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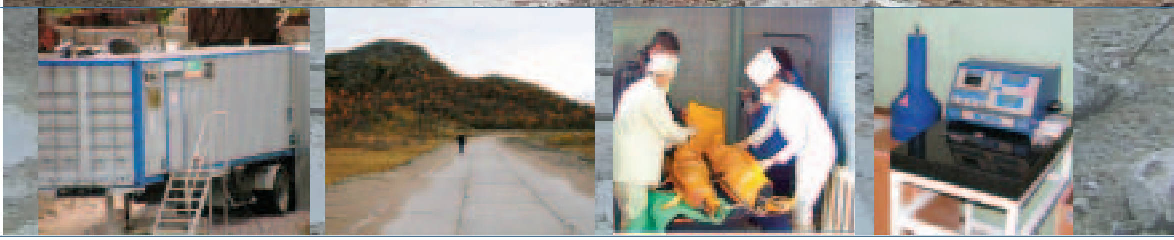

Regulatory improvements related to the radiation and environmental protection during remediation of the nuclear legacy sites in North West Russia

Final report of work completed by FMBA and NRPA in 2007

Statens strålevern
Norwegian Radiation Protection Authority

Reference:
Sneve M K, Kiselev M, Kochetkov O. Regulatory improvements related to the radiation and environmental protection during remediation of the nuclear legacy sites in North West Russia. StrålevernRapport 2008:7. Østerås: Norwegian Radiation Protection Authority 2008.

Key words:
Radiation protection regulations, remediation of contaminated area, spent nuclear fuel, radioactive waste, sanitary shielding zone, surveillance area, radiation-hygienic monitoring, personal radiation monitoring, effective exposure doses, emergency preparedness and response.

Abstract:
This report describes work carried in 2007 under the NRPA – Federal Medical-Biological Agency regulatory support program. It focuses on development of improved regulatory documents and supervision of remediation activities due to be carried out at Andreeva Bay and Gremikha in Northwest Russia. The work program for 2008 is also introduced.

Referanse:
Sneve M K, Kiselev M, Kochetkov O. Regulatory improvements related to the radiation and environmental protection during remediation of the nuclear legacy sites in North West Russia. StrålevernRapport 2008:7. Østerås: Statens strålevern, 2008.. Språk: english.

Emneord:
Strålevernsreguleringer, opprydning av kontaminerte områder, brukt kjernebrensel, radioaktivt avfall, kontrollert og beskyttelses soner, radiologisk overvåking, strålevern av personale, effektive stråledoser, beredskap.

Resymé:
Rapporten beskriver arbeid som ble gjennomført i 2007 som en del av Strålevernets og FMBAs myndighetssamarbeid. Arbeidet fokuserer på utvikling av normative dokumenter og tilsynsprosedyrer under oppryding av anleggene i Andreeva og Gremikha i Nordvest Russland. Rapporten beskriver også arbeidsprogrammet for 2008.

Head of project: Malgorzata K. Sneve.
Approved:

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

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Contents

Executive Summary

This report is a summary of work performed during 2007 as part of the regulatory collaboration between the Norwegian Radiation Protection Authority (NRPA) and the Federal Medical-Biological Agency of Russia (FMBA). The works was primarily carried out by the SRC Institute of Biophysics with support from western experts. The objective of the work was to improve the normative methodical base of regulatory supervision of occupational, public and environmental radiation protection during removal of the Spent Nuclear Fuel (SNF) and in the course of remedial activities at SevRAO facilities at Andreeva Bay (facility No. 1) and Gremikha (facility No. 2), designated as Sites of Temporary Storage (STS). The programme of work represents a natural progression from work performed previously within the NRPA-FMBA collaboration, reported in NRPA report 2007:11.

Studies have been performed on four main topics:

1. Optimization of the occupational radiation protection during SNF and radioactive waste (RW) management on-site SevRAO Facility No.1.

   In the course of work on this topic, the radiation monitoring system in operation at SevRAO facility No.1 has been studied and evaluated. The organization of personal dose monitoring of the occupational exposure at SevRAO facility No.1 has been examined with respect to spent nuclear fuel (SNF) and radioactive waste (RW) storage, and a set of international and national documents on application of the optimization principle (ALARA) to occupational radiation protection has been analyzed.

   Visits to SevRAO facility No.1 have been made in order to study and to analyze organization of the existing radiation monitoring system, including personal dose monitoring of occupational exposure. Existing regulatory guidance documents have been analyzed, and improved guidance developed which is being introduced into practice at SevRAO facilities,

2. Development of radiation hygienic requirements for management of wastes containing toxic substances and man-made radionuclides with specific activity levels lower than LLW (VLLW) at SevRAO facilities.

   This work was commenced because of plans to develop a waste disposal facility for this type of waste at Andreeva Bay and an appropriate up to date regulatory base was required. The need arose especially since this type of facility had not been developed before. National and international documents were reviewed on safe management of industrial wastes being generated at radiation hazardous facilities. Criteria and regulatory requirements for the wastes containing toxic substances and man-made radionuclides with a specific activity level lower than LLW but above clearance levels were also analyzed. In some countries, the term very low level waste (VLLW) has been formulated for such waste. The need to introduce this category into the RW management system during remedial operations at SevRAO sites has been demonstrated. On the basis of the investigations performed and the circumstances at SevRAO facilities, regulatory guidance on implementation of effective supervision of safe waste management of VLLW has been developed in respect to SevRAO. An important feature of the guidance is that is takes account of and is consistent with requirements linked to the non-radioactive hazards associated with the waste material. This guidance provides a possible model for VLLW management at other sites.

3. Development of radioecological criteria for monitoring and control of the marine environment during remediation of the sites of temporary storage taking into account possible end-states.

   In the course of work on this topic, national and international documents and recommendations on ecological regulation and environmental monitoring in places nearby radiation hazardous facilities have been reviewed for relevance to the SevRAO situation. The findings of this analysis have been used during elaboration of radioecological criteria and guidelines on radiation control and monitoring of the areas and marine environment surrounding STSs.

In order to study and to better understand the dynamics of the marine contamination, a database on radionuclide contents in the marine environment media has been developed and filled with available data.

4. Development of operational and medical criteria on initiation of the emergency plan and application of urgent preventive measures at SevRAO facilities.

   Significant attention of many international organizations such as IAEA, ICRP etc., is being paid to this topic. In this light, international experience in development and introduction of operational criteria has been analyzed and national approaches have been compared with international ones. Then, justification of declaration of emergency situations was reviewed in relation to SevRAO operations, including both radiological and medical criteria for timely and adequate decision making relating to occupational and public protection. At the final stage of work, regulatory guidelines establishing operational and medical criteria as well as rules for their application in operation by emergency teams of FSUE SevRAO and CMSCh 120 have been created and approved.

Continuing improvement of supervision functions of FMBA of Russia at SevRAO facilities is appropriate, to keep pace with the progress of operations at the STSs. Accordingly, a number of follow up projects have been planned for 2008. These projects deal with the most relevant issues of supervision of radiation protection assurance at SevRAO facilities, taking account of the continuing remediation programme at the sites.

So, as a continuation of the 2005-2007 investigations, development of a detailed database is envisaged on the radiation situation on the industrial site and in the works areas of SevRAO facility No.1 in 2008, and in 2009, the database arrangement of individual external and internal doses to workers and attached persons at SevRAO facilities No.1 and No. 2. These developments are directed at implementation of the ALARA principle into the practical operation of SevRAO facilities and are very important given the high dose rates and contamination levels which exist at some work locations.

As a continuation of investigations on improvement of the safe RW management supervision at SevRAO, the guidance "Radiation hygienic requirements for arrangement of radioactive waste management at SevRAO Centre of conditioning and storage in Sajda Bay" is planned to be developed, which is the first specialized facility for RW long-term storage in northwest Russia.

As for the supervision of control of the environmental radiation situation during remedial operations, a geographic information system (GIS) is planned to be developed. This will integrate all radioecological data for the STS at Andreeva Bay and its environs, as well as information on the landscape, hydrogeology and geochemistry of the territory. Such a GIS will permit to carry out:

- a detailed analysis of the current radioecological situation at the STS,
- prognosis simulation of the change in radioecological situation in future, and hence,
- optimization of both the extent of radiation monitoring and methods of remediation implementation.

Finally, the emergency exercise of 2006 involveing SRC-IBPh, NRPA and local emergency teams showed the need for periodic specialized subject exercises. During 2008 – 2009, the emergency exercise is planned to be prepared and performed at SevRAO facility No.2, with respect to radiation hygienic and informational aspects. This site was chosen because of its remoteness from normal emergency facilities.

A key feature of the output from all the past and planned projects has been the production of official regulatory guidance documents. So far nine official regulatory documents have been produced within the NRPA-FMBA collaboration programme. Their application and further development in parallel with operations at SevRAO sites is seen as a major contribution to radiation safety management and to the long-term development of an enhanced safety culture.

List of acronyms:

AC	- Activity Concentration
ALARA	- As Low As Reasonably Achievable
ASKRO	- Automated system of radiation situation control
CAA	- Controlled Access Area
CLS	- Centre for conditioning and long-term storage, SevRAO Facility- No. 3 (at Sajda Bay)
CUS	- Centre of decommissioning, SevRAO Facility- No. 3 (at Sajda Bay)
CMSCh 120	- Central Medical Sanitary Unit 120
DF	- Disposal Facility
EC	- European Community
FL	- Federal Law
FMBA	- Federal Medical-Biological Agency of the Russian Federation
FSUE	- Federal State Unitary Enterprise
GD	- Guidance Document
GN	- Russian abbreviation of the state regulations
HLW	- High Level Waste
ICRP	- International Commission on Radiological Protection
ILW	- Intermediate Level Waste
LLW	- Low Level Waste
LRW	- Liquid Radioactive Waste
MNR of Russia	- Ministry of Natural Resources of the Russian Federation
MU	- Russian abbreviation of the Guidelines
MUK	- Russian abbreviation of the Guidelines for control
NPP	- Nuclear Power Plant
NRB-99	- Russian abbreviation of the Radiation Protection Standards
NRPA	- Norwegian Radiation Protection Authority
ONB	- Russian abbreviation of the Main Safety Norms
OSPORB-99	- Russian abbreviation of the Main Sanitary Rules for Radiation Protection Assurance
PDM	- Personal Dose Monitoring
RM	- Radiation Monitoring
RS	- Radioactive Substances
RW	- Radioactive Waste
SNF	- Spent Nuclear Fuel
SP AS-03	- Russian abbreviation of the Sanitary Rules for Design and Operation of NPP
SPORO-2002	- Russian abbreviation of the Sanitary Rules for Radioactive Waste Management
SRC-IBPh	- State Research Centre-Institute of Biophysics
SRW	- Solid Radioactive Waste
STS	- Site of Temporary Storage
VLLW	- Very Low Level Waste
WBC	- Whole Body Counter

1 Introduction

Large-scale operations aimed at SNF removal as well as RW treatment and long-term storage and contaminated land remediation are due to be performed at SevRAO facilities No.1 (at Andreeva Bay) and No.2 (Gremikha) according to the adopted design solutions.

In the course of long-term operations, the containment barriers in SNF and RW storage facilities lost partially their containment effectiveness, so workshops and the site of the facility No.1 became contaminated with radioactive substances above authorized values. This resulted in generation of conditions which are rather different from the designed ones. SNF and RW management under conditions of uncertainty could lead to possible excess occupational and public doses. Implementation of radiation protection supervision requires consideration of these uncertainties. However, existing regulatory documents do not cover this process fully and give rise to the need for new approaches and to develop special guidance and rules. In the course of work completed to the end of 2006, the main requirements for sanitary epidemiological supervision implementation were developed. The work was reported in Sneve et al (2007) and a Guidance document was produced and officially approved: “Hygienic Requirements for Occupational and Public Radiation Protection during Design and Arrangement of SNF and RW management at SevRAO Branch No.1, R 2.6.1.29 - 07 .

However, this document did not cover all regulatory problems, which the supervision bodies must address. Accordingly, the Norwegian Radiation Protection Authority (NRPA), within the program of cooperation with the Federal Medical-Biological Agency (FMBA of Russia), financed four projects to address continuing challenging issues. These were specifically aimed at improvement of the effective and efficient supervision of radiation protection assurance during remedial operations at SevRAO facilities falling into the responsibility of FMBA. At a workshop, which was held on 31 October - 1 November 2006, the decision was made to perform the following investigations in 2007:

- optimization of the occupational radiation protection at the stage of design and construction on SevRAO industrial sites;
- development of the regulatory document to assure safe management of the industrial wastes containing toxic substances and man-made radionuclides, which do not belong to the low level waste category according to their specific activity levels, at SevRAO;
- development of radioecological criteria for monitoring and control of the marine environment during the STS remediation**;**
- development of criteria for identification of emergency conditions and emergency plan to evaluate radiological conditions of the emergency plan initiation**.**

Measures directed to occupational protection are based on valid information on the radiation situation parameters and individual exposure levels, i.e., on radiation monitoring data. Within this topic, the report on the assessment of the radiation monitoring system existing at SevRAO facility No.1 has been prepared. In addition, recommendations on the ALARA principle implementation during SNF and RW management at SevRAO facility No.1 have been elaborated.

An objective of the "Optimization" project was to build some regulatory basis for optimization of personnel radiation protection during operation of new equipment and facilities for SNF management and for RW treatment taking into account special features of the Project implementation under real SevRAO conditions and having in mind relevant international norms and regulations.

When going on to full-scale construction works and commissioning of these facilities, the number and degree of radiation hazardous operations increases, so the radiation monitoring system has to be enhanced, focusing on methods of personal dosimetry, full-scale introduction of ASKRO system etc. – depending upon established engineering procedures of work implementation. As for improvement of the personal dose monitoring (PDM) system, special attention was paid to:

- development of the individual dosimetry method of external beta-exposure to the skin;

- introduction of emergency neutron dosimetry at the sectors of SNF and high level RW management;
- change to thermo luminescent dosimeter use to evaluate external gamma doses;
- introduction of the occupational radionuclide intake assessment method based on the radionuclide activity concentration (AC) in the working area air.

Significant amounts of wastes and materials with very low level activity are being generated in the course of operations and especially in the course of decommissioning of nuclear facilities. The selection of the economical and ecologically safe mode of such material management is accompanied with some difficulties connected with their special features: very low individual exposure but large volumes of material. Therefore, on the one hand, allocation of such low radiation toxic waste to specialized expensive storage and/or disposal facilities is not required; on the other hand, their conveyance to conventional (non-radioactive) waste disposal landfills is accompanied with other hazards with respect to safety and protection. The same applies to their limited or unlimited re-use or re-cycling. The absence of an elaborated regulatory basis for safe management of such waste required the development of a relevant regulatory document taking into account the circumstances existing at SevRAO.

The performed investigations permitted to identify requirements for assurance of safe management of the industrial wastes containing toxic substances and low-level man-made radionuclides, both being accumulated following the nuclear legacy and being generated during SevRAO SNF and RW STS remediation. They also permitted to identify requirements for arrangement, equipment and operation of such waste disposal landfill (site) at SevRAO sites and its decommissioning.

Within studies “Development of radioecological criteria” the investigations have been performed of justification and elaboration of the derived criteria of radiation and radioecological remediation of STSs and their locations. With this purpose two options of the STS end-state were selected: a site for the radiation engineering facility (STS conversion) and a site for the facility with general industrial functions (STS liquidation). The derived criteria will allow control of the established hygienic regulations of remediation in terms of the radiation monitoring results.

In the course of operations at SevRAO sites, some emergency situations can occur, hence, some preventive measures have to be pre-developed to allow urgent actions to be taken in such situations. To solve these problems, during 2005-2006, within the project «Improvement of medical and radiological aspects of emergency preparedness and response at SevRAO facilities», work was been performed to improve the emergency medical preparedness level at SevRAO facility in Andreeva Bay. During this project implementation the need was recognised to develop operational radiological and medical criteria for initiation of the emergency plan at SevRAO sites and for application of the most relevant medical and radiological protective measures. These needs were addressed within the project completed in 2007. The goal was to develop operational radiological and medical criteria for initiation of the emergency plan and application of protective measures at SevRAO facilities at the early and intermediate stages of accident situation evolution. To reach this goal, operational levels are to be identified in terms of total radiation doses.

This report contains the main findings of investigations in the above four projects (section 2 – 5). English translations of the 6 official regulatory guidance documents produced are provided as annexes. Conclusions on the projects are set out in section 6 and perspectives on continuing NRPA-FMBA cooperation are given in section 7. References are provided at the end of each section and a list of acronyms is provided at the front of the report.

References for section 1

Sneve M K, Kiselev M and Kochetkov O (2007). Radiological Regulatory Improvements Related to the Remediation of the Nuclear Legacy Sites in Northwest Russia. Final Report of work completed by FMBA and NRPA to the end of 2006. StralevernRapport 2007:11, Osteras.

2 Optimization of the occupational radiation protection during SNF and RW management on-site SevRAO facility No. 1

The project objective was to arrange the regulatory base for the personnel radiation protection optimization at the stage of operation of some new Combines for SNF management and RW processing, in terms of special features of its implementation under real SevRAO conditions and accounting for the relevant international recommendations.

The valid information on the radiation situation parameters and on individual exposure levels serves as a base to take actions on the occupational radiation protection and to plan safe implementation of radiation hazardous operations – these are the main functions of radiation control.

In 2007, the first stage of works on introduction of the occupational radiation protection optimization principle into the practice of SevRAO facility No.1 has been completed – the radiation control system operating at SevRAO facility No.1 has been assessed, including PDM arrangement and recommendations for application of ALARA methodology during SNF and RW management.

2.1 Development of the guidelines for «Personal dose monitoring of occupational exposure at SevRAO facility No. 1»

Personal dose monitoring (PDM) of the occupational exposure consists of the occupational equivalent dose measurements, radionuclide intake assessments, effective dose calculations, registration and account of doses during operation under conditions of ionizing radiation exposure.

Examination and analysis of arrangement of the radiation monitoring system existing at SevRAO, including the occupational personal dose monitoring was followed by development of the guidelines on the PDM procedure at SevRAO facility No.1. Having this purpose in mind, travels to this facility have been made, and the guidance and guideline documents developed and introduced into the facility practice during PDM arrangement have been analyzed. The performed analysis showed that:

- Dose monitoring of the occupational external exposure is performed according to the techniques:
  - Dose monitoring of the occupational external exposure using the direct reading dosimeters
  - Dose monitoring of the occupational external exposure using the thermo-luminescent dosimeters
- Organization of the occupational external dose monitoring is subdivided into personal dose monitoring and group dose monitoring.
  - Personal dose monitoring consists of occupational dose monitoring using personal dosimeter, which is attached to the particular person, or which this person has gotten for the period of either his/her ionization radiation source (IRS) management or his/her working under IRS exposure.
  - Group dose monitoring is implemented using group monitoring dosimeters as well as by means of dose calculation for the personnel working in the certain area (workshop);
- Monitoring using personal dosimeters is obligatory either for workers, involved in direct operations with man-made IRS, or for those, whose conditions of work impose their staying in the sphere of IRS impact.

Within the facility, external dose monitoring using personal dosimeters is obligatory for the personnel "A" and "B" groups when they work within CAA.

Group dose monitoring covers the rest of the personnel, whose occupation is not connected with staying in CAA and the public of Zaozersk city;

- Individual external neutron doses and equivalent beta-dose to the skin are being calculated;

- The objectives of internal dose monitoring are as follows:
  - under conditions of routine IRS operation – valid determination of individual occupational internal doses in order to assess sufficiency of IRS control measures assuring IRS safe application in compliance with requirements of Regulations and Rules;
  - under conditions of increased (potential hazardous) exposure - valid determination of individual occupational internal doses in order to assess possible medical consequences of such exposure;
- Radionuclide intake monitoring is being performed using WBC spectrometry kit by means of direct measurements of workers. Monitoring is being performed under standard geometries – «whole body» - determination of ^{137}Cs intake, «Lung» - determination of ^{137}Cs and ^{60}Co intakes, and «Thyroid» - determination of ^{131}I intake.

Monitoring frequency:

- the personnel "A" and "B" groups – annually, at the end of each calendar year;
- the personnel involved into radiation hazardous operations, are subjected to monitoring before and after termination of work.

The above-mentioned findings of the performed investigations and the results of the guideline document analysis demonstrate that existing PDM system promotes obtaining full-scale information about occupational doses and complies with OSPORB-99 and NRB-99.

When full-scale construction and commissioning of Combines for SNF&RW management will start, PDM system is reasonable to be improved, focusing on:

- enhancement of personal dosimetry method with respect to external beta exposure to the skin;
- introduction of emergency neutron dosimetry;
- turn to application of thermo-luminescent dosimeters to assess external gamma doses;
- introduction of radionuclide intake assessment method in terms of the radionuclide activity concentrations in air of working area.

These and other recommendations are given in the guidelines «Personal dose monitoring of occupational exposure at SevRAO facility No.1» (Annex 1.)

The final report of the project No.1 M10-07/09 over 2007 «Radiation protection optimization of workers at SNF and RW management on-site FSUE "SevRAO" Branch No.1» contains the comprehensive characterization of the PDM system existing at Facility No.1 and its analysis.

2.2 Development of the guidelines «Procedure of radiation monitoring at SevRAO facility No.1»

Examination and analysis of arrangement of the radiation monitoring system existing at SevRAO, including the occupational personal dose monitoring was followed by development of the guidelines on the PDM procedure at SevRAO facility No.1. Having this purpose in mind, travels to this facility have been made, and the guidance and guideline documents developed and introduced into the facility practice during PDM arrangement have been analyzed.

The performed analysis showed that:

- Radiation safety division is responsible for radiation protection of workers at SevRAO facility No.1. Operation of this division is organized in compliance with «Provisions about radiation safety division», approved by Director of SevRAO. According to the Provisions, one of the main duties of the division is arrangement of periodic industrial (radiation) monitoring in process buildings and on-site STS, within HPZ and in SA. The nomenclature, extent and frequency of RM are defined in terms of: the industrial process characterization; presence of harmful industrial factors; and the extent of their impact of human's health and habitat;

- All radiation indexes, which characterize levels of occupational and public exposure as well as levels of the environmental contamination, fall under monitoring. Table 1.1 presents a listing of subjects and controlled indexes, monitoring of which are imposed as a duty on the radiation safety division.
- During radiation hazardous operations, the following indexes are under control:
  - gamma dose rate;
  - beta fluence density;
  - alpha- and beta- contamination;
  - neutron fluence density (during SNF management).

The mentioned findings of the performed investigations and the results of the guideline document analysis demonstrate that existing RM system promotes obtaining full-scale information about occupational doses and complies with OSPORB-99 and NRB-99.

When going on to full-scale construction works and commissioning of the Combines for SNF&RW management, amount of radiation hazardous operations increases. In order to implement an optimization principle, under these conditions, the radiation monitoring system is reasonable to be enhanced, focusing on increasing monitoring extent and full-scale introduction of ASKRO system – depending upon established engineering procedure of work implementation. The radiation safety division will need additional organizational structure for verification and maintenance of dosimetry and radiometry equipment.

These and other recommendations are given in the guidelines «Procedure of radiation monitoring at SevRAO facility No.1» (Annex 2)

The final report of the project No.1 M10-07/09 over 2007 «Radiation protection optimization of workers at SNF and RW management on-site FSUE "SevRAO" Branch No.1» contains the comprehensive characterization of the RM system existing at Facility No.1 and its analysis.

Table 1. *Listing of the monitored objects and controlled indexes*

No.1	Name of monitored objects	Controlled index
1.	Workshops, rooms, buildings and constructions located on the industrial site	- gamma dose rate; - β-fluence density; - superficial contamination with α- and β-active substances; - neutron dose rate (SNF storage facilities)
2.	Industrial site, routes of workers.	- gamma dose rate; - β-fluence density; - superficial contamination with α- and β-active substances.
3.	Transport, package: - special transport with radioactive consignment; - transport with general engineering consignment	- gamma dose rate; - superficial contamination with α- and β-active substances; - neutron dose rate (as necessary).
4.	Wastes: - solid radioactive waste; - conventional industrial waste;	- gamma dose rate; - superficial contamination with α- and β-active substances; - neutron dose rate (as necessary).

No.1	Name of monitored objects	Controlled index
	- scrap metal.	
5.	Equipment and materials: - technological instruments; - equipment; - building materials and products	- gamma dose rate; - superficial contamination with α- and β-active substances.
6.	Personal protective equipment: - external and internal surfaces of auxiliary PPE; - base PPE.	- contamination with α- and β-active substances.

2.3 Development of the guidelines «ALARA principle application for protection of workers during SNF and RW management»

Under routine radiation source operation, Radiation safety standards (NRB-99) and OSPORB-99 require to follow the main radiation safety principles:

- non-exceeding of authorized individual dose limits due to all radiation sources (dose limit application principle);
- forbidden of all practices relating to radiation source application, if the resulting benefit both for individuals and for the society does not excess risk of possible harm due to additional exposure (justification principle);
- when using any radiation source, keeping individual dose and amount of persons exposed as low as reasonable achieved taking economic and societal factors into account (optimization principle).

Optimization principle is also called ALARA (**A**s **L**ow **A**s **R**easonable **A**chievable) principle. ALARA is the conception of dose limitation based on principles of minimization exposure levels considering economic and social reasonability.

Radiation protection optimization is a constituent of the program directed to achievement and keeping of acceptable safe conditions of activity.

Radiation protection must be a component of overall program for safe work conditions assurance.

An optimization principle must be applied at all stages both of the manufacturing process arrangement and of the radiation facility operation: from design stage, in the course of operation and up to termination of the facility decommissioning and waste disposal.

ALARA technique involves:

- generation of conditions for opening and implementation of each worker potentials (knowledge, skills, experience);
- justified selection and preliminary planning of actions, implementation of which improves safety;
- preparedness for work implementation;
- analysis and evaluation of operations performed, account of experience gained.

In order to introduce the optimization principle ALARA group must be arranged at SevRAO facility No.1. The ALARA group is being established under the chief engineer presidency based on the current radiation safety division to control and manage development and performance of the particular measures aimed at ALARA methodology implementation. ALARA group considers issues of radiation hazardous operation arrangement, including:

- ways of the personnel involvement into work planning;
- preparedness for work under radiation hazardous conditions;
- control of protective measures;
- analysis and evaluation of results obtained, account of the experience gained.

Work implementation planning

When planning radiation hazardous operations, different options of their performance must be considered. Options accompanied with the least dose costs are top priority. At that, the variant of operation implementation is preferable, which (taking account economic factors) ensures:

- the least individual occupational doses;
- minimum discharges and effluents of radioactive substances;
- minimum amount of radioactive waste generated.

Analysis and evaluation of the results

After termination of work, ALARA committee analyses the results. The obtained doses (both individual and collective) are being compared with the predicted (authorized) values. If authorized levels are excess, the reasons are being ascertained to avoid similar events in future.

Effectiveness is being evaluated of completed measures aimed at reduction of doses. A brief report is made containing conclusions and recommendations useful for arrangement similar operations in future.

Involvement of the personnel into implementation of the optimization principle

The conditions must be arranged, when the personnel deliberately select such ways, methods and work organization, which promotes achievement of the highest results (by quality and safety) under minimum time costs for work implementation.

The personnel, on its own, must take measures and methods of protection against ionizing radiations, such as:

- protection by distance;
- protection by time;
- correct application of all type PPE;
- using computerized and automated apparatus, facilities and equipment.

ALARA committee in cooperation with the administration must develop a system of stimulation of work implementation under dose cost minimization accompanied with exactingness and compulsion (presence of the work leaders at radiation hazardous operation performance, periodic and unscheduled inspections, control implemented by the radiation safety division).

These and other recommendations are given in the guidelines «ALARA principle application for protection of workers during SNF and RW management» (Annex 3).

Conclusions within the project

Optimization of the occupational radiation protection is based on reliable and valid information on the radiation situation parameters and on individual exposure levels. These two issues are the functions of radiation monitoring.

Analysis of investigation findings obtained by specialists of Institute of Biophysics and review of guidelines existing in practice of SevRAO facilityNo.1 RSD are evidence that now, at the stage of SNF and RW storage:

- existing radiation monitoring system promotes obtaining of comprehensive information about radiation situation conditions in the main industrial areas; this system complies with OSPORB-99 and NRB-99 requirements;
- existing PDM system promotes obtaining of comprehensive information about occupational doses; this system also complies with regulative requirements.

When going on to full-scale construction works and commissioning of the Combines for SNF&RW management, amount of radiation hazardous operations will increase considerably. In order to implement an optimization principle, under these conditions, the radiation monitoring system is reasonable to be enhanced, focusing on increasing monitoring extent and full-scale introduction of ASKRO system – depending upon established engineering procedure of work implementation. The radiation safety division will need additional organizational structure for verification and maintenance of dosimetry and radiometry equipment.

When improving PDM system, special attention shall be paid to:

- enhancement of personal dosimetry method with respect to external beta exposure to the skin;
- introduction of emergency neutron dosimetry;
- turn to application of thermo-luminescent dosimeters to assess external gamma doses;
- introduction of radionuclide intake assessment method in terms of the radionuclide activity concentrations in air of working area.

To manage development and taking actions for optimization principle implementation, ALARA group must be arranged at SevRAO facility No.1 (based on the current radiation safety division) under the chief engineer presidency.

The ALARA group must deal with arrangement of radiation hazardous operation implementation, including:

- ways of the personnel involvement into work planning;
- preparedness for work under radiation hazardous conditions;
- control of protective measures;
- analysis and evaluation of results obtained, account of the experience gained.

Operation of ALARA group must be based on ALARA technique application, which includes:

- generation of conditions for opening and implementation of each worker potentials (knowledge, skills, experience);
- justified selection and preliminary planning of actions, implementation of which improves safety;
- preparedness for work implementation;
- analysis and evaluation of operations performed, account of experience gained;

- development of recommendations for radiation protection assurance having in mind analysis performed and experience of similar work implementation in past.

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3 Radiation hygienic requirements for management of wastes containing toxic substances and man-made radionuclides with the specific activity levels lower than LLW at SevRAO facilities

Large amounts of wastes and materials with very low level activity are being generated in the course of operation and especially in the course of decommissioning of nuclear facilities. The selection of the appropriate and ecologically safe mode of such material management is accompanied with some difficulties connected with their special features: very low individual exposure at rather large initial volumes. Therefore, on the one hand, allocation of such low radiation toxic waste in the specialized expensive storage and/or disposal facilities is not required; on the other hand, their conveyance to the conventional (non-radioactive) waste disposal landfills is being accompanied with a certain hazard with respect to safety and protection, as well as their limited or unlimited re-use.

3.1 Analysis of Russian regulative documents, international recommendations on management of VLLW and assessment of their applicability to a SevRAO facility in Andreeva Bay

Having in mind the importance of this challenge, and with the purpose of the international consensus in approaches, criteria and digital parameters, needed for optimized decision making in all aspects of waste management (containing man-made radionuclides with activity levels lower than those of their ascription to RW), IAEA implements systematic review and examination of the mentioned challenge. In 1988, based on examinations accomplished, IAEA issued the safety guidance No.1 89 «Principles for the Exemption of Radiation Sources and Practices from Regulatory Control. Safety Series», The main provisions of which had been developed in the Safety Guidance «Application of the Concepts of Exclusion, Exemption and Clearance». Since 1990-s, IAEA has begun to issue recommendations on radioactive waste management within the program RADWASS (Radioactive Waste Safety Standards). The main objective of these recommendations is to help the States to develop national regulations on safe radioactive waste management, including disposal. For example, within this program the waste classification depending on its possible disposal mode has been developed in IAEA. The amended IAEA guidance No.111- G-1.1 contains the new waste category - "Exempt Waste".

The decommissioning practice of radiation hazardous facilities showed that in the during decommissioning of the facility operation life of which is being terminated (NPP, industrial and research reactors etc.) a vast amount of wastes is being generated (soil, construction materials, metal), and their contamination levels with man-made radionuclides is a bit higher than the level of exemption from the regulatory control, but lower than RW. The special Very Low Level Waste, VLLW, category seemed to be reasonable to separate as an independent category and introduced into the practice; such waste could be disposed at the industrial waste landfills.

Now, there is no single opinion regarding VLLW management. In Sweden, the special landfill had been arranged for such waste disposal near NPP in Oscarshamn, where very low level wastes are disposed from all radiation hazardous facilities. In France, this waste is not being conveyed to conventional waste disposal landfill, instead it is stored within industrial sites, where it was generated, or it is transported into RW disposal facility in La-Aube. In Japan, with the purpose of VLLW disposal resulted from the research JPDR reactor dismantlement, a special disposal facility has been built within the industrial site.

