TOMSK POLYTECHNIC UNIVERSITY
ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

Министерство науки и высшего образования Российской Федерации
федеральное государственное автономное
образовательное учреждение высшего образования
«Национальный исследовательский Томский политехнический университет» (ТПУ)

Инженерная школа ядерных технологий
Направление подготовки 14.04.02 Ядерные физика и технологии
ООП/ОПОП Ядерная и радиационная безопасность
Отделение школы (НОЦ) Отделение ядерного топливного цикла

ВЫПУСКНАЯ КВАЛИФИКАЦИОННАЯ РАБОТА МАГИСТРАНТА

Тема работы
Исследование суточных вариаций поровой активности радона в поверхностных грунтах

УДК 550.42:546.296:551.51

Обучающийся

Группа	ФИО	Подпись	Дата
0АМ13	Кажитаев Санжар Муралович		

Руководитель ВКР

Должность	ФИО	Ученая степень, звание	Подпись	Дата
Профессор ОЯТЦ	Яковлева В.С.	Д.т.н.		

КОНСУЛЬТАНТЫ ПО РАЗДЕЛАМ:

По разделу «Финансовый менеджмент, ресурсоэффективность и ресурсосбережение»

Должность	ФИО	Ученая степень, звание	Подпись	Дата
Доцент ОСГН	Спицина Л.Ю.	К.э.н.		

По разделу «Социальная ответственность»

Должность	ФИО	Ученая степень, звание	Подпись	Дата
Доцент ОЯТЦ	Передерин Ю.В.	К.т.н.		

ДОПУСТИТЬ К ЗАЩИТЕ:

Руководитель ООП/ОПОП, должность	ФИО	Ученая степень, звание	Подпись	Дата
Ст. преподаватель ОЯТЦ	Семенов А.О.	К.т.н.		

Томск – 2023г.

TOMSK POLYTECHNIC UNIVERSITY
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образовательное учреждение высшего образования
«Национальный исследовательский Томский политехнический университет» (ТПУ)

School of Nuclear Science & Engineering
Field of training (specialty): 14.04.02 Nuclear Science and Technology
MEP/MPEP Nuclear and radiation safety
Nuclear Fuel Cycle Division

GRADUATE QUALIFICATION WORK OF A MASTER STUDENT

Work theme
Investigation of daily variations of radon pore activity in surface soils

UDC 550.42:546.296:551.51

Student

Group	Full name	Signature	Date
0AM13	Kazhitaev Sanzhar Muralovich		

Scientific supervisor

Position	Full name	Academic degree, academic rank	Signature	Date
Professor NFCD	Yakovleva V.S.	Doctor of technical sciences		

ADVISERS:

Section “Financial Management, Resource Efficiency and Resource Saving”

Position	Full name	Academic degree, academic rank	Signature	Date
Assistant professor	Spitsina L.Y.	Ph.D.		

По разделу «Социальная ответственность»

Position	Full name	Academic degree, academic rank	Signature	Date
Assistant professor	Perederin Y.V.	Ph.D.		

ADMITTED TO DEFENSE:

Programme Director	Full name	Academic degree, academic rank	Signature	Date
Senior lecturer NFCD	Semenov A.O.	Ph.D.		

Tomsk-2023

Министерство науки и высшего образования Российской Федерации
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образовательное учреждение высшего образования
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Инженерная школа ядерных технологий
Направление подготовки (ООП/ОПОП) 14.04.02 Ядерные физика и технологии
Отделение школы (НОЦ) Отделение ядерного топливного цикла

УТВЕРЖДАЮ:
Руководитель ООП/ОПОП
_____ _______ Семенов А.О.
(Подпись) (Дата) (ФИО)

ЗАДАНИЕ
на выполнение выпускной квалификационной работы

Обучающийся:

Группа	ФИО
0АМ13	Кажитаев Санжар Муралович

Тема работы:

Исследование суточных вариаций поровой активности радона в поверхностных грунтах	
Утверждена приказом директора (дата, номер)	*33-46/с*

Срок сдачи обучающимся выполненной работы:	25.05.2023

ТЕХНИЧЕСКОЕ ЗАДАНИЕ:

Исходные данные к работе *(наименование объекта исследования или проектирования; производительность или нагрузка; режим работы (непрерывный, периодический, циклический и т. д.); вид сырья или материал изделия; требования к продукту, изделию или процессу; особые требования к функционированию (эксплуатации) объекта или изделия в плане безопасности эксплуатации, влияния на окружающую среду, энергозатратам; экономический анализ и т. д.)*	*Суточная вариация поровой активности радона в поверхностных грунтах*
Перечень разделов пояснительной записки подлежащих исследованию, проектированию и разработке *(аналитический обзор литературных источников с целью выяснения достижений мировой науки техники в рассматриваемой области; постановка задачи исследования, проектирования, конструирования; содержание процедуры исследования, проектирования, конструирования; обсуждение результатов выполненной работы; наименование дополнительных разделов, подлежащих разработке; заключение по работе)*	- обзор литературных источников - приборы и методы измерения поровой активности в грунте. - определения зависимости суточных вариации поровой активности радона от климатических условий - исследование суточной активности радона в поверхностных грунтах - анализ полученных результатов - финансовая ответственность - социальная ответственность - заключение по работе
Перечень графического материала *(с точным указанием обязательных чертежей)*	Презентация для защиты ВКР

Консультанты по разделам выпускной квалификационной работы *(с указанием разделов)*	
Раздел	**Консультант**
Социальная ответственность	Передерин Юрий Владимирович
Финансовый менеджмент, ресурсоэффективность и ресурсосбережение	Спицина Любовь Юрьевна

Дата выдачи задания на выполнение выпускной квалификационной работы по линейному графику	13.03.2023

Задание выдал руководитель / консультант (при наличии):

Должность	ФИО	Ученая степень, звание	Подпись	Дата
Профессор ОЯТЦ	Яковлева В.С.	Д.т.н.		

Задание принял к исполнению обучающийся:

Группа	ФИО	Подпись	Дата
0АМ13	Кажитаев Санжар Муралович		

TOMSK POLYTECHNIC UNIVERSITY
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Инженерная школа ядерных технологий
Направление подготовки (ООП/ОПОП) 14.04.02 Ядерные физика и технологии
Уровень образования Магистратура
Отделение школы (НОЦ) Отделение ядерного топливного цикла
Период выполнения (осенний / весенний семестр 2022/2023 учебного года)

КАЛЕНДАРНЫЙ РЕЙТИНГ-ПЛАН
выполнения выпускной квалификационной работы

Обучающийся:

Группа	ФИО
0АМ13	Кажитаев Санжар Муралович

Тема работы:

Исследование суточных вариаций поровой активности радона в поверхностных грунтах

Срок сдачи обучающимся выполненной работы:	25.05.2023

Дата контроля	Название раздела (модуля) / вид работы (исследования)	Максимальный балл раздела (модуля)
10.04.2023	*Обзор литературных источников*	10
24.04.2023	*Методы и приборы измерения поровой активности радона в грунте*	15
25.04.2023	*Определения зависимости суточных вариации поровой активности радона от климатических условий*	20
26.04.2023	*Исследование суточной активности радона в поверхностных грунтах*	20
02.05.2023	*Анализ полученных результатов*	15
04.05.2023	*Финансовая ответственность*	10
05.05.2023	*Социальная ответственность*	10

СОСТАВИЛ:

Руководитель ВКР

Должность	ФИО	Ученая степень, звание	Подпись	Дата
Профессор ОЯТЦ	Яковлева В.С.	Д.т.н.		

СОГЛАСОВАНО:

Руководитель ООП/ОПОП

Должность	ФИО	Ученая степень, звание	Подпись	Дата
Ст. преподаватель ОЯТЦ	Семенов А.О.	К.т.н.		

Обучающийся

Группа	ФИО	Подпись	Дата
0АМ13	Кажитаев Санжар Муралович		

TOMSK POLYTECHNIC UNIVERSITY
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«Национальный исследовательский Томский политехнический университет» (ТПУ)

School of Nuclear Science & Engineering
Field of training (specialty): 14.04.02 Nuclear Science and Technology
Level of education: Master's degree
Nuclear Fuel Cycle Division
Period of work (fall/spring semester 2022/2023 academic year)

CALENDAR RATING PLAN
completion of the final qualifying work

Student:

Группа	ФИО
0AM13	Kazhitaev Sanzhar Muralovich

Work theme:

Investigation of daily variations of radon pore activity in surface soils

The deadline for the student's completed work:	25.05.2023

Control date	Section name	Maximum score of a section (module)
10.04.2023	*Literature review*	10
24.04.2023	*Methods and instruments for measuring the pore activity of radon in the soil*	15
25.04.2023	*Determination of the dependence of daily variations of radon pore activity on climatic conditions*	20
26.04.2023	*Investigation of daily radon activity in surface soils*	20
02.05.2023	*Analysis of the results obtained*	15
04.05.2023	*Financial responsibility*	10
05.05.2023	*Social responsibility*	10

COMPOSED:
HEAD OF FQW

Должность	ФИО	Ученая степень, звание	Подпись	Дата
Professor NFCD	Yakovleva V.S.	Doctor of technical sciences		

AGREED:
Head of BEP

Должность	ФИО	Ученая степень, звание	Подпись	Дата
Senior lecturer NFCD	Semenov A.O.	Ph.D.		

Student

Группа	ФИО	Подпись	Дата
0AM13	Kazhitaev Sanzhar Muralovich		

PLANNED RESULTS OF THE DEVELOPMENT OF THE PLO/OPOP

Competence code Name of competence	**Competence code Name of competence**
Universal competencies	
CC (U)-1	Is able to carry out a critical analysis of problem situations based on a systematic approach, develop a strategy for the actions
CC (U)-2	Is able to manage the project at all stages of its life cycle
CC (U)-3	Is able to organize and manage the work of the team, developing a team strategy to achieve the goal
CC (s)-4	Is able to apply modern communication technologies, including in a foreign language(s), for academic and professional interaction
CC (s)-5	Is able to analyze and take into account the diversity of cultures in the process of intercultural interaction
CC (s)-6	Is able to determine and implement the priorities of its own activities and ways its improvement based on self-assessment
General professional competencies	
of the Defense Industry (U)-1	Is able to formulate research goals and objectives, select evaluation criteria, identify priorities for solving problems
OPK(U)-2	Is able to apply modern research methods, evaluate and present the results of the work performed
OPK(U)-3	Is able to formalize the results of research activities in the form of articles, reports, scientific reports and presentations using computer layout systems and office software packages

Competence code Name of competence	**Competence code Name of competence**
Professional competencies	
PC(U)-1	Ability to create theoretical and mathematical models in the field of nuclear physics and technology
PC(S)-2	Willingness to apply methods of research and calculation of processes occurring in modern physical installations and devices in the field of nuclear physics and
PC(S)-3.	Willingness to develop practical recommendations for the use of the results of scientific research
PC(S)-4.	Ability to assess risk and determine safety measures for new installations and technologies, prepare and analyze scenarios of potential accidents, develop methods to reduce the risk of their occurrence
PC (U)-5.	Ability to analyze technical and computational-theoretical developments, to take into account their compliance with the requirements of the laws of the Russian Federation in the field of nuclear and radiation safety, atomic energy
PC (U)-6.	Ability to objectively evaluate the proposed solution or project in relation to the modern world level, to prepare an expert opinion
PC (S)-7.	Ability to formulate technical specifications, use information technologies and application software packages in the design and calculation of physical installations, use knowledge of methods of analysis of environmental and economic efficiency in the design

PC (S)-8	Willingness to apply optimization methods, analysis of options, search for solutions to multi-criteria problems, accounting for uncertainties in the design
PC (S)-9.	The ability to solve problems in the field of science, technology and technology development, taking into account regulatory legal regulation in the field of intellectual property
PC (Y)-10.	Readiness to teach in the main educational programs of higher education and additional professional education (APE)
PC (U)-11.	Ability to design and economic justification of an innovative project, content, structure and order of its development

Abstract

The final qualifying work on the topic "Study of daily variations in the pore activity of radon in surface soils" contains 107 pages, 20 figures, 31 tables, 90 sources used, 1 an appendix.

Keywords: radon flux density, radon volume activity, soil radon dynamics, diurnal variations, detection of meteorological parameters.

The object of the study is the monitoring data of the ionizing radiation flux density in the city of Tomsk at the experimental site of the Tomsk Observatory of Radioactivity and Ionizing Radiation.

The purpose of the work is to study the dynamics of the radon flux density from the soil into the surface atmosphere and to search for influencing factors.

In the course of the study, a search was made for patterns in the behavior of soil radon on a daily, synoptic scale.

Because of the study, the factors influencing the dynamics of radon in the soil were identified, and databases were formed based on the results of measuring the volumetric activity of radon at different depths.

Degree of implementation: High.

Scope: Geophysics, seismology.

Economic efficiency/significance of the work: High.

In the future, it is planned to continue research in this area: to replenish the databases and refine the parameters of the radon transport model in the geological environment.

Scientific novelty: The daily variation of radon pore activity at different depths in the ground has been investigated.

Practical significance: The possibility to study the daily variation of radon pore activity at different depths and with different detectors and radiometers.

SYMBOLS AND ABBREVIATIONS

RFD	Radon Flux Density
VA	Volume activity
TORIR	Tomsk Observatory of Radioactivity and Ionizing Radiation

Table of contents

Introduction

Field autonomous complex, being developed progress master's dissertations, For monitoring of pore activity of radon in surface soils maybe turn out to be useful at usage developed us autonomous field complex on stations involved in monitoring, in combined with appliances, designed to measure the pore activity of radon in soil surfaces, maybe raise authenticity received forecast data, a also to appear opportunity define and/or refine the parameters of the radon transport model in the geological environment and surface atmosphere.

The content of a large amount of radon in the zones faults found application in areas with elevated seismic activity, in the study of tectonic movements of plates. In 1966 in the city Tashkent, capital Uzbekistan in time earthquakes, managed fix, a sharp increase in the saturation of radon, concentrated in groundwater, 5-7 times in a few days before there was a push. On at the moment, such a principle of monitoring these physical processes used to track, fix and predict seismic activities in India, Israel, USA, Taiwan, Turkey and other countries. IN For the effective operation of this complex, Russia needs so that the installation satisfies a number of not unimportant features, such How, severe weather conditions in winter and spring period time. basisto create an autonomous field complex for density monitoring flow radon With terrestrial surfaces in Russia served high cost foreign analogues.

The purpose of this work - is to conduct a study of daily variations in the pore activity of radon in surface soils.

Tasks:

1) Overview and analysis literature by topics scientifically - research work.

2) Conduct an analysis of instruments and methods for measuring the volumetric activity of radon in the soil.

3) Execution calibration installations for definitions correction factor.

4) Calculate the vertical distribution of radon volumetric activity in a multilayer geological environment.

5) Investigate diurnal variations in the pore activity of radon.

Analysis of results.

1 1 Chapter

1.1 Origin and properties of radon

1.1.1 Physical properties of radon isotopes. Radioactive families

Radon normal conditions is yourself radioactive colorless inert gas without stable isotopes. High concentration radon air dangerous For life and health person. Physical propertiesradon indicated below table 1.

Table 1. Physical properties radon

Temperature boiling	- 62 °C
Temperature melting	- 71 °C
Density radon in gaseous state at normal conditions	9.727 kg / m ^{3}
Radius atom	214 pm
Energy ionization	10.74 eV

Radon is 55 times heavier than helium and 7.6 times heavier than air. [1] A large amount of radon and helium dissipates in the water column and the earth. The main amount of radon is concentrated in the upper layers of the earth's crust, which is about 115 tons. The amount of radon in the atmosphere is much less, about 4 kg. Almost zero radon content in the air and ice of Antarctica. [2-4]

Radioactive gas-radon is a decay product of a number of natural radioactive families of uranium and thorium. The most stable radionuclide in this family is Rn 222 (1/2 = 3.8235 days) . uranium family

U 235 (1/2 \u003d 7.13 108 years) includes Rn 219 (T 1/2 \u003d 3.96 s) , it is called actinon (An). The thorium family

Th 232 (1/2 = 1.41 1010 years) includes Rn 220(T 1/2 = 55.6 s) , which is called thoron (Tn). Ultimately, in the process of decay of the chain of these radioactive families, a stable radioisotope of lead is formed, the serial number of which is 82. In the uranium family it is Pb 206, in the thorium family it is Pb 208 , in the anemone family it is Pb 207 . [1-7]

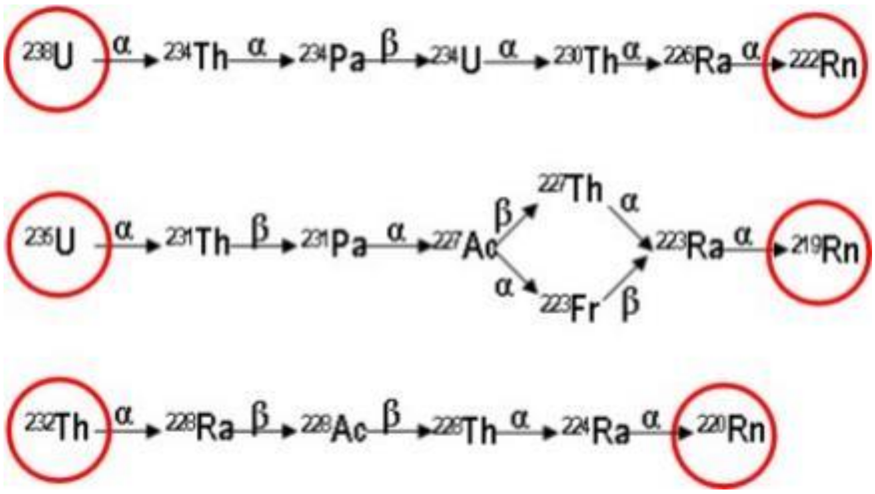

Figure 1. Radon radioactive family chain

1.1.2 Decay products of radon. Physical properties of radon

When emitting an α-particle, radon radioisotopes change their state of aggregation and turn from a group of inert gases into solid radioactive isotopes. [8-10] During the decay of radon, isotopes are formed, such as polonium, bismuth, thallium, and lead. The stable isotope of lead is the last link in the chain of transformations of radon isotopes.

