

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

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ

Satbayev University

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ
НАУК РЕСПУБЛИКИ
КАЗАХСТАН
Satbayev University

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF
KAZAKHSTAN
Satbayev University

SERIES

OF GEOLOGY AND TECHNICAL SCIENCES

6 (456)

NOVEMBER – DECEMBER 2022

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

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. Web of 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.

Бас редактор

ЖҰРЫНОВ Мұрат Жұрынұлы, химия ғылымдарының докторы, профессор, ҚР ҰҒА академигі, Қазақстан Республикасы Ұлттық Ғылым академиясының президенті, АҚ «Д.В. Сокольский атындағы отын, катализ және электрохимия институтының» бас директоры (Алматы, Қазақстан) **Н = 4**

АБСАДЫКОВ Бахыт Нарикбайұлы, техника ғылымдарының докторы, профессор, ҚР ҰҒА жауапты хатшысы, А.Б. Бектұров атындағы химия ғылымдары институты (Алматы, Қазақстан) **Н = 5**

Редакциялық алқа:

ӘБСАМЕТОВ Мәліс Құдысұлы (бас редактордың орынбасары), геология-минералогия ғылымдарының докторы, профессор, ҚР ҰҒА академигі, «У.М. Ахмедсафина атындағы гидрогеология және геоэкология институтының» директоры (Алматы, Қазақстан) **Н = 2**

ЖОЛТАЕВ Герой Жолтайұлы (бас редактордың орынбасары), геология-минералогия ғылымдарының докторы, профессор, Қ.И. Сатпаев атындағы геология ғылымдары институтының директоры (Алматы, Қазақстан) **Н = 2**

СНОУ Дэниел, Ph.D, қауымдастырылған профессор, Небраска университетінің Су ғылымдары зертханасының директоры (Небраска штаты, АҚШ) **Н = 32**

ЗЕЛЬТМАН Реймар, Ph.D, табиғи тарих мұражайының Жер туралы ғылымдар бөлімінде петрология және пайдалы қазбалар кен орындары саласындағы зерттеулердің жетекшісі (Лондон, Англия) **Н = 37**

ПАНФИЛОВ Михаил Борисович, техника ғылымдарының докторы, Нанси университетінің профессоры (Нанси, Франция) **Н = 15**

ШЕН Пин, Ph.D, Қытай геологиялық қоғамының тау геологиясы комитеті директорының орынбасары, Американдық экономикалық геологтар қауымдастығының мүшесі (Пекин, Қытай) **Н = 25**

ФИШЕР Аксель, Ph.D, Дрезден техникалық университетінің қауымдастырылған профессоры (Дрезден, Берлин) **Н = 6**

КОНТОРОВИЧ Алексей Эмильевич, геология-минералогия ғылымдарының докторы, профессор, РҒА академигі, А.А. Трофимука атындағы мұнай-газ геологиясы және геофизика институты (Новосибирск, Ресей) **Н = 19**

АГАБЕКОВ Владимир Еноквич, химия ғылымдарының докторы, Беларусь ҰҒА академигі, Жаңа материалдар химиясы институтының құрметті директоры (Минск, Беларусь) **Н = 13**

КАТАЛИН Стефан, Ph.D, Дрезден техникалық университетінің қауымдастырылған профессоры (Дрезден, Берлин) **Н = 20**

СЕЙТМҰРАТОВА Элеонора Юсуповна, геология-минералогия ғылымдарының докторы, профессор, ҚР ҰҒА корреспондент-мүшесі, Қ.И. Сатпаев атындағы Геология ғылымдары институты зертханасының меңгерушісі (Алматы, Қазақстан) **Н = 11**

САҒЫНТАЕВ Жанай, Ph.D, қауымдастырылған профессор, Назарбаев университеті (Нұр-Сұлтан, Қазақстан) **Н = 11**

ФРАТТИНИ Паоло, Ph.D, Бикокк Милан университеті қауымдастырылған профессоры (Милан, Италия) **Н = 28**

«ҚР ҰҒА 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/>

© Қазақстан Республикасының Ұлттық ғылым академиясы, 2022

Типографияның мекен-жайы: «Аруна» ЖК, Алматы қ., Мұратбаев көш., 75.

Главный редактор

ЖУРИНОВ Мурат Журинович, доктор химических наук, профессор, академик НАН РК, президент Национальной академии наук Республики Казахстан, генеральный директор АО «Институт топлива, катализа и электрохимии им. Д.В. Сокольского» (Алматы, Казахстан) **Н = 4**

АБСАДЫКОВ Бахыт Нарикбаевич, доктор технических наук, профессор, ответственный секретарь НАН РК, Институт химических наук им. А.Б. Бектурова (Алматы, Казахстан) **Н = 5**

Редакционная коллегия:

АБСАМЕТОВ Малис Кудысович, (заместитель главного редактора), доктор геологоминералогических наук, профессор, академик НАН РК, директор Института гидрогеологии и геоэкологии им. У.М. Ахмедсафина (Алматы, Казахстан) **Н = 2**

ЖОЛТАЕВ Герой Жолтаевич, (заместитель главного редактора), доктор геологоминералогических наук, профессор, директор Института геологических наук им. К.И. Сатпаева (Алматы, Казахстан) **Н=2**

