Shemetov et al., 2010, 2013; Snitka et al., 2017, 2017; Zairov et al., 2018, 2020), an analysis of the theory and practice of blasting in the quarries of the Almalyk and Navoi mining and metallurgical plants allowed us to establish that insufficient theoretical and practical research has been carried out on the development of a safety system when carrying out blasting, controlling the magnitude of the damaging factor, helping to reduce damage.

Study of the degree of technological risk at factories producing emulsion explosive compositions

It is known that the main technological and operational properties of EME depend on the correct choice of the composition of the oxidizing agent, emulsifier, method of producing the emulsion, the nature of the sensitizing additive and equipment for their production. It has been established that the composition of EME, having a number of advantages over other types of industrial explosives, has a number of features:

- there is a set of critical parameters of external influences, when exceeded, an initial source (explosion) occurs;
- decomposition of EME occurs at the molecular level and does not require additional reagents;
– EME are characterized by a high concentration and rate of energy release, which, as a rule, ends in an explosive effect affecting the environment (devices, building walls, neighboring buildings and structures, personnel).

Therefore, the production and use of EME requires strict regulation regarding safety conditions. As such a condition, we can consider the level of average technical (theoretical) risk, calculated as the sum of the criteria for the probability (frequency) of occurrence (B) (Table 1) and the severity of the consequences of undesirable events (P) (Table 2) for the most serious events.

Table 1

Risk assessment based on probability of occurrence

Point	Refusal	Frequency of occurrence refusal per year
0	Almost unbelievable	$<10^{-6}$
1	Rare	$10^{-4} – 10^{-6}$
2	Possible	$10^{-2} – 10^{-4}$
3	Likely	$1 – 10^{-2}$
4	Frequent	>1

table 2

Risk assessment based on severity of consequences

Point	Heaviness consequences of failure	Consequences
1	Disdainfully small	Do not fall into any of the following three categories
2	Non-critical	There is no possibility of significant damage to the environment and property, there is no threat to human life,
3	Critical	Possibility of significant damage to the environment and property, threat to human life
4	Catastrophic	Irreparable damage to the environment, significant damage to property, death of people

The level of average technical (theoretical) risk of producing EME, similar to the production of an EME plant, is calculated as follows. According to existing information, 29 events with catastrophic consequences occurred in the world over 40 years of operation of similar industries (Snitka et al., 2017). The number of enterprises in the world is approximately 150 (large and medium-sized). Failure rate per year amounts to

$$R_t = \frac{\Delta \mathrm{T}}{\mathrm{T}} = \frac{(\frac{29}{40})}{150} \approx 5 \times 10^{-3}, \quad (1)$$

where ΔT - is the number of accidents per unit of time t on identical technical systems and objects; T - is the number of identical technical systems and objects subject to a common risk factor.

According to table. 1 B = 2 points and table. 2 P=4 points. The risk level is

B+P=2+4=6 points. (2)

The level of average technical (theoretical) risk for an EME plant is calculated as the sum of the criteria for the probability (frequency) of occurrence (B) and the severity of the consequences of undesirable events (P) for the most serious events. Dangerous events during the operation of the EME plant and measures to prevent them are presented in Table. 3. The most dangerous technological events are: pump explosion when pumping hazardous products and chemicals; pump fire when pumping hazardous products and chemicals; fire or explosion in mixers mixing oxidizing and oil solutions and emulsion matrix, and gas-generating additives; fire (explosion) of mixing and charging machines (MCM).

As a result of the research, a risk assessment was carried out for the two most serious events with critical and catastrophic consequences that occurred at the plant during its operation, which is in accordance with the assessment criteria (probability of occurrence of 2_{events}: 7_{years} = 0.29, that is, corresponds to a probable failure (frequency of occurrence $1–10^{-2}$, B=3), and in terms of severity of the consequences - the first event is a pump failure, rupture of pipelines, fire and spill of liquid nitrate in severity - critical P_1 = 3, and explosion of a product pump – catastrophic P_2 = 4. Risk assessment based on the probability of occurrence (Table 1) and the severity of the consequences (Table 2) gives a summary result

$$\frac{\sum(B_n + Đ_n)}{n} = \frac{(3+3)+(3+4)}{2} = 6{,}5\,. \qquad (3)$$

Based on the results of the assessment, it can be concluded that the overall level of risk during the operation of the EME plant in the current conditions is acceptable, as for a hazardous industrial facility, subject to technical and organizational measures (safety system) aimed at reducing it. At the same time, the source of uncertainty in risk assessment is the human factor and equipment failure.

