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Enhancement of Regulatory Supervision of the nuclear legacy in northwest Russia: involving the military authorities

Statens strålevern
Norwegian Radiation Protection Authority

Reference:
Roudak S F, Sneve M K, Bulatov O R, Vasiliev A P, Malinkin V M Enhancement of regulatory supervision of the nuclear legacy in Northwest Russia: involving the military authorities. StrålevernRapport 2011:10. Østerås: Norwegian Radiation Protection Authority 2011.

Key words:
Cooperation on nuclear and radiation safety, Russian Northern Fleet, radiation protection regulations, removal of radioactive waste and securing spent nuclear fuel, radiation-hygienic monitoring, emergency preparedness and response, supervisory authorities, safety culture.

Abstract:
This report describes work carried out within the cooperation programme between the Norwegian Radiation Protection Authority and the Directorate of State Supervision for Nuclear and Radiation Safety of the Ministry of Defense of the Russian Federation performed in 2008-2009. It focuses on development of improved regulatory documents and supervision procedures for handling spent nuclear fuel and radioactive waste at facilities that are no longer used by the Russian Federation Navy but that are still under military supervision and control.

Referanse:
Roudak S F, Sneve M K, Bulatov O R, Vasiliev A P, Malinkin V M Enhancement of regulatory supervision of the nuclear legacy in Northwest Russia: involving the military authorities. StrålevernRapport 2011:10. Østerås: Statens strålevern 2011. Språk: engelsk.

Emneord:
Atom- og strålesikkerhetssamarbeid, Den Russiske Nordflåte, strålevernregulering, opprydning av radioaktivt avfall og sikring av brukt kjernebrensel, radiologisk overvåking, beredskap, tilsynsmyndigheter, sikkerhetskultur.

Resymé:
Rapporten beskriver arbeid som ble gjennomført i 2008-2009 som en del av myndighetssamarbeidet mellom Statens Strålevern og Statens stråle- og atomsikkerhetstilsyn i Det russiske forsvarsdepartementet. Arbeidet fokuserer på utvikling av normative dokumenter og tilsynsprosedyrer for håndtering av brukt brensel og radioaktivt avfall på anlegg som har blitt tatt ut av Russiske Føderasjon Flåtens tjeneste, men fremdeles er under militært tilsyn og kontroll.

Head of project: Malgorzata K. Sneve
Approved:

Per Strand, director, Department of Environmental Protection and Emergency Response

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Enhancement of Regulatory Supervision of the nuclear legacy in northwest Russia: involving the military authorities

A Collaborative Project of the

Norwegian Radiation Protection Authority

and

Ministry of Defence of the Russian Federation

Statens strålevern

Norwegian Radiation
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Østerås, 2011

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Executive Summary

The Norwegian Radiation Protection Authority (NRPA) has for some years been implementing a regulatory support programme with its sister authorities in the Russian Federation, as part of the Norwegian government's Plan of Action for enhancing nuclear and radiation safety in Northwest Russia. The programme has focussed on regulatory issues arising from the nuclear legacy sites in that area, notably the Sites for Temporary Storage of spent nuclear fuel and radioactive waste at Andreyev Bay and Gremikha, formally naval bases used for servicing and maintenance of nuclear-powered submarines of the Russian Northern Fleet. Previous outputs from the support programme have included regulatory enhancements, including the development of new norms and standards on worker, public and environmental protection during the planned implementation of remediation activities intended to address existing exposure situations, and in the event of accidents, to address emergency situations. The output also included regulatory guidance and procedures to support their effective and efficient implementation. The main regulatory authority involved in that legacy site component of the regulatory support programme was the Federal Medical-Biological Agency of Russia (FMBA), but support has also been given to the the Federal Environmental, Industrial and Nuclear Supervision Service of Russia and other regulatory authorities.

This report sets out the extension of that regulatory support programme to specifically take into account the roles and responsibilities of the Directorate of State Supervision over Nuclear and Radiation Safety of the Ministry of Defence of Russia (DSS NRS). The need for such an extension arises because, in common with other countries, the different aspects of regulation of nuclear and radiation safety are supervised by different organisations, and military aspects are dealt with separately from civilian. Furthermore, remediation of military legacy sites which are due for return to civilian control, and the management of radioactive wastes generated in the process, for storage or disposal either at the sites or elsewhere, are bound to involve both civilian and military authorities.

As progress was made with the planning and implementation of the site remediation programmes at Andreyev Bay and Gremikha, provision was made for the treatment and conditioning of the radioactive wastes arising and, where appropriate, for their long-term storage at new facilities at Saida Bay. This gave rise to an urgent need for the development of practical site specific rules and supervision procedures for the safe management of radioactive waste during all these activities. The arrangements are complex because of the wide range of activities involved and the changing responsibilities as materials move from military to civilian supervision.

The Norwegian Radiation Protection Authority has therefore been working with all the relevant authorities to support development of these further regulatory enhancements. Accordingly, this document describes a series of activites directed at resolving the complex regulatory responsibilities and interactions involved in radioctive waste management, the specification of the radiation protection requirements for safe management of wastes containing nuclear materials, and the specification of criteria for their acceptance for long-term storage.

The work has been carried out mainly by the Russian International Centre for Environmental Safety, in cooperation with other relevant technical support organisations. Account has also been taken of international recommendations and other national experience in the area of site remediation and waste management.

The work reported here provides the background and support for the key regulatory outputs of the programme. Specifically, these include new regulatory guidance 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", jointly issued by DSS NRS and FMBA, which incorporate:

- 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.

These results and regulatory outputs are a substantial step in the continuing co-operation programme between the Russian Federation and Norwegian regulatory authorities. Further cooperation with and between the different Russian Federation regulatory authorities is anticipated as legacy site remediation programmes are implemented.

Abbreviations

ASMRS	Automatic System of Monitoring Radiation Situation
CATU	Closed administrative-territorial unit
CCLS	Centre for Conditioning and Long-term Storage
CIMTSS	Container Inventory-Making and Temporary Storage Site
CPS	Control and protection system
DSU	Dry storage unit (tank)
DSS NRS	Directorate of State Supervision over Nuclear and Radiation Safety
FDCP	Floating dosimetric check point
FDCS	Floating dosimetric check station
FM	Fission materials
FMB	Floating maintenance base
FMBA	Federal Medical-Biological Agency
FMBC	Burnazyan Federal Medical and Biophysical Centre
FSUE	Federal State Unitary Enterptise
HLW	High level waste
ICES	International Centre for Environmental Safety, Russia
IDB	Integrated data bank
ILW	Intermediate level waste
ISF	Interim Storage Facility
LLW	Low level waste
LRW	Liquid radioactive waste
LSF	Long-term Storage Facility
MOD	Ministry of Defence
MED	Maximum equivalent dose
NIKIET	Research and Development Institute of Power Engineering
NM	Nuclear materials
NPP	Nuclear Power Plant
NRB	*Russ.abbr.from* “Norms (Standards) of Radiological Safety”
NRPA	Norwegian Radiation Protection Authority
NRS	Nuclear and radiation safety
NS	Nuclear service
PHW	Potentially hazardous works

PNHW	Potentially nuclear-hazardous works
PRHZ	Potentially radiation-hazardous works
PTS SRW	Pad for temporary storage of solid radioactive waste
RHF	Radiation-hazardous Facility
RMS	Radiating monitoring station
RC	Reactor compartment
RCCS	Regional Centre for Conditioning and Storage
RC LSF	Reactor compartments long-term storage facility
RF	Russian Federation
RU	Reactor unit
RW	Radioactive waste
SFA	Spent fuel assembly
SIR	Source of ionizing radiation
SMP	Strategic Master Plan
SNF	Spent nuclear fuel
SNF SF	Spent nuclear fuel storage facility
SRP	Spent removable parts
SRW	Solid radioactive waste
SRY	Ship-repair yards
SEC NRS	Scientific and Engineering Centre for Nuclear and Radiation Safety
STS	Site for Temporary Storage
SV	Surface vessels
SS	Surface ships
SSCR	Self-sustained chain reaction (criticality)
TA	Technical Assignments
TZ	Technical Assignment (*in Russian - TZ*)
TNT	*Russ.abr.from* ”transport tanker”
TSS	Technical Substantiation of Safety (*in Russian - “TOB”*)
TUK	*Russ.abr.from* “transport and storage container”
VLLW	Very low level waste

Contents

1 Introduction

Two coastal facilities of the Russian Navy, called Shore Technical Bases (STB) were constructed in the 1960s in the Northwest of Russia. They supported re-fuelling and servicing of nuclear-powered submarines, provided facilities for storage of fresh and spent nuclear fuel (SNF) and facilities for management of solid and liquid radioactive waste (RW). These STBs were located in Andreyev Bay and in Gremikha on the Kola Peninsula (see fig 1).

In the early 1990s, the operational use of the STBs was discontinued, and in 1998 the Russian government formally recognised the need to set up a programme for environmental remediation of the sites. In 2001 they were re-designated as Sites for Temporary Storage (STS) and responsibility for the management was handed over to Minatom, the Ministry of Atomic Energy, now reorganized as the State Corporation "Rosatom".

Subsequently, the Federal State Unitary Enterprise (FSUE) SevRAO was set up within Minatom (now Rosatom) to implement the remediation programme, with the two sites designated as Branch No. 1 (STS Andreyev Bay) and Branch No. 2 (STS Gremikha). Upon commissioning in 2006 of the first stage of the reactor compartments long-term storage facility (RC LSF) at a new site in Saida Bay, this was also transferred to SevRAO, and designated Branch No. 3. The facilities at Branch No. 3 are now being extended to provide for treatment and storage of much of the radioactive waste arising from the remediation programme, now termed the Regional Centre for Conditioning and Long-term Storage for Radioactive Waste (CCLS).

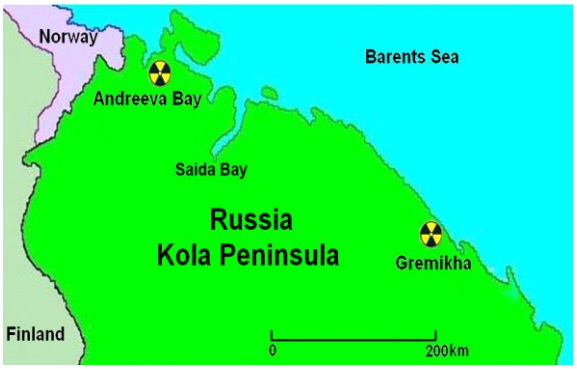

Figure 1. Location of the SevRAO sites on the Kola Peninsula

The main objectives of the remediation programme are the:

- safe recovery of spent nuclear fuel from the STS facilities, for removal to Production Association (PA) Mayak;
- safe dismantling of the facilities at the STSs;
- safe management of radioactive waste during these operations;
- restoration of the sites to meet environmental and human health protection objectives, and
- safe treatment and storage of conditioned solid radioactive waste at Branch No. 3.

Alongside SevRAO, a number of other enterprises in the Russian Northwest are engaged in supporting the management of spent nuclear fuel and radioactive waste. These are, specifically, FSUE "Atomflot", FSUE "Zvezdochka", and the "Nerpa" and "Sevmash" shipyards. These ship-building and ship-repair enterprises perform maintenance and dismantling of naval ships, as well as floating maintenance bases and nuclear service vessels (NSV). Additional solid radioactive waste is generated in northwest Russia by these enterprises.

The overall arrangements for regulatory control are complex because of the wide range of activities involved and the changing responsibilities as materials move from military to civilian supervision. It is also relevant that, as in other countries, the Russian Federation policy on radioactive waste management is evolving.

An important aspect of the situation on the Kola Peninsula is that, by the time the STBs were taken out

of operation, a substantial amount of spent nuclear fuel and radioactive waste had already accumulated. Furthermore, the storage facilities were in a degraded state and the details of the radioactive inventory and the condition of the wastes were not sufficiently known. The situation at the STS sites fell outside those required in normal conditions. To carry out rehabilitation of the STS, improvement of their infrastructure was required to support the safe performance of radiation-hazardous process operations and observance of the basic norms and regulations for protection of workers, the public, and the environment. In addition, because of the unusual nature and condition of the spent nuclear fuel and radioactive waste, and because site remediation of such sites was a new procedure, enhancements were required to regulatory requirements and guidance, and to regulatory procedures.

Within the NRPA regulatory support programme, a regulatory threat assessment was carried out and completed in 2005, to determine the priority areas for regulatory improvements [Ilyin et al 2005]. This work was followed up by more detailed independent regulatory investigation of the situation at the sites and the development of regulatory requirements and procedures, from the perspective of the specific responsibilities of the Federal Medical-Biological Agency of Russia (FMBA), as reported in Sneve et al [2007 and 2008]. Co-operation continues between the NRPA and FMBA, as reported in Sneve et al [2010].

As progress has been made with the planning and implementation of the site remediation programmes at Andreyev Bay and Gremikha, provision has been made for the treatment and conditioning of the radioactive wastes arising and, where appropriate, for their long-term storage at new facilities at Saida Bay, SevRAO Branch No. 3. This has given rise to an urgent need for the development of practical rules and procedures for the safe management of radioactive waste during all these activities.

This report describes the extension of the regulatory support programme to address the waste management issues, and to incorporate the roles and responsibilities of the Directorate of State Supervision over Nuclear and Radiation Safety (DSS NRS) of the Ministry of Defence of Russia. The need for such extension arises because, in common with other countries, the different aspects of regulation of nuclear and radiation safety are supervised by different organisations, and military aspects are dealt with separately from civilian. Furthermore, remediation of military legacy sites which are due for return to civilian control, and the management of radioactive wastes generated in the process, for storage or disposal either at the sites and elsewhere, are bound to involve both civilian and military authorities.

The scope of the work programme described was effective supervision to support nuclear and technical aspects of radiation safety as applied to the military nuclear legacy in the Russian Northwest, including spent nuclear fuel and radioactive waste treatment. This relates to especially dangerous operations which need to be executed during management of spent nuclear fuel and radioactive waste. In order to address these hazards, and to set them into context, initial tasks in the programme were completed by the end of 2008 with the objectives of:

- Exhaustive description and systemization of information on the issue of state supervision of nuclear and radiation safety in the Russian Federation in the field of nuclear energy use, as well as management of spent nuclear fuel and radioactive waste and rehabilitation of sites contaminated as a result of nuclear military activities.
- Identification of the main hazardous operations to be executed under the oversight of the DSS NRS and other supervisory bodies, assessment of the key hazards for definition of the most essential nuclear and radiation sources of hazard and identification of priorities for improving the regulatory oversight procedures.
- Development of suggestions to improve regulatory and methodical documents for some of the identified priority trends.

This work is described in sections 2 – 11.

Based on the results of these investigations, further work was carried out through 2009 (Section 13 – 15) to develop:

- 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 Radioative Waste.

English translations of the official Russian documents which were developed within the programme are provided in the Appendix.

The work was carried our through the Russian International Centre for Environmental Safety (ICES), with the close involvement of DSS NRS and FMBA, and with the technical cooperation of other technical support organisations, such as the Burnazyan Federal Medical and Biophysical Centre (FMBC) and the Research and Development Institute of Power Engineering (NIKIET), taking into account international recommendations and other national relevant experience.

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2 State regulation of radiation protection in the field of nuclear energy use and management of spent nuclear fuel and radioactive waste

Currently a well-shaped system of nuclear and radiation safety regulation, as well as personnel and population protection, has been set up and is in action in the Russian Federation (Fig 2.1).

2.1 Federal Service for Supervision of Consumer Rights Protection and Human Well-Being

The Federal Service for Supervision of Consumer Rights Protection and Human Well-Being (Rospotrebnadzor) is an authorized federal executive authority, which carries out functions of control and oversight in the field of provision of sanitary-epidemiologic well-being of the population, protection of consumer rights and consumer market, including management of natural sources of ionizing radiation, in all branches of industry, except for production of nuclear fuel, management of medical sources of ionizing radiation. Rospotrebnadzor is under the jurisdiction of the Ministry of Health and Social Development of the Russian Federation.

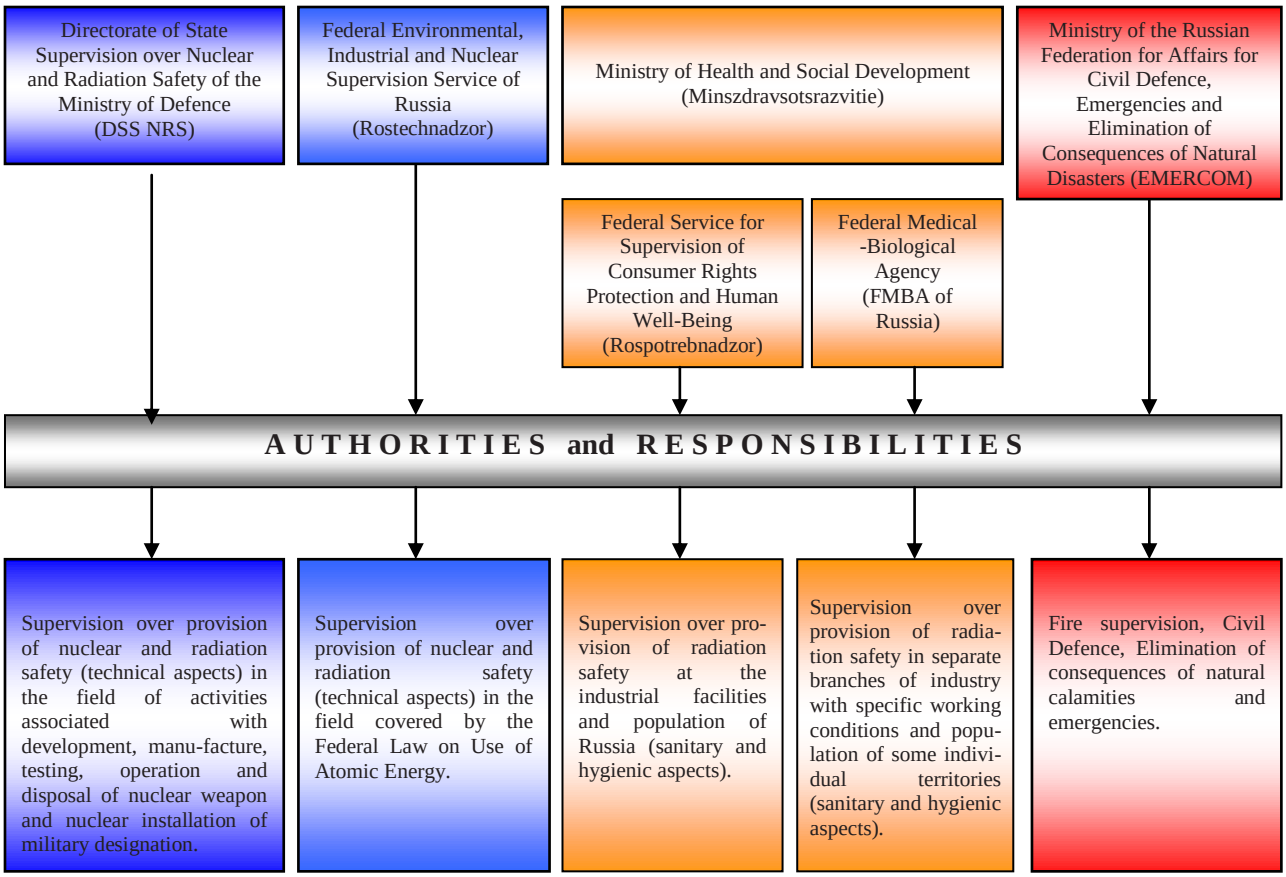

Fig.2.1.Overview of Russian radiation and nuclear safety regulatory authorities involved in management of spent nuclear fuel & radioactive waste

2.2 Federal Medical-Biological Agency

The Federal Medical-Biological Agency (FMBA) is a federal body, which carries out functions of control and oversight in the field of sanitary-epidemiological well-being which includes radiation protection and safety of the staff members of individual branches of industry with especially hazardous working conditions (including management of nuclear and radioactive materials at enterprises of Rosatom) and population of separate territories, medical-sanitary support of the workers of the serviced organizations and population of the serviced territories, rendering medical and medical-social assistance.

The FMBA is under the jurisdiction of the Ministry of Health and Social Development of the Russian Federation.

2.3 Federal Environmental, Industrial and Nuclear Supervision Service of Russia

Basic Provisions

The Russian Federation Government set up the Federal Environmental, Industrial and Nuclear Supervision Service (Rostechnadzor), a federal executive authority, to carry out the functions of approving regulative legal acts, control and oversight in the field of environmental protection in part referred to restrictions of the negative man-made impact; safe performance of works associated with the use of subsoil assets and their preservation; industrial safety; safety in the use of nuclear energy (except for the activities related to development, manufacture, testing, operation and disposal of

nuclear weapons and nuclear propulsion plants of military designation); safety of electrical and thermal installations and networks (except for the utility installations and networks); safety of hydraulic engineering structures at the industrial and power engineering facilities; safety of production, storage and application of explosives of industrial designation; as well as special functions in the field of state safety in the indicated field.

Rostechnodzor is the:

- State body regulating nuclear energy safety;
- Specially authorized body in the field of industrial safety;
- Body of state supervision of mining activities;
- Specially authorized body in the field of environmental protection (expert appraisal) in the identified field of activities;
- Body of state power engineering supervision;
- Specially authorized body in the field of atmospheric air conservation.

Rostechnadzor activities are managed by the Government of the Russian Federation.

Rostechnadzor is responsible within the context of the nuclear legacy supervision for passing the following regulatory legal acts in the identified field of activities:

- Federal norms and regulations in the field of nuclear energy use;
- Procedures to issue permits for the right to carry out work in the field of nuclear energy use;
- Requirements to the structure and contents of the documents referring to the provision of safety of nuclear installations, radiation sources, storage sites for nuclear material and radioactive waste, radioactive waste storage facilities and/or the currently carried out activities in the field of nuclear energy use required for licensing the activities in this field, as well as the procedure to carry out expert appraisal of the indicated documentation;
- Procedure to arrange and carry out supervision over the system of state accounting and control of nuclear materials;
- Requirements to registering the facilities in the State Register of hazardous industrial facilities;
- Procedure to draw up Industrial Safety Declaration of hazardous industrial facilities and the list of information included into it;
- Procedure to carry out engineering investigation of the reasons of accidents, incidents and cases of loss of explosive materials of industrial designation;
- Procedure to carry out expert appraisal of industrial safety and requirements to drawing up of the Review Resume of this Expert Appraisal;
- Requirements to the structure and contents of documents referring to the assessment of the man-made impact on the environment;
- Lists (cadastres) of facilities in relation to which technical norms of releases shall be defined;
- Procedure of issue and format of permits for releases of harmful (contaminating) substances;
- Calculation instructions to define the structure and amount of harmful (contaminating) substances released to the atmosphere;
- Methodical instructions for development of draft regulations (norms) of waste formation;
- Regulations for inventory-making of the facilities to accommodate waste and accounting regulations in the field of waste management;
- Issues permits and identifies limits for waste storage and disposal.

2.4 Ministry of the Russian Federation for Affairs for Civil Defence, Emergencies and Elimination of Consequences of Natural Disasters

Basic Provisions

Ministry of the Russian Federation for Affairs for Civil Defence, Emergencies and Elimination of Consequences of Natural Disasters (Emercom of Russia) is a federal executive body, which carries out the functions on development and implementation of the state policy, regulative & legal control, as well as supervision and control in the field of civil defence, protection of the population and territories from emergencies of natural and man-made nature and provision of fire safety.

The main tasks of Emercom of Russia are:

- Development and implementation of state policy in the field of civil defence, protection of the population and territories from emergencies;
- Organising development and approval of drafts of regulatory legal acts;
- Implementation of oversight (control);
- Implementation of activities for organization and support of civil defence, emergency response, protection of the population and territories from emergencies, including that outside the Russian Federation.

Emercom of Russia implements the following functions:

- Develops and submits to the President of the Russian Federation and (or) to the Government of the Russian Federation:

  - Draft plan of civil defence, proposals on formation of the fundamentals of the state policy;

  - Drafts of laws, other regulatory legal acts and drafts of engineering regulations;

  - Drafts of regulatory legal acts on overcoming consequences of radiation accidents and catastrophes, emergency humanitarian response;

- Develops and approves:

  - Regulatory legal acts on the issues related to the specified field of activities;

  - Statement about the system and procedure of monitoring and prediction of emergencies and information exchange;

- Organizes:

  - Work on prevention and elimination of emergencies of federal and trans-border nature, public and team rescue during these emergencies;

- Implements:

  - Supervision over execution of requirements on civil defence and fire safety as well as on protection of the population and territories from emergencies within its authorities;

  - State regulation of fire safety, related to nuclear energy.

Responsibilities

Emercom of Russia within its competence issues regulatory legal acts and other documents on civil defence, protection of the population and territories from emergencies, implements monitoring of their execution.

2.5 Directorate of State Supervision over Nuclear and Radiation Safety of the Ministry of Defence of the Russian Federation

General Provisions

The Directorate of State Supervision over Nuclear and Radiation Safety of the Ministry of Defence of the Russian Federation (DSS NRS) is a separate subdivision of the Ministry of Defence and is subordinated directly to the Chief of General Staff of the Armed Forces - First Deputy Minister of Defence of the Russian Federation.

The DSS NRS has the right to order scientific and research projects on nuclear and radiation safety, and physical protection of nuclear materials. For review of scientific and technical problems linked to provision of nuclear and radiation safety, and physical protection of the supervised facilities, the Directorate can engage research and development organizations and establishments of the federal executive authority.

While conducting its activities, the DSS NRS interacts with federal executive authorities, (which carry out state control of the activity and state regulation of safety in the field of nuclear energy use and management of radioactive waste), certain troops of the Armed Forces, and primary and central directorates of the Ministry of Defence. The procedure of interaction is defined by separate provisions approved by the leading managers of these federal bodies.

Applicability and Tasks

The DSS NRS is responsible for state oversight over:

- the condition of nuclear and radiation safety;
- physical protection of nuclear weapons, military nuclear installations[1], nuclear materials and their storage sites, radioactive substances, radiation sources, facilities for management of fresh and spent nuclear fuel, and radioactive waste; and
- the systems of accounting[2] and control of nuclear materials, radioactive substances and products based on them.

The following is assigned to the DSS NRS:

- Inspection of the supervised facilities;
- Analysis of the condition of nuclear and radiation safety, physical protection of facilities, regulatory basis in the supervised field and development of proposals on improvement of the system of safety of nuclear weapon and nuclear-propulsion plants, nuclear and radioactive materials and products based on them;
- Participation in the development of legislative and other regulatory legal acts of the Russian Federation and federal programmes in the field of supervision;
- Co-ordination of state standards, rules and norms in the field of supervision (except for sanitary-hygienic norms of irradiation and radioactive contamination);
- Co-ordination of the requirements for personnel training;
- Implementation of registration of the facilities;
- Participation in holding the uniform scientific and technological policy in the field of

[1] Hereinafter, the term nuclear installations means constructions and complexes with nuclear reactors developed and manufactured under the orders of the Armed Forces and operated for defence purposes, including stationary, mobile, floating and unit-type transport (mobile) military surface ships, submarines, deep water stations, space and flying vehicles, missile (air) engines; constructions and complexes with research and educational nuclear reactors, critical and sub-critical nuclear test-beds and prototype test beds; other constructions and complexes containing nuclear materials, mobile units, vessels and floating means for storage and transportation of nuclear fuel and nuclear materials.

[2] Except for the quantitative accounting of nuclear weapons and their constituents.

supervision and development of the state science and technology programmes on provision of nuclear and radiation safety;

- Obligatory participation in the activities of commissions and inspections on emergencies, incidents and events,;
- Deriving under the approved procedure of the required documents, information and references on the state of affairs in the supervised field;
- During inspections - listening to the officials of the enterprises, establishments, organizations, military units, military representations of the RF MOD on safety in the supervised field from the officials of federal executive authorities, military control bodies of the RF MOD, enterprises, establishments, organizations, military units, military representations of the RF MOD;
- Issue under the approved procedure of written permits for the supervised facilities on holding of separate potentially nuclear and radiation hazardous works;
- Control over execution of the issued prescriptions; and
- Prohibition of the supervised facilities to conduct works or operation in case of failure to meet the requirements of rules and regulatory documents on nuclear and radiation safety, physical protection, accounting and monitoring of nuclear materials, if it can result in accidents or emergencies, losses and plunders of nuclear materials, radioactive substances and products based on them, threat to life and health of the people, environmental contamination by radioactive substances;
- Sanctions towards supervised facilities who are not complying with existing regulations.

3 Analysis of regulatory supervision in the field of radiation protection of personnel and the public

The system of regulatory documents forms the basis of regulatory oversight. The regulatory documents system set up at the present time in Russia conceptually meets the internationally recognised regulating system for radiation safety, see Fig. 3.1. This hierarchy can be influenced at all levels by international agreements and treaties, international guidance and other national examples and working practices, but the structure itself and its contents fits entirely with that of the Russian Federation.

The top level regulatory documents on management of ionizing radiation sources, as seen from Figure 3.1, include Federal Laws on:

- Sanitary-Epidemiologic Well-Being of the Population
- Radiation Safety of the Population
- Use of Atomic Energy
- Technical Regulation

The first two laws regulate issues of human safety while managing of ionizing radiation sources. They define the basic criteria of safety and supervision system for its provision. The last two laws define engineering aspects of nuclear and radiation safety and the system to supervise its provision.

The next level ‘Regulatory documents’ is the responsibility of the appropriate ministries and services. Thus, responsibility for everything referring to regulatory documents and supervision of radiation safety in Russia is split in the following manner. The Federal Service on supervision in the field of protection of consumers’ rights and well-being of man (Rospotrebnadzor) is in charge of health

protection, while engineering issues of nuclear and radiation safety belong to the domain of Rostechnadzor and DSS NRS responsibilities.

