ЯДЕРНОЕ ОБЩЕСТВО РОССИИ

УДК 621.039.7

MAIN TRENDS OF INTERMEDIATE- AND LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT IN RUSSIA

S. D. Gavrilov*, V. A. Kremnev*, A. A.Grudakov, S. A. Dmitriyev***, A. A. Resnik****, L. P. Khamyanov*****, S. L. El'yash******

* *DECOM Engineering, Ltd, Moscow*
** *MO «Atomenergoproject», Moscow*
*** *Central Regions' RPA «Radon», Sergiyev Posad, Moscow Region*
**** *State Concern «Rosenergoatom», Moscow*
***** *Russian Research Institute for NPP Operation, Moscow, Russia*
****** *Russian Research Institute of Experimental Physics Sarov, Nizhnij Novgorod*

В России в последние годы наметился определенный перелом в решении проблемы обращения со средне- и низкоактивными отходами, выразившийся в создании перспективных технологий и оборудования для их реализации, а также новых "заделов", основывающихся на фундаментальных достижениях науки и технологий, включая радиобиологию.

INTRODUCTION

Nuclear energy and industry development in Russia has determined the radioactive waste management as one of the crucial factors of the nuclear energy and nuclear industry problem. Principal concepts of the waste management are stated on the base on the available and future nuclear technologies for radioactive waste treatment and disposal as follows:

- minimization of the generated waste categories and kinds during process flow and facility design development;
- exclusion of long-term radioactive waste storage without conditioning at any nuclear production site;
- implementation of the waste treatment process with suitable ILW (intermedia-level waste) and LLW (low-level waste) conditioning at every nuclear site;
- minimization of ILW and LLW by conditioning for long-term storage and/or disposal, and radionuclides concentration in it;
- storage of the treated radioactive waste for long, 50 years and more, period at the available NPPs (nuclear power plants) and other nuclear facilities sites with its

** Доклад на X Международной конференции Ядерного общества России (Обнинск, 28 июня-2 июля 1999 г.)*

possible subsequent removal and shipment for final disposal. This interim storing are used for lack of repositories in Russia. The interim storage life depends on both timing of the repositories commissioning and optimal schedules of the waste shipment and burial there.

The governing factor of the present concept is the development and implementation of the advanced industrial technologies for radioactive waste conditioning. The aim of the concept is a significant, up to a factor of 100, liquid and solid radioactive waste volume reduction with the appropriate radionuclides concentration. Then the liquid waste are solidified and the solid waste conditioned in the monolith form in containers for the long-term storage, shipment and final disposal [1].

In addition, ensuring the safety culture by a set of appropriate procedures allows the operation power station radioactive waste to be reduced by about 50 % as it has been demonstrated by the experience of several NPPs.

HLW (high-level waste)management systems are based on the advanced NPP spent nuclear fuel reprocessing technologies.

INTERMEDIATE- AND LOW-LEVEL WASTE MANAGEMENT

ILW and LLW are no less dangerous. The reasons are that the already accumulated waste is legion and it is distributed around the various geographic regions and sites.

A Working Programme for NPP radioactive waste management is being implemented in Russia [1]. It is a flexible programme based on the prospective ILW and LLW processes and designs for their implementation. An important point is that the Working Programme ... is reviewed every year for its improvement.

Engineering, equipment and facilities for solid ILW and LLW management are, in general, similar to those used in other countries with well-developed nuclear energy. They include a lot of processes such as incineration of combustible and compaction of compressible dry waste with their subsequent supercompacting, metal decontamination and/or melting, etc. Some of the other processes, e.g. insulation melting, are also treated in Russia as quite promising for solid waste conditioning.

The difference of Russia and other countries with WER reactor technologies from the other ones with the developed nuclear energy springs from the great volume of solid radioactive waste to be treated. For instance, for Smolensk NPP (three RBMK units) only the accumulated in bulk already LLW placed in the storage should take from 10 to 15 years for retieval and sorting if the necessary facilities are available.

