

THE 30th ANNIVERSARY OF THE NUCLEAR SAFETY INSTITUTE OF RAS: KEY ACCOMPLISHMENTS IN RW MANAGEMENT

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The Nuclear Safety Institute of the Russian Academy of Sciences (IBRAE RAS) was established with the aim of advancing basic research in nuclear and radiation safety of nuclear power plants and other nuclear facilities. Over the years, development of a modern radioactive waste management system was added as another goal to the list of state tasks raised before the Institute. The paper overviews the historical background of IBRAE RAS activities in RW management covering a period of over 20 years and presents the main areas of its research on this topic. Consolidation of scientific expertise and research to address cross-cutting challenges associated with the establishment and further development of a unified radioactive waste management system, as well as the development of strategic master plans providing for the long-term safety of nuclear legacy facilities is viewed as a pillar of IBRAE RAS success.

Keywords: *The Nuclear Safety Institute of the Russian Academy of Sciences, radioactive waste, the establishment of a unified state system for radioactive waste management, research areas*

Government decision on IBRAE RAS establishment was made as a feedback response to the Chernobyl accident. At this time, basic research on safety carried out by academic community in close cooperation with nuclear industry and regulators was finally acknowledged as a must. The Institute activities were primarily aimed at developing NPP safety assessment methods and tools, evaluating nuclear accidents in terms of the radiological impacts produced on the population and the environment, as well as broadening the scientific knowledge for emergency response planning. In the early years, research performed as part of Chernobyl NPP cleanup activities was mainly focused on behavior of the damaged core unit, construction of the Shelter facility and site remediation itself. As for the territories located outside the site boundaries, the most urgent tasks were associated with radiation safety of population and social and economic “remediation” of contaminated territories. Obviously, these matters along with safety enhancement and

accident prevention remained the key topics of IBRAE RAS research for many years.

Based on the research performed by the Institute, a data bank (radiation, hygienic, demographic, medical, social and other data) was developed enabling the analysis of different post-accident aspects, as well as providing a comprehensive data set for relevant decisions to be made by state authorities. Based on this data bank an integrated decision support system, information storage and retrieval system, reference system and other systems were developed. It should be noted that the tasks set to address the Chernobyl challenges were not associated with RW final disposal. For this reason, it was not included to the formal list of tasks set before the Institute.

Until late 1990’s, RW management challenges addressed by the Institute were associated with two aspects only: first of all, addressing the problems associated with the physics behind reactor fuel melting seen as a continuation of Chernobyl research performed by leading experts [1], and, secondly,

occasional evaluations addressing RW management issues as part of various international projects. By this time, IBRAE RAS experts have already grasped the fact that RW management system existing in Russia required certain upgrading, also in terms of managing RW generated by NPP, scientific institutions, national economy and etc. It also became evident that some aspects required additional rethinking (deep disposal of liquid RW and surface LRW storage facilities). However, RW management topics were not considered as the top-priority area for the Institute among a big number of challenges facing the nuclear industry at this time.

At the same time, public attitude regarding RW management challenge was drastically different. In 1991, the decree of the first Congress of People's Deputies of the Russian Soviet Federative Socialist Republic (RSFSR) On the Development of the State Program for the Management of Radioactive Waste and Spent Nuclear Materials, their Disposition, Disposal and Urgent Measures on Radioecological Remediation at the Territories of the RSFSR was published. This paper directly considered the challenge of radioactive waste management and their disposal as a "task of special importance for the Government". In keeping with its provisions, "draft RSFSR State program for RW management..." was to be developed. RSFSR Council of Ministers was tasked to perform the audit of "all existing facilities for long-term storage and disposal of radioactive waste ...". This task was actually completed only in 2014 when the RW inventorying campaign was finalized.