The solution of VLLW management, both in the world practice and in Russia is possible through introduction of this waste category into the system of the national classification. Analysis of radioactive waste categorization in the States with developed nuclear powered engineering and in Russia, demonstrates that there is a framework in the Russian legislative base (Para.3.11 OSPORB-99), similar to the majority of the European Community States, which permits to solve the problem of such waste disposal. However, a lack of regulative and methodical documents, allowing identification of such legislative base application hampers introduction of VLLW management system into everyday practice of the Russian enterprises.

Comparative analysis of Russian and IAEA classifications (Table 1) shows that industrial waste category (materials and products) with low radionuclide contents corresponds in the international terminology to so-called category of Very Low Level Waste. With the purpose of the single interpretation of the waste categorization system, we consider that the same term is reasonable to be used in Russian documents under development.

VLLW management problem arose in Russia critically in the course of nuclear legacy problem solving, especially during decommissioning and remediation of the ex-Navy shore technical bases (sites of the spent nuclear fuel and radioactive waste temporary storage (SNF and RW STS)), including those located in the Russian Northwest (Andreeva Bay and Gremikha village).

According to the RF Government Directive No.1 518 of 28.05.1998, environmental remediation of SNF&RW STS is recognized as one of the most relevant tasks of Rosatom. In compliance with the decision of RF Ministry of Property, in 2001, mentioned SNF&RW STS were transferred into RF Minatom‘s jurisdiction with the purpose of their environmental remediation. Now, SNF and RW STS fall in administrative responsibility of the Federal state unitary enterprise «SevRAO» (Murmansk city) as its branch facilities: No.11 (STS in Andreeva bay) and No.12 (STS in Gremikha village). In 2002, a Conception was developed of environmental remediation with respect to SNF and RW STS.

The Conception envisages:

1. Remediation of buildings, constructions and territories of SNF and RW STS. This remediation should be implemented up to the level excluding any potential hazard of offshore water and air radioactive contamination (up to “brown lawn” level).
2. Ecological remediation of SNF and RW STS is planned to be implemented in two stages:
   - at the first stage, restoration (building) is carried out of SNF and RW STS infrastructural part, which is necessary to ensure nuclear, radiation and ecological safety of the environment and to assure protection of workers during preparation and performance of remedial operations. Current activity aimed at isolation of available SNF and RW repositories to prevent contact with ground waters and atmospheric precipitation. Comprehensive engineering radiation examination is being performed and designs are being developed including engineering and economic justification of remediation both of SNF&RW STS as a whole, and of some infrastructural components;
   - at the second stage, the remedial designs are implemented having in mind the results of engineering and economic justification.

SNF and RW STS remediation is also planned to be performed in two stages.

Stage 1 – localization of radionuclide migration ways from sources into the environment;

Stage 2 – removing and withdrawal ground with high activity levels, putting localizing coverings on areas with removed ground and surfaces with low contamination.

3. Generation of secondary RW to be disposed must keep at minimum level achievable in practice and these waste characteristics must comply with current Russian norms and rules of nuclear energy use and RW management.

In the context of the recent Provision, the task must be solved of safe waste management including that from VLLW category.

The fact that the amount of such waste is comparable with the RW amounts being accumulated and generated at SevRAO and DalRAO facilities confirms the relevance of this challenge.

At SNF and RW STS, VLLW management situation is complicated, because the design of these radiation hazardous facilities does not contain any technologies for SNF and RW as well as industrial waste management for the post-operational period. However, there are the following special features of these facilities:

- management of RW and of industrial wastes is directed to sorting and disposal of the legacy wastes;
- Sr^{90} and Cs^{137} define the isotope composition, where the quota of Sr^{90} is about 20%;
- VLLW disposal facilities are assumed to be allocated within the industrial site;
- development of definitely specific technologies of SNF and RW management, including VLLW, defines the necessity of implementation of supervision functions with respect to radiation protection of workers, the public and environment considering these special features.

Analysis of waste management on the industrial sites showed their difference from the regulative ones. For example, obvious site contamination is practically absent at the NPP, while at SNF and RW STS, in particular, in Andreeva Bay and in Gremikha, there are significant contaminations. According to data of NIKIET and SRC-IBPh measurements, soil sample activities are in the range 10^2 -10^4 Bq/kg, and at some areas (near the brook close to Building 5 in Andreeva Bay), the specific activity of soil reaches 10^5 Bq/kg.

The special feature of SNF and RW STS in Andreeva Bay is the significant distance between the settlements and industrial site. There are no agricultural lands, forestry and water media, which the public might use to obtain the foodstuffs.

3.2 Development of the sanitary hygienic requirements for VLLW management

The above-mentioned data demonstrate that the waste management problem solving at SevRAO facility requires elaborating provisions relating to VLLW management procedure, variants of release from regulatory control, disposal options, sitting the disposal landfills in terms of above mentioned features, forming both radiation situation and occupational doses. With this purpose within the contract No.1 M10-07/06 between NRPA and SRC-IBPh, according to SPORO-2002 Para 1.3, specialists of the Institute of Biophysics developed the regulative document: The Guidance «Hygienic requirements for industrial waste management at the Federal state unitary enterprise «Northern federal enterprise for radioactive waste management» (VLLW regulations for SevRAO-07) ». This guidance defines a procedure of the regulatory supervision of industrial waste management at SevRAO facility and it is intended for enterprises of FMBA of Russia.

This Guidance establishes:

- requirements for assurance of safe management of industrial wastes containing toxic substances and low level man-made radionuclides, both legacy and generated during SNF and RW STS remediation, as well as requirements for arrangement, equipment and operation of the landfill (site) for these wastes and its decommissioning;
- criteria, rules and restrictions assuring radiation protection of SevRAO workers and of the public on-site, within HPZ and SA during industrial waste management, as well as the necessary monitoring level of the radiation and sanitary epidemiological situation;
- necessary measures for assurance of non-exceeding of the main occupational and public dose limits authorized by NRB-99, prevention (minimization) and mitigation of radioactive contamination of the environment, including that resulted from emergencies during VLLW management;
- requirements for contents of toxic and radioactive substances in industrial wastes conveyed for disposal.

Industrial wastes containing radionuclides with specific activity below levels of their ascription to RW are subdivided into two groups according to OSPORB-99 and these Guidance requirements:

- waste and materials containing man-made radionuclides with the specific activity level lower than their ascription to low level waste (LLW), but higher than levels of their clearance from the regulatory (first group);
- waste and materials cleared from the regulatory control (second group).

Within the developed Guidance, industrial wastes with very low content of radioactive substances (first group) are being separated into the "very low level waste" (VLLW) category according to the international practice.

To assure the occupational, public and environmental radiation protection during VLLW management and disposal, the developed document accounts the following principles:

- non-exceeding of authorized individual dose limits due to all radiation sources (dose limit application principle);
- forbidden of all practices relating to radiation source application, if the resulting benefit both for individuals and for the society does not excess risk of possible harm due to additional exposure (justification principle);
- when using any radiation source, keeping individual dose and amount of persons exposed as low as reasonable achieved taking economic and societal factors into account (optimization principle);
- assurance of the acceptable level of the environmental protect ability against radioactive exposure of waste storage and/or disposal landfills (environmental protection principle);
- such option of waste disposal, which minimizes its possible negative consequences for future generations (principle of non-putting of an excessive radiological burden on future generations).

Safety and protection criteria during management of waste being accumulated and generated on the SevRAO industrial sites are defined in terms of keeping individual and environmental impact in acceptable limits:

- radiation factors under regulation of NRB-99, OSPORB-99, SPORO-2002;
- hazard class of toxic waste under regulation of SP 2.1.7.1386-03, SP 2.1.7.1322-03, SP 2.1.7.1038-01 and GOST 12.1.007-76.

The main idea of the VLLW management Guidance development is to assure the occupational, public and environmental radiation protection. Justification and introduction of the main criteria of radiation protection assurance is being implemented with this purpose. SevRAO workers performing RW sorting and VLLW separation belong to the personnel group A. Workers involved in operations of VLLW management within the industrial site including landfills belong to the personnel group B.

Individual annual effective dose of the occupational exposure due to waste management of the personnel group B must not exceed 5 mSv/year. Planned exposure must not exceed 1.5 mSv/year.

The committed individual annual effective dose of exposure to the critical group of the population due to VLLW involvement in the economical activity must not exceed 10 μSv/year, while the collective effective dose to the public must not exceed 1 mSv/year.

The following main scenario of possible radionuclide spreading in the environment shall be considered for VLLW disposal landfill:

- radionuclide release from the place of disposal;
- migration via ground waters up to the bay offshore waters;
- radionuclide spreading in the bay.

At that, calculation of the public doses is performed using appropriate food chains taking account seafood intakes.

The described effective doses for workers and for the public during VLLW management will not be excess according to OSPORB-99 Para.3.11.4, if the specific activity bounds for beta-emitting radionuclides are within the range from 0.3 kBq/kg to 100 kBq/kg. The recommendations of the Directive [Council Directive of 15.07.80 amending the Directives laying down the basic Safety Standards for the health protection of the general public and workers against the dangers of ionizing radiation (Official Journal of the European Communities, L 246 of 17.08.1980) EUR 7330, Luxembourg] confirm this, when its Article 4 defines that the specific activity levels, which are lower than 100 Bq/g for man-made sources and 500 Bq/g for natural radioactive substances, are the bound values for the source clearance from the regulatory control.

According to the requirements of OSPORB – 99, under condition of unknown radionuclide composition, the waste may be ascribed to VLLW category if it contains 0,3 – 100 kBq/kg of β-emitting radionuclides, 0,3 – 10 kBq/kg of α-emitting radionuclides, 0,3 – 1 kBq/kg of Tran uranium radionuclides.

Under condition of known radionuclide composition, the waste may be ascribed to the VLLW category, if the following two equations are valid

$$0.3\ \text{kBq/kg} < a_i < SAMS \quad \text{and}$$

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

At SevRAO, radioactive contamination of the wastes is mainly due to ^{90}Sr (20%) and ^{137}Cs (80%) with low content of alpha-emitters (<0.1%), therefore sorting of the waste may be implemented according the criteria given in Table 2.

Table 2. *Sorting criteria of the industrial wastes at SevRAO under condition of the isotope composition:* ^{90}Sr *(20%) and* ^{137}Cs *(80%)*

Waste category	Specific β-activity, kBq/kg	Superficial contamination, β-particles/min·cm^2	Dose rate at 0.1 m from the surface of the package, µSv/h
Cleared wastes	≤ 0,3	≤ 50,0	Not more than 0.1 exceeding of the natural radiation background, typical for the particular place
VLLW	0,3 – 12,0	50,0 – 500,0	0,1 – 1,0

When justifying radiation safety of the disposal system with respect to workers, the public and the environment in terms of characteristics of the site, the design special features and characteristics of engineered containment barriers of the landfill, radionuclide composition of waste conveyed to the STS landfill, specific activity exceeding is permitted up to 30.0 kBq/kg. In some packages (not more than 10% of total disposal volume), such waste may be disposed, specific activity of which reaches 100.0 kBq/kg (Table 3).

VLLW packages with lower dose at the surface are emplaced at the periphery and by the landfill sides.

At the landfill arranged on-site, VLLW may be disposed containing toxic substances of III and IV hazard classes.

Table 3 *Acceptable characteristics of VLLW, conveyed to SevRAO disposal landfill, at isotope composition ^{90}Sr (20%) and ^{137}Cs (80%)*

Very low level waste	Specific activity of radionuclides in the package, kBq/kg	Maximum specific activity of radionuclides in the package, kBq/kg	Levels of VLLW superficial beta contamination, part/min*cm^2	Exposure dose rate, µSv/h	Maximum content of long-lived alpha-active radionuclides, %
	0,3-30,0	< 100,0	50,0-500,0	≤ 1,0 at 0.1 m distance from the package	0,1

VLLW containing toxic substances of the I and II hazard class must be conveyed to the facilities involved in such waste decommissioning. When such conveying, small amounts of waste (less than 100 kg) under conditions of known radionuclide composition may be released from regulatory control, if two provisions are valid at the same time:

$$\sum_{i}^{n} \frac{a_i}{SAMS_i} \le 1 \qquad \sum_{i}^{n} \frac{A_i}{MSA_i} \le 1$$

where:

a_i - specific activity of *i* radionuclide in the waste, kBq/kg;

A_i - total activity of *i* nuclide in the waste, kBq;

$SAMS_i$ and MSA_i - specific activity of minimum significance and activity of minimum significance of *i* nuclide, respectively, kBq/kg and Bq. Values of $SAMS_i$ и MSA_i had been established in Annex A-4 of NRB-99.

Having in mind the fact that radionuclides Sr^{90} and Cs^{137}produce the main radiological problem at SevRAO facility, the level of release from the regulatory control of the scrap metal intended for re-use (0.3 kBq/kg) could be determined more precisely. Hygienic regulations "Contents of man-made radionuclides in metals" (GN 2.6.1.2159-07), approved by The Directive of the RF State Chief medical officer No.15 of 08 February 2007, recommend to release metals intended for re-use (with specific activity levels of 10 kBq/kg - for Sr^{90} and 1 kBq/kg - for Cs^{137}) from radiation control. For the scrap metal being containing in the industrial waste accumulated at SevRAO such approaches may be applied not affecting safety and protection if the following condition is valid:

$$\sum_{i=1}^{N} \frac{A_i}{DK_i} \le 1,$$

where: N - the number of different radionuclides in the particular metal;

A_i - specific activity of i-th radionuclide in this metal, kBq/kg;

DK_i - permissible specific activity value of i-th radionuclide in this metal, kBq/kg,

In terms of the waste radionuclide composition on SevRAO industrial sites, the scrap metal specific activity level authorized for clearance from regulatory control will equal to 1.2 kBq/kg.

In addition to elaboration of the acceptable dose criteria, the developed VLLW management Guidance pays attention to safety requirements of the disposal landfill.

At that, maximum safety assumes to be reached, if the project contains materials justifying:

- siting for the landfill construction

- selection of the optimal system of engineered containment barriers, including the landfill structure, as well as engineering and operational procedures;
- radiation monitoring system at operational and post-operational stages;
- system of occupational and public dose monitoring;
- acceptable and reference levels of radiation industrial indexes;
- maximum radionuclide capacity of VLLW disposal landfill;
- the landfill life time and environmental monitoring.

Operation of the disposal landfill includes the following steps:

- commissioning;
- taking on and education of the personnel;
- engineering and radiation control and monitoring during operation;
- acceptance of wastes;
- emplacement of wastes;
- control of discharges and effluents, monitoring maintenance;
- emergency preparedness;
- decommissioning (closure) of the landfill.

VLLW must be disposed in such manner that assures the public and environmental radiation protection for the full period of their potential hazard.

The third important issue of VLLW safe management assurance is release of the disposal landfill (DL) from the regulatory control. The DL operation life must be calculated for the period, after termination of which disposal will not be radiation hazardous. With this purpose, the duration of post-operational period is being determined. Operator (in terms of the designed solutions; results of radiation safety assessment of the landfill under conservation; potential hazard period of VLLW disposed and by agreement with the bodies designated to implement the state sanitary epidemiological supervision) establishes duration of the post-operational period.

The DL safety requirements are based on the principle recommended by ICRP. According to these recommendations, the public risk must not exceed 0.3 mSv/year public dose constraint after the DL closure, taking into account the most possible ways of the landfill evolution.

After termination of operational life of the VLLW disposal landfill environmental monitoring is being established for the entire post-operational period (permanent or periodic sampling and some parameter measurements to define the conditions of the system).

At that, the public effective dose must not exceed 10 μSv/year and this value corresponds to 10^{-6} radiation risk level. This value does not change with dose increasing up to 20 μSv/year. Such radiation risk is being postulated as so-called screening level, i.e. minimum control level, at excess of which additional investigations may be performed to ascertain radiation situation on –site under consideration. If the screening level of radionuclide content in soil does not result in generation of the effective dose exceeding the mentioned one, there are no reasons to perform any ascertaining investigations and radiation monitoring, in other words, radiation monitoring is unnecessary.

At the stage of the landfill conservation a body is being defined, which is responsible for performance of the radiation situation monitoring and of land-using control, at the same time, a scenario is being defined of the landfill future use.

VLLW landfill further use can be implemented according to one of three scenarios with safety justification and by agreement with the bodies designated to implement the state sanitary epidemiological supervision according to the adopted procedure:

- clearance from regulatory control provided that average specific activity over the landfill as a whole, including containment barriers, will not be higher than 0.3 kBq/kg;

- limited use of the disposed wastes in the economic activity with activity level which is lower than SAMS;
- arrangement of the "brown lawn" within the industrial site, keeping at the same time the landfill under conservation on it.

Clearance of VLLW disposed at the landfill from regulatory control, must be implemented according to the criteria given in Table 4.

Table 4 *Clearance criteria of VLLW disposed at the landfill from regulatory control*

Full clearance	Non-exceeding of clearance level by specific activity	Non-exceeding of annual effective dose to the critical group ≤ 10 μSv/year and collective dose ≤ 1 man-Sv	Non-exceeding of public exposure level at unintended human intrusion ≤ 0,1 mSv/year and collective dose ≤ 1 man-Sv/year	Non-exceeding of public dose constraint of 0,3 mSv/year after closure

Conclusions of the project

The materials presented demonstrate that industrial wastes generated during operation and decommissioning of radiation hazardous facilities, including SevRAO, contain radionuclides with different activity levels. General procedure of this radioactive waste management is now specified by «Sanitary rules of radioactive waste management» SPORO-2002, (SP 2.6.1. 1168-02). Main criteria of waste ascription to radioactive category have been identified, and principles and practices of their safe management have been established taking into account special features of the legacy wastes. The Guidance "Hygienic requirements for occupational and public radiation protection assurance during design and arrangement of SNF and RW management at FSUE SevRAO facility No.1" (R 2.6.1.29-07), reflects this fact.

Moreover, besides radioactive waste, large amount of industrial wastes are generated at radiation hazardous facilities, which waste contains very low level radionuclides, lower than the level of its ascription to LLW category. The Guidance being developed within the present contract is aimed at generation of the system of such waste safe management. It was being developed taking into account requirements of Radiation Safety Standards (NRB-99) and as elaboration of OSPORB-99 sub-section 3.11 «Management of materials and products contaminated or containing radionuclides». In addition, the developed document is a component of the document set aimed at improvement of regulatory functions of radiation protection assurance by the supervision bodies of FMBA of Russia.

In this light, the present document does not deal with some problems connected with VLLW management, or presentation of these problems is not comprehensive. In particular, aspects of radiation monitoring of workers, industrial situation and environment during VLLW management – which is a constituent of overall radiation monitoring at SevRAO – found their reflection in the special guidelines «Regulation of radiation monitoring at SevRAO facility NO.1». This document contains the radiation monitoring system, including arrangement and performance of the radiation situation monitoring as well as the occupational dose monitoring at all stages of SNF and RW management.

VLLW safe management is being specified by the fact that in addition to radiation monitoring DL control includes monitoring of:

- gamma dose rate within the storage site and within the disposal landfill at 1.0 m height either from the land surface or from the site, 0.1 m from surfaces of hardware and the landfill constructions;
- activity concentration and radionuclide composition in samples of surface and ground waters at the area of the landfill allocation and in samples of water from ponds nearby the landfill;

- radioactive contamination levels of vehicles, equipment, personal protective equipment, the skin and personal clothes of workers,

It also includes monitoring of:

- concentration levels of hazardous substances in air of working area of the personnel;
- concentration levels of contaminants in common air of the landfill site;
- concentration levels of hazardous chemical substances in samples of surface and ground waters at the site of the landfill location and of water from nearby ponds.

The extent and parameters of radiation monitoring on-site the supervised area (SA) of the site of temporary storage are being specified in the Guidance «Remediation criteria and regulations of sites and facilities from the federal state unitary enterprise "Northern Federal Facility for radioactive waste management (SevRAO)" of the Federal Atomic Energy Agency, contaminated with man-made radionuclides» (R 2.6.1. 25 – 07).

This document specifies types and the extent of Radioecological monitoring. The Guidance determines dose constraints to the public living nearby the industrial sites for the whole operation life of the sites. In terms of safety and protection requirements being justified in this document, the supervision bodies make decisions on ascription of the remedied territory of industrial sites in Andreeva Bay and Gremikha village with VLLW DL located inside to lands of the appropriate category.

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4 Development of radioecological criteria for monitoring and control of the marine environment during remediation at STS, taking account possible end-state objectives

The primary objective of this project is to develop the derived criteria for radioecological situation monitoring and control at implementation of the most suitable remediation option, which currently is conversion (renovation). This work will support definition of a regulatory basis for FMBA to take action during operations in the event that operations result in releases to the marine environment, which are not consistent with protection objectives.

Two problems has been solved within this project

- analysis of Russian regulative documents and of international recommendations on the ecological regulation;
- development of the derived criteria of the residual radioactivity in case of the STS conversion.

4.1 Analysis of Russian regulative documents and of international recommendations on the ecological regulation

The following subtasks have been solved within this task:

- analysis of Russian regulative and guidance documents and of international recommendations on the ecological regulation.
- analysis of approaches of international organizations to ecological monitoring with the purpose of the site control.
- development of the listing of necessary industrial derived radioecological regulations within the authorized dose constraints of the residual radioactivity in the course conversion

4.1.1 Analysis of Russian regulative and guidance documents, as well as of international recommendations on the ecological regulation

Analysis of approaches applied in order to justify criteria of environmental protection assurance, has shown that now, there are no common international criteria of the environmental protection against radiation exposure.

Moreover, as ICRP Publication 91 [1] notes, there is not even single opinion and common understanding of "adequate environmental protection" definition. Therefore, ICRP when formulating principles of the strategy implementation of biota preservation (without human), which complies with the approach to human protection, has no intension to establish any regulatory standards in this field, but it would like this strategy to be adopted and applied by other institutions, regulatory bodies and operators.

The first step towards development of the generally accepted philosophy and methodology for the environmental protection against ionizing radiation was made in the IAEA technical report [2], published in 1999. It deals with a study of possible approaches to the criteria establishment and contains the following general conclusions:

1. Although many countries use the ICRP approach with the purpose of the environmental protection, some States recognize a necessity of development of some guidance and criteria, in order to demonstrate exactly the environmental safety;

2. There is no exact agreement so far, what guidelines, end-points or goals could be used as a basis for the environmental protection, but there are many ideas on this issue;
3. Degree of understanding of radiation effects to organism other than human is sufficient to promote this topic;
4. Approaches and criteria for the environmental protection against radiation effects should be developed having in mind approaches to other environmental contaminants;
5. In order to reduce doubts and to make sure that those criteria would guarantee the desired protection level, certain areas need extra investigations.

Over the recent years, there are many works, including the Russian ones [3, 4], devoted to conceptual elaboration of a challenge of radiological criteria for the environmental protection and development of radiological criteria for the environmental protection. Table 5 [5] shows some of them.

As Table 5 illustrates, the proposed criteria are rather different. This is due not only to different approaches to guaranteeing radiation protection of the environment. For example, [4] and [6] used approaches based on a concept of a dose limit, but even in this case considerable difference remains.

Recommendations [6] are in full compliance with the methodology of the Environmental Risk Assessment, which is currently applied for chemicals in terms of ecotoxicology. It uses the "environmental no-effect values" (ENEV), which are obtained in terms of toxicological effects for individuals (obtained in the laboratory), divided by a safety coefficient (generally from 10 to 1000), with the purpose of extrapolation to real conditions. Different interpretation of literature data leads to different dose limits (or ENEV values) at the range of 0.2 - 2.5 mGy/day. In [4], non-exceeding of 1 % from LD_{50} for the marine organisms is used in order to establish fatality dose limits. This produces lower ranges of dose limits: from 0.07 to 1 mGy/day.

Table 5. *Dose limits for protection of Fauna and Flora against ionizing radiation*

Information sources	**Classes of biotas considered**	**Dose limit or environmental no-effect value (ENEV) ($mGy \cdot d^{-1}$)***
UNSCEAR [22]	Terrestrial plants	10
US DOE [9]	Aquatic animals	10
UK EA [7]	Terrestrial animals	1
	Marine mammals	1
	Terrestrial plants	10
	Other freshwater and coastal marine water organisms	10
	Deep ocean organisms	24
Canada [6]	Algae, macrophytes	2.5
	Terrestrial plants, invertebrates	2.5
	Benthic invertebrates	1.6
	Small mammals	1
	Fish	0.5
	Amphibians	0.2

Russia [4]	Plants, invertebrates	1
	Poikilotherm animals	0.3
	Haematothermal animals (life time < 5 years)	0.14
	Haematothermal animals (life time > 5 years)	0.07
ERICA [81]	Terrestrial, fresh-water and marine bio-media	0.24
ICRP	*Man*	*0.0027*

Notes:* In different works either dose limits, or dose values are given, at which there is no environmental effect (ENEV).

ERICA project proposes to use the adequate screening dose rate of 0.24 mGy/day value for chronic exposure to all types of ecosystems (terrestrial, freshwater and marine), which reflects the predicted dose rate without any consequences arising. This screening value is included into its proposed procedure of level-by-level risk assessment as follows

- Level 1 – Concentration screening: at this level an expert can compare radionuclide concentrations in the environmental components within the particular site (in Bq/l or Bq/kg) with screening values of activity concentrations derived by ERICA. The last were derived by means of reverse calculation from the screening dose rate values proposed by ERICA;
- Level 2 – Dose screening: At this level, an expert can introduce radionuclide concentrations for the particular site and upgrade variables, which effect to the interconnection between these concentrations and dose rates. The calculated dose rates could be compared with the screening dose rate values proposed by ERICA. Here, weighting factors are also introduced for the particular radionuclides to account for cumulative effects of different radionuclides;
- Level 3 – Detailed, site specific and probabilistic analysis. At this level, none predetermined screening values are proposed. Instead them, examples of methods are presented, which could be applied for derivation of suitable dose rate values for the particular ecosystem, community, end-state etc., including probabilistic method.

In USA, DOE supports a "graduated" approach to the environmental protection, many aspects of which are similar to level-by-level approach ERICA to risk assessment. DOE proposed dose norms, which assume to be used as screening criteria, but, in comparison with ERICA norms, they in majority cases are higher:

- for protection of marine organisms - 10 mGy/day (~400 μGy/hour);
- for protection of terrestrial plants - 10 mGy/day (~400 μGy/hour);
- for protection of terrestrial fauna species - 1 mGy/day (~40 μGy/hour).

It is assumed that under conditions of these criteria non-exceeding, a reproductive performance would not change.

Similar to ERICA project, the derived levels of radionuclide contamination of soil, bottom sediments and water are determined on the base of these dose criteria.

Models for dose calculation to environmental media and to biota are given, for example, in [10, 11].

In the Russian Federation, there are no regulations on the environmental radiation protection. Document [12] recommends using the following Radioecological criteria to protect the marine environment:

- for marine mammal - 50 mGy/y;
- for fish - 100 mGy/y;
- for marine invertebrates and plants - 500 mGy /y.

The mentioned dose limits has been determined assuming that doses to the marine biota (which are at least 1% of the fatal dose or of significant dose of chronic exposure) will not result in significant exposure to populations or to communities, even though they can result in some stochastic physiological effects on the particular organisms.

As above examples show, the proposed and applied criteria for guaranteeing radiation protection of the environmental media vary in wide ranges.

4.1.2 International organization approaches to ecological monitoring for site control purposes

In the course of analysis of international organization approaches to ecological monitoring for the media control, more than 20 international and national documents have been considered, including ICRP and IAEA documents, which establish both generic requirements for radiation environmental monitoring performance, and specific requirements for monitoring considering special features of different radiation hazardous facilities.

The special attention was paid to the particular issues of monitoring performance, for example, requirements for the equipment applied, for methods of sampling etc.

Three IAEA documents are the most interesting during elaboration of monitoring and control program at different stages of the STS remediation:

- Environmental and source monitoring for purposes of radiation protection: safety guide. No. RS-G-1.8;
- Surveillance and monitoring of near surface disposal facilities for radioactive waste. IAEA, Safety reports series no. 35;
- IAEA-TECDOC-1118. Compliance monitoring for remediated sites.

In the course of preparation of some sections for the Methodic Guidance, devoted to sampling of the environmental media, recommendations of IAEA technical reports are useful:

- IAEA-TECDOC-1360. Collection and preparation of bottom sediment samples for analysis of radionuclides and trace elements;
- IAEA-TECDOC-1415. Soil sampling for environmental contaminants.

For preparation of chapters relating to implementation of the marine environmental monitoring, approaches are more interesting, which different national, regional and international programs of the marine environmental monitoring applied, when selecting some monitoring subjects to serve as bio indicators.

In compliance with international documents, the environmental monitoring problems under condition of routine operation include:

a. To verify the results of source monitoring and the associated modelling to ensure that the predictions of the public exposure and environmental contamination consistent and that exposure limits (or established dose quotas) are not exceeded;
b. To check environmental radiation conditions for compliance with the authorized environmental limits, if applicable;
c. To provide information to enable the assessment of actual or prospective doses to members of the critical group resulting from discharges due to authorized practices or sources;
d. To detect any unpredicted changes in activity concentrations and to evaluate long term trends in environmental radiation levels because of the discharge practice;
e. To provide information for the public.

In emergency, monitoring has the following goals:

a. to provide information with the purpose of an accident classification;

b. to assist the decision makers in need of taking protective actions and intervention in terms of the current intervention levels;

c. to assist in prevention of radioactive contamination proliferation;

d. to provide information for protection of workers taking urgent actions relating to mitigation of the accident consequences;

e. to provide exact and in-time data on the level and degree of radiation hazard due to the radiological accident;

f. to define an extension of damaged area and hazard duration;

g. to provide detailed physical and chemical characteristics of hazard;

h. to confirm an effectiveness of protective actions, such as decontamination etc.

The monitoring programs should cover all stages of the facility lifetime: from pre-commissioning, commissioning, operational and to closure. The monitoring scale varies with its operational stage. At the pre-commissioning stage, monitoring includes a wide range of investigations directed to specification of special features of the radiation situation generation, acquisition of experience, personnel training and development of the monitoring methods. At the later stages, the monitoring program should use this accumulated experience.

In the monitoring program, the following items should be defined: type and frequency of measurements, procedures of measurement or sampling and their following laboratory analysis, statistical handling of monitoring results, their interpretation and registration. A set of sampling points should be selected carefully in terms of radiation characteristics of a source and the public and environmental exposure pathways. The final part of the monitoring program could include dose evaluation of exposure to individuals or population and their comparison with the appropriate limits.

It is important to note that monitoring programs at routine operation and in emergency conditions should be agreed, because monitoring results under normal conditions are used when determining of emergency exposure contribution into the public and environmental exposure.

Special attention in the course of the literature analysis was paid to radiation monitoring of the marine environmental media. In particular, programs of radionuclide monitoring in the marine environment of the northern hemisphere, Arctic and sub-tropic zone have been considered [13, 14].

When selecting the marine environmental media for monitoring, three factors are to be taken into account. The first factor is biota and sea plants, the most common for this area, if they are components of local foods, or if they are significant for national economics (for example, fishery), due to their role in collective dose generation. For the northern seas, the most significant by this factor are [15]:

- fishes: cod, Peter's fish, capelin (very high priority);
- shrimps;
- molluscs, mussels;
- kelp (laminaria);
- king crabs.

The second factor is an ability of the marine environmental media to concentrate radionuclides, so-called biological indicators. These indicators serve as a significant source of radionuclide ingestion with foods. Moreover, they are sensitive indicators of the environmental contamination, and this is the main reason of their selection. The following types of biological indicators are to be separated:

- seaweeds (fucus) (the best indicators)
- blue mussels (Pu, Am, Tc, Po, Cs, Co, Ra),

- polychaetes (Pu, Tc),
- brittle star (Pu, Tc),

Fucus is the most common usable and verified indicator, but in the Nature, it occurs only in offshore areas, so its use is restricted.

Third, when selecting monitoring subjects, the possibility should be accounted of valid measurement of their radionuclide contents. The property of some radionuclides to be accumulated mainly in the particular organs and tissues can be used to increase sensitivity of the marine media monitoring or to assess dose to biota. So, ^{90}Sr is being accumulated in fish bones and in mussel shells; ^{137}Cs – in fish tissues and in the cod liver; Am, radium isotopes and Pu – in mussel shells, edible parts, fish bones; ^{210}Po and ^{210}Pb in fish meat, edible parts and fish bones.

To evaluate contamination level of the ecosystem as a whole, the following media are useful:

- bottom sediments;
- seawater;
- plankton;
- bird egg.