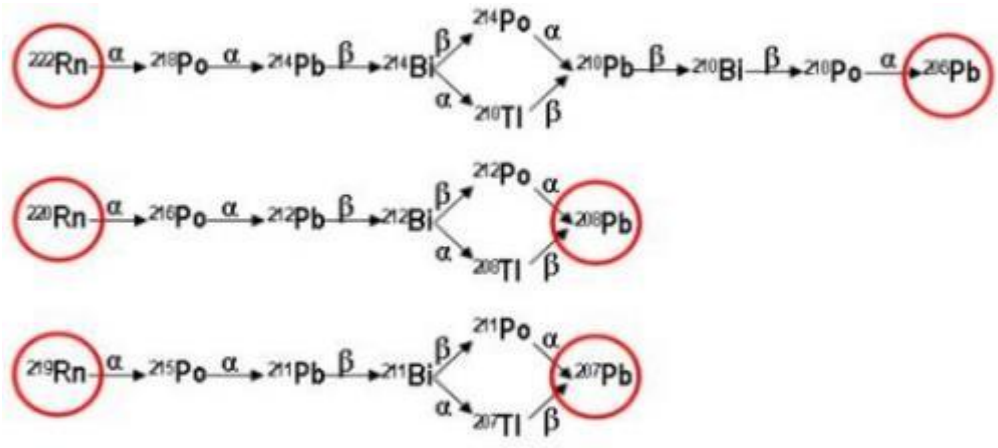

Figure 2. Chains of radioactive decay of radon isotopes

Within the framework of radioecology and radiation safety, when considering the resulting daughter products of radon decay, one can limit oneself to a certain part of the chain containing only long-lived isotopes. In the chain Rn 222 is Pb 210 , with a half-life of 22 years. Pb 210 fails to achieve an equilibrium concentration in the atmosphere, which is why it and the subsequent daughter products of the decay of the chain can be safely neglected.

During the decay of radon, metals are formed that are in a free state for a short time. Metals interact with non-radioactive aerosols that are constantly present in the atmosphere, such as particulate dust, fog droplets, and so on. When metals formed during the decay of radon interact with non-radioactive aerosols, radioactive aerosols are formed. Thus, the linear size of the daughter products of radon decay increases several times. [11-12]

The equivalent volumetric equilibrium activity of radon (EVEA) for a nonequilibrium mixture of short-lived progeny decay products in air is the volumetric activity of radon that is in equilibrium with its progeny decay products and has the same amount of latent energy as this nonequilibrium mixture. [11]

EROA $Rn = F * \text{OA } Rn = 0.5161\ APb + 0.3793\ ABi + 0.1046$,
(1)

where APo , APb , ABi – volumetric activities of short-lived radon decay products Po 218, Pb 214 and Bi 214 , respectively, Bq/m ^{3} ; F is the balance coefficient, the value of which is from 0 to 1.

1.2 Areas applications quantities density flow radon

Currently, the values of the radon flux density are being actively studied. both in theory and in practice to find solutions to a number of different tasks and problems next areas specified below:

Geophysics: seismology - the science forecasting changes stress-strain states bowels terrestrial bark, earthquakes; breath soil.

Geophysics: atmospheric physics, climatology is a science that deals with study and evaluation influence radon, located on earth, on electrical properties top layers atmosphere, study trajectories movements air wt.

Radioe cology. Geoecology. radiation biology - the science, evaluating radiation danger For population from estimates radon - dangers on territory, residential buildings.

1.2.1 Radioecology. Grade radon hazard territories and buildings

1.2.1.1 Radon hazard territories

The density of the radon flux on the earth's surface serves as a criterion for definition potential radon - dangers territories in Russian federation, established rules OSPORB-99. [13] According to sanitary requirements established on territory RF [14], average meaning density flow radon With surfaces land on territory, destinations under construction, Not must exceed 80 mBq / m^2 s. Territory under educational institutions meaning density flow radon should not be 40 mBq/m^2 s. The main condition for the delivery of residential premises so that the average annual equilibrium volumetric activity of radon in air Not exceeded 100 Bq/m^3.[15]

1.2.1.2 Radon hazard buildings

In air residential and public buildings present radon, which is one of the main components of air pollution, and also counts significant factor risk for health population. By

"Norms radiation security" content voluminous activity radon not must exceed 200 Bq/ ^{m3}, For residential buildings. [16]

1.2.2 Forecast earthquakes and volcanic activity

One from weighty tasks geophysics counts search reliable methods short-term forecasting earthquakes and eruptionsvolcanoes. An increase in stresses in soil gases in the air at the surface earth. [20,21] Monitoring characteristics radon fields at borders systems

"lithosphere-atmosphere" allows judge processes, ongoing on earth's crust.

To increase the sensitivity of the radon forecasting method earthquakes try conduct monitoring in districts, where present deep highly active sources radon (breeds with high content uranium; zones tectonic faults in terrestrial bark) For increase amplitude anomalous bursts.

1.2.3 Climatology. Radon - as a tracer of air exchangeprocesses

Radon long time used in quality tracks, which followbehind the air masses vertically and horizontally. (transcontinentalscale) direction. [22-29] In addition to radon, for the study of various dynamic atmospheric processes and refinement of the global chemical models transfer, apply other radionuclides - thoron , Pb^{212}, Pb^{210},

Be^{7}, Be^{10} and CO^{14}. From them radionuclides Pb^{210}, Be^{7}, Be^{10}, which are joining With non-radioactive aerosols and are useful at studying sedimentation because of precipitation rain and snow. Monitoring these natural radionuclides on a large scale are needed to study global changes climate and forecasting. For solutions the aforementioned tasks necessary know behavior and spatial distribution of RFD from the surface of the earth. However, existing knowledge about spatial (over all continents) and temporal variability of the value RFD is still not enough. Construction of detailed maps about RFD based on content data U^{238} (Ra^{226}) requires knowledge of many parameters, such as How type and humidity soil, temperature (or vertical gradient temperature in system priming atmosphere), intensity atmospheric precipitation and etc. This stimulates new experimental research speakers RFD simultaneously With improvement methods measurements.

In addition, radon is a useful tool in determining coefficients diffusion gases and aerosols IN surface atmosphere. [30,31]

More one application radon found in quality indicatorvertical sustainability bottom atmosphere and thickness layer convective mixing. [32,33]

2 Chapter

2.1 Indirect methods - modeling RFD By changed VA radon in surface soils

Way By definition density flow radon founded on models diffusion-advective transfer and two values volumetric activity radon, measured on different depths. The method was field tested with excellent results. Gradedensity radon flux takes into account influence climatic conditions.

Distinctive trait given method is optional knowledge of the value of the advection velocity, since it is based on the use of already measured values of radon volumetric activity in soil air on depth up to 1 meters. Method developed in 3rd options.

First option method By estimates density flow radon

In this method, you can limit yourself to one measurement of the volume activity soil radon and use information O physical geological parameters soils For estimates values A_∞. Denote

measured on depth h concentration radon $A(h) = A_h$. Substitute in

the equation (2)

$$q(z) = -D_e \frac{\partial(\eta A(z))}{\partial z} + \upsilon \eta A(z) \qquad (2)$$

Express coefficient at exhibitor in next form

$$A(z) = A_\infty \left(1 - exp^{-\left(\sqrt{\left(\frac{\upsilon}{2D_e}\right)^2 + \frac{\lambda}{D_e}} + \frac{\upsilon}{2D_e}\right)z}\right). \qquad (3)$$

In accordance with Fick's law and taking into account radiological transferintensity flow radon determined expression (4).

$$\sqrt{\left(\frac{\upsilon}{2D_e}\right)^2+\frac{\lambda}{D_e}}+\frac{\upsilon}{2D_e}=ln\left(\frac{1}{1-\frac{A_h}{A_\infty}}\right)\cdot\frac{1}{h} \quad (4)$$

with taking into account (2) at $z = 0$ expression (4) will accept view

$$q(z)|_{z=0}=D_e\eta A_\infty\left(\sqrt{\left(\frac{\upsilon}{2D_e}\right)^2+\frac{\lambda}{D_e}}+\frac{\upsilon}{2D_e}\right). \quad (5)$$

Let's write down expression (6) rewriting the equation (5), With taking into account (3) we getformula For estimates density flow radon With surfaces land By measured on certain depth volumetric activity radon in soil air.

$$q(z)|_{z=0}=D_e\eta A_\infty ln\left(\frac{1}{1-\frac{A_h}{A_\infty}}\right)\cdot\frac{1}{h} \quad (6)$$

At absence credible information O physical and geological soil parameters instead of values A_∞ Can use in calculations, along with With A_h, meaning voluminous activity radon, measured on another depth.

Second option method By estimates density flow radon

When measurements volumetric activity radon produced on depths that differ by 2 times, the second option is more useful method By estimates density flow radon. Substitute in the equation (2) values of radon volumetric activity A_1 and A_2 measured at depths h_1 and $h2$ _ we get expressions (7) and (2;7)

$$A_1 = A_\infty(1 - exp^{-Yh_1}), \quad (7)$$

$$A_2 = A_\infty(1 - exp^{-Yh_2}), \quad (8)$$

$$Y=\sqrt{\left(\frac{v}{2D_e}\right)^2+\frac{\lambda}{D_e}}+\frac{v}{2D_e}.$$

Where

Express Y and A_∞ through A_1 and A_2. in case, When $h2\_=2h_1$, systemequations (7; 8) It has simple analytical solution. Denote $exp^{-Yh_1}=$, Then $exp^{-Yh_2}=exp^{-2Yh_1}=x^2$ and equations (7; 8) accept view

$$A_1=A_\infty(1-x), \tag{9}$$

$$A_2=A_\infty(1-x^2), \tag{10}$$

Dividing A_2 and A_1 and taking a logarithm both parts equations, we getformula For Y

$$Y=\frac{1}{h_1}ln\left(\frac{1}{\frac{A_2}{A_1}-1}\right). \tag{11}$$

Expression For A_∞ through measured voluminous activity radon A_1 and A_2 looks next way

$$A_\infty=\frac{A_1}{2-\frac{A_2}{A_1}}. \tag{12}$$

Transforming equation (5), taking into account (11) and (12), we obtain a formula for estimating the RFD from the earth's surface using radon pore activities measured at depths that differ by a factor of 2

$$q(z)|_{z=0}=D_e\eta A_\infty\frac{1}{h_1}ln\left(\frac{1}{\frac{A_2}{A_1}-1}\right)\frac{A_1}{2-\frac{A_2}{A_1}}. \tag{13}$$

Third option method By estimates density flow radon

When measurements volumetric activity radon produced on depths that differ by a factor of , the third option is more useful method By estimates density flow radon.

$$T = exp^{-\left(\sqrt{\left(\frac{\upsilon}{2D_e}\right)^2+\frac{\lambda}{D_e}}+\frac{\upsilon}{2D_e}\right)h_1}.$$

At this $h2 = k \cdot h1$, ratio A_1 and A_2 is equal to X,

Having made several transformations with equations (9) and (10), we obtain the expression (14)

$$XTk - -T + (1 - X) = 0. \qquad (14)$$

The resulting nonlinear equation (14) in the general case cannot be solved analytically, however, numerical methods allow solving this equation to determine the unknown quantity .

The advection velocity is expressed in terms of the desired value T in the following way

$$\upsilon = \frac{\lambda z_1 - \left(\frac{ln^2(T) \cdot D_e}{z_1}\right)}{ln(T)}. \qquad (15)$$

Meaning equilibrium voluminous activity radon in soil air equals

$$A_\infty = \frac{A(z_1)}{1-T}. \qquad (16)$$

Taking into account relations (15) and (16), the expression for the radon flux density takes the form

$$q(z)|_{z=0} = D_e \eta \frac{A(z_1)}{1-T}\left(\sqrt{\left(\frac{\lambda z_1}{2ln(T)D_e} - \frac{ln(T)}{2z_1}\right)^2 + \frac{\lambda}{D_e}} + \frac{\lambda z_1}{2ln(T)D_e} - \frac{ln(T)}{2z_1}\right). \quad (17)$$

2.3 Static and dynamic methods measurements

pushing off from designs funded cameras, which used to measure the flux density of radon from the ground surface, measurement methods can be subdivided on two main:

static (Cumulative camera All time be in closed condition. measurements produced directly on accumulated quantityradon in the accumulation chamber, with subsequent measurement, the accumulation camera ventilated.) The method is used more frequently. Dynamic (take place continuous circulation air in storage chamber).

2.4 Detectors for measuringpore activity of radon in the surface soil.

Highly sensitive scintillation intelligent detection unit designed to measure the flux density of alpha particles from contaminated surfaces in the range from 0.1 ppm (min·cm^2).

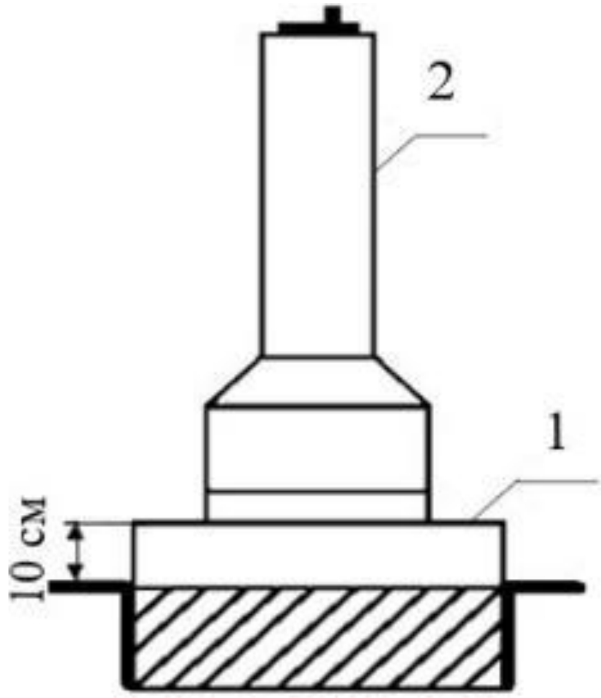

Figure 3. Scheme installations for measurements density flow radon from the surface soil

where 1 is a storage chamber designed to measure the RFD from the soil surface. The camera is installed in the ground so that the distance from the ground surface to the detector is 10 cm; 2 - detection unit BDPA-01 and BDPB-01.

Applications: Radioecology, sanitary and epidemiological supervision , nuclear industry, fire services, emergency rescue services, civil defense, scientific research.

Table 2 shows the main characteristics of the detection units BDPA-01, BDPB-01 for measuring the density of ionizing radiation fluxes.

Table 2. Main characteristics of detection units

Alpha radiation detection units						
Detector	Alpha particle flux density measurement range	239 Pu surface activity measurement range	Pu alpha particle fluence measurement range	Energy range	^{239}Pu Alpha Sensitivity imp·s^{-1} / part·min^{-1} .cm^{-2}	Overall dimensions, weight
	Limit of basic relative measurement error					Degree of protection
Scintil . ZnS (Ag) 30cm^{2}	0.1-10^{5} ppm^{-1} .cm^{-2}	3.4·10^{-3}- 3.4·10^{3} Bq·cm^{-2}	1-3·10^{6} part·cm^{-2}	4-7 MeV	0.15	Ø80x196 mm 0.5 kg
	±20%					IP64
Beta radiation detection units						
Detector	Beta particle flux density measurement range	Surface activity measurement range 90 Sr + 90 Y	Measurement range of fluence of 239 Pu beta particles	Energy range	Sensitivity to beta radiation of the 90Sr+90Y source imp·s^{-1} / part·min^{-1} .cm^{-2}	Overall dimensions, weight
	Limit of basic relative measurement error					Degree of protection
Scintil . Plastic	1-5·10^{5} part·min^{-1} .cm^{-2}	4.4·10^{-2}- 2.2·10^{4} Bq·cm^{-2}	1-3·10^{6} part·cm^{-2}	155keV- 3.5 MeV	0.3	Ø80x196mm 0.5 kg
	±20%					3.5 MeV

The method of monitoring the radon flux density from the soil surface consists of the use of a scintillation (or semiconductor) α -particle detector and an accumulation chamber.

α -particle detector is installed inside the accumulation chamber so that its film is located no closer than 10 cm from the soil surface. Such a limitation makes it possible to exclude the “background”, which can be determined by detecting α -particles resulting from the decay of soil radionuclides.

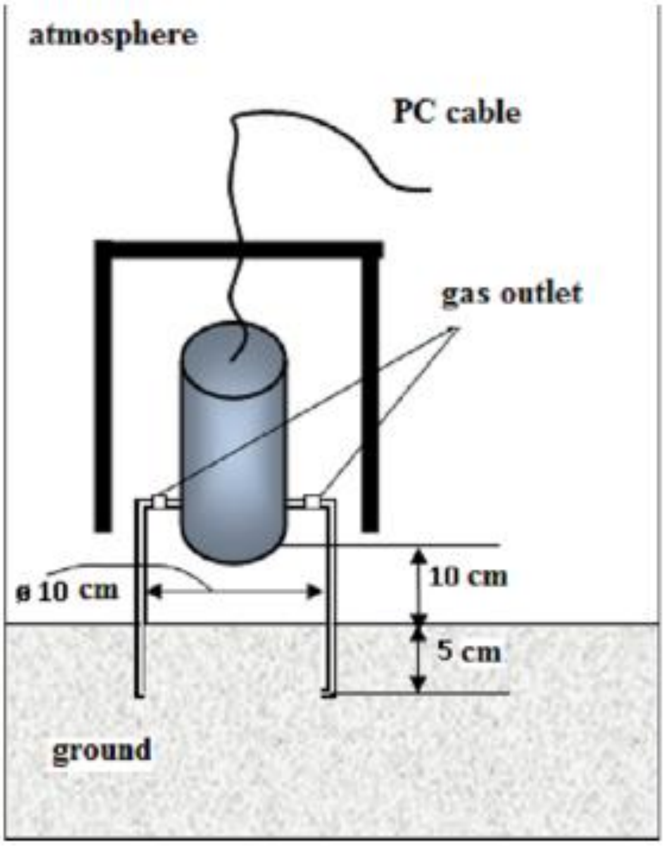

Figure 4. Scheme of installation of a device for monitoring the density of radon flux from the soil surface

The accumulation chamber has ventilation holes for partial discharge of soil gas and for maintaining a semi-equilibrium concentration of radon inside the accumulation chamber. The number and size of holes are chosen in accordance with the condition that the pulse count rate inside the accumulation chamber must be at least 10 times greater than the pulse count rate in the open atmosphere at the same distance from the scintillation α-detector film from the soil surface. This allows us to reduce the statistical error of the measurement results.