In contrast, for the liquid radioactive waste management the dissimilarity in Russia is significant. The sorption process for the basic nuclides of NPP (^{137}Cs, ^{134}Cs, ^{60}Co, ^{90}Sr) is to be extensively used for the NPP operation processes with different chemical content water solutions and liquid waste. The specific sorbents are identified for the separate radionuclides. The non-radioactive solutions and water are produced from the liquid radioactive waste by the process, and the wet solid sorbents with the high capacity by nuclides are conditioned and directed to the long-term storage.

This process also allows cleaning of large amounts out-of-balance process waste water before its discharging to the ground bodies of water. The widespread chemical liquid decontamination for equipment and metal waste to be re-used also requires sorprion of the used liquids. Therefore, the liquid and solid waste treatment processes are interdependent.

Among the advanced technologies for waste treatment in Russia there is also a process of field-fouled ion exchange resin cleanup to change it to the non-radioactive waste category. Another important process just developed by Russian experts is designed for the silt generated at and near NPP. Following the cleaning up, the silt can be used as a fertilizer or stored at an industrial disposal facility.

The removal of the main radionuclides from the decontamination and washing saturated solutions generated while in these and similar processes is also carried out by the specific sorbents.

The final stage of ILW and LLW treatment is the solidification of the concentrated liquid radioactive waste and its space-saving enclosure into standard containers for the long-term storage, shipment and final disposal.

It is significant that the Federal Supervision of Russia over Nuclear and Radiation Safety (Gosatomnadzor of Russia) along with the State Concern «Rosenergoatom» and several Russian institutes and companies in parallel with the development of such processes and facilities being laid down the Russian codes and standards for their use. It should give the timely implementation and suitable effect of the facilities at the sites. We would like to emphasize that the certain support has been provided to the Russian organizations and companies by the European companies, first ones from Germany and the United Kingdom, in such documents development in the frameworks of the TACIS Programme.

RADIOACTIVE WASTE STORAGE AND THE HEALTH EFFECTS OF LOW-LEVEL RADIATION

At the end of our paper we should like to mention the problem that is of special emphasis. The health effects of low-level radiation equally important to all the nuclear energy and industry experts as well as to the specialists from other nuclear technologies. A wealth of experience in the health effects and the biota as a whole influence for different types of the ionizing radiation have been accumulated for 50 and more years.

The available supporting evidence testifies that for small yet exceeding the background dose and dose rate an exposure is not only harmful but, possibly, useful for the population and biota as well [2].

Nevertheless, the suggested for the last decade by the international organizations recommendations for the limits of the dose and dose rate exposure limits for the population and the personnel of nuclear facilities and being adopted thereafter by the national committees for radiation protection, including Russian one, depend, first, on the social and political factors instead of the scientific base [3,4].

Therefore in Russia now, before the additional data obtaining on the health effects of low-level radiation, all waste from NPP and other nuclear facilities are ordered by its radioactivity as:

- non-radioactive materials for free use;
- «controlled» non-radioactive waste for limited use and/or storage without any additional radiation condition;
- low-, intermediate- and high-level waste that must be stored and/or disposed in interim storages or repositories;

If the notions «Non-radioactive waste», «Radioactive waste», and «Radioactive waste for limited use» are well-known, the notion «Controlled» non-radioactive waste for

limited use and/or storage without any additional condition by radiation» is the new one.

This notion make allowance for actualities of the present century end when the scientific evidence on the biota effects low-level radiation comes into conflict with the simplified, often incorrect notion and improper practice of the population, the elected political and public figures, and even of some officials responsible for radiation protection of the population.

The new notion isn't only theoretical one; it is of actual application. Thus, the «controlled» non-radioactive waste ... are to be placed out of the NPP and other nuclear facilities sites because of the vast amount of such waste category. It will allow not only to solve the nuclear energy and industry waste management in Russia and other countries but to assign a considerable sum (about 5 billion dollars per year for the United States [5]) for the advance in the living standard.

References

1. «Working Programme for NPP radioactive waste management», State Concern «Rosenergoatom», 1998.

2. *Kuzin A.M.* Ideas of Radiation Gormesis in Atomic Age, M.:, Nauka, 1995.

3. *Domenicci P.V.* Future Perspectives on Nuclear Issues, Nucl. Plant J., 1998, 16. - № 1. - P. 38.