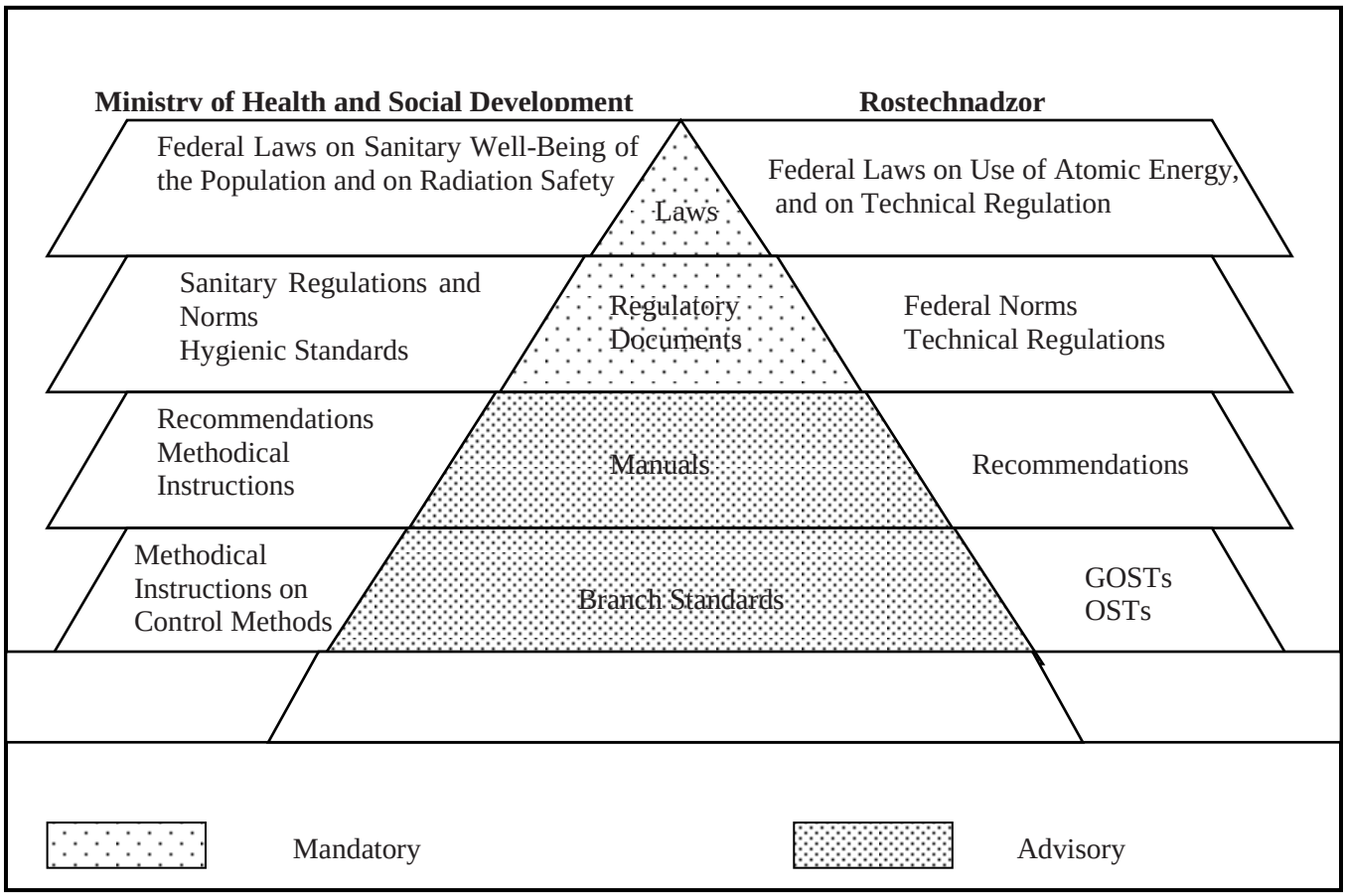

Fig.3.1.Hierarchy of Regulatory Requirements linked to Separate Authorities

The requirements for safety of facilities using nuclear energy, protection of the personnel and population, as well as environmental protection are defined by:

- Engineering and operational regulations;
- Federal norms and regulation in the field of nuclear energy use;
- Sanitary and hygienic regulations and norms;
- Rules and norms on fire and industrial safety;
- Regulatory legal acts on protection of the population and territories from emergencies;
- Regulatory documents regulating use of the natural environment;
- Requirements for construction materials, equipment and pipelines, steel structures, systems and components, buildings and constructions;
- Requirements for management of nuclear fuel, radioactive substances and radioactive waste;
- Requirements for physical protection; and
- Requirements for accounting and monitoring of nuclear materials, radioactive substances and radioactive waste.

It is legislatively defined, that while developing regulatory requirements, priority should be assigned to all aspects of the safety of mankind.

Radiation protection is regulated by the federal sanitary regulations in the Russian Federation. If it is required to take into account the specifics of defined hygienic, epidemiologic, ecological conditions and the condition of health of the population in the territory of the Russian Federation, federal sanitary regulations defined for this territory can be activated.

The sanitary regulations enacted by the Ministry of Health and Social Development of the Russian Federation are subject to state registration. The state registration and official publication of the sanitary regulations are carried out under the procedure approved by the legislation of the Russian Federation.

The period of validity of the sanitary regulations is defined in each case, but it shall be not more than 10 years, with an opportunity for extension by no more than 5 years.

Rostechnadzor implements regulatory control under the Federal law "On Use of Atomic Energy".

The federal norms and rules in the field of nuclear and radiation safety are formed by the Scientific and Engineering Centre for Nuclear and Radiation Safety (SEC NRS) of Rostechnadzor within the structure of the annual Complex Work Plan of Rostechnadzor.

Development and revision of the federal norms and rules are funded from budget and non-budget funds allocated to Rostechnadzor, as well as from federal target programmes.

The federal norms and rules are developed according to Technical Assignments (TA) on development generated by the developers.

The TA is agreed by the SEC NRS management and is approved by the management of structural subdivision of the central office of Rostechnadzor responsible for the appropriate direction of safety.

The DSS NRS within the framework of the methodical assistance to the licensees, develop a package of application documents and meet the conditions of the license validity, participates in engaging Rosatom to development of the following documents:

- Requirements for the structure and contents of the documents acknowledging feasibility of the license applicant to ensure meeting the requirements and conditions defined by the Statement about licensing activities on usage of nuclear materials, while conducting works on nuclear energy use for defence purposes (for nuclear propulsion plants and research nuclear energy plants);
- Requirements for the structure and contents of the documents justifying provision of nuclear and radiation safety; and
- Renewal procedure of the document acknowledging availability of the license granted by Minatom of Russia (now Rosatom) or the Federal Agency for Atomic Energy.

Availability of the subject of supervision by the Ministry of Health and Social Development (the FMBA of Russia) and Rostechnadzor causes the necessity to implement interactions of supervision of the radiation safety provision, which is carried out under the following directions:

- While developing proposals on improvement of the regulatory legal acts in the field of regulation of radiation safety, while using nuclear energy;
- While developing and applying federal norms and regulations in the field of nuclear energy use defined by the requirements to provision of radiation safety while using nuclear energy;
- At organization and implementation of the state supervision for provision of radiation safety, observance of federal norms and regulations in the field of nuclear energy use, development and implementation of measures on protection of the personnel and population in case of emergencies at these facilities and readiness of organizations (enterprises) to eliminate of their consequences;

- At identification of violations in the operation of facilities using nuclear energy, which impact radiation safety of these facilities and the population (including radiation emergencies); and
- Introducing the available information on the condition of radiation safety of the facilities using nuclear energy and the population.

4 Role, tasks and areas of responsibility for bodies in charge of state supervision in the field of nuclear energy use and management of spent nuclear fuel and radioactive waste

Supervisory functions are distributed in the following way: the Ministry of Health and Social Development bears responsibility for supervision in the field of radiation-hygienic aspects of safety, and Rostechnadzor, DSS NRS and Emercom for oversight of nuclear safety and engineering aspects of radiation safety in the sphere of their liability.

Rospotrebnadzor

The following responsibilities are assigned to the Rospotrebnadzor:

- Implements supervision and monitoring of compliance with legal requirements in the field of provision of sanitary-epidemiologic well-being of the population;
- Issues licenses for implementation of activities in the field of ionizing radiation sources applied for medical purposes;
- Maintains registers of
    - different types of products, ionizing radiation sources for medical purposes for the first time imported to the territory of the Russian Federation;
    - people injured by radiation impact and subject to exposure as a result of the Chernobyl and other radiation catastrophes and incidents;
- Identifies reasons and determines origination and spread of infectious diseases and mass non-infectious diseases, including those caused by ionizing radiation sources; and
- Organizes (under the approved procedure) support of social-hygienic monitoring, including radiation.

Federal Medical-Biological Agency (FMBA)

The following responsibilities are assigned to the FMBA of Russia:

- Identification and elimination of the impact of especially hazardous factors of physical (including radiation) nature on the health of the employees of the serviced organizations and population of the serviced territories;
- Medical-sanitary measures for prevention, identification of reasons, localization and elimination of the consequences of emergencies, radiation emergencies and incidents,
- Support of social-hygienic monitoring;
- Operation in the field of protection of the employees of the serviced organizations and population of the serviced territories from emergencies;
- Conducts expert appraisal of the projects of radiation-hazardous enterprises;
- Participates in licensing;

- Maintains registers of persons injured from the impact of especially hazardous factors; and
- Informs authorities and the population on the sanitary-epidemiologic situation and undertake measures on provision of the sanitary-epidemiologic well-being.

5 Differentiation of functions of state sanitary-epidemiologic supervision between Rospotrebnadzor and FMBA

As presented in the previous section, the sanitary-epidemiologic supervision carried out by the FMBA is a constituent of the sanitary-epidemiologic supervision executed by Rospotrebnadzor. However, its authority is limited to the enterprises, organizations and establishments defined by the special Resolution and Orders of the Government of the Russian Federation. As a rule, these are hazardous production facilities, which include all enterprises of Rosatom, as well as the territories adjacent to them and closed territorial formations, where these enterprises are located. The list of the supervised production facilities is revised by the Resolution of the Government of the Russian Federation.

The issues of supervision over safe management of natural ionizing radiation sources (except for uranium production facilities, sources of ionizing radiations used for medical purposes, as well as sources of ionizing radiations used in other branches of industrial activities) are under the supervision of Rospotrebnadzor.

When a radiation emergency occurs, the regional offices of the FMBA provide radiation-hygienic support to the workers of the enterprise and the population of the enterprise settlement. This includes investigation of the condition of environmental entities and regulation of the situation.

The radiation-hygienic support of the population in case of a major industrial emergency or a natural disaster is assigned to the regional offices of Rospotrebnadzor.

After evacuation of the population the radiation-hygienic support of those working in the impacted center, on elimination of consequences of the emergency or natural disaster, in area of the enterprise and its settlement is assigned to the territorial body of the FMBA. In the remaining territory the radiation-hygienic support in full scope, including monitoring of the radiation condition in the places of temporary accommodation of the evacuated population, is carried out by the territorial bodies of Rospotrebnadzor. The scientific and practical institutions of the FMBA render the required assistance to them.

As the sanitary-epidemiologic supervision carried out by the FMBA is a constituent of the sanitary-epidemiologic supervision of Russia, it is legally defined that the responsibility for the sanitary legislation in Russia is born by the State Sanitary Chief Inspector of the Russian Federation, who, as noted above, is the Chairman of the Rospotrebnadzor. The documents of the sanitary legislation include:

- Radiation Safety Norms (NRB-99) SP 2.6.1.758-99.
- Basic Sanitary Regulations of Radiation Safety Provision (OSPORB-99) SP 2.6.1.799-99.
- Sanitary Regulations of Radioactive Waste Management (SPORO-2002) SP 2.6.6.1168-02.
- Sanitary Regulations to Design and Operate NPP (SPAS-03) SanPiN 2.6.1.24-03.
- Hygienic Requirements to Design and Operate Nuclear Research Reactors (SP IR-03) SanPiN 2.6.1.23-03.
- Radiation Safety Provision at Inspections to Detect Failure of Radionuclide Sealed Sources (SP 1284-03) SP 2.6.1.1284-03.

- Hygienic Requirements to Restriction of Population Exposure to Natural Sources of Ionizing Radiation SP 2.6.1.1292-03.
- Hygienic Requirements to Provide Radiation Safety, while Collecting and Selling Metal Scraps SanPiN 2.6.1.993-00.

The sanitary regulations are the basic documents of the sanitary legislation. Quite often holding of effective supervision over provision of radiation safety needs a more detailed study, with reference to a specific branch or direction in the branch. These documents make up the next level and include guidelines, recommendations, and methodical instructions. The FMBA is the supervisory body and the right to approve such documents is granted to the Deputy Chairman of the FMBA.

It is legally defined that the regulatory legal acts referring to the issues of provision of sanitary-epidemiologic well-being of the population approved by federal executive authorities (including the FMBA), state standards, construction norms and regulations, safety engineering regulations, veterinary and phytosanitary rules should not contradict with the sanitary regulations. The inspections process is used to identify contradictions, which then are corrected by the operator.

When sanitary inspection reveals discrepancy to sanitary rules, it forbids this activity or operation until the discrepancy is eliminated.

The following documents on provision of radiation-hygienic aspects of safety at rehabilitation of the former coastal technical bases of the Northern Fleet have been developed and approved by the State Sanitary Chief Inspector of the Russian Federation:

- R 2.6.1.29-07 Hygienic Requirements to Provision of Radiation Safety of the Personnel and Population, while Scheduling and Arranging Works with SNF and radioactive waste in Branch No. 1 of FSUE SevRAO.
- R 2.6.1.25-07 Criterion and Standards for Rehabilitation of Territories and Facilities Contaminated by Man-made Radionuclides, Federal State Unitary Enterprise "Northern Federal Enterprise on Management of Radioactive Waste" of the Federal Agency for Atomic Energy.
- 2.6.5.04-08 Hygienic Requirements to Provision of Radiation Safety, while Management Industrial Wastes at Enterprise "SevRAO".
- Methodical Instructions MU 2.6.1.37-2007 Organization of Radiation Monitoring of Environmental Entities in the Field of Activities of the Federal State Unitary Enterprise "Northern Federal Enterprise on Management Radioactive Waste" of the Federal Agency for Atomic Energy.
- Methodical Instructions MU 2.6.5.6-08 Holdings of Individual Metering Control of Personnel Exposure at Branch No. 1 of FSUE SevRAO.
- Methodical Instructions on MUK Control 2.6.5.7-08 Procedure of Holding of Radiation Monitoring at Branch No. 1 of FSUE SevRAO.
- Methodical Instructions MU 2.6.5.05-08 Specifics to Apply the ALARA Principle, while Management SNF and radioactive waste in Branch No. 1 of FSUE SevRAO.
- Manual R 2.6.6.57-04 Radiation-Hygienic Requirements to Long-Term Storage Sites for Single-Compartment Reactor Units of Dismantled Nuclear-Powered Submarines.
- Methodical Instructions MU 2.6.1.11-06 Radiation-Hygienic Requirements to the Radiation-Monitoring System of Long-Term Storage Sites for Single-Compartment Reactor Unit.
- Methodical Instructions MU 2.6.1.32-01 Radiation Monitoring of Metal Scraps Generated from Dismantling of Nuclear-Powered Submarines.
- R 2.6.6.37-02 Hygienic Standards Defined for Works on Nuclear Powered Submarines Dismantling.

6 Differentiation of functions, while conducting state supervision of radiation safety provision at facilities of Rosatom between Ministry of Health and Social Development, Rostechnadzor and DSS NRS

To exclude duplication of the supervision functions in the field of state regulation of nuclear energy radiation safety, the following principles and provisions are defined:

Ministry of Health and Social Development implements functions of the body of state regulation of safety in part of regulation of radiation protection and safety of the employees of the facilities using nuclear energy and the public.

This Ministry:

- Develops, approves and enforces federal norms and regulations in the field of nuclear energy (sanitary norms, regulations and hygienic standards) regulating radiological aspects of radiation safety provision and (or) harmlessness to humans and defining admissible levels of ionizing radiation including:
    a. Exposure of personnel and the public from regular operation of facilities;
    b. Exposure of the personnel and population from radiation accident;
    c. Exposure of the workers of industrial enterprises and the population to natural sources of ionizing radiation;
    d. Medical exposure of the population.
- Organizes and implements state sanitary supervision of specified federal norms and regulations in the field of nuclear energy use (sanitary norms, regulations and hygienic standards).
- Organizes and conducts sanitary and radiation-hygienic expert examination of engineering documentation justifying radiation safety of the population, while nuclear energy is used.
- Defines the procedure and organizes and implements hygienic certification of products potentially hazardous to the population health.

Development and performance of implementation of the specified functions are carried out by FMBA and Rospotrebnadzor.

Rostechnadzor implements the state regulatory functions on radiation safety at the facilities using nuclear energy (except for generating sources of ionizing radiation), as well as regulation of nuclear and engineering safety of these facilities. Radiation safety here includes standard operation and violations of standard operation, including accidents, as well as the administrative measures aimed at restricting the radiation impact on personnel, the public and the environment, taking into account the defined limits.

Accordingly, Rostechnadzor:

- Organizes development, approval and enforcement of federal norms and regulations in the field of nuclear energy use including engineering and administrative aspects;
- Implements licensing of activities in the field of nuclear energy;
- Organizes and implements state supervision of compliance with the specified federal norms and regulations in the field of nuclear energy use;
- Conducts expert appraisal of safety of nuclear installations, radiation sources and storage sites; and

- Participates in organization and holding of works on certification of equipment, products and technologies for nuclear propulsion plants, radiation sources and storage sites.

The activity of DSS NRS on supervision of facilities, which manage radioactive waste in the Northwest region of the Russian Federation, is aimed at holding periodic inspections of these facilities. The skill level of the personnel directly participating in the works with radioactive waste is checked as well as readiness of personnel and equipment of the enterprise and the attached forces for operation in regular or emergency situations.

In accordance with the Statement approved by the Minister of Defence of the Russian Federation, the following functions are assigned to the DSS NRS:

- Inspection of the supervised facilities;
- Analysis of the state of nuclear and radiation safety, physical protection of the facilities, regulatory basis in the supervised field and development of proposals on improving the safety system of nuclear and radioactive materials and products;
- Participation in the development of legal acts;
- Participation in expert appraisals, inspections; and
- Participation in the activities conducted by inspections on emergencies, incidents and event, which occurred at the supervised facilities and are linked to provision of their nuclear and radiation safety.

The DSS NRS issues:

- Permissions to carry out potentially nuclear and radiation-hazardous works;
- Prescriptions on elimination of identified violations; and
- Prescriptions on suspension of works in case of continued violations of the defined requirements or if posing hazard to people and the environment.

The DSS NRS participates in licensing and inspection of enterprise activities. The inspection checks are conducted under the annual plans approved by the Management of the RF MOD and by the co-ordinated management of Rosatom and Rosprom. The plan includes lists of controllable issues and terms for carrying out the checks. Outline plans are made for a year and a detailed plan is made concrete for each checking procedure carried out.

The objective of inspecting an enterprise management radioactive waste[3] is identification of compliance with the requirements of the regulatory-engineering documents.

Alongside inspecting the condition of nuclear and radiation safety of the enterprise, inspections of the progress of eliminating the previously defined deficiencies may be carried out.

The DSS NRS issues resolutions on performance of the following nuclear and radiation hazardous works, while managing radioactive waste:

- Loading spent nuclear fuel onto railway trains;
- Dispatch of the trains with spent nuclear fuel;
- Re-loading (transfer) of spent nuclear fuel (containers and protective covers, and separate spent fuel assemblies) into the repositories and storage sites;

[3] The radioactive waste management system is understood as waste collection methods, periods of RW interim storage; storage procedure; conditioning, packaging and transportation of various categories of RW (low, medium- and high level); availability of the required spaces and equipments to manage RW; accounting of RW; and scope, intervals and methods of radiation monitoring. Besides this, training of personnel of the enterprises, while managing radioactive waste, is also checked in the context of radiation safety issues.

- Unloading of spent fuel assemblies (including defective ones) from spent nuclear fuel storage facilities;
- Transportation of radioactive substances and radioactive waste by roads of common use in a package of transport Category 3 (for which the level of irradiation in any point of the container outer surface is from 2 up to 10 mSv/h);
- Processing of radioactive waste at the supervised facilities;
- Loading of the first batch of radioactive waste into new storage facilities (re-commissioned upon reconditioning);
- Unloading of solid radioactive waste from storage facilities of radioactive waste with a view of disposal or reconditioning at storage facilities;
- Transfer of a batch of medium level and high level liquid and solid radioactive waste from the enterprise to other enterprises for processing, interim storage or disposal;
- Transfer of reactor compartments from military nuclear propulsion plant, or of compartments of a nuclear service vessel, for storage in the long-term storage site for reactor compartments from a ship repair yard;
- Performance of radiation-hazardous works in the buildings, constructions, spaces, sites, where the level of ionizing radiation is more than 12 μSv/h; and
- Construction, reconstruction or repair of new sections, spaces and workplaces intended for conducting nuclear and radiation-hazardous works at the operating nuclear and radiation facilities.

In the enterprises, handling of radioactive waste the DSS NRS implements state supervision at all stages of that work.

According to the Federal law "On Licensing of Separate Types of Activities" a Statement on Licensing Activities on Usage of Nuclear Materials, while Conducting Works on Usage of Nuclear Power for Defense Purposes' was developed and approved by the Resolution of the Government of the Russian Federation dated June 20, 2000 No. 471 (with revisions dated October 3, 2002).

Organizations with different forms of ownership carrying out activities on usage of nuclear materials, while holding operations on usage of nuclear power for defence purposes, are subject to licensing. As agreed with the DSS NRS, licensing of these organizations is conducted by the State Corporation "Rosatom". The licence is granted to the organizations for 3 years. Supervision of compliance the licensee of the licence requirements and conditions is carried out by the Directorate and a licensing body within their competence.

The DSS NRS participates in the review of the application documents submitted by the enterprise and issues a compliance conclusion on the structure and contents of the documents justifying provision of nuclear and radiation safety. The conclusions are sent to the licensee and the Federal Agency for Atomic Energy.

The Directorate keeps the Register of enterprises, who have obtained the licence of Rosatom. By the current moment the Register of the Northwest region includes 61 enterprises.

According to the Resolution dated 10.07.96 No. 357/135 on differentiation of the sphere of responsibilities at transportation of fresh and spent nuclear fuel between Rostechnadzor and DSS NRS, state supervision for nuclear and radiation safety is conducted by:

Rostechnadzor at stages of:

- Dispatch of trains to Mayak PA; and
- Dispatch of trains from Machine-building Works.

DSS NRS at stages of:

- Unloading spent nuclear fuel from trains at coastal technical bases and floating technical bases and its loading into containers;
- Transportation of containers with spent nuclear fuel; and
- Dispatch of spent nuclear fuel from fleets to Mayak PA.

Rostechnadzor and DSS NRS jointly at stages of:

- Arrival of trains to the fleets; and
- Dispatch of trains from the fleets.

Besides, the Resolution states that:

Rostechnadzor inspects RTP Atomflot and Lotta floating technical base;

DSS RNS inspects documentation on spent nuclear fuel;

Prior to starting the work, the following is checked jointly:

- Execution of paragraphs of the Engineering Regulations on export of spent nuclear fuel; and
- Readiness of Nerpa Ship-Repair Yard and personnel to localize and eliminate possible emergencies.

The permit for transfer of spent nuclear fuel to the supervised facilities is issued separately by Rostechnadzor and DSS NRS.

At the same time, DSS NRS uses in its supervision activities the regulatory-engineering documentation developed by Rostechnadzor.

Rostechnadzor also supervises compliance with norms and regulations in the field of industrial and ecological safety provision.

7 Basic stages and priority hazardous operations in spent nuclear fuel and radioactive waste management and rehabilitation of territories, intended for implementation in Andreyev Bay, Gremikha and Saida Bay

7.1 Basic stages of activities

To describe the basic stages of activity in the field of management of spent nuclear fuel and radioactive waste planned for implementation in Andreyev Bay, Gremikha and Saida Bay, one shall make use of the materials of the Concept of ecological rehabilitation of coastal facilities of the Northwest region, investment substantiation for the infrastructure of management spent nuclear fuel and radioactive waste in the territory of interim storage sites in Andreyev Bay, Strategic Master-Plan (Stage 2) [Russian Acadmey of Sciences, 2007], as well as other administrative and engineering documents, for example, as described in Sarsikov [2004]. These documents are required to be used alongside the current legislation of the Russian Federation, like the procedures for supervision by the regulatory bodies over nuclear and radiation safety.

Two basic stages of activity types in the field of nuclear energy use and management of spent nuclear fuel and radioactive waste intended for implementation at the facilities of the Northwest region should be identified.

These stages are:

- Preparatory stage, at which licensing of enterprises and organizations is carried out; and
- Stage of practical work, at which the supervision procedures by regulatory bodies are carried out.

The rehabilitation of STS for spent nuclear fuel and radioactive waste is significantly determined by the need to resolve problematic issues linked to development and implementation of technologies to handle spent nuclear fuel from nuclear powered submarines. To be safe for personnel, the public and the environment, the spent nuclear fuel should be packed into covers or containers of various types, but it is also necessary to take into account different types of solid and liquid radioactive waste at the facilities; decommissioning of storage facilities, buildings and other constructions; open sites for SRW storage; control of radionuclide release into the environment; and subsequent rehabilitation of the territory to acceptable levels of residual contamination.The basic problems associated with rehabilitation of STS and provision of their safety arise due to the fact that the infrastructure of these facilities is in an unsatisfactory condition, and requires restoration repair, reconstruction and modification. Conditions of accommodation and the mode of storing radioactive waste require development of special technologies in line with the requirements of the modern regulatory documents on radiation safety and international recommendations in the field of radiation safety. Inventory control of spent nuclear fuel and radioactive waste stored at the facilities is also required.

The top level stages of scheduled works at the spent nuclear fuel and radioactive waste STS include:

- Restoration and enhancement to the required standard of the STS infrastructure;
- Rehabilitation of buildings and constructions (renovation, conservation, elimination);
- Management of spent nuclear fuel and radioactive waste; and
- Ecological rehabilitation of the territory to meet the allowed levels of impact at industrial sites.

The top level stages of scheduled works at Saida Bay are:

- Management (accommodation, storage, and subsequent dismantling) of reactor compartments from dismantled nuclear powered submarines and surface ships; and blocks of spent nuclear fuel and radioactive waste storage facilities of nuclear service vessels; and
- Management of radioactive waste.

The main decisions and programmes of work on environmental rehabilitation of facilities and corresponding to territories can be updated based on the conducted feasibility studies and justifications in view of the supposed use of the facilities and territories, specificiates of their location, condition of their infrastructure, volumes of the accumulated spent nuclear fuel and radioactive waste, as well as other defining factors.

All basic aspects of works conducted at rehabilitation of spent nuclear fuel and radioactive waste sites for temporary storage should be conducted under supervision of nuclear and radiation safety by the regulatory bodies.

On the basis of the conducted analysis of the condition of facilities and planned works, and in order to review the issues of organization and supervise procedures, it is expedient to identify the following basic planned stage measures:

Spent Nuclear Fuel and Radioactive Waste STS's at Andreyev Bay and Gremikha

- Restoration and enhancement of the general infrastructure;
- Restoration and enhancement of the infrastructure for management of spent nuclear fuel and radioactive waste;
- Management of spent nuclear fuel with a view of its export:
    - Management of spent nuclear fuel in storage facilities;

- Management of spent nuclear fuel in containers on open sites;
- Management of spent nuclear fuel fragments in Building No. 5.

- Management of solid and liquid radioactive waste;
- Rehabilitation of Building No. 5;
- Rehabilitation of other buildings and constructions;
- Rehabilitation of the territory;
- Rehabilitation of the harbor area;
- Provision of nuclear and radiation safety at all stages of operations; and
- Management of toxic waste.

Reactor compartments long-term storage facility and Regional Centre for Conditioning and Long-term Storage of Radioactive Waste: SevRAO Branch No.3

- Construction and commissioning of the reactor compartments long-term storage facility (RC ISF) in Saida Bay;
- Construction and commissioning of the Regional Centre for Conditioning and Long-term Storage (CCLS) of Radioactive Waste;
- Accommodation and storage of single compartment units of reactor compartments;
- Accommodation and storage of units from spent nuclear fuel storages of nuclear service vessels;
- Accommodation and storage of units from spent nuclear fuel storages for reactor compartments of surface ships with nuclear propulsion plants;
- Accommodation and storage on a special site (facility) of units from damaged nuclear powered submarines;
- Accommodation and management of radioactive waste at the CCLS (facility operation):
  - Management of SRW arriving from other facilities of the region;
  - Management of LRW generated from operation of the Regional Center;
  - Accommodation and storage of high level waste in special storage facilities of the Regional Center;
  - Long-time storage of SRW in storage facilities of the Regional CCLS; and
- Dismantling of reactor compartment units and nuclear service vessels, surface vessels with nuclear propulsion plants, and management of generated radioactive waste.

The listed stages of conducted and planned works are formulated for definition of the basic hazards and development of proposals on improvement of the regulatory legal and methodical basis of the DSS NRS.

At subsequent stages of the work their details will be given with a view to identification of the basic hazardous works, which should be carried out at the specified stages under the supervision of the DSS NRS and other supervisory bodies on the basis of analysis of the information regarding priority projects at decommissioning of the facilities and rehabilitation of the territories (first of all at the Site for Temporary Storage in Andreyev Bay) and linked to execution of especially hazardous works.

7.2 Rehabilitation Objectives and Tasks

Rehabilitation of on-shore areas, radiation-hazardous buildings and facilities, adjacent off-shore areas up to the approved level of the radiation impact on the personnel, population and environment includes:

- Complete export of the accumulated spent nuclear fuel from the STS area;
- Collection and processing of radioactive waste (both accumulated and generated due to remediation activities) with its subsequent location in the STS and/or disposal;
- Decontamination, conservation of the infrastructure facilities and making them environmentally friendly; and
- Remediation of the whole on-shore area and separate parts of the off-shore area so as to meet the approved levels of the radiation impact at the industrial sites.

The ultimate goals have been set forth with due regard to the predicted development and use of the facility and its support infrastructure, also taking account of possible options of spent nuclear fuel and radioactive waste management.