3 Chapter

3.1 Calibration of soil sensors with a radon radiometer

Work on the study of the dynamics of radioactive soil gas radon, mainly for the purpose of constructing short-term earthquake forecasts, has been carried out in many countries for more than one decade. The results of these works are well reflected in the scientific literature. In connection with this, many methods have been developed for measuring the volumetric activity of radon in soil air, which are separated, first of all, by the detected isotope (or mixture):

1) directly by radon;

2) by a mixture of radon isotopes and aerosol daughter products of their decay;

3) only under the LPR. The methods of measurement also differ according to the type of registered ionizing radiation - α, β or γ.

The most common measurement methods are α-radiation and pumping gas from wells, however, they are quite complex and expensive, since they require the separation of radon from the gas - aerosol mixture. Less common, but more convenient for long-term continuous monitoring of soil radon, are measurement methods for β- and / or γ-radiation of the DPR directly in wells. In addition, they are 1–2 orders of magnitude cheaper, which makes it possible to significantly increase the number of simultaneous monitoring points and thereby expand the observation network. It is these methods that have been used for decades at monitoring stations around the world to predict earthquakes. Their main advantage is that they allow obtaining, processing and analyzing data on a quasi-real scale.

One of the tasks of this research work was to check the possibility of measuring radon by direct registration in the soil using one or several

IRs. To do this, at each of the two selected depths (0.5 m and 1 m), alpha, beta and gamma radiation detectors were installed in separate wells. Figure 5 shows the time series of alpha and beta radiation fluxes measured in wells for the period from July 2010 to October 2011. In general, the seasonal changes in VA fluxes at two depths are very similar. However, if we consider the diurnal variation, the synchronism between the fluxes of α- and β-radiations is by no means always observed. At the same time, the soil β-background varies more strongly and more often than the α-background.

During this period, 3 cases of a synchronous strong increase in VA fluxes (hereinafter referred to as anomalies) were detected in the spring and summer periods. The period of onset of the first anomaly is shown in Figure 5, where the rows at 0.5 m are shown in red, and those at 1 m are in blue. At a depth of 0.5 m, the anomaly appeared earlier than at a depth of 1 m for α-radiation. For β-radiation, almost synchronous growth is seen at both depths. The second and third anomalies in the series of VA soil fluxes are considered in detail in the next subsection.

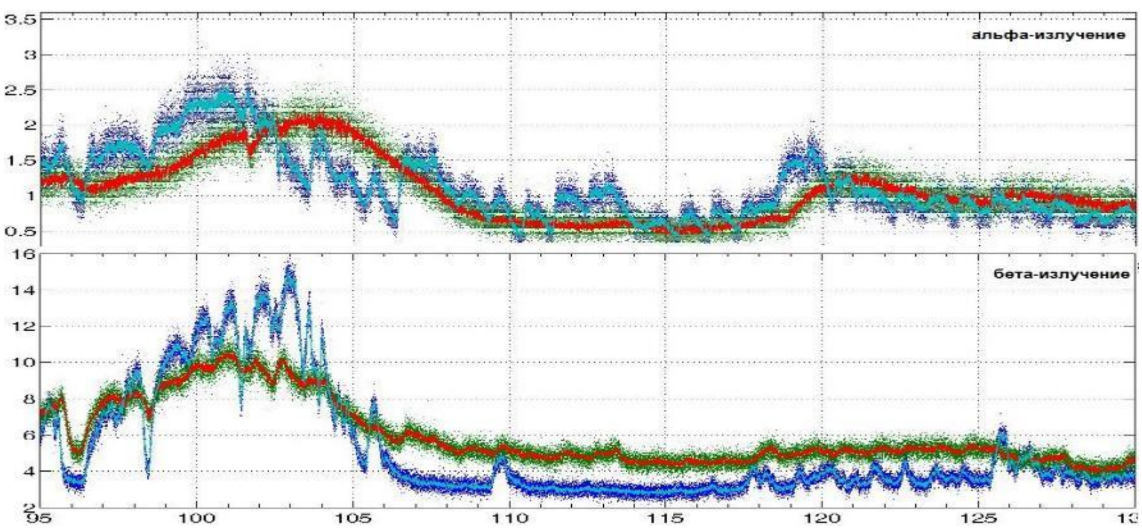

Figure 5 - Series of soil alpha and beta fields during the snowmelt period

Analysis of the dynamics of subsoil fluxes of α- and β-radiation for 2010–2011 identified potential difficulties in the procedure for calibrating detectors and determining correction factors for converting the measurement result into RA of radon. It can be seen that a deeper study of calibration tasks is required here with parallel and long-term measurement of radon VA in wells, as well as the involvement of theoretical calculations on the transfer of IR in the "soil-well" system. It can be assumed that the correction factors for α- and β-fluxes will not be proportional, and, possibly, will be functions of one or more parameters.

Let us consider in detail the process of calibration of soil detectors for α- and β-radiation, which lasted from the beginning of June to the end of July 2011. The layout of wells at the experimental site of the TORIR, in which the detectors of α- and β-radiation BDPA-01 and BDPB-01 are installed (ATOMTEH, Belarus), is shown in Figure 7. The appearance of the radiometer itself is shown in Figure 8. The scheme for calibrating soil detectors using the RTM 2200 radon and thoron radiometer (SARAD, Germany) is shown in Figure 9. Calibration of soil detectors was carried out from 28 May to July 28, 2011. The results of measurements of RA of radon and soil fluxes α- and β- at different depths are shown in Figures 10-12.

Figure 6 - Layout of wells with α-, β- and γ-radiation detectors installed inside

Figure 7 - Appearance of the radon and thoron radiometer RTM 2200

3.2 Dynamics of radon activity and its decay products inside the storage chamber

The dynamics of the accumulation of radon and its decay products in the storage chamber at a constant value of RFD from the ground surface, adopted for calculations of 10 MBq m^{-2} s^{-1} (a typical value observed for loams, provided that radon transfer is carried out only by diffusion). The following parameters were selected for calculations: chamber volume – 3.14 l; height – 0.1 m, respectively, K = 0.1 Bq m^{-3} s^{-1}, accumulation time duration – 1 hour.

The radon accumulation time in the chamber with a duration of 1 hour was selected from the optimization condition. Limiting the upper limit of the range dictated by the requirement for a high sampling rate of time series of radon field data. On the other hand, when the accumulation duration is more than 2 hours, the nonlinearity of the accumulation curve begins to manifest itself strongly.

Figure 8 - Scheme of calibration of soil detectors of the VA with a radon radiometer.

3.3 Results of measurements of radon VA and soil α- and β- fluxes at different depths

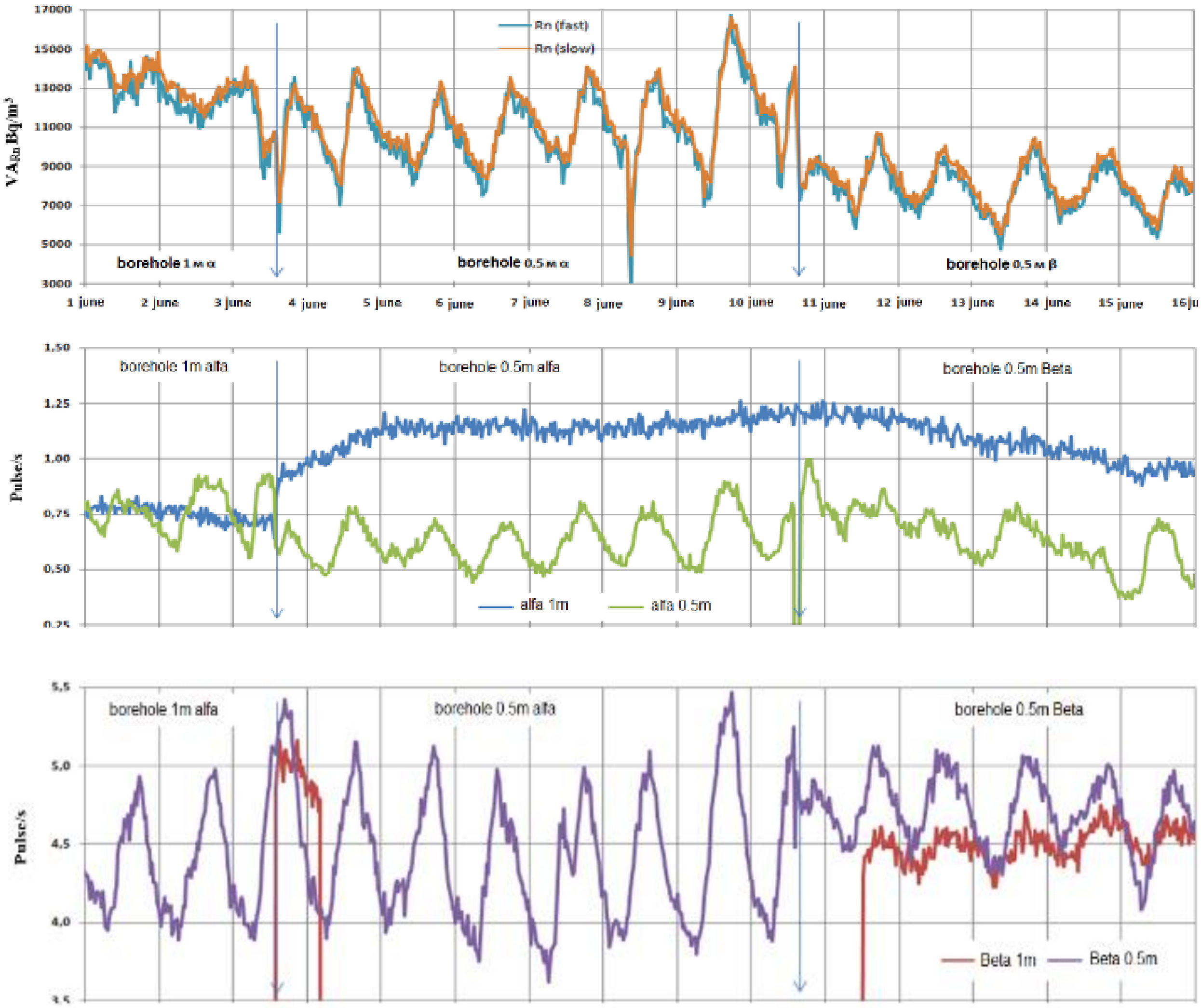

Figure 9 - Dynamics of soil fields of radon and VA from June 1 to June 15

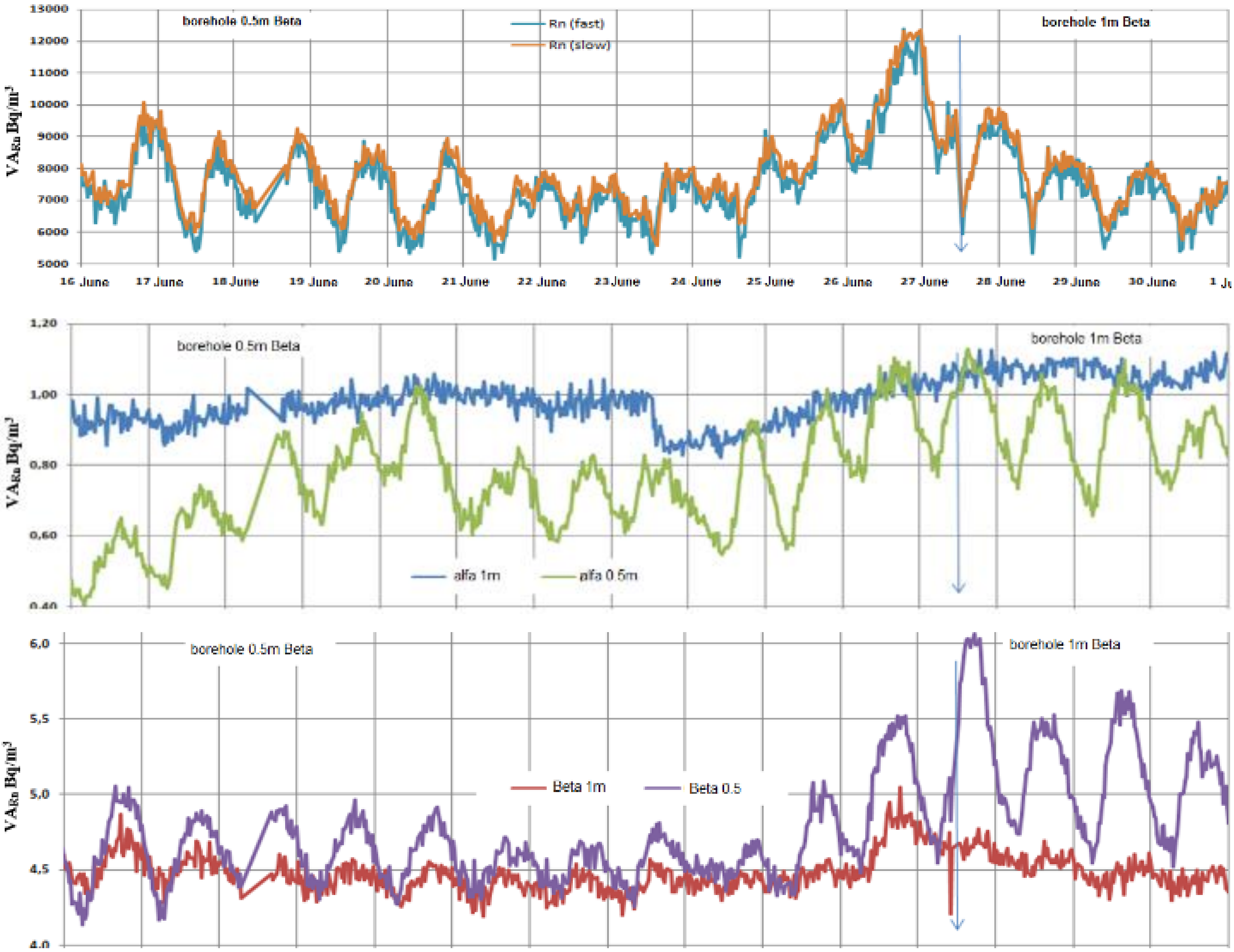

Figure 10 - Dynamics of soil fields of radon and VA from June 16 to June 30

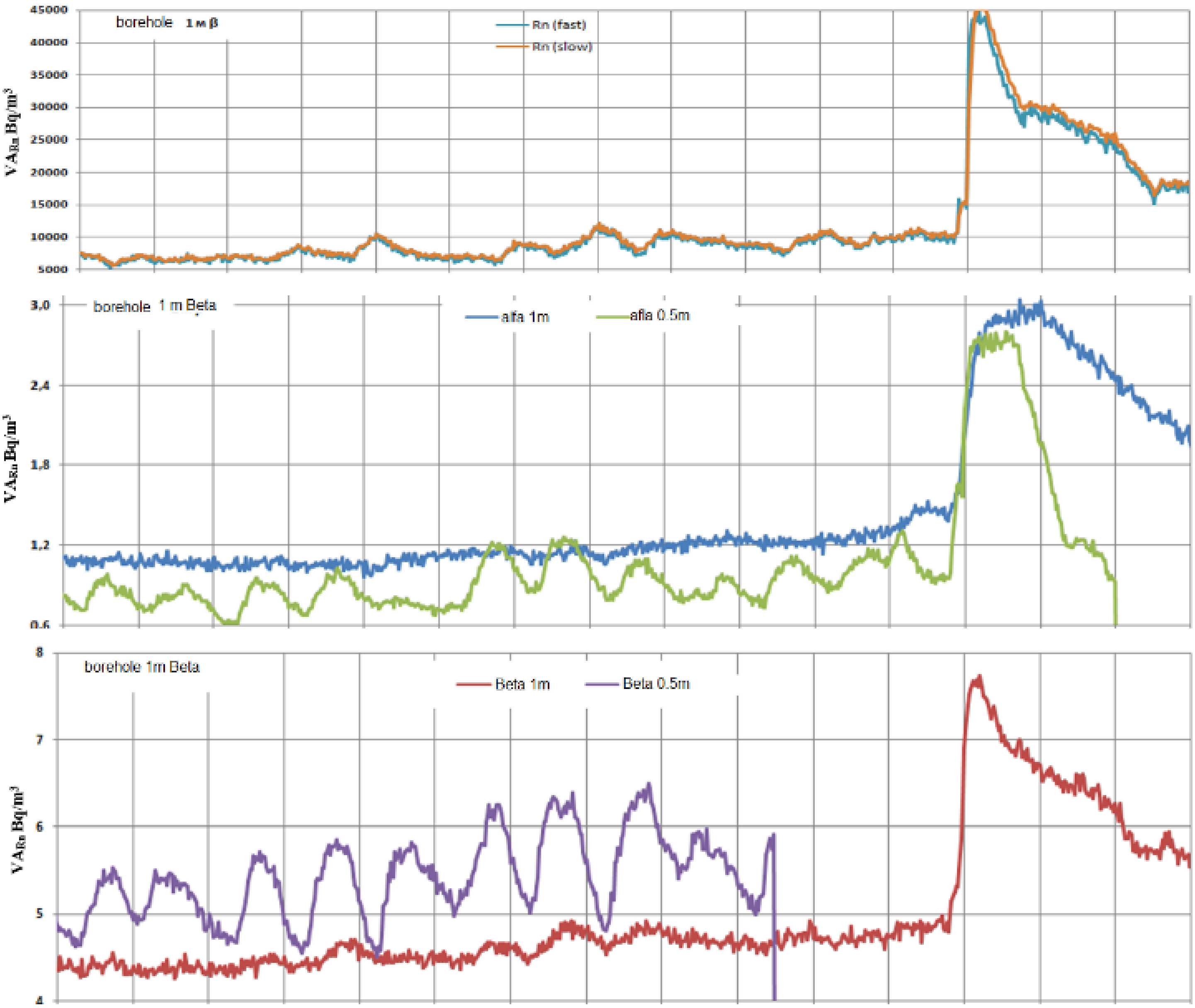

Figure 11 - Dynamics of soil fields of radon and VA from July 1 to July 15

Further, the results of calibration of each well separately are discussed in detail. The calibration results in a 1 m well with an alpha detector are shown in Figure 13. The upper diagram (Figure 13) shows a series of radon VA measured by a radiometer (Rn 1 m) and restored by multiplying by the correction factor Kα1m=16940 Bq/ imp . a series of OA radon (Alpha 1 m). The lower diagram shows the rows of radon VA restored by multiplication by correction factors in 0.5 m wells with alpha - (Alpha 0.5 m) and beta - (Beta 0.5 m) detectors. The correction factors determined for different detectors are summarized in Table 3.