4. *Becker K.* How Dangerous Are Low Doses? The Debate About Linear vs Threshold Effects, Nucl. Europe Worldscan, 1998, 28. - № 3/4. - P. 29.

Поступила в редакцию 28.05.99.

ABSTRACTS OF THE PAPERS

УДК 621.311.25:621.039.004

Requirements to XXI Centure NPPs \ P.N.Alekseev, A.Yu.Gagarinski, N.N.Ponomarev-Stepnoif, V.A.Sidorenko; Editorial board of journal "Izvestia visshikh uchebnikh zavedeniy. Yadernaya energetica" (Communications of Higher Schools. Nuclear Power Engineering) - Obninsk, 1999. - 16 pages.

Power development in the XXI century would follow the trend to more uniform consumption per capita and per region. Among the competing energy sources - fossil fuels, sun and nuclear energy - the principal advantages of nuclear power - almost unlimited fuel resources. Its high energy capacity, ecological compatibility with a possibility of high wastes' concentration - determine the large-scale nuclear power development. The signs of large-scale power - large rate (dozens of percent) in electricity production, diverse areas (electricity, heat supply, technologies, transport) and media of application (land, ocean, space), extension of number of user countries, diversified power systems (centralized, autonomous), obligatory reproduction and reuse of produced fuel - create various requirements to nuclear power installations of the future. Economic efficiency, safety (of reactors and fuel cycle with waste), proper characteristics of nuclear fuel reproduction, guarantees of nuclear arms' nonproliferation are the conditions of such nuclear power development.

Succession in nuclear power development dictates the requirements to the reactor systems of close and long-term perspective.

The acceptable safety level is closely connected with the power scale and with the fields of nuclear energy sources' applications. However, the progress in the direction of reduction of potential hazard from nuclear installations and of protection systems' cheapening is inevitable. While choosing the new directions, the demonstration of new qualities in solving the tasks of future nuclear power would be important.

In the perspective, a variety of reactor technologies could exist. The report discusses the forming requirements to nuclear power plants of the following development stages - in the fields of safety, economy, user characteristics, fuel utilization - and the expected stages of this development.

УДК 621.039.566

Calculation of the Strength of NPP' Failed Pipelines with the Real Elements Method \ V.M.Markotchev, Yu.V.Shamraev; Editorial board of journal "Izvestia visshikh uchebnikh zavedeniy. Yadernaya energetica" (Communications of Higher Schools. Nuclear Power Engineering) - Obninsk, 1999. - 7 pages, 4 illustrations. - References, 5 titles.

The new method - real elements method (MeReEl) - for calculation of the strength of structural elements containing defects and inhomogeneities is considered. The method is based on replacement of structural elements by equivalent rod system and use of experimental diagrams of deformation of samples with different degree of failure. The analysis of limiting condition is founded on the deformation criterion of the mosr failed rod. The algorithm of calculation of a segment of the pipeline containing nonthrough circumferential defect and loaded by bending moment and axial force is given. Using MeReEl computer code, an analysis of the strength of primary circuit pipeline (Di-500) containing nonthrough circumferential cracks in various locations in the cross section is made. Critical sizes for pipeline cracks and influence of the crack centre deflection from the forse plane on the strength of the cross section are estimated.

УДК 621.039.7

Main Trends of Intermediate- and Low-Level Radioactive Waste Management in Russia \ S.D. Gavrilov, V.A. Kremnev, A.A. Grudakov, S.A. Dmitriyev, A.A. Resnik,L.P. Khamyanov,

S.L. El'yash; Editorial board of journal "Izvestia visshikh uchebnikh zavedeniy. Yadernaya energetica" (Communications of Higher Schools. Nuclear Power Engineering) - Obninsk, 1999. - 4 pages. - References, 4 titles.

For the last years in Russia the specific change in the ILW and LLW management has been surfaced. It is resulted in the prospective processes, equipment and installations for waste conditioning as well as for original findings based on the fundamental science, engineering and technology achievements, including progress in radiation biology.