Table 3

Dangerous events during the operation of an EME plant and measures to prevent them

No.	Dangerous events	Possible reasons	Impacts or consequences	Probability estimate, V	Severity of consequences, P	Risk level	Severity	Events on prevention
1.	Pump explosion when pumping hazardous products and chemicals	Warming up the pumped solution. Exceeding the permissible discharge pressure	Fire in the production area. Severe injuries to personnel. Material damage. Lost time to restore equipment functionality	2	3	5	Critical	Control of the computer temperature control system, blocking the operation of the pump or the entire process if the temperature is exceeded; pressure control by independent controllers, pump blocking, installation of thermofuses; control of parameters by the operator of the control system.
2.	Explosion of a pressure container (air receiver, steam generator)	Equipment malfunction	Possibility of injury. Minor material damage. Lost time to restore equipment functionality	1	2	3	Non-critical	Periodic inspection, timely maintenance, repair or replacement of equipment.
3.	Fire in warehouses .	Use of open fire. Equipment malfunction	Possibility of loss of life and injury. Material damage. The need to involve VChPB and VGSCh.				Critical	The use of open flames is prohibited. Control of parameters by the operator of the control system; periodic inspection, timely maintenance, repair or replacement of equipment.
4.	Fire in a vehicle transporting ammonium nitrate. Fire (explosion) MCM	Unauthorized use of open flame. Electrical short circuit	Explosion and the possibility of casualties and injuries. Material damage. The need to involve VChPB and VGSCh.	1	4	5	Catastrophic	The use of open fire and smoking while moving the MCM and while loading blast holes is prohibited. Comply with the vehicle operating instructions.
		Equipment malfunction, tire wear		2	4	6	Catastrophic	Control of parameters by the operator of the control system; periodic inspection, timely maintenance, repair or replacement of equipment.
5.	Pump fires when pumping hazardous products and chemicals. Fire or explosion in mixers	Work without a product. Warming up the pumped solution Mechanical jamming	Fire and possible explosion of the pump. Severe injuries to personnel. Material damage. Lost time to restore equipment functionality	2	3	5	Critical	Control of the computer temperature control system, blocking the operation of the pump or the entire process if the temperature is exceeded; temperature control by independent controllers, pump blocking, installation of thermofuses; control of parameters by the operator of the control system.

Despite the encouraging results of the theoretical calculation of the risk level, it should be borne in mind that during the operation of the EME plant, two emergency incidents occurred with critical (explosion of the pump of the oxidizing solution preparation unit - spill of the oxidizer) and catastrophic (explosion of the matrix pump and pipeline) consequences. Since the main dangerous event is the operation of pumps and mixers, in 3 out of ten cases fire leads to an explosion (Table 4, Fig. 1 and 2). To reduce the likelihood of failure, it is proposed that it would be advisable to introduce additional interlocking and protection circuits for these units.

Table 4

Initial events of the "fault tree"

No.	Event or condition	Probability events
1.	Sensor failure	$2x10^{-4}$
2.	Broken signal transmission circuits from sensors	$1x10^{-5}$
3.	The operator did not switch the system to automatic control from manual (operator error)	$1x10^{-3}$
4.	Sensor power supply circuit interrupted	$1x10^{-5}$
5.	Control system failure	$1x10^{-6}$
3.	The operator did not see (was absent from the control room) the system warning (operator error)	$5x10^{-3}$
7.	The operator did not respond to the ACS warning signal (operator error)	$1x10^{-3}$
8.	The operator did not pay attention to the system warning (operator error)	$5x10^{-3}$
9.	Lack of reaction (incorrect reaction) of the operator due to stress.	$1x10^{-3}$
10.	Open circuit of the pump electric drive control circuit (micromaster)	$1x10^{-5}$
11.	Pump circuit breaker contact stuck	$1x10^{-5}$

Note: mandatory (simultaneous) events, the occurrence of which is sufficient for the occurrence of the main event (accident) (minimum missing events) and their probability: {5}=10^{-6}, {10}=10^{-5}, {11}=10^{-5}, {1x6}=10^{-6}, {1x7}=$2x10^{-7}$, {1x8}=10^{-6}, {1x9}=$2x10^{-7}$, {2x6}=$5x10^{-8}$, {2x7}=10^{-8}, {2x8}=$5x10^{-8}$, {2x9}=10^{-8}, {3x6}=$5x10^{-6}$, {3x7}=10^{-6}, {3x8}=$5x10^{-6}$, {3x9}=10^{-6}, {4x6}=$5x10^{-9}$, {4x7}=10^{-9}, {4x8]= $5x10^{-9}$, {4x9}=10^{-9}. A set of initial events that guarantees the absence of a head event provided that none of them occurs (minimum cut-off states): {1x2x3x4x5x10x11} and {5x6x7x8x9x10x11}