It's only in the late 1990's that the first detailed safety analysis of particular RW management facilities was performed by IBRAE RAS – a monograph Major Radiation Accidents [2] being a collaboration of composite authors with the International Institute for Applied Systems Analysis (IIASA) (F. Parker, S. Novikov), was published. Based on this collaboration, in 1998-1999, IIASA project "Remediation and Protective Measures Associated with the River Techa Contamination Resulting from PA Mayak Radioactive Discharges (for Comparative Evaluation with Clinch River (Oak-Ridge)). The overall message provided therein was that the decision-making process regarding the radiation protection measures implemented at these two sites (Techa Cascade of Water Reservoirs and radioactively contaminated Clinch River) has to be flexible. This preliminary and nevertheless detailed study of challenges facing the TCR served as a major incentive for IBRAE RAS further involvement in the next 20 years of research aiming to ensure its long-term safety. In parallel with this, IIASSA was involved in the first international peer-review of the LRW deep well injection practice. 15 years later, relevant challenges have been also included by the Government into a major research project currently being implemented by the Institute.

IBRAE RAS involvement in the projects implemented under the Franco-German Chernobyl

initiative in 1999–2002 can be seen as a continuation of Institute's previous fruitful collaboration with France (IPSN, further IRSN) resulted from the active position of IPSN administration (F. Vesseron, M. Livolan) on the Chernobyl topic. Under one of these projects, IBRAE RAS experts took part in the inventory taking campaign covering all sites for stockpiling, intermediate and permanent storage of RW resulting from the cleanup of territories in Belarus, Ukraine and Russia contaminated due to the Chernobyl accident. It's worth mentioning that IRSN collaboration with the Institute is still ongoing.

In 1998–2001, the list of nuclear tasks facing the Institute saw rapid extension. Two projects deserve particular attention being a huge undertaking in terms of providing the required regulatory framework in nuclear and radiation safety (NRS). The first one addresses analytical and information support of Minatom (Atomic Energy Ministry of Russia) initiatives in the field of spent fuel management (SNF). The second one – was the engagement of IBRAE RAS experts in the special committee on the delineation of powers and responsibilities. The former one enabled a comprehensive evaluation of the existing keen perception of RW management issues, whereas the latter one – provided clear evidence to the fact that nuclear topics were not addressed as top priority ones under the state regulation system. It should be noted that since then, IBRAE RAS experts have been part of State Duma's Expert Council (L. Bolshov, A. Sarkisov, I. Linge).

By this time, the development of the first federal target program on Nuclear and Radiation Safety (FTP NRS-0) with IBRAE RAS experts being directly involved in was started in Russia. In keeping with relevant provisions of Orders of the President of the Russian Federation PR-2214 of December 11, 1996 and the Government of the Russian Federation AB-P7-06525 of February 28, 1997, FTP NRS-0 was supposed to cover 18 already adopted but not implemented NRS programs, including the RW Program. There were three particular features specific for IBRAE RAS involvement in FTP NRS-0. Firstly, for the first time ever the Institute was actually working in close cooperation with the leading scientists of the Russian Academy of Sciences on the subject of RW management (RAS members N. P. Laverov, B. F. Myasoedov, V. I. Osipov, Corresponding Members V. I. Velichkin, S. V. Yuditsev and others). Secondly, the lessons learned from five revisions of Chernobyl and Ural programs discussing relevant remediation efforts and as well as the know-how for rapid adjustments in case of some regulatory changes introduced to administrative requirements were readily available. Thirdly, constant reliance on in-depth safety assessment and principles of radiation protection. Thus, in 2004–2005, all support functions covering the entire FTP NRS-0 were transferred to the Institute.

