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BIOSPHERE COMPATIBILITY: HUMAN, REGION, TECHNOLOGIES

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V.V. ALEKSASHINA

NUCLEAR POWER IN THE GLOBAL ENERGY AND ENVIRONMENTAL PROBLEMS

The article compares the influence of various types of energy production on man and the environment: carbon sources (coal, oil, gas), hydro and nuclear energy. Dynamics of the world consumption of primary energy sources for the last 100 years (1900-2000), including atomic energy, which began in the 60s of the 20th century (World average consumption of all types of energy for 100 years Grew by 17 times, with a four-fold increase in the population).

Oil and gas today are the basis of the economy of modern society. Annually, 9 billion tons of conventional fuel is burned in the world, resulting in millions of tons of carbon oxides, nitrogen, sulfur, which fall to the Earth in the form of acid rain, which leads to the death of biota. The article gives examples of the impact on the biota and human enterprises of hydrocarbon energy (TPP, TPP, GRES, RTS, boiler houses), as well as the so-called "small energy".

The special table shows the participation of the main industrial countries in the world in creating a greenhouse effect and climate warming (in these processes, NPPs are not involved).

However, nuclear energy has its own environmental problems:

- huge damage from possible accidents;

- Problems of nuclear waste management;

- while in the world there is no experience of decommissioning of nuclear power plants from exploitation with reclamation of used territory.

Prospects of the nuclear industry will depend on ensuring trouble-free operation, addressing the issues of re-processing and disposal of spent nuclear fuel.

Key words: *energy production, civilizational minimum, carbon energy, nuclear energy, the structure of the world energy, global warming, greenhouse effect, disastrous changes in the biosphere, the post-industrial civilization, alternative energy, ecology.*

V.G. GORODETSKY, S.V. IVSHIN, M.A. PREDEINA

DEVELOPMENT OF ISOTOPE PRODUCTION AT JSC "INSTITUTE OF NUCLEAR MATERIALS", TOPICAL ISSUE FOR NUCLEAR MEDICINE

Nowadays the main mission of JSC "INM" in Russian nuclear industry are examinations and investigations to justify safe and effective use of nuclear energy and radiation technologies, as well as production of radioactive isotopes for different uses. JSC "Institute of Nuclear Materials" (JSC "INM") has a powerful production facility: IVV - 2M research reactor to produce isotope materials, hot cells, radiochemical equipment, and a production site to produce irradiation installations. Nowadays production performance of the Institute includes 40% of radioisotopes for industrial, including ^{192}Ir for gamma-emission sources, used in non-destructive testing. An integrated project on production of ionizing sources with ^{192}Ir radionuclide and radiopharmaceutical precursor with ^{177}Lu isotope for nuclear medicine is under implementation. Basing on nuclear technologies and using capacities of IVV-2M, BN-600 and BN-800 reactors JSC "INM" creates an integrated production of highly competitive products, such as radiopharmaceuticals and radionuclide sources for medical and industrial application. In terms of this work a number of projects, aimed at import phase-out, strengthening of JSC "INM" positions at the external market, as well as foreign trade expansion with high-added value products, is implemented. This paper reviews radioisotopes, topical for nuclear medicine. Potential isotopes to be produced at IVV - 2M reactor are defined.

Key words: *nuclear medicine, brachytherapy, radioactive isotopes.*

D.M. DERYABINA, M.V. ZHUKOVSKY

DEVELOPMENT BIOKINETIC MODEL OF THE DRUG BASED ON THE RADIONUCLIDE ^{177}Lu AND METHYLENE DIPHOSPHONATE

The paper discusses the possibility of applying drug based on ^{177}Lu radionuclide for palliative treatment of bone metastases. ^{177}Lu is a perspective radionuclide in terms of applying in nuclear medicine. High-energy beta particles and the relatively short half-life of the radionuclide are used to achieve an effective treatment. The technology-targeted delivery of the radionuclide to the pathological area is used to minimize radiation exposure to