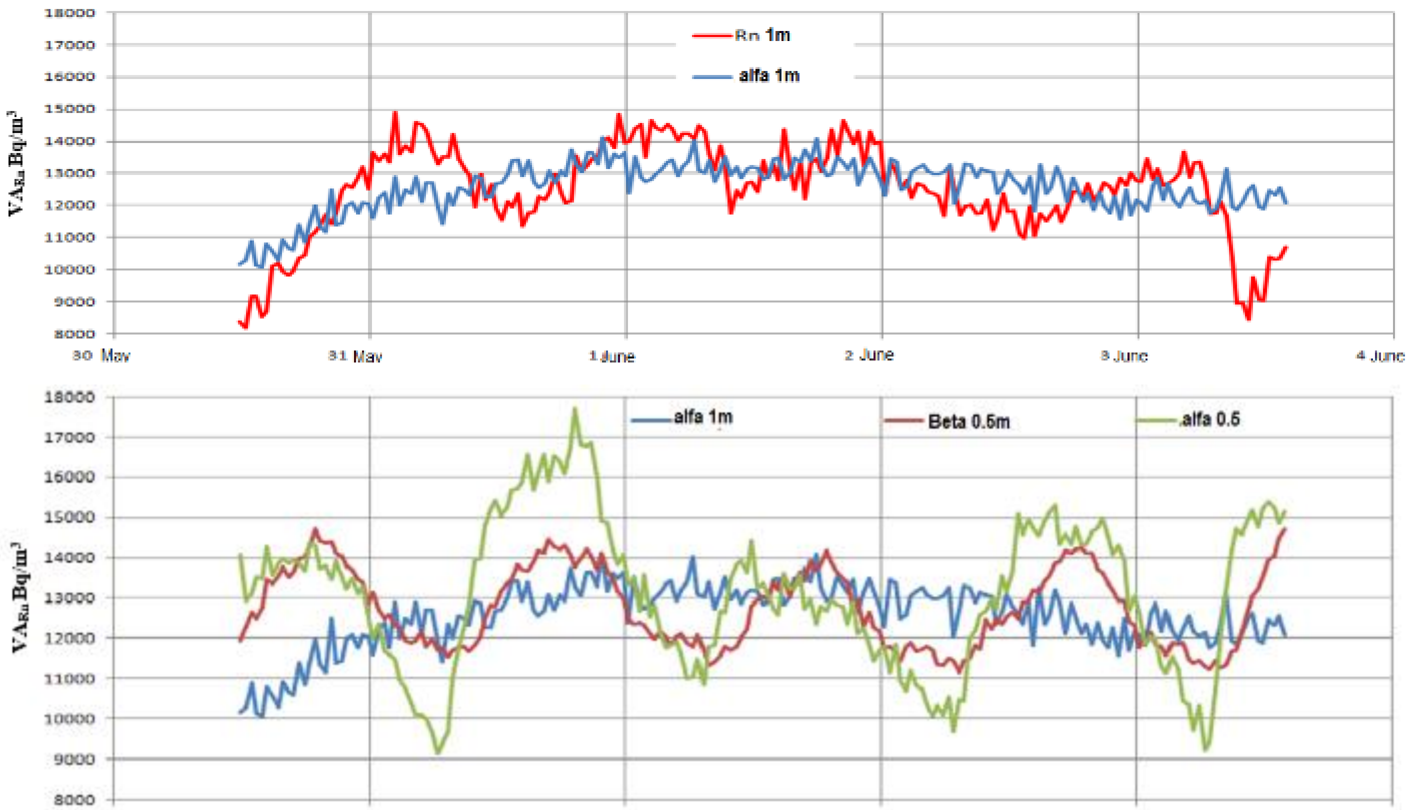

Figure 12 – Calibration results in a 1 m well with an alpha detector

Table 3 - Conversion coefficients to activity units, Bq / imp .

Alfa detector at h=1 m	Alfa detector at h=0,5 m	Beta detector at h=1 m	Beta detector at h=0,5 m
Kα1м	Kα0,5м	Kβ1м	Kβ0,5м
16940	16196	2872	2430

An analysis of the real and reconstructed radon VA series showed the following:

- The alpha detector at a depth of 1 m does not adequately reflect the real change in the RA of radon in the well, there are no daily variations.

- The alpha detector at a depth of 0.5 m shows a delay in time of the moments of the onset of maxima in RA in comparison with a depth of 1 m, the delay is approximately 8 hours. The speed of radon movement is estimated to be 17 10 3 times higher than the speed of radon movement due to molecular diffusion $6 \cdot 10^{-4}$ cm/s.

- A beta detector at a depth of 0.5 m shows approximately the same delay of 8 hours.

- The change in time of alpha and beta fields at a depth of 0.5 m is almost synchronous, but with different amplitudes. The shape of diurnal variations is more like a sawtooth for beta radiation and a cycloid for alpha radiation.

Calibration results in a 0.5 m well with an alpha detector. The upper diagram shows the series of RA of radon measured by a radiometer (Rn 0.5 m) and the series of RA of radon (Alpha 0.5 m and Beta 0.5 m) restored by multiplying by the refined correction factors (Table 3.2). The lower diagram shows the reconstructed VA series from the data of soil alpha and beta detectors.

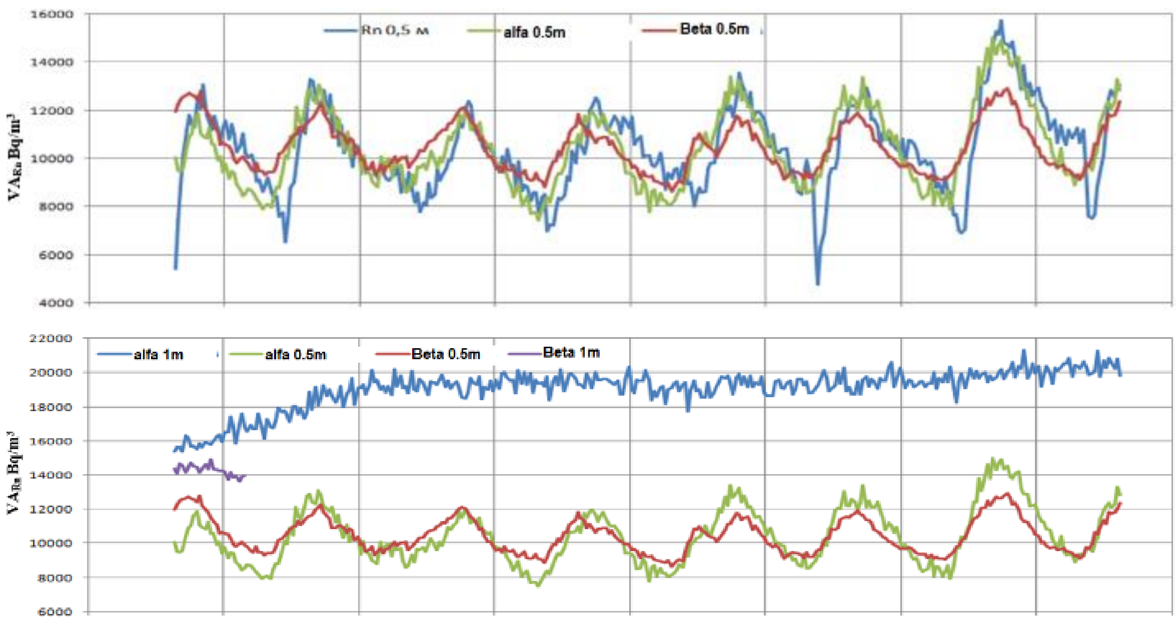

Figure 13 - Calibration results in a 0.5 m well with an alpha detector

Table 4 - Conversion coefficients to activity units, Bq / imp .

Alfa detector at h=1 m	Alfa detector at h=0,5 m	Beta detector at h=1 m	Beta detector at h=0,5 m
Kα1м	Kα0,5м	Kβ1м	Kβ0,5м
–	16609	–	2362

An analysis of the results of the calibration of a 0.5 m well with an alpha detector showed that the temporal changes in the RA of radon, as well as the fluxes of alpha and beta radiation measured at the same depth of 0.5 m, but in different wells, are practically synchronous, have close to sawtooth shape. The amplitude of variations in the flux of alpha radiation changes with time in accordance with the radon field. The amplitude of the flux of beta radiation at 0.5 m depth is almost the same for the period under consideration.

Calibration results in a 0.5 m borehole with a beta detector are shown in Figure 15. The upper diagram of Figure 15 shows a series of radon VA in a 0.5 m borehole, measured by a radiometer (Rn 0.5 m) and restored by multiplying by correction factors (table 5) series of OA of radon for alpha and beta radiation. Here one can clearly see the discrepancy between the amplitudes of RA RA and the flux of beta radiation at a depth of 5 m. Although the diurnal variation is the same. The alpha radiation flux at a depth of 0.5 m changes according to a completely different law than the RA of radon, which is clearly seen in the middle diagram of Figure 15. The lower diagram shows the radon series measured by the radiometer and the reconstructed series according to the beta detector data. In this case, the restoration of the series was carried out not simply by multiplying by the coefficient given in Table 5, but according to the following scheme. The beta-detector pulse count rates (Nβ) were divided into 2 parts: 1) constant (Nβs) due to soil radionuclides not related to the radon component; and 2) the variable ($N\beta$ Rn) due to beta-emitting radon decay chain radionuclides contained in the borehole air and the topsoil in the lower open basement of the borehole, i.e. $N\beta = N\beta s + N\beta Rn$. Radon VA was calculated using the formula

$$VA\ Rn(i) = (N\beta(i) - N\beta s)\ K\beta\ 0.5\ m\ . \tag{18}$$

In this case, the correction factor takes on a different value of $K\beta 0.5m=4570$, and the value of $N\beta s$ was 3 pulses / s for a specific scintillation beta detector and specific conditions for installing a beta detector in a 0.5 m well.

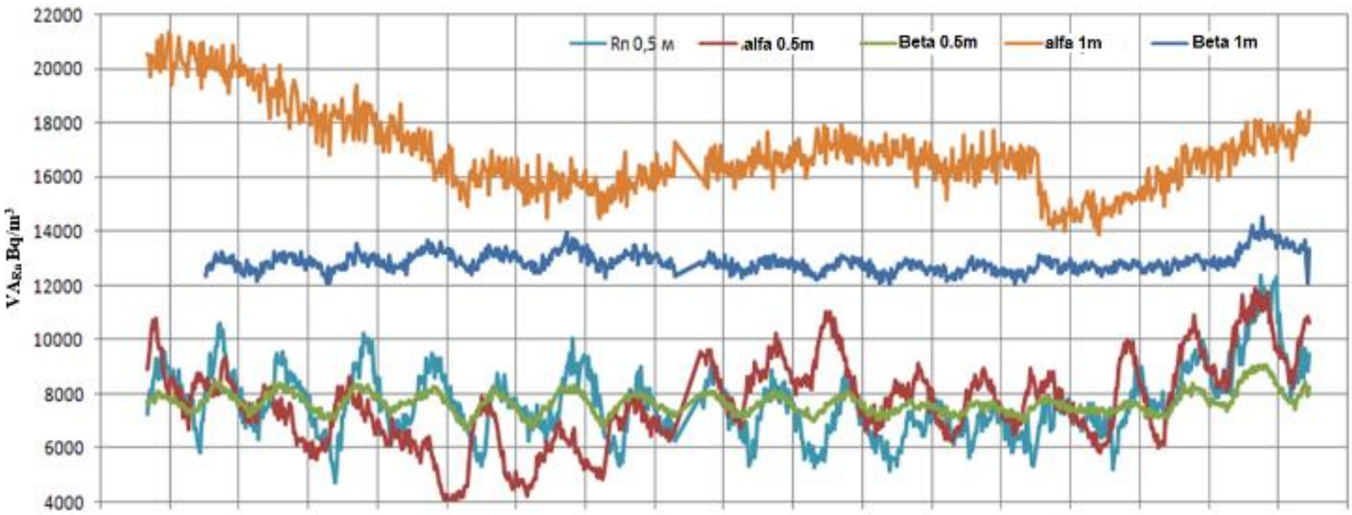

Figure 14 - Calibration results in a 0.5 m well with a β-detector

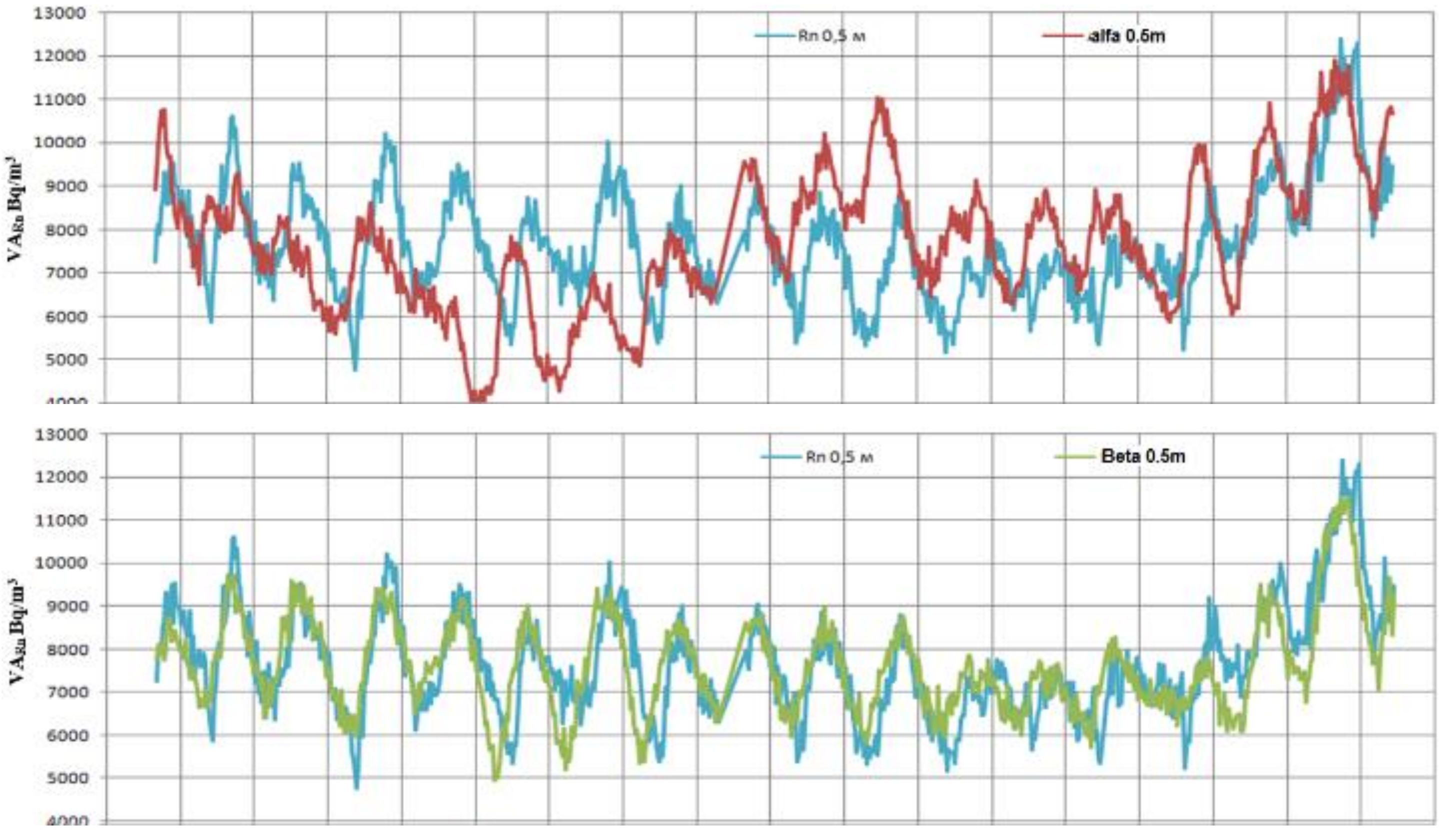

Figure 15 - Calibration results in a 0.5 m well with a β-detector

Table 5 - Conversion coefficients to activity units, Bq / imp .

Alfa detector at h=1 m	Alfa detector at h=0,5 м	Beta detector at h=1 m	Beta detector at h=0,5 m
Kα1m	Kα0,5m	Kβ1m	Kβ0,5м
-	10755	-	1645 VA Rn(i)=(Nβ(i)-3)· 4570

Calibration results in a 1 m well with a β-detector installed inside are shown in Figure 16.