The main tasks are as follows [Russian Academy of Science, 2007]:

- Execution of preparatory measures to ensure nuclear and radiation safety, personnel protection, and creation of the required conditions for STS remediation;
- Completion of comprehensive engineering and radiation surveys of the buildings, facilities, on-shore and off-shore areas, including inventory-making of the accumulated spent nuclear fuel and radioactive waste, construction (reconstruction) of the industrial infrastructure, heat and energy supply systems, physical protection, Automatic System of Monitoring Radiation Situation (ASMRS, *in Russian- ASKRO*), etc. required for provision of nuclear, radiation and environmental safety, as well as occupational safety of personnel, while at work;
- Development and enforcement of administrative and regulatory documents to ensure nuclear and radiation safety, environmental and medical-hygienic oversight of the on-shore facilities' rehabilitation, as well as specialized sanitary rules and regulations as applied to the addressed work conditions, including introduction of the category of "very low level" radioactive waste into special technical regulations and updating the rules to transfer nuclear materials to the category of radioactive waste;
- Construction of a spent nuclear fuel and radioactive waste management facility;
- Spent nuclear fuel unloading from cells of dry storage units, DSU (*also called "dry storage tanks" or "dry storage facilitie"*) and casks, its conditioning and export to a long-term storage site or for reprocessing;
- SRW removal from the existing storage facilities, including sub-surface ones, radioactive waste sorting and conditioning to make it fit for long-term storage;
- Decontamination, dismantling and export of equipment used at remediation works; and
- Decontamination of the affected on-shore area, off-shore local spots, and separate facilities of the STS with the subsequent environmental remediation.

7.3 List of Priority Projects

The List of priority projects for environmental remediation of STS was formed on the basis of the "*Concept of Environmental Remediation of On-shore Maintenance Bases of the Northern Region of*

Russia" and set out in the Strategic Master Plant (SMP) (Phase 2) [Russian Academy of Sciences, 2007]. This includes implementation of the on-going priority projects that had already been started or the commencement of which had been agreed with the investors, performers and Rosatom for the nearest time to come, as well as projects resulting from the Lists of top priority and priority measures defined in the SMP-2.

The presented List of priority projects (Table 7.1) has been compiled reflecting the present-day situation.

Table 6.1. Priority projects currently underway or planned, associated with implementation of especially hazardous operations.

No.	Description
	NPS; RU; SS, NSV
1.	Dismantling of the FMB "Lepse" spent nuclear fuel storage vessel.
2.	Construction of the 2nd line of the Saida on-shore site for long-term storage of reactor compartments.
3.	Construction of the 3rd line of the Saida on-shore site for long-term storage of reactor compartments (Regional Centre for Radioactive Waste Conditioning and Long-term Storage).
4.	Dismantling of Papa-class nuclear powered submarines No. 501.
5.	Dismantling of Alpha-class nuclear powered submarines No. 910.
6.	Scheduled dismantling of nuclear powered submarines in general.
7.	Preparatory works and de-fuelling reactors of nuclear-propelled surface ships.
8.	Dismantling of nuclear-propelled surface ships.
STSG (Site for Temporary Storage in Gremikha)	
9.	Trans-shipment of high level waste from BET8, BET4 and BET2 containers to shielding containers at SRW STS.
10.	Development of Conceptual Design and re-location of spent nuclear fuel and SRW from SRW STS and from the receptacles of Building to temporary shelters, including the choice of the optimum techniques to discharge water from Type 6 and Type 11 containers.
11.	Preparatory works to ensure nuclear and radiation safety.
12.	Management of spent nuclear fuel and radioactive waste from VVR (water-cooled water-moderated reactor), Alpha-class nuclear powered submarines.
13.	Management of high level radioactive waste. Development of facilities, equipment and tools to retrieve rod elements of the control and protection system from "problematic" containers.
14.	Design and construction of a plant to discharge water from Type 6 and Type 11 containers with minimization of secondary high level waste.
STSA (Site for Temporary Storage in Andreyev Bay)	
15.	Development of design documentation and a set of buildings and facilities to manage spent nuclear fuel and to prepare it for shipment from the STSA area.
16.	Development of documentation, acquisition of equipment and performance of works to rehabilitate the radiation condition in Building 5.
17.	Design development and renovation of the existing SRW storage facility.
18.	Development of design and fabrication drawings for construction of the radioactive waste

	reprocessing facility.
19.	Engineering and radiation survey of sub-surface SRW storage facilities, including LRW available in them.
20.	Spent nuclear fuel management in the group of buildings and facilities.

The List covers projects that address urgent issues of spent nuclear fuel management, first of all, those that envisage the performance of works for its preparation to export. Full data on the fuel status is unavailable, and various possibilities of its degradation do not give grounds for optimism for a simple technical solution.

Delay with performance of works will increase degradation of fuel that will result in an enhancement of the hazard at unloading spent nuclear fuel from cells and to essential increase in duration, complexity and cost of all works. Therefore it is appropriate to accelerate development of technology and the equipment for the prompt unloading of spent nuclear fuel providing for the safety of personnel and the environment.

The available experimental data demonstrates existance of the fuel spill and of its separate fragments both at the bottom of Building 5, and in the cells of DSU and in Type 6 containers in Andreyev Bay and in Gremikha. Fuel spill is also found in the spent nuclear fuel storage compartments of the "Lepse" spent nuclear fuel storage vessel.

To carry out operations of the STS Andreyev remediation, including collection of additional data on the spent nuclear fuel and radioactive waste status, survey of buildings and facilities where they are located, SRW and LRW management, partial remediation of the contaminated on-shore area and the adjacent off-shore area, first of all, one needs to set up appropriate conditions for the personnel compliance with the sanitary-hygienic requirements. To this end, the infrastructure components need to be restored or built anew, and safe performance of process operations and observance of the current standards, norms and regulations of the personnel and environmental protection need to be provided.

Also demanding are operations of SRW management. One of the basic tasks is completion of the radiation survey of the storage facilities, especially of sub-surface repositories. The results will serve as input data for choosing the concept of SRW management, of equipment and tools, as well as the basic technology. One should take into account that already at the very onset of the works to manage spent nuclear fuel in Building 5 (in STS Andreyev) much additional SRW is generated, including high level waste: cases made of stainless steel in which spent nuclear fuel is stored in the cells, containers with spent nuclear fuel at DSU, control and protection systems that are high level SRW, metal chains in Building 5 and plants processing LRW from the damaged storage ponds of Building 5. All this needs reprocessing and packing.

7.4 References for section 7

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8 Main sources of potential hazard and hazardous operations to be carried out under supervision of DSS NRS and other supervisory bodies

8.1 General Characteristics of Hazards for Identification of the Most Important Sources of Nuclear and Radiation Hazard

Accumulation of significant amounts of spent nuclear fuel and radioactive waste at unsatisfactory conditions of storage at the STS, as well as on-going activities of the companies engaged in spent nuclear fuel and radioactive waste management, generate a number of sources of nuclear and radiation hazards, specifically:

Sources of nuclear hazard

In STS in Andreyev Bay:

- Spent fuel assemblyes (SFA) stored in DSU;
- SFA stored in Type 6 containers installed in DSU;
- Fuel spill from damaged fuel elements in the DSU cells and in containers.

In STS in Gremikha:

- SFA stored in Type 6 and 11 containers;
- Spent removable parts (SRP) stored in storage facility of SRP (spent nuclear fuel);
- Unloading of SRP from a distressed nuclear powered submarines.

At FSUE "Atomflot":

- SFA from ice-breakers stored in TUK casks at the storage pad;
- Spent nuclear fuel at the storage pad (in-transit, from dismantled nuclear powered submarines, STSA and STSG);
- Floating Maintenance Base "Lepse".

Ship-building and Ship-repair Yards:

- Spent nuclear fuel from nuclear powered submarines reactors and surface ships with nuclear propulsion plants, stored in TUK casks.

Sources of Radiation Hazard

Three bodies of state regulation are responsible for regulation of radiation safety:

- FMBA is responsible for sanitary and hygienic provision of radiation safety;
- DSS NRS is responsible for technical provision of radiation safety;
- Rostechnadzor carries out development of regulatory documents.

The following facilities refer to the main sources of radiation hazard for the environment, the public and personnel:

At STS Andreyev Bay:

- Spent nuclear fuel DSU intended for spent nuclear fuel dry storage in cases, the major part of the cells being filled with ground waters;

- Building 5 - former spent nuclear fuel storage facility;
- LRW storage – regular and irregular storage;
- SRW storage facility;
- Open pads for SRW storage;
- Containers with SRW; and
- Spaces for SRW storage.

At STS Gremikha:

- SFA storage facility;
- Storage facility for spent removable parts;
- LRW storage facilities;
- SRW storage facility;
- Site for Temporary Storage of SRW**;**
- Floating tank for LRW storage; and
- Booster station for LRW receipt/shipment.

At Saida Bay:

- Site for storage of single-compartment reactor units from nuclear powered submarines;
- Site for storage of large-size SRW;
- Storage facility for conditioned radioactive waste;
- Trans-shipment shop;
- Raadioactive waste conditioning shop;
- Dismantling/sorting shop;
- Caissons for operations with radioactive waste; and
- Sites for container washing.

At FSUE "Atomflot"

- SFA trans-shipment during repair of nuclear-propelled vessels (mainly, ice-breakers) and their accommodation in TUK casks at the storage pad; and
- Spent nuclear fuel from ice-breakers and nuclear powered submarines at the storage pad, when in line with the reprocessing technology this spent nuclear fuel cannot be shipped to Mayak PA.

At the ship-building and ship-repair enterprises that perform repair and dismantling of naval ships and nuclear service vessels.

- Shop to repair support systems for nuclear propulsion plants of naval ships, nuclear service vessels, ice-breakers and nuclear powered submarines, as well as their dismantling;
- Shop for LRW re-processing within the structure of shipyards and enterprises having mobile units for LRW reprocessing, that are temporarily delivered to the yard for LRW conditioning and its conversion to SRW;
- Collection and transportation of SRW generated by dismantling and repair of ships and vessels, to Saida Bay for its reprocessing and conditioning with subsequent keeping in the

storage facilities for long-term storage in CCLS; and

- Site for temporary storage of single-compartment units till their shipment to the storage site in Saida Bay.

8.2 Major Hazardous Operations

To define the scope of problems and to develop the policy of regulatory supervision, it is presumed to be reasonable to single out from the whole scope of the priority projects those measures that contain hazardous operations, where criticality and/or excess of the regulated values for personnel and public exposure and radiation contamination of the environment may take place, while these operations are underway.

Such works are broken down into potentially nuclear–hazardous and radiation-hazardous works (PNHW and PRHW, respectively, and the general term is PHW).

Works related to the management of spent nuclear fuel, its damage and small fragments of fuel are nuclear-hazardous.

The operations conducted in the conditions of actual and potential radiation hazard where the radiation condition in the work site is such that the conservatively assessed individual effective dose of the employee may exceed 20 mSv per annum, are defined as radiation-hazardous works.

While planning such potentially-hazardous works, one should address all possible cases, including those associated with the human factor, assess potential hazards and envisage all required measures for deterministic prevention of criticality and measures to avoid the likely radiation risks and to mitigate their impacts.

Analysis of potential hazards associated with the existing situation at the facility allows to state the following:

- Works with spent nuclear fuel and radioactive waste at STS in Andreyev Bay and in Gremikha (in separate buildings, storage facilities and in the open pads there are local spots of radioactive contamination with elevated radiation levels) pose the maximum radiation hazard.
- In terms of magnitude of the potential radiation exposure, spent nuclear fuel that is stored in unsatisfactory conditions in Andreyev Bay and in Gremikha is comparable to the potential of decommissioned nuclear powered submarines. With due regard to the condition of the remaining shielding barriers at the nuclear powered submarines with the spent nuclear fuel still inside, one should admit that top priority works are to bring spent nuclear fuel at the STS to conditions complying with state of the art requirements for nuclear and radiation safety.
- Lack of information about spent nuclear fuel at the STS, including its exact amount, status and storage conditions present an essential blank spot that hampers decision-making about subsequent methods of its management. Therefore, the most important task was arrangement and performance of comprehensive engineering radiation surveys of the on-shore spent nuclear fuel storage facilities.
- The major source of potential hazard is spent nuclear fuel stored in STS, nuclear powered submarines, FMB and the civil fleet facilities such as FMB “Lepse”, “Lotta” and “Imandra”. The major hazard from them is posed by the spent nuclear fuel stored at STS and FMB “Lepse”.
- Based on the development and review of the scenario of various accidents and incidents, the likelihood of ships and vessels’ collision, their sinking, fire occurrence, criticality and flying vehicles followed by destruction of radiation-hazardous facilities and radioactive contamination of the environment has been assessed. It has been shown that the undertaken administrative and engineering measures enable the required reduction of the criticality

likelihood, while de-fuelling nuclear powered submarines and storing this fuel under the available conditions at the STS (See SMP-2 discussed in section 7.)

Based on the conducted analysis, the radiation-hazardous works planned on relevant objects in relation to organization and carrying out of procedures of supervision are presented below.

Spent nuclear fuel and radioactive waste site of temporary storage in Andreyev Bay

The radiation-hazardous works in Andreyev Bay may be broken down into the operations with spent nuclear fuel, its unloading from dry storage units, case-changing, preparation and shipment to Mayak and operations with radioactive waste, where predominant works will be those of the site remediation and radioactive waste preparation for shipment to the CCLS in Saida Bay.

As of today, spent nuclear fuel in Andreyev Bay is accommodated in three facilities – dry storage units (DSU) (See Figures 8.1, 8.2) and in Type 6 containers installed in one of the DSU facilities (See Figure 8.3). The spent nuclear fuel storage conditions in each DSU facility and in Type 6 containers have differences that define divergence in the de-fuelling technology and in management of spent fuel assemblies (SFA).

Figure 8.1. View of the roof of the DSU at STS in Andreyev Bay

Figure 8.2. View of the concrete roofing of the DSU at STS in Andreyev Bay

Figure 8.3. Containers installed in one of DSU facility

Depending on the duration and production specifications, all operations with spent nuclear fuel are broken down into a number of stages. Taking into account the timeline and technology of the work performance, while managing spent nuclear fuel, the following works refer to radiation-hazardous operations [Simakov et al, 2005a]:

- Dismantling of the available buildings (facilities) adjacent to the DSU;
- Transportation of containers with SFA from DSU to the shelter for buffer storage of the containers;
- Preparation of DSU for spent nuclear fuel retrieval and performance of measures to improve the radiation situation in DSU; and
- Unloading spent nuclear fuel from DSU and shipment to "Mayak".

Works with radioactive waste may be broken down into a number of stages. The view of the open pad for SRW in Andreyev Bay is shown in Figure 8.4.

At Phase 1 the engineering-radiation survey of the buildings, facilities, pads, and on-shore area of the facility are carried out. Based upon the survey results, the input data is summarized and design documentation on the facility remediation is developed.

The most complicated radiation situation is observed at the facilities where spent nuclear fuel has been and is being stored. The following process facilities belong hereto:

- Spent nuclear fuel storage facility – DSU ;

- Pool-type spent nuclear fuel storage facility – decommissioned Building 5.

Nowadays the fuel from Building 5 has been removed; the facility contains only intermediate level radioactive waste. The building itself and the equipment remaining in it are contaminated by radioactive substances.

The maximum equivalent dose (MED) measurements carried out by NIKIET specialists [Vasyukhno et al, 2004] in the industrial spaces of Building 5 and in the dry storage tanks have shown that the levels of dose rate of the external gamma radiation are hundreds of times higher than in the normal production spaces of the enterprises belonging to the nuclear energy engineering industries.

The admissible time of the personnel activities in the industrial spaces of Building 5 and DSU measured by specialists of FMBC [Simakov et al, 2005b] is limited based on the conservative approach (provided that during the whole shift the works have been carried out without protective measures). For instance, in the transport corridor of Building 5 the admissible work time before the personnel reach the annual effective dose limit of 50 mSv does not exceed 104 work shifts, while working in medium levels of MED, and 52 work shifts in the maximum MED levels. The admissible time of the personnel stay in the process room of Building 5 and in the DSU spaces is even shorter.

The major contributor to the effective dose is external gamma radiation. The share of the neutron radiation is negligibly small.

While conducting construction works, especially at demolition of old facilities (Building 5, DSU), one needs to carry out radiation-hazardous works.

Taking into account essential amounts of the arising intermediate and low level radioactive waste in spent nuclear fuel and radioactive waste site of temporary storage, production facilities are set up for on-site radioactive waste reprocessing, conditioning, and preparation for shipment to the regional centre, CCLS. This also creates the need to conduct radiation-hazardous works. The scope of these works is even higher, while managing HLW.

The HLW is mainly absorber rods of the control and protection system, traps of activity filters with sorbents, and some elements of the reactor structures. Cartridges with the absorber rods of the control and protection system (CPS) retrieved from the reactor upon completion of the core operation comprise the major share of all accumulated HLW.

Figure 8.4. View of the SRW open pad in Andreyev Bay.

Figure 8.5. SRW storage pad in Gremikha

HLW at STS in Andreyev Bay is managed only within the scopes required for its packing and safe shipment for accommodation in the special long-term storage facility at Saida or transfer to the new transport-technological scheme of managing control and protection system rods currently under development at the same site.

Management of very low level waste (VLLW) occupies a special place. This waste is debris from dismantling of buildings where works with ionizing radiation sources have been carried out and the contaminated soil generated at the land-area remediation. It will not be exported from the STS

area. Operations of identifying the group of very low level waste (VLLW) and radioactive waste sorting are radiation hazards for the personnel. One cannot eliminate completely the hazard to the environment that may be materialized due to some more or less hypothetical destruction of technical barriers of the testing ground for VLLW and migration of radionuclides (mainly Sr-90 and Cs-137) to the phreatic aquifers discharging to the bay.

Spent nuclear fuel and radioactive waste site of temporary storage in Gremikha

All work with spent nuclear fuel depending on the duration and production specifications, similar to those in STS in Andreyev Bay, are broken down into a number of phases [Stepennov, 2004]. The radiation-hazardous operations are as follows:

- Identification of the most radiation-hazardous sources of radiation stored in the containers (see Figure 8.5) and closing (protecting) these containers to substantially ameliorate the radiation situation at the pad for shipment of containers with SFA;
- Relocation of containers with spent nuclear fuel to the container inventory-making and temporary storage site (CIMTSS) where they are installed at individual pads;
- Works at CIMTSS:
    - Measurement of the surface radioactive contamination;
    - Preliminary decontamination of the surface;
    - Water pumping out (or discharge from Type 6 containers) from the container cavity, when it is available and if it is technologically impossible to carry out this operation;
- SFA revision, inventory-making and deficiency-identification to define methods of management of defective SFA (storage, transportation, reprocessing);
- Preparation and export of spent nuclear fuel from Gremikha;
- Trans-shipment to TUK casks from the storage facility of SFA removed from nuclear powered submarines with PWR and their shipment to Mayak PA;
- Works to unload spent removable parts (SRP) from the distressed nuclear powered submarines with frozen coolant (nuclear powered submarines No. 910):
    - Assessment of the radiation condition and performance of decontamination works;
    - Performance of works to prepare the spent removable parts for retrieval and their retrieval from the reactor;
- Operations with spent removable parts from submarines with reactors with LMC stored in storage facility of spent removable parts. As this fuel is stored under the design conditions, its shipment will be carried out under the design transport-technological scheme in the regular mode;
- Opening of some containers with SRW (reinforced-concrete, concrete, metal) for survey and sorting of SRW contained in them by the composition, size and doze rate if transportation of these containers is impossible (or if the state of these containers does not allow to transport them);
- Moving containers with SRW available at the SRW STS into a prepared concrete pad.
- Sorting SRW retrieved from the containers and its stacking into special casks, which are subject to compacting at the SRW compacting station; and
- Before the compacting station is set up, the filled casks are transported to the site for temporary storage.

Upon removal of all SRW from the STS, as well as of containers with SFA, operations of detailed mapping of the radiation conditions both directly at the SRW STS, and the adjacent on-shore area with activity measurements of the soil, used equipment and concrete slabs of the fencing wall will be carried out.

- Equipment decontamination or its re-classification as SRW;
- Dismantling of concrete fencing blocks, their decontamination for further use or re-classification as SRW; and
- Clean-up and decontamination of the pad and the adjacent on-shore area.

The operations of LRW processing will be carried out with the aid of mobile modular units. The rejected waste from LRW processing will be containerized and shipped to the CCLS at Saida Bay for placement in the storage facilities.

It is planned that HLW will be processed only within the scope required for its packing and safe shipment for placement in a special storage facility at the CCLS.

Waste sorting to separate LLW from VLLW, similar to that in STS in Andreyev Bay, will be radiation-hazardous.

CCLS at Saida Bay

The situation of the CCLS in Saida Bay is different from that at the STS, becasue the facilities have been newly designed and the radiation hazards are minimized.

However, the following operations should be referred to as radiation-hazardous:

- Storage of single-compartment reactor units from nuclear powered submarines, which before dismantling have been placed on hold to a storage pad for 70 years. Upon termination of the storage period the RCs are to be dismantled, and the reactor (without disassembly) is to be retrieved from the RC, packed into a special-purpose container and relocated for ultimate disposal;
- Operations on placing reactor compartments of surface ships and compartments - storages of spent nuclear fuel of nuclear service vessels on a pad for their holding and consequent recycling and placement of the conditioned radioactive waste in the storage facilities in Saida;
- Operations of loading the storage facility with conditioned radioactive waste;
- Operations of placing HLW into containers suitable for long-term storage followed by their final disposal;
- Operations in the shop of radioactive waste trans-shipment from the re-usable containers, those having arrived from the facilities of the radioactive waste suppliers; and
- Operations at the conditioning area, including caissons.

Ship-Building and Ship-Repair Yards

Ship-building and ship-repair yards engaged in nuclear powered submarines dismantling, repair and maintenance, are the main generators of radioactive waste in the Northwest of Russia. The specific feature of such radioactive waste is that it is, as a rule, fresh, that defines the levels of its activity and the radioisotope composition.

In this element of the radioactive waste management system in the Northwest of Russia the following operations can be referred to as radiation-hazardous ones:

- Inventory-making and certification of SRW to specify the size and characteristics of the stored radioactive waste;
- Placement, in compliance with the guiding document RD 95 10548-2000, of low and intermediate level SRW with the half-life not more than at that of Co-60 (5.27 years) into the RCs of decommissioned nuclear-powered submarines;

- Operations of sorting, deactivation, drying, fragmentation (if required and if proper equipment and technologies are available), packing into the certificated transport containers of SRW inadmissible for placement in the reactor compartment of to-be-dismantled nuclear powered submarines (Appendix B to RD95 10548-2000), for their relocation to the regional centre in Saida Bay;
- Operations on temporary storage within the companies, until shipment to the CCLS, transport containers with SRW;
- Packing into the certificated 20-feet containers without additional process operations of the container with SRW previously accumulated at the companies for the consequent shipment to the regional centre for reprocessing;
- Shipment of containers with SRW to the regional centre on board a container ship or motor vehicles;
- Operations of HLW management, this waste mainly being absorber rods of the CPS, and the cartridges with absorber rods of the CPS retrieved from the reactor;
- Operations of LRW reprocessing that are carried out in modular or stationary (if any) plants. The rejected waste from the LRW processing is placed into containers and transferred to the transport-technological scheme of SRW management;
- Operations of temporary storage of transport containers with SRW at the companies till shipment to the regional centre,

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The following works can be attributed to radiation-hazardous operations at ship-repair yards:

- Operations on inventory-making and certification of SRW, specification of the size and characteristics of the stored radioactive waste;
- Operations of SRW sorting, deactivation, drying, fragmentation, packing into certificated transport containers for shipment to the regional centre in Saida Bay;
- Operations of packing into certificated 20-feet containers without additional process operations of containers with SRW previously accumulated at the company for the consequent transportation to the regional centre in Saida Bay for processing and conditioning; and
- Export of containers with SRW to the regional centre on board a container ship or a floating maintenance base of FSUE "Atomflot", and by motor vehicles, if required.

The distinctive features of radioactive waste management at FSUE "Atomflot" are as follows:

- Due to the availability at the company of proper production facilities, the SRW can be directly packed into the certificated dual-purpose containers intended for placement to the long-term storage in the regional centre;
- Breaking up of large-size SRW of intermediate and high level and placing in standard transport containers;
- The LRW is processed by stationary installations available at the company, and the thus derived SRW is placed into containers and is stored at "Atomflot". After the storage facilities are filled, the waste is shipped for long-term storage to the regional centre; and
- Isolation of industrial waste that falls into the category of VLLW is performed by placing the waste into a testing ground specifically designed at the site for VLLW disposal.

Nuclear Service Vessels

Floating maintenance base (FMB) and nuclear service vessels, unlike ship-repair yards, have limited areas, and this implies specific performance of radiation-hazardous operations and, hence, forms the specifics of the hazards, in particular:

- These are operations with radioactive waste arising from dismantling of nuclear powered submarines , surface ships with nuclear propulsion plants, de-fuelling of nuclear powered submarines and nuclear surface ships which will be packed into transport containers and shipped to processing facilities of the regional centre, or a ship-repair yards for its placement into the free space of the reactor compartments of dismantled nuclear powered submarines in line with the guiding document RD 95 10548-2000;
- Operations on receipt and temporary storage of SRW generated from spent nuclear fuel unloading during technological maintenance of nuclear powered submarines and nuclear ice-breaking vessels, as well as temporary storage of radioactive waste generated at FMB from decontamination and repair work of the nuclear propulsion plant equipment and process equipment;
- Operations of collection, temporary storage and export of LRW generated from dismantling of nuclear powered submarines, nuclear surface ships, de-fuelling of nuclear powered submarines and nuclear surface ships to ship-repair yards or FSUE "Atomflot" for reprocessing;
- Operations with HLW generated from dismantling of nuclear powered submarines , nuclear surface ships, and its packing into containers to allow their placement in a special storage facility of the regional centre and its shipment to this centre; and
- Operations of sorting and isolation of the category of very low level waste for its disposal at a specially-designated site the construction of which is underway at the STS, as well as is planned for construction at FSUE "Atomflot" and the Murmansk Special Combine "Radon".

8.3 References for section 8

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9 Procedure development to review risks assessments associated with hazardous operations

The current procedure to review risk assessments related to hazardous operations is implemented, while agreeing with the project plans, and it envisages, among other activities, passing the projects via supervisory authorities for review of nuclear and radiation safety compliance. The basis for referring operations to the category of hazardous ones is based on criteria defined in the regulatory documents.

While reviewing potential emergency situations, the following is taken into account:

- Human factor, i.e. the likelihood of error, while performing some operations or if some safety regulations are violated;
- Collapse of the building structures or drop of objects handled by lifting equipment or transported by a transport device;
- Fire;
- Emergency discontinue of power supply; and
- Drastic increase of γ-radiation levels at the work site and other possible situations depending on the characteristics of the facility, work type and applied equipment, etc.

Special focus should be made at nuclear-hazardous works. While preparing them, the report on the technical support of the works safety, all potentially possible, including hardly probable, events should be addressed. As known, it is impossible to completely prevent the possibility of a mechanism failure or drop of an object, for instance, container damage or fuel drop from it. However, in any case, even assuming the most conservative assumptions, the undertaken administrative and engineering measures should completely prevent criticality occurrence, and measures should be taken to prevent excessive exposure of the personnel and to enable elimination of the radiation incident impacts.

Special attention should be paid at the possible impact of the human factor, while working in the constrained conditions of the spaces, among piles of radiation-hazardous objects. The physical and psychological fatigue also enhances the likelihood of personnel errors. Development of more favourable conditions, while preparing for the work, for instance, bringing the radiating monitoring station to the appropriate condition, to use it as changing and locker room, reduces potential risks caused by the personnel errors.

The procedure of review by the staff of the regulatory body of risk assessments should include the following lines of activity:

- The need to review the listed emergencies;
- Completeness of the possible impacts' description;
- Sufficiency of measures to prevent them and/or to mitigate their impacts;
- Assessment of the extent of hazard for the personnel and environment;
- Assessment of reliability and sufficiency of the used protective equipment and instrumentation, including measurment systems;
- Qualification analysis of specialists who have performed the basic calculations and estimates, and of the experts , who have performed the independent expert review; and

- Issue of recommendations, if required, to address additional emergencies and measures to prevent these emergencies or to mitigate their impacts.

However, as follows from the description of the risk review procedure, it assumes availability of specific regulations (or technology) of performing the work under study. As for the priority projects named in the report, currently there are just conceptual decisions in the form of reports on the conducted R & D works. The exception is the project of exporting conditioned spent nuclear fuel from Gremikha LTSS, as well as the project of de-fuelling the nuclear powered submarines for which both the regulations and Technical Substantiation of Safety (TSS) of the works (*the Russian acronym being TOB*) are available. The essence of this TSS is actually identification and analysis of the project risks.

Using the results of these TSSs and then approximating them to other projects similar in contents (remediation of the Site for Temporary Storage and dismantlement of nuclear powered submarines), one can arrive at the conclusion that the risks (events with the indefinite nature the occurrence of which will have negative impacts) should be anticipated, first of all, while managing spent nuclear fuel.

10 Priority Lines of Activity and Actions to Improve the System of Regulatory Supervision and Procedures

10.1 Basic Lines of Activity in Nuclear- and Radiation- Hazardous Works

First of all, they include spent nuclear fuel management activities. But among these works there are the ones that require the closest attention by the supervisory bodies.

This includes management of spent nuclear fuel stored for a long time in the conditions incompliant with the requirement of the regulatory documents, i.e. at the "Lepse", in storage facilities of Andreyev Bay and in containers and pits in the Gremikha storage facilities. Because of the long-term (over ten years) stay in water, the uncontrolled part of the SFA structure has become depressurized. Measurements show a high (up to $3{,}7 \cdot 10^{11}$ Bq/m^3) activity of water in some cells of DSU 2B and presence of α-sources in it There is experimental data that confirm the presence of small fragments of fuel and of separate fragments in the ponds of Building 5 and in the containers at SRW STS in Gremikha. Additional problems will also inevitably arise during works to remove the non-retrievable part of SFA and cases from DSU cells and caissons in the "Lepse".

Non-standard situations also require special attention on behalf of the supervisory bodies. Joint co-ordinated efforts of the specialists of the supervisory bodies and companies performing these operations, procedures of activities' coordination and addenda to the existing regulatory documents should be developed.