healthy organs and tissues. This result is achieved by the rapid delivery of the radiopharmaceutical to the tumor cells. Different complexes are used for bones, for example, methylenediphosphonate (MDP). Methylenediphosphonate represents phosphonate complex involved in the metabolism of human bone tissues. Consequently, methylenediphosphonate labeled with radionuclide will actively accumulate in the bone with greater metabolic activity. Aim of this work is to compare organ and tissue doses created by two different drugs: ^{177}Lu -MDP and radionuclide ^{177}Lu in ionic form. ^{177}Lu is lanthanide radionuclide. ^{177}Lu in ionic form actively accumulates in the liver and bone. Phosphonate compounds form stable radiolabelled complexes. This suggests that, ^{177}Lu -MDP is a non-dissociated form on the whole route of the drug. The distribution and elimination of the drug, in this case, will occur according to the kinetics of the carrier, i.e. methylenediphosphonate. It is shown, that the using of osteotropic complex allows creating a large dose in the pathological areas and minimizing damages in healthy organs and tissues.

Key words: ^{177}Lu , methylene diphosphonate (MDP), palliative therapy, bone metastasis, radionuclide therapy, radiopharmaceutical.

S.V. PIMENOV, A.A. DJAKOV, A.A. EKIDIN

IMPROVEMENT OF METHOD ON CONTROL HERMETICITY OF FUEL SHELLS AT REACTOR IVV-2M

The safety of nuclear reactors is provided by a system of physical barriers to the propagation of ionizing radiation and radioactive substances in their possible escape from fuel to the environment. Radiation monitoring of the state of protective barriers, which necessarily includes the control of the hermeticity of the shells of fuel elements is one of the main types of radiation monitoring for nuclear reactors. The control system for the tightness of fuel tube shells is one of the main systems ensuring the safe operation of a research nuclear facility. The composition of the system for monitoring the hermeticity of the reactor shells includes both operational systems intended for operation at the operating reactor and systems operating on a shutdown reactor. A description of the "wet" version of the method of plastic track detectors for determining the uranium content in the coolant of the primary circuit of the research reactor IVV 2M. The results of the application of various materials as track detectors for the determination of ^{235}U microquantities in a coolant are obtained and analyzed. The choice of lvsan as a plastic track detector, provided high sensitivity and selectivity of determination of uranium. The detection limit of ^{235}U in the coolant does not exceed a value of $3 \cdot 10^{-12} \text{ g/cm}^3$. The method allows to carry out mass transfer studies and uranium accumulation in the first circuit.

Key words: nuclear reactor, coolant, track detector, uranium-235.

A.N. GORBULIN

UNDERGROUND NUCLEAR POWER PLANT

The article considers the historical experience of placing nuclear power plants underground, in particular, using the example of the Mining and Chemical Combine in Zheleznogorsk, Krasnoyarsk-26. Arguments in favor of such an arrangement of A.D. Sakharov, who has repeatedly stated that the energy future lies behind underground nuclear power plants. Also, in the article the author proposes a schematic diagram of such NPPs with the designation of key units: power unit, heat exchanger, research and production complex, waste storage. This arrangement assumes a completely harmless for nature the production of electricity with minimal risks in the event of an emergency. Under the ground, waste can be recycled and stored, followed by disposal. If our scientists manage to close the nuclear fuel cycle on an industrial scale, then such an NPP will be even more valuable, since the need for disposal of nuclear waste will disappear. The main problem will be only decommissioning, which, in the case of an underground nuclear power plant, can be made buried on the spot, unlike the costly withdrawal of terrestrial nuclear power plants. Other illustrated schemes clearly illustrate the concepts of using and placing underground nuclear power plants in various conditions: the underground space of the city, the mountainous terrain, the ocean.

All these solutions show the practical significance of such an idea in the context of the biosphere compatibility of nuclear power plants. This means that such a nuclear power plant will not harm biota, which will completely restore confidence in the nuclear industry, as the most environmentally friendly way of extracting electricity.

Key words: nuclear power plant, reactor, underground nuclear power plant, Krasnoyarsk-26, Zheleznogorsk.