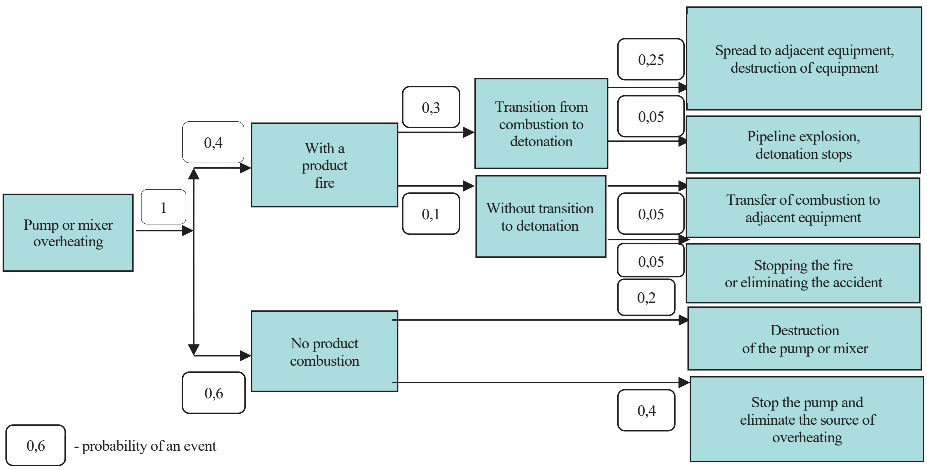
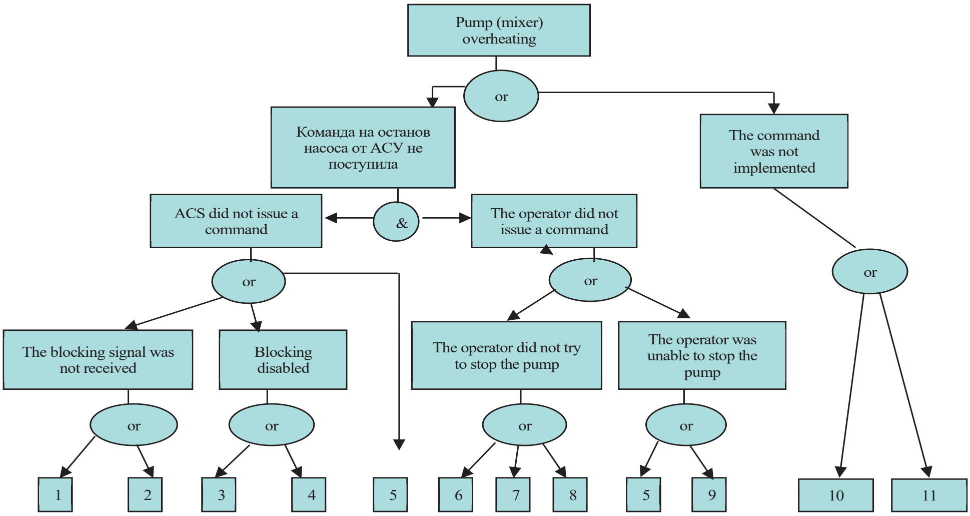


Fig. 1. Event tree of accidents on product pumps or mixers



1, 2, 11 – initial events

Fig. 2. Failure tree of emergency overheating of pumps or mixers in case of emergency overheating, lack of product in the supply tank (or closed pipeline valve) or increase in product pressure due to blockage of pipelines

The analysis of the technological process of manufacturing EME and possible sources of emergency situations allowed us to draw the following conclusion and recommendations:

1. Technological equipment and pipelines for the processing of EME components during its operation at the EME plant are exposed to corrosion, deformation and wear due to mechanical, chemical, temperature and other influences with the formation of various defects and damages. Of the total number of accidents with EME, in 35 % of emergency cases the cause was pumps (pumping), in 16 % of cases - components mixing devices, in 3 % of cases - MCM.

2. At the moment, the service life of the equipment in units of time, maintenance periods, according to the proven parameters of the safe state, work and overhaul cycles assigned and recommended by manufacturers of process equipment or developers of the entire production complex for the production of EME are not included in the operational documentation.

3. In the current situation, the operating organization (EME plant) must predict the further duration of operation (determine the residual resource reserve) of aging equipment based on an examination, taking into account modern methods of assessing and technical diagnosing the condition of potentially hazardous areas.

4. At the stage of periodic maintenance, when drawing up a defective list, control and measurement technical diagnostics of process equipment and pipelines should be carried out, including the condition of housing walls, welds, shafts, rotating units, bearings, electric motors, electrical and electrostatic grounding, electrostatic field strength, insulation integrity.

Thus, based on the research, the risk level of the plant was determined (3.5 points), the analysis of which required the development of a comprehensive safety system for the operation of the EME plant.

Integrated safety system for the operation of the EME plant

Based on research and analysis of the plant's risk level, in order to unconditionally ensure the safe production of emulsion explosives, a comprehensive safety system for the operation of the EME plant has been developed (Fig. 3). It includes an active and passive component. The active component of the security system includes:

– "Control and blocking by level", "Control and blocking by temperature", "Control and blocking by pressure" - is carried out by an automatic control system (ACS) using temperature, pressure measurement sensors, discrete level sensors. If the parameters deviate from the specified values or exceed the set values, the control system warns of a possible accident and stops the production process;

– "Control and blocking by vibration" – installation of vibration sensors is required;

– "Control and blocking based on the state of the actuators" – is carried out by an automatic control system using programmable controllers. Data exchange with actuators is carried out through appropriate means of interface with communication lines and through digital or analog input-output interfaces (I/O cards). The control signal is transmitted to the actuator, which through drives, valves, motors, switches, etc. changes the state of the mechanism;

