Key Radiation Protection Issues In Regulatory Supervision Of Nuclear Legacies

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Abstract: Safe management of nuclear legacies arising from past activities is a critical issue in maintaining confidence in the continuing and future use of radioactive materials. Effective and efficient regulatory supervision of nuclear legacy management is a critical part of that process. The Norwegian Radiation Protection Authority plays an active role in bi-lateral regulatory cooperation projects with parallel authorities in the Russian Federation and with countries in central Asia, as part of Norway's plan of Action to improve radiation and nuclear safety. NRPA is also very active within the IAEA International Working Forum on Regulatory Supervision of Legacy Sites. Based on this experience and by reference to specific legacy sites and facilities, this paper presents some key issues relevant to regulation of radiation protection of nuclear legacies, including radiological characterisation of old and potential accident source terms, mechanisms for planning and control of radiation exposure during hazardous operations, emergency preparedness and response, understanding of local radionuclide migration and accumulation, and evaluation of potential public exposures in the short and long term. The relationship between setting of standards, prognostic assessment of impacts and the permitting of remediation activities is explored within the context of an overall strategy for legacy and radioactive waste management. Consideration is also given to arrangement of effective communication interfaces, important in the support of good decision making and the avoidance of the creation of new nuclear legacies. Some observations of important radiation protection and regulatory challenges relevant to legacy management are then discussed.

KEYWORDS: Legacy Supervision; Regulation; Optimization; Communication

1. Introduction

The Norwegian Radiation Protection Authority (NRPA) has been implementing a regulatory cooperation program in the Russian Federation for over 10 years, as part of the Norwegian government's Plan of Action for enhancing nuclear and radiation safety in northwest Russia. The focus of the work is remediation of nuclear legacy sites, notably the Sites of Temporary Storage (STS) for spent fuel (SF) and radioactive waste (RW) at Andreeva Bay and Gremikha, on the Kola Peninsula, and the management of radioactive waste produced in the remediation process, as summarised at IRPA12 in Sneve et al [2008]. Other examples of important legacy management which have formed part of the NRPA's regulatory cooperation program include the decommissioning and dismantling of Radioisotope Thermoelectric Generators (RTGs) [NRPA, 2007, Sneve et al, 2011] and of the Lepse SF and RW storage vessel [Sneve et al, 2000]. Following good progress of this work with Russian authorities, a similar regulatory cooperation program was set up with the regulatory authorities in Kazakhstan, Kyrgyzstan and Tajikistan. The first technical output, a threat assessment report examining and identifying regulatory priorities, was recently published as an NRPA report [Zhunussova et al, 2011]. This central Asia cooperation program has recently been extended to Uzbekistan. This paper presents some further information on recent progress in Norway's bilateral regulatory cooperation programs, with a view to illustrating the technical and regulatory complexities which NRPA has come to recognise during the course of this work. It then presents some observations of important radiation protection challenges relevant to legacy management.

2. Progress in Regulatory Cooperation Programs

The overall long-term objective of the regulatory cooperation programs is the enhancement of safety culture. This may sound rather soft and intangible, but the work done towards achieving this strategic objective is very practically orientated towards resolving specific issues at specific sites and facilities. The program includes cooperation with the key relevant Russian regulatory authorities: the Federal Medical-Biological Agency (FMBA), the Federal Environmental, Industrial and Nuclear Supervision Service of Russia (Rostechnadzor) and, most recently, the Directorate of State Supervision over Nuclear and Radiation Safety of the Ministry of Defence (DSS NRS). The project outputs have included appropriate regulatory threat assessments, to determine the hazardous activities which are most in need of enhanced regulatory supervision; and development of the norms, standards and regulatory procedures, necessary to address the often abnormal conditions at nuclear legacy sites. With the fundamental input of Russian technical support organizations, project outputs have been prepared and subsequently confirmed as official regulatory documents of the Russian Federation.

The work program has been fully and openly reported in comprehensive reports and scientific journals, as illustrated in NRPA [2005], Ilyin et al [2005], Simakov et al [2008], NRPA [2008], Shandala et al [2008a and b] Sneve [2008], and more recent references described below. The purpose in such publications is to promote sharing of information, discussion of the under-pinning science and dissemination of regulatory developments. We have found this is particularly important for projects which have an international dimension, which so many cold war legacy issues do, so as to engender confidence in the remediation process.

Recent and On-Going STS Projects

The focus of the continuing programme has been to support the application of the enhanced regulatory requirements and guidance outlined above, combined with regulation of RW management linked to the STS remediation activities.