E.V. PATRAKOV, N.I. RAZIKOVA, V.D. POPOV, A.A. SHISTEROVA

ORGANISATIONAL AND PSYCHOLOGICAL ASPECTS OF DETERMINATION OF POPULATION GROUPS FOR ADVOCACY FOR RADIATION SAFETY

The organization of information work with the population on issues of radiation safety presupposes an account of the whole variety of factors that determine the radiation situation and the medical, socio-psychological "portrait" of the population. To determine the categories of the population for the purpose of conducting mass information and explanatory work, methods of theoretical analysis of scientific literature on this issue, translation, synthesis of scientific works were used. Authors analyzed the following: regulatory legal documents; Fundamental theoretical and empirical research in the field of radiation safety, radiation ecology, hygiene, medicine, sociology, psychology; Materials of educational resource centers and public organizations. In the article, on the base of analysis of legal acts and scientific literature, authors' approach to determination of population groups for effective information strategy on radiation safety issues is shown. Organizational and psychological aspects have been revealed. The main methods of advocacy are: lecture; Training module (educational information Internet resource, audio-lecture); Training / role playing; Visual aids / memos; Parliamentary hearings / meetings of committees, commissions, working groups, expert councils; Public hearings / proposals to the Legislation; Scientific and methodological seminars / congresses / conferences; Telecasts / broadcasts; social networks; Quizzes, game contests. Thus, based on the analysis of normative legal documents and scientific literature, the authorial attempt is made to classify groups of the population in the context of conducting mass information and explanatory work on radiation safety. It is important that the classification is carried out taking into account the organizational and psychological aspects of security.

Key words: radiation safety, information, communication, population groups, psychological risks.

N.V. GORIN, M.V. AKEKSANDROVA, L.F. TOKAR', O.S. GOLOVIKHINA

INFORMATION SUPPORT OF EXPLANATORY WORK WITH POPULATION IN THE TERMS OF RADIATION SAFETY ISSUES

Today is it necessary to conduct information-explanatory work with population on radiation safety issues for changing population attitude towards atomic energy and improving radiation competence. The features of living near nuclear hazardous sites were considered, and an opinion was expressed that the problems of radiation are interesting for the population only in that degree, how they influence life quality, health, work and environment, and the questions that disturb the population were outlined. It is stated that any conversation with population on the problems of radiation safety will quickly proceed to the discussion of exactly these issues, that is why the lector is to be ready to discuss them and substantiate the safety and responsibility of SC Rosatom policy, qualification of its specialists and reasonably react against alternative standpoints concerning atomic power engineering development. The main requirements to lectures conducting were discussed, and minimum scope of knowledge, which is desirable to give to the population, was specified. It is important to have memory cards with concentrated information. These cards will be given to trainees after the lectures as handouts. It was noted that it is necessary to use only official sources of information for explanatory work with population that are issued mainly SC Rosatom and big Russian scientific centers. The package was passed for trial application to the schools of Snezhinsk.

Key words: radiation safety, population informing, competent categories of population, competent categories of population.

A.A. EKIDIN, A.V. VASILYEV, M.E. VASJNOVICH

MODERN TECHNOLOGIES OF ENVIRONMENTAL IMPACT MANAGEMENT AS A TOOL FOR COMPLIANCE WITH THE ALARA PRINCIPLE

The basis of strategic planning of activities in solving complex scientific and technical problems is the technology of system management. System methodology, system engineering, and management systems emerged in the mid-

dle of the 20th century as a response to the sharp complication of scientific, technical and managerial problems and increased responsibility for performance. At the heart of effective activity on creation and operation of complex engineering objects lie not only technical, but also management aspects of such activity. Changes in requirements in the field of radiation safety aimed at observing the principle of optimization are reviewed. The results of unique studies coming out of the tightening of requirements to control radiation impact on personnel, the public and the environment are shown. Proven tools for the continuous reduction of environmental impact indicators and ways to solve problems of the modernization of environmental management systems for nuclear power facilities are proposed. For nuclear power facilities the "context" of activities includes internal and external conditions that affect the environmental management system. The organization's context should be considered for managing risks and realizing the capabilities of EMS. The transition from functional management to process management allows for continuous and total management of the impact on the environment. The implementation of the requirements of the international standard ISO 14001: 2015 results in a continuous reduction of the environmental impact on the basis of structured and self-regulating processes of the environmental management system. For objects using nuclear energy, the implementation of the requirements of ISO 14001:2015 ensures the implementation of the ALARA principle in its entirety.