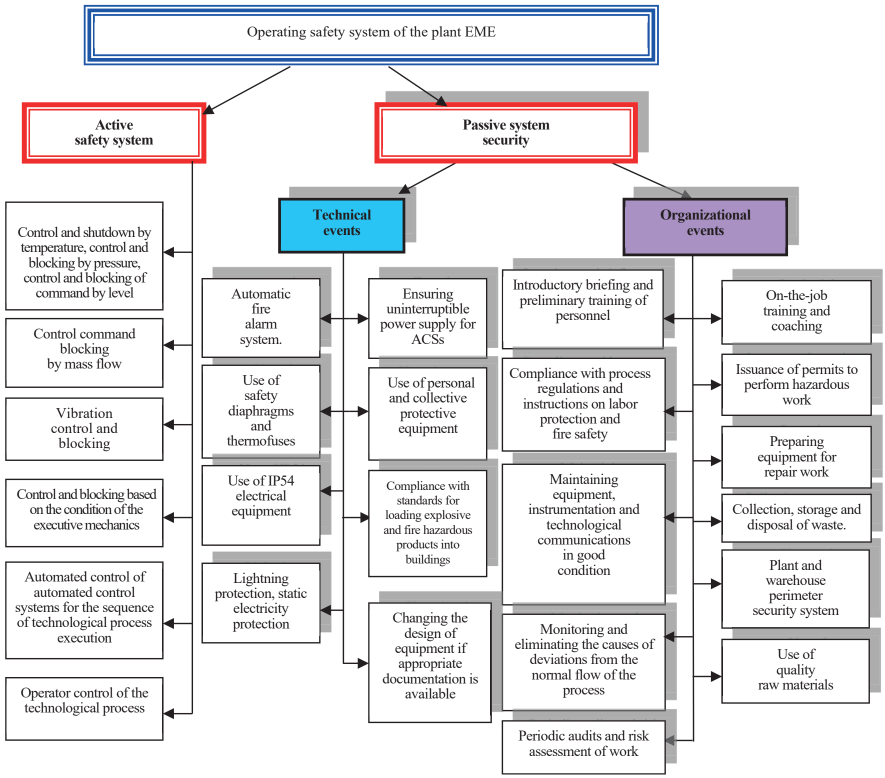


Fig. 3. Recommended integrated safety system for the operation of an EME plant

– “Automated control of automated control systems for the sequence of technological process execution.”

The matrix production process control system includes the following elements:

– automated control system with programmable memory with analog and digital inputs and outputs;

– graphic control station;

- local interfaces with indicators;

– user software;

– database of production parameters.

Data transmission to the automated control system is carried out by receiving signals about the current values of production parameters, which are measured and transmitted by local sensors (such as temperature, pressure, mass flow, rotation speed, level gauges, etc.) Data exchange is carried out through appropriate means of interface with lines communications and via digital or analog input/output interfaces (I/O cards). The system carries out:

– checking and displaying the position of valves and valves on the screen of the graphic control station;

– checking the compliance of the parameters monitored by local sensors with the value specified in the graphical control station;

– ensures maintenance of controlled parameters in a given range using actuators in the case of automatic process control;

– warns the operator of the graphic control station about deviations in the technological process;

– provides reports on the condition of mechanisms from the electronic archive.

– “Control of the technological process by the operator” – the progress of the technological process for the production of EME requires constant monitoring of the graphical interface by qualified personnel (shift foreman, operator for the production of emulsion matrix of at least 8 categories), in order to timely implement preventive and corrective actions to prevent the release of low-quality products and emergency situations.

In addition to the active (instrumental) safety system existing at the EME plant, in order to continue the safe and stable operation of the process equipment, it is proposed to include the following elements in the modernization program:

– duplicate emergency stop button for production in the control room;

- sound signal (siren and beacons) for personnel evacuation when the emergency stop buttons are activated;

the maximum temperature setpoint on mixers and pumps T_R402A01, T_R402B01, T_R40301, T_R50101 from 150 ^{0}C to 140 ^{0}C;

- additional installation of a protection system on the stators of Netzsch pumps;

– in addition to the fire alarm system, install “Flame Detectors” type AMETHYST IP 329-5 01 in the premises for the preparation of oxidizing and oil solutions, packaging, packaging and dispensing complex, which are triggered by the appearance of an open fire with the output of the signal from the sensors to an audio signal (siren and beacons) personnel evacuation.

The passive part of the security system consists of a set of technical and organizational measures. Technical measures of the passive part of the safety system include:

– "Automatic fire alarm system" – is a system of sensors installed in all production and auxiliary premises of the EME plant with a fire signal output to the operator's security console;

– "Use of safety diaphragms and thermofuses" – safety diaphragms with an operation limit of 12 bar and thermofuses with an operation limit of 150 ^{0}C are installed at the outlet of the production pumps;

– "Use of IP54 class electrical equipment" – because all production premises are classified as fire hazardous, the project provides for all electrical equipment to be IP54 class (fireproof);

– "Lightning protection, protection against static electricity" – 8 lightning rods with grounding loops must be installed on the territory of the plant;

– "Providing uninterruptible power supply for automated control systems" – in cases of unauthorized power outage, the automated control system is powered using an uninterruptible power supply with a 12-hour backup;

– "Use of individual and collective protective equipment" – no special protective equipment is required when operating the plant or its components. Sufficient personal protective equipment for each individual worker (suit made of cotton fabric, safety glasses, apron, rubber gloves, gas mask grade B and BKF, petal). Medical first aid kits with a small set of medications are located at workplaces and laboratories so that workers can independently provide first aid. Additionally, in the operator room there is a medical cabinet with an expanded range of medical supplies, as well as a sanitary stretcher. An emergency shower is installed in the production building. The shower is used for the initial treatment of injuries received by workers in contact with caustic substances;

– "Compliance with standards for loading explosive and fire hazardous products into buildings" – to prevent the accumulation of large quantities of explosive and fire hazardous products in the premises, storage spaces are allocated and standards for their loading are established;

– "Changing the design of equipment in the presence of appropriate documentation" – changing the design of equipment is permitted only if there is appropriate design documentation approved in the prescribed manner and agreed with the State Inspectorate "Sanoatgeokontekhnazorat".