In the Russian Federation, the main principles of environmental control and monitoring performance are given in the Federal laws [16-18]. Generally, they had been developed taking into account ICRP recommendations and IAEA requirements. However, in contrast with international approaches “control” and “monitoring” concepts in Russia have different meanings [16]:

- monitoring of the environment (ecological/environmental monitoring) is a comprehensive system of surveillance of the environmental conditions, assessment and prediction of the environmental conditions changes due to natural and anthropogenic factor impacts;
- control in the field of the environmental protection (ecological/environmental control) is a system of actions directed to prevention, detection and suppression of the legislative contempt in the field of the environmental protection, guaranteeing observance of requirements, including norms and normative documents, in the field of the environmental protection, by all economic and other units.

The majority of the Russian documents define requirements especially for the radiation situation monitoring. Among other differences, the following should be noted:

- control documents do not generally contain requirements for dose assessment based on results of monitoring;
- special documents contain requirements for control under conditions of routine operation and in emergency cases.

The structure of the guidelines “Arrangement of radiation monitoring of the environmental media in the operational area of the Federal state unitary enterprise “Northern federal enterprise for radioactive waste management” of the Federal atomic energy agency” has been prepared on the base of the performed analysis results considering requirements of the Russian regulative documents for radiation control of radiation hazardous facilities activity.

In particular, the decision to introduce a section devoted to dose assessment based on radiation monitoring has been made, as well as to give requirements for radiation control and monitoring performance under conditions of routine practice and during emergencies.

4.1.3 Development of the listing of necessary derived Radioecological regulations

The previous Guidance «Remediation criteria and regulations of sites and facilities from the federal state unitary enterprise "Northern Federal Facility for radioactive waste management (SevRAO)" of the

Federal Atomic Energy Agency, contaminated with man-made radionuclides» [18], specifies the criteria as effective dose values.

With the purpose of comparison of monitoring findings with the established dose criteria, some derived levels are reasonable to be elaborated, expressed as values applicable for the measurement results, which are the part of the radiation monitoring program.

According to the above-mentioned document for different options of STS remediation the public and occupational dose constraints due to the residual contamination of the site and due to radioactive discharges have been established.

As for STS, sources of the offshore water contamination are as follows:

- direct washing out of radionuclides via atmospheric precipitations from the surface of the site contaminated mainly with ^{137}Cs, ^{60}Co, ^{90}Sr, ^{152,154}Eu (soil contamination with ^{152,154}Eu is a special feature of STS in Gremikha);
- radionuclide migration from the superficial and deep soil layer and from non-waterproof storage facilities into ground and underground waters and via them into the marine environment (by such way of contamination ^{90}Sr is very important, because of excess migration ability).

These sources may be ascribed as uncontrollable sources of discharges. Therefore, to monitor the marine environmental contamination some derived radioecological regulations must be established in a form of the bottom sediment specific activity and in a form of radionuclide activity concentrations in seawater.

With the purpose of the occupational and public dose monitoring due to the residual site contamination, the derived radioecological regulations must be specified in a form of radionuclide specific activities in the superficial soil layer.

Moreover, there is the local deep (3 m and more from the soil surface) soil contamination at the STS. Such contaminations have no significant impact on human from the external exposure point of view, but they are important for exposure to the underground biota. Special radioecological regulations are to be established for them in a form of radionuclide specific activity values in deep soil layers.

4.2 Development of the derived criteria of the residual radioactivity in case of the STS conversion

The following efforts have been completed within task 2:

1. The database framework has been developed together with sampling protocols reflecting space and time distributions of radionuclides at the STS, and the database has been filled in.
2. Digit values of the derived criteria have been developed.
3. The guidelines “Arrangement of radiation monitoring of the environmental media in the operational area of the Federal state unitary enterprise “Northern federal enterprise for radioactive waste management” of the Federal atomic energy agency” have been developed and approved.

4.2.1 Database

Database on radionuclide contents in the marine media had been developed and it is managed by the special control system (data manager) Access. This data manager simplifies management of data stored, their treatment and joint use.

The data manager Access is enclosed in the standard suite of Microsoft Office Utilities. This program packet is in common use in Russia. The computer based on Pentium processor can be used for operations with the database, provided with at least 16 Mb main memories, 10 Mb hard disc and software: Microsoft Windows 95 and higher, Microsoft Office, Internet Explorer 4.0 and higher.

Figure 1 shows outline of the database developed.

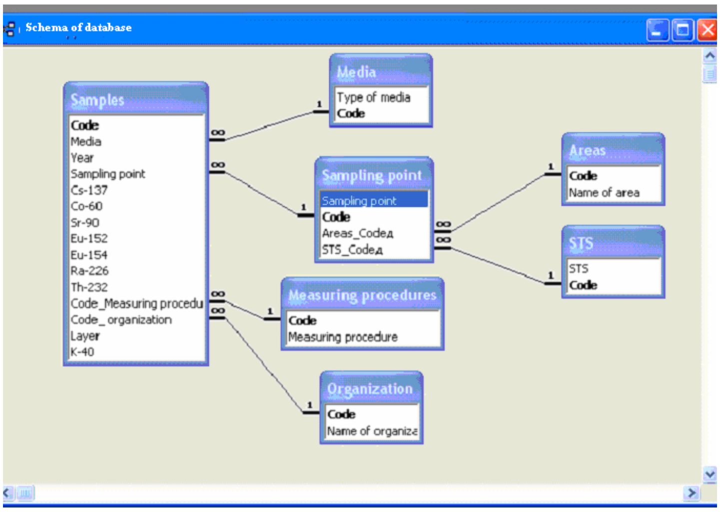

Figure 1. *Database outline*

The database includes 7 interconnected tables, titles of which are shown in fig. 2. These tables contain information on:

- sampling points;
- marine environmental media;
- radionuclides under control;
- date of sampling and date of the sample measurement;
- specific activities of radionuclides in the marine environmental media;
- methods of sample treatment and measurement procedures;
- organizations performed measurements.

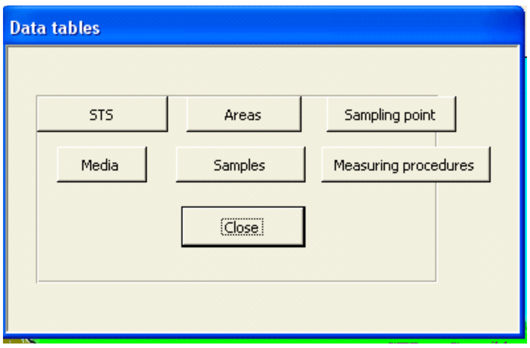

Figure 2. *Main menu for the table selection*

Today, information on man-made (^{137}Cs, ^{90}Sr, ^{60}Co, ^{152}Eu, ^{154}Eu) and natural (^{40}K, ^{226}Ra, ^{232}Th) radionuclide contents in the marine media is being put in the database; table 6 contains generic data on these information source.

Table 6. *Listing of information sources on the marine environmental radioactivity, enclosed into the database*

Information sources	**Year of examination**	**Type of examined media**	**Place of sampling**	**Radionuclides studied**
[3]	1997	Seaweeds, bottom sediments, seawater	Andreeva bay	^{137}Cs, ^{90}Sr
[4]	1999	Bottom sediments	Andreeva bay	^{137}Cs, ^{90}Sr, ^{40}K
[5]	2005, 2006	Seaweeds, bottom sediments, seawater, fish, crab shell	Andreeva bay	^{137}Cs, ^{90}Sr
[6]	2004	Seawater, seaweeds, bottom sediments	Andreeva bay	^{137}Cs, ^{90}Sr, ^{40}K, ^{60}Co, ^{152}Eu, ^{154}Eu, ^{226}Ra, ^{232}Th
[7]	2006	Fish, seawater, bottom sediments, seaweeds	Gremikha	^{137}Cs, ^{90}Sr, ^{60}Co, ^{40}K, U-Ra series, Th series
[8]	2003	Seaweeds	Gremikha	^{137}Cs, ^{90}Sr,
[5]	2005	Seaweeds, bottom sediments, seawater, sea fish	Gremikha	^{137}Cs, ^{90}Sr

In term of information required to put radiation monitoring findings in the database, the "Sampling protocol" has been developed. Table 7 demonstrates such protocol.

Table 7. *Sampling protocol*

Information about organization, which performs sampling	Official name
	Address
	Phone, Fax
Information about the sample	Name of the sample type
	Number of sample
Information about place of sampling	Name of STS
	Shore reference point
	Geographic coordinates: - latitude - longitude
Date of sampling	Day, month, year
Characterization of sampling	For water: Volume of water collected Sample filtration performed (yes/no) Sample acidation performed (yes/no)

	For bottom sediments: Area of sampling Depth of sampling Sample weight: - wet - after drying
	For fish: Species of the fish Total weight Weight of muscles
	For seaweeds: Kind of seaweeds Weight of sample: - wet - after drying

4.2.2 Derived radioecological criteria

In order to develop derived radioecological levels of the marine environmental contamination, two approaches to regulation of radionuclide contents in seawater and in bottom sediments had been considered. These are: ecological approach, which has protection of biota as its strategic object (i.e. tendency to maintain biological diversity of non-human species); and hygienic approach aimed at prevention of unwarranted radiation exposure to human.

Within the ecological approach, "the strictest" ecological criteria have been considered from those:

- proposed within ERICA project [8];
- applied by US DOE for the purpose of environmental protection [9];
- recommended for application in Russia in the course of assessment of acceptable discharges of low-activity process (service) water into marine environment [10].

Within hygienic approach, the following things have been taken into account:

1. available radiation and hygienic regulations, establishing permissible specific activities of ^{137}Cs and ^{90}Sr in seafood (SanPiN «Hygienic requirements for protection and food cost of foodstuffs» [19]), and those which were applied as regulations for STS remediation [20];
2. quota for radioactive discharges into the sea, established for STS in the course of remedial operations and in case of «conversion» implementation as STS remediation option [20, 21].

Assessments of permissible radionuclide contents in seawater and in bottom sediments, at which ecological and hygienic regulations are kept within authorized limits, showed that the hygienic approach established stricter requirements for the marine environmental contamination, than the ecological one. This means that observance of requirements for the public radiation protection assurance will also assure radiation protection both of the marine environment, and terrestrial animals and plants.

Derived levels of soil superficial contamination have been developed for two scenarios of the STS territory general industrial use under condition of uniform space contamination of the territory:

- scenario 1– mainly outdoors operations (construction of new buildings and structures; docker's or stevedore's work etc.).
- scenario 2 – mainly indoors operations (in the office, in the storehouse etc.).

Under condition of general industrial use of the STS area, the effective dose to the critical group of the population due to the residual man-made contamination must not be higher than 1 mSv per year;

The derived levels of the soil superficial contamination in case of the STS conversion have been calculated under condition that effective dose due to the residual man-made contamination must not exceed 3 and 1 mSv per year, respectively, for the personnel A and B groups, when they stay on the contaminated site during 1700 and 2000 hours per year.

Derived levels of the permissible contamination of deep soil layers were being assessed for conditions of exposure to underground animals with 10 mGy per day.

Tables 8 – 11 demonstrate the developed radioecological criteria.

Table 8. *Authorized specific activity of radionuclides in bottom sediments and seawater under STS routine operation*

Radionuclide	Bottom sediments, Bq/kg	Seawater, Bq/l
^{60}Co	1.7E3	1.5
^{90}Sr + ^{90}Y	2.7E2	2.7
^{137}Cs	6.8E2	2.6

Table 9. *Authorized specific activity of radionuclides in soil under condition of general industrial use of STS territory, Bq/kg*

Radio-nuclide	Scenario 1		Scenario 2	
	Thickness of contaminated soil layer		Thickness of contaminated soil layer	
	0.10 m	1.0 m	0.10 m	1.0 m
^{60}Co	1.2E+03	9.1E+02	9.1E+03	1.2E+04
^{90}Sr+^{90}Y	3.7E+05	3.2E+05	4.0E+06	3.7E+06
^{134}Cs	2.0E+03	1.6E+03	1.8E+04	2.0E+04
^{137}Cs	5.3E+03	4.2E+03	4.8E+04	5.3E+04
^{152}Eu	2.2E+03	1.8E+03	1.8E+04	2.2E+04
^{154}Eu	2.4E+03	1.9E+03	2.0E+04	2.4E+04
^{238}Pu	9.1E+03	8.3E+03	9.1E+04	4.8E+04
^{239}Pu	8.3E+03	8.3E+03	8.3E+04	4.5E+04
^{240}Pu	8.3E+03	8.3E+03	8.3E+04	4.5E+04
^{241}Pu	4.8E+05	4.8E+05	4.8E+06	2.5E+06
^{241}Am	1.0E+04	1.0E+04	1.0E+05	5.3E+04

Table 10. *Authorized specific activity of radionuclides in soil during STS conversion, Bq/kg*

Radionuclide	Controlled access area (A group work there)		Uncontrolled area (B group work there)	
	Thickness of contaminated soil layer		Thickness of contaminated soil layer	
	0.10 m	1.0 m	0.10 m	1.0 m
^{60}Co	5.6E+03	3.8E+03	1.1E+03	1.6E+03
$^{90}Sr+^{90}Y$	2.9E+06	2.3E+06	6.6E+05	8.3E+05
^{134}Cs	9.9E+03	7.1E+03	2.0E+03	2.8E+03
^{137}Cs	2.2E+04	1.6E+04	4.5E+03	6.3E+03
^{238}Pu	2.3E+06	2.3E+06	6.4E+05	6.4E+05
^{239}Pu	3.0E+06	3.0E+06	8.4E+05	8.4E+05
^{240}Pu	3.0E+06	3.0E+06	8.5E+05	8.5E+05
^{241}Pu	3.0E+08	3.0E+08	8.4E+07	8.4E+07

Table 11. *Authorized specific activity of radionuclides in deep soil layers*

Radionuclide	Authorized specific activity, Bq/kg
^{137}Cs	9.1E+05
^{60}Co	2.8E+05
^{154}Eu	4.7E+05
^{90}Sr	6.4E+05
^{238}Pu	7.3E+07
^{239}Pu	1.3E+08
^{240}Pu	8.1E+07
^{241}Pu	7.5E+07
^{241}Am	1.3E+07

4.2.3 Guidelines «Arrangement of the environmental radiation monitoring in the operational area of the Federal state unitary enterprise "Northern federal enterprise for radioactive waste management" of the Federal Atomic Energy Agency»

The Guidelines developed for STS is based on research radiation and hygienic monitoring defined as a system of overall dynamic observation, including long-term permanent control both of radiation hygienic situation parameters and doses of the public living nearby STS radiation hazardous facilities.

This document regulates sanitary epidemiological and organizational requirements for organization of radiation hygienic control and monitoring of radioactive environmental contamination within health protection zones and supervised areas, resulted from the past and current STS industrial activity with the purpose of radiation protection assurance for the public and environment falling into the area of SevRAO nuclear and radiation hazardous facility impacts.

It establishes the requirements for arrangement of radiation hygienic monitoring (selection of observation points, determination of parameters under control, frequency and extent of control) in the following situations:

- under condition of routine SNF&RW STS operation;
- in the course of STS remediation including SNF&RW removal;
- in case of radiological accident.

The Guidelines are intended for specialists of FMBA territorial bodies and centers of hygiene and epidemiology responsible for supervision (control) over occupational and public radiation protection in SNF&RW STS impact areas.

The Guidelines contain the following sections:

1. Scope
2. Regulative references
3. Terms and definitions
4. General provisions
5. Arrangement of radiation monitoring in health protection zone and supervised area at routine operation of SNF&RW STS, including:
   - Main requirements for HPZ and SA of SNF&RW STS;
   - Selection of radiation situation check points in HPZ and in SA;
   - Necessary controlled radiation parameters;
   - Requirements for implementation of environmental radiation control and monitoring. Extent and frequency of examination.
6. Arrangement of radiation control during SNF&RW removal from the STS area, including:
   - Selection of radiation situation check points during SNF&RW removal from the STS area;
   - Selection of controlled radiation parameters;
   - Requirements for the environmental radiation control and monitoring performance during SNF&RW removal from STS territory. The extent and frequency of examination;
   - Statistic treatment of the results.
7. Arrangement of control during radiological accidents
8. Public effective dose assessment, including:
   - Public effective dose assessment during STS routine operation;
   - Effective dose assessment within HPZ and SA during SNF&RW discharge;
   - Current dose assessment after the accident on the base of radiation control results.

Annex A (reference). Sample mass calculation with the purpose of analysis

Annex B (reference). Public effective dose assessment at routine STS operation

Annex C (reference). Effective dose assessment for the personal group B and for the public in HPZ and in SA of STS during SNF&RW discharge

Annex D (reference). References.

Conclusions within the project

1. In the course of Task 1 of the Project accomplishment, the report «Development of radioecological criteria for monitoring and control of the marine environment during remediation of the sites of temporary storage taking account possible end-state objectives. Task 1 – Project planning. Analysis of the Russian regulative documents and international recommendations on ecological regulation» has been made.
2. In the course of Task 2 accomplishment:
   - the final report «Development of radioecological criteria for monitoring and control of the marine environment during remediation of the sites of temporary storage taking account possible end-state objectives» has been made;
   - the database on radionuclide contents in the marine media has been developed;
   - the guidelines «Arrangement of the environmental radiation monitoring in the operational area of the Federal state unitary enterprise "Northern federal enterprise for radioactive waste management" of the Federal Atomic Energy Agency» have been developed and approved in FMBA of Russia.

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5 Development of the operational radiological and medical criteria to initiate an emergency plan and apply early protective actions at the SevRAO facilities

To develop operational radiological and medical criteria to initiate an emergency plan and apply early protective actions at the SevRAO facilities at the early and intermediate phases of an emergency, the following two tasks were determined.

Task 1. Project planning. Analysis of national and international approaches related to estimation of operational radiological and medical criteria at the early phase of an emergency.

Task 2. Development and submission for approval of operational radiological and medical criteria related to decision-making support taking into account the specific of potential radiological and medical hazards in case of emergencies at the SevRAO facilities

5.1 Analysis of national and international approaches related to estimation of operational radiological and medical criteria at the early phase of an emergency

In the framework of this task the following subtasks were determined:

- Subtask 5.1.1. Preparation and presentation of a detailed project plan, review by all participants and finalization, accounting for review comments.
- Subtask 5.1.2. Analysis of international approaches and experience concerning assessing and application of operational radiological and medical criteria at the early phase of an emergency.
- Subtask 5.1.3. Comparative analysis of national versus international approaches and experience concerning assessing and application of operational radiological and medical criteria at the early phase of an emergency.

Experience from response to recent nuclear and radiological emergencies has clearly demonstrated the importance of an efficient response system that includes, among other components, emergency plans, procedures, and internally consistent operational criteria. An analysis of lessons identified from recent responses has shown that a lack of crucial components in the emergency response system could result in major radiological and non-radiological consequences at the national level. It is worth noting that national response arrangements that are incompatible among countries can result in major mistrust by the public. It is considered important to have internationally agreed criteria and guidance for emergency response established in advance of an emergency.

Recommendations for provision the response to nuclear or radiological emergency are given in many international publications [1-20]. In the recent publications [1, 8, 14, 20] advanced recommendations based on a rigorous examination of the response to past emergencies and lessons derived were prepared. In the recently issued Fundamental Safety Principles [20] of ten fundamental safety principles, two are directly dealing with the radiation accidents, namely, Principle 8: Prevention of accidents. All practical efforts must be made to prevent and mitigate nuclear or radiation accidents, and Principle 9: Emergency preparedness and response Arrangements must be made for emergency preparedness and response for nuclear or radiation incidents.

Analysis of requirements and guidance prepared by IAEA related to assessment and application of operational radiological and medical criteria at the early phase of an emergency has been done with regard to the following sections:

- public criteria framework
- emergency workers' criteria framework
- secondary emergency response criteria

Upon consideration of the above sections we made our comments and suggestions on the considered documents from the point of view of their internal logicality, completeness, and pragmatic value.

Under comparison of the Russian regulatory documents and the IAEA standards and requirements similarities have been noted with respect to identification of the primary objectives of protection and safety in case of nuclear or radiological emergency; the practical goals of emergency response; the dose levels at which intervention is expected to be undertaken under any circumstances; requirements to the facilities related to different threat categories. However, criteria on averted dose for the public, dosage of the stable iodine, and the permissible dose levels for emergency workers in case of life-saving actions are somewhat different.

Comparison of the IAEA standards and requirements and the main Russian regulatory documents on radiation safety with respect to emergency preparedness and response within the context of estimation of radiological and medical criteria at the early phase of an emergency is given in Table 12.

Table 12. *Comparison of the IAEA standards and requirements and the Russian regulatory documents [21, 22] on radiation safety with respect to emergency preparedness and response within the context of estimation of radiological and medical criteria at the early phase of an emergency*

Contents
Similarities between the IAEA standards and requirements and the Russian regulatory documents
The primary objectives of protection and safety in case of nuclear or radiological emergency (to prevent the occurrence of deterministic effects in individuals … and reduce of the occurrence of stochastic effects in the population …).
The primary objective for nuclear installations in case of emergency (to take all reasonably practical measures to prevent accidents in nuclear installations and to mitigate their consequences should they occur…).
The practical goals of emergency response (to regain control of the situation; to prevent or mitigate consequences at the scene; to prevent the occurrence of deterministic health effects in workers and the public; to render first aid and to manage the treatment of radiation injuries, etc.)
The principles of justification, optimization are the same.
Dose levels at which intervention is expected to be undertaken under any circumstances are the same (action levels of dose for acute exposure, projected absorbed dose within 2 days: whole body – 1 Gy, lung – 6 Gy, skin – 3 Gy, thyroid – 5 Gy, foetus – 0.1 Gy, etc.).
Each radiation facility should be specified in a corresponding threat category (five categories are identified by the IAEA and four categories are settled by the Russian regulatory document [22])
In the design documentation for each radiation facility the list of all possible radiation emergencies should be identified. In Russian that list is approved by the State Sanitary-Supervision Bodies.
The emergency plan of radiation protection of the personnel and the population in case of nuclear or radiological emergency should have been elaborated and prepared in advance and all necessary arrangements related to detailed instructions, equipment, medical and technical supplies, etc. should be in properly places.
In case of an emergency the notification should be provided to the authority and public.
Special emergency teams including specialists in radiation protection, medical staff trained to provide medical first aid at the scene of the accident, etc. should be created and properly trained to be prepared for

Contents
an emergency.
Discrepancies **between the IAEA standards and requirements and the Russian regulatory documents**
Public. Intervention and action levels in emergency exposure situations. Dose avertable by the protective action for the public: *Sheltering* IAEA-115 [3]: within two days 10 mSv SRS-99 [21]: within 10 days a whole-body dose of 5 mGy (level A) - 50 mGy (level B) *Temporary evacuation* IAEA-115: within one week 50 mSv SRS-99: within 10 days a whole-body dose of 50 mGy (level A) - 500 mGy (level B) *Iodine prophylaxis* IAEA-115: absorbed dose from radioiodine for children of 100 mGy SRS-99: within 10 days absorbed dose from radioiodine for adults of 250 mGy (level A) - 2500 mGy (level B) for children of 100 mGy (level A) - 1000 mGy (level B)
Public. *Stable iodine prophylaxis* IAEA (WHO [23]) – Protection against inhalation intake SRS-99 – Protection against inhalation and ingestion intake *Recommended dosage of stable iodine* WHO [23] >12 y – 100 mg (equivalent mass of iodine) 3-12 y – 50 mg 1 mo – 3 y – 25 mg <1 mo – 12.5 mg Russia >2 y – 125 mg of KI ≤ 2 y – 40 mg of KI
Emergency workers. IAEA No dose restrictions are recommended for life saving actions if 1) the benefit to others clearly outweighs the rescuer's own risk and 2) the emergency worker can mane an informed decision concerning their risk. No special permission of a Regulatory Authority is required. SRS–99 Excessive planned exposure for emergency workers is allowed only for life-saving actions and/or preventing exposure to people. This excessive planned exposure is restricted with effective dose of 100 mSv after receiving a special permission of a territorial body of the State Sanitary Supervision, and of 200 mSv after receiving a special permission of a federal body of the State Sanitary Supervision. Limitations are relied on the emergency workers concerning past over-exposure and available medical restrictions.

5.2 Development and submission for approval of operational radiological and medical criteria related to decision-making support taking into account the specific of potential radiological and medical hazards in case of emergencies at the SevRAO facilities

In the framework of this task the following subtasks were determined:

Subtask 5.2.1. Development of the set of potential emergencies and the parameters of radiological conditions following those emergencies taking into account available spent nuclear fuel and radioactive wastes, as well as conditions of their storage and actions, planned to be applied to them at the SevRAO facilities.

Subtask 5.2.2. Modelling of the measuring results of radiation monitoring based on the system of monitoring available at the SevRAO facilities and settling the operation radiological criteria in order to provide an adequate emergency response to any emergency from the considered set of potential emergencies.

Subtask 5.2.3. Development of operational radiological criteria to provide decision-making support related to introduction of early protective actions taking into account the considered set of potential emergencies at the SevRAO facilities.

Subtask 5.2.4. Development of methodical capabilities of MSCh-120 and RU-120 to implement radiological and medical criteria to introduce urgent protective actions related to the people involved in radiological emergencies.

In addition, during the implementation of the above subtasks the drafts of two regulatory documents have been prepared:

- A guidance document for radiological and medical criteria for introduction of urgent protective actions;
- Recommendations on the implementation of guidance document for radiological and medical criteria by the emergency teams of MSCh-120 and RU-120 for emergency response.

Operational radiological criteria

IAEA, WHO, and ICRP constantly encourages states "to implement instruments for improving their response…to nuclear and radiological emergencies" and "to participate actively in the process of strengthening international, national and regional capabilities for responding to nuclear and radiological emergencies, and to make those capabilities more consistent and coherent" [1].

Taking into account that the principle of limitation (exposure of radiation workers and individuals of public must not exceed dose limits) is not applicable in radiological emergencies, regulatory authorities should solve the problems of generic optimization and the problems of interaction with operators during case by case optimization.

Activities aimed at preventing and alleviating the consequences of radiological and non-radiological emergencies include provision of emergency preparedness (monitoring of safe operation, emergency planning) as well as emergency response in case of any emergency. Usually, there are three statuses of the system of emergency response depending upon current conditions [24]:

- routine preparedness;
- alert;
- emergency conditions.

The reason to switch the system of emergency response from one status to another is violation of the conditions or the scope of secure work at the radiation-hazard facility, as well as dose criteria for decision making.

At present in order to switch the system of emergency response from usual preparedness to emergency status at the site of temporary storage of RAW and SNIFF at Andreeva Bay there is a numeric criterion if the exposure rate at the storage of RAW, or in working premises, or on-site increases more than a factor of ten. Strictly speaking, this criterion is not based on dose justification, but on the dynamics of radiological conditions. As a matter of fact, it means settling two statuses of the system of emergency response: (1) usual preparedness and (2) emergency conditions. This approach has been approved in the program of laboratory monitoring under radioactive waste management [25], where two statuses of radiological conditions are indicated:

1) normal radiological conditions, when working conditions at the facility are within the safe scope;
2) emergency conditions, when emergency occur.

As a result of the inspection carried out by the specialists of SRC-IBPh in 2005 [26] it was proposed to develop the criteria to identify the conditions of "Alert" and "Emergency conditions" in order to make the emergency plans at the SevRAO facilities more nationally and internationally harmonized.

According to the IAEA general recommendations the framework of emergency response criteria needs to be [14]:

- as simple as possible and as complex as necessary;
- internally consistent (for those who develop the criteria);
- logically consistent when viewed by the public and decision makers (for decision makers).

The last recommendations of the IAEA are based on the following quantities [14]:

- projected dose that may be controlled (managed) by precautionary urgent protective actions;
- ongoing and lasting dose (individual or collective) that may be controlled (managed) by ongoing protective and other actions;
- received dose, the outcome of which may be managed (mitigated) by medical actions, public information or counselling.

In order to determine in advance an appropriate measurable surrogate quantity for the operational criterion, at least three requirements were identified to be met. This surrogate quantity shall be:

- prompt and easily measurable;
- representative;
- important with respect to dose assessment; the quantity shall characterize the leading factor of radiation impact.

Among monitoring parameters listed above, the gamma-exposure rate meets the three requirements (prompt and easily measurable, representative, and important with respect to dose assessment) for the SevRAO facilities. The other monitoring parameters in the early phase of an emergency should be considered as additional quantities.

For the personnel involved in emergency protective actions the main radiation pathways are:

- external exposure from radionuclides deposited on the ground surface;
- internal exposure from inhalation intake of airborne aerosols due to resuspension of radionuclides from the ground surface.

Operational levels to classify the emergency zones under implementation of emergency protective actions settled in [21] are given in Table 13.

Table 13. *Classification of emergency zones under implementation of emergency protective actions*

Zone	Dose criterion. Effective dose, mSv d^{-1}	Operational level. Dose rate of gamma-exposure, mSv h^{-1}
A	$E \leq 7.5 \cdot 10^{-2}$	$P_\gamma \leq 0.01$
B	$7.5 \cdot 10^{-2} < E \leq 50$	$0.01 < P_\gamma \leq 5$
C	$50 < E \leq 200$	$5 < P_\gamma \leq 20$
D	$E > 200$	$P_\gamma > 20$

Under justification of the basic and operational criteria it is necessary to account for the categories of the exposed people in emergency conditions as well as zoning under normal and emergency conditions.

In addition to that zoning, according to regulatory document [27] two zones are identified in the SSZ:

- zone of controlled entrance: working premises where sources of exposures are managed and radiation impact is possible to personnel of category A. Entrance to those working premises should be allowed through radiological checkpoint;
- zone of free entrance – auxiliary rooms and offices, where sources of exposures are mot managed under normal conditions and, as a rule, radiation impact to personnel is excluded.

According to the plan the equivalent dose rate for a normal duration of work of the personnel inside and outside the working rooms, taking into account the conservative factor of two, the following values of the equivalent dose rate have been settled (see Table 14).

It looks reasonable to settle the operational criteria to announce "Alert" different for various zones and for various groups of people based on the main dose limits (see Table 1.3 in SRS-99 [21]) taking into account effective dose:

SSZ - zone of controlled entrance   20 mSv / 1700 h per year = 12 μSv h^{-1} ≈ 10 μSv h^{-1};

SSZ - zone of free entrance   5 mSv / 2,000 h per year = 2.5 μSv h^{-1} ≈ 2 μSv h^{-1};

At the borderline of SSZ   1 / 0.25mSv / 8,800 h per year = 0.4 μSv h^{-1} ≈ 0.5 μSv h^{-1}.

(here 0.25 is shielding factor).

It is reasonable to settle the operational criteria to announce "Emergency conditions" different for various zones and for various groups of people as follows:

- for personnel of group A on the basis of the criterion for sheltering of 20 mSv during the first day;
- for personnel of group B on the basis of the criterion for sheltering of 5 mSv during the first day;
- for the public on the basis of the level A criterion of 5 mSv during the first 10 days.

Under such suggestions the operational criteria are equal to 1, 0.2, and 0.02 mSv h^{-1}.

Table 14. *The values of equivalent dose rate used for developing radiation protection from external exposure of the personnel under RAW and SNF management.*

Personnel	Rooms and territories	Duration of exposure, h per year	Planned equivalent dose rate, μSv h^{-1}
Group A	Rooms for permanent work of the personnel	1,700	6.0
	Rooms where personnel periodically work	850	12.0
Group B	Rooms in the zone of free entrance at the site	2,000	1.2

Analysis of the scenarios of possible design basis and beyond design basis emergencies showed that the radiological conditions are mainly determined by ^{137}Cs and the leading radiation factor for the public was external gamma-exposure. In case of self-sustained chain-reaction in the first phase of an emergency (during the passage of the radioactive cloud) in addition to external exposure, the internal exposure from inhalation intake of radioactive isotopes of plutonium becomes important. So, such protective action as sheltering (or protection of respiratory system) should be applied in the first phase of an emergency in case of exceeding the criteria on dose in lungs. Inhalation intake has short duration (more than 80% of internal exposure is due to inhalation intake of radionuclides during the passage of the radioactive cloud). At later phases of an emergency the external exposure becomes the leading radiation factor for the public. Introduction of such protective action as evacuation should be based on exceeding the criterion of whole-body dose.

Medical and sanitary criteria

Medical and sanitary assistance for personnel of the serviced enterprise and population in the probable radiation emergencies is one of the most important tasks of Medical Sanitary Unit (MSU) #120 and others medical institutions of FMBA.

The specialized service of the urgent medical aid is created by FMBA for the rendering of the medical aid to victim with the emergencies. Recommendations regarding the conducting therapeutically - evacuation guarantee of victims are developed and published [28, 29].

Rendering of the medical aid to victim is achieved in accordance with the system of the stage treatment of each victim.

The following stages of medical aid to victims in the radiation emergencies have been identified: first medical aid, pre-hospital aid, first physician's aid, qualified and specialized medical aid.

Depending on specific emergency, quantities of victims and structure of radiation injuries, volume of medical aid in each stage, and quantity of stages can change.