Emergency Response Training Exercise, Gremikha. The goal of the exercise was the improvement of emergency preparedness of managerial systems, emergency teams and wider emergency response in case of a radiation accident at STS Gremikha. Emphasis was placed on practicing the interaction of emergency response organizations, when applying radiological countermeasures for personnel and Gremikha village residents under the framework of emergency planning and response decisions made by Rosatom and the FMBA. Accordingly, an emergency exercise was organized and carried out:

- to demonstrate and practice the operation of the managerial system and emergency response network;

- to practice the interaction between operator and regulator when making urgent decisions and recommendations applying countermeasures action for personnel and the public, and
- to develop recommendations for necessary countermeasures for improvements.

The exercise took place took place successfully in June 2009, despite the difficult weather conditions at the time and the remoteness of the location, making the exercise all the more realistic.

DATAMAP: Radio-ecological mapping at Andreeva Bay. The main idea of the project was to integrate all relevant radio-ecological data, i.e. radiation situation parameters, landscape information, and hydrogeological as well as geochemical data, within maps of the STS area at Andreeva Bay. A geo-information system has been developed allowing:

- analysis of the current radio-ecological situation at STS, e.g. to identify areas which require remediation and or further data sampling to ensure adequate control;
- prognosis of changes of radio-ecological situation, e.g. due to radioactive decay and migration of contamination from its current location, and
- optimization of radiation monitoring and methods of remedial work implementation.

The geo-information system is intended for regulatory and supervision bodies, operators and for persons involved in processes of STS remediation in Andreeva Bay.

DOSEMAP: Mapping of radiation situation in workshops. The primary objective of this project was to support the control and planning of personnel radiation exposures protection in the course of remediation work, including particularly hazardous SF and RW removal activities. A mapping system has been developed allowing:

- Analysis of the radiation situation inside workshops;
- Calculation of internal and external radiation exposure linked to particular assumptions for remediation operations, for example to identify optimal routes for movement and transfers, and
- Recording of radiation exposures of individuals involved in the work.

Recommendations were also developed for operators of the STS on application of the developed databases for planning and optimization of radiation hazardous operations.

Radiation Protection Requirements for the Saida Bay Centre of Conditioning and Long-term Storage of RW. In the course of STS remediation, SF is planned to be removed for processing at PA "Mayak", while RW generated from such work and past activities, and from dismantlement of nuclear submarines, is planned to be located for storage in the Centre of Conditioning and Long-term Storage of Radioactive Wastes at Saida Bay. The project objective was to develop the regulatory requirements for occupational, public and environmental protection assurance during arrangement and implementation of radioactive waste management at the Centre. Regulatory requirements were

developed, allowing for the better planning of RW management at the STSs, in preparation of RW for transfer to Saida Bay.

Personnel Reliability Management. It is well recognized that human factors are a significant contributor to causes of accidents. This project was to:

- analyze important occupational psychological and psycho-physiological characteristics of workers involved in SF management, and to study methods of their assessment;
- develop medical and technical requirements for an expert-and-diagnostic system of risk monitoring of performance reliability of persons involved in SF management;
- develop relevant criteria of persons with negative prognosis of their performance reliability on the basis of psychological and psycho-physiological information;
- develop hardware, software and informational tools for risk monitoring within the expert-and-diagnostic information system, and
- develop proposals for practical implementation of the system.

The relevant hardware and software tools have been developed and tested in an operational environment.

The above work is described further in NRPA [2011], alongside continuation projects on:

- practical application of the Mapping and Dose Databases,
- implementation of the Geo-Information System at Andreeva Bay, including enhanced prognostic assessment capability;
- practical monitoring of performance reliability and development of regulatory processes for monitoring of safety culture;
- improvement of whole body counting methods to control internal exposure to the SevRAO workers involved in the SNF and RW management in irregular situations, and
- harmonization of expert group approaches when elaborating emergency assessments and recommendations on medical and protective measures in case of radiation events.

Waste Acceptance Criteria at Saida Bay. In addition to the above work carried out primarily through cooperation with the FMBA, a further project has been completed to develop Guidelines to Re-categorize Nuclear Materials as Radioactive Waste. This work was set up in cooperation with the DSS NRS, but it was quickly recognized that other authorities would need to be involved in order to make any outputs coherent with the wider legacy and waste management strategy. The need for the guidance initially arose because of the potential for small fragments of SF to arise within RW during the course of remediation work at the STSs. The project resulted in new regulatory guidance issued jointly by jointly issued by the DSS NRS and FMBA on “Safety Provision while Managing Radioactive Waste Containing Nuclear Materials at the Enterprises of the State Atomic Energy Corporation Rosatom in the Northwest of Russia”. It comprised:

- Radiation-Hygienic Requirements for Provision of Safe Management of Products Containing Nuclear Materials, and
- Administrative Requirements Providing Safe Management of Products Containing Nuclear Materials, while Transferring them to the Category of Radioactive Waste.