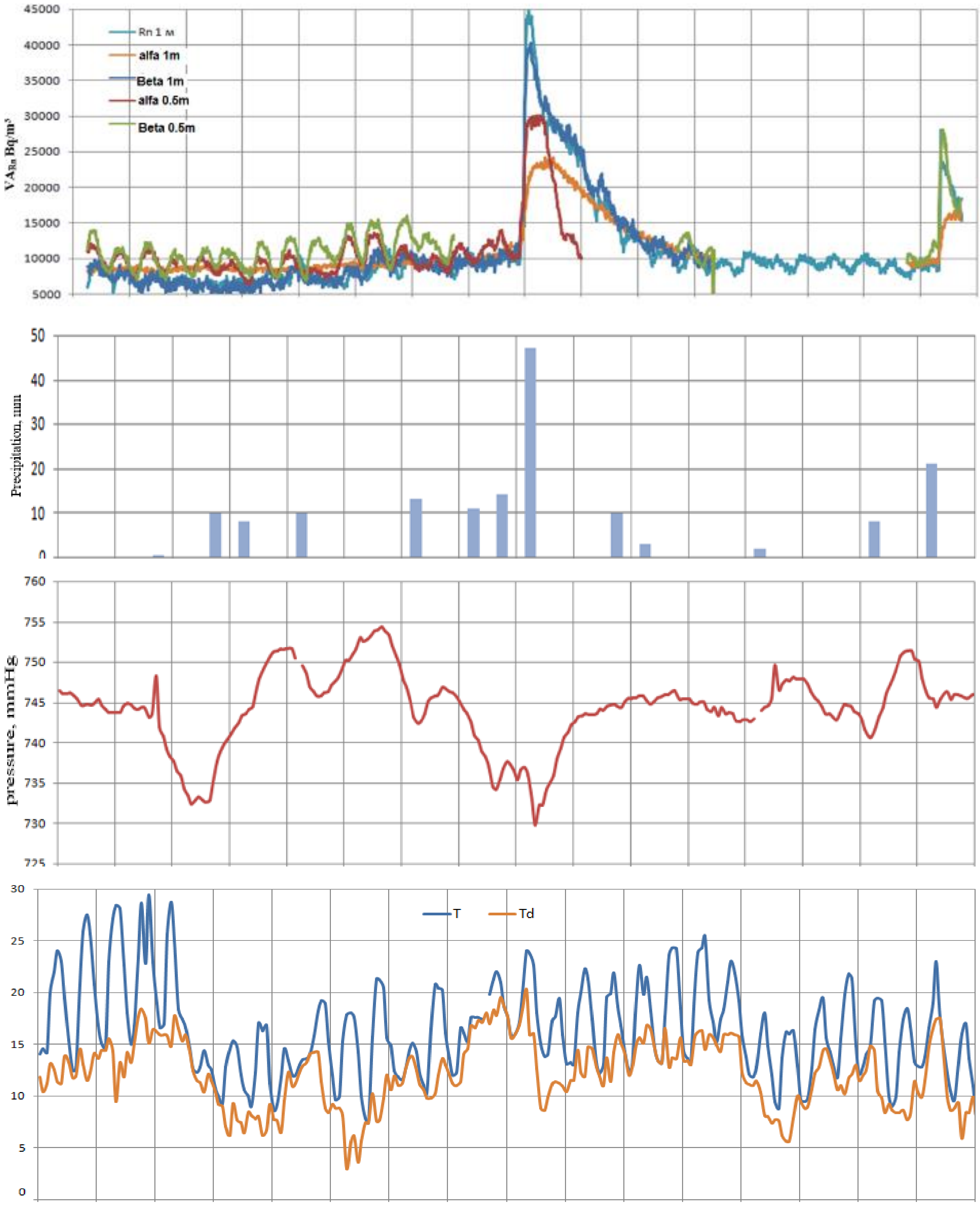

Figure 16 — Calibration results in a 1 m well with a β-detector

measured by a radiometer (Rn 1 m) and restored by multiplying by previously determined correction series of radon OA for alpha and beta radiation. The following diagrams in Figure 16 show the dynamics of meteorological quantities: rainfall; Atmosphere pressure; air temperature at a height of 2 m (T) and dew point temperature (Td) .

The last stage of detector calibration only added questions, instead of clearing everything up. During the calibration period, 2 abrupt increases in RA of radon were observed. Unfortunately, during this period there were several failures of the detectors. However, the three working detectors responded in the same way as the radon/ thoron radiometer with an abrupt increase in the pulse count rate during the periods of July 13–15 and July 27–28 (Figure 16).

However, when checking the previously determined correction factors (when measured in a well alpha 1 m) with the new ones presented in Table 6, large discrepancies were obtained. The coefficient Kα1m decreased by almost 1.5 times. In addition, this coefficient took different values for the first half of the measurement period (from June 27 to July 19) and the final stage (from July 26 to July 28). The diurnal variation for the "Alpha 1 m" series did not manifest itself, although the RA of radon at a depth of 1 m experienced diurnal variations.

Reconstruction of the radon RA series according to the data of a beta detector at a depth of 1 m was carried out according to the same scheme as described above. The resulting equation is shown in Table 6, and the results of recalculating the beta series into the radon OA series are shown in Figure 18 in the middle diagram. A good agreement with the values measured by the radon radiometer was obtained, however, the fact that the reaction of the beta field to a change in the RA of radon was ahead by approximately 2–2.5 hours was confirmed.

As for the radon VA series reconstructed from data on alpha and beta radiation at a depth of 0.5 m, presented in Figure 3.26, we can conclude that the daily variation is similar, but the average values and amplitudes of the calculated volumetric activity do not match. The fourth calibration experiment also revealed a shift in time between the onset of the maximum at depths of 1 and 0.5 m. However, this time the opposite situation is observed, when the maximum appears 0.5 m earlier than 1 m.

Table 6 - Conversion coefficients to activity units, Bq / imp .

Alfa detector at h=1 m	Alfa detector at h=0,5 m	Beta detector at h=1 m	Beta detector at h=0,5 m
Kα1m	Kα0,5m	Kβ1m	Kβ0,5m
7961/ 9098	-	2275 VA Rn(i)=(Nβ(i)-3,8)· 10200	-

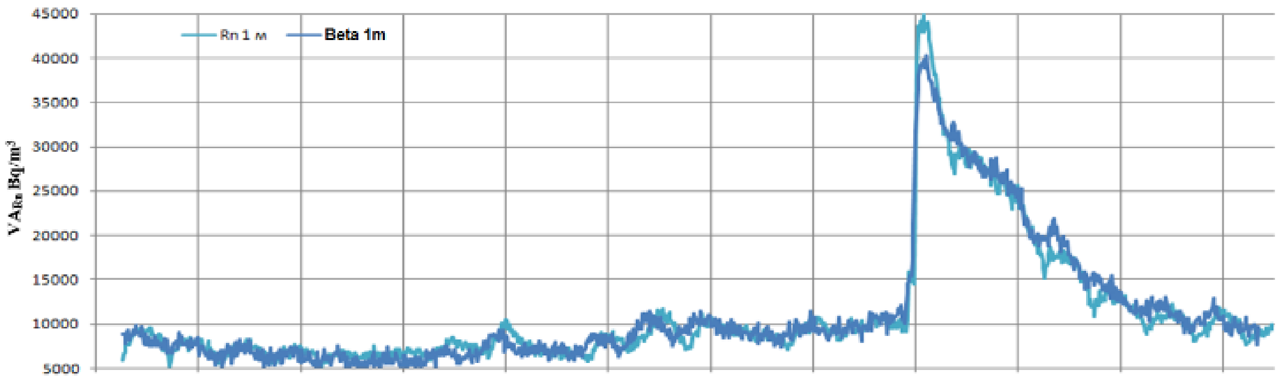

Figure 17 - Dynamics of radon RA measured and reconstructed from β- and α-radiation at a depth of 1 m

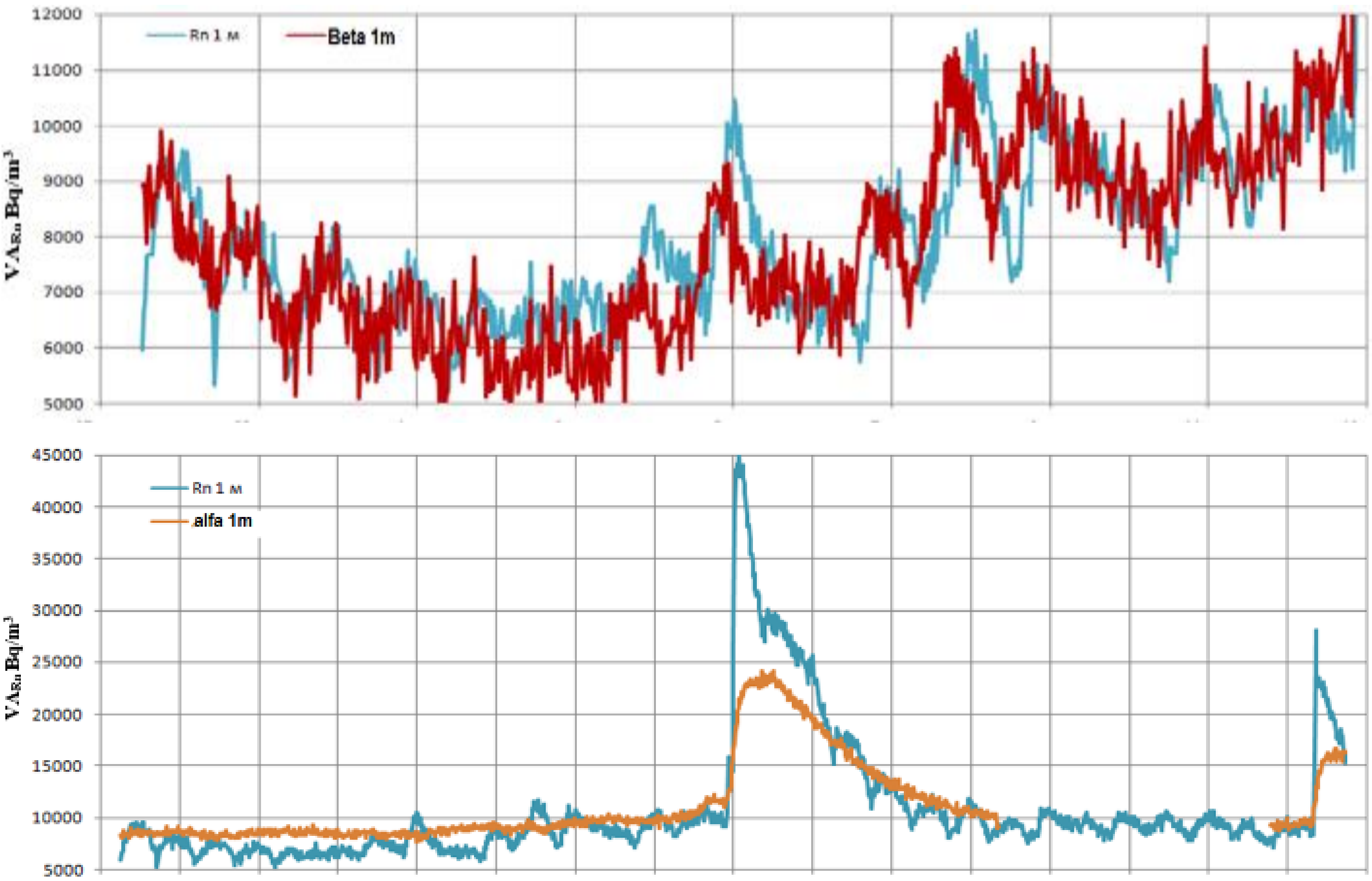

Figure 18 - Dynamics of radon RA measured and reconstructed from β- and α-radiation at a depth of 1 m

Analysis of the results of the performed calibration experiments showed the following.

When calculating correction factors for converting the measured value into units of radon volumetric activity in soil air, one should take into account the fact that forced pumping of air from a well reduces the flow of β- and α-radiations. At the same time, the range of diurnal variations is significantly reduced.

The α-radiation field at a depth of 1 m does not reflect the dynamics of the radon field and, therefore, is not suitable for use in monitoring subsurface radon. However, with anomalous radon releases, the α-radiation field at a depth of 1 m reacts in a noticeable way, which makes this parameter acceptable for use in the prediction of hazardous phenomena, with some limitations.

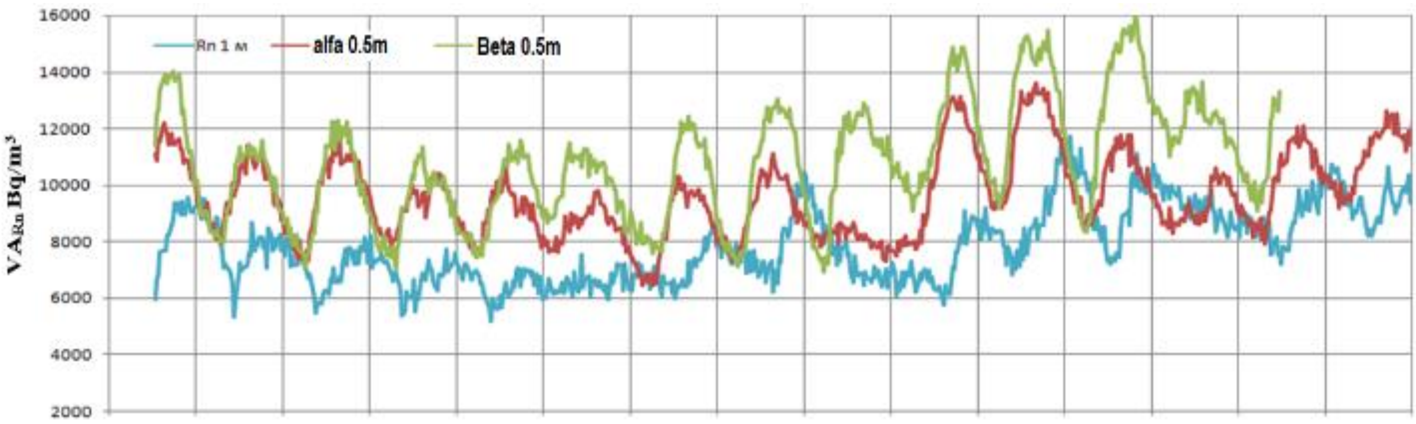

Figure 19 - Dynamics of RA at a depth of 1 m and fields of β- and α-radiation at a depth of 0.5 m

3.4 Conclusion on the chapter

The field of β-radiation at depths of 0.5 and 1 m quite well reflects the dynamics of the radon subsoil field, the daily variation is well traced. However, the daily course of the β-field in some periods has a shift compared to the daily course of the radon field, i.e. the time of the onset of the maximum in the dynamics of the β-field is ahead/late by several hours.

The dynamics of RA of radon in soil air at the same depth, but at a distance of 1.5–2 m, can differ significantly. The maxima in the daily course of RA of radon at different depths occur at different times, at a depth of 0.5 m - approximately at 16-18 hours, and at a depth of 1 m - at 24 hours. The delay in some periods reaches 8 hours.

Correlation analysis between the radon field and meteorological values revealed only a significant relationship with the amount of rainfall.

A 2-month experiment on the calibration of β- and α-radiation detectors installed in wells did not make it possible to unambiguously determine the correction factors for converting to units of volumetric activity. As a result, it was decided to conduct a second experiment with some adjustment of the experimental design, as well as refinement of the VA detector installation scheme. The requirements for the conditions for calibrating the readings of the VA detector in units of RA of radon are as follows:

- Wells with VA detectors installed inside should not be opened during calibration, i.e. tubes for pumping air from the well, which are cyclically connected to the radon radiometer, should be installed at least a day before the start of the experiment.

- The VA detectors should not be removed from the well or moved in the well during calibration, as this leads to a distortion of the time series of data.

- To calculate the coefficient of decrease in the range of diurnal variations after the start of pumping air from the well, it is necessary to record data from the VA detector at least a week before the start of the experiment, and after its completion.

The development of the project infrastructure made it possible to analyze the results of the calibration of soil detectors by 0.5 and 1 мusing a radon radiometer, which showed the following:

at depth, 0,5 мthe temporal changes in the α- and β-fields are practically synchronous, but have different amplitudes ;

in the daily course of radon VA at different depths, the maxima at depth 0,5 мare recorded at ~16–18 h, and at depth 1 мat 24 h; the delay in time of the moments of the onset of maxima in radon VA is ~ 8 h.

ЗАДАНИЕ ДЛЯ РАЗДЕЛА
«ФИНАНСОВЫЙ МЕНЕДЖМЕНТ, РЕСУРСОЭФФЕКТИВНОСТЬ И РЕСУРСОСБЕРЕЖЕНИЕ»

Студенту:

Группа	ФИО
0АМ13	Кажитаеву Санжару Мураловичу

Школа	ИЯШТ	**Отделение школы (НОЦ)**	ОЯТЦ
Уровень образования	Магистратура	**Направление/специальность**	Ядерные физика и технологии

Исходные данные к разделу «Финансовый менеджмент, ресурсоэффективность и ресурсосбережение»:	
1. Стоимость ресурсов научного исследования (НИ): материально-технических, энергетических, финансовых, информационных и человеческих	*Бюджет проекта – не более 326500.74 руб., в т.ч. затраты по оплате труда – не более 158376.94 руб.*
2. Нормы и нормативы расходования ресурсов	*Значение показателя интегральной ресурсоэффективности – не менее 4.2 баллов из 5*
3. Используемая система налогообложения, ставки налогов, отчислений, дисконтирования и кредитования	*Contributions to extrabudgetary funds - 30%*
Перечень вопросов, подлежащих исследованию, проектированию и разработке:	
1. Оценка коммерческого и инновационного потенциала НТИ	*Calculation of competitiveness* *SWOT analysis*
2. Разработка устава научно-технического проекта	*Work structure, determination of labor intensity, development of a research schedule*
3. Планирование процесса управления НТИ: структура и график проведения, бюджет, риски и организация закупок	*Calculation of the budget for the implementation of research*
4. Определение ресурсной, финансовой, экономической эффективности	*Integral financial indicator.* *An integral indicator of resource efficiency.* *Integral efficiency indicator*

Перечень графического материала *(с точным указанием обязательных чертежей):*

1. *«Портрет» потребителя результатов НТИ*
2. *Оценка конкурентоспособности технических решений*
3. *Матрица SWOT*
4. *График проведения и бюджет НТИ*
5. *Оценка ресурсной, финансовой и экономической эффективности НТИ*

Дата выдачи задания для раздела по линейному графику	13.03.23

Задание выдал консультант:

Должность	ФИО	Ученая степень, звание	Подпись	Дата
доцент ОСГН ШБИП ТПУ	Спицына Любовь Юрьевна	к.э.н.		