Special importance has timely taking of the urgent measures of first medical aid, pre-hospital aid and first physician's aid. In this case the standard problems of medical response with the extraordinary situations are solved:

- the elimination of the factors, which threaten the life of victim at the given moment;
- the fulfilment of the measures, which remove or which decrease the probability of the occurrence of severe complications or development of the disease;
- the fulfilment of the measures, which make it possible to evacuate victims without essential worsening of their state, the correct selection of the evacuation direction.

Standard solutions of the above-indicated problems are provided for the SevRAO facilities:

- the removal of people from the zone of the potential- dangerous action of radiation factors, conducting of sanitary treatment, the use of other methods of the protection of personnel and population from irradiation;
- the application of means of pharmacological protection, early etiotropic treatment of the radiation injures, standard methods of treatment of trauma and burns in cases of combined radiation injuries;
- the guarantee of the evacuation route.

Solution of the problems presented exceeds the scope of usual medical practice, it requires knowledge and habits according to the analysis of the parameters of radiological situation and individual conditions of irradiation of the victims.

In force standards and the rules of radiation safety do not quite fully regulate the order of the medical evacuation guarantee of victims with the radiation emergencies. Especially much vagueness remain in the determination of indications and contra- indications to the application of some invasive procedures for treatment or prophylaxis of radiation injuries with the inhalation, oral and wound entering of radioactive materials.

Medical-sanitary criteria are used as criteria to include an individual (victim or the witness of emergency) in the complex of diagnostic, therapeutic, preventive and rehabilitative actions.

Such actions are described in detail in the protocols of treatment and prophylaxis of radiation injuries, sanitary treatment, dynamic radiation - hygienic observation and the rehabilitation of the victims and the people involved.

It is necessary to say that all the measures pointed out above differ by the tempo of their realization. They include [28]:

- *special* measures – actions, whose immediate fulfilment is necessary for saving the life of the victim. In such cases the direct threat of life represent as the already formed damages (for example, arterial haemorrhage), as well as the continuous evolution of the emergency.
- *urgent* measures - actions, which ensure the maintenance of health or decrease damage of victim's health, although there is no direct danger for the life of victim at the specific moment of time. Their fulfilment must be begun as fast as possible, but in safe (from radiation and other parameters) situation.

The urgent measures include also therapeutic and prophylactic measures in the cases of the planned increased irradiation and in persons, who had above-norm external irradiation or internal entering of radioactive materials.

Both special and urgent measures cannot be put off to the following stage of medical aid [28], but the volume of special and urgent aid in the different stages is distinguished.

- *delayed* measures - actions, whose fulfilment does not have strict time parameters, as a rule, they bear preventive nature, can be required, if victim was situated in the zone of emergency, which has the specific characteristics of radiological situation.

The medical and sanitary criteria of conducting the special, urgent and delayed measures of the medical aid are the basis of the treatment-evacuation guarantee of the persons, implicated in the radiation emergency.

Taking into account medical and sanitary criteria below are formulated:

- principles of medical triage of victims
- indications and contraindications for medical assistance
- the rule of medical and radiation- hygienic observation of the implicated persons

- the order of conducting victims with the inhalation, oral and wound entering of the radioactive materials.

Based on the criteria of medical interference the personnel of the emergency formations of the SevRAO facilities and the medical personal of MSU of FMBA will be able to effectively render first medical, pre-hospital, first physician's and qualified medical aid to victim.

Medical and sanitary criteria developed during the implementation of the project have been realized in two draft regulatory documents:

- A guidance document for radiological and medical criteria for introduction of urgent protective actions;
- Recommendations on the implementation of guidance document for radiological and medical criteria by the emergency teams of MSCh-120 and RU-120 for emergency response.

5.3 Conclusions on the project

Analysis of international (IAEA) and national (Russian) requirements related to assessing and application of operational radiological and medical criteria at the early phase of an emergency has been conducted.

In our opinion some concepts and statements in the IAEA publication are idealistic, for example, the concept of averted dose which is not accepted in actual experience. Another example, the requirement that provision of medical intervention to treat severe deterministic health effects should be solely based on the dose received exceeding the operational criteria looks unrealistic (as a rule this dose is unknown in an acute situation and the status of the casualties is usually assessed on the basis of the national medical triage system).

Anyway, despite some distinctions exist in numerical values of radiological criteria recommended by the IAEA and available in Russia, both systems of operational criteria at the early phase of an emergency are on the whole consistent.

It is important to stress that according to SRS-99 [21] the State Sanitary Supervision Bodies should settle operation intervention levels (doses, dose rates, levels of radioactive contamination) for any facility, taking into account its specific, threat category, possible emergency scenarios, and radiological conditions realized.

Under development of operational radiological and medical criteria to support decision-making accounting for specific of potential radiological and medical threats, the selection of the ambient dose equivalent as an operational radiological criterion for potential emergencies at the SevRAO facilities has been justified. This selection is met to the three requirements: prompt and easily measurable; representative; and important with respect to dose assessment. Numerical values for operational criteria to announce two levels of radiological conditions, to provide emergency zoning, prompt assessment of justification of introducing intervention for radiation protection of the public have been determined.

The requirements on limitation of exposure to the personnel of Group A, accounting for possible application of planned elevated exposure as exceptional cases have been taken into account under emergency zoning.

The values corresponding to low intervention level (level A) given in section 6 in NRB-99 [21] were used as the basis to develop operational criteria for the public.

Accounting for uncertainties in modelling of the dependencies between the basic and operational quantities, we finally rounded the results of calculations up to the values 1-2-5-10. This is consistent with approaches used to justify the dose criteria, dose restrictions, and intervention levels.

The basic purpose of emergency preparedness and medical emergency management is not to allow the appearance of the determined effects and to decrease the probability of the stochastic consequences of the accidental irradiation of the people.

Medical emergency preparedness includes the measures of the medical interference, whose application depends on different dose characteristics. The procedure of medical actions by the emergency service of enterprise and by medical staff of MSU # 120 is determined on the basis of the parameters of the emergency (the situation criteria) and by the individual dose characteristics of victim (dose criteria). For the determination of the dose criteria may be used both data from the service of radiation safety of enterprise and results of medical and hygienic inspection of victims in medical institutions of FMBA (Medical Sanitary Unit # 120, Centre Sanitary Supervision-120, State Research Centre –Institute of Biophysics, Clinical hospital # 6). Obtained data are systematized for each stage of medical aid, also, on the urgency of conducting the procedures.

The most typical erroneous actions of medical personnel with some forecasted situations and states of victims in the different stages of medical aid are described.

The developed criteria are practical management for decision making on medical interference.

The usage of medical and sanitary criteria will make it possible to successfully solve the tasks of emergency medical reaction and to in advance plan the actions of the service of the medical protection of SevRAO facilities and medical institutions of FMBA.

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6 Summary conclusions on the projects completed in 2007

Summarizing materials above we can make the following conclusions.

On Optimisation of exposures during operations (project manager: A V Simakov)

1. Analysis of the system for the radiation situation monitoring and of the system for individual dose monitoring which operate at SevRAO facility No.1 has been performed.

It was shown that now, at the stage of SNF and RW storage:

- existing radiation monitoring system promotes obtaining of comprehensive information about radiation situation conditions in the main industrial areas; this system complies with OSPORB-99 and NRB-99 requirements;
- existing PDM system promotes obtaining of comprehensive information about occupational doses; this system also complies with regulative requirements.

2. When going on to full-scale construction works and commissioning of the Combines for SNF and RW management, amount of radiation hazardous operations will increase considerably. In order to implement an optimization principle, under these conditions, the radiation monitoring system is reasonable to be enhanced, focusing on increasing monitoring extent and full-scale introduction of ASKRO system – depending upon established engineering procedure of work implementation.
3. When improving PDM system, special attention shall be paid to:
    - enhancement of personal dosimetry method with respect to external beta exposure to the skin;
    - introduction of emergency neutron dosimetry;
    - turn to application of thermo-luminescent dosimeters to assess external gamma doses;
    - introduction of radionuclide intake assessment method in terms of the radionuclide activity concentrations in air of working area.
4. In order to manage and to perform actions aimed at the optimization principle implementation, the requirements of the Guidelines MU 2.6.5.0.-08 developed within the present project and aimed at ALARA strategy introduction into SevRAO Facility No.1 practice must be observed.

On VLLW management (project manager: V G Barchukov)

1. The Russian sanitary legislation envisages availability of the waste category, which complies with international practice and corresponds to the very low level waste (VLLW) category.
2. To put terminology of Russian regulative basis into compliance with the international one, industrial waste containing man-made radionuclides with specific activity levels lower than LLW, but higher the level of exemption from radiation control, are reasonable to separate into the category of "very low level waste" (VLLW).
3. OSPORB-99 Para.3.11 defines the main criteria specifying the bound values for this waste category (specific activity levels). In respect to SevRAO conditions the level of clearance from the radiation control is 0.3 kBq/kg, but that VLLW specific activity level must be less than 12 kBq/kg on average, while with the purpose of the containment barrier justification, average values of specific activity may reach 30 kBq/kg, and in some packages – up to 100 kBq/kg.
4. The public risk after the landfill closure must be less than 10^{-6}; 10 μSv/year public effective dose assures this value. The public risk is being maintained at less than10^{-6} level when dose increases up to 20 μSv/year according to current assumptions for risk per unit dose

5. VLLW landfill safety during the post-operational period is being defined by the most acceptable scenario of its use after completion of the relevant investigations and its coordination with the supervision bodies according to the established procedure.

On criteria for monitoring and control of the arine environment (project manager: N K Shandala)

1. A database has been developed on radionuclide contents in the marine environmental media. This database is stored in the special data manager software Access. The database includes a set of inter-connected tables containing the following information:
   - sampling points;
   - marine environmental media;
   - radionuclides under control;
   - specific activities of radionuclides in the marine environmental media;
   - methods of sample treatment and measurement procedures;
   - organizations performed measurements.

The database includes verified information on radionuclide activities in the marine media from different literature sources. Protocols of sampling and of sample measurements in respect to the marine environmental media have been developed.

2. On the base of dose criteria and remediation regulations for STS sites and facilities, derived levels had been developed of marine and terrestrial environmental contamination in a form of:
   - specific activity of radionuclides in soil (residual activity);
   - specific activity of radionuclides in bottom sediments;
   - activity concentration of radionuclides in seawater.

The derived criteria will permit to control the observance of established hygienic regulations of remediation in terms of results of radiation control and monitoring.

3. Official guidelines have been developed, which regulate sanitary epidemiological and organizational requirements for organization of radiation hygienic control and monitoring of environmental media radioactive contamination within health protection zones and supervised areas of STS (selection of observation points, determination of parameters under control, frequency and extent of control) in the following situations:
   - under condition of routine SNF&RW STS operation;
   - in the course of STS remediation including SNF&RW removal;
   - in case of radiological accident.

The research radiation hygienic monitoring serves as the methodological base of the developed document. This monitoring is being defined as a system of overall dynamic observation, which includes long-term permanent control both of parameters of the radiation hygienic situation and of doses to the public living nearby radiation hazardous STS facility locations.

On criteria for implementation of emergency plan and early response actions (project manager: M N Savkin)

1. Based on the analysis of international (IAEA) and national (Russian) requirements related to assessing and application of operational radiological and medical criteria at the early phase of an emergency some distinguishes have been identified. However, they are not principal a conclusion

can be done that the both systems of operational criteria at the early phase of an emergency recommended by IAEA and used in Russia as a whole are consistent.

2. The ambient dose equivalent has been selected as an operational radiological criterion to support decision-making accounting for specific of potential radiological and medical threats at the SevRAO facilities. This selection is met to the three requirements: prompt and easily measurable; representative; and important with respect to dose assessment. Numerical values for operational criteria to announce two levels of radiological conditions, to provide emergency zoning, prompt assessment of justification of introducing intervention for radiation protection of the public have been determined. The values corresponding to low intervention level given in section 6 in NRB-99 were used as the basis to develop operational criteria for the public.

3. The data from the service of radiation safety of enterprise and results of medical and hygienic inspection of victims in medical institutions of FMBA (Medical Sanitary Unit # 120, Centre Sanitary Supervision-120, State Research Centre –Institute of Biophysics, Clinical hospital # 6) have been used as the basis for development of medical criteria. Obtained data are systematized for each stage of medical aid, also, on the urgency of conducting the procedures. The most typical erroneous actions of medical personnel with some forecasted situations and states of victims in the different stages of medical aid are described. The developed criteria are practical management for decision making on medical interference. Usage of medical and sanitary criteria will make it possible to successfully solve the tasks of emergency medical response and to preparedness planning the actions of the service of the medical protection of SevRAO facilities and medical institutions of FMBA.

7 NATO workshop on “Challenges in Radiation Protection and Nuclear Safety Regulation of the Nuclear Legacy“

Introduction

NATO Advanced Research Workshop took place in September 25-27, 2007 in Moscow on **Challenges in Radiation Protection and Nuclear Safety Regulation of the Nuclear Legacy.** This was a second workshop organised by Norwegian Radiation Protection Authority (NRPA) and russian regulators. First one on **Radiation and Environmental Safety in North-West Russia and Related Use of Impact Assessment and Risk Estimation**[1] was organised by (NRPA) and Rostechnadzor. A variety of conclusions was drawn about the need for improvements in environmental risk assessment and related regulations and regulatory guidance necessary for effective and efficient supervision of nuclear legacy sites. Accordingly, a range of activities has been progressed by a number of Russian and overseas organisations which specifically address activities for remediation of SevRAO operated sites in northwest Russia. Significant among these has been the regulatory cooperation program between the NRPA and the Federal Medical Biological Agency (FMBA) of Russia.

Taking account of these developments, a further NATO workshop was held in September 2007 under the Security Through Science framework to consider the current challenges in radiation protection and nuclear safety regulation of the nuclear legacy. The overall objective was to share East-West competence and experience in regulatory work associated with radiation protection and nuclear safety supervision of installations built during the cold war, particularly in relation to regulatory strategies for safe decommissioning of unique or unusual nuclear facilities and remediation activities.

Participation

There were over 60 participants from 8 countries as well as representatives from the International Commission on Radiological Protection, the International Atomic Energy Agency and NATO. The organisations involved included regulatory authorities, operators and technical support organizations. This wide level of participation reflects the importance placed upon international cooperation on nuclear legacy management issues.

Presentations and Papers

The workshop programme was organized under the following session headings:

Session I: Nuclear Legacy Challenges

Session II: Regulatory Implementation of Treaties, Standards and Recommendations

Session III: Challenges in Practical Implementation of Remediation Strategy in Russia and Abroad

Session IV: Safety Regulation Experience in Russia and Abroad

All presentations will be published in 2008 as NATO Security Through Science (STS) Series with the same title as workshop.

[1] Strand P, Sneve MK, Pechkurov, AV, eds. Radiation and environmental safety in North-West Russia: Use of impact assessments and risk estimation. Proceedings of the NATO advanced research workshop, Moscow, Russia 8-10 December 2004. NATO Security Through Science (STS) Series - C: Environmental Security. Dordrecht: Springer, 2006.

Overall Conclusions

From the presentations and discussions it can be concluded that the Russian standards are generally consistent with international recommendations, but that there is scope for continuing improvement of regulatory processes and procedures, as well as the need for more appropriate norms and standards to manage special situations.In part these needs and observations arise because of the unusual conditions at SevRAO sites, but they also arise at other Russian sites and in similar sites in other countries, so that continuing cooperation can be useful in a wider Russian context and in other countries. It may also help international agencies to develop more practically effective recommendations and guidance.

Particular problems arise in the decommissioning of uranium mining and milling facilities, Long term policies for land use, contaminated land management and hazardous and radioactive waste management present easily expressed multiple objectives but they present complex risk management challenges. For example, policy suggests that further legacies should not be created for future generations to manage, but early action may create additional hazards now.

It can also be concluded that the reason for poor conditions at some sites has been the lack of, or poor development of, a broad safety culture involving all workers at all levels in safety management. Interactions at the technical level between relevant organisations do take place, but the structures under which they occur are not very flexible, and the processes for local, regional and federal coordination could be made more effective.

While development work suggested above is clearly to be valued, at the same time, those with the specific responsibility must be ready to provide vigorous supervision of current and planned operational projects in a timely and effective manner.

Regulatory processes must be clear and readily interpreted, so that all partners know what is required. This can be achieved by early prescription of requirements. At the same time, the inherent inflexibility in such an approach can lead to difficulties in managing new information, whether this is about the wastes themselves, the local environment or changes in safety and protection objectives. A suitable balance has to be sought.

While the regulator has to be able to take firm action by the use of sanctions and the courts to correct errors and omissions in on the part of operators, there is also a need to promote and encourage operators to come forward with recognition of possible past failures. Good behaviour should be rewarded.

An important question was raised concerning how to organize interfaces among interest groups concerned with legacy management:

- Scientific and technical evaluation – different scientific and engineering disciplines
- Regulatory approach – inter-regulatory cooperation on safety, human health and environmental protection
- Practical solution – operators, waste producers and waste managers
- Political situation – politicians, local and regional representation
- Public acceptance – local and regional public interest groups

There is a need for an efficient process for:

- working together
- managing information flow
- getting the balance right in multi-attribute problem assessment, while
- not forgetting the separate responsibilities of each interest group,
- and not using complexity as an excuse to do nothing.

A proposed starting point, suggested by the Environment Agency of England and Wales (EA), is to adopt an agreed set of principles. The intention is that all involved have shared objectives and the early dialogue reduces the chance of having to make corrections and changes later. Furthermore, to achieve the best environmental results, the EA traditional regulatory activity such as licensing, compliance assessment and enforcement, has needed to be supplemented with partnership working and regulatory advice and influence.

Recommendations

The Russian Federation has responsibility to manage its own nuclear legacy. But it is also one of several countries in the global network of nuclear activities. Harmonisation of approaches is valuable in building future cooperation, but local conditions may influence the best local solution. Accordingly, future exchanges, such as those provided for by this workshop, should be encouraged.

Development of a broader and deeper safety culture should be a long term objective, while at the same time maintaining the highest standards of radiation protection and nuclear safety as possible.

There are many complex issues to be addressed and they cannot all be solved at once. Clear recognition of the major threats, as well as weakness in regulatory processes, can be useful in directing future resources. However, at this stage it is clear that there are specific regulatory issues to address with respect to regulatory requirements and guidance for nuclear legacy sites concerning:

- site remediation,
- waste forms for long term storage and disposal, and
- disposal facilities.

In turn, such work is dependent on better radioactive waste and contamination characterisation, as well as site characterization information.

Such guidance needs to be thoroughly based on the best use of scientific and technical information. At the same time, part of the solution relates to policy issues and value judgements, and so broader interaction among regulators, operators and other stakeholders is to be encouraged.

8 Perspectives of future regulatory cooperation between NRPA and FMBA of Russia

The regulatory documents developed in 2007, solved a number of important radiation protection problems in improvement of supervision functions of FMBA of Russia at SevRAO. Nevertheless, a number of challenges remain., These include:

- development of a database for supervision of radiation monitoring performance and of the occupational exposure;
- overall application of ALARA principle introduction at SevRAO, including arrangement of work during RW management at SevRAO facility No.3 (Saigda Bay);
- development of monitoring following system of environmental contamination; and
- performance of the emergency exercise under condition of participation of RD and CH&E 120 at SevRAO facility No.2 (Gremikha).

To solve the mentioned problems, four projects are planned to be implemented in 2008-2009.

The first task of all contracts will be devoted to planning and elaboration of the adequate quality assurance during project implementation. The following sections describe the substantive work programmes for each project.

8.1 Databases on radiation situation and on individual occupational doses at SevRAO facilities

As continuation of investigations accomplished in 2005-2007, the database is planned to be arranged on the radiation situation on the industrial site and in workshops of SevRAO facility No.1 (2008), and in 2009 – arrangement of the database of individual doses of external and internal exposure to workers and to attached persons at SevRAO facilities No.1 and No.2. These developments are aimed at further consistent introduction of the optimization principle of the occupational radiation protection into SevRAO facility practice.

The mapping database (DB) on the radiation situation and the database on individual occupational doses will permit:

- to increase efficiency and quality of operator activity control implemented by the regulatory bodies;
- to increase efficiency and quality of radiation monitoring;
- to visualize results of many-year observation of radiation situation parameters (including gamma dose rate, site contamination with some radionuclides, beta fluence density, air contamination by radioactive aerosols etc.;
- to make prediction of individual occupational doses to plan operations at contaminated sites during construction of infrastructure units on-site STS;
- to make prediction of individual occupational doses with the purpose of the personnel protection optimization during planning SNF&RW management operations using ALARA strategy;
- as necessary, to carry out retrospective restoration of individual occupational dose records;
- in a short period, to select workers to be involved in the particular radiation hazardous operations and in consequence mitigation operations taking account accumulated and predicted doses.

Stages of work:

2008:

- Development of software;
- Visit to SevRAO facility No.1;
- Mapping database arrangement on radiation situation (in interactive mode).

2009:

- Database arrangement on individual internal and external doses of the personnel and of attached employees;
- Continuation of the mapping database filling on the radiation situation at SevRAO facility No.1 with factual data;
- Mapping database arrangement on radiation situation and the database on occupational doses at SevRAO facility No.2 (Gremikha village);
- Preparation of the guidelines for radiation protection regulatory bodies on the application of the developed Databases for optimization of the occupational exposure;
- Preparation of recommendations for operator of the SevRAO facility No 1. on application of the developed Databases for planning and optimization of radiation hazardous operations.

Since 2010, similar work is reasonable to extend to SevRAO facility No.3 (Sajda bay) and to DalRAO facilities.

8.2 Requirements for Assurance of Technology Safety and Protection of Workers, the Public and Environment during Arrangement of Radioactive Waste Management in the Centre of Conditioning and Storage at SevRAO Facility-3

During decommissioning of radiation hazardous facilities, operators deal with large amounts of RW. This problem is currently in special focus at SevRAO facilities, which is the first authority in Russia with special responsibilities for SNF and RW management in the course of radiation-hazardous facilities decommission in the Russian Northwest. To solve this problem, as well as to arrange a system of safe RW treatment and storage, SevRAO facility No.3 in Sajda Bay has been built in Northwest Russia as a Centre for long-term storage, which is an organizational constituent of SevRAO as its facility No.3 in Sajda Bay. In addition to single units of the reactor compartments, RW generated and accumulated at SNF and RW STS in Andreeva Bay and in Gremikha village, RW from all radiation hazardous facilities of the Russian Northwest are planned to be conveyed to this Centre. This defines the necessity of development of acceptable safety criteria; work organization at this facility is also significant during conditioning and storage of all types of Low Level Radioactive Waste (LLW) and Intermediate Level Radioactive Waste (ILW).

The objective of this project is to develop the regulatory requirements for assurance of technology safety and human protection during planning and implementation of radioactive waste management in the Centre of conditioning and long-term storage of radioactive wastes at SevRAO facility No.3 (CLS). This objective will be reached by FMBC specialists jointly with experts from DSS NRS RF MoD.

To reach this goal preliminary assessment of radiological threats is to be conducted during design and construction of the Centre of decommissioning at SevRAO facility-3 (Sajda Bay) (CUS). With this purpose, existing uncertainties are to be identified and analyzed when arranging operations of conditioning and long-term storage of RW being accepted from radiation hazardous facilities of the northwest Russia. Threats resulted from the absence of the particular requirements for safe RW management in CUS must be evaluated and containment barriers are to be subjected to analysis having in mind the RW long-term storage.

Taking into account that the CUS design is planned to be implemented by German organizations, it is reasonable to understand how radiation safety, protection and supervision is being assured in the similar RW storage facility in Lubmin.

Analysis of the German regulative requirements for safe RW management is also necessary, as well as assessment of their applicability for the regional CUS of radioactive wastes at SevRAO facility No.3 (Sajda Bay).

After the preliminary threat assessment, a plan is to analyze RW accepted for long-term storage in CUS at the CLS in Sajda Bay. These data will be resulted from analysis of the design materials of the III stage (CUS), studying of factual materials on operation of the Sajda CDL I and II stages, and examination of the special features both of the industrial and environmental radiation situation generation, and occupational and public doses. Special features of LLW and ILW storage arrangement in the Sajda CUS of SevRAO facility No.3 will be identified and the principal requirements for safety of technologies and for human protection during RW CLS (SevRAO facility No.3) decommissioning and release from radiation control will be elaborated.

The identified uncertainties and found special features of the CUS of SevRAO facility No.3 together with the regulatory criteria and safety requirements being developed on their base will be presented in the elaborated guidance «Requirements for Assurance of Technology Safety and Protection of Workers, the Public and Environment during Arrangement of Radioactive Waste Management in the Centre of Conditioning and Storage at SevRAO Facility-3».

8.3 Computer Map Development of Radioecological Data on the Site of SNF and RW Temporary Storage in Andreeva Bay

At the present time, operator (SevRAO) performs some urgent operations at the site of temporary storage (STS) of SNF&RW in Andreeva bay under conditions of degradation of containment barriers at STS. These operations are aimed at putting the site and hazardous buildings into adequate regulative conditions. Radioecological situation at STS changes following such operations.

The main idea of the project is to integrate all relevant radioecological data, i.e. radiation situation parameters, landscape information, and hydro geological as well as geochemical data, within maps of the STS area in Andreeva Bay. As a result, a geoinformation system will be developed. This will allow us:

- To perform detailed analysis of the current radioecological situation at STS,
- To simulate and predict possible change of radioecological situation,
- To optimize the extent of radiation monitoring and methods of remedial work implementation.

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

The output materials, including geoinformation system, are intended for regulatory authorities in order to maintain supervision and control, as well as for persons involved in management of the spent nuclear fuel and radioactive waste, and remediation of SevRAO facility sites.

8.4 Preparation and conducting the emergency training on the radiation protection of the personnel of the Ostrovnoy Branch of SevRAO and the population of Gremikha village

During 2005-2007 two projects on “Improvement of medical and radiological aspects of emergency preparedness and response at SevRAO facilities” and “Development of the operational radiological and medical criteria to initiate an emergency plan and apply early protective actions at the SevRAO facilities” were fulfilled by the specialists of the SRC-IBPh in collaboration with the specialists from NRPA. Those projects have already resulted in improved medical emergency preparedness at the

SevRAO facilities at Andreeva Bay. In order to introduce into practice the regulatory requirements and recommendations, an emergency training at the site of temporary storage of SNF and RAW at Andreeva Bay was conducted in 2006. Most attention was paid to the medical aspects of emergency response – to provide first medical aid to injured people. The necessity was identified to develop operational radiological and medical criteria harmonized with the approaches by IAEA, WHO, etc. in order to initiate an emergency plan at SevRAO facilities and to apply medical and radiological protective actions in the most consistent and comprehensive manner.

It is logical to continue the improvement of emergency regulation by preparing and conducting emergency training aimed at radiation protection of the public and the personnel at the Ostrovnoy Branch of SevRAO, accounting for new requirements and criteria. The Ostrovnoy Branch of SevRAO is important and specific object for such training due to geographical features of its location with respect to nearest settlement and territorial agencies of FMBA of Russia.

The primary objective of this project is to prepare and conduct the emergency training on elaboration of decision-making and application of preventive actions on radiation protection of the personnel of the Ostrovnoy Branch of SevRAO and the population of Gremikha village.

The main project activities planned include:

- *Analysis of the current status of emergency preparedness, notification and possibilities for implementation of countermeasures with regard to the public and the personnel of the SevRAO facilities (Gremikha)*
- *Development and improvement of the system of emergency response regarding emergency preparedness, as well as preparedness of emergency teams and managing bodies*
- *Development and carrying out of an emergency training exercise at Ostrovnoy Branch of SevRAO*

Annex 1 Personal dose monitoring of occupational exposure at SevRAO facility No. 1

State system of sanitary and epidemiological regulation of Russian Federation

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2.6.5. NUCLEAR POWER ENGINEERING AND INDUSTRY

Personal dose monitoring of occupational exposure at SevRAO facility No.1

Guidelines

MU 2.6.5. 6 - 08

Legal edition

Moscow 2008

1. The Guidelines «Personal Dose Monitoring of the Occupational Exposure at SevRAO Facility No.1». – M., Federal Medical-Biological Agency, 2008.
2. The Guidelines have been developed: FSUE «State Research Centre – Institute of Biophysics of FMBA of Russia: YuV Abramov, AV Simakov (leader of work), SV Stepanov, AG Tsovianov.
3. The Guidelines have been recommended for approval by the sub-commission for the special regulation of the Federal Medical-Biological Agency of Russia (protocol No.1 45, 2008).
4. The Guidelines have been approved by the Deputy Head of the Federal medical-biological agency of Russia, the State Chief medical officer on sites and facilities serviced VV Romanov.
5. The Guidelines have been introduced since 1 March 2008.
6. The Guidelines are being introduced firstly.

УТВЕРЖДАЮ
Approved

Заместитель руководителя
Федерального медико-биологического
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территориям

_______________ В.В. Романов

"24" ~~~~~ 2008 г.

Data of enforcement: since 1 March 2008

2.6.5. NUCLEAR POWER ENGINEERING AND INDUSTRY

PERSONAL DOSE MONITORING OF OCCUPATIONAL EXPOSURE AT SEVRAO FACILITY NO.1

MU 2.6.5. 6 - 08

1 Scope

1.1 The Guidelines «Personal dose monitoring of the occupational exposure at SevRAO facility No.1» (hereinafter referred to as MU) are intended for application in the course of the dose monitoring system arrangement at SevRAO facility No.1 under regulated conditions of work using sources of ionizing radiation.

1.2 MU are intended for application by the federal authority responsible for the sanitary and epidemiological supervision and by the Radiation safety division of SevRAO facility No.1, operation of which is arranged in compliance with the accreditation scope using both accepted equipment and certified techniques.

1.3 MU have been developed under requirements of NRB-99, OSPORB-99, MU 2.6.1.16-2000, MU 2.6.1.25-2000 and MU 2.6.1.26-2000 and they establish the procedure of planning, arrangement and implementation of the occupational dose monitoring due to regulated man-made exposure of radiation sources.

1.4 Any methodic, instructive and guidance documents in the field of radiation monitoring system arrangement at SevRAO facility No.1 must comply with the provisions of the present MU.

1.5 MU can be amended only under agreement of the RF Federal medical-biological agency (hereinafter referred to as FMBA of Russia).

2 Regulative references

The Guidelines have been developed on the base of and accounting the following regulative and guidance documents:

Federal Law on "Nuclear Energy Use" No.170-FZ of 21.11. 95;

Federal Law on "Radiation Protection of the Public" No.1 3-FZ of 09.01.96;

Federal Law on "Sanitary and Epidemiological Prosperity of the Public" No.1 52-FZ of 30.03.99;

Radiation Safety Standards (NRB-99). SP 2.6.1.758-99;

Main Sanitary Rules of Radiation Safety Assurance (OSPORB-99). SP 2.6.1.799-99;

Hygienic Requirements for Design of Facilities and Installations in Nuclear Power Industry (SPP PUAP-03). SanPiN 2.6.1. 07 – 03

3 Terms and definitions

Source of ionizing radiation - (within the present document - radiation source) radioactive substance or facility, emitting or able to emit ionizing radiation, falling into the scope of NRB-99 and OSPORB-99 (section «Terms and definitions» of OSPORB, Para 28.);

Radiation monitoring – receiving of information about radiation situation at the enterprise, in the environment, as well as about individual's exposure levels (includes dose and radiometry monitoring);

Personnel "A" group - persons involved into operations using man-made radiation sources;

Personnel "B" group - persons working at the radiation facility or on-site its health protection zone and falling (according to their conditions of work) into the area of man-made radiation source impact.

4 General provisions

4.1. MU is aimed at improving and enhancement of reliability of the occupational dose determination having in mind implementation of the optimization principle with respect to radiation protection of workers during radiation hazardous operations of SNF and RW management.

4.2 Dose monitoring under regulated conditions of work using radiation sources is performed with the purpose of reliable determination of:

- individual effective doses of external and internal occupational exposure;
- individual equivalent doses of external exposure to some organs.

4.3 Subjects of monitoring are individual effective doses, as well as equivalent doses to the skin, hands, feet, and to the lens of the eye for the personnel "A" and "B" groups. Dose monitoring of the bottom abdomen surface is also introduced for female personnel "A" group, up to 45 years old.

4.4 The facility administration makes a list of persons ascribed to the personnel "A" group under agreement with the federal authority responsible for the sanitary and epidemiological supervision.

4.5 The attached persons not employed to SevRAO and involved into some operations performed in radiation hazardous areas are subjected to dose monitoring; after termination of this work, as necessary, they can receive the certificate illustrating the incurred dose to submit this certificate to the place of permanent work.