The task is to ensure warranted safety of the works' performance and to enable their performance within the reasonable timeline and under the allocated funding. Extra constraints will hamper performance of these operations, will increase their duration and cost, but will not increase the personnel safety. Therefore, agreed optimization of the requirements to the oversight procedure is required.

Non-standard situations may also occur while managing SRW stored in sub-surface storages in Andreyev Bay. It is known that these facilities for many years have been filled with ground waters converted into LRW. Seasonal migrations of LRW from the storage facilities to the soil and of ground waters from the soil to the storage facility have been noted. The exact structure of the SRW is unknown. As for the activity, the contents of the storage facility differ by orders of magnitude. In Gremikha some concrete containers with high level waste at the SRW STS, as well as a container with fragments of the control and protection system, pose problems.

Development of specialized non-standard equipment, its testing and certification is required for the safe retrieval of some separate SRW items from the storage facilities and containers. As with management of spent nuclear fuel, personnel safety depends on the fact, how reliable and user-friendly this equipment is.

Checks of the equipment function and staff training should be carried out at special custom-made test-beds. Besides provision of personnel safety, it is required to ensure labour efficiency, especially for work in places with an elevated radiation background, in order to reduce both individual and collective radiation burdens.

Representatives of the supervisory body should participate at all work stages, i.e. inventory-preparation and making, design development, construction and testing of non-standard equipment, development of the procedure and work plan. This will allow to identify possible contradictions or errors and to eliminate them in advance.

Therefore, in the next few years the following lines of activities that require close attention of the supervisory bodies have been and will remain priority ones:

- Management of spent nuclear fuel stored in improper conditions (the "Lepse", Andreyev Bay, Gremikha); and
- Management of SRW stored in sub-surface repositories in Andreyev Bay, and of "problematic" SRW from the containers in Gremikha.

It is required to revise the work procedure of the supervisory bodies by engaging them in the review of problematic issues at the initial stage of scheduled operations. This will speed up the works and will enhance their safety.

10.2 Identification of Priority Actions for Improving the System of Regulatory Supervision

Analysis of the works described above on remediation of the facilities linked to hazardous operations shows that they are all essentially unique and non-standard. Therefore, the first conclusion that can be drawn, while making transition to practical works on elimination of the nuclear legacy of the nuclear fleet in the Northwest of Russia, is expediency of involving the supervisory bodies into these works at the initial stage, and their engagement into review of problematic issues at the initial stage of the scheduled operations. This will facilitate prompt improvement both of the procedures of the regulatory oversight, and of the regulatory documentation defining the requirements for work conditions and their results, which will enhance safety of these operations.

It is also expedient to:

- Expand the scope of PNHW and PRHW to be executed under the written approval of the Directorate of State Supervision over Nuclear and Radiation Safety of the RF (Order of the Chief of DSS NRS of the RF MoD No. 15 dated 30.03.2004).
- Revice the regulatory documentation, only after test-proving the norms to be introduced at separate facilities and with gradual accumulation of work experience.

The above noted unique and non-standard nature of the hazardous operations at remediation of STSA and STSG on the one hand, and high generalization of the Federal Norms and Regulations, on the other hand, require a large number of methodical explanations for their application, i.e. methodical instructions – the development of which should lay the basis for activities to improve the supervision procedures.

Besides, there are some gaps in the federal regulatory requirements. These arise because up to now only the top level of normative documents containing so-called "reference" norms has been developed. Therefore, it is necessary to develop normative documents of a lower level which will contain concrete positions and procedures on how to implement the high level requirements (for example: "Rules to

Reclassify Nuclear Materials in Category of Radioactive Waste (NP-072-06)" and "Safety under the management of radioactive waste. General provisions (NP-058-04)").

In this work it was proposed to focus on one priority aspect of work in spent nuclear fuel management. The example chosen was management of small fuel fragments contained in solid radioactive waste of various types and origin. Such small fragments of fuel may be present in silt sediments in the wet storage ponds, at the bottom of SFA cases, at the bottom of containers and in the caissons of the "Lepse", as well as in wet storage facilities of NPPs. It is not expedient to isolate these small fragments of fuel from a huge mass of waste in order to contain them later as fission materials, as it is too labour-consuming, hazardous, complicated and expensive. This is confirmed on the basis of experience of operators in Russia and the USA. Taking into account this experience, the regulator has issued "Rules to Reclassify Nuclear Materials in Category of Radioactive Waste (NP-072-06)". Based on the Decree of the Federal Service on Process and Nuclear Supervision dated December 12, 2006 No. 6, these "Rules" were approved and enacted on June 1, 2007. However, detailed criteria and procedures of performance of this had not been developed.

These Rules identify requirements to the set of measures to classify as radioactive waste those products not intended for follow-on use, removal of nuclear materials contained in them from the state registration on such materials, and registering them in the state accounting system for radioactive waste generated from these products and containing nuclear materials.

It is assumed in these Rules that these nuclear materials are stored in the specially allocated spaces of the material balance area, the actual amount of the nuclear materials is known, and this amount may be updated with the aid of physical inventory-making. But in these Rules the requirements to substantiation of nuclear safety, while managing these materials at the stage of their reclassification as radioactive waste, are missing.

One of the specific facilities where one will deal with small fragments of fuel containing nuclear materials, is wet-type ponds for spent nuclear fuel storage in Building 5 of Andreyev Bay. There, upon the results of investigations, at the bottom there is ~ 34 m^3 of sediments consisting of corrosion products of the pond metal walls. The specific activity of the sediments is ~ 10^9 Bq/kg, the dose rate gamma radiation defined mainly by Cs-137 equals ~ 0.1 Gy/h. However, while conducting measurements in several points close to the bottom of the pond, a local excess by an order of magnitude of the average MED was identified. Presence of α-emitters - ~ 10^5 - 10^6 Bq/kg - also testifies the presence of small fragments of fuel in the sediments. Under the Work Plan of the Grant Implementing Agreement No. 004 dated 01.10.07 concluded between the EBRD and SevRAO, specialists should carry out detailed analysis of gamma radiation distribution over the bottom of all ponds, to identify "hot" spots, to conduct spectrometric measurements in them and to collect samples in these places. Amount, physical condition and the total activity of the small fragments of fuel should be identified. Based on this data, a decision should be made on management of the bottom sediments that impacts the decision-making on management of Building 5. However, besides the derived data about the radioactive waste structure and the amount of nuclear materials in it, availability of a regulatory document defining the methods to manage this radioactive waste was needed.

10.3 References for section 10

NP-072-06. Rules to Re-categorise Nuclear Materials as Radioactive Waste, 2006.

NP-058-04 Safety of Radioactive Waste Management. General Provisions NP-058-04 approved by the Resolution of the Federal Environmental, Industrial, and Nuclear Supervisio Service dated December, 31, 2004, No. 15 and enacted since June 6, 2005.

11 Proposals on improvement of regulatory documents to ensure nuclear and technical aspects of radiation safety

This Section sets out suggestions for the development of new and updated regulatory documents on provision of nuclear and technical aspects of radiation safety, based on the progress in the programme at the end of 2008.

Development of regulatory documents on supervision of nuclear and technical aspects of radiation safety is a complicated and responsible process. On one hand, these documents should contain requirements on personnel and on applied technologies and equipment to provide safety during the scheduled works. To this end, the regulatory document establishes a system of criteria, rules (regulations) and restrictions which, when strictly followed, guarantee safety of the personnel and population in the adjacent territory. It also includes a complete set of the required actions which provide the dose limits of the personnel and population exposure non-exceeding those set by NRB-99 (Norms of Radiation Safety), even in emergencies.

On other hand, the requirements of the regulatory document should give due regard to the actual conditions existing at the facilities, available technologies, time frames and scopes of funding in order not to form insuperable obstacles to work performance.

The available experience of performing similar works in Russia and abroad, skills of the personnel and the possibility of applying new technologies and equipment developed and being under development at the Rosatom enterprises, should be taken into account.

Regulatory documents should contain exact wordings, clear to the executors and avoid double interpretation. They should take account of possible personnel errors, while performing especially critical operations or decision-making. Administrative and engineering decisions and solutions preventing occurrence of emergencies or mitigating their impacts should be provided. In addition, it should be born in mind that the main risks faced are associated with the unsatisfactory state of spent nuclear fuel and radioactive waste, conditions of their storage and, in the majority of cases, absence of authentic and full information concerning the parameters of these factors. The technological aspect of radiation safety provision for cases, not typical from the point of view of the status and conditions of spent nuclear fuel and radioactive waste storage, is the weakest point in the general system of exercising the procedures of supervision. The available regulatory basis has been developed for regular conditions of managing spent nuclear fuel and radioactive waste and is, practically, hardly applicable in the current circumstances.

11.1 Expert Review of the Draft Administrative Regulation of the RF MOD on Execution of the Functions of State Oversight over Nuclear and Radiation Safety

Analysis of the practice of the state function of state supervision over nuclear and radiation safety at development, manufacturing, testing, operation, storage and dismantlement of nuclear weapons and nuclear energy/propulsion plants of military designation[4] by the RF MOD shows that separate regulatory legal acts for its implementation has been missing.

Respective work has been carried out in the RF MOD since 2005. It has resulted in the instruction of the Government of the Russian Federation dated February 16, 2008 No. VZ-P7-949. In compliance with this, it has been ordered that while defining the procedure of state supervision over the defined field of activity, including development and approval of administrative regulations of the state

[4] Hereafter, the "development, manufacturing, testing, operation, storage and dismantlement of nuclear weapons and nuclear power/propulsion plants of military designation" is called "the defined field of activity".

functions in this field, full use should be made of the authorities of the RF MOD defined by the legislation of the Russian Federation.

According to the specified instruction of the Russian Federation Government and on the basis of the Governmental Act of 11.11.05 No. 679, Draft Administrative Regulations of the RF MOD on execution of the function of state oversight over nuclear and radiation safety in the defined field of activity were developed.

They establish the time frame and sequence of administrative procedures and administrative actions of the RF MOD, the procedure of co-operation between its structural divisions and officials, as well as co-operation of the RF MOD with legal entities, other state and local authorities, establishments and organisations, while exercising the state function of oversight over nuclear and radiation safety in the defined field of activity (hereafter called "the state function").

Performance of Expert Review of the Draft Administrative Regulations.

As development of the Draft Administrative Regulations of execution of the state function progresses, an independent expert appraisal (peer review) of the document was carried out. The independent expert appraisal is to be performed by the organisations functioning in the defined field. The result of the independent expert appraisal is the Expert Review Resume (Conclusion) and included the following **s**uggested key improvements**:**

- Proper sequencing of the administrative procedures and administrative actions for execution of the state function;
- Elimination of excessive administrative procedures and excessive administrative actions at execution of the state function;
- Establishment of the procedure of co-operation between structural divisions of the RF MOD and officials, as well as its co-operation with the supervised organisations (irrespective of their organizational-legal forms and forms of ownership), other state authorities (the Ministry of Industry and Trade of the Russian Federation, Federal Agency for Science and Innovations, Federal Space Agency, Federal Agency for Special-Purpose Construction) and the authorised organisations (for example, with the State Corporation on Atomic Energy 'Rosatom', Joint Ship-building Corporation, etc.), while exercuting the state function;
- Reduction of the amount of documents to be submitted by the applicants (supervised organisations) for execution of the state function;
- Application of new forms of the documents that allow to eliminate the need of multiple submissions of identical information;
- Decrease in the quantity of contacts made by the applicants (supervised organisations) with the officials authorised to carry out the state function;
- Reductions of the time frame to perform the state function, as well as the time frame to perform some separate administrative procedures and administrative actions within execution of the state function; and
- References to responsibility of the officials authorised to carry out the state function for observance of the Regulations by them, while performing the administrative procedures or administrative actions.

11.2 Development of a Manual "Requirements to Provision of Technical Aspects of Radiation Safety, while Managing Radioactive Waste in the Northwest of Russia (Saida Bay)"

As of today, most of the radioactive waste with various levels of radioactivity and toxicity is stored in the STS in Andreyev Bay, Gremikha settlement, and at the shipyards dismantling nuclear powered submarines.

The State Corporation "Rosatom" and the administration of the Murmansk region have undertaken a joint resolution on construction in the area of the Saida Bay of the Regional Centre for Conditioning and Long-term Storage of Radioactive Waste (CCLS). In the Regional Centre it is planned to manage solid and solidified intermediate and low level waste formed from recycling in the Northwest of Russia. The specifics of the CCLS in Saida Bay is that unlike the STS in Andreyev Bay and Gremikha settlement, it is buildt with due regard to the state of the art requirements to provide radiation safety and, consequently, the radiation hazards are minimised there.

It is assumed that the CCLS will dismantle, deactivate, condition and temporary store radioactive materials and waste and carry out radiation monitoring.

The construction design of the CCLS is being developed by the German Party according to the German safety standards. The project is based on the existing storage facility for radioactive waste coming from the nuclear energy plant in Greifswald /Lubmin. The design envisages use of German and Russian equipment and technologies.

However, there is no regulatory decision regarding the issues to ensure radiation protection of the personnel and the public, and preservation of the environment at implementation of the programme to set up grounds for long-term storage of radioactive waste, disposal sites for very low level waste and centres for conditioning and storage of low and intermediate level radioactive waste. Interface of the German and Russian legislative and regulatory bases for the effective supervision over radiation safety is also required.

Now, within the framework of cooperation of the FMBA and the NRPA in the field of regulation of the safe use of nuclear energy, the Manual "Requirements to Provision of Safety and Protection of the Personnel, Population and Environment, while Arranging Works with Radioactive Waste in the Centre for Conditioning and Long-term Storage of the Federal State Unitary Enterprise Northern Federal Enterprise for Radioactive Waste Management" has been developed. [Roudak et al, 2011]

The Manual takes into account the specifics of the enterprise. It establishes a system of sanitary & hygienic criteria and restrictions to guarantee provision of radiation safety of the employees (personnel) of the CCLS and the population at the enterprise, in the sanitary-protective zone and the zone of control over radioactive waste management, as well as the required level of control over the sanitary-epidemiologic conditions. Thus, such an important issue as provision of technical aspects of radiation safety supervised by the DSS NRS remains pending and requires decision-making in the form of development of a guidance document.

The proposed new document should define the requirements to the set of technological measures to ensure compliance with the basic dose limits for personnel and public exposure regulated by NRB-99, to prevent and eliminate radioactive environmental contamination, including that resulting from emergencies. Alongside the experts from the DSS NRS authorised to carry out the state supervision of nuclear safety and technical aspects of radiation safety at the SevRAO enterprise, this document is also intended for experts of design and operating organisations.

The developed document should define:

- Requirements to the technologies to ensure the safe management of radioactive waste in the CCLS and its long-term storage;
- Requirements to the technologies of collecting and packing the radioactive waste exported from the organisations owners of the radioactive waste;
- System of technical measures to provide radiation safety, while managing radioactive waste during its conditioning and long-term storage;

- Requirements on the means of radiation dosimetry control which is one of the elements of the multi-barrier protection system; and
- Technical requirements to the radiation control and monitoring.

11.3 Development of a Manual on Provision of Nuclear and Technical Aspects of Radiation Safety at Dismantling of Nuclear Service Vessels

As the problem of nuclear powered submarines dismantling is being solved, the issue of the need to recycle nuclear service vessels (NSV) comes to the agenda. The majority of nuclear service vessels was built or converted into nuclear service vessels in the 1960s-70s during the period of en mass construction of the military and civil nuclear fleet. The existing facilities allow to properly address the issue of nuclear powered submarines dismantling, but the problem of NSV dismantling is still pending, as their recycling is accompanied by formation of significant amounts of radioactive waste of a complicated configuration that does not allow to carry out decontamination of such SRW by traditional methods.

The main types of nuclear service vessels include:

- Floating maintenance bases intended for recharge (loading/unloading of nuclear fuel, temporary storage of spent nuclear fuel). While performing recharge, this type of NSV also carries out radioactive waste management, i.e. accommodation and storage of liquid radioactive and solid radioactive waste, performs complex works with the aid of special management equipment and provides nuclear ships and vessels with the required media (special purpose water, sorbents for filters etc.);
- Special-purpose tankers, transport bulk tankers (*TNT in Russian*), floating tanks (*PEKs in Russian*) intended for LRW collection, storage and transportation; and
- Floating dosimetric check stations (FDCS) intended for provision of access to the nuclear ships and vessels during recharge, provision of sanitary treatment of specialists engaged in it and carrying out of the radiation control (including individual dosimetry control).

Thus, from the point of view of dismantling, nuclear service vessels have a variety of key differences as contrasted to the nuclear powered submarines dismantling:

- The process of their dismantling is inseparably linked to provision of radiation safety and establishment of controlled-access areas over the whole length of the to-be-disposed vessel;
- Dismantling of nuclear service vessels generate very large amounts of SRW. (The weight of the formed SRW practically corresponds to the weight of the disposed vessel); and
- Nuclear service vessels are radioactively contaminated actually all over the vessel.

The specific features that impact dismantling of nuclear service vessels include:

- Their unsatisfactory technical condition which is defined, first of all, by the service life of these vessels. For example, the Lepse vessel was laid in 1934, and in 1961 it was converted into a nuclear service vessel;
- Absence of the on-shore infrastructure for radioactive waste processing that has resulted in the large accumulation on these vessels, worsening the conditions of safe storage; and
- Deviations of the storage conditions from the standard ones at some nuclear service vessels, in particular at the Lepse FMB (this complicating their recycling).

Presence of spent nuclear fuel on the vessel defines the radiation condition, and spent nuclear fuel removal is the first stage of practical phase of dismantling. So, on the Lepse FMB the spent nuclear fuel activity in the storage facility makes now about $2.5 \cdot 10^{16}$ Bq (680 thousand Ci). The dose rate of gamma radiation in the storage facility and in the adjacent premises substantially exceeds the natural radiation background. Some spent fuel assemblies are defective. That prevents their free extraction from the storage facility under the original technological scheme.

The unloading of damaged fuel and radioactive waste is an operation which is hypothetically associated with contamination by radionuclides of the nuclear service vessel and the used reloading facility (floating maintenance bases and onshore constructions). Spent nuclear fuel extraction is a difficult technological and radiation-hazardous operation that requires development of individual regulations for each nuclear service vessel. This operation will demand application of special equipment and a decision on the transport-technological scheme of management, including temporary storage of defective fuel and its further transportation.

To perform this type of work, development of a necessary infrastructure is required. However, the unusual circumstances and uncertainties require deviation from the usual technologies of spent nuclear fuel management. This leads to the necessity to apply special methods of supervision over nuclear and technical aspects of radiation safety which should be defined in the regulatory document. The proposed document should address the specifics of the necessary work without violating basic nuclear and radiation safety standards.

The proposed document devoted to these issues, should first study the problem of supervision over the safe management of spent nuclear fuel and, in particular, defective assemblies. Thus, it must reflect the criteria of nuclear and radiation safety provision of all options of spent nuclear fuel management applicable as of today.

11.4 Development of a Manual on Provision of Nuclear and Technical Aspects of Radiation Safety, while Performing Radiation-hazardous Works with Spent Nuclear Fuel and Radioactive Waste Stored at Production Sites of FSUE SevRAO

The Manual "Hygienic Requirements for Provision of Radiation Safety of the Personnel and Population, while designing works with spent nuclear fuel and radioactive waste in Branch No. 1 of FSUE SevRAO" (R-GTPSevRAO-07) has been developed by the FMBA as an enhancement to the methodical documents to provide effective radiation protection of the personnel and population, as well as to support the radiation-hygienic and medical aspects of emergency response to the spent nuclear fuel removal and performance of rehabilitation works at SevRAO.

The proposed document should present the criteria of hypothetical radiological hazard to the personnel, population and environment. It takes into account the historically generated specifics at the production site of SevRAO necessary for effective sanitary-epidemiologic supervision. However, the problems of carrying out effective supervision over nuclear and technical aspects of radiation safety were left beyond this document. Meanwhile, their high urgency defines the need for such a document.

Thus, the proposed document should contain the whole complex of problems of nuclear and technical aspects of radiation safety from designing to physical protection. In particular, the regulatory document should reflect the requirements for the designed constructions, technologies and the mechanisms, so as to support a proper level of nuclear safety and radiation safety.

The document planned for development should contain technical requirements for provision of radiation control. As two basic industrial facilities (for managing spent nuclear fuel and radioactive waste) function at SevRAO, the requirements to the system of radiation control should be developed for two independent subsystems:

- Subsystem of the spent nuclear fuel facility, the tasks of which also include operational control of the alarm system indicating a criticality occurrence; and
- Subsystem of the radioactive waste facility, the tasks of which also include operational control of auxiliary constructions.

For the safe and reliable functioning, the proposed document should envisage the requirements for performance of effective repair of the process equipment used during operation of the facilities for management of spent nuclear fuel and radioactive waste. The requirements for the created specialised repair shops for the basic process equipment, for the development of technical regulations on performance of periodic surveys, control and repair of the process equipment, as well as requirements for mechanisation of repair works and development of a standard set (for each type of equipment) of special accessories and appliances should be provided to this end. In addition, the document should address:

- Transport of radioactive waste;
- Emergency preparedness, beyond the issues falling under the responsibility of FMBA;
- Misuse or unauthorized use of radioactive materials; and
- Physical protection.

11.5 Proposal for Improvement of the Regulatory Document "Rules to Re-categorize Nuclear Materials as Radioactive Waste" (NP-072-06)

This proposal was to develop revisions and additions to the existing regulatory document "Rules to Re-categorize Nuclear Materials as Radioactive Waste" (NP-072-06) enacted since June 1, 2007 by the Federal Environmental, Industrial and Nuclear Supervision Service (Act dated 12.12.2006 No. 6). These Rules state requirements for a set of measures to transfer nuclear materials not intended for further use to the category of radioactive waste, but many of these requirements cannot be implemented in the conditions of the dry storage units (DSU) and the storage facility in a state of emergency in Andreyev Bay, same as for the Lepse FMB. Nor do they set out the requirements and recommendations on substantiation of nuclear safety, while managing these materials at a stage of their re-categorisation as radioactive waste, there are no accurate criteria defining the admissible contents of radionuclides that vary in form and structure.

Under the Grant Implementing Agreement No. 004 dated 01.10.07 with the European Bank for Reconstruction and Development, inspection of pools in Building 5 took place in 2009, providing estimates of the quantity, physical condition, specific contents and total activity of the small fragments. On the basis of these data, a decision on the technology to manage bottom sediments, including fuel fragments should be made.

The results of this inspection and the subsequent decisions affect the scheduling of works to manage fuel small fragments in the DSU cells, containers in Andreyev Bay and Gremikha and caissons on the Lepse. Therefore, the suggested update on the Rules can be considered urgent and necessary. As well as the above mentioned aspects, it can be useful to provide recommendations on:

- Drawing up radioactive waste map with identification of radiation "hot" spots;
- Radioactive waste sampling, definition of its structure and specific activity; structure and specific activity of nuclear materials;
- Choice of method to manage radioactive waste (type of immobilisation, type of containers);
- Performance of calculations with substantiation of deterministic safety of packages with the radioactive waste even in the worst possible scenarios of filling the radioactive waste containers with water; definition of admissible concentration and the total amount of nuclear materials in the packing;
- Release of the report on engineering substantiation of safety (*in Russian-TOB*) of the transportation and storage of radioactive waste packings containing nuclear materials; and
- Co-ordination of reports with the decision-making and supervisory bodies.

11.6 References for section 11

NRB-99. SP 2.6.1.758-99 Norms of Radiological Safety, or Russian Radiation Safety Standards (NRB-99).

Roudak S.F., Sneve M.K., Kiselev M., Shandala N.K. (2011) Progress report on the regulatory cooperation program between the Norwegian Radiation Protection Authority and the Federal Medical Biological Agency of Russia. Final report of projects and other activities completed in 2008+2009 and plans for 2010-2011. StrålevernRapport2011:7.

NP-072-06. Rules to Re-categorise Nuclear Materials as Radioactive Waste.

12 Response to the 2008 proposals and basis for work carried out in 2009

Analysis of operations on rehabilitation of facilities associated with hazardous operations at the STSs at Andreyev Bay and Gremikha settlement (STSA, STSG), as well as in other places and facilities in the northwest of Russia, demonstrated that all of them are essentially unique and non-standard. When starting practical operations on environmental rehabilitation work, it is expedient to involve supervisory authorities at an early stage, to engage them in review of problematic issues at the initial stage of the planned activities. It promotes the fastest improvement both of the procedures of regulatory supervision, and development of regulatory documents that define the requirements to the conditions of the work performance and their results, and accelerate both the work and implementation of safety improvements.

The non-standard nature of hazardous operations at STSA and STSG and a high generality of federal norms and regulations, result in a requirement to develop appropriate regulatory documents of a lower level, as well as guidance documents and methodical recommendations for their application that shall contain specific provisions and procedures compliant with the developed nowadays FNR requirements.

Noting the proposals summarised in Section 11, the priority was recognised to develop a guidance document that defines requirements in relation to management of radioactive waste which conatins nuclear materials, particularly fuel spills and fragments.

The work programme to address this need included:

- Analysis of the available information about the technical state and conditions of nuclear material fragments present at relevant facilities in the northwest of Russia;
- Review of recommendations on categorisation of radioactive waste;
- Review of the Russian regulatory, administrative-managerial and methodical documents, as well as international recommendations on transfer of nuclear materials to radioactive waste, including consideration of:
    - safety requirements for managing radioactive waste containing nuclear materials based on review of the Russian regulatory-legal basis and the situation at sites in the northwest of Russia, and
    - criteria for radioactive waste packages placed for long-term storage in the Regional Centre of radioactive waste management in Saida bay.

Together this led to development of the new guidance 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, jointly issued by DSS NRS and FMBA, and incorporating:

- 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.

The results of this work are set out in the following Sections.

13 Technical state and conditions of spent nuclear fuel storage at facilities

13.1 Technical State and Conditions of Spent Nuclear Fuel Spills in Andreyev Bay

Spent nuclear fuel from cores of nuclear powered submarines and ice breakers stored at the STS in Andreyev Bay was originally stored in the cooling pools of Building 5, the first line of which (two pools) was commissioned in 1962. In 1974 two additional pools (the second line) were commissioned. In February 1982 water leak to the environment from the right pool of the second line was detected, and in 1983 leak signs were also identified in the left pool of the second line.

Force-majeure circumstances demanded undertaking the most urgent measures for unloading all spent nuclear fuel from the pools of Building 5 to the three regular tanks of 1,000 m^3 each of Buildings 1 at LRW processing plant.

During 1983-1987 these tanks were converted to temporary “dry” type storage facilities (DSU 2A, 2B, 3A) (See Figs. 8.3 to 8.3 above). Vertical cells made of steel carbon pipes were arranged in the tanks to store spent nuclear fuel, and the annular space was grouted. Spent nuclear fuel stored in the cells is contained in cans (See Fig. 13.1).

Fig. 13.1. Can made of carbon steel, without a protective plug, with two SFA

By 1990, DSU 2A, 2B and 3A were 95 % filled with the cans. About 3,000 cans were stored at the facility at the end of 2009.

Long-term storage of spent nuclear fuel from nuclear powered submarines in the condition that does not meet the requirements of regulatory documentation has led to degradation of fuel element cladding and release of fission products and fuel particles to water. Therefore, there is no doubt that after unloading spent fuel assemblies (SFA) from the cans stored in the DSU cells, fuel spills (as fragments, particles and dissolved) may remain at the bottom of many cans, as well as at the bottom of cells.

The situation is more complicated in the four pools of the former spent nuclear fuel storage facility in a state of emergency (Building 5).

During unloading the canisters from the pools not less than 100 of them, due to corrosion and break of chains, have fallen to the bottom of the pools and stayed there in a mess for a long time. During their recovery some SFA have dropped out of them to the bottom of the pools [Bulganin et al, 2004]. Therefore, the number of defective assemblies has increased. It has accelerated fuel degradation at

long-term (~ 20 years) storage of spent nuclear fuel in DSU cells some of which are filled with ground waters.

NIKIET employees have conducted measurements of the Equivalent Dose Rate (EDR) in all four pools, totally in 28 points – 5 points in each small pool and 9 points in each large one [Aden et al, 2000]. Additional measurements have been made and reported in Vasiliev et al [2004].

It is evident from the measurement results that the right small pool is the "dirtiest"; (the EDR in it reaches 150 mSv/h at a distance of 1.4 m from the bottom), whereas the left large pool is relatively "clean".

According to available data, at the bottom of the pools one can find fuel fragments that define the local dose rate. To define the pools' status, photos have been taken. Practically the whole area of the pools' bottom has been photographed (see Figs. 13.2 – 13.13, except for small segments in the right large pool (most obstructed from above) and in the left large pool (for the same reason)).

Review of the photos shows that all pools, except for the left small one, are completely drained. No large size objects are identified at the pools' bottom. The only exception is a part of a wooden flooring (its size being about 1×1.5 m) in the right large pool. In all pools there are pieces of small diameter pipes (sometimes long enough, up to 2-3 m – Fig. 13.5), scraps of cables, junk rubbish, even a life buoy (Fig. 13.7). Despite the small size, many objects located at the bottom are rather heavy – for example, lead plugs from multiple-use canisters, lead sheets (Figs. 13.6, 13.7).

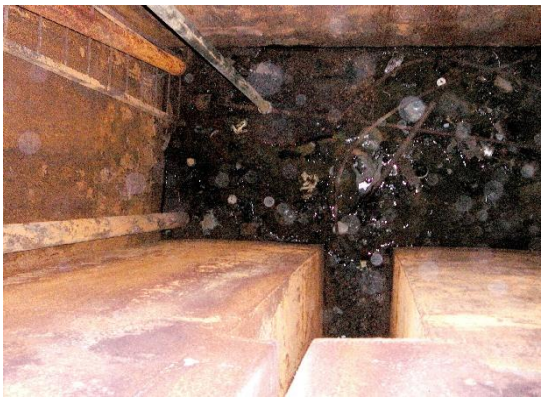


Fig. 13.2. Left small pool, photo-fragment

Fig. 13.3. Left small pool, photo-fragment

Fig. 13.4. Left large pool, photo-fragment

Fig. 13.5. Left large pool, photo-fragment

Fig. 13.6. Left large pool, photo-fragment, with lead sheets at the bottom.