Organizational measures for the passive part of the safety system include: "Introductory briefing and preliminary training of personnel", "Training and briefing on the job" - each employee hired at the EME plant undergoes introductory briefing, as well as preliminary safety training and initial briefing on the job place, according to the "Regulations on the organization of training and testing of knowledge in labor protection". Compliance with technological process regulations and instructions on labor protection and fire safety — each employee is obliged, of course, to comply with all the requirements of technological instructions, instructions on labor protection and fire safety. For violation of the requirements of these instructions, the employee bears disciplinary, administrative and criminal liability. Maintaining equipment, instrumentation and technological communications in good condition — to maintain equipment in good condition, scheduled preventive maintenance is carried out in accordance with the approved schedule, operating instructions and developed operational passports. Issuing permits to perform hazardous work - high-risk work orders are issued for high-risk work (according to the approved list). A permit is issued for hot work. Preparation of equipment for repair work - preparation of equipment and premises for repair work is carried out according to technological maps developed for each unit or unit. They provide measures for the safe cleaning of equipment and premises. Employees who have undergone production and technical training, as well as those instructed in the rules and precautions for repairs, are allowed to inspect and repair equipment. Collection, storage and disposal of waste – collection, storage and disposal of industrial waste is carried out in accordance with the developed "Waste Disposal Instructions". Security system for the perimeter of the plant and warehouses — security of the plant is carried out by military forces in accordance with the law. The use of quality raw materials is one of the main parameters for ensuring safety and obtaining quality products. Raw materials and consumables are allowed into production on the basis of incoming control data or certificates provided by the manufacturer. The requirements for the quality of raw materials are set out in the technological process regulations. Periodic audits and risk assessment of work — to monitor the safety of work, compliance with technological discipline and assessment, inspections are carried out in accordance with the requirements of current safety regulations.

Organizational measures for the passive part of the safety system are ensured by the following.

1. Maintaining the equipment of the EME plant in technically sound condition. For this purpose, maintenance and repair of equipment during operation, scheduled preventive maintenance and metrological support are carried out. Servicing of the equipment during operation is carried out by the shift personnel of the "EME plant" section under the guidance of a foreman. Such work includes: removing and cleaning filters on pipelines with EME components; replacement, adding coolant to the equipment; maintenance of the cartridge machine; adding oil or distilled water to the lubricating containers of stirrers and mixers; setting up and adjusting belt conveyors; tightening flange connections and replacing gaskets on pipelines; cleaning bins, funnels and containers; elimination of crystallization of pipelines with an oxidizing solution; eliminating plugs in pipelines with oil solution; checking the heating system; keeping all equipment clean.

2. Carrying out scheduled preventive maintenance, performed by qualified repair personnel under the guidance of an electrician. These works include: replacement of equipment stuffing boxes; replacement of pump stators; cleaning level sensors; replacement of pumps and drives; cartridge machine repair; replacement of valve seals; repair and replacement of shut-off and control equipment; dispenser repair; repair of rotors and replacement of mixer seals; repair of tanks and pipelines; laying the heating cable and adjusting the heating system; repair of the ventilation system; steam generator

repair; repair and cooling systems; compressed air compressor repair; repair of screw conveyors and drives; repair of belt conveyors and drives.

3. Ensuring that personnel comply with the requirements of technological regulations, work instructions, technological maps and labor protection instructions.

4. Recruitment – conducting preliminary testing of employees upon hiring.

The recommended integrated safety system for the operation of the EME plant made it possible to reduce the existing risk level of the plant from 6.5 points to 4.0 points. Technical and organizational measures of the safety system that ensure the safety of the production of EME are developed on the basis of the "Methodology for organizing a system for the safe operation of hazardous production in the chemical industry" in accordance with ILO standards.

Thus, a comprehensive safety system for the operation of an EME plant is recommended, which allows for the safe production of EME at the plant while reducing the existing risk level of the plant from 6.5 points to 4.0 points.

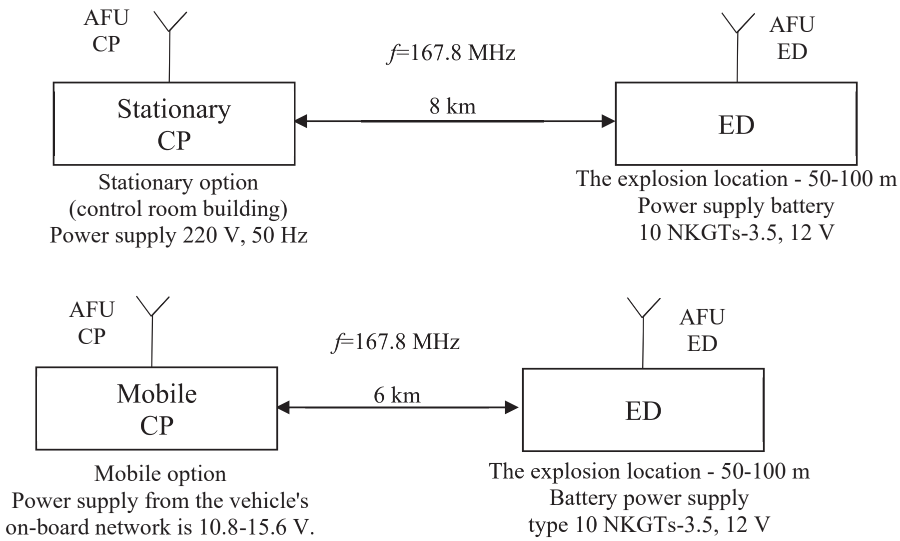
Recommendations for ensuring safe blasting conditions