СНОУ Дэниел, Ph.D, ассоциированный профессор, директор Лаборатории водных наук университета Небраска, штат Небраска, США) **Н = 32**

ЗЕЛЬТМАН Реймар, Ph.D, руководитель исследований в области петрологии и месторождений полезных ископаемых в Отделе наук о Земле Музея естественной истории (Лондон, Англия) **Н = 37**

ПАНФИЛОВ Михаил Борисович, доктор технических наук, профессор Университета Нанси (Нанси, Франция) **Н=15**

ШЕН Пин, Ph.D, заместитель директора Комитета по горной геологии Китайского геологического общества, член Американской ассоциации экономических геологов (Пекин, Китай) **Н = 25**

ФИШЕР Аксель, ассоциированный профессор, Ph.D, технический университет Дрезден (Дрезден, Берлин) **Н = 6**

КОНТОРОВИЧ Алексей Эмильевич, доктор геолого-минералогических наук, профессор, академик РАН, Институт нефтегазовой геологии и геофизики им. А.А. Трофимука СО РАН (Новосибирск, Россия) **Н = 19**

АГАБЕКОВ Владимир Еноквич, доктор химических наук, академик НАН Беларуси, почетный директор Института химии новых материалов (Минск, Беларусь) **Н = 13**

КАТАЛИН Стефан, Ph.D, ассоциированный профессор, Технический университет (Дрезден, Берлин) **Н = 20**

СЕЙТМУРАТОВА Элеонора Юсуповна, доктор геолого-минералогических наук, профессор, член-корреспондент НАН РК, заведующая лабораторией Института геологических наук им. К.И. Сатпаева (Алматы, Казахстан) **Н=11**

САГИНТАЕВ Жанай, Ph.D, ассоциированный профессор, Назарбаев университет (Нурсултан, Казахстан) **Н = 11**

ФРАТТИНИ Паоло, Ph.D, ассоциированный профессор, Миланский университет Бикокк (Милан, Италия) **Н = 28**

«Известия 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 соединений.*

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/>

© Национальная академия наук Республики Казахстан, 2022

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75.

Editorial chief

ZHURINOV Murat Zhurinovich, doctor of chemistry, professor, academician of NAS RK, president of the National Academy of Sciences of the Republic of Kazakhstan, general director of JSC “Institute of fuel, catalysis and electrochemistry named after D.V. Sokolsky» (Almaty, Kazakhstan) **H = 4**

ABSADYKOV Bakhyt Narikbaevich, doctor of technical sciences, professor, executive secretary of NAS RK, Bekturov Institute of chemical sciences (Almaty, Kazakhstan) **H = 5**

Editorial board:

ABSAMETOV Malis Kudysovich, (deputy editor-in-chief), doctor of geological and mineralogical sciences, professor, academician of NAS RK, director of the Akhmedsafin Institute of hydrogeology and hydrophysics (Almaty, Kazakhstan) **H=2**

ZHOLTAEV Geroy Zholtaevich, (deputy editor-in-chief), doctor of geological and mineralogical sciences, professor, director of the institute of geological sciences named after K.I. Satpayev (Almaty, Kazakhstan) **H=2**

SNOW Daniel, Ph.D, associate professor, director of the laboratory of water sciences, Nebraska University (Nebraska, USA) **H = 32**

ZELTMAN Reyamar, Ph.D, head of research department in petrology and mineral deposits in the Earth sciences section of the museum of natural history (London, England) **H = 37**

PANFILOV Mikhail Borisovich, doctor of technical sciences, professor at the Nancy University (Nancy, France) **H=15**

SHEN Ping, Ph.D, deputy director of the Committee for Mining geology of the China geological Society, Fellow of the American association of economic geologists (Beijing, China) **H = 25**

FISCHER Axel, Ph.D, associate professor, Dresden University of technology (Dresden, Germany) **H=6**

KONTOROVICH Aleksey Emilievich, doctor of geological and mineralogical sciences, professor, academician of RAS, Trofimuk Institute of petroleum geology and geophysics SB RAS (Novosibirsk, Russia) **H = 19**

AGABEKOV Vladimir Enokovich, doctor of chemistry, academician of NAS of Belarus, honorary director of the Institute of chemistry of new materials (Minsk, Belarus) **H = 13**

KATALIN Stephan, Ph.D, associate professor, Technical university (Dresden, Berlin) **H = 20**

SEITMURATOVA Eleonora Yusupovna, doctor of geological and mineralogical sciences, professor, corresponding member of NAS RK, head of the laboratory of the Institute of geological sciences named after K.I. Satpayev (Almaty, Kazakhstan) **H=11**

SAGINTAYEV Zhanay, Ph.D, associate professor, Nazarbayev University (Nursultan, Kazakhstan) **H = 11**

FRATTINI Paolo, Ph.D, associate professor, university of Milano-Bicocca (Milan, Italy) **H = 28**

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/>

© National Academy of Sciences of the Republic of Kazakhstan, 2022

Address of printing house: ST «Aruna», 75, Muratbayev str, Almaty.