Fig. 13.7. Left large pool, photo-fragment. Lead and a life buoy.

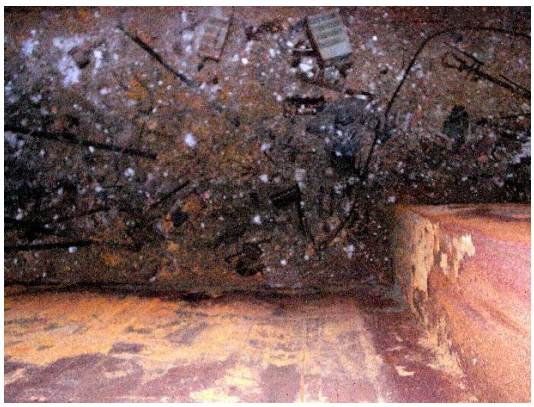


Fig. 13.8. Right small pool, photo-fragment

Fig. 13.9. Right small pool, photo-fragment

Fig. 13.10. Right small pool, photo-fragment

Fig. 13.11. Right large pool, photo-fragment (with a wooden board at the bottom).

Fig. 13.12. Right large pool, photo-fragment

Fig. 13.13. Right large pool, photo-fragment with plugs from multiple-use canisters at the bottom.

The sediments in the pools correspond to the category of Intermediate level radioactive waste (ILRW). Specific activity of about 10^9 Bq/kg is almost completely defined by radiation from corrosion products at the bottom (tens of mSv/h). The values from 100 to 600 mSv/h near the bottom of the right small pool are an exception. Obviously, they are caused by the presence of a SFA fragment at the bottom.

The following estimates of activity and volumes of corrosion products in all four pools have been derived upon the results of EDR measurements:

- In the left small pool ~ 120 Ci (volume ~ 5.5 m^3);
- In the left large pool ~ 320 Ci (volume ~ 12 m^3);
- In the right small pool ~ 1,200 Ci (volume ~ 5.5 m^3);
- In the right large pool ~ 920 Ci (volume ~ 11 m^3).

All in all, the cooling pools contain about 2,500 Ci in the corrosion products, the volume of which is about 34 m^3. Presence of fuel spills and SFA fragments is possible in the sediment layer. Location of at least one fragment is defined with a high degree of probability.

13.2 Review of Information on the Condition of Spent Nuclear Fuel Stored at the FMB 'Lepse'

The "Lepse" vessel built in 1936 was converted in 1961 into a floating maintenance base (FMB) (See Fig. 13.14) and handed over to the Murmansk Marine Shipping Company (MMSC) for operation to provide recharge of nuclear fuel of ship reactors belonging to the nuclear icebreaker fleet. In 1988 the "Lepse" was decommissioned and placed for storage at FSUE Atomflot, just 2 km off Murmansk. Spent nuclear fuel, solid and liquid radioactive waste are presently stored at the "Lepse".

Condition of SFA Storage Facility

The SFA storage facility consists of two tanks representing cylinders of 3,580 mm diameter and 3,440 mm height with a conic bottom (Fig. 1.19-1.21). In each tank there are 366 steel canisters for SFA storage. From below the canisters are shut by welded caps.

The "Lepse" storage facility contains SFA of eleven cores at different periods operated on the nuclear ice breakers "Lenin", "Arktika" and "Sibir". The SFA belong to seven types of cores that differ in the fuel element type, fuel, initial enrichment and material of the fuel element cladding.

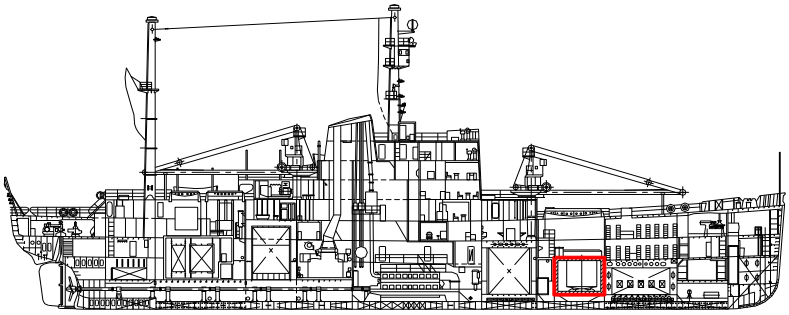
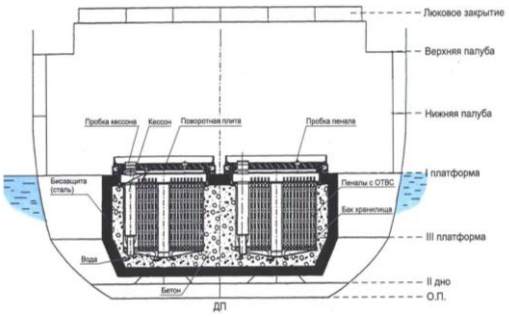


Fig. 13.14. Floating Maintenance Base "Lepse". General arrangement.



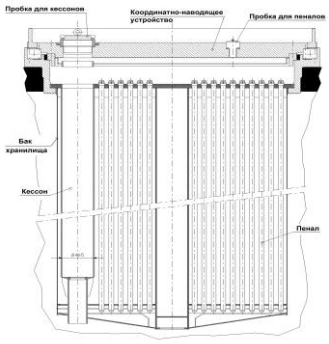


Fig. 13.15. Storage space for spent nuclear fuel *Fig. 13.16. Storage facility tank*

Totally, the storage facility contains 639 SFA, including 19 in caissons.

The conditions of the majority of SFA by the operation completion was characterised by the presence of cracks or ulcers in the fuel element cladding. Direct contact of fuel to the heat-carrier leading to fuel washout from fuel elements took place.

The quantity of SFA of the cores that at the time of operation completion contained fuel elements with essential damages of cladding equals 179 SFA in the right tank (from 335) and 249 in the left tank (from 304). 197 SFA of the core of reactors of the ice breaker "Sibir" by the operation completion had actually tight cladding with defects like "gas leak (bleed)". These SFA contain about 50 % of the total activity in storage facilities of the FMB "Lepse".

Based upon estimates, the total activity of SFA by the defining (~ 98 %) radionuclides in storage facilities of the "Lepse" by the end of 2010 will make ~ $2.6 \cdot 10^{16}$ Bq in fission products ($^{90}Sr+^{90}Y$; $^{137}Cs+^{137m}Ba$) and ~ $1.4 \cdot 10^{15}$ Bq in actinides ($^{238,241}Pu$, ^{241}Am).

Assessment of SFA Condition in the "Lepse".

According to the estimates of the SFA condition at the time of the operation termination, the majority of SFA may have essential defects. For fuel elements with the cladding made of stainless steel it meant numerous lengthy (up to 40 mm) cracks with the opening up to 0.2 mm.

The fuel assemblies of the reactor core of the ice breaker "Sibir" are characterized by insignificant defects of cladding, practically without opening. However, it is known that during operation of this core there was destruction of the burnable absorber rod with essential swelling. Thus, at some fuel assemblies appreciable distortion and even ruptures took place. It lead to mechanical damage of some SFA at unloading.

Assessment of the actual condition of fuel stored at the FMB "Lepse" allows to draw the following prognostic conclusions:

- Essentially large part of SFA practically has no damage or has insignificant damage and is hoped to be retrieved from the canisters without difficulties;

- It is not improbable that at some assemblies rather strong fuel elements' swelling and (or) fuel elements' fragmentation and, respectively, spill of fuel composition may take place;
- The task of damaged SFA retrieval from the caissons will be most difficult. Their fuel elements have lost tightness already during operation in the reactors of nuclear ice breakers. As a result of long-term storage of the SFA in water, corrosion processes have led to "swelling" of the assemblies and increase in their diameter, occurrence of cracks in the canister tube around the fuel part of the assembly; and
- The damaged SFA can be removed only together with the canisters that will be cut off in the bottom part. This will lead to the fuel spill and fragments' drop to the tank bottom.

Some minor part of SFA refers to non-processable ones:

- Three assemblies of the core with fuel consisting of uranium-zircon alloy (the concept of the latter managment is under development); and
- Assemblies non-retrievable from canisters.

The non-processable SFA will be placed for long-term storage to the annex of Building 5, FSUE Atomflot, other assemblies in special canisters will be taken for subsequent shipment to Mayak Reprocessing Combine.

Thus, after removal of all SFA, fuel spills of various types and enrichment, basically from 4 to 45 % will inevitably remain at the bottom of spent nuclear fuel storage of the FMB "Lepse", though some minor amount of fuel may be of 90 % enrichment.

In any option this mixture will represent Intermediate Level SRW containing fission materials.

13.3 Safety Substantiation at Possible Management of Spent Nuclear Fuel Spills and Fragments (during preparation for immobilisation as part of Radioactive Waste)

In all the cases outlined above it is required to choose an environmentally safe and economically effective way of managing the media potentially containing fission materials. The hazard and economic inexpediency of retrieval of the nuclear materials found in the media is obvious. At the same time, there are no arguments to deny the possibility of their immobilisation and reduction to the criteria of appropriateness of placing for long-term storage in the form of radioactive waste. It gives grounds to consider their transfer to the category of radioactive waste as the basic method of their management. The basic federal norms in this case will be NP-072-06 /4/ "Rules to Re-categorise Nuclear Materials as Radioactive Waste" and NP-058-04 "Safety of Radioactive Waste Management. General Provisions".

While handling nuclear materials for the purpose of their re-categorising as radioactive waste, the basic requirements shall be deterministically-substantiated provision of nuclear safety at all work stages and in the end state, as well as transfer of nuclear materials to such a form that would prevent a possibility of criticality occurrence under the external impacts and a possibility of nuclear material retrieval for the purpose of the subsequent unauthorised use. The end state of the nuclear materials transferred to the category of radioactive waste shall correspond to the criteria of appropriateness of the radioactive waste storage site into which it will be placed for long-term storage.

In compliance with NP-058-04 "Safety of Radioactive Waste Management. General Provisions", item 5.7:

- "During disposal of radioactive waste containing nuclear fission substances (materials), engineering solutions and administrative measures require that criticality prevention shall be provided. The properties of the engineering and natural barriers shall prevent possibility of criticality occurrence as a result of a possibility of radionuclide concentration at their migration in the system of radioactive waste dumping".

Neither in NP-072-06, nor in NP-058-04 has this requirement been developed in the form of specific technological and administrative measures on prevention of possible nuclear and radiation incidents at the stage of preparation of the mixture of nuclear materials to their transfer to radioactive waste.

Moreover, the specified documents do not envisage agreement of the methodologies to transfer products containing nuclear materials to radioactive waste with the supervisory authorities.

Meanwhile, as experience shows, technical difficulties occur most often specifically at the intermediate stages of works, as responsibility is transferred.

The maximum hazard is posed by fuel fragments found in the silt and sediments at the bottom of pools storing spent nuclear fuel in Andreyev Bay and at the bottom of canisters and caissons of the "Lepse" where they are mixed with others radioactive waste and inert substances (rust from walls of pools, concrete spills). The exact composition of nuclear materials is not known in advance, nor the total amount and activity.

Therefore, as the first step, a radiation map of radioactive waste located at the bottom, with identification of "hot" spots shall be compiled.

Radioactive waste sampling, including that in "hot" spots, definition of their radionuclide structure and specific activity, structure and specific activity of nuclear materials (fission materials), their percentage in the radioactive waste shall be conducted.

For the known composition of mixture with the maximum concentration of fission materials, it is necessary to estimate the extent of hazard posed by radioactive waste containing FM, from the viewpoint of critical mass development.

For verification of the calculations it is necessary to conduct calibration calculations of reference critical assemblies from the "International Handbook of Evaluated Criticality Safety Benchmark Experiments" NEA/NSC/DOC (95) 03/I-VII having chosen those of them where the spectra of neutrons are the closest to those in the mixture.

Admissible concentration and the total amount of nuclear materials in the package are defined with the aid of calculations.

The calculation results together with the chosen process scheme are used to release a report on technical substantiation of safety (*in Russian- TOB*) of transportation and storage of the generated packages.

Substantiation of the admissible quantity of packages in the storage facility, technical and organisational measures for prevention of the possibility of criticality occurrence is also given.

It is also required to define the applied methods of conditioning to provide conformity of characteristics of the received radioactive waste to the criteria of appropriateness of the Regional Centre of their long-term storage (most likely, in the Centre of Conditioning and Long-Term Storage (CCLS) in Saida Bay).

In view of the major uncertainty about the structure and quantity of fuel spills within SRW, being at the bottom of the caissons, canisters and tanks of spent nuclear fuel storage spaces at the FMB "Lepse", it is impossible now to choose an optimum option for its management. It is obvious that the radiation studies described above and performance of neutron-physical calculations for substantiation of nuclear safety will be required.

One of the addressed options is cementing of fuel fragments that remain in the "Lepse" after unloading all SFA that can be retrieved by some method. But even in this case, the data about the radionuclide content of radioactive waste containing nuclear materials shall be required and an entry shall be made in the package data cards.

While making analysis and substantiation of all options, it is also required already at early stages to involve representatives of supervision authorities to avoid subsequent review of the options unacceptable from the point of view of safety, both for the personnel, and for future generations and the environment.

13.4 References for section 13

Bulygin V.K, Vasiliev A.P., Netecha M.E. "Some Generalised Data on the Nature of Radiation Conditions' Formation while Storing and Unloading SNF from Cooling Pools of Building 5 (Andreyev Bay) in 1982-1992." Technical reference of ICES on Task 1 under Contract No.0073 /DTI-FSU-NLP-81025-C01-V003-WBS4.6 with RWE NUKEM., 2004.

Aden V.G, Bulkin S.Yu., Vazinger V.V., et al. "Inspection of Technical State of Dry Storage Unit (2B) in Andreyev Bay." Report of FSUE NIKIET (RDIPE), 15.537, 2000.

Vasiliev A.P., Minaev O.M, Netecha M.E, Vasjukhno V.P, et al. "Additional Radiation and Engineering Surveys of Building 5 in Andreyev Bay in November, 2004." ICES Summary Report on Task 1 under Contract No.0073 /DTI-FSU-NLP-81025-C01-V003-WBS4.6 with RWE NUKEM., 2004.

14 Classification of radioactive waste

14.1 General Provisions

The main objective of radioactive waste management is its reliable containment to ensure radiation safety of man and the environment for the whole period of hypothetical hazard posed by the radioactive waste.

Proceeding from the main objective, a system of regulatory control of safety at radioactive waste management should regulate the requirements to safety, i.e.:

- at various stages of radioactive waste management pre-disposal, including its accepted classification, processing, conditioning, storing and transportation; and
- at radioactive waste disposal.

The engineering and administrative measures aimed at radioactive waste management up to its disposal should be implemented based on the review results of radioactive waste characteristics and criteria of appropriateness (quality criteria) of radioactive waste for its storage and (or) disposal.

The classification of radioactive waste serves for simplification and sequencing of activities aimed at radioactive waste management. The classification system may include multiple schemes of waste classification. The choice of this or that particular scheme depends on physical, chemical and radiation safety properties of the waste important from the viewpoint of safety at its handling. The development and approval of a classification system assumes identification of waste categories that can be specific both to a country and for a separate enterprise inside a country.

While developing a classification, one needs to define the basic properties of waste according to which categories (groups) of waste will be specified, and based on this to define and structure the criteria of referring waste to a specific category (group).

The development and establishment of a system of waste classification can be conducted at various stages of waste management and pursue several objectives, namely:

At the concept level:

- Development of the strategy of waste management;
- Planning and designing of installations for radioactive waste management; and
- Specification of a method of radioactive waste conditioning and (or) disposal;

At the level of facility operation:

- Definition of technological operations and organization of waste handling;
- Definition of potential hazard of various waste types; and
- Simplification of documenting and accounting procedures;

For information exchange:
Specification of concepts and terms required for unambiguous understanding of the subject of discussion during the dialogue of specialists from various countries, as well as between representatives of the regulatory authorities, experts, representatives of the operating agency and the public.

A variety of provisions of legislative and standard documents reflects trends existing in the Russian Federation aimed at harmonization of approaches to safety provision, while managing radioactive waste, with the principles followed by the international community and safety criteria. It is proven by the facts of our country's joining a number of international conventions, and especially, joining of the Russian Federation in January, 1999 the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management and its ratification in 2005 [Joint Convention, 1997].

Ratification of the Joint Convention commits to the further improvement of the system of regulatory control in the field of radioactive waste management. In particular, in the field of handling radioactive waste resulting from previous activities it requires further development towards implementation of such important principles as protection of the future generations and not imposing excessive burden on the future generations.

It follows from the provisions of the Joint Convention that in case of need, all reasonably feasible improvements with a view of safety increase of the installations (storage facilities) formed as a result of the previous activity should be undertaken.

Development of the works on disposal radioactive waste, solution of the problems of decommissioning nuclear plants and rehabilitation of the contaminated areas demands availability of a clear classification of radioactive waste according to the method of its disposal. Besides, the methodology of defining the clearance levels to exempt materials with a very low level of activity from the regulatory control is to be defined.

The classification of liquid and solid radioactive waste with identification of three categories depending on the specific activity and radionuclide structure currently adopted in the Russian Federation defines methods of radioactive waste management, but practically does not focus on the method of radioactive waste disposal. Besides, while managing radioactive waste generated as a result of the previous activities and at decommissioning of the facilities engaged in the previous activities, significant amount of radioactive waste of such a low level of activity is formed the disposal of which, in view of its low potential hazard, does not require undertaking of the same engineering measures, as for disposal of low- and intermediate-level radioactive waste.

The regulatory documents of the Russian Federation does not to the full extent reflect the provisions related to withdrawal of radioactive substances (materials) from the field of safety regulation (clearance), and appropriate well-substantiated criteria to withdraw radioactive substances (materials) from the field of safety regulation (clearance levels) are not specified.

Presence of a well-defined classification of radioactive waste, a clear concept of radioactive substances (materials) withdrawal from the field of safety regulation and accurate criteria of withdrawal, as it is done in the majority of the developed foreign countries, may allow to essentially optimize the process of radioactive waste management and respective financial expenses, especially at decommissioning of nuclear installations, rehabilitation of the contaminated areas and management of radioactive waste resulting from the previous activities.

The present section is dedicated to the review of the approaches to IAEA recommendations on radioactive waste classification and radioactive waste classification existing in the Russian Federation.

14.2 IAEA Recommendations on Radioactive Waste Classification

During 2009, the IAEA developed a draft of a new radioactive waste classification scheme which was taken into account during the project. The key features, which were retained in the final version [IAEA GSG-1, 2009] are as follows.

The classification scheme is based on the consideration of the long-term safety provided at various disposal options of radioactive waste that have recently been accepted or addressed. The classification scheme takes into account the following options of radioactive waste disposal with an elevated level of containment in the long-term aspect:

- Exemption or withdrawal from radiological control;
- Storage till decay;
- Near surface storage at special facilities (like dump sites);
- Near surface storage on special facilities, such as ditches, mines or small drill holes, the depth of disposal being up to several dozen meters;
- Disposal at special facilities at an average depth between several dozens and several hundreds meters, including disposal in drill wells of a small diameter; and
- Deep geological disposal at a depth of several hundred meters or more.

In accordance with this approach six classes of waste are used as the basis for the classifications scheme:

1. Exempt waste (EW): Waste that meets the criteria for clearance, exemption or exclusion from regulatory control for radiation protection purposes.

2. Very short lived waste (VSLW): Waste that can be stored for decay over a limited period of up to a few years and subsequently cleared from regulatory control according to arrangements approved by the regulatory body, for uncontrolled disposal, use or discharge. This class includes waste containing primarily radionuclides with very short half-lives often used for research and medical purposes.

3. Very low level waste (VLLW): Waste that does not necessarily meet the criteria of EW, but that does not need a high level of containment and isolation and therefore is suitable for disposal in near surface landfill type facilities with limited regulatory control. Such landfill type facilities may also contain other hazardous waste. Typical waste in this class includes soil and rubble with low levels of activity concentration.

4. Low level waste (LLW): Waste that is above clearance levels, but with limited amounts of long lived radionuclides. Such waste requires robust isolation and containment for periods of up to a few hundred years and is suitable for disposal in engineered near surface facilities. This class covers a very broad range of waste. Low level waste may include short lived radionuclides at higher levels of activity concentration and long lived radionuclides, but only at relatively low levels of activity concentration.

5. Intermediate level waste (ILW): Waste that, because of its content particularly of long lived radionuclides, requires a greater degree of containment and isolation than that provided by near surface disposal. However, ILW needs no provision or only limited provision for heat dissipation during its storage and disposal. Intermediate level waste may contain long lived radionuclides, in particular alpha-emitting radionuclides,that will not decay to a level of activity concentration acceptable for near surface disposal during the time for which institutional controls can be relied upon. Therefore waste in this class requires disposal at greater depths, in the order of tens of metres to a few hundred metres.

6. High level waste (HLW): Waste with levels of activity concentration high enough to generate significant quantities of heat by the radioactive decay process or waste with large amounts of long lived radionuclides that need to be considered in the design of a disposal facility for such waste. It includes spent reactor fuel which has been declared as waste, vitrified waste of processing reactor fuel and any other waste demanding a comparative level of localization and isolation. Disposal in deep, stable geological formations usually several hundred metres or more below the surface is the generally recognized option for disposal of HLW.

More detailed quantitative border lines concerning a wider range of parameters can be developed according to the national programmes and requirements.

In Fig. 14.1 the vertical axis shows the range of radioactivity levels from insignificant to a very high concentration of radionuclides. As the level increases, the need of waste containment (localization and isolation) from the biosphere increases.

Over the horizontal axis one can see that the range of half-lives is from short (seconds) till very long periods of time (millions of years). From the point of view of safety of radioactive waste, the radionuclides the half-life of which is less than thirty years are considered as short-lived. Such differentiation between short-lived and long-lived waste is very useful, because the radiation hazard associated with short-lived radionuclides essentially decreases after a few hundreds of years radioactive decay – the time during which sufficient confidence of control over safety achievement is assumed to exist. Restrictions on the activity of this storage facility (disposal site) will depend in particular on radiological, chemical, physical and biological properties of separate radionuclides.

Spent nuclear fuel of the type at the STS is clearly HLW in the scheme described above. Fuel fragments and nuclear materials might be considered as ILW if the amount is small so that the heat output is of no technical significance to its storage or disposal.

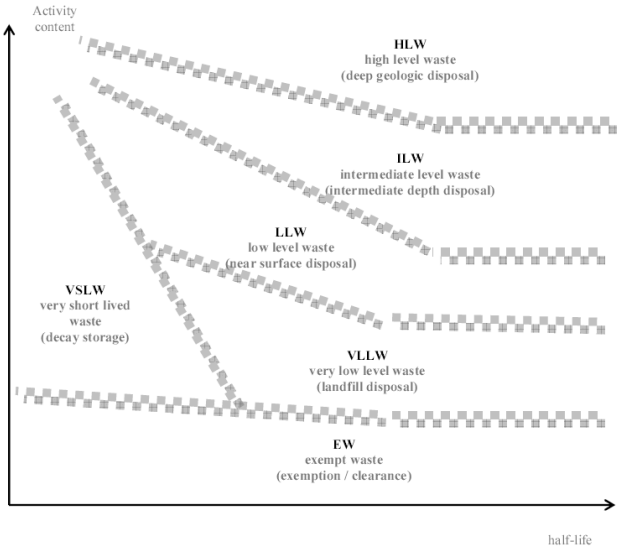


Fig. 14.1. Modified waste classification system [IAEA GSG-1, 2009]

Analysis of this information on classification schemes in other countries allows us to draw the following conclusions:

- The classification of radioactive waste used in various countries strongly differs according to different purposes of classification (provision of radiation safety of the personnel, waste disposal, specifics of waste types, etc.).
- In the majority of countries, classification is carried out according to assumed disposal option. It is to be noted that in some countries (for example France and UK) the numerical values of the

permissible contents of radionuclides are set through safety analyses, taking into account specific features of this management method.

14.3 Classification of Radioactive Waste Accepted in the Russian Federation

The Federal Law on Use of Atomic Energy does not cover radiation sources that under any conditions of their management generate:

- an individual annual effective dose not more than 10 μSv;
- an individual annual equivalent dose in the skin not more than 50 mSv and in the crystalline lens not more than 15 mSv; and
- a collective effective annual dose not more than 1 man-Sv or when at a collective dose more than 1 man-Sv the estimation under the optimization principle shows inexpediency to decrease the collective dose.

No limitations are introduced to the use in economic activities of any solid materials, raw materials and products when specific activity of radionuclides in them is less than 0.3 kBq/kg (under the condition of the absence of the removable radioactive contamination of the surface of materials and products). In co-ordination with the Federal Body authorized to carry out the state sanitary-and-epidemiologic supervision, for separate beta-emitting radionuclides it is possible to set higher values of specific activity of raw materials, materials and products suitable for unlimited use.

According to the classification adopted in the Russian Federation, radioactive waste is subdivided into liquid, solid and gaseous [SPORO, 2002 and OSPORB, 1999].

Liquid radioactive waste includes any radioactive liquids, solutions of organic and inorganic substances, pulps, etc not subject to further use. Liquid waste is considered radioactive if specific activity of radionuclides in it more than 10 times exceeds the values of intervention levels presented in Appendix P-2 of NRB-99 [NRB, 1999].

Solid radioactive waste includes radionuclide sources with the expired resource, materials, products, equipment, biological objects, contaminated objects of the environment, solidified liquid waste not intended for further use in which the specific activity of radionuclides exceeds the values of the minimum significant specific activity (MSSA) presented in Appendix P-4 of NRB-99.

With the known radionuclide structure in waste it is considered radioactive if the sum of ratios of the specific activity of radionuclides to its minimum significant activity exceeds 1.

With the unknown radionuclide structure the solid waste is considered radioactive if its specific activity is more than:

- 100 kBq/kg - for beta-emitting radionuclides;
- 10 kBq/kg - for sources of alpha-emitting radionuclides; and
- 1 kBq/kg - for transuranium radionuclides.

Gamma-emitting waste of the unknown structure is considered radioactive if the absorbed dose rate at its surface (0.1 m) exceeds 0.001mGy/h over the background at observance of the measurement conditions according to the approved methodologies.

Liquid and solid radioactive waste (Table 14.1) is subdivided by the specific activity into three categories. In case when based on the characteristics of radionuclides presented in the Table the waste belongs to various categories, the highest waste category is given to it.

For preliminary sorting of solid waste it is recommended to use the criteria by the level of radioactive contamination and the dose rate of gamma radiation at a distance of 0.1 m from the surface, provided that the measurement conditions in conformity with the proven methodologies are met:

- Low level waste - from 0.001 mGy/h to 0.3 mGy/h;

- Intermediate level waste - from 0.3 mGy/h to 10 mGy/h; and
- High level waste - more than 10 mGy/h.

Table 14.1 Classification of liquid and solid radioactive waste in Russia

Waste category	Specific activity, kBq/kg		
	Beta-emitting radionuclides	Alpha-emitting radionuclides (except for transuranium)	Transuranium radionuclides
Low level	$< 10^3$	$< 10^2$	$< 10^1$
Intermediate level	10^3 - 10^7	10^2 - 10^6	10^1 - 10^5
High level	$> 10^7$	$> 10^6$	$> 10^5$

While managing radioactive waste, besides its aggregate state and specific activity, one should also take into account its other physical and chemical characteristics, in particular, explosion and fire hazard, organic or inorganic nature, etc.

The choice of the radioactive waste disposal option (near surface disposal or deep geological disposal), designs of the storage facility and properties of barriers should be defined and proven in the Radioactive Waste Disposal Site (RWDS) Design depending on the radioactive waste characteristics (radionuclide structure, specific activity, the period of hypothetic hazard, physical and chemical properties), taking into account the natural conditions of the RWDS location.

For waste containing a mixture of radionuclides, the total concentration is defined as "the sum of shares" by division of the concentration of each nuclide into the respective permissible concentration. The sum of shares should not exceed 1.0.

If radioactive waste does not contain radionuclides presented in the Table 14.2, this waste belongs to a category for which there is no restriction as far as near surface disposal is concerned.

The top (conservative) value of 3.7×10^3 Bq/g for uranium and transuranium alpha-emitters with a half-life over 5 years is allowed for separate radioactive waste packages provided that on the average in RWDS their specific activity will not exceed 370 Bq/g.

In the estimates, the bulk weight of radioactive waste is assumed to be 2 t/m^3.

Table 14.2 Permissible contents of radionuclides in radioactive waste disposed in near surface RWDS

Radionuclides	Activity, Bq/m^3 (Bq/g)
Radionuclides with the half-life less than 5 years	unlimited
H_3	unlimited
^{14}C	3.0×10^{11} Bq/m^3
^{14}C in the activated metal	3.0×10^{12} Bq/m^3
^{59}Ni in the activated metal	8.1×10^{12} Bq/m^3
^{60}Co	unlimited
^{63}Ni	2.6×10^{13} Bq/m^3
^{63}Ni in the activated metal	2.6×10^{14} Bq/m^3
^{90}Sr	2.6×10^{14} Bq/m^3

^{94}Nb in the activated metal	7.4×10^{9} Bq/m^3
^{137}Cs	1.7×10^{14} Bq/m^3
^{99}Tc	1.1×10^{11} Bq/m^3
^{129}I	3.0×10^{9} Bq/m^3
^{241}Pu	$1.3\cdot\times10^{5}$ Bq/g
^{242}Cm	7.4×10^{5} Bq/g
Uranium and transuranium alpha-emitting radionuclides with the half-life more than 5 years	3.7×10^{3} Bq/g

According to NP-069-06, [2006] short-lived (with a half-life less than 30 years, as well as ^{137}Cs) low-intermediate- and high-level radioactive waste with a limited content of long-lived radionuclides is subject to near surface disposal. The maximum specific activity of alpha-emitters (uranium, etc.) with a half-life more than 5 years in a separate radioactive waste package (in the cells of radioactive waste disposal) should not exceed $3.7\cdot10^{3}$ Bq/g provided that on the average in RWDS their specific activity does not exceed 370 Bq/g.

14.4 References for section 14

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management //Vienna: IAEA, INFCIRC/546, 1997.