Due to the decrease in the width of the working platforms and the high concentration of mining equipment in the working area of the quarry, transport communications serving several horizons fall into the places where the opening workings are transferred (vehicle trenches and ramps) during drilling and blasting operations. During multi-day charging, the blocking of sections of transport communications located near the charging blocks on the upper horizons leads to a stop of the entire mining and transport complex located on the underlying horizons. Due to the fact that the geological structure of rocks with the deepening of the quarry is characterized by an increase in the system of technological disturbances of varying power, a gradual collapse of blast holes drilled in the fault zone occurs, the speed of which is up to several hours. During multi-day charging, a significant part of the wells on the blocks often turn out to be littered and unsuitable for loading, and their cleaning and restoration is impossible due to the lack of drilling rigs nearby. In the case of water content in a mountain range, the situation becomes even more complicated, and the measures taken (rubbing the walls of wells during drilling, drilling such areas last, increasing the depth of overdrill and etc.) are ineffective. This leads to a sharp deterioration in the development of a rock mass by blasting, the yield of oversized materials increases, and in some cases, after partial mining of the blasted block by an excavator, it is necessary to carry out repeated drilling and blasting.

When producing massive explosions using EME and non-electric means of initiation (NMI), during multi-day loading in cramped mining conditions, when it is impossible to move technological roads intended for transporting rock mass, the movement of heavy dump trucks in the immediate vicinity of charged blocks is allowed, provided that safety of vehicle operation. The technological road on the side of the charging unit must be fenced with a reliable safety shaft made of rock mass with a height of at least 1 m, preventing vehicles from passing onto the charging unit. Along the road passing near charged blocks, on the side of vehicle traffic, at a distance of at least 20 m from the block, prohibiting road signs "Stopping is prohibited" must be installed. The end of the area covered by this sign must be indicated by a road sign "End of all restrictions area”. In this case, only the maximum number of people limited by the mass explosion regulations is allowed to be at a distance less than the charged wells 20 m. It is not allowed 100 m to use open fire, smoke, or carry incendiary or smoking accessories closer to the location of explosive materials. Measures must be taken to prevent the formation of open fire. When using a non-electric initiation system, the danger zone is introduced before connecting the mounted surface network to the source of the initiating pulse.

When charging wells in areas with high water content and in zones of tectonic faults provided for in the hydrogeological characteristics of the mass explosion project, in order to avoid premature collapse of the drilled wells, it is allowed to charge them immediately after drilling (from under the machine). These works should only be carried out when carrying out measures that ensure safety, taking into account the actual conditions of the workplace, providing for compliance with specific safety measures. Drilling rigs must be installed on a planned site and located so that the undercarriage tracks are no closer 6 m to the loaded (charging) wells. The minimum permissible distance between the machine tracks and the charged wells is established by the massive explosion project. The live flexible cable supplying power to the drilling machine must be routed so that it is not located on the charged (charged) part of the unit. There should be no overhead power lines on the charged unit. The horizontal distance from the outermost wires of overhead power lines to the border of the charged unit must be at least 20 m. On the drilling rig and Storage of flammable, lubricating and other combustible substances and materials that can ignite from short-term exposure to a low-energy ignition source is not allowed near it. On a drilling rig located less 20 m than the charged block, it is prohibited to carry out repair work using welding and gas-cutting equipment. The drilling rig operator and his assistant should not carry incendiary or smoking materials. They must not use open fire. The drilling rig must be technically sound and clean; Contamination with oil or other combustible materials is not allowed. It is unacceptable for personnel to work in oily clothing. The work area where the drilling rig is located must be kept clean. The machine must have primary fire extinguishing equipment.

The equipment set includes control panels (CP) and explosive devices (ED), which ensure the transmission and reception of control commands under the condition of direct visibility between the transmitting and receiving antennas of at least 6 km (Fig. 4).



CP - control panel; ED - explosive device
Fig. 4. Explosion radio control equipment

The CP can be used both in stationary conditions and on moving objects. EDs are installed directly at the site of work in a quarry at a distance of 50–100 m from the block being blasted. The equipment makes it possible to initiate blasted blocks remotely, with one command with a given sequence and delay intervals, frees blasters from work on laying pipelines to a safe area, reduces downtime of mining equipment, increases safety and reliability during blasting operations, and reduces the cost of initiation means.