UDC 614.841

S. Tsvirkun, M. Udovenko*, T. Kostenko, V. Melnyk, A. Berezovskyi

Cherkasy Institute of Fire Safety named after Chernobyl Heroes of National
University of Civil Protection of Ukraine, Cherkasy, Ukraine.

E-mail: max.udovenko@gmail.com

**ENHANCING THE SAFETY OF EVACUATION OF VISITORS OF
SHOPPING AND ENTERTAINMENT CENTRES**

Abstract. The paper is devoted to the study of the peculiarities of evacuation of children from entertainment centers and recommendations for improving the safety of visitors to shopping malls based on the results of mathematical modeling of fire development and evacuation processes. To solve the problems set in the work, the FDS software package was used. The FDS mathematical model is based on the use of differential equations in partial derivatives, describing the spatial and temporal distribution of temperature and velocity of the gaseous medium in the room, concentrations of gaseous components (oxygen, combustion products, etc.), pressures and densities. Based on the results of determining the time of negative impact of fire hazards and determining the estimated time of evacuation of people from the children's park located in the mall, it is concluded that spatial planning solutions of the facility allow for evacuating people in case of fire. The scientific novelty of the obtained results is that the time of negative impact of fire hazards and the time of evacuation of people from the children's park of the shopping and entertainment centre was determined for the first time for the conditions of such parameters of a building spatial planning solution. The practical significance of the obtained results is the ability to use the principles and approaches outlined in the article for similar service facilities to determine the required evacuation time, which will increase the safety of visitors and staff in the event of an emergency.

Key words: fire hazards, evacuation, mathematical modelling, FDS.

С. Цвиркун, М. Удовенко*, Т. Костенко, В. Мельник, А. Березовский

Украина азаматтық қорғау Ұлттық университетінің Чернобыль Батырлары атындағы Черкасс өрт қауіпсіздігі институты, Черкасс, Украина.

E-mail: max.udovenko@gmail.com

САУДА-ОЙЫН-САУЫҚ ОРТАЛЫҚТАРЫНА КЕЛУШІЛЕРДІ ЭВАКУАЦИЯЛАУ ҚАУІПСІЗДІГІН АРТТЫРУ

С. Цвиркун, М. Удовенко*, Т. Костенко, В. Мельник, А. Березовский

Черкасский институт пожарной безопасности имени Героев Чернобыля Национального университета гражданской защиты Украины, Черкасс, Украина.

E-mail: max.udovenko@gmail.com

ПОВЫШЕНИЕ БЕЗОПАСНОСТИ ЭВАКУАЦИИ ПОСЕТИТЕЛЕЙ ТОРГОВО-РАЗВЛЕКАТЕЛЬНЫХ ЦЕНТРОВ

Аннотация. Статья посвящена изучению особенностей эвакуации детей из развлекательных центров и рекомендациям по повышению безопасности посетителей торговых центров по результатам математического моделирования развития пожара и процессов эвакуации. Для решения поставленных в работе задач использовался программный комплекс FDS. Математическая модель FDS основана на использовании дифференциальных уравнений в частных производных, описывающих пространственное и временное распределение температуры и скорости газовой среды в помещении, концентраций газообразных компонентов (кислорода, продуктов сгорания и др.), давлений и плотности. По результатам определения времени негативного воздействия пожарной опасности и определения расчетного времени эвакуации людей из детского парка, расположенного в ТРЦ, делается вывод, что объемно-планировочные решения объекта позволяют обеспечить эвакуацию людей при пожаре. Научная новизна полученных результатов заключается в том, что впервые определено время негативного воздействия пожарной опасности и время эвакуации людей из детского парка торгово-развлекательного центра для условий таких параметров пространственной конструкции здания, планировочные решения. Практическая значимость полученных результатов заключается в возможности использования изложенных в статье принципов и подходов для объектов аналогичного обслуживания для определения необходимого времени эвакуации, что повысит безопасность посетителей и персонала в случае возникновения чрезвычайной ситуации.

Ключевые слова: пожароопасность, эвакуация, математическое моделирование, FDS.

Introduction. In the recent years, the service industry has been actively developing throughout the world. One of the services provided is children's playrooms (children's

amusement parks) in shopping and entertainment centres. As a result, large groups of unaccompanied children can now be found in not only kindergartens or schools, where their composition is almost homogeneous, represented mainly by children, but also in children's playrooms, where parents leave their children supervised by the staff of the shopping malls.

When analysing scientific sources devoted to the study of the process of evacuation of people from buildings of different functional profiles in emergencies, conspicuous is the fact of poorly explored issues of evacuation of children and the impact of such features on the general evacuation process. The topic mentioned is described in detail in several scientific studies, and only in relation to the evacuation of children from preschools (Tsvirkun, 2020:3), (Shikhalev, 2013:5). There are reasonable concerns regarding the possibility of service staff to establish psychological contact with children in such a short time, to study the mental and behavioural characteristics of an individual child in case of danger, which is one of the main components of successful evacuation of children during a fire. It is not clear how children will behave if there is a real threat of exposure to fire hazards.