IBRAE RAS's long-term involvement in the development and support of these state programs also resulted in its unique know-how in the development of comprehensive approaches aiming to address the accumulated nuclear legacy challenges. In 2003, development of the Strategic Master Plan on the Disposition and Environmental Remediation of Decommissioned Nuclear Fleet Facilities and Relevant Supporting Infrastructure (SMP APL) was started under its leadership. Experts from National Research Center Kurchatov Institute, NIKIET named after N.A. Dollezhalya and a number of other organizations were also actively engaged in this work. SMP APL development was performed under scientific supervision of A. A. Sarkisov, Scientific advisor of the Institute and member of the Russian Academy of Sciences [3]. In 2007, the Plan was reviewed and approved by the State Corporation Rosatom and Eurobank and became an effective tool both as regards the general management of remediation efforts implemented by SC Rosatom, and calling for technologies and funds under international cooperation projects.

In March 2003, President Putin's decree was published requiring "...the development of additional measures aiming to prevent potential environmental disaster resulting from current and past operations at PA Mayak. The scientific escort of this project was run by IBRAE RAS (L. A. Bolshov, I. I. Linge). Executive managers and leading specialists from the Atomic Ministry of Russia (Minatom) (M. I. Solonin, A. M. Agapov, V. M. Korotkevich, E. G. Kudryavtsev), PA Mayak enterprise (V. I. Sadovnikov, Yu. V. Glagolenko, E. G. Drozhko, A. A. Abramov, Yu. G. Mokrov), Russian Academy of Sciences (B. F. Myasoedov, V. I. Velichkin), the Ministry of Natural Resources of Russia (M. L. Glinsky, A. V. Pechkurov), FMBA of Russia (L. A. Ilyin, V. V. Romanov) were also involved in this work. In 2005, activities scheduled under the Comprehensive Plan for... were started. However, full-scale implementation of the planned projects became possible only after the federal target program Nuclear and Radiation Safety in 2008–2015 (FTP NRS) had been launched. Strategic Master-Plan Addressing TCR Challenges (SMP TCR) was developed later seeing as its basis most effective and feasible use of material and financial resources with due consideration of national and international radiation and environmental safety requirements [4]. SMP TCR laid a solid scientific basis enabling to stabilize the situation around TCR and defining the most effective strategy providing for the final solution of the problem.

In late 2005, Russian nuclear industry saw some drastic changes. Ratification of the Joint Convention on the Safety of Spent Nuclear Fuel Management and on the Safety of Radioactive Waste Management by Russia required not only the development of relevant regulatory framework covering RW and SNF management aspects, but also urgent preparation of the First National Report of the Russian

Federation on the compliance with its obligations. IBRAE RAS was tasked with the development of this Report. Since then this work was seen as a regular practice. In spring 2018, the Fifth National Report of the Russian Federation was presented at IAEA headquarters in Vienna [5]. For the first time ever, the strategy for nuclear industry development was set in parallel with the tasks addressing the accumulated challenges in RW management.

In spring 2006, the outline of the new federal target program on Nuclear and Radiation Safety emerged. Relevant order of the President of the Russian Federation defined the timeframe covered by the new program — 2008–2015. The program was fully drafted by IBRAE RAS experts – this work was basically finalized in 2007 when the program concept was approved. The concept has set forth specific responsibilities aiming to eliminate the re-occurrence of the accumulated challenges. In summer 2007, finishing touches were applied to elaborate the new FTP NRS, as well as to complete all relevant documents prior to their approval by the Government of the Russian Federation. In parallel, Federal law on Radioactive Waste Management was being developed by the SC Rosatom. However, at this time IBRAE RAS was not able to participate in it to the fullest extent possible as it was extremely busy with the preparation of the new FTP. In autumn 2007, this opportunity finally arose. Moreover, in September 2007, IBRAE RAS signed an agreement with Swedish SKB-IC (specialized company established by Swedish NPP operators and responsible for safe RW management of NPP sites, including their transportation and final disposal) enabling a thorough and comprehensive study of the lessons learned by other countries in the field of RW management. This agreement offered over 5 years of successful collaboration. It also involved a number of workshops conducted in 2009–2011 to discuss the lessons learned by Sweden and other countries in the field of RW disposal, including the existing financial system covering RW disposal costs, safety assessment methods for RW disposal facilities, RW classification system for disposal purposes. Technical tours to Swedish RW disposal sites were arranged for IBRAE RAS experts, as well as for the personnel of different SC Rosatom organizations. It should be noted that the international cooperation projects implemented by the Institute also covering the area of RW management allowed its employees to get acquainted with RW management programs of different countries advancing this energy generation sector with tours being arranged to relevant nuclear sites (figure 1).