Due to the fact that the parameters are relative and dimensionless quantities, a substantiation of the predictive assessment of blasting operations near mining equipment and utilities in deep quarries was carried out in terms of the damaging effect of pieces of blasted rock

$$R_{range} = 1250 \cdot \eta_3 \sqrt{\frac{f \cdot d}{a \cdot (1+\eta_{stop})}}, \quad (4)$$

where R_{RANGE} – is a predictive estimate of the maximum range of dispersal of rock pieces, m; η_3 – coefficient of filling the hole with an explosive substance, equal to the ratio of the length of the charge in the hole to the depth of the drilled hole; f – rock strength coefficient according to the prof. scale. MM. Protodyakonov; d – diameter of the hole to be blasted, m; a – distance between wells in a row or between rows, m; η_{stop} - the coefficient of filling the well with the dam, equal to the ratio of the length of the dam to the length of the upper part of the well free from charge. When the upper part of the hole is completely filled with the stopper, $\eta_{stop} = 1$; when blasting without stopping, $\eta_{stop} = 0$.

A predictive estimate of the maximum scattering of rock pieces during the explosion of borehole charges can be determined by the formula (Kutuzov et al., 1988; Barron et al., 1972):

$$R_{range} = 126(fd)^{0.33}(dQ)^{0.17}. \quad (5)$$

The influence of the size of the cutting on the range of scattering of rock pieces is estimated by a reduction factor ("blocking coefficient") in the form

$$K_{stop} = \frac{1}{(0.8+0.002L_{stop}^{-1.8})}, \quad (6)$$

where K_{stop}- is the coefficient of influence of the size of the stopping on the range of scattering of rock pieces; $L_{stop}^{-1.8}$ - length of the ram, expressed in charge diameters, m.

Wind drift of pieces of the exploded mass to the leeward side is recommended

$$\Delta R = 5 \cdot V \quad (7)$$

where ΔR is the wind drift of pieces of the exploded mass to the leeward side, m; V – wind speed, m/s.

Results and discussion

Taking into account the above, the maximum scattering range of pieces of the exploded mass

$$R_0 = R_{range} \cdot K_{stop} + \Delta R. \quad (8)$$

Calculation of the maximum scattering range of pieces of blasted rock, given in table. 5 shows that the scattering range of pieces of rock according to the developed method, taking into account the use of stopping and wind drift, is lower, respectively, by 71.5 m and 46.5 m, which makes it possible to reduce downtime of mining equipment due to a decrease in the distance of their transportation from the danger zone before and after blasting.

Table 5

Calculation of the maximum scattering range of pieces of blasted rock

Rock strength coefficient on a scale prof.M.M.Protodyakonov	f	13
Borehole charge diameter	d, m	0.25
Distance between wells in a row	a, m	6
Distance between rows of wells	b, m	7
Ledge height	H_L, m	10
Loading density	p, g/cm3	0.9
Charge length	L_{ch}, m	6.7
Stopper length	L_{stop}, m	5
Specific consumption of explosives	q, kg/m^3	0.7
Mass of borehole explosive charge	Q, kg	296
Wind speed	V, m/s	5
Wind drift	Δ	25
Maximum dispersion range of pieces according to the uniform rule DBO formula.	m	480
Dispersion range of rock pieces according to the developed method: – excluding wind and cutting – taking into account the use of stopping – taking into account wind drift and the use of stopping	 m m m	 543 408.5 433.5

The development of safe conditions for blasting in large deep quarries in terms of the introduction of a non-electric system for initiating borehole charges and radio control of explosions, changes in the procedure for carrying out mass explosions, the development of a predictive assessment of blasting operations near mining equipment and utilities in terms of the damaging effect of pieces of blasted rock made it possible to increase safety and efficiency of blasting operations in deep quarries by reducing downtime of mining equipment and annual costs for blasting operations.

Thus, a method for conducting blasting in quarries using a non-electric system for initiating borehole charges has been recommended, safe conditions for blasting in large deep quarries have been developed in terms of introducing radio control of explosions, developing a predictive assessment of blasting operations near mining equipment and utilities in terms of the damaging effect of pieces blasted rock, which made it possible to change the procedure for carrying out mass explosions, to increase the safety and efficiency of blasting operations in quarries.

Conclusions

According to the results of the assessment, it can be concluded that the overall level of risk in the operation of the EVV plant in the current conditions is acceptable as for a hazardous industrial facility in compliance with technical and organizational measures (safety system) aimed at its reduction. At the same time, the source of uncertainty of risk assessment is the human factor and equipment malfunction.

Development of safe conditions of blasting operations in large deep pits in terms of introduction of non-electric system of initiation of borehole charges and radio control of blasting allowed to increase safety and efficiency of blasting operations in conditions of deep pits by reducing the downtime of mining equipment and annual costs of blasting.

On the basis of research and analysis of the risk level of the plant with the purpose of unconditional provision of safe production of emulsion explosives, a complex system of safety of operation of the EVV plant was developed.

In general, the results of the study proposed a number of specific practical recommendations.

1. A comprehensive safety system for the operation of an EME plant is recommended, which allows for the safe production of EME at the plant while reducing the existing risk level of the plant from 6.5 points to 4.0 points.

2. A method for conducting blasting operations in deep quarries using a non-electric system for initiating borehole charges was recommended, which made it possible to change the order of mass explosions.

3. Safe conditions for blasting in deep quarries were recommended in terms of introducing radio control of explosions, developing a predictive assessment of blasting operations near mining equipment and utilities in terms of the damaging effect of pieces of blasted rock, which made it possible to increase the safety and efficiency of blasting in deep quarries.