Another aspect of the problem is the small amount of research on the parameters of the children evacuation process. In the absence of reliable data on the speed of movement, errors are likely when applying programs to calculate the evacuation parameters. There is no empirical data on the behaviour of children during the forced evacuation in case of fire in the premises of the shopping and entertainment centre. The problem is exacerbated by the fact that children's playrooms (children's amusement parks) are arranged not only on the first floors of shopping and entertainment complexes, but also on the second floors and higher.

Analysis of recent research and publications. Assessing the risk of an adverse event is generally seen as a first step towards quantifying the hazards of facilities, and proposing acceptable risk criteria to develop contingency plans and measures to reduce the potential hazards of business facilities. This article is devoted to the assessment of individual fire risk. It is proposed to assess the individual fire risk following the appropriate scale and the main colour codes and severity levels of risk, where orange (high risk) is added, which makes it possible to more accurately define the boundaries of risk and adapt to generally accepted risk levels. Fire risk forecasting is implemented taking into account the method of calculating fire risks. It is proposed to use graphic editors to visualize the calculation of fire risks for public buildings. Plotting the risks of death from fire in the certain group in the appropriate colours makes it possible to obtain a map of the risk of death from fire, which will allow members of the fire and rescue service to be aware of the possible risks and dangers at a certain facility (Yemelyanenko, 2020:14).

A significant amount of current scientific studies is devoted to the modelling of evacuation processes. Different approaches can be used to model a person's behaviour during a fire in order to carry out evacuation. One study provides a critical overview of the most commonly used modelling methods to represent the evacuation process during fire (Ronchi, 2020:8). There are studies that have developed a simplified simulation

model to calculate the evacuation time on each floor of a building, taking into account a building with different types of accommodation on different floors (e.g. office building, residential building, commercial building, etc.) and different aggregation factors that can be caused by a different configuration of stair doors on each floor. (Sano, 2018:14). In (Kostenko, 2021:9), the expediency of using FDS (Fire Dynamic Simulator) software suite to model the dynamics of fire hazards is shown.

The problem of children evacuation includes the small number of studies to investigate the parameters of the children evacuation process. In the absence of reliable data on the speed of movement, errors are likely to occur when applying software to calculate the evacuation parameters. There is no empirical data on the behaviour of children during the forced evacuation in case of fire in the mall facilities. Therefore, it is impossible to predict exactly how an organized group of children will affect the overall evacuation process.

Some foreign studies (Larusdottir, 2014:1) focus on the specifics of evacuating children. These include:

- children are very dependent on adults as for the beginning of the evacuation and as for following the evacuation routes;

- the speed of evacuation of children differs significantly from the speed of evacuation of adults;

- at the beginning of the evacuation, the method of alerting is of great importance; thus, the most effective method is the ‘alarm’, which is accompanied by voice instructions;

- during evacuation, children are more inclined to focus on large crowds of people (children) than on adults who are engaged in their evacuation;

- children use railings on the stairs only in the case of self-evacuation, if there is an adult nearby, they almost never use railings;

- drills have a positive effect on the time of evacuation from the room.

The Illinois Building Regulations (USA) (Building Code 2018 of Illinois, 2018:1) define the requirements for children’s entertainment centres (for structures higher than 3 meters and with an area of more than 14 sq.m). All structures at the children’s playgrounds (centres) shall be made of non-combustible materials; if the structures contain combustible materials, they shall meet the requirements for wood, plastic, foam, aluminium, textiles. Also, some requirements are defined for flooring materials. Fire-fighting equipment, which is used to equip playgrounds, shall be not inferior to the equipment of the adjacent premises located on the same floor. The structures of the playgrounds shall be located at a distance of at least 1.5 m from walls, structural elements and potential exits. The structures of the playgrounds shall be spaced for at least 6 meters. The structures of the playgrounds shall have an area of not more than 28 sq.m, unless otherwise permitted by special fire investigation.

Setting the objectives of the article. The objective of the article is to increase the safety of visitors in the premises of the Children’s Planet Park, located in the mall, based on the results of mathematical modelling of fire spread and evacuation processes.

To achieve this objective, the following tasks need to be solved:

- to analyse the ways of evacuation within the framework of spatial planning solutions of the mall facility;

to calculate the necessary and actual time of visitors' evacuation;
to determine the features of evacuation from children's entertainment centres located in the mall.

Study methods. The main modern approaches to the study of safe evacuation are computer modelling using computational fluid dynamics (CFD). FDS software suite was used to determine the fire hazards (McGrattan, 2000:1). FDS numerically solves the Navier-Stokes equation for low-velocity temperature-dependent flows, with special emphasis on the spread of smoke and heat transfer during a fire. The FDS mathematical model is based on the use of differential equations in partial derivatives, describing the spatial and temporal distribution of temperature and velocity of the gaseous medium in the room, concentrations of gaseous components (oxygen, combustion products, etc.), pressures and densities.

Presentation of the study basic material. Ensuring the evacuation of people consists in spatial planning and design solutions, which allow completing the evacuation from the facility before the onset of the maximum allowable values of fire hazards to a man.

When analysing the drawings of the Children's Planet amusement park, located in the mall, it was decided to calculate the time of evacuation and the occurrence of fire hazards following two scenarios.