Key words: optimization principle, radionuclide, environmental management system, enterprise context, process approach.

A.I. KRYSHEV, T.G. SAZYKINA

AN APPROACH FOR APPLICATION OF THE ECOLOGICAL CRITERIA IN CALCULATION OF PERMISSIBLE LEVELS OF RADIONUCLIDES TO THE ATMOSPHERE

The numerical criteria are proposed for radiation safety of natural biota from atmospheric releases of radionuclides – the control concentrations of radionuclides in the environment (soil and air). These levels are calculated in such a way that if they are not exceeded then biota (organisms, populations, ecosystems) can be considered as protected from the negative radiation effects. The following levels of chronic exposure are used as the thresholds for permissible radiation exposure of terrestrial biota: 1 mGy/day for mammals, vertebrate species and pine tree; 10 mGy/day for plants (except pine tree) and invertebrate species. The control concentration of radionuclide in soil using the radioecological criteria is determined as the activity concentration of the radionuclide in the surface level of soil (Bq/kg), which corresponds to the chronic dose rate for the reference species of biota (annual average) equal to their threshold dose rate. Similarly, control concentration of radionuclide in air using the radioecological criteria is determined as the activity concentration of the radionuclide in air (Bq/m³), which corresponds to the chronic dose rate for the reference species of biota (annual average) equal to their threshold dose rate. If the minimum value of the control concentrations among all reference species in the terrestrial ecosystem, affected by atmospheric releases of a nuclear facility, is not exceeded then the whole ecosystem and its biodiversity could be considered as protected from ionizing radiation. The control concentrations on the ecological criteria are calculated for radionuclides, which are regulated in the releases of Russian nuclear power plants. The procedure of consideration of the ecological criteria for calculation of permissible limits of the radionuclides atmospheric releases by nuclear power plants is described.

Key words: radionuclide, release, biota, criteria, ecosystem.

G.P. MALINOVSKY, A.V. VASILYEV, A.D. ONISHCHENKO

RETROSPECTIVE ASSESSMENT OF EXPOSURE TO NATURAL IONIZING RADIATION FOR POPULATION LIVING IN THE RADIOACTIVELY CONTAMINATED AREA IN URAL REGION

Water, bottom sediments and floodplain of the Techa River were contaminated with a number of short-lived and long-lived radionuclides as a result of radioactive waste discharges at Mayak nuclear facility. The most intensive discharges occurred in 1950-1951. Doses of population exposure associated with the contamination were earlier estimated by specialists of URCRM. The aim of the study is to retrospectively estimate the radiation dose due to indoor radon of the population living in the contaminated area during the period of most intensive discharges of

radioactive waste into the Techa River. The analysis was performed on the basis of dependences of the radon intake on geogenic and anthropogenic factors, obtained earlier in the course of a representative radon survey of the territory. Each settlement was divided into several zones depending on the level of radon concentration in dwellings. The geometric mean radon concentration in a subsample of buildings with certain characteristics belonging to a certain zone was accepted as the geometric mean radon concentration in this zone in the 1950s. To estimate the efficiency of the reconstruction, the multiplicative error was calculated. Effective annual radiation doses due to indoor radon in settlements the Techa River region during the period of maximum discharges were 2.5 - 13.5 mSv (dose coefficient 13 mSv / WLM). The mean multiplicative error of the radon concentration is 0.8.

Key words: indoor radon, dose, Techa River, dose reconstruction.