5 Monitoring of external exposure

5.1 Personal dose monitoring for the controlled groups of workers

5.1.1 The following techniques are applied for dose monitoring of external occupational exposure:

- personal dose monitoring (PDM) , involving determination of individual occupational doses based on consecutive measurements of individual characteristics of whole body, skin, hand/feet and lens of eye exposure of workers from the personnel "A" group; these measurements are conducted using individual dosimeters during the specific control period.
- group dose monitoring (GDM) involving determination of individual occupational doses based on consecutive measurements of radiation situation characteristics over the specific control period both in workplaces and in some parts of the industrial site taking into account duration of the personnel staying in those workshops and/or at those areas.

5.1.2 Personal dose monitoring of external occupational exposure covers those workers from group "A", whose doses in the workplaces exceed or (according to prediction) can exceed the following levels of monitoring introduction (L_{mi}):

- Annual effective external photon dose - 1 mSv;
- Annual equivalent dose to the lens of the eye - 50 mSv;
- Annual equivalent doses to the skin, hands and feet - 50 mSv;
- Monthly equivalent dose to the surface of the bottom abdomen of up to 45-year women – 0.2 mSv.

GDM is being performed with respect to the rest of the personnel "A" group and for the personnel "B" group.

5.1.3 PDM introduction for the current year is implemented either in terms of the annual GDM results or on the base of temporary PDM results over the previous year provided that excess L_{mi}.

5.1.4 PDM of external photon exposure to the personnel "A" group is performed using individual thermo-luminescent dosimeters (TLD) (1 g/cm^2 thick tissue-equivalent body), carrying on the chest. During management of both SNF and high level RW, reading frequency is monthly, while for the personnel of the RW treatment Combine this frequency is quarterly. Indications of such dosimeters define external gamma radiation contribution into total effective dose.

5.1.5 With the purpose of operative monitoring of the shift (daily) whole-body external gamma dose, individual direct reading dosimeters are applied with established threshold of the particular reference level exceeding (DKG AT-2503 type or similar).

5.1.6 Dose monitoring of the occupational external exposure is performed according to the techniques:

- Dose monitoring of the occupational external exposure using the direct reading dosimeters.
- Dose monitoring of the occupational external exposure using the thermo-luminescent dosimeters.

5.1.7 The person on-duty from the radiation safety division distributes dosimeters before the beginning of work and he takes them away after the termination of work. Reading of individual dosimeters, account and registration of occupational external doses is performed:

- under normal (routine) radiation situation – after termination of workday, or a shift;
- during a radiological accident – just after departure from the emergency area.

5.1.8 PDM of equivalent doses to the bottom abdomen is introduced for up to 45-year women. Such monitoring frequency is once in a month.

5.1.9 Monitoring of equivalent doses to the lens of the eye, to the skin and to hands/feet of workers involved into SNF and high level RW management, must be performed using individual dosimeters.

5.1.10 In case of individual dosimeter absence, calculation is permitted of beta equivalent dose to the skin by means of the equation:

$$H_{external} = 3.6 \times 10^6 \times \ \Delta t \times \sum \phi \ (E_R) \times h(E_R)_T^{external} \, , \qquad (5.1)$$

where: t-work time duration, during which personnel stays in the workshop, hours per year;

ϕ (E_R)-average density of R-type particle fluence with E_R energy in the workplace, part/cm^{2}sec (tab 8.2. NRB-99);

$h(E_R)_T^{external}$-equivalent external dose to the organ T per unit fluence of R-type particles with E_R energy at exposure to the parallel beam under face-back geometry (NRB-99 tab 8.2.);

$3{,}6\times10^6$ –transfer coefficient both of hours into sec, and Sv into mSv.

If there are no data on beta-emitter energy, the average density can be calculated using the equation:

$$\phi \ (E_R)=P_{beta}/159.6, \qquad (5.2)$$

where: P_{beta}-contamination with beta-active substances being measured using KRAB-2, KRAB-3, KRBG-1, or KRB-1 type radiometer distr./cm^{2}min;

159.6 - transfer coefficient from distr./cm^{2}min into part./cm^{2}sec..

5.1.11 To evaluate maximum annual equivalent dose both to the lens of the eye, hands, feet, to the skin and to the bottom abdomen, relative coefficients are permitted to be used; such coefficient is a ratio between dose to the particular organ or tissue and dose, which individual dosimeter has registered at the area of chest in the course of annual PDM.

5.1.12 Under regulated conditions of the radiation source management ay SevRAO facility No.1, monitoring of individual neutron dose using personal dosimeters is unreasonable.

5.1.13 Individual external neutron doses during SNF management are calculated as a product of neutron dose rate over the particular period:

$$H = P_n \times t, \quad (5.3)$$

where P_n-neutron dose rate, μSv/h;

t-exposure duration, hour.

DKS-96N neutron dosimeter measures equivalent neutron dose rate.

5.2 Individual dose monitoring by means of group dose monitoring

5.2.1 Group dose monitoring means determination of individual occupational doses based on measurements of ambient external dose equivalent (gamma or neutron) $\dot{H}(10)_i$ (ambient dose rate) either in the workshop or on-site, taking into account duration of worker staying there.

Effective external dose value is calculated using the following the equation:

$$E^{external} = \sum_i \dot{H}(10)_i \times \Delta t_i , \quad (5.4)$$

where Δt_i – duration of worker staying in the i-th workshop over the controlled period (in hours) at the average ambient equivalent dose rate $\dot{H}(10)_i$, μSv/h.

5.2.2 Gamma ambient external dose rate is determined on the base of DTU dosimeter readings. These dosimeters are equipped with DTG-4 detectors from DVG-02T kit and located in workplaces in workshops and in buildings at STS technical area having in mind the exposition time. The group monitoring dosimeters are read after termination of work, while for the shift on-duty and for the armed guard – daily, after termination of duty.

6 Monitoring of internal exposure

6.1 Personal monitoring of internal exposure

6.1.1 Individual internal dose calculation is based on personal monitoring of radionuclide intake, performed using WBC spectrometry kit by means of direct measurements of workers.

6.1.2 Monitoring is performed under standard geometries – «whole body» - determination of ^{137}Cs intake, «Lung» - determination of ^{137}Cs and ^{60}Co intakes, and «Thyroid» - determination of ^{131}I intake. Monitoring is performed according to the following techniques:

- Measurement procedure of man-made radionuclides in human organism using WBC.

  - Calculation of committed effective internal dose.

Monitoring frequency:

- the personnel "A" and "B" groups – annually, at the end of each calendar year;
- the personnel involved into radiation hazardous operations, are subjected to monitoring before and after termination of work.

6.1.3 The results of internal monitoring are registered in the relevant protocol and recorded in the personnel dose cards annually.

6.2 Monitoring of individual internal doses by means of group dose monitoring

6.2.1. Monitoring of individual internal doses by means of group dose monitoring is performed on the base of results of air contamination monitoring in workshops, using the equation:

$$E(\tau)^{гр} = 1{,}4 \times \sum_{U,G} e(\tau)_{U,G}^{внутр} \times \sum_{k} \{Q_{U,G}\}_k \times \Delta t_k \qquad (6.1)$$

where $e(\tau)_{U,G}^{внутр}$ - committed effective internal dose per unit intake of U radionuclide compound, which is ascribed to G type at inhalation (hereinafter referred to as dose coefficient, for short) under standard conditions of internal exposure, *Sv/Bq*;

Δt_k - duration of the personnel staying in the *k*-th workshop (in the *k*-th workplace) during a calendar year (in hours), at the average annual activity concentration $\{Q_{U,G}\}_k$ of G type U compound in the *k*-th workshop (in the *k*-th workplace), *Bq/m*^{3}. If the type of compound is unknown, maximum of $e(\tau)_{U,G}^{внутр}$ values from NRB-99 Annex A-1should be set. As for SevRAO facility No.1,^{137}Cs, ^{90}Sr and ^{60}Co are radionuclides, which must be taken into account in calculation of committed effective internal doses under regulated conditions of radiation source management.

Δt_k values are determined on the base of time study of staying in the workplace (in the workshop).

7 Individual dose registration

7.1 Individual effective dose is a sum of individual external gamma effective doses and individual effective internal dose.

7.2 Doses being determined using individual or group monitoring, are registered in the worker's individual card, if they exceed the record level equal to:

- for annual effective dose – 1 mSv;
- for annual equivalent dose to the lens of the eye – 2 mSv;
- for annual equivalent dose to the skin – 5 mSv.

7.3 Individual external gamma dose over the work shift is registered in the Journal of dosimeter distribution with the further recording in the individual card and in the electronic database of the occupational dose account (individual Dose Card).

Results of personal occupational dose monitoring are stored during 50 years.

A chief of RM section analyses occupational dosimetric costs monthly and informs (in a written form) a chief of the radiation safety division, he also summarizes annually data of the occupational external exposure and submit these data to the chief of the laboratory from the radiation safety division to fulfill individual dose cards of the personnel.

7.4 Individual dose account and their comparison with dose limits are carried out in terms of nominal values without any uncertainties.

Annex 2 Procedure of Radiation Monitoring at FSUE SevRAO Facility No. 1

State system of sanitary and epidemiological regulation of Russian Federation

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2.6.5. NUCLEAR POWER ENGINEERING AND INDUSTRY

PROCEDURE OF RADIATION MONITORING AT FSUE SEVRAO FACILITY NO.1

(General provisions)

Guidelines for monitoring

MUK 2.6.5. 7- 08

Legal edition

Moscow 2008

Procedure of radiation monitoring at SevRAO facility No.1: The Guidelines for monitoring. – M., Federal Medical Biological Agency of Russia, 2008.

1. MUK has been developed: FSUE "State Research Centre – Institute of Biophysics of FMBA of Russia": YuV Abramov, AV Simakov (leader of work), and AG Tsovianov.

2. MUK has been coordinated with the Chief of the Regional Department No.120 of FMBA of Russia VR Alexeeva.

3. MUK has been recommended for approval by the sub-commission for the special regulation of FMBA of Russia (protocol No.1 45, 2008).

4. The Guidelines have been approved by the Deputy Head of the Federal medical-biological agency of Russia, the State Chief medical officer on sites and facilities serviced VV Romanov.

5. The Guidelines have been introduced since 1 March 2008.

6. The Guidelines are being introduced firstly.

УТВЕРЖДАЮ

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“ 24 ” [illegible] 2008 г.

Enforcement date: since 1 March 2008

2.6.5. NUCLEAR POWER ENGINEERING AND INDUSTRY

PROCEDURE OF RADIATION MONITORING AT FSUE SEVRAO FACILITY NO.1

(General provisions)

MUK 2.6.5. 7 - 08

1 Scope

1.1 MUK «Procedure of radiation monitoring at FSUE SevRAO facility No.1» (hereinafter referred to as Procedure) are intended for arrangement of radiation monitoring system in SevRAO facility No.1 under controlled conditions of radiation source operations.

1.2 The Procedure is intended for application by both the federal authority responsible for sanitary epidemiological supervision and radiation safety division of SevRAO facility No.1.

1.3 The Procedure has been developed in compliance with requirements of NRB-99, OSPORB-99, MU 2.6.1.16-2000, MU 2.6.1.25-2000, MU 2.6.1.26-2000 and establishes requirements for planning, arrangement and performance of monitoring relating to occupational dose, radiation situation, and radiation characteristics of industrial wastes under conditions of regulated man-made radiation exposure.

1.4 Radiation safety division (RSD) carries out radiation monitoring within the accreditation scope of the analytical laboratory using adequately accepted instruments and certified methodologies.

2 General provisions

2.1 Radiation monitoring under controlled conditions of radiation source operations is performed in order to determine:

- individual effective external and internal occupational doses;
- individual equivalent external occupational doses to some organs;
- quantitative parameters of radiation situation

with the purpose of subsequent adequacy assessment of actions aimed at radiation source control, which actions assure safe application of the radiation sources in compliance with NRB-99 and OSPORB-99.

2.2 The present document is valid during 5 years. The federal authority responsible for the sanitary epidemiological supervision makes decision relating to the necessity of the Procedure re-edition or amendments of some its paragraphs, provided that either technological process of treatment and storage of radioactive materials was changed or some corrections have been introduced into regulative and guidance documents basic for the present MUK.

3 Monitoring of individual occupational doses

3.1 Monitoring of individual occupational doses at SevRAO facility No.1 is arranges in compliance with requirements of MU 2.6.5. – 08 «Implementation of personal dose monitoring with respect to occupational exposure at SevRAO facility No.1».

3.2 Individual effective doses to the personnel "A" and "B" groups are subjects of monitoring at SevRAO facility No.1. Monitoring of equivalent dose to the surface of bottom abdomen is carried out for up to 45 years old female personnel "A" group.

3.3 The personnel "A" group includes workers, whose occupation is connected with permanent or temporary application of radiation sources (RS) regulated by NRB-99 and OSPORB-99.

3.4 The personnel "B" group includes workers, whose occupation is not directly connected with RS application, but these workers fall into the area of RS impact.

3.5 Persons, who are not employees of SevRAO facility No.1 and staying at radiation hazardous workplaces for a short period, are subjected to dose monitoring; after the termination of this period, they get a document indicating the incurred dose, to register at the place of their permanent employment.

3.6 The administration of SevRAO facility No.1 makes listings of occupations and posts, workers of which are ascribed to the personnel "A" and "B" groups and updates these listings as necessary. These listings serve as a basis for annual lists of the personnel group "A" and "B". In addition, programs are made of both manufacturing inspection of radiation factors and industrial environmental monitoring within the industrial site and adjacent area.

3.7 Monitoring frequency and a listing of equipment applied are given in «The Program of Radiation Monitoring in Organization and Technical Zones of FSUE SevRAO Facility in Zaozersk city» and «The Program of Laboratory Control of the Environment and of Internal Occupational Exposure».

4 Radiation situation monitoring in workshops and on the industrial site

4.1 Radiation situation monitoring is carried out in compliance with «The Program of radiation monitoring in organization and technical zones of FSUE SevRAO facility No.1» and "Program of laboratory control during RW management".

4.2 The following indexes are subjected to monitoring:

Table 1. *Listing of the monitored subjects and controlled indexes*

No.1	Name of monitored subjects	Controlled index
1.	Workshops, rooms, buildings and constructions located on the industrial site	- gamma dose rate; - β-fluence density; - superficial contamination with α- and β-active substances; - neutron dose rate (SNF storage facilities); - aerosol activity concentrations in air; - aerosol nuclide composition.
2.	Industrial site, routes of workers	- gamma dose rate; - β-fluence density; - superficial contamination with α- and β-active substances.
3.	Transport, package: - special transport with radioactive consignment; - transport with general engineering consignment	- gamma dose rate; - superficial contamination with α- and β-active substances; - neutron dose rate (as necessary).
4.	Wastes: - solid radioactive waste; - conventional industrial waste; - scrap metal; - liquid radioactive waste	- gamma dose rate; - superficial contamination with α- and β-active substances; - neutron dose rate (as necessary); - activity concentration and radionuclide composition of liquid radioactive waste (LRW).

No.1	Name of monitored subjects	Controlled index
5.	Equipment and materials: - technological instruments; - equipment; - building materials and products.	- gamma dose rate; - superficial contamination with α- and β-active substances.
6.	Personal protective equipment: - external and internal surfaces of auxiliary PPE; - base PPE.	- contamination with α- and β-active substances.

4.3 Portable instruments are used for monitoring of gamma and neutron dose rates, as well as for that of beta-fluence density and radiation examination of superficial contamination of workshops, buildings, and constructions with alpha and beta-emitting nuclides. With the purpose both to obtain the most valid results and to identify type of superficial contamination with α- and β-emitting nuclides (fixed or non-fixed contamination), measurements are generally performed using two methods (instrumentation and taking smears).

4.4 Radiation monitoring is performed using the following techniques:

- MOP. Dose monitoring of workshops in controlled area and in radiation safety area;
- MOP. Dose monitoring in SNF and RW repositories;
- MOP. Monitoring of superficial contamination of both workshops and equipment;
- MEP. Measurement of non-fixed contamination (smear method).

4.5 Maps (full and brief), which have been developed at the facility, are used in the course of measurements. Brief maps are used for radiation examination when supporting for radiation hazardous operations or in some other cases (for example, in the course of measurements in BDS checkpoints) according to instructions of RSD chief. In this case, the measurement results are being registered in the «Journal of radiation hazardous operation support». Full maps are used for radiation examination implemented in compliance with the adopted annual schedule, which is a part of the radiation monitoring program. The results of monitoring are being registered in the appropriate act.

Monitoring frequency varies from once in a day to once in a year, depending upon both a type of workshop and a type of operations performed.

4.6 Laboratory monitoring of air in the workshops is being performed in Building No.1 6 (LRW storage facility), Building No.1 67 (SRW storage facility), BDC tanks (IFA storage facilities), RSD laboratory in Building No.1 50 (II class laboratory), decontamination site by means of sampling and sample analysis. Sampling frequency is monthly.

Gamma-spectrometry complex «Canberra InSpector» is applied for analysis (nuclide composition determination of gamma-emitting radionuclides) and UMF-2000 low background installation (determination of total beta-activity). Monitoring is being performed using the following strategies:

- «Monitoring of activity concentration of alpha- and beta-active aerosols in workshops within controlled access area»;
- «Monitoring of man-made radionuclide activity concentration in air».

The assessment of the obtained data is being performed according to the Annex A-1 of NRB-99 and reference levels developed at the facility and coordinated with CGSEN No.120.

When RL are excess, the chief of the laboratory informs the chief of the RS department, reasons of the radiation situation worsening are being ascertained and measures are being taken to make the situation normal (route).

4.7 In the course of radiation hazardous operations, controlled indexes are as follows:

- gamma dose rate;
- beta fluence density;
- contamination with alpha and beta-emitting nuclides;
- activity concentration of aerosols in air;
- neutron dose rate (during SNF management).

4.7.1 In this case, radiation monitoring is carried out using the following techniques:

- MOP. Dose monitoring of workshops and rooms in the controlled access area;
- MOP. Dose monitoring in SNF&RW storage facilities;
- MOP. Dose monitoring of the controlled access area;
- MOP. Monitoring of superficial contamination;
- MEP. Measurement of non-fixed contamination (smear method).

4.7.2 In this case, radiation monitoring is subdivided into three stages:

The first stage. Before the beginning of work:

- radiation survey of the work place (if radiation situation is unknown) throughout all above-mentioned indexes;
- determination of permissible duration of worker staying there;
- setting the authorized dose threshold in individual dosimeters;
- check of availability and preparedness of base and auxiliary PPE;
- performance of arrangement and engineering actions before the beginning of work. Results are registered in the "Journal of radiation hazardous operation support".

The second stage. In the course of work:

- permission to start work and admittance of the personnel involved in operations;
- implementation of permanent gamma dose rate monitoring within the place of the personnel staying;
- implementation of periodic contamination monitoring of external and internal PPE surfaces and of the skin.

In case of either sharp increase of gamma dose rate or excess authorized level of PPE and skin contamination, operations are paused. The personnel go out from the hazardous area under condition of radiation safety observance. Dosimetrist immediately informs the RSD chief about existing radiation situation. Operations can be resumed in this area only after ascertaining reasons of the situation and by authority of the chief engineer.

The third stage. After the termination of work:

After the termination of work, radiation survey of the work place is performed throughout all radiation indexes. The personnel is subjected to obligatory radiometric examination before enter to RMP and after termination of sanitary treatment. Results of radiation monitoring are registered in the «Journal of radiation hazardous operation support».

The automated aerosol monitoring installations UDA-1AB are used in workshops during radiation hazardous operations with the purpose of urgent evaluation of activity concentrations of alpha- and beta-active aerosols. These installations permit to obtain activity concentration values in 1 hour.

4.8 Radiation monitoring of the industrial site as well as of personnel and vehicle routes is performed using instrumentation or smear methods throughout the controlled indexes given in Table No.1 items 2, 3 according to the following techniques:

- MOP. Dose monitoring of the controlled access area;
- MOP. Dose monitoring of the radiation safety area;
- MOP. Monitoring of soil superficial contamination.

4.9 Radiation monitoring is being performed daily (according to the brief map) and periodically (weekly or monthly) according to the full map. Full and brief maps are made (updated) annually, in terms of reached results in radiation protection assurance at the facility; these maps are the parts of the radiation monitoring program.

4.10 The person on-duty in the radiation safety division performs daily radiation examination according to the brief map, after the personnel departure from the site. The examination results are registered in the Journal of radiation survey both of the technical-organizational area, and of the personnel and vehicle routes. Data of the examination are compared with reference levels. If the results obtained are higher than the reference levels, the person on-duty immediately informs the chief of the shift, takes actions to ascertain reasons of excess RL, and operates according to the chief of the shift instructions.

4.11 Radiation survey according to the full maps is a job of people's on-duty in the radiation safety division; generally, they perform this job on Sundays: the results of weekly examinations are registered in the Journal of the site and route radiation surveys, while the monthly results are registered in the appropriate act. It should be noted that under condition of a blanket of snow absence, changes of contamination with alpha and beta-active substances are identified both directly and using the smear method.

4.12 The site radiometry survey with respect to superficial contamination with alpha- and beta-active substances in autumn-winter season under condition of a blanket of snow presence is implemented using direct measurement method on the routes of the personnel and vehicle moving; while beyond these routes such survey is not performed usually.

4.13 Radiation monitoring of vehicles is subdivided into:

- monitoring of the special transport with radioactive consignments,
- monitoring of transport with conventional technical consignments

and such kind of monitoring is performed using the following techniques:

- MOP. Dose monitoring of the special transport with radioactive consignments;
- MOP. Dose monitoring of transport with conventional technical consignments (without any consignment);
- MOP. Superficial contamination monitoring of vehicles and packages.

4.14 On the exit of the controlled access area, any motor transport, regardless its ascription and consignment removed, is subjected to radiation examination according to maps, which have been developed depending upon the model of vehicle. The dosimetrist responsible for the particular type of operation performs the examination; in some cases, a worker responsible for decontamination or person on-duty from RSD can do this job. And depending upon the consignment removed, the above-mentioned strategies are applied in the course of radiation monitoring, while superficial contamination monitoring is implemented in a similar manner each time. If superficial contamination with alpha- and beta-active substances had been detected and a dose rate excesses the maximum permissible levels, the motor transport and the package (consignment) are subjected to decontamination. The results of radiation monitoring both before decontamination and after its termination are registered in the Journal of radiation examination of transport and package (consignment) ».

4.15 Radiation examination of other vehicles, operation of which assumes staying in the radiation safety area, and examination of vehicles for the personnel transportation, is performed according to the established schedule using the strategy of «Superficial contamination monitoring of vehicles and packages» and accompanied with making of the appropriate act.

4.16 Radiation monitoring of radioactive waste is performed using the following techniques:

- MOP. Dose monitoring of conventional and domestic wastes;
- MOP. Radiation monitoring of SRW.

4.17 When managing solid radioactive waste, radiation monitoring is arranged in compliance with the «Instruction of solid radioactive waste management»; the personnel of radiation monitoring section perform such monitoring.

4.18 Dose monitoring of conventional industrial and domestic wastes is carried out as far as generated, in case of either removal from the technical-organizational area or planned storage within this zone. Either the person on-duty from the radiation safety division or the special appointed dosimetrist performs the relevant measurements. The results of monitoring are registered in the Journal of waste radiation examination.

4.19 Radiation monitoring of the scrap metal is arranged in compliance with hygienic requirements for radiation protection assurance during collection and utilization of the scrap metal SanPiN 2.6.1.993-00 and the Guidelines MUK 2.6.1.1087-02 (approved by the RF State Chief medical officer on 4 January, 2002).

4.20 During the scrap metal collection, its manufacturing radiation monitoring is implemented in two steps:

entrance radiation monitoring, which covers all entering scrap metal

and radiation monitoring of the scrap metal consignment, ready for utilization; the results of such monitoring serve as a basis for the sanitary epidemiological certificate. Radiation monitoring laboratories, which have the appropriate accreditation, perform radiation monitoring of the scrap metal consignment, ready for utilization. Since the facility (according to its destination) does not deal with the scrap metal management (purchase and sale), and the scrap metal is generated in the course of remediation of the site and of the environment, entrance radiation monitoring of the scrap metal is performed as far as its collection on the storage site, in compliance with the above-mentioned guidelines. The results of monitoring are registered in the Journal of the manufacturing radiation monitoring of the scrap metal».

4.21 Monitoring of LRW activity is being performed using the sampling and the sample analysis method according to the «Instruction for LRW sample analysis in the laboratory of the RS division». The personnel responsible for the appropriate storage facilities perform this monitoring. The sample analysis is being performed by the direct method using the spectrometry complexes «Canberra InSpector» and «Progress BG».

The assessment of the resulting data is being performed according to SPORO-2002 Para.3.3.

Data on LRW activity are being registered in the protocols and submitted to the chief of the RS division and to the chief engineer of the facility monthly. At the end of the calendar year, a plot of activity variation with time is being made.

Monitoring is being performed using the following strategies:

- MOP. LRW radiometry monitoring;
- MOP. MMR specific activity monitoring in water media.

5 Environmental monitoring

5.1 The environmental radiation monitoring is carried out in compliance with the "Program of the laboratory monitoring of the environment and of internal occupational exposure".

5.2 Monitoring covers all radiation indexes specifying environmental contamination levels (table 2).

Monitoring frequency varies from once in a week to once in a year, depending upon the subject of monitoring and upon location of checkpoints (HPZ or SA)).

Table 2 *Listing of the environmental media of HPZ and SA subjected to laboratory monitoring and controlled radiation parameters*

Subject of monitoring	Controlled radiation parameter
1. Aerosols in common air.	Activity concentration of radioactive aerosols Radionuclide composition of aerosols
2. Precipitation.	Density of radioactive precipitation from atmosphere Radionuclide composition of precipitation from atmosphere
3. Seawater	Activity concentration and radionuclide composition
4. Hydrobionts, bottom sediments	Specific activity and radionuclide composition
5. Fresh water from open ponds	Activity concentration and radionuclide composition
6. Fresh water from technical water-pipe	Activity concentration and radionuclide composition
7. Soil	Specific activity and radionuclide composition
8. Plants.	Specific activity and radionuclide composition
9. Supervised area	Gamma dose rate Beta fluence density

5.3. Aerosol sampling for monitoring of common air contamination is performed using portable samplers equipped with the special aerosol filters. Monitoring is implemented according to the following techniques:

- MOP. Activity concentration monitoring of near-land air.
- MOP. Activity concentration monitoring of man-made radionuclides in near-land air.

5.4 Sampling of (atmospheric) precipitation is performed using sedimentation method using collector-tanks with 5-7 day exposition. Monitoring is performed according to the following techniques:

- MOP. Radiometry monitoring of radioactive precipitation.
- MOP. Superficial activity monitoring of man-made radionuclides in atmospheric precipitation.

5.5 Water sampling from open ponds is performed using the portable sampler. Monitoring is implemented according to the following techniques:

- MOP. Monitoring of gross alpha- and beta- activity concentration of water media.
- MOP. Specific activity monitoring of man-made radionuclides in water media.

5.6 Sampling of hydrobionts and of bottom sediments is performed in points of seawater sampling. Monitoring is performed according to the technique «MOP. Specific activity monitoring of man-made radionuclides in bottom sediments, water plants and periphyton».

5.7 Soil and plant sampling is carried out in autumn. Samples are subjected to physical reduction. Sample analysis is performed using radiometry and spectrometry equipment. Monitoring is performed according to the following techniques:

- SP. Soil sample preparation for measurement of gross alpha- and beta-activity.
- MOP. Soil superficial contamination monitoring.
- MOP. Specific activity monitoring of man-made radionuclides in soil.
- MOP. Specific activity monitoring of man-made radionuclides in plants.

5.8 Water sampling from the technical water-pipe is performed from the distribution system in the laboratory. The sample analysis is performed by means of the direct method using radiometry and spectrometry equipment. Monitoring is performed according to the following techniques:

- MOP. Monitoring of gross alpha- and beta-activity concentration of water media.
- MOP. Specific activity monitoring of man-made radionuclides in water media.

5.9 Radiation monitoring of HPZ and SA territories is performed using either instrumentation method or smear method throughout controlled indexes in compliance with the following techniques:

- MEP. Measurement of equivalent dose rate in the checkpoint.
- MOP. Soil superficial contamination monitoring.

Radiation monitoring is implemented periodically. Maps are made (updated) annually, in terms of reached radiation protection at the facility.

The examination data are compared with the reference levels. If the results obtained are higher than the reference levels, the chief of laboratory immediately informs the RSD chief, takes actions to ascertain reasons of excess RL and jointly with the RSD chief develops measures for RL normalization.

Under condition of a blanket of snow absence, measurements of contamination with alpha- and beta-active substances are preformed both directly and using the smear method.

Radiometry survey of the site with respect to superficial contamination with alpha- and beta-active substances in autumn-winter season under condition of a blanket of snow presence is performed using the direct measurement method.

The results of monitoring are registered in the appropriate act.

5.10 Radiation monitoring of vehicles for the personnel transportation is performed according to the technique:

«MOP. Monitoring of superficial contamination of vehicles and of package».

Radiation monitoring of vehicles for the personnel transportation is performed according to the established schedule and accompanied with the relevant act.

6 Presentation, registration and storage of the monitoring results

6.1 The results of radiation situation monitoring can be presented in the following forms:

- electronic databases;
- in a form of a plot on the monitor with indication of the established levels of controlled values (using the personal computer);
- audio alarm of excess established levels (using the personal computer).

6.2 The results of radiation monitoring are recorded in the following registration forms:

- journals;
- radiometry examination acts;
- dose cards;
- in electronic form (using the personal computer).

6.3 The results of all dose monitoring types, as well as data on gross dose accumulated by the personnel over the whole occupational period are registered and stored in compliance with OSPORB-99 requirements.

6.4 The person on-duty of the RSD records individual occupational doses in the Journal and put in the electronic form. The incurred annual occupational dose is subsequently put in the individual card of the worker.

6.5 Copy of the individual exposure data is transferred to the place of new employment, if a worker changes his (her) place of employment for other institution, where operations are implemented using radiation sources. The original is kept in the initial place of employment. Data on individual doses of attached persons are transferred to the place of their permanent work.

6.6 The results of the environmental monitoring are recorded in the protocol in the following registration forms:

- examination protocols;
- examination acts;
- magnet and optic carriers.

6.7 Volume of registered and stored information is identified by the following tasks:

- statistic accounts for the state control bodies;
- dynamics follow-up of all controlled radiation parameter changes, characterizing radiation conditions;
- registration of environmental contamination levels (as necessary, for example, after an accident).

6.8 Data of examinations being specified by the statistic account requirements, according to OSPORB-99, are stored during 50 years. Moreover, generation of necessary data is taken into account, which must be submitted to ASKRO of Rosatom and EGASKRO of Russia, etc.

6.9 The report about the radiation monitoring laboratory work is submitted to the State sanitary and epidemiological supervision bodies not later than 15 February of the following the accounting year according to form No.18 – Instruction on making report of the industrial sanitary laboratories, sanitary epidemiological units, medical treatment institutions on industrial and sanitary monitoring.

Annex 3 Special features of ALARA principle application during SNF and RW management at SevRAO facility No. 1

State sanitary-epidemiological regulation of the Russian Federation

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2.6.5 NUCLEAR POWER ENGINEERING AND INDUSTRY

SPECIAL FEATURES OF ALARA PRINCIPLE APPLICATION

DURING SNF AND RW MANAGEMENT AT SEVRAO FACILITY NO.1

Guidelines

MU 2.6.5. 05 - 08

Legal edition

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1. «Special features of ALARA principle application during SNF&RW management at SevRAO facility No.1»: Guidelines. – M., Federal Medical Biological Agency of Russia, 2008.
2. The Guidelines have been developed: FSUE "State Research Centre – Institute of Biophysics of FMBA of Russia": YuV Abramov, OV Isaev, OA Kochetkov, AV Simakov (scientific leader), and SV Stepanov.
3. The Guidelines have been recommended for approval by the sub-commission for the special regulation of FMBA of Russia (protocol No.1 45, 2008).
4. The Guidelines have been approved by the Deputy Head of the Federal medical-biological agency of Russia, the State Chief medical officer on sites and facilities serviced VV Romanov.
5. The Guidelines have been introduced since 1 March 2008.
6. The Guidelines are being introduced firstly

Introduction

Under routine radiation source operation, Radiation safety standards (NRB-99) require to follow the main radiation safety principles:

- non-exceeding of authorized individual dose limits due to all radiation sources (dose limit application principle);
- forbidden of all practices relating to radiation source application, if the resulting benefit both for individuals and for the society does not excess risk of possible harm due to additional exposure (justification principle);
- when using any radiation source, keeping individual dose and amount of persons exposed as low as reasonable achieved taking economic and societal factors into account (optimization principle).