As for the draft Federal law on RW issued in 2007, according to its developers, it was quite a detailed document. Nevertheless, some of its provisions were judged as misleading and inadequate by particular experts. By the end of the year, it became clear that the document would not be approved by SC Rosatom and its new vision should be developed.



Figure 1. Geography of business trips arranged for IBRAE RAS experts

Thorough elaboration of the draft law started in late fall 2007. The key developers were I. I. Linge, V. D. Kovalchuk, S. V. Strizhova, I. L. Abalkina (IBRAE RAS), O. A. Supataeva (IGP RAS). An important contribution to the concept was offered by discussions involving A. M. Agapov (SC Rosatom), S. N. Brykin (VNIKhT), R.B. Sharafutdinov (FSUE "STC NRS"). Already in March 2008, provisions of the draft law were reported and approved by SC Rosatom. At the subsequent stages, active participation of E. L. Elfimova and Yu. D. Poliakov in the approval process played a crucial role in the successful enactment of the law.

Another activity was implemented in parallel with the above mentioned – parameter evaluation of the existing and prospective RW management systems. Based on its findings, IBRAE RAS working in collaboration with other nuclear specialists developed a Road-Map for the Establishment of a Unified State System for RW Management [6].

18 months of active discussions by the Federal Assembly resulted in the enactment of the law on July 15, 2011. This work was really beneficial in terms of the knowledge gained on the processes going hand in hand with the draft law review. It became clearer that the existing legal framework is quite fragile, vulnerable and complex in respect of several aspects [7]. Firstly, as regards nuclear initiatives: by this time already a two-year long discussion has been held around the criteria set forth in OSPORB-1999/2010 regarding the categorization

of liquid and gaseous waste as RW, suggesting the same specific activity values to be set as for SRW and compulsory LRW immobilization [8]. As a way of addressing this challenge a formula was suggested enabling to specify basic criteria at the level of Government resolutions. As it was shown later, this approach also had some drawbacks. Secondly, preliminary fees collected to cover RW disposal costs, the practice widely used abroad and not implemented in our country due to less harsh financial mechanisms applied. Thirdly, almost complete independency of the national operator from RW generators.

The time period between 2011 and 2012 may be seen as a development stage that involved the approval of a series of Government Resolutions based on which the new legal framework was shaped. Unfortunately, at this stage not all the tasks set behind the Institute were accomplished. Partially, it was due to its independency from the key institutions – i.e. the State Corporation Rosatom and the Ministry of Environment of the Russian Federation. Inadequacy of legal framework in this field was basically considered to be due to the chosen way for joint development of regulations on waste criteria (for categorizing waste as radioactive waste, special (non-retrievable) RW and RW classification). This process did not suggest any staged development accounting for all possible interrelations. Shortly before the review process was launched, IBRAE RAS sent a request to the Government of the Russian Federation stating that scientific and practical

