DOI 10.12737/article_59b10531b5b9a1.53751147

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REGULATION OF THE SPENT NUCLEAR FUEL MANAGEMENT AT THE ANDREEVA BAY SITE FOR TEMPORARY STORAGE ON THE KOLA PENINSULA

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Abstract

Purpose: To share the experience in regulation of radiation safety and protection of workers involved in management of the spent nuclear fuel (SNF) and radioactive waste (RW), as well as radiation protection of the population and environment in the vicinity of sites for temporary storage at Andreeva Bay on the Kola Peninsula.

Material and methods: Spent fuel from Russian nuclear powered submarines has been stored at shore based facilities for more than 20 years, notably at Andreeva Bay. The storage facilities were for some years poorly maintained and a significant fraction of the fuel that is still in store at the site was damaged. Over the last years, huge work has been done to improve the technical infrastructure and prepare for removal of the SNF from the temporary stores, management of existing RW.

Results: This paper presents progress with projects of the FMBA of Russia and NRPA cooperation for regulation of radiation safety and protection. During the researches, the following issues were addressed: radiological threat assessment to identify the priority directions of regulation; detailed analysis of the radiation situation on sites, at the territories and nearby the sites; radiation control and monitoring of the environmental conditions; development of the computer maps and geo-information system; emergency preparedness and response; improvement of radiation safety culture; etc.

Based on the received results of monitoring and assessment of the current risks, site-specific regulatory documents have been developed for the bodies and institutions under the FMBA of Russia involved in the activities to control the facility. Those documents include the requirements for radiation protection of workers and population; personal dose monitoring; the RW management including the very low level RW; implementation of the environmental monitoring; radiation monitoring nearby the Andreeva Bay SevRAO facility; and remediation of the sites as remediation criteria and regulations.

The next stage of work is to carry out the regulation of large-scale removal of SNF during 2017–2021 and its subsequent transfer to Mayak PA, and operations to bring the infrastructure of the site into the safe conditions, i.e., ecological remediation of the site – by 2025.

Lessons learnt from this work are being used in support of improved international recommendations and guidance on how to address legacy issues.

Conclusion: The experience accumulated during regulation of the remediation process of the former Naval Coastal Technical Bases has helped to identify new relevant areas of improvement of the regulatory supervision at nuclear legacy sites. The study of potential hazard of radiation exposure to the personnel during technological operations of SNF and RW management is very important issue. In this light, the regulator in cooperation of the operator should develop some effective and efficient activities for dose monitoring. When dealing with the protection of the population and environment, a methodology of comprehensive radiation and chemical monitoring should be developed and models of radiation and chemical risks should be improved taking into account features of contamination of the site under remediation. An important link of the social focus of the regulator and the operator is to improve strategies of public communications near legacy sites under remediation.

Key words: *spent nuclear fuel, radioactive waste, site for temporary storage, threat assessment, radiation protection and safety, radiation monitoring, regulatory supervision, remediation*

Поступила: 28.04.2017. Принята к публикации: 12.07.2017

Introduction

The site for temporary storage (STS) of spent nuclear fuel (SNF) and radioactive waste (RW) at Andreeva Bay on the Kola Peninsula in the Northwest Russia was originally commissioned in early 1960s as a shore technical base for the servicing of nuclear powered vessels of the Russian Northern Fleet. In 2000, responsibility for the site was given to Minatom, now called the State Atomic Energy Corporation, Rosatom. At the time, the condition of the facility's infrastructure did not fully meet the requirements for nuclear, radiation and environmental safety. As a response to this, an enterprise dedicated to dealing with the situation was created, and the site was re-designated as the Andreeva Bay STS, a branch of the Northwest Center for RW Management (SevRAO), under the Federal State Unitary Enterprise for Radioactive Waste Management (RosRAO) [1–3].

The Federal Medical Biological Agency (FMBA of Russia) as a federal executive body implements control and supervision in the field of health and epidemiological wellbeing of the personnel of the Andreeva Bay STS and the population living in the vicinity of the STS. FMBA of Russia regulates radiation safety and protection in this area jointly with the Norwegian Radiation Protection Authority (NRPA). In 2008, the Agreement was signed between the Russian Ministry of Health and Norwegian Ministry of Health in this field.

At the initial stage of work, in 2004, the State Research Center – A.I. Burnasyan Federal Medical Biophysical Center (SRC-FMBC) within cooperation with NRPA made an initial threat assessment [4]. In summary, the key threats were noted to arise due to:

- Poor information on the radiological and physical condition of SNF and RW in facilities at the site.
- Presence of defective SNF assemblies.
- Presence of radioactively contaminated ground and additional industrial buildings and structures used as temporary storage for RW that contribute to increased levels of man-made radionuclides and external radiation at the site.