In effect, the project has provided provisional waste acceptance criteria for the RW being delivered to the storage facility at Saida Bay. The work has also taken into account international recommendations and included a review of supervision practice in other countries, such as the justification and explanation of waste acceptance criteria for storage and disposal facilities.

Radioisotope Thermoelectric Generators. The NRPA regulatory support program has included support to the development of regulatory supervision over RTG decommissioning in cooperation with Rostechnadzor [NRPA, 2007]. That project resulted in the issuing of enhanced regulatory requirements and guidance concerning safety monitoring, emergency preparedness, physical protection and environmental impact assessment. A follow-up project has just been completed, to inform regional inspectors and operators, as well as representatives of controlling organizations and those rendering services, on regulatory requirements and procedures, and provide them with practical guidance on their application, with the focus on:

- Explanation of regulatory requirements and rules;
- Completion of full-scale threat assessments base to support licensing decisions;
- Enhancement of in-depth supervision over radiological safety and introduction of a new supervision approach as necessitated by reported RTG-related events, and
- Supervision over emergency preparedness.

Implementation of the project has included practical training and exercises.

Scientific Underpinning. NRPA sees that regulatory supervision needs to be thoroughly underpinned by science. NRPA therefore sees value in promoting strong links between regulators and researchers, by participating in workshops, such as those organised within the EC project: Strategy for Allied Radioecology (STAR). Projects within the regulatory support program with a strongly scientific objective have recently been set up, to investigate:

- internal exposure levels in population in Mayak PA area due to protracted exposure to long-lived nuclides, and
- to characterize the current status of icthyofauna in the Techa River.

International Engagement. Because the regulatory issues mentioned above are not unique to Russia or any other single country, advantage has been taken of technical exchange of information with

authorities in France, the UK and the USA, including, for example, a major workshop supported by NATO [Sneve and Kiselev, 2008], which included participation of experts from the IAEA and the International Commission on Radiological Protection. Most recently, NRPA has been active in helping to set up and participate in the IAEA'S International Forum for Regulatory Supervision of Legacy Sites (RSLS). The RSLS objectives include supporting:

- development of new regulations and regulatory guidance addressing unusual situations arising in actual legacy situations at specific sites;
- development of regulatory procedures for licence application review and for monitoring compliance with licence conditions in actual legacy situations at specific sites;
- application of methods for environmental impact assessment, so as to build confidence into prospective assessments of possible future situations;
- development of guidance and recommendations regarding the application of optimisation at the national strategic and site specific levels based on the practical experience from different countries and sites;
- development of international guidance on regulatory supervision of legacy sites, and
- peer reviews of regulatory supervision of remediation projects.

3. Recognition of Technical and Regulatory Complexity

The range of radiation and nuclear safety and security issues arising at legacy sites is very large, encompassing issues of worker, public and environmental protection in planned situations and in abnormal or possible accident situations. The condition of many of the facilities and the SF and RW is not in compliance with original requirements. That is to say, the normal situation at these sites is, generally speaking, abnormal. Therefore, even planned situations require special consideration and the development and application of new techniques and corresponding regulatory requirements and guidance.

A typical situation that can arise is that in order to avoid continuing degradation of an already poor storage facility, a hazardous operation has to be undertaken. Proper planning can reduce the risks and associated with the remediation operations, and, while not completely eliminating all risks, bring them to within acceptable bounds. However, the nature and scale of the existing hazard may indicate a degree of urgency. Early action may reduce continued degradation and avoid possible acute releases from acute failure of containment. However, the remediation action itself, may create its own accident risks, and lead to exposure of workers, or generate effluent discharges affecting the public and the environment, or generate a much larger volume of radioactive waste, or all of these things. This requires an effective prognostic assessment capability, which allows the implications of different management alternatives to be evaluated. In turn this has to rely on sufficient characterization of the source terms and of the environments into which radioactive material may be released. However, it

also needs to rely on clear and coherent guidance on radiation risks and their control within the context all the other legacy issues. Apart from radiation protection and radioactive waste, it has to be recognized that there are other physical and pollution hazards to take into account, such as asbestos, heavy metals and organic compounds.