Задание принял к исполнению студент:

Группа	ФИО	Подпись	Дата
0АМ13	Кажитаев Санжар Муралович		

TASK FOR SECTION
"FINANCIAL MANAGEMENT, EFFICIENCY OF RESOURCES AND ECONOMY OF RESOURCES"

Student:

Group	Full name
0AM13	Kazhitaev Sanzhar Muralovich

School	**SNSE**	**Research and Education Centr**	**DNFC**
The level of education	Master's degree	**Direction/ specialty**	14.04.02 Nuclear physics and technology

Initial data for the section "Financial Management, Resource Efficiency and Resource Saving":	
1. The cost of scientific research resources (SR): material and technical, energy, financial, informational and human	The project budget is no more than 326530.74 rubles, incl. labor costs - no more than 158376.94 rubles.
2. Rates and rates of resource consumption	Electricity tariff 2.45 rubles. for 1 kW * h
3. The used system of taxation, rates of taxes, deductions discounting and crediting	Contributions to extrabudgetary funds - 30%
List of questions to be researched, designed and developed:	
1. Assessment of the potential, prospects and alternatives to the NI position of resource efficiency and resource conservation	Calculation of competitiveness SWOT analysis
2. Formation of a plan and schedule for development and introducing NI	Work structure, determination of labor intensity, development of a research schedule
3. Drawing up the budget of the NI	Calculation of the budget for the implementation of research
4. Assessment of the resource, financial, budget efficiency of scientific research	Integral financial indicator. An integral indicator of resource efficiency. Integral efficiency indicator
List of graphic material (with exact indication of the required drawings)	
1. "Portrait" of the consumer *2. Assessment of the competitiveness of scientific research* *3. SWOT Matrix* *4. Gantt chart* *5. NI budget* *6. The main indicators of the effectiveness of research*	

Date of issue of the task for the section on a line chart	13.03.2023

The assignment was given by the consultant:

Position	ФИО	Academic degree, title	Signature	Data
Assistant professor	Spitsyna Lyubov Yurievna	Ph.D.		

The student accepted the assignment:

Group	Full name	Signature	Data
0AM13	Kazhitaev Sanzhar Muralovich		

4 Chapter 4 Financial management, resource efficiency and resource saving

One of the most essential features in any research work is financial management. For every project or research to be started and completed successfully, one has to have a fair knowledge about financial management. Financial management can basically be defined as the process of organizing, directing, controlling, monitoring and strategic planning of financial resources of an institute or an organization, in order to achieve a set of goals and objectives. Application of management principles to financial resources of the institute or organisation plays a very vital part in financial management. Finance or money plays an essential role when it comes to the management of a business because it is needed in order to meet the requirements of the economic world and in addition, every business requires money in order to survive. No matter how small or big a business is, money needs to be put into it so as to keep it running, achieve a set of goals and gain more profit. The main aim of every businessman is to gain lots of profit, no one wants to do a business that would fail or would not generate profits hence to achieve this, one has to manage his or her finance properly.

The purpose of this section "Financial Management, Resource Efficiency and Resource Saving" discusses the issues of competitiveness, resource efficiency and resource saving, as well as financial costs regarding the object of study of Master's thesis. Competitiveness analysis is carried out for this purpose. SWOT analysis helps to identify strengths, weaknesses, opportunities and threats associated with the project, and give an idea of working with them in each particular case. For the development of the project requires funds that go to the salaries of project participants and the necessary equipment, a complete list is given in the relevant section. The calculation of the resource efficiency indicator helps to make a final assessment of the technical decision on individual criteria and in general.

In addition, it would help determine the accomplishment of the research work so as to develop a mechanism for managing and supporting specific project solutions at the implementation stage of the project lifecycle to increase productivity. The financial management solves the following objectives:

– Planning and preparation of research work.
– Budget calculation for research work.
– Development of evaluation of commercial potential.

4.1 Consumer portrait

To date, various companies, including private accredited ones, provide radiation monitoring services. They monitor soil radon and the density of radon flux from the earth's surface, mainly for the purpose of predicting earthquakes, or, occasionally, in radioecological and geoecological surveys before construction begins.

At the moment, radiation monitoring includes synchronous continuous automated high sampling rate (1–10 min.) measurements of the characteristics of ionizing radiation fields. the density of radon and thoron fluxes from the ground surface, as well as the volumetric activity of radon, thoron and their daughter decay products at depths up to 5 m and heights up to 35 m. This method requires expensive equipment, such as the Alfaradplus measuring complex, MKS-08P dosimeters-radiometers and other measuring instruments.

4.2 Competitiveness analysis of technical solutions

In order to find sources of financing for the project, it is necessary, first, to determine the commercial value of the work. Analysis of competitive technical solutions in terms of resource efficiency and resource saving allows to evaluate the comparative effectiveness of scientific development. This analysis is advisable to carry out using an evaluation card.

The monitoring ad measuring of radiation level in the environment has become a very important factor in our world today and this can be achieved by using an appropriate device or equipment known as the radiation detector. Scintillation detectors are mostly used for measuring radiation outdoor and are mostly affected by environmental conditions such as temperature. Since radiation detectors are been developed most often, it is important to find the most effective and accurate method for estimating the correct algorithm for calculating dose rate under different environmental condition, especially at different temperature range, taking into consideration low cost. This algorithm must be able to calculate radiation dose rate at both low and high levels. In this work, a method with a very low cost was chosen to investigate the effect of current temperature on the readings of flux density of radon to the surface atmosphere and to obtain a temperature correction factor that can be used to calculate the results of flux density These methods include:

The use of climatic chamber to depict the environmental conditions for different temperature range.

The use of an inorganic scintillation detector and laptop to measure dose rate and count rate at low background gamma radiation.

The use of excel software to analysis the results.

The scintillation detector (BDKG-03) was used because that is the radiation detector used in TPU for gamma radiation monitoring. An experiment conducted showed that the scintillation detector (BDPA-01) is the best Dosimetric method sensitive to background radiation because it had a smaller standard deviation compared to the gas discharge counter.

There are different sources of low background radiation that can be used as a source to calibrate radiation detectors that are used for monitoring in the environment. For this research, two sources can be considered:

Gamma background radiation – P_f.

Low radioactive source – P_i.

First of all, it is necessary to analyze possible technical solutions and choose the best one based on the considered technical and economic criteria.

Evaluation map analysis presented in Table 1. The position of your research and competitors is evaluated for each indicator by you on a five-point scale, where 1 is the weakest position and 5 is the strongest. The weights of indicators determined by you in the amount should be 1. Analysis of competitive technical solutions is determined by the formula:

$$C = \sum W_i \cdot P_i, \qquad (4.1)$$

C - the competitiveness of research or a competitor;

Wi– criterion weight;

Pi – point of i-th criteria.

You can use the following criteria for the model of expert evaluation:

– noise immunity;

– set of terminals relay protection;
– reliability of relay protection;
– smart interface quality;
– energy efficiency;
– ease of operation;
– ability to connect to PC;
– estimated lifetime;
– safety;
– etc.

Table 4.1 Evaluation card for comparison of competitive technical solutions

Evaluation criteria ***Example***	**Criterion weight**	**Points**		**Competitiveness** Taking into account weight coefficients	
		P_{f1}	P_i	C_f	C_i
1	2	3	4	7	8
Technical criteria for evaluating resource efficiency					
1. Energy efficiency	0.1	4	3	0.4	0.3
2. Reliability	0.2	5	4	1	0.8
3. Safety	0.2	5	4	1	0.8
4. Functional capacity	0.1	5	5	0.5	0.5
Economic criteria for performance evaluation					
1. Development cost	0.1	5	4	0.5	0.4
2. Market penetration rate	0.1	3	4	0.3	0.4
3. Expected lifecycle	0.2	5	4	1	0.8
Total	**1**	**32**	**28**	**4.7**	**4.0**

The results of the competitiveness analysis shows that gamma background radiation have the highest value of competitiveness. This shows that they are the best option to choose when investigating the effect of ambient temperature on the readings of low gamma background radiation in order to obtain a temperature correction factor that can be used to calculate the results of low gamma background radiation.

4.3 SWOT analysis

Complex analysis solution with the greatest competitiveness is carried out with the method of the SWOT analysis: Strengths, Weaknesses, Opportunities and Threats. The analysis has several stages. The first stage consists of describing the strengths and weaknesses of the project, identifying opportunities and threats to the project that have emerged or may appear in its external environment. The second stage consists of identifying the compatibility of the strengths and weaknesses of the project with the external environmental conditions. This compatibility or incompatibility should help to identify what strategic changes are needed.

Table 4.2 SWOT analysis

	Strengths: S1. Low cost. S2. Simplicity of method. S3. Reliability of results obtained. S4.Small relative error for both the dose rate and the count rate. S4. Very safe. S5. Very important factor for all radiation detectors.	**Weaknesses:** W1. Taking measurement and analyzing takes lots of time. W2. Difficulty in getting data the actual temperature in different places. W3. Need to know how to operate the detector and climatic chamber technically.

		W4. Software sometimes take long to open.
Opportunities: O1.Data can be used to calculate dose rate for low background radiation in BDPA-01 scintillation detector. O2. Research institute could use the method to find the influence of ambient temperature on gamma background radiation of any radiation detector used outdoor. O3. Researchers can use the method can be used to estimate the algorithm for calculating dose rate under the influence of different temperature range.	***Strategy which based on strengths and opportunities:*** 1. Obtained a method, which can be used to calibrate dose rate in radiation detectors.	***Strategy which based on weaknesses and opportunities:*** Using open sources with data of temperature for measurement.
Threats: T1. Lack of financial support in purchasing of equipment. T2. Lack of demand since it is needed only after development of a radiation detector. T3. Need of a climatic chamber to depict the environmental weather conditions.	***Strategy which based on strengths and threats:*** Finding another equipment that can replace the climatic chamber to depict the environmental condition accurately.	***Strategy which based on weaknesses and threats:*** Not being able to complete project due to lack of financial support and lack weather data.

Analyzing the SWOT-analysis table, we can say that the proposed set of activities has enough strengths and opportunities.

The main weakness is the dependence on third-party sources of information about the climatic conditions of the area.

At the same time, it is worth talking about the need for constant modernization of technologies and equipment. In addition, compliance with environmental legislation is an important task.

4.4 Project Initiation

The initiation process group consists of processes that are performed to define a new project or a new phase of an existing one. In the initiation processes, the initial purpose and content are determined and the initial financial resources are fixed. The internal and external stakeholders of the project who will interact and influence the overall result of the research project are determined.

4.4.1 Project Stakeholders

Table 4.3 Stakeholders of the project

Project stakeholders	**Stakeholder expectations**
Tomsk Polytechnic University (TPU)	Supervision and approval of research work came from TPU. The acquired results can be used to calculate the dose rate of low gamma background radiation in the environment when using scintillation detector (BDPA-01).
Radiation Safety Service	Development of a method for modeling of radon flux density based on current atmospheric temperature

4.4.2 Objectives and Outcomes of Project

Table 4.4 Purpose and results of the project

Purpose of project:	To investigate the effect climate changes such as temperature, pressure, air humidity on the readings of flux density of radon in surface atmosphere
Expected results of the project:	– Creation of a model of radon flux density in the surface atmosphere.

	– Identification of seasonal patterns in the dynamics of radon SPR into the surface atmosphere based on experimental data
Criteria for acceptance of the project result:	Validation of results by using the obtained model of flux density of radon with the experimental data.
Requirements for the project result:	Agreement between the results of project and the results of other authors on similar works.
	Industrial application. The results would help conducting radiation monitoring in different industries.
	Technical specification: To be able to calculate the correct flux density of radon an area with created model based on climatic data.

4.4.3 Project Participants

The organizational structure of the project involves all participants or people who participated in the research work, the number of hours they spent and the roles they played in the research. In this research work, there were two participants.

Scientific supervisor

Executor

Table 4.5 Structure of the project

№	Participant	Role in the project	Functions	Labor time, hours (working days (from table 7) × 6 hours)
1	Scientific Supervisor – A professor and a lecture of the Nuclear Science and Technology	Head of project	Formulating of research topic and giving directions of how to achieve the main aim. Ensuring that all task	48×6 = 288

	department at TPU.		pertaining to the main objectives are done on time. Verification of results obtained.	
2	Executor – A student of the Nuclear Science and Technology department at TPU.	Executor	Performing of task and researching of literature review. Collecting of data and analysing of results.	82×6 = 492

4.4.4 Project limitations and Assumptions

Project limitations are all factors that can be as a restriction on the degree of freedom of the project team members.

Table 4.6 Project limitations

Factors	**Limitations / Assumptions**
3.1. Project's budget, rubles	326500.74
3.1.1. Source of financing	TPU
3.2. Project timeline:	25/01/2023 to 25/05/2023
3.2.1. Date of approval of plan of project	25/01/2023
3.2.2. Completion date	25/05/2023

4.4.5 Project Schedule

As part of planning a science project, you need to build a project timeline and a Gantt Chart.

Table 4.7. Project Schedule

Job title	**Duration, working days**	**Start date**	**Date of completion**	**Participants**
Development of the technical task	6	1/02/2023	7/02/2023	Scientific Supervisor

Drafting and approval of terms of reference	11	7/02/2023	21/02/2023	Scientific Supervisor
Choosing of a research direction	2	21/02/2023	24/02/2023	Scientific Supervisor, Executor
Collection and study of literature	24	24/02/2023	24/03/2023	Executor
Choosing of experimental method	2	24/03/2023	25/03/2023	Scientific Supervisor, Executor
Choosing of a place to conduct research	2	25/03/2023	26/03/2023	Scientific supervisor
Conducting of experiment to collect data of count rate and dose rate of gamma radiation using the BDKG-03 and climatic chamber	3	26/08/2023	29/03/2023	Executor
Analysis of results obtained	16	29/03/2023	16/04/2023	Executor, Scientific supervisor
Summary of results	4	16/04/2023	20/04/2023	Scientific Supervisor, Executor
Checking and assessment of results	4	20/04/2023	23/04/2023	Scientific supervisor, Executor
Compilation of results for report	7	23/04/2023	2/04/2023	Executor
Preparation of report	4	2/05/2023	6/05/2023	Executor
Defence preparation	16	6/05/2023	25/05/2023	Executor

A Gantt chart, or harmonogram, is a type of bar chart that illustrates a project schedule. This chart lists the tasks to be performed on the vertical axis, and time intervals on the horizontal axis. The width of the horizontal bars in the graph shows the duration of each activity.

Table 4.8 A Gantt chart

№	Activities	Participants	T_c, days	Duration of the project											
				February			March			April			May		
				1	2	3	1	2	3	1	2	3	1	2	3
1	Development of the technical task	Scientific Supervisor	6												
2	Drafting and approval of terms of reference	Scientific Supervisor	11												
3	Choosing of a research direction	Scientific Supervisor, Executor	2												
4	Collection and study of literature	Executor	24												
5	Choosing of experimental method	Scientific Supervisor, Executor	2												
6	Choosing of a place to conduct research	Scientific supervisor	2												
7	Conducting of experiment to collect data of count rate and dose rate of gamma radiation using the BDKG-03 and climatic chamber	Executor	3												

8	Analysis of results obtained	Executor, Scientific supervisor	16												
9	Summary of results	Scientific Supervisor, Executor	4												
10	Checking and assessment of results	Scientific supervisor, Executor	4												
11	Compilation of results for report	Executor	7												
12	Preparation of report	Executor	4												
13	Defence preparation	Executor	16												

Scientific Supervisor Executor

4.5 Scientific and technical research budget

The amount of costs associated with the implementation of this work is the basis for the formation of the project budget. This budget will be presented as the lower limit of project costs when forming a contract with the customer.

To form the final cost value, all calculated costs for individual items related to the manager and the student are summed.

In the process of budgeting, the following grouping of costs by items is used:

Material costs of scientific and technical research;

costs of special equipment for scientific work (Depreciation of equipment used for design);

basic salary;

additional salary;

labor tax;

overhead.

4.5.1 Calculation of material costs

The calculation of material costs is carried out according to the formula:

$$C_m = (1 + k_T) \cdot \sum_{i=1}^{m} P_i \cdot N_{consi} \qquad (4.2)$$

where

m – the number of types of material resources consumed in the performance of scientific research;

N_{consi} – the amount of material resources of the i-th species planned to be used when performing scientific research (units, kg, m, m^2, etc.);

P_i – the acquisition price of a unit of the i-th type of material resources consumed (rub./units, rub./kg, rub./m, rub./m^2, etc.);

k_T – coefficient taking into account transportation costs.

Prices for material resources can be set according to data posted on relevant websites on the Internet by manufacturers (or supplier organizations).

Table 4.9 Material costs

Name	**Unit**	**Amount**	**Price per unit, rub.**	**Material costs, rub.**
Office supplies	-	1	1000	1000.00
Transportation	Unit	8	100	800.00
Printing	Unit	200	4	800.00
Total				2600.00

4.5.2 Calculation of the depreciation.

Depreciation is not charged if an equipment cost is less than 40 thousand rubles, its cost is taken into account in full.

If you use available equipment, then you need to calculate depreciation:

$$A = \frac{C_{перв} * H_a}{100} \quad (4.3)$$

A - annual amount of depreciation;

$C_{перв}$ - initial cost of the equipment;

$H_a = \frac{100}{T_{сл}}$ - rate of depreciation;

$T_{сл}$ - life expectancy.

For this research, a gamma radiation detector (BDPA-01), a climatic chamber and a laptop, which cost 200000 rubles, 400000 and 30000 respectively, were used. The gamma detector and the laptop both had a life expectancy of 5 years whiles that of the climatic chamber was 10 years. The depreciation for the gamma detector, climatic chamber and laptop can be calculated as follows:

Radiometer:

$$D = \frac{Cost}{Time} \quad (4.4)$$

$$D = \frac{100000}{5 \times 365} = 54.8 \frac{rubles}{day} \quad (4.5)$$

Since the equipment was used for 3 days

$$A = 109.6 \times 3 = 164.38 \text{ rubles} \quad (4.6)$$

Storage chamber:

$$D = \frac{Cost}{Time} \quad (4.7)$$

$$D = \frac{400000}{10 \times 365} = 109.589 \frac{rubles}{day} \quad (4.8)$$

Since the equipment was used for 3 days

$$A = 109.589 \times 3 = 328.767 \text{ rubles} \quad (4.9)$$

Table 4.10 Depreciation of special equipment (+software)

№	equipment identification	Quantity of equipment	Total cost of equipment, rub.	Life expectancy, year	Depreciation for the duration of the project, rub.
1.	Radiometer Alpharad	1	118000	10	164.38
2.	Climatic chamber	1	400000	10	328.77
3	Laptop	1	30000	-	30000
Total					30493.15

4.5.3 Basic salary

This point includes the basic salary of participants directly involved in the implementation of work on this research. The value of salary costs is determined based on the labor intensity of the work performed and the current salary system

The basic salary (S_b) is calculated according to the formula:

$$S_{\text{b}} = S_a \cdot T_{\text{w}} , \tag{4.10}$$

where S_b – basic salary per participant;

T_w – the duration of the work performed by the scientific and technical worker, working days;

S_d - the average daily salary of an participant, rub.