- The need to develop and apply new technology and equipment renovate or replace old facilities for handling SNF and RW.
- Unsafe physical condition of a number of buildings and structures at the industrial site.
- The need to apply specialized personal protection equipment for use during radiation-hazardous work in open areas under adverse weather conditions typical of the Arctic area.

Radioecological radiation situation at the Andreeva Bay STS today

Since 2004 and up to now, SRC-FMBC has completed 25 collaborative projects devoted to regulation of radiation protection of workers, the public and environment, emergency response and preparedness and improvement of safety culture at the Andreeva Bay facility [5].

Substantial progress to address the above-mentioned threats [4] has included refurbishment of infrastructure and characterization and stabilization of the radiation situation inside relevant buildings and over the site generally. A clear example is provided below that illustrates the physical conditions in one of the dry storage units before (Fig. 1a) and after (Fig. 1b) installation of horizontal shielding consisting of three-layer steel slabs [6].

Figs 2a and 2b illustrate the improvement in radiation conditions. Such improvements have been necessary to prepare for removal of SNF being stored at the facility. Regulatory supervision of optimization in the design and planning of these operations has been a significant factor [6–8].

In order to monitor the changing exposure conditions and to improve capabilities in radiation protection of workers, an information and analytical system on radiation protection of workers was developed. The designed software tools help to reduce uncertainty in the assessment of radiation exposure during operations, i.e., to have more precise information of the potential radiation doses. This result is achieved by visualization of the radiation field and by the ability of creation of different scenarios and simulation on the computer with real-time assessment of radiation effects on participants of these works. The system includes a variety of visualization tools which supports understanding and communication of the radiation situation and training in operational tasks. Using this software it is possible to solve problems connected with accumulation of measured data, calculation of radiation fields, input of the personnel routes and basic radiation situation analysis. This in turn supports optimization of worker radiation exposure and efficient regulatory supervision of STS remediation works.

Crucial to safety during hazardous operations linked to SNF and RW recovery is the effective implementation of the software at STS Andreeva Bay. Given the heterogeneity of the radiation field and the changes with time that occur during construction and remediation works, an important aspect has been development of optimum techniques for interpolation between measurement points. Similar techniques have been used to better assess future dose rates linked to residual surface contamination levels. In addition, an improved overall picture of the radiation dynamics over the site has been built up [6, 8].

In addition to radiation survey in facilities and buildings, the ecological situation was assessed. The comprehensive study of the environmental conditions around STS Andreeva Bay and ecological assessment of the terrestrial ecosystems by bio-indication methods were carried out. This included measurement and laboratory analysis of environmental media collected, including gamma dose rate measurement at the industrial site and activity measurement of gamma emitting manmade radionuclides in the STS offshore water area, and chemical characterisation of ground waters. Results showed that work in preparation for SNF removal had not resulted in additional contamination of the industrial site and adjacent supervision area. The database for site environmental monitoring results was restructured to include the additional types of data obtained [9–11].

The biodiversity of species on-site the STS was assessed and an index of fluctuating asymmetry was estimated. Results indicated localized deviations from the norm for the region. The results for physical and chemical parameters of water samples taken from monitoring wells at the STS indicated exceeding of drinking water standards in some limited cases; however the water is not used for that purpose. Phyto-toxicity, cyto-toxicity and geno-toxicity of water samples were assessed using a standard alliums technique. Again, deviations from the expected norm were found in some cases [12].

The studies completed have laid the foundation for further research aimed at a dynamic assessment of the radiation situation on the site after SNF and RW has been removed. This work would contribute to long-term site management planning.

Development of the regulatory framework

Key developments in the field of radiation safety regulation at the Andreeeva Bay STS have included [5, 13, 14]:

- Criteria and standards for the remediation of sites managed by SevRAO contaminated by manmade radionuclides.