Scenario No. 1. The centre of the fire is located in the switchboard near the evacuation exit, the trampoline and the area of the iXbox machines, and there is a maze nearby. Thus, a fire is modelled in the place of probable presence of the largest number of children. According to the scenario, the trampoline is completely filled, with 150 children located there. The fire was caused by a short circuit. The time of occurrence of fire hazards and the time of evacuation of people by evacuation routes are calculated.

Scenario No. 2. The initial conditions of scenario No. 2 are the same as for scenario No. 1, namely the centre of the fire is located in the switchboard near the evacuation exit, trampoline and the area of iXbox machine, and there is a maze nearby. Scenario No. 2 differs in taking into account the probability that visitors (according to statistical studies) are evacuated the way they entered a particular room.



Figure 1 - Room model for simulation of the dynamics of fire hazards

Determination of the estimated time of evacuation of people from the rooms is carried out using a simplified analytical model of human traffic flow (State standard of Ukraine 8828, 2019:5).

FDS software suite was chosen to model the dynamics of fire hazards. The choice of the software suite is due to the complex geometry of the ceiling (roof) of the facility, which makes it impossible to use simpler methods of calculating fire hazards.

When obtaining graphical and analytical results of the calculation of the fields of fire hazards, the locations of the calculation points were taken as the places of the longest presence of people according to the relevant scenario, in the immediate vicinity of the evacuation exits.

Maximum permissible values for each of the fire hazards (McGrattan, 2000:1):

- by elevated temperature: 70°C;
- by loss of visibility: 20 m;
- by low oxygen content: 0.226 kg/cu.m;
- by CO₂ concentration: 0.11 kg/cu.m;
- by CO concentration: $1.16 \cdot 10^{-3}$ kg/cu.m;
- by HCl concentration: $2.3 \cdot 10^{-5}$ kg/cu.m.



Figure 2 - Schematic of the room and location of sensors measuring indicators of fire hazards

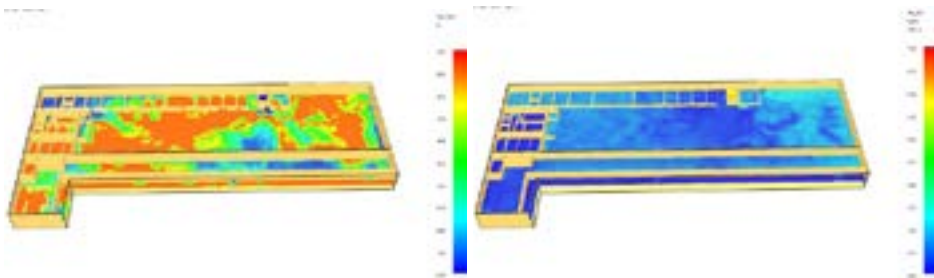


Figure 3 - Distribution of visibility fields and HCl concentrations in the room

The fire seats were chosen in such a way as to either block one of the evacuation exits or create difficult conditions for evacuation. Thus, the fire develops in the worst-case scenario; we assume that the automatic fire extinguishing system, which is installed in the shopping and entertainment complex, failed. In these conditions, the time of

occurrence of fire hazards in 23 key locations of the children's amusement park is calculated (required evacuation time). The estimated evacuation time, which depends on the spatial planning solutions, shall be less than the required evacuation time.

Fire load characteristics:

- lower heat of combustion 30.7 MJ/kg;
- linear velocity of flame propagation 0.0071 m/s
- specific heat of 749 kJ/sq.m
- specific mass burnout rate 0.024 kg/sq.m*s
- smoke-generating capacity 521 Np*sq.m/kg
- oxygen consumption 2.19 kg/kg
- carbon dioxide emission 0.65 kg/kg
- carbon monoxide emission 0.13 kg/kg
- hydrogen chloride emission 0.02 kg/kg

Table 1. Time to reach the fire hazard

Sensors	Time to reach the fire hazard*						
	CO content	CO ₂ content	HCl content	Underestimated O ₂ content	Elevated temperature	Loss of visibility	Heat flow
Sensor 1	489	-	424	-	499	290	-
Sensor 2	-	-	434	-	-	376	-
Sensor 3	345	-	203	394	394	170	-
Sensor 4	338	-	158	361	361	139	-
Sensor 5	403	-	171	398	378	129	-
Sensor 6	417	-	192	412	378	165	-
Sensor 7	-	-	500	-	-	480	-
Sensor 8	437	-	252	430	408	203	-
Sensor 9	428	-	205	423	390	181	-
Sensor 10	462	-	300	-	471	295	-
Sensor 11	-	-	392	-	-	295	-
Sensor 12	-	-	378	-	489	311	-
Sensor 13	-	-	360	-	-	298	-
Sensor 14	-	-	320	-	-	304	-
Sensor 15	-	-	451	-	-	439	-
Sensor 16	-	-	478	-	-	468	-
Sensor 17	-	-	484	-	-	453	-
Sensor 18	-	-	482	-	-	421	-
Sensor 19**	-	-	-	-	-	-	-
Sensor 20	-	-	270	-	-	228	-
Sensor 21	-	-	405	-	-	338	-
Sensor 22	-	-	394	-	-	388	-
Sensor 23	-	-	363	-	-	288	-