The average daily salary is calculated by the formula:

$$S_d = \frac{S_m \cdot M}{F_{\text{v}}} , \tag{4.11}$$

where,

S_m – monthly salary of a participant, rubles;

M – the number of months of work without leave during the year: at holiday in 48 days, M = 11.2 months, 6 day per week;

F_v – valid annual fund of working time of scientific and technical personnel (251 days).

Table 4.11 The valid annual fund of working time

Working time indicators	
Calendar number of days	365
The number of non-working days - weekend - holidays	 52 14
Loss of working time - vacation - isolation period - sick absence	 48
The valid annual fund of working time	251

Monthly salary is calculated by formula:

$$S_{month} = S_{base} \cdot (k_{premium} + k_{bonus}) \cdot k_{reg} \,, \qquad (4.12)$$

where, S_{base} – base salary, rubles;

$k_{premium}$ – premium rate;

k_{bonus} – bonus rate;

k_{reg} – regional rate.

Table 4.12 Calculation of the base salaries

Performers	**S_{base}, rubles**	**$k_{premium}$**	**k_{bonus}**	**k_{reg}**	**S_{month}, rub.**	**W_d, rub.**	**T_p, work days (from table 7)**	**W_{base}, rub.**
Scientific Supervisor	40000	-	-	1,3	52000	1784.86	48	85673.28
Executor	19870				25831	886.63	82	72703.66
Total								158376.94

4.5.4 Additional salary

This point includes the amount of payments stipulated by the legislation on labor, for example, payment of regular and additional holidays; payment of time associated with state and public duties; payment for work experience, etc.

Additional salaries are calculated on the basis of 10-15% of the base salary of workers:

$$W_{add} = k_{extra} \cdot W_{base}, \qquad (4.13)$$

where,

W_{add} – additional salary, rubles;

k_{extra} – additional salary coefficient (10%);

W_{base} – base salary, rubles.

Table 13. Additional Salary

Participant	**Additional Salary, rubles**
Scientific Supervisor	8567.32
Executor	7270.37
Total	15837.69

4.5.5 Labor tax

Tax to extra-budgetary funds are compulsory according to the norms established by the legislation of the Russian Federation to the state social insurance (SIF), pension fund (PF) and medical insurance (FCMIF) from the costs of workers.

Payment to extra-budgetary funds is determined of the formula:

$$P_{social} = k_b \cdot (W_{base} + W_{add}) \qquad (4.14)$$

where,

k_b – coefficient of deductions for labor tax.

In accordance with the Federal law of July 24, 2009 No. 212-FL, the amount of insurance contributions is set at 30%. Institutions conducting educational and scientific activities have rate - 30%.

Table 4.14 Labor tax

	Project leader	**Executor**
Coefficient of deductions	30 %	
Salary (basic and additional), rubles	94240.60	79974.03
Labor tax, rubles	25444.96	21672.96
Total		47117.92

4.5.6 Overhead costs

Overhead costs include other management and maintenance costs that can be allocated directly to the project. In addition, this includes expenses for the maintenance, operation and repair of equipment, production tools and equipment, buildings, structures, etc.

Overhead costs account from 30% to 90% of the amount of base and additional salary of employees.

Overhead is calculated according to the formula:

$$C_{ov} = k_{ov} \cdot (W_{base} + W_{add}) \quad (4.15)$$

where,

k_{ov} – overhead rate.

Table 4.15 Overhead

	Project leader	**Executor**
Overhead rate	40%	
Salary, rubles	94240.60	79974.03
Overhead, rubles	37696.24	31989.61
Total, rubles		69685.85

4.5.7 Other direct costs

Energy costs for equipment are calculated by the formula:

$$C = P_{el} \cdot P \cdot F_{eq}, \quad (4.16)$$

where,

P_{el} – power rates (5.8 rubles per 1 kWh);

P – power of equipment, kW;

F_{eq} – equipment usage time, hours.

Table 4.16 Other direct costs

	Power rates, kWh	**Power of equipment, kW**	**Equipment usage time, hr**	**Energy cost, rubles**
Climatic chamber	5.8	0.5	24	69.60
Laptop	5.8	0.5	492	1426.80
Gamma radiation detector (BDKG-03)	5.8	0.5	24	69.60
Total				1566.00

4.5.8 Formation of budget costs

The calculated cost of research is the basis for budgeting project costs.

Determining the budget for the scientific research is given in the table 4.17

Table 4.17 Items expenses grouping

Name	**Cost, rubles**
1. Material costs	2600.00
2. Equipment costs	30493.15
3. Basic salary	158376.94
4. Additional salary	15837.69
5. Labor tax	47117.92
6. Overhead	69685.85
7. Other direct costs	1566.00
Total planned costs	**325677.55**

4.6 Evaluation of the comparative effectiveness of the project

Determination of efficiency is based on the calculation of the integral indicator of the effectiveness of scientific research. Its finding is associated with the definition of two weighted average values: financial efficiency and resource efficiency.

The integral indicator of the financial efficiency of a scientific study is obtained in the course of estimating the budget for the costs of three (or more) variants of the execution of a scientific study. For this, the largest integral indicator of the implementation of the technical problem is taken as the calculation base (as the denominator), with which the financial values for all the options are correlated.

The integral financial measure of development is defined as:

$$I_f^d = \frac{C_i}{C_{max}} \quad (4.17)$$

where,

I_f^d – integral financial measure of development;

C_i – the cost of the i-th version;

C_{max} – the maximum cost of execution of a research project (including analogues).

As an analogue, the method of temperature stabilization of a radiation detector is done by placing the detector in the climatic chamber and measuring the dose rate and count rate of a gamma ray source.

The integral financial measure of development can be calculated as:

$$I^d{}_f = \frac{C_i}{C_{max}} \quad (4.18)$$

where,

C_i – the cost of the research work using gamma background radiation = 325707.14

And C_{max} – the maximum cost of execution of research project using a gamma radioactive source = 400,000.00

$$I^d{}_f = \frac{325677.55}{400000.00} \quad (4.19)$$

$$I^d{}_f = 0.814 \quad (4.20)$$

and

$$I^a{}_f = \frac{C_i}{C_{max}} \tag{4.21}$$

$$I^a{}_f = \frac{400000.00}{400000.00} \tag{4.22}$$

$$I^a{}_f = 1 \tag{4.23}$$

The obtained value of the integral financial measure of development reflects the corresponding numerical increase in the budget of development costs in times (the value is greater than one), or the corresponding numerical reduction in the cost of development in times (the value is less than one, but greater than zero).

Since the development has one performance, then I_f^a = 1.

The integral indicator of the resource efficiency of the variants of the research object can be determined as follows:

$$I_m^a = \sum_{i=1}^{n} a_i b_i^a \qquad I_m^p = \sum_{i=1}^{n} a_i b_i^p \tag{4.24}$$

where,

I_m – integral indicator of resource efficiency for the i-th version of the development;

a_i – the weighting factor of the i-th version of the development;

b_i^a, b_i^p – score rating of the i-th version of the development, is established by an expert on the selected rating scale;

n – number of comparison parameters.

The calculation of the integral indicator of resource efficiency is presented in the form of table 4.18.

Table 4.18 – Evaluation of the performance of the project

Criteria	Weight criterion	Points	
		I_m^a	I_m^p
1. Energy efficiency	0.2	5	3
2. Reliability	0.1	4	4
3. Safety	0.2	5	5
4. Functional capacity	0.1	4	4
Economic criteria for performance evaluation			
1. The cost of development	0.1	4	4
2. Market penetration rate	0.1	5	5
3. Expected life	0.1	4	4
4. After-sales service	0.1	4	5
Total	**1**	**4.5**	**4.2**

$$I^a{}_m = \sum_{i=1}^{n} a_i b_i^a \tag{4.25}$$

$$I^a{}_m = (0.2 \times 5) + (0.1 \times 4) + (0.2 \times 5) + (0.1 \times 4) + (0.1 \times 4) + (0.1 \times 5) + (0.1 \times 4) + (0.1 \times 4) \tag{4.26}$$

$$I^a{}_m = 4.5 \tag{4.27}$$

$$I^p{}_m = \sum_{i=1}^{n} a_i b_i^a \tag{4.28}$$

$$I^p{}_m = (0.2 \times 3) + (0.1 \times 4) + (0.2 \times 5) + (0.1 \times 4) + (0.1 \times 4) + (0.1 \times 5) + (0.1 \times 4) + (0.1 \times 5) \tag{4.29}$$

$$I^p{}_m = 4.2 \tag{4.30}$$

The integral indicator of the development efficiency (I_e^P) is determined on the basis of the integral indicator of resource efficiency and the integral financial indicator using the formula:

$$I_e^P = \frac{I_m^P}{I_f^d} \quad (4.31)$$

$$I_e^a = \frac{I_m^a}{I_f^a} \quad (4.32)$$

$$I_e^P = \frac{I_m^P}{I_f^d} = \frac{4.5}{0.877} = 5.13 \quad (4.33)$$

$$I_e^a = \frac{I_m^a}{I_f^a} = \frac{4.2}{1} = 4.2 \quad (4.34)$$

Comparison of the integral indicator of the current project efficiency and analogues will determine the comparative efficiency. Comparative effectiveness of the project:

$$E_C = \frac{I_e^P}{I_e^a} \quad (4.35)$$

$$E_c = \frac{5.13}{4.2} = 1.221 \quad (4.36)$$

Thus, the effectiveness of the development is presented in table 4.19.

Table 4.19 Efficiency of development

№	**Indicators**	**Points**	
		P	a
1	Integral financial measure of development	0.814	1
2	Integral indicator of resource efficiency of development	4.5	4.2
3	Integral indicator of the development efficiency	1.221	1

Comparison of the values of integral performance indicators allows us to understand and choose a more effective solution to the technical problem from the standpoint of financial and resource efficiency.

4.7 Conclusion

Thus, in this section was developed stages for design and create competitive development that meet the requirements in the field of resource efficiency and resource saving.

These stages include:

- development of a common economic project idea, formation of a project concept;
- organization of work on a research project;
- identification of possible research alternatives;
- research planning;
- assessing the commercial potential and prospects of scientific research from the standpoint of resource efficiency and resource saving;
- determination of resource (resource saving), financial, budget, social and economic efficiency of the project.

ЗАДАНИЕ К РАЗДЕЛУ

«СОЦИАЛЬНАЯ ОТВЕТСТВЕННОСТЬ»

Обучающемуся:

Группа	ФИО
0АМ13	Кажитаеву Санжару Мураловичу

Школа	ИЯТШ	Отделение (НОЦ)	ОЯТЦ
Уровень образования	Магистратура	**Направление/ООП/ОПОП**	Ядерная и радиационная безопасность

Исходные данные к разделу «Социальная ответственность»:	
1. Описание организационных условий реализации социальной ответственности − заинтересованные стороны (стейкхолдеры) программ социальной ответственности организации, проекта, инновационной разработки, на которых они оказывают воздействие; − стратегические цели организации, проекта, внедрения инновации, которые нуждаются в поддержке социальных программ; − цели текущих программ социальной ответственности организации	*Объект исследования: динамика плотности потока радона в приземной атмосфере. Заинтересованные стороны: службы радиационной безопасности.*
2. Законодательные и нормативные документы	
Перечень вопросов, подлежащих исследованию, проектированию и разработке:	
1. Правовые и организационные вопросы обеспечения безопасности: − специальные (характерные при эксплуатации объекта исследования, проектируемой рабочей зоны) правовые нормы трудового законодательства; − организационные мероприятия при компоновке рабочей зоны.	*− Трудовой кодекс Российской Федерации от 30.12.2001 N 197-ФЗ (ред. от 24.04.2020); − ГОСТ 22269-76. Система «человекмашина». Рабочее место оператора. Взаимное расположение элементов рабочего места. Общие эргономические требования.*
2. Производственная безопасность: 2.1. Анализ выявленных вредных и опасных факторов 2.2. Обоснование мероприятий по снижению воздействия	*Вредные и опасные факторы: − отклонение показателей микроклимата; − повышенный уровень электромагнитных излучений; − недостаточная освещенность рабочей зоны; − повышенный уровень шума; − опасность поражения электрическим током.*

Дата выдачи задания к разделу в соответствии с календарным учебным графиком	13.03.2023

Задание выдал консультант по разделу «Социальная ответственность»:

Должность	ФИО	Ученая степень, звание	Подпись	Дата
Доцент	Передерин Ю.В.	к.т.н		

Задание принял к исполнению обучающийся:

Группа	ФИО	Подпись		Дата
0АМ13	Кажитаев Санжар Муралович			

TASK FOR SECTION "SOCIAL RESPONSIBILITY"

To the student:

Group	Full name
0AM13	Kazhitaev Sanzhar Muralovich

School	SNSE	Research and Education Centr	DNFC
The level of education	Masters	Direction/ specialty	14.04.02 Radiological Safety

Subject FQW:

Investigation of seasonal trends in density dynamics radon flow from the earth's surface

Initial data for the section "Social responsibility":	
1. Characteristics of the research object (substance, material, device, algorithm, technique, working area) and its scope	*Object of research: dynamics of radon flux density in the surface atmosphere. Stakeholders: Radiation safety services.*
List of questions to be researched, designed and developed:	
1. Legal and organizational security issues: - special (typical for the operation of the research object, the projected working area) legal norms of labor legislation; -organizational measures for the layout of the working area.	*− Labor Code of the Russian Federation of 30.12.2001 N 197-FZ (as amended on 24.04.2020);* *− GOST 22269-76. The "human machine" system. Operator's workplace. Mutual arrangement of workplace elements. General ergonomic requirements*
2. Industrial safety: **2.1. Analysis of the identified harmful and dangerous factors** **2.2. Rationale for mitigation measures**	Harmful and dangerous factors: - deviation of microclimate indicators; - increased noise level; - insufficient illumination of the working area; - increased level of electromagnetic radiation; - danger of electric shock.

Date of issue of the task for the section on a line chart	13.03.2023

The assignment was given by the consultant:

Position	Full name	Academic degree, title	Signature	date
Associate Professor	Perederind Yuriy Vladimirovich	Ph.D		

The student accepted the assignment:

Group	Full name	Signature	date
0AM13	Kazhitaev Sanzhar Muralovich		

5. Social responsibility

5.1 Introduction

At present, one of the main directions for improving preventive work to reduce occupational injuries and occupational morbidity is the introduction of a labor protection management system.

Occupational safety is a system of legislative, socio-economic, organizational, technological, hygienic and therapeutic and preventive measures and means that ensure safety, health and performance of a person in the process of work.

A hazardous production factor is such a production factor, the impact of which, under certain conditions, leads to injury or other sudden, sharp deterioration in health.

A harmful production factor is such a production factor, the impact of which on a worker, under certain conditions, leads to illness or a decrease in working capacity.

The purpose of this section of the WQR is to develop and analyze industrial safety issues in room 123, 10 of the TPU building.

5.2. Legal and organizational issues of security

5.2.1. Organizational events

Persons who have reached the age of 18, of both sexes, who have passed a preliminary and periodic medical examination, introductory briefing, primary briefing at the workplace, a training course in safe working methods, an internship for at least 2 shifts and a test of knowledge of labor protection requirements, who have passed the briefing, are allowed to work. for 1 group on electrical safety and knowing this manual. The frequency of re-briefing is at least 1 time in 6 months.

Conducting all types of briefing should be recorded in the Instruction Log of the established form, with the obligatory signatures of the person who received and conducted the briefing, indicating the date of the briefing, the name and numbers of the briefing, the name and numbers of the instructions for the types of work for which the briefing is carried out.

5.2.2. Technical measures

The document that establishes the most general requirements for the organization of the workplace when performing work while sitting is GOST 12.2.032-78. According to this document, a workplace for performing work while sitting is organized for light work that does not require free movement of the worker. The design of the workplace and the relative position of all its elements (seat, controls, information display tools, etc.) must comply with anthropometric, physiological and psychological requirements, as well as the nature of the work. So, for example, the performance of labor operations "often" and "very often" should be provided within the zone of easy reach and the optimal zone of the motor field.

When choosing a desk, the following requirements should be taken into account. The height of the working surface of the table is recommended within 680 - 800 mm. The height of the working surface on which the keyboard is installed must be 650 mm. The working table must be at least 700 mm wide and

not less than 1400 mm long. Legroom must be at least 600 mm high, at least 500 mm wide, at least 450 mm deep at the knees and at least 650 mm at the level of the outstretched legs.

The height of the seat of the working chair above the floor level is 420 - 550 mm. There should be a work chair. The design of the work chair should provide: the width and depth of the seat surface is at least 400 mm; seat surface with recessed front edge. The monitor should be located at the level of the operator's eyes at a distance of 500 - 600 mm.

It should be possible to adjust the screen:

- height +3 cm;
- tilted from 10 to 20 degrees relative to the vertical;
- in left and right directions.

The keyboard should be placed on the table surface at a distance of 100-300 mm from the edge. The normal position of the keyboard is its placement at the level of the operator's elbow with an angle of inclination to the horizontal plane of 15 degrees. It is more convenient to work with keys that have a concave surface, a quadrangular shape with rounded corners. The design of the key should provide the operator with a clicky feel. The color of the keys should contrast with the color of the panel.

With monotonous mental work that requires significant nervous tension and great concentration, it is recommended to choose soft, low-contrast floral shades that do not scatter attention (low-saturated shades of cold green or blue colors). When working, requiring intense mental or physical tension, shades of warm tones are recommended that excite human activity.