Fig. 1a

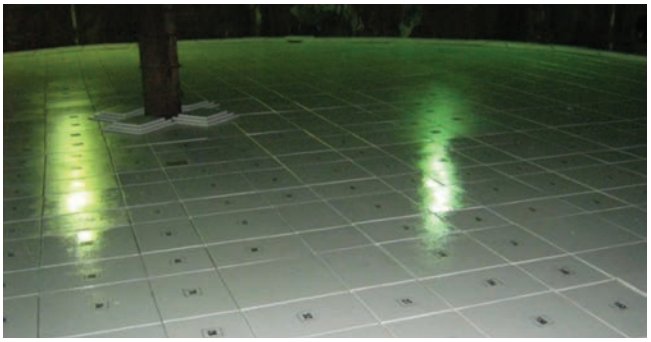

Fig. 1b

Fig. 1. View of interior of dry storage unit before (a) and after (b) installation of new shielding

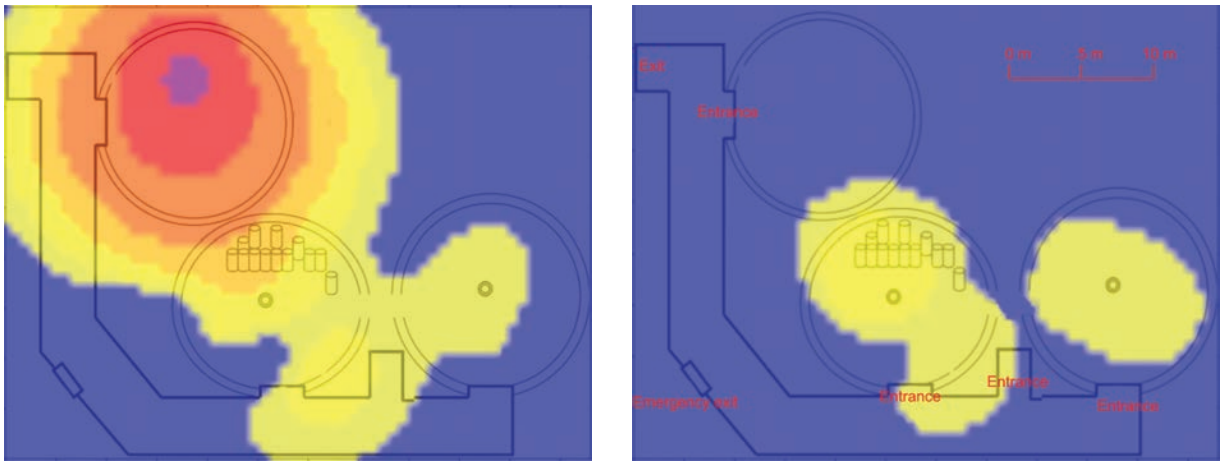

Fig. 2a

Fig. 2. Improvement in radiation situation from 2010 (2a) to 2012 (2b), key below

Fig. 2b

- Adaptation of the radiation dose record keeping system to facilitate safe working and dose control, taking account of high dose rates encountered.
- Application of an information and analytical system for prediction of doses to workers that would arise under alternative operational plans.
- Updated methodology for regulatory aspects of management of emergency planning and response, and related multi-organization training exercises.
- Development of a diagnostic informational system for pre-shift monitoring of individual performance reliability and annual medical and psychological examination of workers involved in critical hazardous operations.
- Training in and improvement of arrangements for emergency preparedness and response.

In parallel with the radiation optimization, procedures were put in place for managing wastes arising in the recovery and decommissioning activities, notably:

- Re-categorization of nuclear materials as RW at the enterprises of northwest of Russia. This addressed questions such as how small must a fragment of SNF be so as not to be regulated as nuclear material for safeguards and other purposes.
- Development of safety requirements for management of industrial waste that is radioactively contaminated at very low levels.
- Requirements for radiation protection of workers, the public and environment during arrangement of RW management at the Center of Conditioning and Long-Term Storage, the SevRAO facility at Saida Bay, also located on the Kola Peninsula.

Finally, procedures were developed for safety culture assessment and regulatory actions in case of its reduced level.

Collectively, the above developments reflect that holistic regulatory consideration has been given to the entire process of addressing the legacy at Andreeva Bay STS. For example, there is little point in proceeding with remediation and decommissioning activities if there is no strategy and regulatory basis for managing the wastes arising. This reflects the overall objective of the regulatory cooperation program, to build a deeply embedded and effective safety culture.

Highlights of technical improvements made under the enhanced regulatory regime, outline hierarchically in Fig. 3, had included by mid 2015 [14]:

- Solid RW had been removed from open storage and placed under cover.
- 359 m^3 of solid RW had been removed to the Saida Bay Centre – Long-Term Storage Facility.
- 292 spent fuel assemblies, out of a total of 22,000, had been removed by special train to PA Mayak for further management.

By this time, it was considered appropriate to update the threat assessment, so as to address any new and/or confirm continuing regulatory priorities. The main threat identified [10] was still the large amount of degraded SNF and RW, which are stored under improved but nonetheless, irregular conditions. To address these continuing issues, several projects were initiated within the regulatory cooperation program, which are just now being completed.