IAEA GSG-1; Classification of Radioactive Waste. International atomic Energy Agency, General Safety Guide GSG-1. Vienna. (2009).

SPORO-2002: Sanitary Regulations of Radioactive Waste Management(SPORO-2002) , Ministry of Health of Russia, 2002.

OSPORB-99: Basic Sanitary Regulations of Radiation Safety Provision, OSPORB-99.

NRB-99: Norms of Radiological Safety, NRB-99.

NP-055-04: Disposal of Radioactive Waste. Principles, Criteria and Basic Safety Requirements, NP-055-04.

NP-069-06: Near Surface Disposal of Radioactive Waste. Safety Requirements, NP-069-06.

15 Review of the Russian and international documents on control and accounting of nuclear materials and re-categorising nuclear materials as radioactive waste

15.1 Review of International Recommendations on Managing Radioactive Waste Containing Alpha-emitting and Trans-uranium Radionuclides

The basic problem of managing spills of nuclear materials from the viewpoint of radiation-hygienic safety is managing radioactive waste containing, alpha-emitting and trans-uranium radionuclides along with beta-emitting.

The solution of the problem of managing such waste includes two aspects. These are the managment of radioactive waste and partially, with reference to radiation-hygienic issues, the managment of spent nuclear fuel.

In 1961 the IAEA published Safety Series No 5, dealing with the establishment of appropriate safety procedures and practices for the disposal of radioactive waste in the sea. It published guidance on radioactive waste disposal in the ground [IAEA Safety Series No. 15, 1965]. In 1977 the IAEA outlined a programme for the production of a set of guidance documents on underground disposal. Some of them established international standards for the planning and establishment of underground waste repositories. In 1978 the IAEA published a Guide on the safety concepts and principles for use - by the competent bodies, while applying restrictions to the planned release of radioactive substances to the environment.

Towards the end of the 1980's the IAEA established the Radioactive Waste Safety Standards (RADWASS). The RADWASS-programme was intended to establish an ordered structure for the safety documents on waste management. In 1995 in the category of Safety Fundamentals the basic document of RADWASS-programme [IAEA Safety Series. No. 111-F, 1995] was published. This document defines the basic principles and concepts of safe handling of radioactive waste. These principles find a detailed implementation in the standards and guides of RADWASS-programme.

The experience in geological burial and environmental rehabilitation is small or missing. In these areas the methodologies and concepts are still at the development stage, and in the RADWASS-programme this fact is also reflected — now it is impossible to make firm recommendations about all important safety problems in the mentioned areas. The majority of safety problems demanding solution is connected with the need of long-term safety maintenance when high level waste still remains dangerous.

One of the IAEA fundamental tasks consists of playing the role of a centre to transfer nuclear technologies, including those of radioactive waste management, and for the purposes of addressing its task in the field of technology of waste management the Agency actively works at improvement of old and development of new effective remedies.

Efforts in the field of radioactive waste management technologies are aimed solving three major problems:

- Management of waste containing, alpha emitters and trans-uranium radionuclides with levels of specific activity less than LLW;

- Management of waste containing radionuclides with activity levels that allow to refer them to the categories of LLW and ILW. Their isolation is carried out by the method of burial that varies from subsurface storage facilities to specially equipped engineering geological repositories; and
- Management of high level waste.

International Approaches to Very Low Level Waste

As of today, to exempt from radiation control, foreign countries most often practice the value of 100 Bq/g (2.7 μCi/kg) that is close to the norm of 2 μCi/kg as per [OSPORB-99, 1999]. While exercising control of transport operations, the bottom level of surface activity is used, i.e.: 0.4 Bq/cm^2 for β- and γ-emitters and low energy α-emitters and 0.04 Bq/cm^2 for other emitters [OSPORB-99, 1999].

However, the experience shows that the problems of restrictions can arise at levels of radioactive contamination below the specified values.

The concept of exclusion and exemption of sources from control was discussed at sessions of working groups of the International Atomic Energy Agency (the IAEA) in connection with sea dumping of radioactive waste. In 1988 the IAEA together with the Organisation for Economic Co-operation and Development (OECD) published a series of documents devoted to the issue of application of principles to release from regulatory control. The ICRP in Publication No. 46, 1985 adopted the same as the IAEA Safety Series No.89,1988.

Meanwhile, various national and regional groups studied the information. Based on the developed materials, the following terms and principles of exemption or release of ionizing radiation sources from control have been established [IAEA Safety Series No.RS-G-1.7, 2006].

Exclusion - a source is excluded from control, for exposures that are unamenable to control.

Exemption - a source is released from control if two main principles are met:

1. Individual doses shall be low enough, not causing concern for people exposure and not demanding application of special regulations.
2. Further reduction of doses is not justified from the point of view of procedural actions of radiological protection.

The level of negligible risk that separates the area of risk optimisation and the area of certainly acceptable risk makes 10^{-6}/y. It matches the individual effective dose of about 20 μSv/y, if it is assumed in round figures that the risk factor is $5*10^{-2}$ Sv^{-1}.

Thus, it is impossible to mix the terms "radioactive material" and "radioactive waste". In the IAEA draft on radioactive waste classification [IAEA SGS-1, 2009] [5]the following definitions of the categories of waste released from the control are given:

- Waste conditionally exempted from control - separate waste or type of activity that can be released from control by the regulatory bodies depending on local conditions;
- Waste unconditionally exempted from control - waste for which control for radiation protection is not introduced.

In other words, waste exempted from control from the physical point of view, it can be managed disregarding its radioactive properties.

Levels of conditional exemption from control

As a result of analysis of various scenarios under the IAEA recommendations, concentration levels of various radionuclides for conditional exemption from control [IAEA SGS-1, 2009] have been calculated. Table 15.1 lists specific activity of waste as recommended by the IAEA, with reference

[5] At the time this work was done, the final version was not available.

to solid materials below which the waste is subject to unconditional release from the regulatory control.

Table 15.1 Specific activity of solid materials below which their unconditional exemption from radiation control is allowed.

Radionuclide	Specific activity, Bq/g	Average specific activity, Bq/g
^{22}Na, ^{24}Na, ^{54}Mn, ^{60}Co, ^{65}Zn, $^{134\ 137}$Cs, $^{226\ 228}$ Ra, $^{228\ 230\ 232}$ Th, $^{234\ 235\ 238}$ U, $^{239\ 240}$ Pu, ^{241} Am, ^{244} Cm	0.1-1.0	0.3
^{58}Co, ^{50} Fe, ^{90}Sr, ^{106}Ru, ^{210}Po	1-10	3
^{51}Cr, ^{57}Co, ^{123}I, ^{129}I, ^{144}Ce, ^{241}Pu	10-100	30
^{14}C, ^{32}P, ^{89}Sr, ^{99}Tc	100-1,000	300
^{3}H, ^{35}S, ^{45}Ca, ^{63}Ni, ^{147}Pr	1,000-10,000	3,000

Levels of unconditional exemption from control.

Since in the analyzed documents there is no exact gradation for "unconditional" and "conditional" clearance from control, Table 15.2 presents the lowest levels for release from control, Table 15.3 lists levels for unconditional clearance from control practised in different countries.

Table 15.2 Lowest levels for release from control of radioactive materials Bq/g, Bq/cm^2

Item #	Radionuclide group	Radionuclides	Minimum levels
1.	^{232} Th - A series of and trans-uranium alpha emitters.	$^{239\ 240}$ Pu , ^{241} Am, ^{244} Cm.	0.04
2.	Uranium and gamma-emitting radionuclides with average and high energies.	$^{234\ 235\ 238}$ U, $^{57\ 60}$Co, $^{134\ 137}$Cs , $^{22\ 24}$Na, ^{54}Mn, ^{65}Zn, ^{35}Sb, ^{152}Eu.	0.2
3.	Low power beta-emitters with small release of gamma-emitters.	^{241} Pu, ^{106} Ru, ^{144} Se, ^{90} Sr, ^{90} Y, ^{51} Sg	2.0
4.	Pure beta-emitters of average energy.	^{14}C, ^{32}P, ^{35}S, ^{45}Ca, ^{63}Ni, ^{55}Fe	200
5.	Pure beta-emitters of low energy.	^{3}H, ^{36} C1, ^{129}I, ^{99} To	2,000

Table 15.3. Levels of unconditional exemption from control for solid radioactive waste practiced in different countries

Country	Specific activity, Bq/g	Surface activity, part./cm^2	Radionuclides
Russia	100	8.3*10-^{1}	Beta-emitters
	10.0	8.3*10^{-2}	Alpha-emitters
	1.0	8.3*10^{-3}	Trans-uranium
France	100	0.4	Beta-gamma-alpha-emitters of low toxicity
Italy	0.1	0.1	Alpha-emitters
Germany		0.05	Alpha-emitters

Basically two approaches can be considered, while developing derivative levels of VLLW management. The first one is radiation-hygienic, dosimetric, i.e. the so-called "risky" one, when the calculation basis is formed by the already substantiated normalised value, for example, a dose or a risk level. The second is radiation-environmental, when at derivative rationing in the addressed situation (in this case – VLLW management) levels of the already available radioactive contamination, i.e. the global background of the territory, is taken as the basis.

The basic bottom level for comparison is the man-caused background from the global fallout after nuclear weapon trials. For $^{239\,240}$Pu it makes – (1.6^{-11}) mCi/km^2 , for ^{l37}Cs – (92 ± 33) mCi/km^2, for ^{90}Sr – (30-35) mCi/km^2. The limits of "conditionally pure" waste which for plutonium are equal to the background values, for ^{l37}Cs three times exceeding the background, for ^{90}Sr - 30-70 times, are closest to the levels of the man-caused background.

The criterion of "conditionally pure" waste is below the levels staled by the IAEA [IAEA SGS-1, 2009] for unconditional exemption from control for Pu – by 10 times, for ^{90}Sr and ^{l37}Cs - 3 and 2 times, respectively. If compared to the level of release for uncontrolled disposal in the ground, this criteria are 16 times less for Pu, 3 times less for ^{l37}Cs, but 15 times higher for ^{90}Sr.

Waste with low and average radioactivity levels (LALRW) is defined by the IAEA as radioactive waste, in which the concentration or quantity of radionuclides is above the level of their release from control established by the regulatory authority, but thus the contents of radionuclides in them and the calorific value are below those characteristic of high level waste (i.e. about 2 kW/m^3). LALRW is often subdivided into short-lived and long-lived. It is generated as a result of operation of nuclear power plants [~ 500 m^3/GW (el) · year] and other installations of the fuel cycle [~ 90 m^3/GW (el) · year] formed as a result of activities for uranium processing enterprises, [~ 60 000 m^3/GW (el) · year], from the enterprises engaged in extraction and crushing of uranium ore, and decommissioning of these enterprises.

15.2 Russian Approaches to Safety Provision, while Managing Radioactive Waste Containing Alpha -emitting and Trans-uranium Radionuclides

The Russian approaches to the management of radioactive waste containing alpha-emitting and trans-uranium radionuclides essentially do not differ from the international recommendations. Thus, in the Russian regulatory-methodical documentation the term radioactive waste means substances not intended for further use in any aggregate state in which the contents of radionuclides exceeds the levels established by NRB-99. Nuclear materials are understood as materials containing or capable to reproduce fission radioactive substances. From a radiation protection viewpoint, the safe radioactive

waste and nuclear materials handling essentially does not differ and is defined by the specific contents of radionuclides in the materials.
Laws of the Russian Federation and regulatory acts define the basics of waste management with a view to prevent harmful impact of waste on the health of man and the environment, as well as involving such waste in economic activities as additional sources of raw materials. On radiation-hazardous facilities the issues of radioactive waste management are supervised by the divisions of Rosatom, TVEL Concern, and Rosenergoatom. In the organisations that manage radioactive waste an important role is played by the state services that exercise regulation and state oversight in this field.
The bodies that regulate radiation safety, Minzdravsotsrazvitiya (Ministry of Health and Social Development) and Rostechnadzor, develop Federal norms and regulations that control activities of the enterprises, while managing radioactive waste.

The following refers to the Sanitary legislation documents:

- SP 2.6.1.758-99 Norms of Radiological Safety, or Russian Radiation Safety Standards (NRB-99);
- SP 2.6.1.799-99. Basic Sanitary Regulations of Radiation Safety Provision (OSPORB-99);
- SP 2.6.6.1168-02. Sanitary Regulations of Radioactive Waste Management (SPORO-2002).

Rostechnadzor has developed:

1. Concept of formation of the system of regulatory documents that control safety at radioactive waste management. Approved by Governmental Resolution No. 8 dated 05.11.97.

2. Basic Federal Norms and Regulations:

- Safety Requirements NP-020-2000. Collection, Processing, Storage and Conditioning of Solid Radioactive Waste;
- Safety Requirements NP 019-2000. Collection, Processing, Storage and Conditioning of Liquid Radioactive Waste;
- Safety Requirements. NP-021-2000. Management of Gaseous Radioactive Waste.

All legislative and regulatory acts listed above address regular practice of radioactive waste management at industrial enterprises. The issues of managing radioactive waste accumulated as a result of the previous activity of the defence enterprises, generated at elimination of the nuclear fleet, decommissioning of nuclear power plants, re-categorising nuclear materials as radioactive waste, etc. remained beyond the scope of the legislative regulation. Solution of these problems is carried out within the Federal and branch programmes.

It is to be noted that regulation of radioactive waste management in Russia has historically been caused by the requirements of norms and regulations of the Sanitary legislation. The basic sanitary requirements have been formulated already in the first sanitary rules. Then, simultaneously with the development of the international and domestic standards of radiation safety, the requirements to the systems of radioactive waste management have been defined by the following regulatory acts: OSP-72; OSN-72/87; NRB-76/87; NRB-96, NRB-99; SPORO-64; SPORO-85; SPORO-2002; SPAS-79; SPAS-03, etc.

At the enterprises of atomic power engineering of Russia, there are various systems of radioactive waste management. Radiation safety of the personnel and the public in each specific case is regulated by special hygienic norms in conformity with the requirements of [SPORO-2002], item 1.3. “For radiation facilities in cans when sources of radioactive waste generation, places of its collection, temporary storage, as well as transportation routes, processing and disposal stations are located within the organisation territory, it is necessary to be guided by the special sanitary requirements that take into account the specifics of radioactive waste management in these conditions.”

Radioactive Waste Categorisation

For all enterprises of the country there are uniform requirements of radioactive waste categorising. OSPORB-99 and SPORO-2002 present classification of radioactive waste (Table 15.4).

Table 15.4 Categorization of liquid and solid radioactive waste

Waste category	Specific activity, kBq/kg		
	Beta-emitters	Alpha-emitters (except trans-uranics)	Trans-uranics
Low Level	Less than 10^3	Less than 10^2	Less than 10^1
Intermediate Level	From 10^3 to 10^7	From 10^2 to 10^6	From 10^1 to 10^5
High Level	More than 10^7	More than 10^6	More than 10^5

For preliminary sorting of solid waste, use of criteria by radioactive contamination level (Table 15.5) and by the dose rate of gamma radiation at a distance of 0.1 m from the surface is recommended, provided that conditions of measurement are observed in conformity with the approved methodologies:

- Low Level – from 0.001 mGy/h to 0.3 mGy/h;
- Intermediate Level – from 0.3 mGy/h to 10 mGy/h;
- High Level – more than 10 mGy/h.

Table 15.5 Categorization of solid radioactive waste by the level of radioactive contamination

Waste category	Level of radioactive contamination, particle / (cm^2·min)		
	Beta-emitters	Alpha-emitters (except trans-uranics)	Trans-uranics
Low Level	From $5{\cdot}10^2$ to 10^4	From $5{\cdot}10^1$ to 10^3	From $5{\cdot}10^2$
Intermediate Level	From 10^4 to 10^7	From 10^3 to 10^6	From 10^2 to 10^5
High Level	More than 10^7	More than 10^6	More than 10^5

The waste containing very low quantities of radioactive substances is not included in this classification.

15.3 Issues of Safe Management of the Generated and Previously Accumulated Radioactive Waste Containing Spills of Nuclear Materials

Two basic subsystems of radioactive waste management are defined:

1. For management of long-lived radioactive waste and spent nuclear fuel; and
2. For management of short-lived waste.

Management of long-lived waste including that containing spent nuclear fuel spills is associated with the solution of some specific problems. First, this is management of nuclear materials re-categorised as Radioactive Waste. The basic safety requirements of nuclear materials management, while re-categorising them as radioactive waste, are stated in detail in section 2.4. According to NP-072-06, transfer of nuclear materials to radioactive waste shall be carried out in the balance zone of materials in the place of their accounting. Secondly, the issue of containment in the package of alpha-emitting radionuclides is important. According to the Concept No.2.3676, Appendix B Criterion 3 of shipment to the regional centre on conditioning and long-term storage of radioactive waste in the package, the radioactive waste shall have:

1. Specific activity:
   - In regular package - $\leq 1 \cdot 10^9$ Bq/kg (trans-uranium nuclides are not allowed);
   - In a special package – without restrictions.
2. Total activity in the package – not more than the limit of total activity of the storage facility.
3. Percentage of nuclides meeting the restrictions

(1) ^{137}Cs ≤ 70 (5) ^{63}Ni ≤ 35

(2) ^{90}Sr ≤ 35 (6) ^{54}Mn ≤ 10

(3) ^{60}Co ≤ 30 (7) ^{144}Ce ≤ 20

(4) ^{59}Ni ≤ 0.5 (8) Trans-uranics ≤ 0.01

Thus, the RB-023-02 Guide, in item 4.1.17 "Contents of Nuclear Materials in radioactive waste" notes that the contents of nuclear materials in the radioactive waste package shall be limited to prevent a possibility of criticality occurrence at storage and dumping of the radioactive waste package (s).

Thirdly – the procedure of managing such waste after long-term storage is important. After storage for a period sufficient for decay of radionuclides with a rather short half-life (half-life less than 30 years), this waste shall be disposed off to final isolation.

Therefore, while discussing the issue of managing radioactive waste containing alpha-emitting and trans-uranium radionuclides, first of all, it is necessary to isolate those for which subsurface disposal is admissible (within dozens metres from the surface).

Table 15.6 Admissible contents of radionuclides in Radioactive Waste disposed in subsurface constructions

Radionuclides		Volume specific activity, Bq/m^3	Weight specific activity, Bq/kg
Radionuclides with half-life less than 5 years		Not limited	Not limited
^{3}H		Not limited	Not limited
^{14}C		3.0E+11	1.5E+08
^{14}C in activated metal		3.0E+12	1.5E+09
^{59}Ni in activated metal		8.1E+12	4.1E+09
^{60}Co		not limited	Not limited
^{63}Ni		2. 6E+13	1.3E+10
^{63}Ni in activated metal		2,6E+14	1,3E+11
^{90}Sr		2.6E+14	1.3E+11
^{94}Nb in activated metal		7.4E+09	3.7E+06
^{137}Cs		1.7E+14	8.5E+10
^{99}Tc		1.1E+11	5.5E+07
^{129}I		3.0E+09	1.5E+06
^{241}Pu			1.3E+08
^{242}Cm			7.4E+08
Uranium and trans-uranium alpha-emitting radionuclides with half-lives more than 5 years	Separate packages		3.7E+06
	On the average		3.7E+05

For radioactive waste containing alpha-emitting and trans-uranium radionuclides in quantities above those specified in Table 15.6, as well as for Intermediate Level Waste with beta-emitting radionuclides that will be accumulated in the Centre of Conditioning and Long-term Storage (CCLTS) in Saida Bay, the issue of their isolation shall be dealt with.

In LLW stored in Saida CCLTS at present, alpha-emitters and trans-uranics with levels of specific activity less than that of LLW (Table 15.6), can be re-categorised as VLLW after long-term storage. Requirements to such waste are addressed in the Guide "Hygienic Requirements to Provision of Radiation Safety, while Managing Industrial Waste at SevRAO Enterprise".

Radiation-hygienic issues of safe managment of radioactive waste containing alph -emitting and trans-uranium radionuclides, presently, have been solved in the earlier developed documents dedicated to the improvement of the sanitary-epidemiologic oversight of the FMBA of Russia at dismantling ships and vessels with nuclear propulsion plants and rehabilitation of the former maintenance bases of the Northern Fleet.

In particular, the procedure of safe handling of industrial wastes containing man-made radionuclides with activity levels less that those of LLW is reflected in the Guide 'Hygienic Requirements to Managing Industrial Waste at the Federal State Unitary Eenterprise 'Northern Federal Enterprise for Radioactive Waste Management' [R ONAO SEVRAO-08].

This document offers a complete set of the required actions to provide non-excess of the regulated by NRB-99 basic limits of exposure doses for the personnel and population, to prevent and eliminate radioactive environmental contamination, including that as a result of emergencies. It is thus defined that the personnel occupied with waste sorting is referred to Group A, and the personnel occupied in jobs at the VLLW disposal site is referred to Group B.

The industrial waste containing radionuclides with specific activity below the levels for referring them to radioactive waste, including alpha-emitting and trans-uranium radionuclides, is subdivided into two groups:

- Waste and materials containing man-made radionuclides with a level of specific activity below the one for Low Level Waste (LLW), but above the levels to exempt them from regulatory control (the first group).
- Waste and materials exempted from regulatory control (the second group).

Sanitary-epidemiologic and radiation safety of this category of waste is determined by:

- Size of specific and general activity of the dumped waste within a year;
- Contents of toxic substances, heavy metals and other components that stipulate class of danger of the waste by the degree of impact on man and the environment;
- Fire & explosive characteristics of waste;
- Possible release of waste components to the environment at normal degradation or non-scheduled destruction of engineering protective barriers of the waste disposal site during and/or after the termination of the disposal site operation.

The individual annual effective dose of production exposure due to of managing industrial waste for the personnel of group A shall not exceed 5 mSv/y. The planned exposure shall not exceed 1.5 mSv/y. The expected individual annual effective dose of exposure of a critical group of the population because of the use of industrial waste with very low contents of radionuclides in economic activities shall not exceed - 10 μSv/y.

Waste with a known radionuclide content is released from regulatory control, if the following condition is met:

$$\sum_{i}^{n} \frac{a_i}{a_{0i}} \leq 1$$

Where: a_{0i} - maximum value of an *i*-nuclide specific activity in waste in the absence of other radionuclides at which it is released from regulatory control, kBq/kg.

According to OSPORB-99 for all radionuclides the value of a_{0i} equals 0.3 kBq/kg. Thus for SevRAO enterprise the criteria of referring industrial waste to VLLW (Table 15.7) are defined.

Table 15.7 Criteria for sorting industrial waste at SevRAO with the isotopic content: ^{90}Sr (20 %) and ^{137}Cs (80 %) *[R ONAO SEVRAO-08]*

Waste category	Specific β-activity, kBq/kg	Surface contamination, β - particle/m*cm^2	Dose rate at 0.1 m from waste package surface, μSv/h
Exempted waste	≤ 0.3	≤ 50.0	Non-excess of the natural-emitting background characteristic of the area by more than 0.1
VLLW	0.3 – 12.0	50.0 – 500.0	0.1 – 1.0

Note: *specific activity and surface contamination (impurity) are applied simultaneously, without excluding each other.*

Gamma-emitting waste with an unknown radionuclide content is considered as VLLW, if the following inequality is met:

$$P_1 < P \leq P_2,$$

Where P – dose rate near waste surface (0.1);

P_1 – dose rate caused by the natural radiation background characteristic of the area;

P_1- dose rate near the surface (0.1) of waste with unknown radionuclide structure at excess of which it is considered as solid radioactive waste (hereinafter- SRW),

P_2- according to SPORO-2002 = 1 μSv/h.

According to the OSPORB – 99 requirements, when radionuclide composition is unknown, industrial waste can be referred to the category of VLLW, if the contents of β-emitting radionuclides are 0.3 – 100 kBq/kg, α-emitters 0.3 – 10 kBq/kg, and trans-uranics 0.3 – 1 kBq/kg.

The Guide defines that VLLW is allowed to be accommodated at SevRAO site, if the isotope composition is as presented in Table 15.8, i.e. ^{90}Sr (20 %) and ^{137}Cs (80 %) [R ONAO SEVRAO-08].

Table 15.8 Criteria for industrial waste containing man-made radionuclides for accommodation at SevRAO site for isotope composition: ^{90}Sr (20 %) and ^{137}Cs (80 %)

Very Low Level Waste	Specific activity of radionuclides in package, kBq/kg	Maximum specific activity of radionuclides in package, kBq/kg	Levels of surface β-contamination of VLLW, partic./min*cm^2	Equivalent dose rate, μSv/hour	Maximum contents of long-lived α-active radionuclides, %
	0.3-30.0	<100.0	50.0-500.0	<1.0 at a distance of 0.1 m from package	0.1

Upon expiry of the disposal site operation time its further use is provided by the management under one of the three scenarios:

- Exemption from regulatory control provided that average specific activity over the disposal site as a whole, including protective barriers, will not exceed 0.3 kBq/kg;
- Limited use of dumped waste in economic activities with an activity level less than Minimum Significant Specific Activity (MSSA);
- Formation in the territory of the industrial site of a "brown field" with preservation on it of the conserved disposal site.

When exempting the VLLW disposal site from regulatory control, the same requirements as to an industrial waste disposal site, whose management is regulated by "Hygienic Requirements to Location and Neutralisation of Production and Consumption Waste", are applied [SanPiN 2.1.7.1322-03]. The VLLW disposal site released from regulatory control at the production site according to the recommendations of the international organisations shall not exceed of the boundary dose for the population that equals 0.3 mSv/y after closing. These requirements are reached, if the following conditions are met:

$$\sum_{i}^{n} \frac{a_i}{a_{0i}} \leq 1$$

Where: - a_{0i} - maximum value of an *i*-nuclide specific activity in waste in the absence of other radionuclides at which it is released from regulatory control, kBq/kg.

Sanitary-hygienic requirements to provision of radiation safety of the personnel and population at designing and performing radiation-hazardous operations, while handling spent nuclear fuel and radioactive waste at FSUE SevRAO, are specified in the Guide "Hygienic Requirements to Provision of Radiation Safety of the Personnel and Population at Design and Organisation of Works with spent nuclear fuel and radioactive waste in Branch No. 1 of FSUE SevRAO" [R 2.6.1.29-07, 2007].

It is thus defined that buildings and premises, as well as the territory where the work with spent nuclear fuel and radioactive waste is carried out, shall be divided into two zones:

- Controlled access zone (hereinafter CAZ) - industrial premises where management of radiation sources is carried out and impact of radiation factors on the personnel of group A is probable. The zone premises shall be accessed through a sanitary check point;
- Free access zone (hereinafter FAZ) - auxiliary and administrative premises where at normal operation no handling of radiation sources is carried out and, as a rule, the impact on the personnel of radiation factors is practically prevented.

In the FAZ the movement of personnel and vehicles is carried out without any restrictions. The procedure of movement of the personnel and vehicles in the controlled access zone is defined by the radiation safety service.

It is noted about the nature of jobs on spent nuclear fuel and radioactive waste management in the conditions of actual or potential radiation hazard, that when the predicted maximum individual effective dose of the worker (calculated on the basis of conservative estimations) can exceed 20 mSv per year, they shall be referred to radiation-hazardous works. Categories of radiation-hazardous works (RHW) are specified in Table 15.9.

Table 15.9 Categories of radiation-hazardous works

RHW category	Maximum individual effective dose, mSv/y
RHW of Category IV	> 20 - 30
RHW of Category III	> 30 - 40
RHW of Category II	> 40 - 50
RHW of Category I	> 50

The values of the designed equivalent dose rate for a standard duration of the personnel stay in the premises and in the territory with due regard to the safety factor equal 2 shall not exceed those presented in Table 15.10.

Table 15.10 Equivalent dose rate used, while designing protection for the personnel of the facility for spent nuclear fuel and radioactive waste management from external ionising radiation

Personnel	Designation of premises and territories	Duration of exposure, h/y	Designed equivalent dose rate, μSv/h
Group A	Premises of the personnel permanent stay	1,700	6.0
	Periodically attended premises	850	12.0
Group B	Premises of free access zone in the industrial site territory	2,000	1.2

Prior to the beginning of works to remove spent nuclear fuel from dry storage units, the radioactive waste from Building 5 and other radiation-hazardous works in the operating buildings and constructions of SevRAO, a complex of protective measures to decrease the dose rate of external radiation is to be conducted. It is thus noted that the calculation of a permissible dose rate upon undertaking protective measures shall additionally include the contribution of internal exposure.

The values of the external dose rate when undertaking protective measures in DSU 2-A, 2-B and 3-A and Building 5 shall not exceed:

- For premises of the personnel constant stay – 9.0 μSv/hour; and
- For periodically attended premises – 18.0 μSv/h.

Operational modes and hardware registration of technological processes of spent nuclear fuel and radioactive waste management shall provide:

- The maximum possible decrease of the impact of ionising radiation on the personnel;
- Remote control of the process with the maximum automation of operations;
- Possibility of performing visual control over the process and equipment functioning by means of devices that reduce the personnel exposure (protective glasses, periscopes, television and robotic devices, etc.);
- Mechanisation of technological operations of loading, unloading, drying, filtration, package, sampling, etc. with the performance of the specified operations in the isolated technological spaces at rarefaction (in vacuum); and
- Reliability and sustainability of the production equipment.

The equipment intended for management of spent nuclear fuel and processing of radioactive waste containing nuclear fission materials shall be manufactured and operated taking into account the requirements for nuclear safety.

The system of radiation control shall provide organisation of a database of an individual radiation control and parameters of radiation conditions in industrial premises, in the sanitary-protective zone and in the observation zone.

Requirements of the personnel radiation protection at radioactive waste handling are regulated by NRB-99 and OSPORB-99. The radiation impact on the population caused by radioactive waste management, including storage and dumping stages, shall not exceed 1 % from the regulated by NRB-99 average annual effective dose on the population from man-made sources of radiation that makes 10 μSv/y (item 3.12.19 OSPORB-99).

SRW collection is regulated to places of loading into containers-collectors. The parameters of the containers shall take into account the parameters of transport security of the container or transport package containers and meet the requirements of nuclear and radiation safety. Special containers are used, as a rule, as collecting containers. Metal barrels and boxes, plastic tanks and craft-bags can also be applied.