* time (in seconds) of the occurrence of a specific dangerous factor of fire from the beginning of the fire is indicated

** simulation of the spread of fire hazards for 500 seconds was carried out; during this period of time critical values were not reached at the location of sensor No. 19



Figure 4 - Schematic of evacuation routes

Table 2. Time of crossing reference points (scenario No. 1)

Route	Section number	Estimated time (seconds)*	Required time (seconds)	Sensor	Numbers of sections that are taken into account to determine the estimated time of evacuation
Route No. 1	26	116.4	165	6	11, 14, 18, 22, 25, 26
Route No. 1	29	195.6	480	7	11, 14, 18, 22, 25, 26, 27, 28, 29
Route No. 2	55	114.6	181	9	40, 43, 46, 50, 52, 55
Route No. 2	60	172.2	295	10	40, 43, 46, 50, 52, 55, 56, 57, 58, 59, 60
Route No. 3	97	276	298	13	72, 73, 75, 76, 85, 86, 87, 97
Route No. 4	146	176.4	304	14	111, 112, 113, 123, 127, 132, 135, 136, 137, 140, 146
Route No. 5	179	378.6**	439	15	160, 163, 164, 165, 168, 169, 170, 178, 179
Route No. 6	237	190.2	228	20	217, 218, 220, 221, 228, 237
Route No. 7	269	205.8	468	16	194, 209, 250, 252, 253, 254, 267, 268
Route No. 8	309	118.2	421	18	280, 284, 285, 286, 309
Route No. 9	333	114.6	180	-	320, 321, 323, 327, 333

* taken into account time of the beginning of the evacuation +0.5 minutes, according to [9]

** 5 minutes have been added to the estimated time to evacuate children from the maze

Table 3. Time of crossing reference points (scenario No. 2)

Route	Section number	Estimated time (seconds)*	Required time (seconds)	Sensor	Numbers of sections that are taken into account to determine the estimated time of evacuation
Route No. 6	240	228.6	(intermediate section)	-	217, 218, 220, 221, 228, 240
Route No. 8	309	379.2	421	18	217, 218, 220, 221, 228, 240, 280, 284, 285, 286, 309
Route No. 9	333	114.6	180		320, 321, 323, 327, 333

* taken into account time of the beginning of the evacuation +0.5 minutes, according to [9]

According to the results obtained, the safe evacuation from the premises of the mall is possible.

Discussion and conclusion. Based on the results of determining the time of negative impact of fire hazards and determining the estimated time of evacuation of people from the children’s park located in the mall, it is concluded that spatial planning solutions of

the facility allow for evacuating people in case of fire. However, it should be noted that children are more prone to panic than adults are, and in case of fire, they tend to hide instead of leaving the room. Therefore, the staff of the institution must flawlessly control the number of children on playground attractions such as trampolines and mazes, and establish clear instructions on how to act in case of fire.

The scientific novelty of the obtained results is that the time of negative impact of fire hazards and the time of evacuation of people from the children's park of the shopping and entertainment centre was determined for the first time for the conditions of such parameters of a building spatial planning solutions.

Due to the lack of regulatory framework in Ukraine that regulates the requirements for children's playgrounds located in large shopping centres, the study data may be the basis for developing a concept for child safety in such facilities given the risk of an emergency.

We suggest the following provisions of the concept to be taken into account:

Drills interval. The playground staff shall participate in regular drills, as noted, e.g., in (MSDH, 2022:2), which require monthly training of the staff to evacuate children from the playgrounds in the event of a fire or other emergency.

Arrangement of evacuation exits. Emergency exit doors shall be fitted with means of exit only in the event of fire, and must not be opened by children during normal operation.

Alerting the parents. We suggest to develop a concept of alerting the parents about an emergency situation, e.g., with the help of text messages specifying the location of children after evacuation.

Spatial planning solutions. The structures of children playgrounds shall provide for the possibility of rapid unimpeded access of adults to children. Such a measure will save those children who are scared and do not try to leave the room on their own.

Information materials, where in the form of games and taking into account different age groups of children, information will be provided on the sequence of actions in case of an emergency.

The practical significance of the obtained results is the ability to use the principles and approaches outlined in the article for similar service facilities to determine the required evacuation time, which will increase the safety of visitors and staff in the event of an emergency.

In our opinion, the behaviour of the staff of shopping malls in case of fire needs to be studied further. If a series of experiments is successfully carried out in several shopping and entertainment complexes, preferably in different regions of the country and at different times of the year, it will be possible to compare the results of field studies with the results obtained by computer simulation, to make necessary calculations and to draw conclusions.