Organization of Emergency Exercise Based on a Hypothetical Radiological Accident at STS Andreeva Bay

The main objective was to assess the effectiveness of interactions among all participants involved in the process of training. In 2006, 2009 and 2016 three large-scale exercises were conducted with participation of many

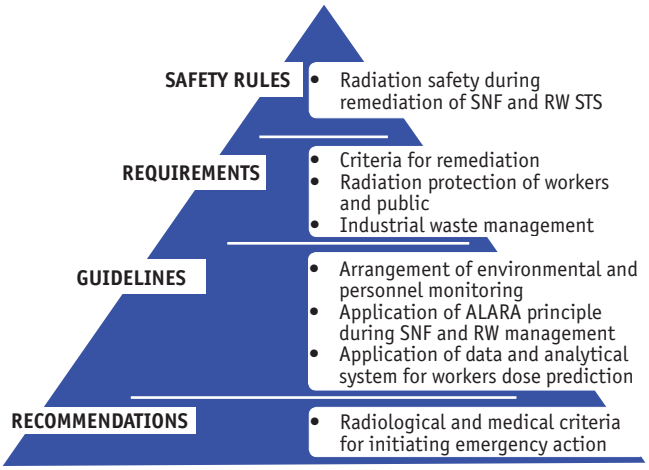

Fig. 3. Hierarchy of regulatory documents developed for Andreeva Bay STS

institutions and agencies, including regulatory and executive bodies and IAEA. An important outcome was the successful experience in the use of the computer simulation methods for the purpose of radiological assessment and minimisation of doses during implementation of emergency actions In addition, during the exercise, the procedure was tested for notification of IAEA and authorities in Scandinavian countries about an accident in real time [8, 15].

The exercise demonstrated the effectiveness of the accepted procedures and equipment for notification about the radiological emergency at the local, territorial and federal levels.

Areas of future work

Between 2017 and 2021 large-scale operations have been planned to be conducted at the Andreeva Bay STS facility, divided into the three stages:

1. SNF removal from the Dry Storage Facilities.
2. Removal of spent fuel assemblies from Building number 5.
3. Removal of RW accumulated during the previous operation of the facility and those being generated at the stage of SNF removal.

FMBA of Russia will regulate all these works of operator. At each stage of SNF removal the following researches will be carried out:

- Analysis of accepted design decisions and assessment of the compliance of the procedures of SNF removal implementation with the current regulatory documents;
- Evaluation of the radiation situation parameters at the main working areas;
- Occupational dose assessment;
- Development, jointly with SevRAO and territorial regulatory body under FMBA of Russia, of activities to optimize the occupational protection.

Sharing Experience

An important aspect of the bilateral regulatory cooperation program between FMBA of Russia and NRPA is the sharing of information with other interested organizations that are concerned with similar issues. It is recognized that this must be of mutual benefit to all concerned, learning from each other's experiences. Accordingly, NRPA and FMBA of Russia and partners have organized and documented several workshops looking at legacy and waste management issues, the two being so closely linked, as documented in [16]. With participation from the SRC-FMBC and FMBA of Russia, the U.S. EPA, U.S. NRC, and U.S. DOE, and many other national organizations as well as the internationally, the ICRP, NEA-OECD and IAEA, it was possible to bring together a very wide range of experience and expertise.

Our (FMBA of Russia & NRPA) bilateral activities served as a basis for establishment of the IAEA International Forum for Regulatory Supervision of Legacy Sites (RSLS). This Forum began its work in 2011 and operates successfully today. Taking into account that there is a lack of international recommendations or guidance on legacy site issues, the special technical document will be issued. The key aspects of the Forum RSLS activity and other issues of nuclear legacy regulation are presented in [17]. Several examples of sites with problematic SNF and RW issues were discussed.

Another relevant and example of shared experience is provided in a recent report from the NEA addressing Management of Radioactive Waste after a Nuclear Power Plant Accident [18].

Issues arising at old storage sites like Andreeva Bay STS share some similarities with conditions in the long term after a major accident. The need for further international guidance was indicated on:

- the transition from emergency response (though existing exposure) situation to normal radiation exposure regulation;
- stakeholder engagement, with emphasis on later stages of recovery;
- communication processes, and
- how to address chemicals alongside the radiological risks.

Participants in the FMBA of Russia -NRPA bilateral cooperation program are involved in international legacy management activities, including Expert Group on Legacy Management of the Nuclear Energy Agency at the Organization of Economic Cooperation Development.