Containers-collectors with SRW shall be arranged in specially-allocated places equipped with pallets, lifts, elevators, auxiliary stock, radiation control devices. The gamma dose rate on the external surface of the container-collector shall not exceed 50 μSv/h.

Packaging of the processed radioactive waste is the last operation of conditioning and consists of placing the processed waste into a special container with its subsequent sealing. The levels of radioactive contamination on the external surface of the package (container) shall not exceed the sizes given in Table 3.5.1 of OSPORB-99.

The gamma dose rate on the surface of walls of designed long-term storage facilities shall not exceed 6 μSv/h.

Transportation of radioactive waste of various categories and groups beyond the STS shall be carried out in TUK casks of appropriate type that take into account the requirements of NP-053-04 and SanPiN 2.6.1.1281-03.

For Branch No. 1 of SevRaO the Guide establishes a quota on the dose of the population exposure that equals 150 μSv/y. This quota refers to the total exposure of the population from radioactive gas-aerosol emissions to the atmosphere and liquid dumps to the surface water.

Restriction of the population exposure in case of beyond-design accidents at STS is conducted according to the principles of intervention and the dose values that are the criteria for decision-making about intervention, are stated in NRB-99. Thus, it is necessary to consider the specifics of generating the doses from presence and/or emission of long-lived radionuclides, including trans-uranium ones.

15.4 Review of the Russian Regulatory Basis for Managing Radioactive Waste Containing Nuclear Materials

From the chronology of development of the situation occurring at the addressed facilities of SevRAO and the FMB “Lepse”, it is possible to ascertain the following:

1. The facilities entering at present the structure of SevRAO, up to the early XXIst century belonged to the Ministry of Defence, and, in compliance with the current legislation, did not fall under the effect of Law “On Use of Atomic Energy”.

Long-term storage of spent nuclear fuel from nuclear powered submarines in conditions that do not meet regulatory requirements, has resulted in degradation of fuel element cladding and release of fission products and fuel particles in water. It has been proven by measurements of radionuclides

water in cells of DSU 2B. In the water samples collected at various depths, the activity of ^{137}Cs and ^{90}Sr was about 10^9 Bq/l, and the activity of α-emitters about 10^5 Bq/l.

While unloading cans with SFA from pools of the emergency storage facility in Building 5, some SFA dropped out of cans to the storage facility bottom. Some covers (not less than 100) because of corrosion and break of chains have fallen to the bottom of the pools and stayed there in a mess for a long time. At their retrieval some SFA dropped to the bottom of pools. Therefore, the number of defective assemblies increased. It accelerated fuel degradation at long-term (~ 20 years) storage of spent nuclear fuel in DSU cells some of which are filled with groundwater.

Therefore, it is doubtless that after unloading SFA from the cans stored in DSU cells, fuel spills may remain at the bottom of many cans, as well as at the bottom of cells.

In the cooling pools of Building 5 there is about 2,500 Ci of corrosion products, their volume being ~ 34 m^3. Fuel spills and SFA fragments are possible in the deposit layer.

The conducted exposure dose rate measurements in the industrial premises of Building 5 and dry storage units have shown that the levels of external gamma dose rate are essentially higher than what is allowed for industrial premises of the nuclear industry and power engineering enterprises.

The admissible operating time of the personnel work in industrial premises of Building 5 and DSU, calculated on the basis of a conservative approach (at a working condition within the whole shift without organisation of additional protective measures), is limited. So, for example, in the transport corridor of Building 5 the admissible operating time, does not exceed 104 labour shifts while working in the conditions of influence of average exposure dose rate levels, and 52 labour shifts while working under the impact of the maximum exposure dose rate levels. The admissible operating time of the personnel in the process hall of Building 5 and in DSU premises is even more limited.

The limiting factor that defines admissible operating time of the personnel in industrial premises of Building 5 and DSU is the effective dose that allows to use this value as a criterion for development of protective measures at design and organisation of works to manage spent nuclear fuel and radioactive waste in these premises.

The major contributor to the effective dose is external gamma radiation. The contribution of neutron radiation is negligibly small.

On DSU 3A site the cells are closed by concrete slabs, and beta-radiation that influences the skin and crystalline lens of the eye is practically absent. The whole exposure dose is defined only by gamma radiation. On DSU 2A site and DSU 2B site the cells are closed with metal plugs and the sites themselves are contaminated by beta-emitting nuclides.

To provide radiation safety of the personnel, while unloading spent nuclear fuel from DSU cells and in case of need to conduct works in Building 5, at the design stage and at organisation of such jobs it is necessary to provide a protective measures, including:

- Remote performance of works;
- Shielding of external gamma radiation;
- Application of individual protective equipment; and
- Application of automation equipment.

2. The FMB “Lepse” has been converted, as much as it was possible at that time (1961), for supporting of recharge of nuclear fuel of ship reactors of the nuclear icebreaker fleet according to the standards and regulations effective at that time. The FMB “Lepse” was decommissioned in 1988, and during its operation it did not fall under the action of Federal Law No. 170-FZ, 1995.

The storage facility of the “Lepse” houses SFA of eleven cores at various times operated on the nuclear ice breakers “Lenin”, “Arktika” and “Sibir”. The SFA belong to seven types of cores that differ in the type of fuel elements, fuel, initial enrichment and the material of fuel element cladding.

In total, the storage facility contains 639 SFA, including 19 of them – in caissons.

The condition of the major parts of SFA by the operation end was characterised by the presence of cracks or holes in fuel element cladding. Direct contact of fuel to the heat-carrier, leading to washout of fuel from fuel elements took place.

By estimates, the total activity of SFA by the defining (~ 98 %) radionuclides in the storage facility of the "Lepse" at the late 2010 will make ~ $2.6 \cdot 10^{16}$ Bq in fission products ($^{90}Sr+^{90}Y$; $^{137}Cs+^{137m}Ba$) and ~ $1.4 \cdot 10^{15}$ Bq in actinides ($^{238,241}Pu$, ^{241}Am).

Thus, the radical reasons of discrepancy of the given facilities with the law requirements are imperfection of nuclear technologies and emergencies resulted from the previous activities.

All federal standards, norms and regulations are to some extent aimed at meeting the requirements of the Law "On Use of Atomic Energy" and the IAEA recommendations. As the addressed facilities (see Section 1) for whatever reasons did not fall under the effect of the Law, and, as a consequence of it, they also not to the full extent met the requirements of the federal norms and regulations.

Review of practice in other countries shows that such facilities are not only in the Russian Federation, but also in the United States of America. Experience from the USA shows that there are complex issues to address in the management and supervision of fuel spill and fragments of contaminated wastes of the type described above.

While developing the SMP in the group engaged in works in Andreyev Bay, the problem of managing spent nuclear fuel spills and fragments contained in the sediments and at the bottom of pools in Building 5 was discussed with the Project International Consultant. The information received stated that while conducting similar works in Hanford, a decision to restrict the size of spent nuclear fuel fragments that can be referred to radioactive waste (not more than 1/3 inches) was made. This restriction led to the need to develop a complicated system for search, extraction and actually "screening" the media containing spent nuclear fuel particles. Because of it, while conditioning liquid radioactive waste containing spent nuclear fuel spills and fragments, both economic expenses and additional dose loads of the personnel have essentially increased. Therefore, it is presumed to be expedient to develop other criteria to asses possible referring of spent nuclear fuel particles to radioactive waste not connected with the geometrical sizes of the particles, based on the application of less dose-imposing methods of managing radioactive waste containing spent nuclear fuel spills and fragments that would be economically justified, environmentally safe and, at the same time, would provide nuclear safety, that deterministically prevents a possibility of criticality occurrence at all stages of managing radioactive waste containing nuclear materials.

The basic safety requirements for handling nuclear materials, re-categorising them as radioactive waste, and transferning them to the addressed facilities are contained in the following regulatory legal acts of the Russian Federation:

- Federal Law No. 170-FZ On Use of Atomic Energy passed by the State Duma on 10/20/1995;
- Statement on the State System of Control and Accounting of Nuclear Materials No. 352 approved by the Resolution of the RF Government on May 6, 2008 ;
- Basic Rules of Control and Accounting of Nuclear Materials NP-030-05 approved by Rostechnadzor Resolution No. 19 dated December 26, 2005 and enacted since May 01, 2006;
- Rules to Re-categorise Nuclear Materials as Radioactive Waste NP-072-06 approved by Rostechnadzor Resolution No. 6 dated December 12, 2006 and enacted since June 1, 2007;
- Requirements to Organisation of Material Balance Zone NP-081-07 approved by Rostechnadzor Resolution No. 2 dated November 19, 2007 and enacted since June 1, 2008;
- Safety of Radioactive Waste Management. General Provisions NP-058-04 approved by the Resolution of the Federal Environmental, Industrial and Nuclear Supervision Service No. 15 dated December 31, 2004 and enacted since June 6, 2005.

Federal Law No. 170-FZ "On Use of Atomic Energy" specifies general requirements, while performing a type of activity that is of interest:

- In Chapter VI. "Location and Construction of Nuclear Plants, Radiation Sources and Storage Sites",
- In Chapter X. "Management of Nuclear Materials, Radioactive Substances and Radioactive Waste",
- In Chapter IV. "State Control of Atomic Energy Use",
- In Chapter XI. "Physical protection of nuclear installations, radiation sources, storage sites, nuclear materials and radioactive substances".

Development of the law provisions specified above is implemented in the following standard documents:

Statement on the State System of Control and Accounting of Nuclear Materials No. 352 approved by the Resolution of the RF Government on May 6, 2008.

The State system of control and accounting of nuclear materials is an element of the system of state control of the atomic energy use and is intended for execution of the following tasks:

- Provision of control over nuclear materials' management;
- Provision of safety, timely identification and prevention of losses, unauthorised use and plunders of nuclear materials; and
- Definition of the admissible quantity of nuclear materials in places of their location;

The State system of control and accounting of nuclear materials includes:

- Control bodies that provide its functioning at the federal level and in the organizations that carry out management of nuclear materials;
- Standard legal support of activities on control and accounting of nuclear materials;
- Information-analytical support of the system functioning, as well as processing and transfer of information about presence and movement of nuclear materials;
- Systems of control and accounting of nuclear materials of the organisations in which the nuclear materials are handled; and
- Control and supervision of the status of control and accounting of nuclear materials.

Basic Rules of Control and Accounting of Nuclear Materials NP-030-05 approved by Rostechnadzor Resolution on December 26, 2005 No. 19 and enacted since May 01, 2006.

The basic Rules of control and accounting of nuclear materials (hereinafter – the Rules) define the basic requirements to the state control and accounting of nuclear materials and special non-nuclear materials (hereinafter – nuclear materials) available in any chemical compounds and physical forms, as well as criteria of their control and accounting.

The present Rules cover the activity connected with manufacture, use, processing, storage and transportation of nuclear materials.

The present Rules are not applicable to the nuclear materials within nuclear ammunition, nuclear charges and their components.

Structure of the State Control and Accounting of Nuclear Materials

The State control and accounting of nuclear materials shall be carried out:

- In material balance zones (MBZ);
- By organisations that carry out management of nuclear materials, operating organisations (hereinafter - organisations); and

- By control bodies exercising control of atomic energy use, carrying out control and accounting of nuclear materials at the departmental and federal level.

Principles of State Control and Accounting of Nuclear Materials

Nuclear materials shall be subject to the State control and accounting, starting from the minimum quantity specified by the present Rules.

Nuclear materials shall be classified by categories with a view to provide a differentiated approach to the definition of procedures and methods of control and accounting.

The operating organisations shall define MBZ within a nuclear installation or a storage site of nuclear materials.

The key points of nuclear materials 'measurements shall be defined in every MBZ.

Access control devices (ACD) that confirm authenticity of the previous measurements of quantitative characteristics and attributive features of nuclear materials are applied to nuclear materials.

The accounting of nuclear materials shall be based on the results of measurements of quantitative characteristics of nuclear materials.

It is allowed to:

- Use the results of previous measurements of quantitative characteristics of nuclear materials, if their authenticity is confirmed by the proper condition of the applied ACD, by respective support measurements; and
- Application of calculation methods (techniques) based on the results of preliminary measurements, experimental research.

Rules of Re-categorising Nuclear Materials as Radioactive Waste NP-072-06 approved by Rostechnadzor Resolution No. 6 dated December 12, 2006 and enacted since June 1, 2007.

"Rules to Re-categorise Nuclear Materials as Radioactive Waste" define requirements to a complex of actions for transfer to the category of radioactive waste some substances in the form of compounds, alloys and a product containing nuclear materials registered in the State system of control and accounting of nuclear materials (hereinafter – products) not intended for further use, to removal from the State registration of nuclear materials contained in them and registration in the State system of control and accounting of radioactive waste containing nuclear materials generated from these products.

The present Rules cover the activity connected with manufacture, use, processing and storage of nuclear materials. The requirements of the present Rules are not applicable to re-categorising products as radioactive substances.

The name and quantity of products re-categorised as radioactive waste, are defined by the operating organisation that provides control and accounting of nuclear materials and radioactive substances, by the organisation performing works and rendering services for the operating organisation, are registered in the registration documents and reflected in deliverable forms of the system of state accounting and control of nuclear materials.

The information on the generated radioactive waste (substances not intended for further use that are in any aggregate status in which the content of radionuclides exceeds the levels defined by the norms of radiation safety), containing nuclear materials, is entered in the registration documents and is reflected in the deliverable forms of the State system of control and accounting of radioactive substances and radioactive waste. The methodologies according to which the products are re-categorised as radioactive waste in the organisation shall be agreed with the bodies that control atomic energy use.

The products referred to the category of radioactive waste shall pass immobilization, if required, and be transferred to a status meeting the criteria of appropriateness of the conditioned radioactive waste for storage or dumping and placed in the radioactive waste storage facility. The radioactive waste

containing nuclear materials is registered in the State system of control and accounting of radioactive substances and radioactive waste.

Before transfer of products to the radioactive waste category, access control devices (means intended for detection of unauthorised withdrawal, use, movement of nuclear materials, intrusions into to the restricted access zone which are subdivided into observation systems and device of intrusion indication) shall be applied to them.

Products can be re-categorised as radioactive waste provided that the following conditions are met:

- Retrieval from the to be re-categorised products containing nuclear materials in them with use of state of the art technologies is impossible or is economically inexpedient; and
- The products to be referred to the category of radioactive waste can be immobilized and are transferred to the condition meeting the criteria of radioactive waste appropriateness.

Preparation of products for re-categorising as radioactive waste shall include:

- Definition of the list of products supposed to be re-categorised as radioactive waste; and
- Placing of the products prepared for transfer to the category of radioactive waste into specially allocated places of the material balance zone.

Federal norms and regulations "Safety at Radioactive Waste Management. General Provisions" NP-058-04 approved by the Resolution of the Federal Environmental, Industrial and Nuclear Supervision Service No. 15 dtd. December 31, 2004 and enacted since June 6, 2005.

NP-058-04 defines goals and safety principles, while managing radioactive waste, as well as general requirements to safety provision. The objectives of safety provision are:

- Provision of reliable protection of the employees and population from radiation impact of radioactive waste above the safety levels defined by radiation norms;
- Provision of reliable isolation of LRW and SRW from the environment, protection of the present and future generations, biological resources against the radiation impact above the limits defined by the norms of radiation safety; and
- Prevention of releases (dumping), while managing radioactive waste in the environment in the quantity exceeding the maximum permissible emissions (dumping).

While handling radioactive waste, the following principles shall be observed:

- Provision of acceptable level of security of the employees and population from the radiation impact of radioactive waste in compliance with the principles of substantiation, regulation and optimisation (the principle of human health protection);
- Provision of acceptable level of the environmental protection from the harmful radiation impact of radioactive waste (the principle of the environment preservation);
- Accounting of the interrelation between the stages of radioactive waste generation and managing it (the principle of interdependence of the stages of radioactive waste formation and management);
- Predicted levels of exposure of the future generations caused by radioactive waste dumping shall not exceed admissible levels of the population exposure specified by effective regulatory documents (the principle of protection of the future generations);
- Non-imposing on the future generations of the unreasonable burden associated with the need of safety provision during radioactive waste management (the principle of non-imposing of excessive burden on the future generations);

- Radioactive waste formation and accumulation shall be limited by the minimum practically achievable level (the principle of control of radioactive waste generation and accumulation); and
- Prevention of accidents with radiation impacts and mitigation of possible consequences in case of their occurrence.

General Requirements to Safety, while Managing Radioactive Waste:

- Referring waste to radioactive, LRW and SRW categorising by specific activity and radionuclide structure (low-, intermediate- and high-level), SRW classification by the level of radioactive contamination of the surface and by the dose rate of gamma radiation at a distance of 0.1 m from the surface shall be carried out according to the criteria specified by the radiation safety norms and regulations.

Radioactive waste collection and sorting shall be made in places of its formation separately from non-radioactive waste.

- Safety of radioactive waste management shall be provided on the basis of application of the system of physical barriers to prevent the spread of radioactive substances to the environment. The quantity and designation of the barriers shall be defined and proved in the design of Facilities of Atomic Energy Use (FAEU*).*
- The FAEU design and operational documentation shall contain specific engineering solutions and administrative measures for safety provision, while managing radioactive waste of each category.

- Management of radioactive waste of various categories (low-, intermediate- and high-level) and non- radioactive waste shall be made in separate FAEU systems.

- FAEU design and operational documentation shall present radionuclide composition, activity and quantity of the radioactive waste generated at normal operation of the FAEU and at accidents.

- FAEU design and operational documentation shall present engineering solutions and administrative measures for safe storage of radioactive waste of each category, as well as define and substantiate the maximum permissible quantity (volume) of the stored radioactive waste, its specific and general activity, radionuclide structure and periods of storage.

- The design and constructional materials of radioactive waste storage facility shall prevent release to the environment of radionuclides above the levels defined by the standard documents and provide service life of the storage facility not less the operation period of the FAEU on which it is located.

While managing radioactive waste, radiation control according to requirements of regulatory documents shall be carried out.

Only the totality and interaction of the requirements of the documents specified above provide meeting of basic provisions of the Federal Law No. 170-FZ, 1995 and the Federal Law No. 3-FZ, 1996. These reference documents are quite sufficient for performing works on preparation of conditioned spent nuclear fuel (corresponding to all effective standards and regulations) to be re-categorised as radioactive waste under the condition of conformity of the objects of their location to the requirements of the reference document to FAEU.

As shown above, some spent nuclear fuel at SevRAO facilities and the FMB "Lepse" is not conditioned, i.e. not to the full extent to meet the Federal norms and regulations requirements to safe handling of spent nuclear fuel and its condition. Industrial premises of these facilities where spent nuclear fuel is located do not meet the requirements of the regulations either.

Proceeding from the above, development of federal norms and regulations (rules) in the form of methodical documents, shall contain recommendations on additional administrative-engineering measures to provide the same safety level as for spent nuclear fuel preparation for re-categorising as radioactive waste, as prescribed by the federal norms and regulations for such operations with conditioned spent nuclear fuel.

15.5 Appropriateness Criteria Concerning Radioactive Waste Packages Placed for Long-term Storage in the Regional Centre of Radioactive Waste Management in Saida Bay

Presently, NIKIET has developed and prepared a draft of the guidance document [Guidance document RD No.2.3678] in which the criteria of appropriateness concerning radioactive waste packages subject to long-term storage in the regional centre (RC) in Saida Bay are formulated.

The criteria contain requirements in relation to:

- Radiation parameters of waste and packages;
- Aggregate state of waste;
- Form and physical and chemical properties of waste; and
- Package sets.

In compliance with this document, the radioactive waste meeting the following criteria are accepted for storage.

Criterion No. 1:

The radioactive waste is not the one forbidden for placement in the RC (See Table 3.13) or not subject to processing in the RC (See Table 3.14).

Table 3.13. Radioactive Waste forbidden to place in the RC

1	LRW of all types (except solidified ones).
2	Activity filter traps containing non-solidified pitches and sorbents.
3	SRW containing "hazardous materials" (item 6.2. SPORO-2002): a) Explosive and self-igniting materials; b) Toxic materials of class I and II of danger; c) Materials releasing heat in contact with water; d) Materials capable to release gases, steams, sublimates; e) Pathogenic and infectious materials.

Table 3.14 Types of waste accepted and not allowed for treatment in the RC

I. Types of waste accepted for treatment in the RC
1. Cementing waste and slag. 2. Bitumen waste. 3. Polymeric blocks. 4. Metal waste. 5. Non-metallic non-pressed waste. 6. Barrels with solid adioactive waste.

7. Solidified pitches and sorbents. 8. Other waste not falling under the Category II below.
II. Types of waste not allowed for treatment in the RC
1. Combustible waste. 2. Non-solidified LRW. 3. Very Low Level Waste.

The contents of poisonous, toxic, pathogenic and infectious substances in the radioactive waste must not exceed the values defined by the special instruction (developed and submitted to the suppliers by the operating organisation).

Criterion No. 2:

The radioactive waste form is optimum steady to the impacts possible in the RC conditions, such as:

- Aggregate state – solid (Bitumen-laminated, cemented SRW, including solidified LRW).
- Solidified waste in the package is structurally and chemically homogeneous.
- Radioactive waste strength characteristics provide undertaking of loads arising, while managing it.
- Thermal stability of radioactive waste:
  - Flash temperature – $\geq 200^0$C;
  - Ignition temperature – $\geq 250^0$C;
  - Spontaneous ignition temperature – $\geq 400^0$C.
- While laminating with bitumen some salt concentrates and filter-perlites, the moisture content is ≤ 1 %, ion-exchange pitches content is $\leq$ 3-5 %.
- Liquid contents in the package ≤ 3 %.

Criterion No. 3:

Radioactive waste is capable to preserve aggregate state by non-exceeding the following parameters:

- Bitumen-laminated waste:
  - Leaching rate of Cs and Sr $\leq 10^{-3}$ g/(cm^2 days);
  - Volume increase of a compound after 90 days of stay in water by $\leq$3 %;
- Grouted (cemented) waste:
  - Leaching speed of Cs $\leq 10^{-3}$ g/(cm^2 days);
  - Limit of mechanical strength at compression – $\geq$ 4.9 MPa (50 kgf/cm^2);
  - At the maximum absorbed dose the decrease in the mechanical strength is $\leq$ 25 %;
  - At 100 "thawing-freezing" cycles in the temperature range from - 40 ^{0}C to + 40 ^{0}C decrease in the mechanical strength is $\leq$ 25 %.

Criterion No. 4:

Documenting and tag-identification of radioactive waste package provide its adequate support at the subsequent management stages (See Table 3.15).

Table 3.15 Requirements to Radioactive Waste package sets

1	The container shall be certified.
2	The choice of the container design and construction materials of the container used for manufacturing of the radioactive waste package shall be based on: a) SRW physical and chemical characteristics; b) Methods of SRW subsequent management; c) Criteria of radioactive waste subsequent management.

3.	The design and container materials shall provide preservation of its integrity and working capacity, including strength characteristics at the subsequent stage of the SRW package management.
4	Construction materials of the container and those used for covering its surfaces shall provide protection from the atmospheric impact and a possibility for decontamination.
5.	The container used for package of radioactive waste shall preserve integrity during the expected period of storage till disposal and prevent unacceptable migration of radionuclides outside. The container shall provide a possibility of: a) Safe radioactive waste package retrieval from the storage facility at the end of the storage period; b) Its placing in an additional container; c) Transportation of radioactive waste package to a dump site; d) Managing of the radioactive waste package at dumping. If a radioactive waste package does not meet the storage or transportation requirements, an additional container shall be used.
6.	The container design shall provide safety and radiation safety of the radioactive waste during its transportation and long-term storage in the RC (up to 50 years) to be tailored for transportation by road, railway and sea.
7.	The design of containers for Low Level Waste shall allow manual loading and unloading of radioactive waste packages.
8.	For concrete containers the use of body reinforcement by rod or wire bars and concrete with the following characteristics is mandatory: a) Class of durability - not less than B40 (M500); b) Grade of frost resistance - not less than F200; c) W10 grade of water permeability.
9.	Resistance of the container to internal and external loads shall meet the defined parameters.
10	Construction materials of the container and its external coating shall provide protection from atmospheric precipitation.
11.	Requirements for containers to be taken into account, while developing design and choosing materials, are as follows: – Tightness, including diffusion permeability of the container material (taking into account the container service life) in conformity with the defined norms; – Mechanical strength designed for stacking and handling the containers; – Restriction of weight and volume in view of load-carrying capacity of equipment and layout decisions of facilities currently in operation and at the stage of design; – Durability of strop devices (taking into account the container service life); – Provision of the set biological protection; – Corrosion resistance to the impact of the environment contacting it, both from the outside and from the inside; – Compatibility of waste and container materials; – Heat resistance; – Decontamination capability; – Simplicity of manufacturing, service, sealing; – Acceptable cost.

Criterion No. 5:

Radiation parameters of radioactive waste packages provide safety of the personnel and long-term storage:

1. Values of radiation parameters must not exceed the admissible ones:

Equivalent dose rate (mGy/h)			
On external surface of package		At 1 m from external surface of package	
≤ 2		≤ 0.1	
Radioactive contamination (particle/(cm^2 x min))			
Non-fixed		Fixed	
Alpha active	Beta active	Alpha active	Beta active
≤ 10	≤ 100	not regulated	≤ 2000

2. The type and category of the package correspond to the specific activity of radioactive waste:

	Specific activity, kBq/kg	
Package type	Beta active	Alpha active
Regular package *)	$\leq 10^7$	$\leq 10^6$
Special package **)	$> 10^7$	$> 10^6$

*) Radioactive waste package made with the use of:

– As primary package – regular steel 200-litre barrels;
- As external package – regular containers accepted for application by the RC.

**) The radioactive waste package manufactured under an individual design and providing safe transportation of radioactive waste (from Large-Size Equipment or HLW) and their storage in the RC without overloading to other packages.

3. Total activity of a regular package – not more than $1.5 \cdot 10^{13}$ Bq.
4. The radionuclide contents must meet the limitations:

Radionuclide	Activity	Note
^{14}C not in activated material	3.0 x 10^{11} Bq/m^3	For waste containing mixture of radionuclides, the total concentration is defined as "the sum of shares" by division of the concentration of each nuclide by respective admissible concentration. The sum of shares shall not exceed 1.0. If radioactive waste does not contain radionuclides listed in the Table, this waste refers to a category for which there is no restriction. The top value for trans-uranium radionuclides is allowed provided that on the average in the storage facility their specific activity will not exceed 370 Bq/g
^{14}C in activated metal	3.0 x 10^{12} Bq/m^3	
^{59}Ni in activated metal	8.1 x 10^{12} Bq/m^3	
^{63}Ni	2.6 x 10^{13} Bq/m^3	
^{63}Ni in activated metal	2.6 x 10^{14} Bq/m^3	
^{90}Sr	2.6 x 10^{14} Bq/m^3	
^{94}Nb in activated metal	7.4 x 10^{9} Bq/m^3	
^{137}Cs	1.7 x 10^{14} Bq/m^3	
^{99}Tc-99	1.1 x 10^{11} Bq/m^3	
^{129}I	3.0 x 10^{9} Bq/m^3	
^{241}Pu	1.3 x 10^{5} Bq/g	
^{242}Cm	7.4 x 10^{5} Bq/g	

Trans-uranium alpha radiating ones with half-lives more than 5 years	3.7 x 10^3Bq/g	The estimated the bulk density of radioactive waste is assumed to be 2 t/m^3.

Criterion No. 6:

Strength characteristics, material and design of the external package provide safe handling.

Criterion No. 7:

The configuration and dimensions of the packages correspond to the technical capabilities of the facility infrastructure and provide unification of processes at subsequent stages of handling them:

- Primary package – steel barrel (587.5×867.5 mm, capacity – 200l);
- External package:
  – regular container (See Note to item 1 of Criterion No. 5);
  – special package (the sizes which do not exceed 20 feet containers, and weight not more than 75 t).

15.6 References for section 15

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Appendix: “Safety Provision while Managing Radioactive Waste Containing Nuclear Materials at the Enterprises of the State Atomic Energy Corporation “Rosatom” in the Northwest of Russia”

Guide

(Final version)

State Sanitary-Epidemiologic Regulation of the Russian Federation

2.6.5. NUCLEAR POWER ENGINEERING AND INDUSTRY

SAFETY PROVISION WHILE MANAGING RADIOACTIVE WASTE CONTAINING NUCLEAR MATERIALS AT THE ENTERPRISES OF THE STATE ATOMIC ENERGY CORPORATION “ROSATOM” IN THE NORTHWEST OF RUSSIA

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Guide

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2. The Guide has been recommended for approval by the sub-committee for special regulation of the FMBA of Russia (protocol No. 3/2010 of 17.03. 2010).
3. The Guide has been agreed with the Head of Directorate of State Supervision over Nuclear and Radiation Safety of the Ministry of Defence of the Russian Federation Yu.G. Sych.
4. The Guide has been approved by the Deputy Head of the Federal Medical-Biological Agency, the State Chief Medical Officer on sites and facilities serviced V.V. Romanov.
5. The Guide is introduced since 01 May, 2010.
6. First issue.

CONTENTS

AGREED WITH

Head of Directorate of State Supervision over Nuclear and Radiation Safety of the Ministry of Defence of the Russian Federation

_____ Yu.G. Sych

"16" March 2010

APPROVED BY

Deputy Head of Federal Medical-Biological Agency, State Chief Medical Officer on attended organizations and territories

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"18" March 2010

2.6.5. NUCLEAR POWER ENGINEERING AND INDUSTRY

Safety Provision while Managing Radioactive Waste Containing Nuclear Materials at the Enterprises of the State Atomic Energy Corporation "Rosatom" in the Northwest of Russia

(R NM - 10)

Guide

R 2.6.5. 005 – 10

16 I. SCOPE

1.1. The Guide "Safety Provision while Managing Radioactive Waste Containing Nuclear Materials at the Enterprises of the State Atomic Energy Corporation "Rosatom" in the Northwest of Russia" (hereinafter referred to as "Guide") has been developed based on the legislation of the Russian Federation, requirements of sanitary, as well as federal standards and regulations in the field of atomic energy use (hereinafter referred to as "mandatory requirements"), and with due regard to the recommendations presented in the documents of the International Atomic Energy Agency (hereinafter referred to as the IAEA).