As well as the generally understood issues of environmental and human health protection, there are also legitimate concerns over security, including the control of large sources and nuclear material. The security aspect adds additional constraints to the selection and justification of appropriate management decisions. The resolution of many of these legacy issues involves military and civilian authorities, including those involved in safety, security and environmental and human health protection.

To complete the picture, it is necessary to mention the challenge of fitting the management of these legacy sites and situations into still evolving international recommendations on radiation protection, waste management and so on, which in turn have implications for nationally based regulatory requirements. In Russia, for example there is a new Federal Law on the Management of Radioactive Waste, which was adopted by the State Duma on June 29, 2011, and approved by the Council of the Russian Federation on July 6, 2011.

4. Integration of Regulatory Effort and Communication Interfaces

The range of disciplines and relevant experts involved in all the different aspects of safety, and environmental and human health protection associated with legacy site supervision is very large. NRPA staff and their colleagues in sister organisations in Russian take the view that opportunities for cross cooperation between regulators have been relatively limited in the past and should be increased. The current practical work therefore is designed to improve such opportunities through joint technical meetings:

- between managers and shop workers;
- between different operators – e.g. waste producers and waste disposal organisations;
- between operators and regulators;
- between nuclear safety regulators, radiation protection regulators and other pollution and safety regulators;
- between scientists, policy makers and wider stakeholders; and between all of them and all of those mentioned above.

To support this, a joint standing committee of Russian regulatory authorities has just been set up, with the remit to:

- provide overall coordination of regulatory supervision of legacy sites within the context of the nation regulatory framework;
- investigate particular technical issues relevant to specific types of legacy, and
- develop enhanced processes for interaction, to address challenges which come up from individual sites.

The intention is to facilitate implementation of a national framework while also allowing evolution of that framework to be guided by on-site experience. This joint committee can then also be suitably informed so as to interact with the IAEA RSLS.

5. Radiation Protection and Regulatory Challenges in Nuclear Legacy Management

The material above seeks to illustrate the complexity of legacy management and the challenges which that complexity raises for regulatory authorities. One of the starting points for discussion within the IAEA RSLS was to understand what is meant by a {nuclear}[1] legacy site, bearing in mind that the IAEA safety and waste glossaries do not mention legacies. The approach was taken at RSLS to be inclusive and to adopt a working definition that a legacy site is a facility or area that has not completed remediation and is radioactively contaminated at a level which is of concern to regulatory bodies. The status of a site has implications for its radiological supervision, as regards, for example, whether it exposures at a site should be considered as existing or planned exposures, which in turn affects the application of reference levels [Hedemann-Jensen and McEwan, 2011].

NRPA's bi-lateral cooperation experience has shown us that it is vital that each regulatory authority has its own clear lines of responsibility and for those lines of responsibility to be clearly communicated to all stakeholders. This should be obvious, but our experience shows that it takes some time to develop a common understanding of legacy situations, so that those responsibilities can be recognised.

Optimization is a major feature of radiation protection, and includes consideration of economic and social factors, which raises difficult questions such as:

- How should regulators include economic and social factors in its decision making process, without being or appearing to be involved in political issues?
- How practically can you separate the scientific and the social value judgments?
- How should a regulator compare or balance short and long term risks to different groups of people, which assessment of options present as alternatives?

[1] Brackets are place around legacy here due of different uses internationally about the use of the term nuclear site. Some uncertainty may arise for example about if the term applies to uranium ore processing facilities.

- Assuming that one adopts the current advice not to use assessment of radiation doses to estimate health effects, how can a regulator, or anyone else, compare the radiological consequences with other human health consequences associated with legacy remediation options?

The questions raise their own challenges regarding the regulatory decision making process, such as:

- development of consistent protection objectives and regulatory approaches for radioactive and other contaminants, for humans, non-human biota and in special areas such as groundwater protection;
- corresponding development of consistent derived standards relevant to those protection objectives, and approaches for their assessment;
- development and application of transparent methods to support decisions on choices between options, and maintain a balanced and proportionate response to all risks, and
- improved communication of uncertainties so that decisions are taken on a risk informed basis.

Prospective radiological assessments are used to assess outcomes of alternative management options for legacies. Bearing in mind the uncertainties involved, through what process does a regulator evaluate the adequacy of the following:

- waste and contamination characterization;
- site and environmental characterization;
- model selection: conceptual and mathematical abstractions;
- data for use in models?

These challenges remain to be addressed by the joint standing regulatory committee and through working with the IAEA's RSLS.

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