Conclusions

The experience accumulated during regulation of the remediation process of the former Naval Coastal Technical Bases, has helped to identify new relevant areas of improvement of the regulatory supervision at nuclear legacy sites. The study of potential hazard of radiation exposure to the personnel during technological operations of SNF and RW management is very important issue. In this light, the regulator in cooperation of the operator should develop some effective and efficient activities for dose monitoring. When dealing with the protection of the population and environment, a methodology of comprehensive radiation and chemical monitoring should be developed and models of radiation and chemical risks should be improved taking into account features of contamination of the site under remediation. An important link of the social focus of the regulator and the operator is to improve strategies of public communications near legacy sites under remediation.

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DOI 10.12737/article_59b106429c5b80.00887618

Регулирование обращения с отработавшим ядерным топливом на пункте временного хранения в Губе Андреева на Кольском полуострове

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Реферат

Цель: Обзор опыта регулирования радиационной безопасности персонала, участвующего в операциях по обращению с отработавшим ядерным топливом (ОЯТ) и радиоактивными отходами (РАО), а также населения, проживающего в районах расположения пункта временного хранения (ПВХ) ОЯТ и РАО в Губе Андреева на Кольском полуострове, и защиты окружающей среды на близлежащих территориях.

Материал и методы: На протяжении более 20 лет ОЯТ с российских атомных подводных лодок хранилось на береговых технических базах, в частности, в Губе Андреева. Со временем состояние хранилищ ухудшилось, и значительная часть ОЯТ, которое все еще находится в хранилищах на площадке, была повреждена. За последние годы была проделана большая работа, направленная на улучшение технической инфраструктуры на территории ПВХ, обращению с имеющимися РАО, подготовку к вывозу ОЯТ.

Результаты: Показаны достижения в работе по проектам сотрудничества ФМБА России и NRPA, направленным на регулирование радиационной безопасности. Исследования проводились по следующим направлениям: радиологическая оценка угроз для определения приоритетных направлений регулирования; подробный анализ радиационной обстановки на объектах и прилегающих территориях; радиационный контроль и мониторинг состояния окружающей среды; разработка электронных карт и геоинформационной системы; противоаварийная готовность и аварийное реагирование; повышение культуры радиационной безопасности и др.

Полученные результаты мониторинга и оценки текущих рисков послужили основой для разработки регулирующих документов, которые предназначены для органов и учреждений ФМБА России, осуществляющих контроль и надзор за деятельностью предприятия СевРАО. Эти документы содержат требования к: радиационной безопасности персонала и населения; индивидуальному дозиметрическому контролю; обращению с РАО, включая особо низкоактивные РАО; проведению экологического мониторинга; радиационному контролю в районе расположения предприятия СевРАО в Губе Андреева; реабилитации территорий в виде критериев и нормативов реабилитации.

Следующим этапом работы станет регулирование процесса широкомасштабного вывоза ОЯТ в течение 2017–2021 гг., его последующая транспортировка на ПО «Маяк», а также дальнейшая работа по приведению инфраструктуры объекта в безопасное состояние, т.е. проведение экологической реабилитации территории вплоть до 2025 г.

Уроки, извлеченные из этой деятельности, используются для обеспечения соблюдения современных международных рекомендаций и руководств по решению вопросов обращения с ядерным наследием.

Выводы: Опыт, накопленный при регулировании процесса реабилитации бывших береговых технических баз ВМФ, позволил определить новые актуальные направления совершенствования регулирующего надзора на объектах ядерного наследия. Важным является изучение потенциальной опасности облучения персонала при выполнении технологических операций по обращению с ОЯТ и РАО. В этой связи регулятору совместно с оператором необходимо разработать эффективные и действенные мероприятия по контролю доз. При решении вопросов обеспечения защиты населения и окружающей среды необходимым является развитие методологии комплексного радиационно-химического мониторинга и совершенствование моделей оценок риска радиационной и химической природы с учётом особенностей загрязнения реабилитируемого объекта. Важным связующим звеном социальной направленности деятельности регулятора и оператора является совершенствование коммуникативных стратегий работы с населением, проживающим в районе расположения реабилитируемых объектов наследия.

Ключевые слова: *отработавшее ядерное топливо, радиоактивные отходы, пункт временного хранения, оценка угроз, радиационная безопасность, радиационный контроль, регулирующий надзор*

Поступила: 28.04.2017. Принята к публикации: 12.07.2017

REFERENCES See P. 15–16.