УДК 621.039.526

Evaluation and Comparison of Plutonium Potential Hazard \A.G. Aseev, S.A. Subbotin; Editorial board of journal "Izvestia visshikh uchebnikh zavedeniy. Yadernaya energetica" (Communications of Higher Schools. Nuclear Power Engineering) - Obninsk, 1999. - 9 pages, 1 table. - References, 7 titles.

An attempt to reevaluate plutonium as very toxic element was made in the article. Plutonium radiation hazard and plutonium properties dangerous for human being and the environment are considered. Estimation of its chemical toxicity also was suggeseted and it was compared with radiation plutonium toxicity. An estimation of real danger related to plutonium is represented in this article.

УДК 519.688:621.039.572

FACT98 Code for Three-Dimensional Neutronics and Thermal Hydraulics Calculations of Boiling VK-300 Reactor\ S.V. Barinov, V.V. Vasil'ev, V.K. Vikulov, V.K. Davidov, A.P. Zhirnov, Yu.I. Mityaev, A.V. Radkevich, M.I. Rozhdestvensky; Editorial board of journal "Izvestia visshikh uchebnikh zavedeniy. Yadernaya energetica" (Communications of Higher Schools. Nuclear Power Engineering) - Obninsk, 1999. - 4 pages, 1 illustration. - References, 1 titles.

FACT98 code permits to calculate stationary states of a reactor, burn-up of fuel subject to overload and transposition of fuel assemblies as well power distribution, control rods displacement, reactivity effects and coefficients etc. Later is planed to add into the program calculation of the transient process on the basis of a spatial neutron dynamics and thermal hydraulics.

УДК 621.039.526:621.039.534.6

Evaluation of effects of (γ,n) & (n,2n) reactions on criticality and kinetics of heavy-water reactor \ Yu.V. Volkov, T.G. Petrosov, M. Moniri; Editorial board of journal "Izvestia visshikh uchebnikh zavedeniy. Yadernaya energetica" (Communications of Higher Schools. Nuclear Power Engineering) - Obninsk, 1999. - 7 pages, 5 illustrations. - References, 4 titles.

The effect of photoneutron reactions on criticality and dynamic of a heavy water reactor has been evaluated. It has been shown that these reactions are not to be considered during neutron-physical calculations of a nuclear reactor having practically feasible dimensions. At the same time the effect of delayed photoneutron reactions on dynamics of a heavy water reactor is essential. The digital reactimeter for such reactor has been developed and tested in imitation experiment.

УДК 621.039.526

Numerical and Experimental Investigations of Stable Heat-Exchange Conditions with Liquid Metal Boiling under Fast Reactor Accident Heat Removal Regime \ A.P. Sorokin, A.D. Yefanov, Ye.F. Ivanov, D.Ye. Martsiniouk, G.P. Bogoslovskaya, K.S. Rymkevich, V.L. Malkov; Editorial board of journal "Izvestia visshikh uchebnikh zavedeniy. Yadernaya energetica" (Communications of Higher Schools. Nuclear Power Engineering) - Obninsk, 1999. - 11 pages, 8 illustrations. - References, 8 titles.

The description of test facility, sensors, measurement procedure and the experimental data on investigation of liquid metal coolant boiling in a model of fast reactor fuel subassembly under the accident heat removal conditions with small circulation rates are represented. The physics, performances and stability of various boiling regimes observed in experiments (nucleate, slug, disperse-annular) are analyzed. Experimental pattern map for liquid metal boiling was obtained. The description of a mathematical model of liquid metal boiling in the natural circulation circuit and results of test accounts for conditions with increasing of energy generation and with sharp reduction of pressure are represented.

УДК 621.039.544.35:621.039.526

Development of the Chemical Treatment Methods for Thorium Materials in a Uranium - Thorium Fuel Cycle \ B.Ya. Zilberman, L.V. Sytnik, B.Ya. Galkin, A.G. Gorsky, V.B. Pavlovich, E.Ya. Smetanin, F.P. Raskach; Editorial board of journal "Izvestia visshikh uchebnikh zavedeniy. Yadernaya energetica" (Communications of Higher Schools. Nuclear Power Engineering) - Obninsk, 1999. - 7 pages, 3 illustrations, 3 tables. - References, 3 titles.