Optimization principle is also called ALARA (**A**s **L**ow **A**s **R**easonable **A**chievable) principle. ALARA is the conception of dose limitation based on principles of minimization exposure levels taking economic and social reasonability into account.

ALARA principle is a constituent of the general safety culture of the facility, and its objective is minimization of risks. Safety culture means qualified and psychological education of each person, under which safety assurance is the priority goal and internal aspiration leading to adequate understanding of responsibility and to self-control in the course of operations affecting safety. To establish the safety culture at the level of the facility, the following actions must be taken:

- to share the responsibility;
- to control work implementation;
- to confirm qualification and to educate the personnel;
- to arrange a system of encouragement and penalties;
- to perform revisions, to make analytical reviews and comparisons.

УТВЕРЖДАЮ
Approved

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________________ В.В. Романов

“ 24 ” [illegible] 2008 г.

Enforcement date: since 1 March 2008

2.6.1 IONIZING RADIATION, RADIATION SAFETY AND PROTECTION

SPECIAL FEATURES OF ALARA PRINCIPLE APPLICATION DURING SNF&RW MANAGEMENT AT SEVRAO FACILITY NO.1

MU 2.6.1. 05 - 08

1 Scope

1.1 The Guidelines (hereinafter referred to as MU) define a procedure of optimization principle application in the course of radiation hazardous operations of SNF and RW management at SevRAO facility No.1.

1.2 The Guidelines are intended for application by the federal authority responsible for the sanitary and epidemiological supervision as well as by the radiation safety team of the facility, when planning radiation hazardous operations using radiation sources.

1.3 MU can be amended or supplemented only under coordination with the Federal medical-biological agency.

2 Regulative references

The Guidelines had been developed on the base of and accounting the following regulative and guidance documents:

- Federal law on "Preservation of the Environment" No.1 7-FZ of 10.01.02;
- Federal law on “Nuclear Energy Use” No.170-FZ of 21.11. 95;
- Federal law on “Radiation Protection of the Public” No.1 3-FZ of 09.01.96;
- Federal law on “Sanitary and Epidemiological Prosperity of the Public” No.1 52-FZ of 30.03.99;
- Radiation Safety Standards (NRB-99). SP 2.6.1.758-99;
- Main Sanitary Rules of Radiation Safety Assurance (OSPORB-99). SP 2.6.1.799-99;
- Hygienic Requirements for Design of Facilities and Installations in Nuclear Power Industry (SPP PUAP-03). SanPiN 2.6.1. 07 – 03.
- Sanitary Rules of Radioactive Waste Management (SPORO-2002). SP 2.6.6.1168-02.
- Safety during radioactive waste management. General provisions (NP-058-04). M. 2004.
- General requirements for the structure, statement and design of regulative and guidance documents of the state sanitary and epidemiological regulative system. Guidance R. 1.1. 003-96. Legal edition, Moscow, Goscomsanepidnadzor of Russia, 1996.

3 Terms and Definitions

The present MU applies the following terms and definitions:

Optimization principle – when using any radiation source, keeping individual dose and amount of persons exposed as low as reasonable achieved taking economic and societal factors into account.

Ionizing radiation source management – all types of the radiation source management in the workplace, including radiation monitoring.

Radiation monitoring – receiving of information about radiation situation at the enterprise, in the environment, as well as about individual's exposure levels (includes dose and radiometry monitoring).

Radioactive waste – substances in any aggregate state, which are not intended for future use and which contain radionuclides in amounts exceeding levels authorized by NRB-99 and OSPORB-99.

4 General Provisions

4.1 Radiation protection optimization (ALARA) – is a constituent of the program directed to achievement and keeping of acceptable safe conditions of activity.

Radiation protection must be a component of overall program for safe work conditions assurance.

4.2 An optimization principle must be applied at all stages both of the manufacturing process arrangement and of the radiation facility operation: from design stage, in the course of operation and up to termination of the facility decommissioning and waste disposal.

4.3 ALARA technique involves:

- generation of conditions for opening and implementation of each worker potentials (knowledge, skills, experience);
- justified selection and preliminary planning of actions, implementation of which improves safety;
- preparedness for work implementation;
- analysis and evaluation of operations performed, account of experience gained.

4.4 Subjects of optimization (keeping at reasonably achievable low level) are:

- dosimetric costs of workers (individual and collective doses) under priority of individual doses;
- activity of discharges/effluents;
- specific activity and total amount of RW generated.

5 Guidance for the optimization principle introduction

5.1 To manage development and taking actions for optimization principle implementation, ALARA group is arranging at SevRAO facility No.1 (based on the current radiation safety division) under the chief engineer presidency.

5.2 ALARA group considers issues of radiation hazardous operation arrangement, including:

- ways of the personnel involvement into work planning;
- preparedness for work under radiation hazardous conditions;
- control of protective/preventive measures;
- analysis and evaluation of results obtained, account of the experience gained.

6 Introduction of the optimization principle

6.1 Work planning

6.1.1 When planning radiation hazardous operations, different options of their performance shall be considered. Options accompanied with the least dose costs are top priority. At that, a variant of the operation performance connected with the least individual occupational doses is preferable.

6.1.2 Such options of work performance must also have advantage, which ensure minimum discharges and effluents of radioactivity and minimum amount of radioactive waste generated, taking economic factors into account.

6.2 Pre-starting procedure

6.2.1 In the course of pre-starting procedure, the preliminary analysis is carried out of experience gained in similar operations to identify actions aimed at limitation of occupational doses.

6.2.2 Selection is made of optimum numerical and personal strength of the team to the operation performance. Optimum number of persons in the team is minimum number of workers, able to perform the operation within the particular period.

6.2.3 Means are specified for communication between members of the team, and for interaction with work leaders, and with dosimetry division responsible for dose monitoring in the course of work.

6.2.4 Pre-starting procedure includes the personnel exercises with the purpose of training safe skills of working operation. As necessary, exercises are performed using training apparatuses. Qualified and educated personnel are able to accomplish the same work within a shorter period and with lower dose costs. Each worker must be interested in dose cost reduction.

6.2.5 Optimal ergonomic tools and instruments are selected, including gripping devices, manipulators, computer-aided installations etc.

Before the beginning of work, radiation survey of an assumed workplace is carried out.

6.2.6 Subdivision of the site into some special areas is performed. Such places are indicated in the map, which are characterized by the highest external gamma dose rate, where time of the personnel staying is limited. Places characterized by the lowest external gamma dose rate are indicated in a special manner, to show areas for the personnel staying, as possible (for example, when performing pre-starting operations, or in free time etc.). The personnel routes are indicated across the site to restrict external exposure.

6.2.7 Protective (preventive) actions are taken:

- set protective screens and floor-mats;
- equipment with additional ventilation and exhausts;
- dust pressing;
- application of film coatings.

6.2.8 Correct workplace arrangement helps to dose cost reduction in the course of work. It is reached by means of qualitative and fast performance of:

- selection of optimal PPE, assuring the required protection coefficient, and not affecting work conditions, at the same time;
- sufficient illumination;
- normal microclimate;
- absence of mechanical difficulties.

In case of necessity, special instructions shall be developed of safe work implementation.

6.2.9 Authorized doses, permissible work duration, reference levels of radiation factors are calculated and the dose warrant/permission is made.

This permission indicates:

- name of the operation;
- data of the operation performance;
- place of the operation performance;
- reference levels of radiation factors (external gamma dose rate and activity concentration of beta-aerosols, etc.);

- authorized individual effective and equivalent doses;
- work duration (maximum time of staying at the particular area);
- individual and collective PPE applied;
- listing of safety measures and radiation protection instructions, requirements of which are necessary for observance in the course of work.

The needed extent of radiation monitoring is identified, including emergency monitoring.

6.2.10 Before the beginning of work under radiation hazardous conditions, the personnel are subjected to obligatory medical examination.

6.3 Work implementation

6.3.1 Operations, mentioned in the warrant/permission are performed accompanied with the dosimetrist, who carries out the required radiation monitoring. Moreover, the personnel implement self-monitoring using personal dosimeters, which also measure external gamma dose rate. The established thresholds of excess reference level alarm are set in these dosimeters.

6.3.2. In the course of work, two-way communication must be provided between operator and the work leader, as well as between operator and accompanied dosimetrist.

6.4 Analysis and evaluation of the results

6.4.1 After termination of work, the results are to be analyzed. The obtained doses (both individual and collective) are compared with the predicted (authorized) values.

If authorized levels are exceeded, the reasons are ascertained to avoid similar events in future.

6.4.2 Effectiveness is evaluated of completed measures aimed at reduction of dose costs. A brief report is made containing conclusions and recommendations useful for arrangement similar operations in future.

6.5 Involvement of the personnel into implementation of the optimization principle

6.5.1 The conditions must be arranged, when the personnel deliberately select such ways, methods and work organization, which promotes achievement of the highest results (regarding quality and safety) under minimum time costs for work implementation.

6.5.2 The personnel, on its own, must take measures and methods of protection against ionizing radiations, such as:

- protection by distance;
- protection by time;
- correct application of all type PPE;
- using computerized and automated apparatus, facilities and equipment.

ALARA committee in cooperation with the administration must develop a system of stimulation of work implementation under dose cost minimization accompanied with exactingness and compulsion (presence of the work leaders at radiation hazardous operation performance, periodic and unscheduled inspections, control implemented by the radiation safety division)

Reference list

1. General principles of occupational radiation protection. ICRP Publication 75. Yekaterinburg. Uralrescenter. 1999. -93 p.
2. Radiation protection optimization during monitoring of occupational exposure. IAEA safety reports series No.1 21. 2003.
3. Dose assessment for the reference person for the public radiation safety purposes and for radiation protection optimization: extent of the process. ICRP Publication 101.
4. Optimization of occupational radiation protection of RF Minatom's facilities. Recommendations MR 30-1490-2001.
5. Annual limits of radionuclide intake by workers, on the base of recommendations of 1990. ICRP Publication 60. ICRP Recommendations, 1990.
6. V.A. Kutkov, V.V. Tkachenko e.a. Foundation of radiation monitoring at NPP. M.-Obninsk. 2005. – 267 p.

Annex 4 Hygienic requirements for industrial waste management at the Federal state unitary enterprise «Northern federal enterprise for radioactive waste management»

State sanitary epidemiological regulation of Russian Federation

2.6.5. ATOMIC POWER ENGINEERING AND INDUSTRY

Hygienic requirements for industrial waste management at the Federal state unitary enterprise «Northern federal enterprise for radioactive waste management»

(VLLW regulation for SevRAO-08)

Guidance

R 2.6.5.04 - 08

Legal edition

Moscow 2008

Hygienic requirements for industrial waste management at the Federal state unitary enterprise «Northern federal enterprise for radioactive waste management» (VLLW regulation for SevRAO-08): Guidance. – M., Federal medical-biological agency of Russian Federation, 2008.

1. The Guidance has been developed by: FSUE «State research centre – Institute of Biophysics at FMBA RF: VG Barchukov, OA Kochetkov (the leader), SG Monastyrskaya, NP Sajapin, MP Semenova, BE Serebryakov; OAO "VNIIAES": EA Ivanov, FSUE Head Institute VNIPIET: AV Demin, GP Zaruchevskaya, FSUE «SevRAO»: AN Krasnoshchekov, YuP Droga, AS Kosnikov.
2. The Guidance has been recommended for approval by the sub-commission for special regulation of FMBA RF (protocol No.1 45 of 2008).
3. The Guidance has been approved by the Deputy Head of the Federal medical-biological agency, State Chief medical officer on facilities and sites serviced VV Romanov.
4. The Guidance has been introduced since 1 March, 2008.
5. First introduction.

УТВЕРЖДАЮ

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территориям

_____________ В.В. Романов

“24” декабря 2008 г.

Introduction date: since 1 March 2008

2.6.5. ATOMIC POWER ENGINEERING AND INDUSTRY

HYGIENIC REQUIREMENTS FOR INDUSTRIAL WASTE MANAGEMENT AT THE FEDERAL STATE UNITARY ENTERPRISE «NORTHERN FEDERAL ENTERPRISE FOR RADIOACTIVE WASTE MANAGEMENT»

(R VLLWSev RAO-08)

R 2.6.5.04 - 08

1 SCOPE

1.1 The Guidance «Hygienic requirements for industrial waste management at the Federal state unitary enterprise «Northern federal enterprise for radioactive waste management» (R VLLWSev RAO-08) (hereinafter referred to as the Guidance) had been developed taking account requirements of the Radiation Safety Standards (NRB-99). It also evolves subsection 3.11 «Management of materials and products contaminated with or containing radionuclides» of the "Main Sanitary Rules of Radiation Safety Assurance" (OSPORB-99).

1.2 The Guidance establishes requirements for safe management of industrial waste (hereinafter referred to as waste) containing toxic substances and low level man-made radionuclides, both legacy and generated during remediation of sites of temporary storage (STS) of spent nuclear fuel (SNF) and radioactive waste (RW) at SevRAO facility. It also establishes requirements not only for arrangement, maintenance and operation of the landfill (site) for this waste, but also for its decommissioning.

1.3 The Guidance establishes the system of criteria, rules and restrictions ensuring safety and protection of workers from SevRAO facility and the public on-site, within the health protection zone (hereinafter referred to as HPZ) and in the supervised area (hereinafter referred to as SA) during the waste management. It also sets an adequate level of control over radiation and sanitary epidemiological situation.

1.4 The Guidance identifies a set of urgent measures to assure non-exceeding of the main occupational and public dose limits authorized by NRB-99; prevention and mitigation of the environmental contamination, including that resulted from emergencies.

1.5 The guidance establishes requirements for contents of toxic and radioactive substances in waste conveyed for disposal.

1.6 If the waste is hazardous, at the same time (I-II toxicity class, explosive-, fire-hazardous etc.), the relevant regulative and juridical acts regulate its management.

1.7 The Guidance does not cover remedial measures on-site STS. In the course of contaminated STS land remediation, the Guidance "Criteria and norms of remediation of SevRAO FAAE sites and facilities contaminated with man-made radionuclides" (R.2.6.1.25-07) should be applied.

1.8 The Guidance is intended for specialists of FMBA RF bodies and units, responsible for implementation of the state sanitary epidemiological supervision of SevRAO facilities.

1.9 Organizations, operation of which is connected with design, arrangement and operation of the waste management system on SevRAO industrial sites, can be governed by the requirements of the present regulative document

2 Regulative references

The Guidance had been developed according to and in terms of the following laws and other regulative documents:

Federal law "About sanitary-epidemiological prosperity of the public" No.1 52-FZ of 30 March 1999. (Collection of RF legislation, 1999, No.14, p. 1650);

Federal law «About radiation safety of the public» of 9 January 1996 No.1 3-FZ («Collection of RF legislation », 1996, No.13, p. 141);

Federal law "About use of atomic energy" of 21.11.1995 No.170-FZ ("Collection of RF legislation ", 2002, No.13, p. 1180; 27.11.1995, No.1 48, p. 4552; 17.02.1997, No.1 7, p. 808; 16.07.2001, No.1 29, p. 2949; 07.01.2002, No.1 (part 1), p. 2; 01.04.2002, No.13, p. 1180; 17.11.2003, No.1 46 (part 1), p. 4436);

Federal law «About industrial wastes and consumption residues» of 24 June 1998 No.1 89 – FZ ("Collection of RF legislation ", 1988, No.1 26, p. 3009, amendments of 29 December 2000, 10 January 2003, 22 August, 29 December 2004, 9 May 2005);

SP 2.6.1.758-99 «Radiation Safety Standards», NRB-99, approved by the Chief medical officer of Russian Federation 02 July 1999, by letter of the Ministry of Justice of Russia of 29.07.99. No.1 6014-ER are recognized as not needed the governmental registration;

SP 2.6.1.799-99 «The main sanitary rules of radiation safety assurance» OSPORB-99, approved by the Chief medical officer of Russian Federation 27.12.1999;

SP 2.6.1.1168-02 «Sanitary rules of radioactive waste management» SPORO-2002. Approved by the Chief medical officer of Russian Federation 16 October 2002, introduced by the directive of the Chief medical officer of Russian Federation of 23 October 2002 No.1 33. Had been registered in the RF Ministry of Justice 06 December 2002, registration No.1 4005;

SP 2.6.1.07-03 «Hygienic requirements for design of nuclear facilities and installations» SPP PUAP-03. Approved by the Chief medical officer of Russian Federation 08 January 2003, introduced by the directive of the Chief medical officer of Russian Federation of 04.02.2003 No.1 6. Had been registered in the RF Ministry of Justice 03 April 2003, registration No.1 4365;

Amendments and supplements No.1 to SanPiN 2.6.1.07 - 03 «Hygienic requirements for design of nuclear facilities and installations». SanPiN 2.6.1.37-03. Approved by the Chief medical officer of Russian Federation 17.05.2003, introduced by the directive of the Chief medical officer of Russian Federation of 15 May 2003 No.1 95, had been registered in the RF Ministry of Justice 22 May 2003, registration No.1 4582;

SanPiN 2.6.1.993-00. «Hygienic requirements for radiation safety assurance during collection and dismantling of the scrap metal». Approved by the Chief medical officer of Russian Federation 29 October 2000. Had been registered in the RF Ministry of Justice 08.05.04, registration No.1 2701.

SP 1.1.1058-01 «Arrangement and performance of the manufacturing inspection of observance of the sanitary rules and taking the sanitary and epidemiological (prophylactic) actions». Approved by the Chief medical officer of Russian Federation 10 July 2001, introduced by the Directive of the Chief medical officer of Russian Federation of 13.07.2003 No.18 from 01 January 2002. Had been registered in the RF Ministry of Justice 30 October 2002, registration No.1 3000;

SP 2.2.1. 1312-03 «Hygienic requirements for design of industrial plants under construction and restoration». Approved by the Chief medical officer of Russian Federation 22 April 2003, introduced by the directive of the Chief medical officer of Russian Federation of 30 April 2003 No.1 88 of 25 July 2003. Had been registered in the RF Ministry of Justice 19 May 2003, registration No.1 4567;

SanPiN 2.2.3.1384-03. «Hygienic requirements for arrangement of construction and construction operation performance». Approved by the Chief medical officer of Russian Federation 11 June 2003 introduced by the directive of the Chief medical officer of Russian Federation of 11 June 2003 No.141 from 30 June 2003. Had been registered in the RF Ministry of Justice 11 June 2003, registration No.1 4714;

SanPiN 2.1.7.1287-03. «Sanitary and epidemiological requirements for quality of soil». Approved by the Chief medical officer of Russian Federation 16 April 2003 No.1 53 from 15 June 2003. Had been registered in the RF Ministry of Justice 5 May 2003, registration No.1 4500;

SanPiN 2.1.7.1322-03. «Hygienic requirements for allocation and neutralization of industrial wastes and consumption residues». Approved by the Chief medical officer of Russian Federation 30 April 2003 No.1 80 from 15 June 2003. Had been registered in the RF Ministry of Justice 12 May 2003, registration No.1 4526;

SP 2.1.7.1386-03. «Identification of hazard class of toxic industrial wastes and consumption residues». Approved by the Chief medical officer of Russian Federation 16 April 2003 No.144 from 15 June 2003 had been registered in the RF Ministry of Justice 19 June 2003, registration No.1 4755;

SP 2.1.7.1038-01. «Hygienic requirements for arrangement and equipment of sites for solid domestic (conventional) wastes». Approved by the Chief medical officer of Russian Federation 30 May 2001 No.16. Had been registered in the RF Ministry of Justice 26 June 2001, registration No.1 2826.

GOST 12.1.007-76 «Harmful substances. Classification and general safety requirements». Approved and introduced by the Directive of the USSR Governmental Committee on standards of 10.03.76 No.1 579. Re-edition (September 1999) with amendments No.1, 2 approved in September 1981, March 1989 (IUS No.12-1981 and No.1 6-1990.)

Hygienic regulations «Man-made radionuclide contents in metals», GN 2.6.1.2159-07, approved by the RF State Chief medical officer on 08 February, 2007, No.1 5.

The State Standard «Shallow facilities for radioactive waste disposal. General provisions.» GOST R.52037-2003. Approved and introduced by the Directive of RF Gosstandard of 01.04.2003, No.1104-st.

3 General Provisions

3.1 Arrangement of a system for management of waste with low level contents of toxic substances and man-made radionuclides at SevRAO is an inherent part of the system of radiation and chemical safety assurance for workers and for the public during operation, decommissioning and remediation of SevRAO territory.

3.2 The Guidance establishes:

- general radiation and hygienic requirements for radiation protection of the public and workers during management of waste containing man-made radionuclides with specific activity levels lower than LLW;
- waste classification by: specific activities of man-made radionuclides contained; exposure dose rate; superficial contamination; and period of the waste potential hazard;
- waste classification by hazard (toxicity) class;
- system of restrictions during waste management;
- authorized levels of material contamination intended for use in the economical activity;
- requirements for safety assurance of waste disposal;
- requirements for radiation control and monitoringy.

3.3 According to requirements of OSPORB-99 and the Guidance, industrial wastes containing radionuclides with specific activity, which is lower than levels of their ascription to RW, are subdivided into two groups:

- waste and materials containing man-made radionuclides with specific activity level, which is lower than the level of their ascription to low level waste (LLW), but higher than levels of clearance from regulatory control (the first group);
- waste and materials released (cleared) from regulatory control (the second group).

3.4 Within the present document, waste with very low radioactive substance contents (the first group) had been separated into the "very low level waste" (VLLW) category, in compliance with the common international practice.

3.5 The Guidance had been developed taking account the national experience and international practice of management and disposal of very low level waste.

3.6 When arranging VLLW management and planning occupational doses, radiation background must be accounted, specific for the particular area of SevRAO industrial site, because this background serves as the secondary source of radioactive exposure.

3.7 The public protection against radiation exposure and mitigation of environmental contamination must be provided by means of predictive safety assessment of VLLW disposal.

3.8 At SevRAO facility, sanitary epidemiological and radiation safety of waste, containing low levels of man-made radionuclides and chemicals, is defined by:

- activity and specific activity values of waste disposed during a year, affecting external and internal exposure to workers and the public;
- contents of toxic substances, heavy metals and other components specifying the waste hazard class by extent of individual and environmental impact;
- fire and explosive risk characteristics of the waste;
- possible release of the waste components into the environment under condition of normal degradation or abnormal damage of engineered containment barriers of the waste storage/disposal facilities during and/or after termination of the facility operation.

3.9 The industrial waste must be classified at the stage of design of the management system of radioactive and non-radioactive waste according to the set of priority attributes:

- radiochemical composition;
- physical and chemical properties, chemical form and aggregative state (solid, liquid);
- VLLW volume;
- activity and specific activity;
- hazard class by toxicity;
- explosive-fire risk;
- amount of infectious agents.

3.10 Arrangement of unauthorized places for VLLW storage and/or disposal within HPZ of SevRAO facilities is forbidden.

3.11 For VLLW landfill, as for each other radiation facility located on SevRAO industrial sites, quotas must be established of radioactive discharges and effluents into environment, including offshore waters.

3.12 SevRAO as operator of VLLW disposal landfill must ensure:

- effective public and environmental protection through application of adequate protective measures in compliance with radiation safety rules;
- minimization of radiation and chemical exposure and of the landfill contamination resulted from other radiation and chemical sources;
- account of biological, chemical and radiation risks for the present and future generations, which risks are due to storage and disposal of materials containing radioactive substances;
- keeping account documents concerning content and construction of the disposed subject;

- monitoring and restriction both of unauthorized access to the landfill, and unplanned radioactive contamination of the environment.

4 Safety and protection criteria during waste management

4.1 Safety and protection criteria during management of waste being accumulated and generated on the SevRAO industrial sites are defined in terms of keeping individual and environmental impact in acceptable limits:

- radiation factors under regulation of NRB-99, OSPORB-99, SPORO-2002;
- hazard class of toxic waste under regulation of SP 2.1.7.1386-03, SP 2.1.7.1322-03, SP 2.1.7.1038-01 and GOST 12.1.007-76.
- 4.2. The following principles must assure radiation safety and protection of workers, the public and environment during management and disposal of waste with low levels radionuclide contents:
- doses or risks must not exceed the authorized levels, both for the present and for future human generations (principle of limitation (normalization));
- all types of waste related activity are forbidden, if individual and society benefit does not exceed risk of possible harm due to additional exposure (justification principle);
- keeping individual exposure doses and amount of persons exposed as low as it is reasonably achievable both for the present and for future human generations (principle of optimization);
- assurance of acceptable environmental protectability against radioactive exposure of landfills for waste storage and/or disposal (principle of the environmental preservation);
- such option of waste disposal, which minimizes its possible negative consequences for future generations (principle of non-putting of an excessive radiological burden on future generations).

4.3 The public protection against exposure of VLLW disposed must be assured by means of reliable waste isolation from the environment (underground waters, atmosphere, offshore waters, and soil) for the period of its hazard keeping.

4.4 Long-term safety of the disposal landfill must be provided by combination of: favourable hydrogeological characteristics of the site selected for disposal arrangement; engineering features of the design; appropriate isotope composition of waste; limit establishment for long-lived radionuclide contents; operational procedures and measures of industrial inspection.

4.5 SevRAO workers performing RW sorting and VLLW separation belong to the personnel group A. Workers involved in operations of VLLW management within the industrial site including landfills belong to the personnel group B.

4.6 Individual annual effective dose of the occupational exposure due to waste management of the personnel group B must not exceed 5 mSv/year. Planned exposure must not exceed 1.5 mSv/year.

4.7 The committed individual annual effective dose of exposure to the critical group of the population due to VLLW involvement in the economical activity must not exceed 10 μSv/year, while the collective effective dose to the public must not exceed 1 man-Sv/year.

4.8 The calculation of doses to the public takes into account the main types of internal and external radiation exposure to the critical group of the population, which is determined according to NRB-99.

4.9 The acceptable derived levels of monofactor exposure from NRB-99 may be used as safety criteria in addition to the mentioned dose limits.

4.10 The following main scenario of possible radionuclide spreading in the environment shall be considered for VLLW disposal landfill:

- radionuclide release from the place of disposal;
- migration via ground waters up to the bay offshore waters;
- radionuclide spreading in the bay.

At that, calculation of the public doses is performed using appropriate food chains taking account seafood intakes.

5 Classification of industrial wastes by the radiation factor

5.1 Criteria of waste clearance from regulatory control.

5.1.1 SevRAO wastes being released from regulatory control in any situation of their management, including re-use, must assure non-exceeding of:

- committed individual annual effective dose to the critical group of the population of 10 μSv/year;
- collective annual effective dose to the public of 1 man-Sv/year.

5.1.2 Gamma emitting waste of unknown radionuclide composition can be released from the regulatory control, dose rate at its surface at distance of 0.1 m (P) does not exceed the upper bound of dose rate range (P_1) due to the natural radiation background, typical for the particular place.

$$P \le P_1 \qquad (5.1)$$

5.1.3 Waste with known radionuclide composition at any mass, are released from control, if the following equation is valid:

$$\sum_i^n \frac{a_i}{a_{0i}} \le 1 \qquad (5.2)$$

where: a_{0i} - maximum specific activity value of i nuclide in the waste if any other radionuclides are absent, when it is released from control, kBq/kg. According to OSPORB-99, a_{0i} value for all radionuclides is 0.3 kBq/kg.

For some beta-emitting radionuclides in metal intended for re-melting, a_{0i}, values which are higher than 0.3 kBq/kg had been established (Annex 10 of OSPORB-99.)

5.1.4 Small amounts of waste (less than 100 kg) under conditions of known radionuclide composition may be released from regulatory control, if two provisions are valid at the same time:

$$\sum_i^n \frac{a_i}{SAMS_i} \le 1 \qquad \sum_i^n \frac{A_i}{MSA_i} \le 1 \qquad (5.3)$$

where:

a_i - specific activity of i radionuclide in the waste, kBq/kg;

A_i - total activity of i nuclide in the waste, kBq;

$SAMS_i$ and MSA_i - specific activity of minimum significance and activity of minimum significance of *i* nuclide, respectively, kBq/kg and Bq. Values of $МЗУА_i$ и $МЗА_i$ had been established in Annex A-4 of NRB-99.

5.1.5 Waste and materials being cleared from regulatory control, may be conveyed for disposal on industrial waste landfills beyond the areas of SevRAO industrial sites or they may be used in the economical activity without any restriction.

5.2 Criteria of waste ascription to very low level category

5.2.1 During preliminary sorting, industrial waste can be ascribed to VLLW category in terms of its gamma dose rate at distance of 0.1 m from the surface and in terms of radioactive contamination level provided that conditions of measurement comply with adopted procedures.

5.2.2 SevRAO gamma emitting waste under condition of its unknown radionuclide composition is considered to be VLLW if the following equation is valid:

$$P_1 < P \leq P_2, \qquad (5.4)$$

where P – dose rate at the surface (0,1 m) of waste; P_1 - natural radiation background dose rate at the particular place; P_2 - dose rate at the surface (0,1 m) of waste with unknown radionuclide composition, at exceeding of which the waste is considered as solid radioactive waste (SRW), P_2 - according to SPORO-2002 = 1 μSv/h.

5.2.3 The upper limits for dose rate mentioned in item 5.2.2 had been established for average magnitudes of these values for the wastes. The averaging is performed according to the certain type of wastes, consignment, and waste package.

Concentration in smaller samples of the wastes must not exceed larger volume average authorized limit more than 10 times. If the established upper limits are exceeded more than 10 times for some sample (package) of the wastes, this sample (package) is considered as SRW.

5.2.4 According to the requirements of OSPORB – 99, under condition of unknown radionuclide composition, the waste may be ascribed to VLLW category if it contains 0,3 – 100 kBq/kg of β-emitting radionuclides, 0,3 – 10 kBq/kg of α-emitting radionuclides, 0,3 – 1 kBq/kg of transuranium radionuclides.

5.2.5 Under condition of known radionuclide composition, the waste might be ascribed to the VLLW category, if the following two equations are valid:

$$0{,}3 \text{ kBq/kg} < a_i < SAMS \qquad (5.5)$$

$$\sum_i^n \frac{a_i}{SAMS_i} \leq 1 \qquad (5.6)$$

5.2.6 When defining the waste category at SevRAO, the fact should be had in mind that ^{60}Co, ^{90}Sr and ^{137}Cs make the main contribution (more than 95 %) into its activity and dose of exposure to workers.

^{90}Sr is that radionuclide, which represents the main threat for the public, because of its large content in the wastes significant migration potential in the environmental media.

5.2.7 Provided that there is a customer of the certain type of activity, and based on the sanitary epidemiological certificate issued by the bodies responsible for implementation of sanitary epidemiological supervision, the wastes of VLLW category can be conveyed for re-use.

5.2.8 In case of impossibility and unreasonability of VLLW re-using, this waste are disposed in the special landfills arranged on the industrial sites.

5.2.9 Radionuclides, specific activity of which in the wastes is less than 30 Bq/kg, are ignored in calculations of acceptable radionuclide contents in VLLW or in materials cleared from control.

5.2.10 The body of the state sanitary epidemiological supervision grants the sanitary epidemiological certificate confirming compliance of the waste categorization with this Guidance.

6 Classification of industrial wastes by the chemical factor

6.1 On the industrial sites of SevRAO facility, a hazard class by the chemical factor must be specified both for wastes under clearance from regulatory control and for those belonging to VLLW category.

Classification of wastes by toxicity separates 4 classes:

1 class – excessive hazardous;

2 class – high hazardous;

3 class – moderate hazardous;

4 class – low hazardous.

6.2 The State standard «Harmful substances. Classification and general safety requirements» (GOST 12.1.007-76) and sanitary rules «Definition of hazard class of toxic industrial wastes and consumption residues» (SP 21.7.1386-03) specify a procedure of the chemical hazard class definition of the waste.

The organizations under accreditation for this type of operations define the toxicity class of the waste in compliance with the mentioned documents.

6.3 The hazard class is defined for each type of wastes, conveyed to the VLLW disposal facility or removed from the industrial site of SevRAO facility. The certificate of each waste consignment must include information about the class of chemical hazard. If there are several types of the wastes in the consignment, the chemical hazard class of the most hazardous type of the wastes is ascribed to this consignment.

7 Collection, sorting, storage, processing and conveyance of industrial wastes

7.1 VLLW collection and sorting

7.1.1 Wastes containing low level radioactive substances before the acceptance for treatment must be collected and subdivided into two groups: VLLW and wastes under clearance from regulatory control. As necessary, such wastes may be separated from RW.

7.1.2 Workers of the industrial sectors (personnel group A) perform collection, sorting, and preparation for storage of VLLW being generated or separated from RW at radiation facilities located within the industrial sites.

7.1.3 Workers involved in operations within the industrial sites (personnel group B) perform collection, sorting, and preparation for storage of VLLW being resulted from decommissioning of industrial and auxiliary buildings (after decontamination accomplishment at these facilities), as well as from remediation of the site.