REFERENCES

Baron V.L., Bleyman I.L., Vasiliev G.A. et al. (1972). Technical rules for conducting blasting operations on the surface. — Moscow: Nedra, — 1972, — 240 p.

Bibik I.P., Rubtsov S.K., Sytenkov D.V. (2008). Control of blasting of rocks in quarry technological flows. — Tashkent: Fan, — 2008. — 424 p.

Kuchersky N.I. (2007). Modern technologies in the development of primary gold deposits. — M.: "Ore and Metals", — 2007. — 696 p.

Kutuzov B.N., Skorobogatov V.M., Mosinets V.N. et al. (1988). Handbook of explosives. — Moscow: Nedra, —1988. — 511 p.

Khakimov S.I., Urinov S.R. (2021). Sublevel stoping with applying artificial hardening stowing pillars for extraction of veins in complicated geotechnical conditions. Gornye nauki i tekhnologii = Mining Science and Technology (Russia). — 2021; — 6(4): —252–258. https://doi.org/10.17073/2500-0632-2021-4-252-258

Malgin O.N., Rubtsov S.K., Shemetov P.A., Shlykov A.G. (2003). Improving technological processes of drilling and blasting operations in open-pit mining. – Tashkent:"Fan" Academy of Sciences of the Republic of Uzbekistan, — 2003. — 199 p.

Malgin O.N., Rubtsov S.K., Shemetov P.A., Shlykov A.G. (2003). Improving the technology of drilling and blasting processes in open-pit mining. — Tashkent: Fan, — 2003. — 199 p.

Norov Yu.D., Shemetov P.A., Zairov Sh.Sh., Tukhtashev A.B. (2011). Improving methods for controlling rock crushing by explosion. – Monograph.: "Bukhara." — Bukhara, — 2011. — 200 p.

Norov Yu.D., Shemetov P.A. (2011). New technologies and safety in blasting operations. — Bukhara, — 2011. — 202 p.

Norov Yu.D., Ochilov Sh.A. (2016). The problem of controlling the crushing of rocks under the influence of the explosion energy of borehole charges of explosives in open-pit mining // Mining Bulletin of Uzbekistan. — Navoi, — 2016. — No. 4. — Pp. 17–23.

Petrosov Yu.E., Ochilov Sh.A. (2017). Method of blasting explosives with paired close-in borehole charges when blasting high benches in deep quarries // Mining Bulletin of Uzbekistan. — Navoi, — 2017. — No. 3. — Pp. 45–51.

Raimzhanov B.R., Bibik I.P., Shemetov P.A. (2001). Increasing the duration of the explosive effect due to the use of an asymmetric charge in the driving process // Scientific practical conference: "Innovation-2001". – Tashkent: Publishing house. "Yangi asr avlodi", — 2001. — Pp. 189–191.

Rakhimov V.R., Kazakov A.N. (2013). Study of the stress-strain state of the massif taking into account tectonic stresses // Mining Bulletin of Uzbekistan. — Navoi, — 2013. — No. 3. — Pp.95–103.

Tolstov E.A., Sytenkov V.N., Filippov S.A. (1999). Processes of open-pit mining of ore deposits in rock massifs. — Tashkent: "Fan", — 1999. — 276 p.

Shemetov P.A., Islomov A.N. (2010). Main directions of resource saving during explosive destruction of rocks in quarries // Mining Bulletin of Uzbekistan. — Navoi, — 2010. — No. 2. — Pp. 22–26.

Shemetov P.A., Ochilov Sh.A. (2013). Improvement and development of blasting operations in Uzbekistan // Mining Bulletin of Uzbekistan. — Navoi, — 2013. — No. 4. — pp. 14–18.

Snitka N.P., Nasirov U.F., Mislibaev I.T., Nutfulloev G.S. (2017). Resource-saving technologies for drilling and blasting operations in quarries. – Monograph. – Tashkent: "Fan", — 2017. — 256 p.

Snitka N.P., Nasirov U.F., Umarov F.Ya., Zairov Sh.Sh. (2017). Control of drilling and blasting parameters and side stability in deep quarries. – Monograph. – Tashkent: "Fan", — 2017. — 344 p.

Zairov, S.S., Makhmudov, D.R., Urinov, S.R. (2018). Theoretical and experimental research of explosive rupture of rocks with muck piles of different geometry. Gornyi Zhurnal, — 2018, — 9, — Pp. 46–50. — DOI: 10.17580/gzh.2018.09.05

Zairov S.S., Urinov S.R., Nomdorov R.U. (2020). Ensuring Wall Stability in the Course of Blasting at Open Pits of Kyzyl Kum Region. Gornye nauki i tekhnologii = Mining Science and Technology (Russ.). — 2020. — 5(3): — 235–252. https://doi.org/10.17073/2500-0632-2020-3-235-252

CONTENTS

Publication Ethics and Publication Malpractice in the journals of the National Academy of Sciences of the Republic of Kazakhstan

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of Sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of Sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайтах:
www:nauka-nanrk.kz
http://www.geolog-technical.kz/index.php/en/
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Подписано в печать 15.12.2023.
Формат 70х90$^{1}/_{16}$. Бумага офсетная. Печать – ризограф.
19,0 п.л. Тираж 300. Заказ 6.

РОО «Национальная академия наук РК»
050010, Алматы, ул. Шевченко, 28, т. 272-13-19