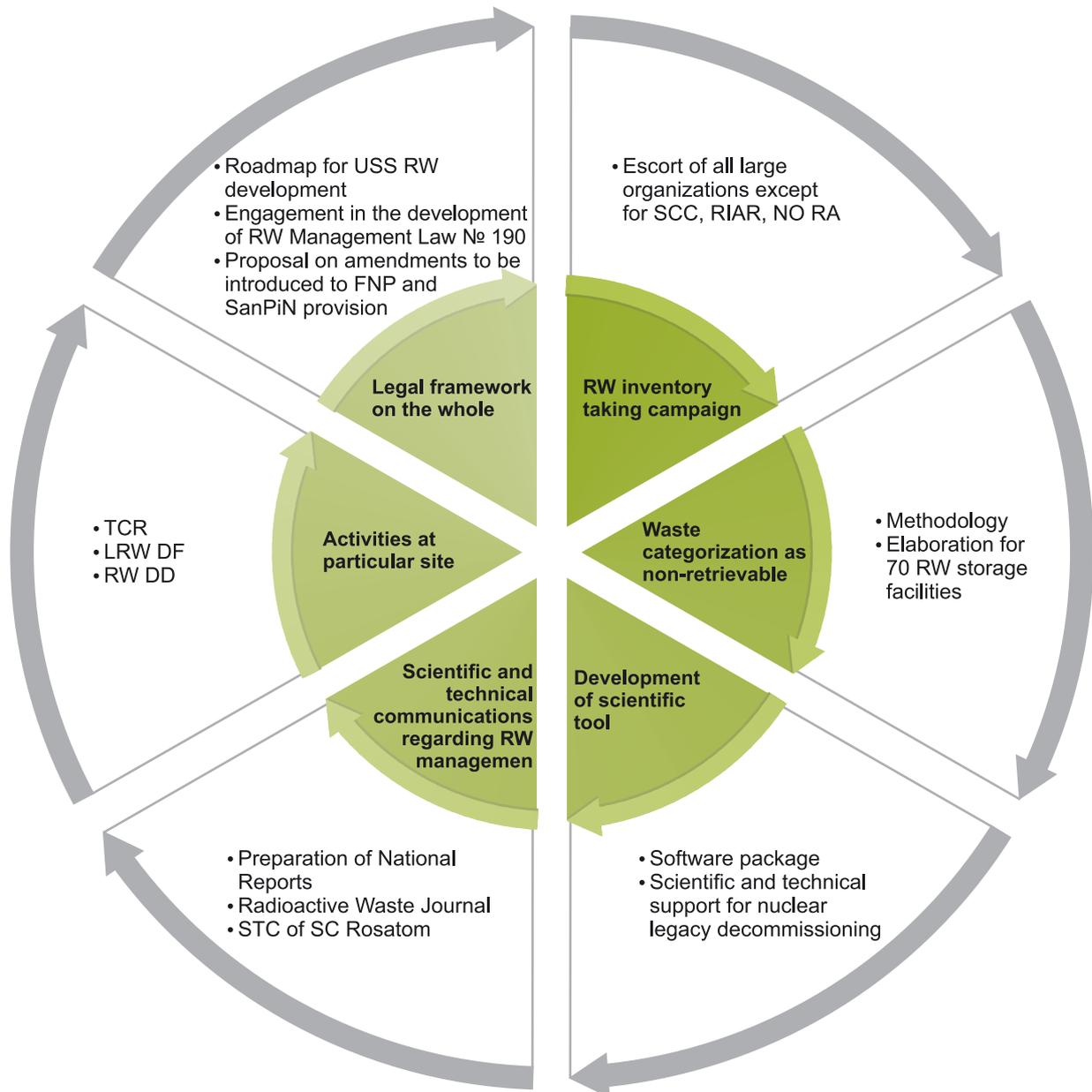


Figure 2. Main focus areas of IBRAE RAS in RW management

knowledge should be consolidated to address this matter. The letter explained that "...a few possible drawbacks can result from approval of ill-considered criteria and classifications. Firstly, thus, organizations are forced to bear unjustified costs providing no safety enhancement, which is in total disregard of radiation protection principles. In general, for the whole country it could account for many billions of rubles per year. Secondly, it would slow down the development of a modern RW management system. The time period during which Russian nuclear sector operation was accumulating RW was very long. Thus, its totally unreasonable to extend it further on. Many RW management aspects indicate that such operation supposing that nuclear back-end systems are not upgraded to the modern world standards significantly reduces its potential lifetime." Some important amendments

were proposed to be introduced to the document [9]. Due to time constraints, only one of them was considered in detail — namely, the one associated with waste categorization as liquid RW, which was eventually approved by the Government.