7.1.4 VLLW collection as far as possible must be conducted nearby places of their generation. Different packages (containers) are used in the course of sorting and collection, depending upon:

- specific activity value and chemical characteristics;
- dimensions (small- and big-volume);
- explosive and fire hazards;

- authorized methods of waste processing;
- type of use in the economic activity or disposal.

The containers for VLLW must differ from those for SRW collection. Containers for VLLW have function of package, while containers for SRW have also additional function - to serve as engineered barrier. As a rule, containers have different marking and colour.

7.1.5 Mixture of VLLW with RW is forbidden during VLLW collection.

7.1.6 At SevRAO, radioactive contamination of the wastes is mainly due to ^{90}Sr (20%) and ^{137}Cs (80%) with low content of alpha-emitters (<0.1%), therefore sorting of the waste may be implemented according the criteria given in Table 1.

7.1.7 If there are wastes of another isotope composition, these criteria must be re-calculated using the equations given in items 5.5 and 5.6.

7.1.8 When sorting legacy wastes of unknown composition and under condition of its definition impossibility, sorting may be performed in terms of gamma levels (equations 5.1 and 5.4).

7.1.9 VLLW being conveyed for interim storage must be packed. In order to prevent the repeated contamination with radioactive substances during collection of VLLW, their short-term storage on the working sites in bulk is forbidden.

7.1.10 The outside surface of the package (container-collector) filled with VLLW contains identifying information in compliance with the management system adopted at SevRAO.

Table 1. *Criteria of waste sorting at SevRAO under condition of known isotope composition: ^{90}Sr (20%) and ^{137}Cs (80%)*

Waste category	Specific beta-activity, kBq/kg	Superficial contamination, β-particles/m*cm^2	Dose rate at 0.1 m distance from the package surface, μSv/h
Cleared wastes	≤ 0,3	≤ 50,0	Non-exceeding of natural radiation background, specific to the particular place, more than 0.1
VLLW	0,3 – 12,0	50,0 – 500,0	0,1 – 1,0

Note: *specific activity and superficial contamination are applied simultaneously, not excepting each other.*

7.1.11 The package filling up with wastes must be performed under radiation monitoring.

7.2. VLLW conveyance, interim storage and processing

7.2.1 Conveyance of packages (containers-collectors) within the working divisions must be performed using electric trolleys, elevators, cranes, as well as special small carts with handles, length of which is not less than 1 m to make impossible the package tilting.

Conveyance of waste packages from places of their generation and collection to the site of their interim storage must be performed using routes, which make impossible vehicle and industrial site contaminations.

7.2.2 Within the industrial site of SevRAO facility, waste transportation to the temporary storage facilities or to disposal landfills is performed by specially equipped transport.

Construction and operational conditions of the special transport must minimize any possibility of emergency, environmental loss and contamination in passing and in the course of waste reloading from one type of transport to another.

7.2.3 Vehicle, which removes the wastes containing man-made radionuclides with specific activity levels which are lower than LLW from the industrial site, is a subject of radiation monitoring to confirm an absence of radioactive contamination of outer surfaces.

7.2.4 VLLW conveyance from the territory of SevRAO facility is permitted under the following conditions:

- availability of an adequate package and marking of consignment;
- availability of specially equipped vehicles, which ensure radiation and environmental safety;
- availability of the waste certificate and documentation for conveyance and transfer with indication of waste amount, purpose and point of destination;
- availability of the sanitary epidemiological certificate granted by the bodies designated to implement the State sanitary epidemiological supervision of VLLW consignment.

7.2.5 A carrier or a transport owner is responsible for safety of conveyance from the moment of loading till the waste unloading.

7.2.6 The radiation monitoring team of the facility performs radiation monitoring of the consignment conveyed.

7.2.7 Temporary store facilities or interim storage sites for VLLW must be designed for the whole operation life of the landfill.

7.2.8 VLLW temporary storage shall be implemented during time needed for collection of such waste amount, which is established by the relevant regulation.

7.2.9 VLLW being accepted for interim storage must be sorted in terms of:

- material nature;
- option of processing planned;
- scenario of use or disposal planned.

7.2.10 During VLLW interim storage, its potential radiation and ecological hazard will depend upon: activity value; specific content of the particular radionuclide; type and energy of radiation; half-life; substance toxicities enclosed in VLLW; as well as types and conditions of containers and packages.

7.2.11 For each storage site or facility, maximum activity concentrations (radionuclide capacity) must be established, at reaching of which further VLLW acceptance must be stopped.

7.2.12 The storage site or facility dimensions must ensure thoroughfare and manoeuvring of lifting-and-shifting vehicles.

7.2.13 Gamma dose rate induced by the VLLW container (package), outer walls of such container storage facility and the border around storage site must not exceed 1 μSv/h at 0.1 m distance.

7.2.14 Store facility and sites must be provided with machines for load/unload operations, storing and transportation of entering VLLW.

7.2.15 VLLW entering for interim storage must have covering documents with indication of the waste amount, isotope composition, form and type of package.

7.2.16 Sitting, selection of conditions and manner of VLLW interim storage are determined in terms of safety with economic factors taken into account. VLLW longer-term storage must not cause generation of solid radioactive wastes.

7.2.17 VLLW storage is implemented using containers under protection against (atmospheric) precipitation.

Containerless storage of VLLW is permissible. Under condition of containerless VLLW storage, protection must be provided against contamination spreading via dust (tarpaulin cover etc.). Superficial and underlying waste waterproofing (shelter against precipitation, allocation on asphalt or concrete site, arrangement of storm collectors etc.) must also be provided.

7.2.18 To reduce the waste volumes, to decrease a tendency to deposition or compacting after disposal and to minimize radionuclide release from VLLW, waste treatment can be performed during disposal (compacting, incineration, re-melting etc.), provided that this is practicable and economically feasible.

7.2.19 Metallic wastes meeting the requirements of GN 2.6.1.2159-07 "Man-made radionuclide contents in metals" after decontamination may be subjected to unlimited reuse with the economical purposes, if this is economically reasonable (the appropriate procedure is under SanPiN 2.6.1993-00 regulation).

7.2.20 Burnable VLLW shall be conveyed for incineration in special installations equipped with filters of gas-aerosol treatment (purification), if this is practicable and economically reasonable. If incineration is unreasonable, content of such kind of wastes in VLLW under disposal must not exceed 10 %.

8 Disposal of very low level wastes

8.1 Design of the disposal landfill

8.1.1 The special developer must implement designing of landfills for VLLW disposal according to the request of the operator. Such developer organization must have a license for this type of activity.

8.1.2 Designing of sites for VLLW disposal must be performed at the same time as designing of SNF and RW management at the STS, based on recommendations of international organizations and having in mind good foreign practice.

8.1.3 When developing and implementing the design of the disposal landfill, the principle must be governed by, recommended by ICRP, according to which risk for the public after the landfill closure must not exceed 0.3 mSv/year dose constraint (taking account the most possible ways of the landfill evolution).

8.1.4 The design must contain justification of siting for the landfill construction in comparison with alternative options on the base of special examinations and economic calculations, including evaluation of potential doses to the critical group of the public. The results of radiation protection and ecological review must confirm siting of the landfill.

8.1.5 Geologic, hydrogeological and seismic characteristics must be taken into account in the course of siting.

8.1.6 The site must not be perspective in respect to its possible involvement into the economic activity.

8.1.7 The site must have local ways for transport with materials, equipment and waste as such.

8.1.8 When considering characteristics of the site, change must be taken into account of natural and man-made conditions of the landfill allocation which can arise over the whole lifecycle.

8.1.9 The site for arrangement of VLLW landfill must be examined in respect to radiation and chemical exposure of other subjects, existing or planned on-site STS.

8.1.10 The design of the site for arrangement of VLLW landfill must justify the following data:

- siting for the landfill construction;
- selection of the optimal system of engineered containment barriers, including the landfill structure, as well as engineering and operational procedures;
- radiation monitoring system at operational and post-operational stages;
- system of occupational and public dose monitoring;
- acceptable and reference levels of radiation industrial indexes;
- maximum radionuclide capacity of VLLW disposal landfill;

- the landfill life time and environmental monitoring.

8.1.11 The designed system of VLLW disposal must ensure:

- waste isolation from the environment;
- monitoring of possible radionuclide discharges into the environment;
- observation of the site during the established period after disposal.

8.1.12 The design must define the containment barriers to limit migration into soil and spread of radioactive and toxic substances in the environment under condition of selected option of VLLW disposal. This is ensured by application of:

- arrangement and equipment of drainage system;
- covering of bottom and walls of the site with waterproof film, use of clay etc.;
- construction of roof and other types of covering to prevent atmospheric precipitation ingress;
- arrangement of multilayer covering after termination of the landfill operation.

8.1.13 Insulation properties (filtration and sorption) of natural barriers of the disposal site must limit both any contact of underground waters with engineered containment barriers and migration of radionuclides and chemicals (containing in wastes) into the nearby area of the disposal site, in case of the engineered barrier damages.

8.1.14 The adopted technical solution with respect to the disposal site construction must not cause elimination of insulation properties of the natural barrier.

8.1.15 The design defines selection of disposal type (surface, shallow, or deep); deepness of allocation of sections and/or cells for waste disposal and their construction (required to ensure safety and protection of the disposal facility); properties and amount of barriers (and their functions), depending upon:

- waste form;
- waste amount;
- radionuclide composition of the waste;
- activity and specific activity of the waste;
- waste class of hazard;
- features of waste packages;
- duration of potential hazard of the waste;
- properties of host rocks;
- geological and hydrogeological characteristics of the region and of the site for the landfill allocation.

8.1.16 The design of the site for VLLW landfill must consider possible design basis accidents and measure for their prevention.

8.1.17 Depending upon characteristics of the disposal facility and weather conditions, the following must be envisaged:

control of unexpected water ingress inside the landfill;

prevention of superficial and underground water penetration into the place of disposal;

collection and treatment of contaminated water and filtrates up to authorized norms.

8.1.18 Siting for the landfill construction is permitted under condition of the positive sanitary epidemiological certificate issued by the bodies designated to implement the state sanitary epidemiological supervision.

8.2 Operation of the disposal landfill

8.2.1 Operation of the disposal landfill includes the following steps:

- commissioning;
- taking on and education of the personnel;
- engineering and radiation control and monitoring during operation;
- acceptance of wastes;
- emplacement of wastes;
- control of discharges and effluents, monitoring maintenance;
- emergency preparedness;
- decommissioning (closure) of the landfill.

8.2.2 The volume and characteristics of wastes accepted in the landfill, must comply with the designed documentation according to the Instruction (Technical regulation) developed at the facility and coordinated with the bodies designated to implement the state sanitary epidemiological supervision.

8.2.3 VLLW must enter to the landfill in a packed form by the special transport.

8.2.4 VLLW package (container, plastic bag) must be strong, ensure integrity of the content, and minimize the waste dispersal (scattering) in transport, on roads and on the landfill.

8.2.5 The waste accepted for disposal must have covering (accompanying) documents presenting the waste characteristics.

8.2.6 The VLLW registration journal must be arranged at the disposal landfill (recommended form of which is given in Annex 2 of this Guidance), which contains information about date of the VLLW reception and name of division of the industrial site – waste producer, type, amount (volume, mass), activity and radionuclide composition, near surface (0.1 m) gamma dose rate, class of hazard and code of place of waste disposal.

The waste producer division provides information about waste under conveyance for disposal by agreement with the radiation safety and protection team of the particular site.

8.2.7 In the course of the disposal landfill operation, entrance control of packages must be performed to confirm compliance with safety and acceptance criteria, including:

- availability and completeness of accompanying documentation;
- integrity of packages;
- marking of packages;
- dose rate at the surface of the package;
- assessment of measured data compliance with the certificate data of the package.

8.2.8 When justifying radiation safety of the disposal system with respect to workers, the public and the environment in terms of characteristics of the site, the design special features and characteristics of engineered containment barriers of the landfill, radionuclide composition of waste conveyed to the STS landfill, specific activity exceeding is permitted up to 30.0 kBq/kg. In some packages (not more than 10% of total disposal volume), such waste may be disposed, specific activity of which reaches 100.0 kBq/kg (Table 2).

8.2.9 If the package does not comply with the established requirements and it is impossible to lead its characteristics to the safety criteria, the VLLW package is to be returned to the waste forwarder (producer).

Table 2. *Acceptable characteristics of VLLW, conveyed to SevRAO disposal landfill, at isotope composition ^{90}Sr (20%) and ^{137}Cs (80%)*

	Specific activity of radionuclides in the package, kBq/kg	Maximum specific activity of radionuclides in the package, kBq/kg	Levels of VLLW superficial beta contamination, part/m*cm^2	Exposure dose rate, µSv/h	Maximum content of long-lived alpha-active radionuclides, %
Very low level waste	0,3-30,0	< 100,0	50,0-500,0	≤ 10,0 at 0.1 m distance from the package	0,1

8.2.10 VLLW package emplacement at the landfill must be carried out according to the procedure and within time constraints, envisaged in the landfill design.

8.2.11 VLLW packages with lower dose at the surface are emplaced at the periphery and by the landfill sides.

8.2.12 When allocating VLLW packages, fire safety requirements are to be taken into account.

8.2.13 At the landfill arranged on-site, VLLW may be disposed containing toxic substances of III and IV hazard classes.

8.2.14 VLLW must be disposed in such manner that assures the public and environmental radiation protection for the full period of their potential hazard.

8.2.15 During the operational period of VLLW load at the landfill, the following must be envisaged:

- a roof to avoid atmospheric precipitation ingress into the disposal area (rain, snow);
- a system for stopping both of atmospheric precipitation penetration and emergency underground water ingress;
- collection and treatment of contaminated water and filtrates up to authorized norms.

8.2.16 During VLLW disposal, occupational and public protection is assured through observance of established norms and regulations, as well as by means of the environmental contamination monitoring.

8.2.17 Members of the STS personnel carry out all operations at the landfill, provided that they have special occupational skill to implement necessary set of operations.

8.2.18 Uncontrolled access of unauthorized persons to the disposal facility must be forbidden.

8.2.19 In the course of the VLLW disposal landfill operation, once in five years, operator must carry out safety assessment of disposal taking account operation experience.

8.2.20 VLLW disposal landfill located beyond the industrial site must have a reliable enclosure for the whole period of its potential hazard, which ensures prevention of human intrusion to the landfill (for example, 2 m height concrete fence). If at unauthorized getting in the VLLW disposal facility an individual could be exposed to dose less than 0.3 mSv/year, some warning signs and light enclosure (barbed wire, light concrete fence) are enough.

9 Decommissioning of VLLW disposal landfill

9.1 VLLW landfill life time must be calculated for the period at the end of which the disposal will not pose any radiation hazard (about 10 half-lives of the defining radionuclide)

9.2 After termination of operation, the landfill must be closed and conserved according to the design requirements and criteria, established by the current Russian legislation.

9.3 In the course of conservation, marking must be made on the surface of the landfill construction, according to the requirements of GOST R 52037-2003

9.4 Operator (in terms of the designed solutions; results of radiation safety assessment of the landfill under conservation; potential hazard period of VLLW disposed and by agreement with the bodies designated to implement the state sanitary epidemiological supervision) establishes duration of the post-operational period.

9.5 After termination of operational life of the VLLW disposal landfill environmental monitoring is established for the entire post-operational period (permanent or periodic sampling and some parameter measurements to define the conditions of the system).

9.6 Organization responsible for implementation of radiation situation monitoring and land-using control must be designated at the stage of the landfill conservation.

9.7 SevRAO VLLW disposal landfill closure is possible on the base of safety assessment, the findings of which must determine a scenario of the landfill site future use.

9.8 VLLW landfill further use can be implemented according to one of three scenarios with safety justification and by agreement with the bodies designated to implement the state sanitary epidemiological supervision according to the adopted procedure:

- clearance from regulatory control provided that average specific activity over the landfill as a whole, including containment barriers, will not be higher than 0.3 kBq/kg;
- limited use of the disposed wastes in the economic activity with activity level which is lower than SAMS;
- arrangement of the "brown lawn" within the industrial site, keeping at the same time the landfill under conservation on it.

9.9 Clearance of VLLW disposed at the landfill from regulatory control, must be implemented according to the criteria given in Table 3.

9.10 During clearance of the landfill from regulatory control, requirements must be met similar those for the landfill of industrial waste, management of which is regulated by "Hygienic requirements for allocation and neutralization of industrial waste and consumption residue" (SanPiN 2.1.7.1322-03).

9.11 According to recommendations of international organizations, VLLW disposal landfill located on the industrial site and released from regulatory control must assure non-exceeding of 0.3 mSv/year public dose constraint after closure, taking account possible optimization implementation, as Annex 5 presents.

These requirements are observed if the following equation is valid:

$$\sum_{i}^{n} \frac{a_i}{a_{0i}} \leq 1 \qquad (5.2)$$

where: a_{0i} - maximum specific activity value of i nuclide in the waste if any other radionuclides are absent, when it is released from control, kBq/kg.

Table 3. *Clearance criteria of VLLW disposed at the landfill from regulatory control*

<table>
<tr><td>Full clearance</td><td>Non-exceeding of clearance level by specific activity</td><td rowspan="2">Non-exceeding of annual effective dose man to the critical group
≤ 10 μSv
and collective dose
≤ 1 man-Sv</td><td rowspan="2">Non-exceeding of public exposure level at unintended human intrusion
≤ 0,1 mSv/year
and collective dose
≤ 1 man-Sv/year</td><td rowspan="2">Non-exceeding of public dose constraint of 0,3 mSv/year after closure</td></tr>
<tr><td>Limited clearance</td><td>Excess clearance level</td></tr>
</table>

9.12 Permission for unlimited use of the VLLW disposal landfill site may be received under the positive sanitary epidemiological certificate issued by the bodies designated to implement the state sanitary epidemiological supervision, in terms of findings of investigation, the main goal of which is to confirm that conditions of end-state established by the regulatory body are observed.

9.13. If unlimited use of the site cannot be permitted, adequate control must be kept, providing comprehensive information about radiation situation for human health protection and environmental preservation.

10 Management of waste cleared from regulatory control

10.1 Materials and waste cleared from regulatory control may be removed from the industrial site without any restriction.

10.2 These materials and waste may be used in the economic activity without any restriction. They need not subsequent radiation control implemented by regulatory bodies.

10.3 If there is no any customer for these materials and waste, they may be conveyed to the industrial waste landfill for disposal.

10.4 During STS facility operation and decommissioning, cleared materials and waste (soil, crushed stone etc.) can be used as tamping and isolating materials at VLLW disposal landfill.

10.5 At the industrial site the regulation must be established of the waste clearance from regulatory control. At that, control and account must be set of cleared material amount, their specific activity and type of use or of disposal.

11 Radiation and Toxic control and monitoring

11.1 Radiation dose monitoring of workers, working environment on- and off-site during VLLW management must be a constituent part of overall monitoring at SevRAO, regulated by the Guidance «Hygienic requirements for occupational and public radiation safety assurance during planning and arrangement of SNF and RW management at SevRAO facility No.1» (R 2.6.1.29 – 07) and by the special Guidelines «Radiation monitoring procedure at SevRAO facility No.11»

11.2 System of radiation monitoring must include monitoring arrangement and implementation with respect to radiation situation and occupational doses at all stages of VLLW management including its disposal.

11.3 Radiation monitoring arrangement must include: extent, nature, frequency, account and procedure of the result registration, report forms, reference and acceptable levels of controlled indexes.

11.4 Radiation monitoring must include:

VLLW monitoring at the stage of collection, sorting, treatment, conditioning, storage and disposal;

- Monitoring of radiation situation in workplaces;
- Monitoring of temporary storage sites and disposal landfills;
- Environmental monitoring;
- Personal dose monitoring of workers.

11.5 Radiation monitoring must be implemented both in operation and in post-operation period of the disposal landfill.

11.6 Radiation monitoring of VLLW must provide:

- Measurement of VLLW specific activity and isotope contents;
- Measurement of superficial α-, β- contamination (fixed and non-fixed) of consignment or package;
- Measurement of equivalent gamma dose rate near VLLW consignment or at the surface of metallic wastes (0.1m from the surface);
- Measurement of equivalent gamma dose rate at the surface of package or vehicle (0.1m and 1.0 m from surface);
- Test radiation monitoring of metal scrap samples to find local sources of gamma-radiation in it.

11.7 Radiation monitoring of the storage site and monitoring of the disposal landfill must include monitoring of:

- Equivalent gamma dose rate within the storage site and on the disposal landfill at 1.0 m height from surface of land or of the site, 0.1 m from surface of hardware, construction and landfill;
- Activity concentration and radionuclide composition is samples of surface and ground waters at the site of the landfill location and of waters from ponds nearby the landfill;
- Levels of radioactive contamination of vehicles, equipment, personal protective equipment, the skin and personal clothes of workers;
- Levels of harmful substance concentrations in air of workplaces;
- Levels of contaminant concentrations in common air of the landfill site;

- Levels of harmful chemical substance concentrations in samples of superficial and ground waters in the area of the landfill allocation and of water from ponds nearby the landfill.

11.8 A system of control observational boreholes must be built with the purpose of radiation monitoring of radionuclide release from the disposal area and radionuclide spreading into the environment.

11.9 Systematic monitoring of superficial and ground waters must provide information about release of radioactive and unhealthy chemical substances into the environment during VLLW disposal landfill operation and in the course of its decommissioning.

11.10 Measurement of ground water behaviour and monitoring of water level in test boreholes and contents of radionuclides and chemical substances along the waste landfill perimeter must be performed at least once in a quarter.

11.11 Monitoring of soil conditions is carried out in the range of impact of waste disposed (soil of areas nearby the landfills), is places of interim waste storing. The extent of investigation and listing of test monitoring parameters is defined on case-by-case basis taking account objectives agreed with the bodies implementing the state sanitary epidemiological supervision.

11.12 Extent and parameters of radiation monitoring of the STS HPZ and SA territories had been specified in the Guidance «Criteria and norms for remediation of sites and facilities from federal state unitary enterprise «SevRAO», contaminated with man-made radionuclides» (R 2.6.1. 25 – 07)

11.13 Types and extent of radioecological monitoring must be determined at the design stage. The extent of investigations and listing of test monitoring parameters is defined on case-by-case basis taking account objectives agreed with the bodies implementing the state sanitary epidemiological supervision.

11.14 Contents of chemical contaminants in the environment are defined using methods involved in MAC justification or other methods, which have metrological certificate and are included into the state inventory of methodologies and procedures.

11.15 Some special guidance documents define methods and procedures of radiation monitoring.

11.16 The procedure of radiation monitoring must provide:

- determination of specific activities in samples with total relative error of not more than 20 %;
- measurement of gamma dose rate at the distance of 0.1 m from the waste surface and in workplaces with the confidence parameter of the lower boundary not higher than 0.1 μSv/h;
- determination of non-fixed radioactive contamination of working surfaces with alpha- and beta-active radionuclides at the level, which is not higher than 0.1 and 1.0 part/(cm^2*min), respectively;
- determination of total dustiness of air in the area of workers' breathing with the confidence value of the lower bound not higher than 1mg/m^3.

11.17 The radionuclide composition and total specific activity of VLLW must be determined in terms of each isotope contribution according to results of gamma spectrometry analysis.

11.18 Sampling must be representative regardless the waste aggregative state (metallic construction, construction debris, filters, special clothes or dispersed wastes – ashes, soil etc.), because each type of wastes has different contamination.

11.19 All investigations must be performed in laboratories under the appropriate accreditation.

11.20 Results of industrial inspection are registered in special journals; this information is used for assessment of radiation and hygienic situation during VLLW management, and as necessary – for elaboration of organizational, engineering and sanitary-epidemiological actions directed to reduction of occupational doses and environmental contamination. The results of radiation monitoring are registered in radiation-hygienic certificate of SevRAO facility annually, according to the guideline document.

11.21 The design of the disposal landfill defines the extent and duration of post-operational monitoring; they could be corrected as necessary during its closure in terms of safety assessment taking the existing situation into account. The local department of FMBA RF approves the procedure of post-operational monitoring.

12 Occupational and public dose monitoring

12.1. Personal dose monitoring of workers involved in the system of VLLW management and disposal depends upon the type of operations performed; it must include:

- radiometry monitoring of the skin and PPE contamination;
- monitoring of radioactive substance intakes;
- monitoring of external beta, gamma and roentgen radiations.

12.2. Effective occupational doses must be calculated on the base of monitoring results.

12.3. Group dose monitoring must be performed in order to determine group effective (committed at internal exposure) occupational and public doses on the base of radiation situation monitoring.

12.4. The special guidance documents approved by FMBA RF regulate the procedure of dose monitoring.

12.5. Individual doses of workers involved in VLLW management are accounted according to the adopted procedure.

Appendix 1

Maximum specific activities of radionuclides in metals, at which their unlimited use is permitted within Russian Federation (Hygienic regulations «Man-made radionuclide contents in metals», GN 2.6.1.2159-07):

Radionuclide	Permissible specific activity a_{0i}, kBq/kg
^{54}Mn	1,0
^{65}Zn	1,0
^{94}Nb	0,4
$^{106}Ru+^{106m}Rh$	4,0
$^{125}Sb+^{125m}Te$	1,6
^{134}Cs	0,5
$^{137}Cs+^{137m}Ba$	1,0
^{152}Eu	0,5
^{154}Eu	0,5
$^{90}Sr+^{90}Y$	10,0
^{226}Ra	0,4

If there is radionuclide mixture in the metal (or some product based on it), its unlimited use within Russian Federation is permitted only in case when the following equation is valid:

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

where: n - number of different radionuclides in the metal;
a_i - specific activity of i-th radionuclide in the metal, kBq/kg;
a_{0i} - permissible specific activity value of i-th radionuclide in the metal, as it is given in the table, kBq/kg.

For all radionuclides, which are absent in the table a_{0i} = 0,3 kBq/kg is used.

Appendix 2

Recommended form of the Journal of registration of very low level wastes entering for interim storage

No. 1	Date of the waste reception	VLLW name and type of waste	Source of VLLW and date of reception	Number of container-collector	Mass and volume of waste	EDR at distance of 0.1 m from VLLW	Superficial contamination of VLLW	Radionuclide composition	Specific activity of VLLW	Name and signature of the person responsible for VLLW	Name and signature of recipient of VLLW for storage
1	2	3	4	5	6	7	8	9	10	11	12

Recommended form of the Journal of registration of very low level wastes entering for disposal

No.1	Name of division where wastes are come from	Name and type of waste	Radionuclide composition	Specific activity of VLLW	Waste amount (mass, volume, amount of containers)	Superficial contamination of VLLW	Total activity	EDR at distance of 0.1 m from the waste	Place of burial	Signature of the responsible person performed disposal
1	3	4	5	6	7	8	8	9	11	12

Appendix 3

Procedure of harmful substance hazard class establishment

(GOST 12.1.007-76 Harmful substances. Classification and general safety requirements)

This standard covers harmful substances, which are contained in raw material, products, half-finished products, and industrial wastes, and establishes general safety requirements for their manufacturing, application and storage.

The standard does not cover harmful substances containing radioactive and biological substances (complex biological combinations, bacterium, microorganisms etc.).

Class of hazard of harmful substances is established depending upon norms and indexes given in the table.

Name of index	Norm for class of hazard			
	1-го	2-го	3-го	4-го
Maximum acceptable concentration (MAC) of harmful substances in air of working area, mg/m^3	Less than 0,1	0,1-1,0	1,1-10,0	More than 10,0
Average fatal dose at intake in stomach, mg/kg	Less than 15	15-150	151-5000	More than 5000
Average fatal dose at putting on the skin, mg/kg	Less than 100	100-500	501-2500	More than 2500
Average fatal concentration in air, mg/m^3	Less than 500	500-5000	5001-50000	More than 50000
Coefficient of possible inhalation poisoning (CPIP)	More than 300	300-30	29-3	Less than 3
Area of acute exposure	Less than 6,0	6,0-18,0	18,1-54,0	More than 54,0
Area of chronic exposure	More than 10,0	10,0-5,0	4,9-2,5	Less than 2,5

Ascription of a harmful substance to class of hazard is implemented depending upon index, a value of which corresponds to the highest class of hazard.

Appendix 4

Terms and definitions

The Guidance uses the following terms and definitions:

Acceptance rate of the landfill – total activity of all wastes, which could be received by the landfill according to the design.

Approximate safe exposure level of harmful substance (ASEL) – concentration of the toxic substance in common air not affecting human health.

Certificate, sanitary epidemiological - document confirming compliance (incompliance) with sanitary rules with respect to factors of the habitat, economic and other activity, production, work and services, as well as draft regulative acts, operational documentation.

Controlled access area – workshops at SevRAO SNF&RW STS, where workers from group A can be exposed to radiation factors.

Hazard class of waste (toxicity) - quantitative waste characteristic specifying its type and level of hazard (toxicity).

Hazardous waste – waste containing detrimental substances, which either has hazardous properties (toxicity, explosive risk, fire risk, high reactivity), or contains infectious agents, or may represent an actual or potential threat for the environment and human health either directly or in contact with other substances.

Hazardous waste certificate - document confirming that the waste belongs to a particular hazard class, and containing information on the waste composition.

Health protection zone - an area around the radiation source, where individual exposure level, at routine operation of the particular radiation source, can exceed the authorized dose of the public exposure.

Industrial waste - remainder of raw material, half-finished products, materials, apparatus and equipment, being become useless in the course of manufacturing, as well as structure units of buildings and constructions, which are to be demolished in the course of the facility decommissioning.

Industrial waste and consumption residue - remainder of raw material, half-finished products, materials or other products, being generated in the course of manufacturing or consumption, as well as goods (manufacture) lost its consumer properties.

Industrial wastes cleared from regulatory control – wastes containing man-made radionuclides with specific activity levels, which are not higher than the clearance level.

Landfill for solid conventional (domestic) waste - special building for isolation and, as necessary, specially equipped to be suitable for disposal and neutralization of solid conventional wastes, which building ensures sanitary and epidemiological safety of the public.

Maximum acceptable concentration – the state hygienic regulation of the industrial environment quality, intended for prophylactics of unhealthy impacts of toxic factors on workers' health, which regulation is also applied at the stage of design of the industrial buildings, technological processes, equipment, and ventilation, for control purposes.

Monitoring – permanent or periodic sampling and measurements of the particular parameters with the purpose of definition of the system conditions.

Operation life of the landfill – period of the landfill operation during its loading and conservation.

Post-operational period of the landfill – period of the landfill operation after its conservation. Post-operational period consists of:

- controlled period (monitoring) from conservation till confirmation of safety;
- uncontrolled period since release from control till closure.

Radiation safety of the public **—** condition of protectability of the present and future human generations against unhealthy impact of ionizing radiation.

Radioactive contamination – presence of radioactive substances on the surface, inside material, in air, in human's body or in any other place, in amount exceeding levels given in NRB-99 and OSPORB-99.

Radionuclide capacity of SevRAO VLLW landfill – maximum value of total activity of radionuclides in VLLW being allocated on the landfill within the designed operation life of SevRAO SNF&RW STS taking its decommissioning into account. This value is defined at the stage of design in terms of radiation safety and protection criteria and VLLW nuclide composition

Supervised area – a territory beyond the health protection zone, where radiological monitoring is performed.

Toxic waste - waste containing substances, which, if released into the environment, present or may present a threat for human health.

Unused waste – waste, which cannot be currently used in the national economy or its use is unreasonable taking economic, ecological and social factors into account.

Very low level waste – waste containing radionuclides with specific activity levels, which are higher clearance criterion, but not needed strong containment and isolation, and, therefore, suitable for disposal in shallow facilities under limited regulatory control. Such shallow facilities may contain other hazardous wastes too. Construction debris and soil with low activities are specific wastes from this class.

Waste and/or waste package consignment **-** separate amount of waste and/or waste packages in the place of waste collection and/or interim storage, handling for removal from the workshops of the controlled access area into the uncontrolled area and/or for transportation from SevRAO SNF&RW STS.

Waste disposal - isolation of waste unsuitable for further use, in special repositories to limit release of hazardous substances into the environment with no intention to take further management action with respect to that waste.

Waste in use - waste, which is in use in the national economy as a raw material (half-finished product) or as addition to it, with the purpose of manufacture of the secondary productions or fuel, both within the facility where the waste used is generated, and outside it.

Waste management - types of activity relating to documented (including certified) arrangemental and technological operations of waste management regulation, including prevention, minimization, account and control of waste generation, accumulation, collection, allocation, decommissioning, neutralization, transportation, storage, disposal and transboundary conveyance.

Waste neutralization - waste treatment, including incineration and decontamination using special installations, in order to prevent harmful waste impact on human health and environment.

Waste sorting - waste separation and/or mixture into constituents of different quality according to the certain criteria.