Information about the authors:

Tsvirkun Serhii – PhD, Associate Professor, Deputy Head of the Department of construction objects safety and labor protection, Cherkasy Institute of Fire Safety named

after Chornobyl Heroes of National University of Civil Defense of Ukraine, Cherkasy, Ukraine, tsvirkun80@ukr.net, <https://orcid.org/0000-0002-1807-9330>;

Udoenko Maksym – Senior Researcher of the Department of Organization of Scientific Activity, Cherkasy Institute of Fire Safety named after Chornobyl Heroes of National University of Civil Defense of Ukraine, Cherkasy, Ukraine, max.udovenko@gmail.com., <https://orcid.org/0000-0002-4143-8645>;

Kostenko Tetiana – Doctor of Technical Sciences, Professor, Associate Professor of the Department of construction objects safety and labor protection, Cherkasy Institute of Fire Safety named after Chornobyl Heroes of National University of Civil Defense of Ukraine, Cherkasy, Ukraine, tatiana.kostenko@gmail.com, <https://orcid.org/0000-0001-9426-8320>;

Melnyk Valentyn – PhD, Head of the Faculty of Fire Safety, Cherkasy Institute of Fire Safety named after Chornobyl Heroes of National University of Civil Defense of Ukraine, Cherkasy, Ukraine, poiskoviksy@yahoo.com, <https://orcid.org/0000-0002-1760-229X>;

Berezovskyi Andriy – PhD, Associate Professor, Head of the Department of construction objects safety and labor protection, Cherkasy Institute of Fire Safety named after Chornobyl Heroes of National University of Civil Defense of Ukraine, Cherkasy, Ukraine, andrey82-07@ukr.net, <https://orcid.org/0000-0002-4043-1206>.

REFERENCES

Building Code 2018 of Illinois, 4 Special Detailed Requirements Based on Occupancy and Use, 424 Children's Play Structures. <https://up.codes/s/children-s-play-structures>.

Kostenko V., Gamiy Y., Kostenko T., Tsvirkun S., Udoenko M., Dynamics of motion of gases from a source of spontaneous combustion of coal in mine workings, Rudarsko-geološko-Naftni Zbornik, n36(2) (2021) 109–117. <https://doi.org/10.17794/rgn.2021.2.10>.

Larusdottir A.R., Evacuation of Children: Focusing on daycare centers and elementary schools, Technical University of Denmark, Department of Civil Engineering, BYG Rapport R-295 (2014) 158.

McGrattan Kevin, Forney Glenn Fire Dynamics Simulator, User's Manual. 2000. <https://nvlpubs.nist.gov/nistpubs/Legacy/IR/nistir6469.pdf>.

MSDH (Mississippi State Department of Health). Regulations governing licensure of child care facilities. Rule 1.12.7 Fire/Disaster Evacuation Drills. https://msdh.ms.gov/msdhsite/_static/resources/78.pdf.

Ronchi E., Developing E. and validating evacuation models for fire safety engineering, Fire Safety Journal, Vol. 120 (2020) 103020. <https://doi.org/10.1016/j.firesaf.2020.103020>.

Sano T., Ronchi E., Minegishi Y., Nilsson D., Modelling pedestrian merging in stair evacuation in multi-purpose buildings, Simulation Modelling Practice and Theory, Vol. 85 (2018) 80-94. <https://doi.org/10.1016/j.simpat.2018.04.003>.

Shikhalev D., Khabibulin R., Evacuation control systems in buildings of shopping and entertainment centers [Sistemy upravleniya evakuatsiyey v zdaniyakh torgovo-razvlekatel'nykh tsentrov], Pozharovzryvobezopasnost', No. 6 (2013) 61–65. (in Russ.).

State standard of Ukraine 8828:2019 «Fire safety», Kyiv, 2019 (in Ukr.).

Tsvirkun S., Udoenko M., Vedula S., Questions about the peculiarities of the evacuation of children from the playrooms of the mall [Pytannya shchodo osoblyvosti evakuatsiyi ditey z ihrovyykh kimnat TRK], X Vseukrayins'ka naukovo-praktychna konferentsiya z mizhnarodnoyu uchastyu «Nadzvychny sytuatsiyi: bezpeka ta zakhyst» (2020) 231-233. (in Ukr.).

Yemlyanenko S., Ivanusa A., Yakovchuk R., Kuzyk A., Fire risks of public buildings, News of National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences, 6 (2020) 72-85. <https://doi.org/10.32014/2020.2518-170X.133>.