Since 2013, RW management matters addressed by the Institute under Government contracts has been defined by a number of factors (figure 2). Thus, it could be stated that the tasks assigned to the Institute are comprehensive in their nature and are aimed solely at optimizing the national RW management system according to safety criteria set for the current and future generations.

In general, basic approaches could be identified for each aspect of the RW Unified State System (USS RW) that IBRAE RAS proposes to indicate relevant long-term strategy, concept or tactics for future period.

Obviously, radiation protection principles shall be used in the development of USSR RW legal framework. Relevant long-term strategy is defined by provisions of the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management. List of main areas has already been compiled [10].

As for RW inventory taking and the state system for accounting and control, comprehensive information updating is required, i.e. data series enabling to attain the specified end result and arranged by time and origin shall be used in the analysis. It became evident that in-depth structured accounting shall be applied, for example, providing the elimination of waste accumulation in tailings and in packages and ready for disposal. The latter one is to a greater extent associated with liquid RW. The inventory taking campaign was completed, however, identification of some new RW seems to be inevitable, thus, requiring some additional processes to be run.

IBRAE RAS engagement in the methodology development for waste categorization as non-retrievable RW, as well as scientific and technical support of its application suggest that existing constraints on waste categorization as non-retrievable waste should be withdrawn. Thus, enabling to extend the potential for in-situ conservation of facilities, as well as providing an increased responsibility for unjustified RW categorization as retrievable waste [11].

As part of activities associated with scientific tools development (software, methods, data basis), the key approach suggests a transition to comprehensive demonstration of long term safety and economic feasibility. This work can be exemplified by the development of geomigration and geofiltration modelling tools (computer code GERA [12]) and thermal modelling for deep repositories (3-D finite element code FENIA [13]). IBRAE RAS also provides scientific and technical support of nuclear decommissioning activities for a number of legacy facilities (TCR, AECC, ChMZ, PDC UGR and etc.).

Certain facilities require that work planning and execution should be made considering the whole life-time of such facilities. To date, strategy for TCR transition to an environmentally safe state [4] has been defined, the necessity for closure concept development and specifying preliminary time schedules have been indicated for LRW deep well injection facilities [14], R&D strategy has been defined for the planned SRW deep geological disposal facility [15].

IBRAE RAS closely cooperates with main nuclear enterprises, leading international organizations and scientific and engineering centers, extends its open information network. Such interaction tools also include:

- Continuous involvement in the development of National Reports of the Russian Federation on the Compliance with Obligations of the Joint

Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management [16], engagement in IAEA and OECD NEA working groups and other international organizations;

- Establishment of Radioactive Waste Journal;
- Engagement of IBRAE RAS experts in Scientific and Technical Councils (STC) of the State Corporation Rosatom№ 5 and№ 10, Session№ 1 Environmental and Radiation Safety of RW Long-Term Storage, Non-Retrievable RW Disposal and Disposal Facilities of Rosatom's STC № 10, Russian Scientific Committee on Radiological Protection.

Conclusions

To conclude the brief overview of IBRAE RAS background in RW management, the main areas conditioned upon the history of its development and formation seems worth to be mentioned.

Development of a modern RW management system is considered to be critical for the long-term evolution of atomic energy and nuclear industry in Russia. Nuclear legacy challenges associated with actually accumulated RW inventory, as well as RW generated due to nuclear decommissioning and RW from SNF reprocessing are nevertheless topical.

At present time IBRAE RAS runs largescale multilevel basic and applied R&Ds in the field of RW management under Government contracts serving the interests of the State Corporation Rosatom, NO RAO, PA Mayak and other nuclear fuel cycle enterprises. In the short run, competence growth considering the above-mentioned areas of interest, availability of high scientific and engineering potential and its consistent enhancement will enable to extend the list of tasks and services addressed by IBRAE RAS's experts.

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