5.3 Industrial safety

5.3.1 Analysis of harmful and dangerous factors

Calculations are carried out at the workplace at a personal computer. Identified hazardous and harmful factors are shown in Table 5.1.

Table 5.1 – Harmful and dangerous factors

Factors (according to GOST 12.0.003-2015)	Stages of work			Regulations
	Design	Evaluation of the results	Create a report	
1. Deviation of microclimate indicators	+	+	+	1.SanPiN 1.2.3685-21.2. 2. SP 52. 13330.2016 3. PUE 4. GOST 12.1.038-82
2. Absence or deficiencynecessary artificial lighting	+	+	+	
3. Increased voltage in the electrical circuit, the closure of which can occur through the human body	+	+	+	
4. Mental overstrain, monotony of work	+	+	+	
5. Fire safety	+	+	+	
6. Noise and vibration	+	+	+	
7. Static electricity	+	+	+	

5.3.2. Microclimate

In accordance with SanPiN 1.2.3685-21, hygienic requirements are established for the indicators of the microclimate of workplaces in industrial premises, taking into account the intensity of energy consumption of workers, the time of work and periods of the year. The indicators characterizing the microclimate of the room are:

- air temperature;
- surface temperature;
- relative humidity;
- speed of air movement;
- intensity of thermal radiation.

These indicators of the microclimate should ensure the preservation of the thermal balance of a person with the environment and the maintenance of an optimal or acceptable level of the thermal state of the body. Optimal and permissible microclimate parameters are presented in tables 5.2, 5.3.

Table 5.2 – Optimal values of microclimate indicators

Period of the year	Category of work	Air temperature, ℃	Surface temperature, ℃	Relative humidity, %	Air speed
Cold	I	22-24	21-25	60-40	0,1
Warm	I	23-25	22-26	60-40	0,1

Optimal microclimatic conditions provide a general and local sensation of thermal comfort during an 8-hour working day, with a minimum stress of thermoregulation mechanisms, do not cause deviations in health, create the prerequisites for a high level of efficiency and are preferred at workplaces.

Table 5.3 – Permissible values of microclimate indicators

Period of the year	Category of work	Air temperature, ℃		Surface temperature, ℃	Relative humidity, %	Air speed	
		T°< T°опт.	T°> T°опт.			T°< T°опт.	T°< T°опт.
Cold	Ia	20,0-21,09	24,1-25,0	19,0-26,0	15-75	Cold	Ia
Warm	Ia	21,0-22,9	25,1-28,0	20,0-29,0	15-75	Warm	Ia

Acceptable microclimatic conditions do not cause damage or health disorders, but can lead to general and local sensations of thermal discomfort, tension in thermoregulation mechanisms, deterioration of well-being and decreased performance.

To select a suitable exhaust fan for room 123 of housing 10 with an area of 25 m^3, we use the following formula

$$L = S \cdot h \cdot k$$

Where L is the fan capacity, m^3/hour; S is the area of the room, m^2; h - ceiling height, m; k is the rate of air exchange, then we get:

$L = 25 \cdot 3 \cdot 2 = 150$ m^3/hour

Fan "Event 150C" is able to provide the required air extraction performance for a given room. [90].

Table 5.4 Fan specifications of “Event 150C”.

Type of instalation:	wall
Channel type:	circular
Voltage:	220 V
Power (W)	22
Efficiency:	320 m^3/h
Number of speeds:	1
Duct diameter:	150 mm

In room 123 of building 10, all microclimate standards are met in accordance with SanPiN 2.2.4.548-96.

5.3.3 Artificial lighting

Artificial lighting is divided into working, emergency, security and duty.

The standardized characteristics of indoor and outdoor lighting are provided both by general lighting fixtures and by their joint action with emergency lighting fixtures.

Work lighting should be provided for all premises of buildings, as well as for areas of open spaces intended for work, the passage of people and traffic. For rooms with zones with different natural lighting conditions and different operating modes, separate control of the lighting of such zones is necessary.

Standard lighting indicators for office premises are shown in Table 5.4.

Table 5.3 - Standard lighting indicators for the main premises of public, residential and auxiliary buildings.

Premises	The plane of normalization of illumination and KEO, the height of the plane above the floor, m	Category and sub-category of visual work	Artificial lighting				
			Illumination of working surfaces, lx		UGR combined discomfort score, no more	Illumination ripple coefficient,	Light source color rendering index Ra
			With the combined	In general			
Cabinets and work rooms, offices, representative offices	G-0,8	B-1	400/200	300	21	15	80

The total illumination in a room with personal computers should be 300 lux.

As sources of artificial lighting at the workplace, 4 office LED lamps are used, the location of which is shown in Figure 5.1.

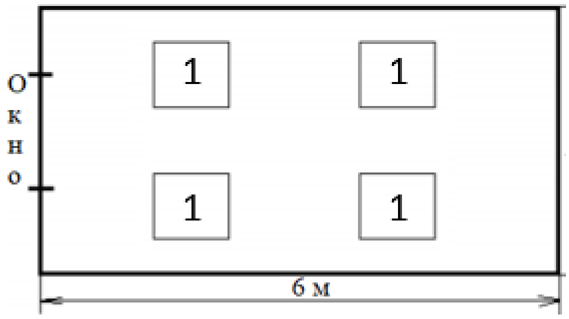

Figure 5.1 - Layout of fixtures at the workplace of a lighting engineer: 1- fixtures.

Let's calculate the artificial illumination of the room using the utilization factor method. The characteristics of the LED luminaire used in office space are as follows:

- power 40 W;
- luminous flux 4240 lm;
- light temperature 4000 K;
- IP 40.

$$i = \frac{A \cdot B}{h \cdot (A + B)}$$

where: A is the length of the room, m; B is the width of the room, m; h is the height of the luminaire suspension above the working surface, m.

$$i = \frac{A \cdot B}{h \cdot (A + B)} = \frac{6 \cdot 4}{2 \cdot (6 + 4)} = 1{,}2$$

The reflection coefficient of the walls is taken ρ = 50%.

According to SP 52.13330.2016, the minimum illumination on the working surface must be at least Emin = 300 lux.

Let's calculate the luminous flux of the lamp. There are 4 lighting devices in the room, N = 2; safety factor of LED luminaires k = 1.1; the numerical ratio of uneven illumination z = 1; the index of the room determines the utilization factor of the luminous flux, η = 0.51. Then the luminous flux is:

$$\Phi = \frac{E \cdot k \cdot S \cdot z}{N \cdot \eta} = \frac{300 \cdot 1{,}1 \cdot 24 \cdot 1}{4 \cdot 0{,}51} = 3882\ lm$$

We compare the calculated value of the luminous flux with the value of the selected light fixture, 4240 lm.

$$-10 \leq \frac{\Phi_{\text{станд.}} - \Phi_{\text{расч.}}}{\Phi_{\text{станд.}}} \cdot 100\% \leq 20$$

$$-10 \leq \frac{4240 - 3882}{4240} \cdot 100\% \leq 20$$

$$-10 \leq 8.44 \leq 20$$

We get that the luminous flux of the selected lighting device is suitable for lighting rooms where computers with an illumination of 300 lux are installed.

Many types of industrial and scientific activities are characterized by an increased load on the visual system and attention processes. In combination with physical inactivity, neuro-emotional stress, long-term preservation of a non-optimal basic working posture leads to the development of visual and general fatigue and a decrease in working capacity.

In the prevention of general and visual fatigue in representatives of a number of professions, an important role belongs to the provision of visual comfort. This includes general illumination, room color, light distribution, etc. The optimal location of objects of the labor process at a distance of 30-100 cm from the eyes.

When working for a long time at a personal computer, regulated breaks during which gymnastics is performed must be taken into account. It consists of general strengthening and special exercises for the eyes. The latter should be based on the principles of training and relaxation of accommodation, as well as manipulations that improve the blood supply to the eyes.

Also, correctly designed and executed lighting ensures a high level of efficiency, reduces the load on the organs of vision, has a positive psychological effect on workers, and helps to increase labor productivity.

5.3.4 Electrical safety

Electrical safety is a system of organizational and technical measures and means to protect people from harmful and dangerous effects of electric current, electric arc, electromagnetic field and static electricity.

The premises for electrical safety are divided into 3 groups:

1. A room without increased danger (dry, well-heated, room with non-conductive floors, with a temperature of 18–20 °, with a humidity of 40–50%).

2. A room with increased danger (where there is one of the following signs: high temperature, humidity 70-80%, conductive floors, metal dust, the presence of grounding, a large amount of equipment).

3. Premises are especially dangerous, in which there are two signs from the second group or there are caustic or poisonous explosive substances in the room.

According to [75], electrical safety must be ensured by the design of electrical installations, technical methods and means of protection. Electrical installations and their parts are designed in such a way that workers are not exposed to dangerous and harmful effects of electric current and electromagnetic fields, and comply with electrical safety requirements.

First of all, safety is ensured by the use of collective protective equipment, and then, if it cannot be ensured, personal protective equipment is used.

The means of collective protection against electric shock include: protective devices, which can be stationary and portable. Fences can be interlocked with devices that cut off the operating voltage when removed; insulating devices and coatings; protective grounding, neutralization and protective shutdown devices; remote control devices; safety devices, etc.

Also, personal protective equipment is divided into basic and additional. The main protective insulating means include insulating rods, insulating pliers and electrical voltage indicators, dielectric gloves, fitting and assembly tools with insulating handles. Additional insulating protective equipment includes means that supplement the main ones, and can also serve to protect against touch voltage and step voltage. Dielectric galoshes, dielectric rugs, insulating supports [76] serve as additional protective equipment.

5.3.5 Noise

Industrial noise is the noise in workplaces, on sites or on the territory of enterprises, which occurs during the production process. Noise and vibration worsen working conditions, have a harmful effect on the human body, namely, on the hearing organs and on the entire body through the central nervous system. As a result, attention is weakened, memory deteriorates, reaction decreases, and the number of errors during work increases. Noise can be generated by operating equipment, air conditioning units, daylight fixtures, and can also be emitted from outside.

In accordance with SanPiN 1.2.3685-21 [77], the standardized indicators in the workplace are:

- equivalent sound level per work shift;
- maximum sound level;
- peak sound level.

The standard equivalent sound level in the workplace is 80 dB. At noise levels above the permissible level, it is necessary to provide RMS and PPE.

Collective protection means [78]:

- elimination of the causes of noise or its significant attenuation in the source of education;

- isolation of noise sources from the environment by means of sound vibration isolation, sound and vibration absorption;

- the use of means that reduce noise and vibration along the path of their propagation.

Personal protective equipment [78]:

- the use of overalls, footwear and hearing protection: headphones, earplugs, antiphones.

5.3.6 Static electricity

All conductive parts of process equipment and other objects that generate or store static electricity must be grounded, regardless of whether other ESD devices are used. An ESD grounding device must have a maximum resistance of 100 ohms. According to [SanPin 1.2.3685-21] collective protection means against static electricity are: anti-electrostatic substances, humidifying devices, neutralizers, shielding substances. Anti-static footwear, gowns, and anti-electrostatic hand protection should be used as personal protective equipment.

5.4 Fire and explosion safety

Depending on the characteristics of substances and materials in the room, according to the explosion and fire hazard, the premises are subdivided into categories A, B, C, D and F in accordance with [86].

The room in question belongs to category C, since it contains solid combustible substances in a cold state. Possible causes of fire:

- work with open electrical equipment;
- short circuits in power supplies;
- non-observance of fire safety rules.

In order to reduce the risk of fire and minimize possible damage, preventive measures are taken, which are subdivided into organizational, technical, operational and regime. Organizational and technical measures consist in conducting regular briefings of employees responsible for fire safety, training employees in the proper operation of equipment and the necessary actions in the event of a fire, certification of substances, materials and products in terms of ensuring fire safety, production and use of visual agitation tools to ensure fire safety [86]. Operational measures include preventive inspections of equipment.

Regime measures include the establishment of rules for organizing work and compliance with fire safety measures. To prevent a fire, the following fire safety rules must be observed:

- maintenance of premises in accordance with fire safety requirements;
- proper operation of the equipment (correct connection of equipment to the power supply network, control of equipment heating);
- training of production personnel in fire safety rules;
- availability, correct placement and use of fire extinguishing equipment.

In a room with electrical equipment, in order to avoid electric shock, it is advisable to use carbon dioxide or dry powder fire extinguishers. These fire extinguishers are designed to extinguish fires of various substances and materials, electrical installations under voltages up to 1000 V, flammable liquids. Chemical and foam extinguishers are not permitted.[86] Fire extinguishers should be located at the protected object in accordance with the requirements so that they are protected from direct sunlight, heat flows, mechanical influences and other adverse factors (vibration, aggressive environment, high humidity, etc.). They must be clearly visible and easily accessible in the event of a fire. It is preferable to place fire extinguishers near the places where fire is most likely to occur, along the paths of the passage, as well as near the exit from the premises. Fire extinguishers should not interfere with the evacuation of people during a fire. According to fire safety requirements, there are 2 OP 3 fire extinguishers (portable powder fire extinguishers) on the floor, stairwells are equipped with hydrants, and there is a fire alarm button[86].

5.4 Safety in emergencies

Emergency situation - a situation in a certain area resulting from an accident, dangerous natural phenomenon, catastrophe, natural or other disaster that may or have resulted in human casualties, damage to human health or the environment, significant material losses and disruption of the living conditions of people.

The most common emergencies in the building where the bachelor's job was developed are intrusion and fire.

Table 5.5 - Emergency situations, measures to prevent emergencies and eliminate the consequences of an emergency

№	Emergency situation	Emergency prevention measures	Measures to eliminate the consequences of an emergency
1	Falling from height	1. Maintenance of the premises in proper order. 2. Limitation of working space. 3. Timely briefing.	1. Examine or interview the victim; 2.if necessary - call an ambulance; 3. stop bleeding, if any; 4. if there is a suspicion that the victim has a broken spine (sharp pain in the spine at the slightest movement), it is necessary to provide the victim with complete rest in the supine position until qualified medical care is provided.
2	corresponding growth	1. Covering stair steps with anti-slip coating. 2. Timely briefing.	1. Call an ambulance; 2. stop bleeding, if any; 3. if there is a suspicion that the victim has a broken spine (sharp pain in the spine at the slightest movement), it is necessary to provide the victim with complete rest in the supine position until qualified medical care is provided.
3	Falling down the stairs	1. Grounding of all electrical installations. 2. Limitation of working space. 3. Ensuring the inaccessibility of live parts of the equipment. 4. Timely briefing.	1. Quickly release the victim from the action of the electric current [26]; 2. call an ambulance; 3. if the victim has lost consciousness, but breathing is preserved, he should be laid down comfortably, unbuttoned tight clothing, create an influx of fresh air and ensure complete rest; 4. the victim should be allowed to smell ammonia, sprinkle water on his face, rub and warm the body; 5. In the absence of breathing, artificial respiration and heart massage should be done immediately.
4	Electric shock	1. Timely briefing. 2. Establishment of means of automatic fire extinguishing in premises. 3. Installation of smoke and fire detectors. 4. Providing evacuation routes and maintaining them in proper condition. 4. Control of the work of electrical appliances.	1. De-energize the room, cut off the air supply; 2. immediately report the fire to the duty officer or to the guard post; 3. If possible, take measures to evacuate people, extinguish a fire and save material assets.

First case: penetration of unauthorized persons. To ensure the safety of the employee and prevent the entry of unauthorized persons into the enterprise, a number of security measures should be used:

1. Organize a checkpoint.

2. Hire a security guard to bypass the building.

3. Install video surveillance systems in production halls, as well as at all entrances and exits from the building.

4. Install warning security systems in case of unauthorized entry into the enterprise outside of working hours.

Second case: fire. Possible causes of sunburn:

- malfunction of current-carrying parts of installations;
- work with open electrical equipment;
- short circuits in the power supply;
- non-observance of fire safety rules;
- presence of combustible components: documents, doors, tables, cable insulation, etc.

Fire prevention measures are divided into: organizational, technical, operational and regime.

Organizational measures provide for the correct operation of equipment, the correct maintenance of buildings and territories, fire-prevention instructions for workers and employees, training of production personnel in fire safety rules, the publication of instructions, posters, and an evacuation plan.

Technical measures include: compliance with fire regulations, norms in the design of buildings, in the installation of electrical wires and equipment, heating, ventilation, lighting, proper placement of equipment.

Regime measures include the establishment of rules for organizing work, and compliance with fire safety measures. To prevent a fire from short circuits, overloads, etc., the following fire safety rules must be observed:

- elimination of the formation of a combustible environment (equipment sealing, air control, working and emergency ventilation);

- the use of non-combustible or hardly combustible materials in the construction and decoration of buildings; correct operation of equipment (correct connection of equipment to the power supply network, control of equipment heating);

- correct maintenance of buildings and territories (exclusion of the formation of an ignition source - prevention of spontaneous combustion of substances, limitation of hot work);

- training of production personnel in fire safety rules;

- publication of instructions, posters, availability of an evacuation plan;

- observance of fire safety rules, norms in the design of buildings, in the installation of electrical wires and equipment, heating, ventilation, lighting;

- correct placement of equipment;

- timely preventive inspection, repair and testing of equipment.

In the event of an emergency it is necessary to: Inform the management (duty officer);

Call the appropriate emergency service or the Ministry of Emergency Situations - tel. 112;

Take measures to eliminate the accident in accordance with the instructions.

5.5 Conclusions to the section social security

The industrial safety technique has been developed and analyzed in the course of this scientific and technical research.

Measures to create the necessary microclimate conditions have already been introduced in this room. The noise in the room is in accordance with the established norms. Electrical safety measures are also carried out in this laboratory.

The chapter discusses harmful and dangerous factors:

- microclimate [79];
- noise [78];
- illumination [82];
- fire hazard [86];
- electrical safety [89];

Also considered are the causes and means of protection, emergencies and emergencies, measures to prevent them, measures to eliminate their consequences. The radiation safety of work and the potential danger from electromagnetic radiation were considered separately.

The audience in question is assigned to class B for fire hazard [87] and 1 for the electrical safety [83].

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application 1