E.I. NIKITENKO, E.L. MURASHOVA

THE COMPOSITION OF THE NOBLE RADIOACTIVE GASES EMISSIONS FROM THE OPERATION OF AN INDUSTRIAL NUCLEAR REACTOR FACILITY AT FSUE "PA "MAYAK"

The analysis of the radionuclide composition of noble radioactive gases (NRG) is necessary for the safe operation of the reactor installation, and it is also obligatory in accordance with the RF Government Decree of the Government of the Russian Federation of 08.07.2015 No. 1316-r "On Approval of the List of Pollutants for Which State Regulation Measures are Applied In the field of environmental protection ". The study was carried out in a heavy-water two-loop industrial reactor, in contrast to power plants with a constant fuel composition, the amount and composition of gas-aerosol emissions of an industrial reactor depends on the type of fuel loaded into the reactor and the campaign period. In this paper, the characteristics of inert radioactive gases and methods for estimating their volumetric activity are presented. An estimation of the composition of gaseous emissions in different periods of operation of the industrial reactor facility of the enterprise FSUE "PA" Mayak ". It is shown that with the regular operation of an industrial reactor, the sensitivity of the gamma spectrometric method on the channel is insufficient. To assess the qualitative and quantitative composition of inert radioactive gases, a preliminary concentration of the analyzed gas mixture is necessary. The method of preliminary concentration of a gas mixture by means of cryogenic freezing is shown. The possibility of using the control of the qualitative and quantitative composition of NRG for additional control of the hermeticity of the shells of the reactor channels is considered. The dynamics of the release of inert radioactive gases during the period of the study using preliminary concentration of the NRG gas mixture and for 2012-2016 is shown, their contribution to the total activity of the gas-aerosol releases of the reactor facility is shown.

Key words: radioactive noble gases, cryogenic freezing, nuclear reactor, emissions, Ar-41, Xe-133.

M.D. PYSHKINA

THE DETERMINATION OF MAIN DOSE-FORMING NUCLIDES IN NPP PWR AND VVER RELEASES

In this paper the structure of gas-aerosol releases of NPP with PWR and VVER type of reactor facilities in the period from 1995 to 2015 is analyzed. Radionuclide groups forming 99 % of effective dose to the population were identified. Radiation doses to the population were calculated per 1 GWh generated electrical power. The contribution of radionuclide, controlled on russian NPP, was defined and it is less then 2,3 %. For all the NPPs considered, inert gases predominate in the sum of the ejected activity. Specific for each considered group of nuclear power plants is the radionuclide composition of IRH. At least 88% of the total activity that does not take into account IRH is made by tritium and carbon. For all PWR and VVER NPPs, tritium predominates in total activity, which does not take into account IRH. An increase in the average annual effective dose of population exposure due to the expansion of the list of controlled radionuclides at nuclear power plants is observed. Based on the requirement for the control of nuclides constituting 99% of the annual effective dose, the following radionuclides are distinguished at all nuclear power plants: C - 14, H - 3, Ar - 41, Xe - 133, Xe - 135, Kr - 88, Kr - 87, I - 131.

Key words: NPP, airborne discharges, radionuclides, reactor facility.

I.V. YARMOSHENKO

RADON AS A FACTOR OF POPULATION EXPOSURE IN RUSSIA

Indoor radon exposure of humans is considered in the context of safe handling with natural radioactive materials – soil under the building and construction structures. Within the framework of natural science disciplines – radiobiology, radioecology, radiation epidemiology, radiation geoecology and building physics – the regularities of radon entry and accumulation, the health effects of exposure to radon are studied and the methods of protection against radon are justified. Available scientific basis allows solving the radon problem in Russia at the system level within the integrated state strategy. Over the past few decades, the processes of formation, transport, accumulation of radon, as well as the issues of human irradiation with daughter radon products and the effects of irradiation have been thoroughly studied by natural-science methods. Based on the results of radiobiological, radiation-epidemiological and dosimetric studies, the danger of radon is associated with lung irradiation and an increased risk of lung cancer with inhalation intake of radon children. The created methodical and metrological support allows carrying out both mass radon surveys and radiation-hygienic control in separate buildings. The levels of accumulation of radon in residential buildings in Russia averages about 48 Bq / m³ and in 95% of the premises do not exceed 160 Bq / m³. This level of exposure increases the mortality of lung cancer by about 7%. In the course of a large number of studies, the main geogenic and anthropogenic factors determining the radon exposure situation in buildings in various territories have been established. Based on the systematization of the available information, physically justified models of convective and diffusion radon intake into buildings have been built, which allow developing effective methods for reducing the volume activity of radon in existing buildings and planning protection against radon of new buildings.

Keywords: radon, exposure, radiation dose, protection.