1.2. The Guide specifies requirements for meeting the provisions of SP 2.6.1.799-99 "Basic Sanitary Regulations of Radiation Safety Provision (OSPORB-99)" (letter of the Ministry of Justice of Russia dated 6/1/2000 No. 4214-ER are recognized as those that do not require the state registration as they are of regulatory-technical nature and do not contain new legal norms) /8*/, sections 3, 4 of the Resolution of the Federal Environmental, Industrial and Nuclear Supervision Service dated December 12, 2006 No. 6 "On Approval and Enactment of Federal Norms and Regulations in the Field of Atomic Energy Use "Rules to Re-categorize Nuclear Materials as Radioactive Waste" (NP-072-06), /5/ as well as the Basic Branch Rules of Nuclear Safety at Usage, Processing, Storage and Transportation of Nuclear-Hazardous Fission Materials (PBYa-06-00-96) /7/, while managing radioactive waste (further on - RW) containing nuclear materials (further on - NM).

1.3. The Guide specifies radiation-hygienic and administrative requirements that ensure safe handling of products containing nuclear materials, including the requirements:

- On the conditions and procedure to refer to the category of RW the products containing NM the intended use of which is either economically inexpedient or impossible with state of the art technologies;
- On the organization and conditions of safe management of products containing NM the specific activity of which exceed the values specified in Appendix 1 SPORO-2002 /9/ while referring these materials to the category of RW;
- On provision of security of the products containing NM, while re-categorizing them as RW;
- On documentary state accounting of the formed RW according to Basic Rules of Control and Accounting of Radioactive Substances and Radioactive Waste in Organization. NP-067-05/3/.

1.4. The Guide does not substitute provisions of effective regulatory legal acts the requirements of which are mandatory for execution, while managing NM and RW.

1.5. Requirements of the Guide provisions are applicable to the activities related to management of RW containing NM, this RW being located in Sites for Temporary Storage of SNF and RW of Rosatom State Atomic Energy Corporation located in the Northwest of Russia, while holding rehabilitation works at them.

1.6. The Guide is intended for the bodies and institutions that exercise supervision over nuclear and radiation safety.

1.7. The bodies and institutions of state supervision at the level of this Guide operate within the authorities and scope of responsibility specified by the legislation of the Russian Federation.

The FMBA of Russia and its territorial bodies implement measures of control (supervision) over radiation safety of the personnel and population, while managing RW containing NM.

The Directorate on Nuclear and Radiation Safety of the Ministry of Defence of the Russian Federation carries out measures for control (supervision) against the parameters of nuclear safety and technical aspects of radiation safety, including re-categorizing NM as RW.

1.8. The Guide can be used by the operating organizations that conduct management of RW containing NM, as well as by the organizations the activity of which is associated with designing and

* When references to the regulatory documents are made, identification numbers of sources correspond to those of Section 2. When references to the provisions of the present document are made, a respective item of the document is indicated.

construction of radiation-hazardous facilities of the State Atomic Energy Corporation "Rosatom" (hereinafter – the State Corporation "Rosatom") in the Northwest of Russia.

17 II. GENERAL PROVISIONS

2.1. Creation of safe conditions of SNF and RW management is an integral part of the general system of providing nuclear and radiation safety in the Northwest of Russia.

Meeting of radiation-hygienic requirements to radiation safety provision based on the review of technical and technological capabilities with due regard to the economic expediency of their development and introduction should be a mandatory condition of managing RW containing NM at the facilities in the process of remediation.

2.2. To ensure safety, while handling RW containing NM, one is to be guided by the following general principles:

- Provision of nuclear safety;
- Provision of radiation safety;
- Conservation of the environment;

2.2.1. The basic principles of nuclear safety provision are as follows:

- Prevention of criticality occurrence, both under regular conditions, and at any deviation from a regular situation.
- Prevention of uncontrollable and unapproved processing, accumulation, movement, transfer, transportation of nuclear-hazardous fission nuclides.
- Prevention of infringement of the conditions and requirements of nuclear safety regulated by the design documentation, regulatory documents on nuclear safety (rules, manuals, regulations) both under normal conditions, and at the accident initiating events. An approximate list of initiating events is presented in Appendix to PBYa-06-00-96.
- Provision of nuclear safety mainly through the usage of safe equipment, facilities and automation devices.

2.2.2. The principles of radiation safety provision include:

- Non-excess of permissible limits of individual exposure doses (the regulation principle);
- Prohibition of all types of activity with nuclear materials and radioactive waste at which the derived benefit for the person and society does not exceed the risk of possible harm caused by additional exposure (the substantiation principle);
- Maintenance of individual exposure doses and the number of exposed persons in the organization that carries out radiation-hazardous operations at the as low as really achievable level, taking into account economic and social factors (the optimization principle). (The English abbreviation is ALARA principle that stands for As Low As Reasonably Achievable).

2.2.3. The principle of environmental protection - Provision of an acceptable level of security of the environment from radioactive impact, while re-categorizing nuclear materials as radioactive waste (the principle of environmental protection).

2.3. The procedure of conducting radiation control is specified by the administration of the enterprises where the RW containing NM is managed, and is defined taking into account the specifics and conditions of the carried out works. After its registration the document is sent to the supervision bodies on the agreement.

2.4. The procedure of referring products containing NM to the category of RW includes:

- Substantiation of the impossibility or inexpediency of their further use;
- Immobilization of products containing RW;
- Transfer of RW containing NM to a condition that satisfies the criteria of appropriateness of the conditioned RW for transfer to a specific RW storage facility;
- State accounting of the formed RW.

2.5. The products containing NM from which the extraction of NM contained in them for the further use with the application of state of the art technologies is technically and economically inexpedient should be referred to the category of RW, and they can be transferred to the condition that meets the criteria of appropriateness of the conditioned RW for transfer to a specific RW storage facility.

2.6. While referring products containing NM to the RW, one is to define the nomenclature and structure of such products. To this end it is expedient to:

- Make a radiation map of objects containing products with NM located at their bottom or distributed over the volume with identification of "hot" spots;
- Define the radionuclide structure and specific activity of radioactive and nuclear materials in the products, as well as their percentage.

2.7 The products containing NM after conditioning and placing into packages should be accounted in the system of state control and accounting of RS and RW according to the Basic Rules of Control and Accounting of Radioactive Substances and Radioactive Waste in Organization NP-067-05/3/.

18 III. RADIATION-HYGIENIC REQUIREMENTS TO PROVISION OF SAFE MANAGEMENT OF PRODUCTS CONTAINING NUCLEAR MATERIALS.

18.1 *3.1. Requirements to Personnel Safety.*

3.1.1. While planning radiation-hazardous works and while developing measures to provide radiation safety, while managing RW containing NM, one is to be guided by SP 2.6.1.2523-09 (NRB-99/2009) /6/, OSPORB-99 /8/, R 2.6.1. 29-07 "Hygienic Requirements to Provision of Radiation Safety of the Personnel and Population at Designing and Organization of Workswith SNF and RW in Branch No. 1 of FSUE "SevRaO"/11/, and on provision of nuclear safety one is to be guided by "Basic Branch Rules of Nuclear Safety at Usage, Processing, Storage and Transportation of Nuclear-Hazardous Fission Materials" (PBYa-06-00-96) /7/.

3.1.2. All works concerning management of products containing NM, while re-categorizing them as RW should be conducted in a controlled access area. Depending on the nature of technological processes, attendants' participation in them, arranged equipment, nature and possible degree of contamination of premises and territory the enterprise administration can allocate additional administrative-technical zones. Thus all movements of the personnel and vehicles should be supervised by the radiation safety service.

3.1.3. At departure from the controlled access area where works with the products containing NM are held, while re-categorizing them as RW, radiation check points and devices for decontamination of vehicles should be provided.

3.1.4. The persons performing works with the products containing NM, while classifying them as RW are referred to the personnel of Group A, and those who are to work in the field of their impact are referred to Group B personnel.

3.1.5. While performing works with the products containing NM, care should be taken to prevent any unreasonable exposure of the personnel, and the actual exposure doses are to be reduced to the lowest achievable level.

3.1.6. While planning of specific works with the products containing nuclear materials, while categorizing them as RW and undertaking the required administrative decisions on provision of radiation safety of the personnel and population, including emergency cases, it is necessary to be guided by the hygienic standards of exposure doses defined in sections 3, 6 of NRB-99/2009/6/.

3.1.7. If the planned works with the products containing nuclear materials can lead to formation of the maximum individual effective dose that exceeds 20 mSv per annum it is necessary to define specific protective and administrative actions.

3.1.8. The individual annual effective dose of industrial exposure of Group B personnel should not exceed 5 mSv/y.

3.1.9. Before starting works with the products containing NM, while re-categorizing them as RW, a package of protective actions to decrease the dose rate of external irradiation should be conducted. While

calculating admissible dose rates of external exposure after holding protective measures, it is necessary to additionally assess the contribution of the internal exposure, thus the safety factor may be disregarded.

3.1.10. While planning works with the products containing NM, training of the personnel who will perform these works should be provided.

3.1.11 Officials and structural units who will held responsibility for these works should be appointed in the organization that conducts works with the products containing NM.

18.2 *3.2. Radiation-Hygienic Requirements to Technological Processes and Production Equipment.*

3.2.1. While preparing to manage the products containing NM, the operating organization should define (develop) the procedure and technology of managing products containing NM in the form of work programmes or a project, having thus addressed the following aspects:

- Choice of the methods of immobilization and conditioning, while managing products containing NM and RW, types of containers and substantiation of their nuclear and radiation safety;
- Performance of neutron-physical calculations with the use of standard codes such as MCNP, MCU-RFFI/A, MMKFK-2 that estimate multiplying systems by the Monte-Carlo method to assess the extent of hazard of a criticality occurrence at all stages of the re-categorizing process (the calculations shall be conducted with the use of conservative approaches);
- Verification of the used calculation codes and used libraries of nuclear data by calibration calculations of reference critical assemblies taken from the "International Handbook of Evaluated Criticality Safety Benchmark Experiments" NEA/NSC/DOC (95) 03/I-VII, having selected those of them, where the spectra of neutrons are closest to those in the products containing NM;
- Definition based on the calculation results of acceptable concentration and the total amount of NM in the package that deterministically provides criticality prevention at any deviation from a regular situation;
- Release of the report on technical substantiation of safety (TOB), having included the following into it: calculation results that substantiate nuclear and radiation safety, while performing the whole set of operations, process flow chart of managing the products containing NM, as well as the procedure of transportation and storage of RW in packages.

The report shall be presented for agreement to the control body and for expert review to the State authority that supervise over nuclear and radiation safety for obtaining the expert conclusion.

3.2.2. The developed operational modes and technological processes:

- should provide the maximum decrease of the impact of ionizing radiation on the personnel;
- be conducted with the highest degree of automation and provide remotely-controlled performance of works;
- possess a high reliability;
- possess an opportunity of visual monitoring and control.

3.2.3. While choosing technologies of managing the products containing NM, preference should be given to:

- Scientifically-substantiated and practically-proven technologies;
- Technologies having the most simple and reliable methods of collecting products containing NM, their reprocessing (if required), conditioning and transportation;
- Technologies promoting formation of the minimum quantity of secondary RW;
- Technologies with the least quantity of process stages;
- Humidified operations of processing dust-releasing materials to reduce release of radioactive aerosols;
- Technologies having the minimum number of failures.

3.2.4. The equipment intended for managing products containing NM should be:

- reliable and accessible for repair;
- made of corrosion-proof and radiation-proof materials;

- easy to decontaminate and accessible for remote washing by decontamination solutions, substances, and have no stagnant zones;
- made and operated with due regard to the nuclear safety requirements /7/.

3.2.5. Industrial operations of managing RW containing NM should be carried out by remotely-controlled equipment or with the aid of robotics.

18.3 *3.3. Requirements to Radiation Control.*

3.3.1. The radiation control while referring products containing nuclear materials to RW is a component of the radiation control of the enterprise.

3.3.2. The purpose of the radiation control is deriving information:

- For assessment of exposure doses of the personnel occupied in the works with products containing NM, while categorizing them as RW;
- For development of recommendations and undertaking actions for improvement of radiation conditions and personnel protection, as well as for assessment of their efficiency;
- For optimization of protection and decision-making on intervention in case of radiation accidents, contamination of areas and buildings with radionuclides.

3.3.3. While designing works on referring products containing NM to RW, types and scope of radiation control, both in the conditions of normal operation and at radiation accidents are defined. Thus the project should contain a list of required dosimetric, radiometric, spectrometric, etc. devices, equipment and methods applied at implementation of the radiation control, placement of stationary devices, points of constant and periodic checks, structure of the required premises and, if necessity, augmentations to the staff of the radiation safety service.

3.3.4. The persons who directly carry out the radiation control in industrial premises and in the territory of the industrial site where works on classification of products containing NM as RW are held, should have special training and be referred to Group A of the "personnel" category.

3.3.5. The radiation control should include both individual control of the personnel exposure, and control of exposure conditions in industrial premises and on the industrial site where works on categorizing the materials containing NM as RW are conducted.

3.3.6. The individual control over the exposure of Group A personnel includes:

- Control of the equivalent dose of external exposure with the use of individual dosimeters (depending on the nature of works and the accepted level of introduction of the individual control (LCI));
- Control of the equivalent dose of external gamma radiation;
- Control of exposure of integuments, hands and eye crystalline lens;
- Emergency control of external neutron radiation (both by individual dosimeters, and by zone ones);
- Control of the dynamics and levels of ingress of radioactive substances and their contents in the body to assess annual uptake - depending on the nature of works;
- Control of annual equivalent and effective doses.

3.3.7. Control over exposure of Group B personnel is carried out based on data from control of the dose of external gamma radiation with the use of individual dosimeters and results of control of volume activity of air aerosols at workplaces. It is allowed to conduct control of the dose of external irradiation based on the data of control of the dose rate of external gamma radiation at workplaces.

3.3.8. Control of the radiation conditions in the industrial premises and in the industrial site area where works on categorizing products containing NM as RW are conducted includes:

- Continuous and periodic monitoring/control at the personnel workplaces over the dose rate of external radiation (including gamma radiation and neutrons);
- Monitoring/control over the contents and nuclide structure of radioactive gases and aerosols in the breathing area of Group A personnel;
- Monitoring/control of contamination levels by radioactive substances of surfaces of work premises and the equipment, integuments, overalls and footwear of the workers;
- Monitoring/control of emissions of radioactive substances to the atmosphere and their nuclide structure;
- Monitoring /control over the contents of radioactive substances and their nuclide structure in the liquid and solid RW;
- Monitoring/control over the contents of safe management of radioactive waste;

- Radiometric control over the generated non-radioactive waste;
- Monitoring/control of the contamination levels of transport vehicles.

3.3.9. Before conducting the works, check (reference) levels (hereinafter – CL) under all factors of radiation conditions (dose rate, dose of the personnel exposure, etc.) should be specified.

3.3.10. CL are defined by the administration of the enterprise and are agreed with the body authorized to carry out the state sanitary-and-epidemiologic supervision.

3.3.11. Cases of CL excess should be analyzed, and the reasons causing them - to be eliminated. In case of change of the radiation conditions when the nature of carried out works is changed or due to other objective reasons the CL can be revised.

18.4 *3.4. Requirements to the Personnel Individual Protection.*

3.4.1. While conducting works to categorize products containing NM as RW, individual protection of the personnel from radioactive substances, ionizing radiation and other professional factors (noise, vibration, ultrasound, adverse meteorological conditions, presence of toxic substances, etc.) is provided in compliance with the requirements of MU 2.2.8.020-09 /12/. The personnel should use the following kits of individual protection means (IPM) presented in section 6 of MU 2.2.8.020-09:

- While conducting preparatory work - Basic Kit of IPM No. 2 and Additional Kits of IPM No. 2;
- While conducting a set of works to categorize products containing NM as RW – besides the Basic Kit No. 2 and Additional Kit of IPM No.2 - Additional Kit No. 3 (while performing works in the conditions of radioactive contamination of surfaces above 1,000 beta-part./(cm^2·min) or Additional Kit of IPM No. 4 (while performing works in the conditions of radioactive contamination of surfaces above 5,000 beta-part./(cm^2·min). Additional Kit of IPM Nos. 3, 4 are stored in the Sanitary Lock and are put on, as a rule, in addition to the IPM already available on the worker;
- While performing metal cutting and welding as well as other special works - Additional Kit of IPM No. 5;
- For elimination of consequences of possible emergencies - Emergency Kit of IPM. Depending on the place of work performance, Additional Kit of IPM No. 5 is stored in the Industrial Locker Room, in the Sanitary Check Point or in the Sanitary Lock.

3.4.2. In compliance with SanPiN 2.2.8.46-03, the contaminated overalls and additional IPM, as well as special footwear should undergo regular decontamination, and the underwear, socks and towels should be washed with provision of the required disinfection. The method of IPM application and decontamination is stated in MU 2.2.8.020-09.

3.4.3. Considering the environmental conditions in which the personnel of the enterprises located in the Northwest of Russia works, premises for drying the used IPM should be provided in the service areas. They should be located near the IPM application locations (Sanitary Check Points, Sanitary Locks, etc.).

3.4.4. The personnel conducting works on welding or cutting of metal contaminated with radionuclides should be provided with special individual protection means for the welder made of spark-proof materials capable of decontamination.

18.5 *3.5. Requirements to Optimization of Radiation Protection*

3.5.1. While conducting works on referring products containing NM to RW, actions for optimization of radiation protection of the personnel should be undertaken, they being an integral part of the programme for achievement and maintenance is acceptable safe conditions of industrial activity.

3.5.2. The objects of optimization (maintenance at the optimum achievable low level) are as follows:

- Dose burdens on the personnel (individual and collective doses) with the priority of individual doses;
- Activity of emissions and dumps;
- Specific activity and total amount of the generated RW.

3.5.3. While planning radiation-hazardous operations, various options of their performance should be addressed. The priority is given to the options with the least dose burden, the minimum emissions

and radio-activity of dumps, as well as the minimum quantity of the generated radioactive waste. Review of similar works conducted before should be thus carried out, and the obtained experience be considered in the optimization programme.

3.5.4. Before conducting the works, the minimum number of workers capable to perform the work during the allocated time should be defined. The most ergonomic tool is to be selected, and personnel training for exercising safe methods of conducting the operations is to be conducted.

3.5.5. Based on the radiation inspection of the work place a map with specification of places with the maximum dose rate of external gamma radiation where the personnel presence should be restricted, and places with the minimum dose rate of external gamma radiation is compiled. Based on the derived data, zoning of the area is made and routes of the personnel movement are outlined.

3.5.6. The works should start with conducting protective measures (installation of protective screens and floor-mats, equipment of additional ventilation and local suction, dust suppression, use of film coatings), as well as proper organization of the workplace.

3.5.7. A dosimetric order-permit should be issued for the works. It should contain calculation of the permitted dose, admissible operating time, check (reference) levels of radiation factors.

3.5.8. The conducted works should be necessarily accompanied by the radiation control which is carried out by the dose-metering man or the worker himself with the aid of individual dosimeters and by specification of the activation threshold for the alarm system that signals about excess of the reference levels.

19 IV. ADMINISTRATIVE REQUIREMENTS PROVIDING SAFE MANAGEMENT OF PRODUCTS CONTAINING NUCLEAR MATERIALS, WHILE TRANSFERRING THEM TO THE CATEGORY OF RW.

19.1 *4.1. Substantiation of the Decision on Referring Products Containing Nuclear Materials to the Category of RW*

4.1.1. Assessment of expediency to refer products containing NM to the category of RW should be conducted with due regard to the available practice:

- Methods to provide nuclear safety, radiation safety of the personnel and population, prevent damage to the environment according to the effective operating requirements of regulatory documents;
- Technologies of products' disposal.

In case of absence of technologies to manage such products one is to consider technical possibility and economic feasibility of their development and implementation.

4.1.2. Assessment of expediency to refer products containing NM to the category of RW can be conducted either by the organization that carries out their management, or by a specialized organizations under its commission. Thus types of technological processes and other specifics of formation of the products, chemical composition and physical shape of products, as well as types of NM contained in the products should be given due regard to.

4.1.3. The structure of information about the products containing NM which are expedient to be referred to the RW category should include the data sufficient for their use in practical activities at decision-making concerning the possibility of referring each specific product to the RW category.

Such data includes:

- Materials on substantiation of referring the products containing NM to the category of RW;
- Sets of measures to provide nuclear and radiation safety at long-term storage of the products referred to the category of RW;
- Measures to support transfer of products containing NM to the condition meeting the criteria of appropriateness of the conditioned RW for long-term storage at the dump site according to effective standards and rules. The approximate structure of such characteristics of the conditioned RW in the form of packages is presented in Appendix 4 /10/;
- Conditions of further storage or dumping of RW containing NM.

4.1.4. The decision about the possibility of referring the products containing NM to the category of RW is to be made based on the comparison of values of its characteristics derived as a result of respective measurements, and the values adopted as criteria of appropriateness specified in the respective regulatory documents.

4.2. Organization of Referring Products Containing Nuclear Materials to RW

4.2.1. Referring the products containing NM to the category of RW shall be conducted at the place of their location.

4.2.2. To refer the products containing NM to the category of RW, a Commission is appointed by the Order of the operating agency head (or a person authorized by him). The Commission structure is defined based on the specifics of production and technological processes. Chief Engineer or his Deputy is appointed Chairman of the Commission. If the nomenclature of re-categorized products and the Commission structure remain constant, issue of one such a document for several cases of re-categorizing products as RW is allowed.

4.2.3. The structure of the Commission shall include both persons responsible for accounting and storage of NM and RW, condition of nuclear and radiation safety of the facility, as well as representatives of supervision bodies. Depending on the intensity and the arrangement of operations with NM and RW in the organization, several Commissions may be set up.

4.2.4. The following shall be included into the procedures of referring the products containing NM to the category of RW:

- Preparation of products containing NM to categorizing;
- Performance of support measurements/calculations of their characteristics and documentary registration of the measurements (results);
- Decision-making about a possibility to categorize products containing NM as RW and its documenting;
- Undertaking measures that prevent extraction of NM from products with the application of modern industrial technologies (if that is not provided initially);
- Bringing of the products to the appropriate forms and states, prevention of access to them and unauthorized use, etc.;
- State registration and accounting of products containing NM and converted into RW.

4.2.5. The following is required as preparatory measures to refer products to the category of RW:

- Issue of an administrative document to set up a Commission to re-categorizing products as RW;
- Check of readiness of administrative-engineering and operating documents;
- Bringing the equipment and measuring instruments to the state of readiness for operation in compliance with the effective operating documents;
- Personnel instruction and admittance to work;
- Performance of backup measurements, calculations of values of the characteristics of products subject to re-categorizing as RW and check of their compliance with the values of characteristics of the products adopted as criteria;
- Transfer of products containing NM to the form of accounting entities;
- Placement of the generated accounting entities to specially allocated sites.

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4.2.6. In all cases, for measuring the amounts of NM in the products subject to categorizing as RW, accounting entities shall be formed.

4.2.7. While referring the products containing NM to the category of RW, it is necessary, if possible, to provide backup measurements of the amount and structure of NM. Thus, the results of previous measurements of the quantitative characteristics of NM can be used, if their authenticity (reliability) is supported by the appropriate condition of the applied access control devices, by appropriate backup measurements, as well as assessments derived at application of the methodologies based on the calculation methods using the results of preliminary measurements, experimental studies.

4.2.8. The data about the products containing NM and categorized as RW shall enter the accounting documents, in view of the requirements stated in /3/ and /9/ to RW accounting.

4.2.9. Based on the results of the preparation of products containing NM and to be categorized as RW, the Commission shall:

- assess compliance of the parameters of characteristics of the accounting entities of the products to be categorized as RW, values of the characteristics of the products taken as criteria of appropriateness specified in the respective regulatory documents;
- produce a review resume ("conclusion") about the need and sufficiency of undertaking measures that prevent extraction of NM from the products.

4.2.10. The Commission shall draw up the results of its activities as an Act about the possibility to categorize the products containing NM as RW. The recommended content of the Act is given in Appendix 5

4.2.11. The documents proving safe handling of this RW and agreed with supervision bodies under the approved procedure are attached on the Act.

4.2.12. In case the Commission members have some doubts concerning authenticity of the presented to them results of measurements, calculations of the characteristics of products, they may demand repeated measurements and calculations to be conducted under their control.

4.3. Documentary registration of referring the products containing NM to the category of RW

4.3.1. If it is recognized as expedient to undertake measures to the products containing NM to prevent extraction of NM from them, upon performance of appropriate set of actions it is required to make an Appendix to the Act. This Appendix will state the possibility to categorize products as RW and will specify the following:

- Amount of products containing NM to which measures preventing extraction of NM from them are undertaken;
- Applied method of preventing extraction of NM from the products;
- Quantitative content of NM in these products.

4.3.2. Based on the Act about a possibility to categorize products as RW, the chief of the organization or a person assigned by him shall issue an administrative document about categorizing the product as RW and documenting this fact. As per this administrative document, upon the work performance, the products are registered in the State system of control and accounting of RS and RW.

4.3.3. While categorizing products containing NM as RW in the system of RS and RW accounting, RW arrival is reflected by a respective code.

4.3.4. Categorizing products containing NM as RW is deemed completed upon documentary registration in the State system of control and accounting of RS and RW.

4.4. Provision of NM Safety while referring the products containing NM to the category of RW

4.4.1. Before undertaking measures that prevent extraction of NM from products converted to RW, their security in compliance with the requirements effective for NM shall be provided by conducting appropriate administrative and engineering measures, application of ACD and support of continuous monitoring of access to NM.

4.4.2. Upon undertaking measures that prevent extraction of NM from products and their conditioning, to prevent unauthorized access to them, it is also necessary to apply ACD according to the requirements effective for RS and RW.

4.4.3. It is recommended to apply the following as ACD:

- Before undertaking measures that prevent extraction of NM from products, categorized as RW - the intervention indication devices applied in the organization to NM according to the Programme of IID Application;
- Upon undertaking measures that prevent extraction of NM from products, use of seals without a unique identifier but activated with seal-applicators registered in the organization in due manner is allowed alongside with the IID.
- Systems of television observation over the storage facility;
- Systems of controllable pass to the storage facility with the personified code of access;
- Radio motion alarms.

19.2 *List of Abbreviations*

ACD	- Access control devices
CL	- Check (reference) levels
IPM	- Individual protection means
RS	- Radioactive substances
RSS	- Radiation safety service
RW	- Radioactive waste
SCR	- Self-sustained chain reaction
SNF	- Spent nuclear fuel
IID	- Intervention indication device
NM	- Nuclear materials

19.3 *Appendix 1*

19.4 *Standard References*

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Appendix 2

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5. Rules to Re-categorize Nuclear Materials as Radioactive Waste. NP-072-06. Moscow, 2005.

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19.7 *Terms and definitions*

1. **Immobilization of products** – Conversion of products referred to the category of radioactive waste to the forms preventing extraction by state of the art technologies of NM included into the RW structure and their further use.
2. **RW conditioning** - transfer of RW containing NM to the forms suitable for safe storage, and (or) transportation, and (or) disposal.
3. **Criteria of RW appropriateness** - a complex of requirements to quantitative and qualitative parameters of RW and its packages to be met for the safe accommodation for long-term storage at the RW Regional Centre.
4. **Provision of nuclear safety** – creation and maintenance of conditions aimed at prevention of criticality **occurrence** (self-sustained chain reaction of fission).
5. **RW management** - all types of activities associated with collection, transportation, processing, **conditioning**, storage and disposal of RW.
6. **Radioactive Waste reprocessing** – process operations aimed at change of the aggregate state and (or) **physical** and chemical properties of radioactive waste and carried out at its preparation for storage and (or) dumping.
7. **Radiation safety of the population** – secure condition of the present and future generation of people from the harmful impact of ionising radiation on their health.
8. **Radioactive waste** – substances not intended for the further use in any aggregate state, materials, **products**, devices, equipment, objects of biological origin the contents of radionuclides in which exceeds the levels specified by the Federal norms and rules in the field of radioactive waste management.
9. **Accounting entity of radioactive substances or radioactive waste** – a subject amenable for identification, containing RS or RW the characteristics of which are registered by a document and (or) a separate entry (line) in the registration documents of RS or RW the integrity of which remains invariable during a certain period of time.
10. **Operating organization/agency** – an organization setup in compliance with the legislation of the Russian Federation and recognized by the appropriate body that controls use of atomic **energy** as suitable to operate a nuclear installation, a radiation source or a storage site and to carry out by own forces or with engagement of other organizations the activity to accommodate, design, build, operate and decommission the nuclear installation, radiation source or storage site, as well as the activity on managing nuclear materials and radioactive substances.
11. N**uclear materials** - materials containing or capable to reproduce fission nuclear substances (nuclides).

19.8 *Appendix 4*

19.9 *Characteristics of Conditioned RW*

19.10 *For Disposal as Packages*

1. Total activity of RW package, specific activity of RW and radionuclide structure of RW.
2. Equivalent doze rate of RW package.
3. Surface contamination of RW package.
4. Structural stability of RW form.
5. Water-tightness of the form of solidified RW.
6. Content of corrosion-active substances.
7. Heat release.
8. Thermal stability.
9. Radiation stability.
10. Gas formation.
11. Biological stability.
12. Content of free moisture in RW package.
13. Content of substances forming complex compounds.
14. Absence of explosive and self-ignitable substances.
15. Absence of substances reacting with water with heat release and formation of combustible gases.
16. Content of poisonous substances, chemically toxic substances, pathogenic and infectious materials.
17. Content of nuclear-hazardous fission nuclides.
18. Configuration of RW package. Its sizes and weight.
19. Identification of RW package.

19.12 *Recommended Contents of the Act about Possibility of referring the products containing NM to the category of RW*

The following shall be reflected in the Act:

a) Basis for the Commission set-up, its structure;

b) Basis for transfer of the prepared products to the category of RW;

c) Indication of locations of the products prepared for transfer to the category of RW;

d) Conclusions and suggestions of the Commission (possibility to re-categorize the prepared products as RW);

d) Numbers of packages and seal identifiers;

e) Data required for NM withdrawal from registration, and data required for RW registration;

f) Signatures of the Commission members.

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