CONTENTS

M.K. Absametov, Z.A. Onglassynov, L.V. Shagarova, M.M. Muratova GIS-ASSESSMENT OF GROUNDWATER SUPPLY TO POPULATION AND BRANCHES OF ECONOMY OF KAZAKHSTAN WITH ACCOUNT TO LONG-TERM WATER DEMAND.....	6
Ye.Ye. Akylbekov, V.M. Shevko, D.K. Aitkulov, G.E. Karataeva RECYCLING OF CHRYSOTILE-ASBESTOS PRODUCTION WASTE WITH EXTRACTING MAGNESIUM AND OBTAINING A FERROALLOY AND CALCIUM SILICATES.....	19
S.S. Demessinova, D.M. Kalmanova, O.A. Dagmirzayev, I.D. Kaldybayev, N.S. Lutsenko, A.Yu. Nurgaliyev ALGORITHM FOR CONTROL OF REMOTE SENSING SPACECRAFT FOR MONITORING SUBSOIL USE OBJECTS.....	34
B. Durmagambetov, D. Abdrazakov, D. Urmanova ADVANCED METHODS OF FRACTURE GEOMETRY ANALYSIS AND PARAMETERS SENSITIVITY STUDY.....	45
A.M. Khairullaev, N.O. Berdinova, S.A. Syedina, G.B. Abdikarimova, A.A. Altayeva 3D BLOCK MODELING OF GEOMECHANICAL PROPERTIES OF ORE DEPOSITS USING MODERN GMIS.....	58
N.Zh. Karsakova, K.T. Sherov, B.N. Absadykov, M.R. Sikhimbayev, T.K. Balgabekov THE CONTROL PROBLEMS OF THE LARGE DIAMETER HOLES IN PROCESSING OF THE LARGE PARTS.....	70
T. Imanaliyev, S. Koybakov, O. Karlykhanov, B. Amanbayeva, M. Bakiyev PROSPECTS FOR THE DEVELOPMENT OF WATER RESOURCES MANAGEMENT IN THE SOUTH OF KAZAKHSTAN.....	80
M. Li, T. Ibrayev, N. Balgabayev, M. Alimzhanov, A. Zhakashov WATER DISTRIBUTION IN CHANNELS OF THE MOUNTAINOUS AND PIEDMONT AREA.....	96
S.R. Massakbayeva, G.S. Aitkaliyeva, B.R. Abdrakhmanova, M.A. Yelubay, S. Azat EVALUATION OF THE PROPERTIES OF THERMODIFUSION ZINC COATING OF COUPLINGS OF PUMP-COMPRESSOR PIPES PRODUCED BY "KSP STEEL".....	106

T. Mendebaev, N. Smashov PREREQUISITES FOR THE CONSTRUCTION OF A CLOSED SYSTEM OF OPENING AND DEVELOPMENT OF GROUNDWATER DEPOSITS.....	118
Zh.M. Mukhtarov, S.R. Ibatullin, M.Yu. Kalinin, G.E. Omarova DEVELOPMENT OF METHODOLOGICAL FOUNDATIONS AND RESEARCH OF TECHNICAL SOLUTIONS TO INCREASE THE VOLUME OF THE NORTHERN ARAL SEA WITH MINERALIZATION OF THE FLOW OF THE SYRDARIA RIVER.....	131
A.K. Mussina, A.S. Abdullayeva, M. Barandun THE IMPORTANCE OF CONDUCTING RESEARCH METHODS TO ASSESS THE STATE OF GLACIAL-MORAINÉ LAKES.....	147
B.B. Orazbayev, M.D. Kabibullin, K.T. Bissembayeva, G.S. Sabyrbayeva, A.J. Mailybayeva HEURISTIC APPROACH TO SOLVING THE PROBLEM OF FUZZY CONTROL OF THE REFORMING TECHNOLOGICAL PROCESS.....	156
K.N. Orazbayeva, M.K. Urazgaliyeva, Zh.Zh. Moldasheva, N.K. Shazhdekeyeva, D.O. Kozhakhmetova PROBLEMS OF INCREASING THE DEPTH OF OIL PROCESSING IN KAZAKHSTAN AND APPROACHES TO THEIR SOLUTION.....	169
A.P. Permana, S.S. Eraku, R. Hutagalung, D.R. Isa LIMESTONE FACIES AND DIAGENESIS ANALYSIS IN THE SOUTHERN OF GORONTALO PROVINCE, INDONESIA.....	185
R.G. Sarmurzina, G.I. Boiko, N.P. Lyubchenko, U.S. Karabalin, G.Zh. Yeligbayeva, N.S. Demeubayeva HYDROGEN OBTAINING FROM THE SYSTEM ACTIVATED ALUMINUM – WATER.....	196
S. Tsvirkun, M. Udovenko, T. Kostenko, V. Melnyk, A. Berezovskyi ENHANCING THE SAFETY OF EVACUATION OF VISITORS OF SHOPPING AND ENTERTAINMENT CENTRES.....	214
B.T. Uakhitova, L.I. Ramatullaeva, I.S. Irgalieva, R. Zhakiyanova, ZH.U. Zhubandykova MODELING OF INJURY PROGNOSIS IN FERROALLOY PRODUCTION.....	224

G.K. Umirova, D. Ahatkyzy

SOME FEATURES OF STRUCTURAL INTERPRETATION OF CDP 3D SEISMIC DATA UNDER CONDITIONS OF THE BEZMYANNOYE FIELD.....233

O.G. Khayitov, A.A. Umirzokov, Sh.Sh. Turdiev, V.R. Kadirov, J.R. Iskandarov

ON SOME RESULTS OF STUDYING THE CAUSES OF ANOMALOUSLY HIGH FORMATION PRESSURE ON THE HYDROCARBONS DEPOSITS OF THE BASHKENT DEEP.....247

A.S. Zhumagulov, M.T. Manzari, S.A. Issayev

PETROLEUM PLAYS AND PROSPECTIVITY OF THE SHU-SARYSU BASIN.....261

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)

Директор отдела издания научных журналов НАН РК *А. Ботанқызы*
Заместитель директор отдела издания научных журналов НАН РК *Р. Жәліқызы*

Редакторы: *М.С. Ахметова, Д.С. Аленов*

Верстка на компьютере *Г.Д. Жадыранова*

Подписано в печать 06.12.2022.

Формат 70x90^{1/16}. Бумага офсетная. Печать – ризограф.

20,0 п.л. Тираж 300. Заказ 6.