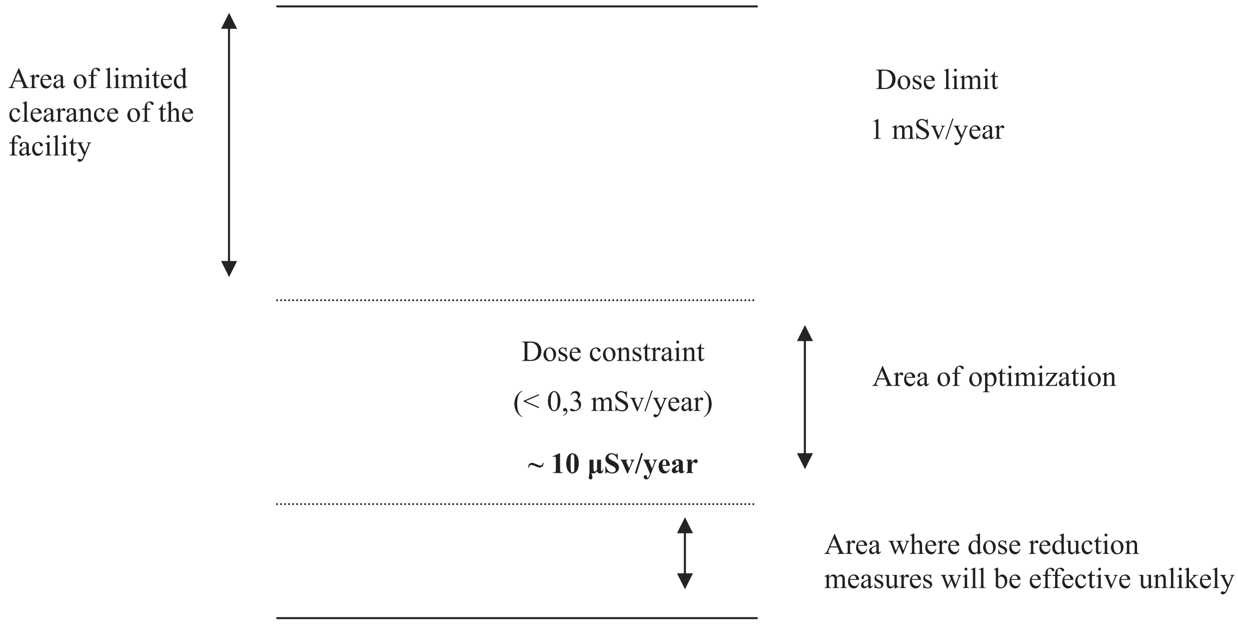
Waste storage - waste keeping in the facilities of waste allocation with the purpose of its later disposal, decontamination or use.

Waste transportation - an activity involving waste conveyance between places or facilities of their generation, accumulation, storage, decommissioning, disposal and/or elimination.

Workers (personnel) **–** persons whose occupation deals with man-made radiation sources (group A) or persons whose occupation implies their falling into the area of impact of such sources within the industrial site of SNF and RW STS (group B).

Appendix 5

Approach to the facility clearance optimization



Appendix 6

List of Acronyms

AMS	activity of minimum significance
ASEL	approximate safe exposure level
ASL	approximate safe level
BOD20	biochemical oxygen demand
CAA	controlled access area
COD	chemical oxygen demand
CPIP	coefficient of possible inhalation poisoning
FMBA RF	Federal medical-biological agency of Russian Federation
FSUE SevRAO	Federal state unitary enterprise "Northern federal enterprise for radioactive waste management"
HPZ	health protection zone
IAEA	International Atomic Energy Agency
LLW	low level waste
MAC	maximum acceptable concentration
NRB-99	Russian abbreviation of radiation safety standards
OSPORB-99	Russian abbreviation of the main sanitary rules of radiation safety assurance
RW	radioactive waste
SA	supervised area
SAMS	specific activity of minimum significance
SanPiN	Russian abbreviation of sanitary rules and regulations
SCW	solid conventional waste
SNF	spent nuclear fuel
SPORO-2002	Russian abbreviation of sanitary rules of radioactive waste management
SRC-IBPh	State research centre - Institute of Biophysics
SRW	solid radioactive waste
VLLW	very low level waste
VNIIAES	Russian abbreviation of All-Russian research institute of NPP operation
VNIPIET	Russian abbreviation of All-Russian design and research institute of complex energetic technology

Appendix 7

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4. «Technological and organizational aspects of radioactive waste management» Learning course series, No.1 27, IAEA, Vienna, 2005, 230 pp.
5. «Safety assessment of shallow radioactive waste disposal» Safety regulation series, No.1 WS-G-1.1 IAEA Safety guidance, Vienna, 1999, 44 pp.
6. «Regulatory control of radioactive releases into the environment» Safety series, No.1 WS-G-2.3 IAEA Safety guidance, Vienna, 2005, 66 pp.
7. «Pre-disposal management of radioactive waste including decommissioning» Safety requirements. Safety series, No.1 WS-R-2 IAEA Vienna, 2003, 42 pp.
8. «Pre-disposal management of radioactive wastes of low and intermediate activities» IAEA Safety guidance. Safety series, No.1 WS-G-2.5, Vienna, 2005, 79 pp.
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11. Guidance «Hygienic criteria for occupational and public radiation safety assurance at planning and arrangement of SNF and RW management at SevRAO facility No.1» (R 2.6.1.29 – 07). Approved by Deputy Head of FMBA RF, State Chief medical officer on facilities and sites serviced VV Romanov 19 May 2007, Federal medical-biological agency, 2007. – 41 pp.

Annex 5 Arrangement of the environmental radiation monitoring in the operational area of the Federal state unitary enterprise "Northern federal enterprise for radioactive waste management" of the Federal Atomic Energy Agency

State sanitary and epidemiological regulation of Russian Federation

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2.6.1. IONIZING RADIATION, RADIATION SAFETY

Arrangement of the environmental radiation monitoring in the operational area of the Federal state unitary enterprise "Northern federal enterprise for radioactive waste management" of the Federal Atomic Energy Agency

Guidelines

MU 2.6.1. 37 - 2007

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1. Arrangement of the environmental radiation monitoring in the operational area of the Federal state unitary enterprise "Northern federal enterprise for radioactive waste management" of the Federal Atomic Energy Agency: Guidelines.- M: Federal medical-biological agency, 2007. – 27 pp.
2. The Guidelines have been developed: FSUE State research centre - Institute of biophysics at FMBA of Russia (L.A. Ilyin, N.K. Shandala, N.Ya. Novikova, A.V. Titov, T.I. Gimadova, F.K. Levochkin, N.P. Sajapin, V.A. Seregin, E.G. Metlyaev), Federal medical-biological agency (V.R. Alekseeva), FSUE «SevRAO» (A.N. Krasnoshchekov, P.A. Rekunov).
3. The Guidelines have been recommended for approval by FMBA RF sub-commission for the special regulation of Commission for the State sanitary and epidemiological regulation of Rospotrebnadzor (protocol No.1 41 of 19 December, 2007).
4. The Guidelines have been approved by the Deputy Head of the Federal medical-biological agency, State Chief medical officer on sites and facilities serviced V.V. Romanov.
5. The Guidelines are being introduced since 01 February, 2008.
6. First entering into force.

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«25» __________ 2007 г.

Approved

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Introduction date: 1 February, 2008

2.6.1. IONIZING RADIATION, RADIATION SAFETY AND PROTECTION

Arrangement of the environmental radiation monitoring in the operational area of the Federal state unitary enterprise "Northern federal enterprise for radioactive waste management" of the Federal Atomic Energy Agency

Guidelines

MU 2.6.1. 37 – 07

1. Scope

1.1. The Guidelines "Arrangement of the environmental radiation monitoring in the operational area of the Federal state unitary enterprise "Northern federal enterprise for radioactive waste management" of the Federal Atomic Energy Agency" (hereinafter referred to as ***MU***) regulate sanitary hygienic and organizational requirements for arrangement and implementation of radiation hygienic monitoring and supervision of environmental radioactive contamination within the health protection zones (hereinafter referred to as HPZ) and supervised areas (hereinafter referred to as SA) of sites for spent nuclear fuel (SNF) and radioactive waste (RW) temporary storage (hereinafter referred to as SNF&RW STS), resulted from the past activity of the former Navy bases and current industrial activity of SNF&RW STS of the Federal state unitary enterprise "Northern federal enterprise for radioactive waste management" of the Federal Atomic Energy Agency (SevRAO). The major objective of such regulation is to assure radiation protection of the public living in the supervised area of SevRAO nuclear and radiation hazardous facilities.

1.2. The ***MU*** methodological base is research radiation hygienic monitoring, which can be defined as a system of comprehensive dynamic surveillance, including long-term permanent control both over radiation hygienic situation parameters and public doses in the areas of radiation hazardous facility allocation.

1.3. The ***MU*** establishes requirements for arrangement and implementation of radiation hygienic control (selection of supervision points, specification of controlled parameters, frequency and extent of examination) in the following situation:

- in the course of SNF&RW STS routine operation;
- in the course of SNF&RW removal from the SNF&RW STS building and constructions;
- in the course of radiological accident.

1.4. The ***MU*** are intended for specialists of FMBA territorial bodies and centers of hygiene and epidemiology responsible for supervision (control) over occupational and public radiation protection in SNF&RW STS impact areas.

Radiation protection teams at SevRAO facilities can apply the ***MU*** in the course of environmental radiation monitoring on-site STS; designers can also apply the ***MU*** in the course of the environmental monitoring system development.

1.5. SevRAO facility can apply the ***MU*** when developing the program of environmental radiation monitoring in HPZ and in SA within overall monitoring of the facility, which program is approved by the Chief engineer of the facility and coordinated with the Chief of FMBA territorial body.

2. Regulative references

The Guidelines had been developed on the base of and accounting the following RF laws and other regulative documents**:**

Federal law of 30 March 1999 No.1 52-FZ on «Sanitary and Epidemiological Prosperity of the Public» with amendments of 22 August 2004 No.122-FZ (RF Legislation Collection of 5 April 1999, No.14, p. 1650 with amendments of 30.12.2001 No.196-FZ 2002 No.11 Article 2; of 10.01.2003 No.186-FZ, 2003 No.127 part 1 p.2700; of 22.08.2004 No.122-FZ, 2004.No.1 35 p.3607; of 09.05. 2005 No.145 – FZ, 2005 No.19 p.1752);

Federal law of 9 January 1996 No.1 3-FZ on «Radiation Protection of the Public» (RF Legislation Collection of 15 January 1996 No.1 3 p. 141);

Federal law of 10 January 2002 No.1 7-FZ on «Preservation of the Environment» (RF Legislation Collection of 14 January 2002, No.1 2, p. 133);

Federal law of 2 January 2000 No.1 29-FZ on «Quality and Safety of Foods» (RF Legislation Collection of 10 January 2000 No.1 2 p. 150);

RF Federal law of 27 April 1993 No.1 4871-1 on «Measurements Uniformity Assurance» (Bulletin of Congress of RF national deputies and RF Supreme Soviet of 10 June 1993, No.1 23 p. 811);

RF Water Codex of 3 June 2006 No.1 74-FZ (RF Legislation Collection, 1995, No.1 47 p. 4471);

Federal law of 3 June 2006 No.1 73-FZ «About the RF Water Codex introduction»;

RF President Order of 11 October 2004 No.1304 on «The Federal Medical-Biological Agency» (RF Legislation Collection, 2004, No.1 42, p.4107);

RF Government Directive of 15 December 2004 No.1 789 «Issues of the Federal Medical-Biological Agency» (RF Legislation Collection, 2004, No.1 51, p.5202);

RF Government Directive of 11 April 2005 on «The Federal Medical-Biological Agency» (RF Legislation Collection, 2005, No.16, p.1456);

RF Government Directive of 15 September 2005 No.1 569 on «Provisions of the State Sanitary and Epidemiological Supervision Implementation in Russian Federation (RF Legislation Collection of 26.09.2005, No.1 39, p.3953);

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Listing of organizations and Listing of sites, falling into the area of the Federal medical-biological agency service, approved by the RF Governmental Directive of 21 August, 2006 No.1156-r (amended 16 December, 2006 No.1745-r) (RF Legislation Collection, 2006, No.1 52 (part III) p. 5614, No.1 49 (part II) p. 5267);

Standards of radiation safety (NRB-99). SP 2.6.1.758-99, approved by the RF State Chief medical officer 02 July 1999. (Need not the state registration, according to the Mail from the RF Ministry of Justice of 29.07.1999 No.1 6014-ER);

Main sanitary rules of radiation safety (OSPORB-99). SP 2.6.1.799-99, approved by the RF State Chief medical officer 27.12.1999 (Need not the state registration, according to the Mail from the RF Ministry of Justice of 01.06.2000 No.1 4214-ER);

Sanitary rules of radioactive waste management (SPORO-2002). SP 2.6.6.1168-02, approved by the RF State Chief medical officer directive of 23.10.2002 No.1 33. Registered in the RF Ministry of Justice 06.12.2002, registration No.1 4005 (Bulletin of regulative acts of the federal authorities of 20 January 2003 No.1 3);

Sanitary rules. Hygienic requirements for safety and food costs of foodstuffs. SanPiN 2.3.2.1078-01. Approved by the RF State Chief medical officer 14 November 2001 No.1 36. Registered in the RF Ministry of Justice 22 March 2002. Registration No.1 3326 (Bulletin of regulative acts of the federal authorities of 3, 10 June 2002, N 22, 23);

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Guidelines MUK 2.6.1.1194-03 "Radiation monitoring. Strontium-90 and Cesium-137. Foodstuffs. Sampling, analysis and hygienic assessment", approved by the RF State Chief medical officer 20 February 2003.

3. Terms and definitions

The Guidelines use the terminology in compliance with NRB –99, OSPORB –99, and MR 2.6.1.27-03 [1, 2, and 3]. In addition, the following terms are in use.

Aspiration method – method for determination of radioactive aerosol contents in air by means of air infiltration (air passing through filter material) using centrifugal electric fan (aspiration installation), (Bq/m^3).

Radiation measurements - measurements of values and parameters, specifying sources and fields of ionizing radiations, as well as radiation exposure to different subjects, including people.

Information value of radiation monitoring - ability of reliable detection of radioactive effluent/discharge impacts due to the facility using radiation monitoring and control methods, adopted in the industrial branch.

Control - test, verification or surveillance with the purpose to confirm compliance with the established (authorized) regulations.

Radiation hygienic control of the environmental media - a set of organizational engineering actions to control radioactive substance contents in the environmental media.

Littoral (intertidal) zone – a part of seabed, restricted by tidal oscillations, inhabited by animals and plants.

Monitoring - a system of permanent examinations and control, implemented according to the certain program with the purpose to assess the environmental conditions, analyze process occurred and timely find tendencies of environmental change.

Minimum measurable activity – activity of the radionuclide in the sample, at measurement of which using the particular radiometry installation during exposition time of 1 hour, the relative random (statistic) uncertainty of the result is 50% at confidence probability P=0.95

Controlled parameter - physical quantity specifying radiation properties of radiation control subject.

Dietary intake – intake (daily, annual) of main food groups by individual.

Contamination density - ratio between the radionuclide activity at the surface of material and the superficial area of this material, kBq/m^2

Inhalation intake - intake of radioactive substance via respiratory organs (including substances, occurring finally in the digestive system).

Foodstuffs - foods, which an individual eats either in natural form or after cooking.

Industrial site - protected and enclosed area for allocation of industrial, administrative, sanitary domestic and auxiliary buildings, constructions and other units of the enterprise.

Resident area - territory, at which residential areas as well as streets and squares etc. between them are located.

Sedimentation - deposition of water- or gas- suspended solid particles, due to gravity effect.

Sedimentation method – method for determination of local precipitation density from air, which precipitations are contaminated with radioactive substances, (Bq/m^2 /days, month, year)

Supra-littoral zone- a part of seabed (coastal strip), located above the highest tide, inhabited by animals and plants

Sub-littoral zone- a part of seabed, adjacent to littoral zone, which is always covered with water, up to 200-500m depth, inhabited by animals and plants

Check point - a section of the environmental media (territory, pond etc.), which is affected by man-made sources and which is the subject of radiation hygienic monitoring.

Background check point - a section of the environmental media (territory, pond etc.), which is not affected by man-made sources and which is the subject of radiation hygienic monitoring in order to identify the extent of impact and dynamics of man-made sources on the controlled areas.

4. General provisions

4.1. The Guidelines supplement available regulative and legislative acts relating to the public radiation protection assurance and regulate the procedure of radiation hygienic control and monitoring implementation within SevRAO SNF&RW STS.

4.2. Radiation situation in HPZ and in SA of SNF&RW STS had been resulted from the past activity of the former Navy bases and current industrial activity of SevRAO during remediation of STS areas.

Industrial activity of SNF&RW STS identifies a nature of the site radioactive contamination, specifies parameters and extent of radiation hygienic control and monitoring.

4.3. The radiation control teams of the facility and FMBA centers of hygiene and epidemiology perform radiation control at SevRAO facilities within HPZ and SA areas [4].

4.4. Depending upon the task under solution, the following types of control exist:

- control to check that the current regulations are not exceeded (hereinafter referred to as control);
- control to study accumulation and behaviour of radionuclides in the environment (hereinafter referred to as monitoring).

4.5. The extent of radiation control in HPZ and in SA must provide information about radiation situation parameters at routine operation of the facility, during STS area remediation and in the course of radiological emergency; occupational doses for workers from the personnel B group under conditions of the facility routine operation, and doses for the public living within SA.

4.6. The extents of control and monitoring must be rather sufficient to solve the following tasks:

- to define how radiation safety principles and regulation requirements are observed;
- in terms of underground water conditions, to obtain necessary information about environmental impact dynamics of STS contamination sources;

- to assess dynamics of accumulation and migration of radionuclides in the controlled area, in water and in food chains and to make long-term prediction of radiation situation development;
- to calculate annual effective (equivalent) dose of the public exposure, which is design value defined on the base of radiation monitoring results with respect to environment, foods and drinking water, in terms of local features of foodstuffs, water supply and structure of the public food intake.

The samples examined must characterize conditions of the environmental contamination at the places of sampling. The amount of samples must be sufficient to provide valid results suitable for investigation of accumulation and behavior of radionuclides in the environment (uncertainty of main radiation situation parameter assessments must not be higher than 50 %).

4.7. On the instructions of FMBA territorial bodies, specialists from industrial and sanitary laboratories of FMBA centers of hygiene and epidemiology perform the test sampling of radioactive contamination of common air and precipitation, soil, plants, seaweeds, bottom sediments in offshore seawaters and water from open ponds within the facility industrial site (in check points specified in compliance with the radiation control regulation of the facility), in HPZ and SA - in check points selected according to the ***MU***.

Performance of radiation control and monitoring of the environmental media within SA, including foods and drinking water, is a priority direction of activity implemented by specialists from Centres of hygiene and epidemiology.

4.8. Organizations, responsible for radiation control implementation and for surveillance of the radiation situation at the sites, must be provided with legislative, regulative, and methodical documentation, as well as they must be equipped with the relevant dosimetry and radiometry instrumentation. The personnel must be educated at the special training units (licensed for this type of activity) to become familiar with research methods applied during radiation control.

4.9. In pursuance of the RF Law «About measurements uniformity assurance» in the course of area and laboratory tests, measuring tools and methods are to be used, which have certificate of metrological attestation and which are permitted for application according to the adopted procedure.

5. Arrangement of radiation monitoring in health protection zone and supervised area at routine operation of SNF&RW STS

5.1. Main requirements for HPZ and SA of SNF&RW STS

5.1.1. At SNF&RW STS routine operation, within HPZ area, the exposure level can exceed the authorized public dose limit - 1.0 mSv/year. At the outer HPZ border, under conditions of routine operation, the public dose (1.0 mSv/year) must not be exceeded; while under conditions of design basis accident, the public exposure dose must not be higher than 5 mSv/year [1 -5].

5.1.2. SA is a territory beyond HPZ, on which radiation control is carried out. The inner SA boundary coincides with the outer HPZ boundary.

Public radiation exposure within SA beyond HPZ during design basis accidents must be limited by the value of maximum annual limit for the public (5 mSv), because in this case protective measures are unnecessary [1].

The outer SA boundary is limited by information value of radiation monitoring on this territory, under condition of routine facility operation and at possible emergencies. Here, information value means an ability of reliable detection of radioactive effluents/discharges impact by means of radiation control and monitoring methods applied in the particular industrial branch. Radiation exposure to the critical group of population beyond SA during design basis accidents must be limited by the value of annual dose limit for the public (1 mSv) [4, 5].

5.1.3. With the purpose of practical control implementation, in terms of doses regulated and requirements for dose parameters of radiation control, some reference levels are established for the main controlled parameters. The reference levels are calculated in accordance with established procedure.

5.2. Selection of radiation situation check points in HPZ and in SA

5.2.1. Check points being selected for measurement of controlled radiation parameters (directly or by means of sampling in these points), specifying radiation situation, must describe special features and impact tendencies of past and current industrial activity, as well as features and impact tendencies of SNF&RW STS existence, with respect to the environmental radiation conditions.

5.2.2. When selecting check points within HPZ, special features must be accounted of radiation situation generation due to the presence of facilities for liquid radioactive waste (LRW) and solid radioactive waste (SRW) temporary store on the industrial site, repositories of irradiated fuel assemblies (IFA), control bore-holes, floating tanks for LRW in the marine offshore waters etc.

5.2.3. When selecting check points, extent of contamination source impact within HPZ must be evaluated in terms of gamma dose rate, beta fluence density in situ and radioactive contamination of soil at different distances from the contamination source.

5.2.4. Check points for sampling in marine offshore waters (seawater, bottom sediments, seaweeds and sea animals) within HPZ are selected having in mind possible impact of industrial contaminators located on the industrial site and within HPZ during routine and remedial operations.

5.2.5. If there is the marine offshore waters in HPZ, check points are selected in the coastal strip - in the supra-littoral zone - such part of seabed, which is located higher than the highest tide, but surrounding by seawaters at strong wind and storm, and in the sea - at the site within tidal oscillations (littoral zone) [6].

5.2.6. In the course of routine STS operation and during SNF&RW removal, SA borders and area of SA territory in the marine offshore waters are specified using topographic specification of the sea and coastal area.

5.2.7. Within SA, check points for sampling (seawater, bottom sediments, seaweeds and sea animals) during routine and remedial operation are selected having in mind possible impact of industrial contaminants (located on the industrial site and within HPZ) on the marine offshore waters.

Check points in SA within the marine offshore waters are selected in the littoral zone (such part of seabed, which is limited by tidal oscillations) and in the top horizon of the sub-littoral zone (shallow water part of the sea shelf, which is always covered with water), because the majority zoobenthos is examined in shallow water.

5.2.8. Background check point in the marine offshore waters is selected beyond area of man-made impact spreading both of SNF&RW STS, and LRW canisters in the marine offshore waters etc.

5.2.9. When selecting check points on land within SA, special features must be taken into account of radiation situation generation following the past and current industrial STS activity, as well as radiation background in situ, landscape (forest, mountains, lakes, rivers etc.), hydrogeological and geochemical nature of the territory under control (type of soil, mineral composition etc.).

Check points are established in areas with the highest and the lowest gamma dose rates in situ, located in places with different types of soil, as possible.

The background check point is selected beyond area of possible facility's impact, at the leeward side, taking the predominant wind direction into account.

5.2.10. Specialists from the radiation safety division of the facility participate in identification of check points for radiation hygienic monitoring with the purpose of long-term supervision during planned remediation of sites and STS buildings, and these points are considered as reference ones. In the course of check point selection during monitoring, STS remediation plan should be taken into account, in addition to results of the laboratory radiation control implemented at the facilities.

5.2.11. The number of fixed check points in SA must provide portliness of radiation parameters and must be sufficient for the spatial specification of radioactive substance content levels on the territory under control.

5.2.12. Drinking water sampling is performed from each water pool or artesian hole used for drinking water supply.

5.2.13. Settlements located within SA or in its vicinity serve as subjects of surveillance. The amount of check points in the settlement depends on its area; the points are located: at the entrance, at the exit and 2-3 points are on-site, while near the settlement – by one point in the largest forestlands, ponds (including that in the sea), in places of industrial fishing, and in gathering areas of mushrooms and wild berries.

The nearest settlement from the leeward side (taking predominant wind direction into account), which does not affected by man-made impact of SNF&RW STS, is selected as reference background point.

5.2.14. Selection of check points within radiation hygienic environmental monitoring performed within HPZ and SA must be coordinated with radiological division of the radiation safety department of the facility.

5.3. Necessary controlled radiation parameters

5.3.1. Selection of controlled parameters at routine operation of SNF&RW STS depends upon the nature of contamination sources, generating radiation situation on-site; it is carried out according to the regulation of the facility radiation control.

5.3.2. Controlled parameters within HPZ and SA of the facility are as follows:

- gamma dose rate in check points within HPZ, SA, in controlled settlements and in their vicinity (forestlands, farmlands etc.), μSv/h;
- external doses in situ and in the marine offshore waters, determined using thermo- luminescent dosimetry method;
- gross alpha and beta activity of aerosols as well as ^{90}Sr, ^{137}Cs, and ^{60}Co activities in near-land air and precipitations, Bq/m^3, Bq/m^2 .
- specific gross alpha and beta activity as well as ^{90}Sr , ^{137}Cs, and ^{60}Co specific activities in drinking water and water from open ponds (including that in seawater), Bq/l;
- activity concentrations of ^{90}Sr ,^{137}Cs, and ^{60}Co in ground waters, Bq/l;
- specific activities (contamination densities) of ^{90}Sr and ^{137}Cs in soil and in bottom sediments, Bq/kg (kBq/m^2);
- specific activities (contamination densities) of natural radionuclides in soil: ^{40}K, ^{226}Ra and ^{232}Th, which are necessary to account their contribution into gamma dose rate, Bq/kg (kBq/m^2);
- specific activities of ^{90}Sr ,^{137}Cs, and ^{60}Co in vegetation (grass, seaweeds), Bq/kg;
- specific activities of ^{90}Sr ,^{137}Cs, and ^{60}Co in local foods: sea- and fresh-water fish, seafood, venison, game, berries, mushrooms etc., Bq/kg;
- specific activities of ^{90}Sr and ^{137}Cs in imported foods (bread and bakery foods, meat and meat foods, milk, vegetables, fruits etc.), Bq/kg.

5.3.3. In order to specify the environmental contamination nature and tendency in check points selected, monitoring of the following environmental media parameters is carried out:

- gross activity concentrations and specific activities of ^{90}Sr , ^{137}Cs, and ^{60}Co in water from control boreholes, in spring waters from melted snow, in check points of the HPZ coastal strip (supra-littoral zone) and in the littoral zone in the areas of contamination source impact, Bq/l;
- specific activities (contamination densities) of ^{90}Sr , ^{137}Cs, and ^{60}Co in soil and bottom sediments of the coastal strip and in the littoral zone, Bq/kg (kBq/m^2);
- specific activities of ^{90}Sr ,^{137}Cs, and ^{60}Co in vegetation (grass, seaweeds of the littoral zone), Bq/kg;
- specific activities of ^{90}Sr ,^{137}Cs, and ^{60}Co in seafood (fish, molluscs), inhabited the area of selected check points of the coastal strip.

5.3.4. The results of radiation monitoring serve as a basis for calculation of current internal and external public doses.

5.4. Requirements for implementation of environmental radiation control and monitoring. Extent and frequency of examination

5.4.1. Gamma dose rate control within HPZ and SA is performed in fixed points, location of which is specified in Para 5.2 of the present ***MU***.

Wearable dosimeters with 20 keV lower limit of energy dependence should be used in the course of photon dose rate measurements.

In the course of sampling check points establishment, gamma survey data are taken into account. As necessary, alpha and beta rates are also measured in the points of gamma background measurement. The measurements are performed according to the instruction for application of the relevant devices [7].

The recommended frequency of dose rate measurement is at least monthly in HPZ, while in SA – at least twice in a year.

5.4.2. In order to obtain data on external dose fields for the purpose of operative control in case of emergency contamination or contamination during SNF&RW removal from STS territory, permanent dose control is performed in check points using the stable thermo-luminescent dosimeters. Dosimeters from DVG-02T detector kit based on lithium fluoride in DTU cassettes should be used as gamma dosimeters. MKD dosimeters (multi-layer skin dosimeters) from the same kit are recommended to use for beta-gamma dose measurement. Assembly consisted of two dosimeters must be packed and welded in opaque plastic sachet of 150-200 μm thickness to avoid penetration of dust and moisture. Dosimeters of mentioned types must be set together in such manner that MKD dosimeter window is screened neither by gamma dosimeter nor by clips. To avoid dosimeter screening by walls of buildings and constructions, they must be set in the open places not closer than 10 m from stone, brick and Ferro concrete buildings. In cities and in settlements, such assemblies are preferably to set on sites of administrative, industrial, treatment, meteorological and other facilities of special service destination, having in mind their safety (integrity) and convenience of further replacement, as well as ability, as necessary, of radiation situation assessment at evacuation centre location (the public assembly place in case of evacuation necessity).

The dosimeter assembly can be set on the base (made from wood or asbestos-cement pipe), equipped with a wooden shelf, set at 1±0.2 m height from the land surface, which, shelf, is fixed asymmetrically in such manner that its edge protrudes to locate dosimeters on its lower surface. At that, MKD dosimeter window and the number of gamma dosimeter must be directed downward to the land. In some cases, dosimeters can be located on horizontal branches of trees and bushes, or in other convenient places. Dosimeter assemblies are located mainly in check points at places of sampling (soil, grass, water, berries) and on site the littoral zone.

After termination of exposition, gamma dosimeters are picked up from the check points and, at the same time, replaced by new dosimeters. MKD dosimeters, intended for beta-gamma measurements, are removed from check points, as necessary, including cases of possible accident (on suspicion of accident). There are at least two assemblies in the background check point. Control frequency is once in a year.

5.4.3. Soil and vegetation sampling is carried out in areas of at least 5 m length with the highest and the lowest dose rate values, under condition of undisturbed matted soil surface and at the absence of evidence of superficial soil layer wash-out or inwash. Distance from the nearest buildings and trees must be not less than their two heights [7].

Soil sampling is carried out using a sampler (sampling device) of known area, by quadrate method at up to 10 cm depth at virgin lands and up to 25 cm at plough-lands. Sampling area and sample mass is registered.

In order to evaluate radionuclide migration by floor profile, soil is sampling layer-by layer at depth 0-10cm and 10-20cm.

To make laboratory examination, averaged sample is composed of the samples collected; the average sample mass is 1.0 kg.

Vegetation sample is collected on the site of soil sampling; this sample average mass is at least 1.0 kg.

Soil and vegetation samples are collected once in a year (in the period of maximum growing (vegetative) season).

5.4.4. Water from open fresh ponds in SA is collected in drinking water supply points or in their vicinity and in places of water use.

All water samples must be subjected to radiation hygienic control according to requirements of SanPiN 2.1.4.1074-01 [8, 9]. In case of excess regulations on gross alpha and beta activity, the main dose-forming radionuclides must be specified (^{90}Sr, ^{137}Cs, ^{60}Co) [7, 10-13].

In order to determine specific activity of ^{90}Sr , ^{137}Cs, and ^{60}Co, water sample is collected with mass of at least 20 litres. Frequency of sampling is once in a year.

5.4.5. Seawater samples are collected in the selected check points and in the background check point in the marine offshore waters.

Control of dose-forming radionuclides is necessary for the particular territory, so their contents are determined in the samples (Para.5.2).

The sample mass is at least 20.0 liters. The sampling frequency is twice in a year (in spring and in autumn, in particular after the spring flood). Sampling is reasonable to perform before ebb (tide).

5.4.6. Samples of bottom sediments, seaweeds and water plants are collected in seawater supply points.

The superficial layer of sediments is used for control and monitoring. Sampling in shallow water is carried out by means of careful taking superficial layer down using a wide-mouth bottle or a scoop at 10 cm depth. At deeper places a bottom sampler or scoop net is used. Area of sampling, its depth and weight are registered. The sample mass is at least 1.0 kg.

Seaweeds and water plants, growing at the bottom are selected for analysis. Just after taking down, water plants are rinsed to clean from silt and sand, excess water is removed using filter paper, and weighted. The sample mass must be at least 2.0 kg.
Bottom sediment and seaweed sampling is performed at least once in a year.

5.4.7. Seafood samples (molluscs, fish) are collected in vicinity of check points selected in the marine offshore waters.

For marine media monitoring, mollusk and fish samples are used as a whole, after preliminary washing with fresh water and after gilling from scale, entrails and fins. Total sample mass is 3 – 4 kg. Seafood sampling is performed season-by-season (in summer and in autumn), at least twice in a year.

5.4.8. Water sampling around radioactive waste repositories is carried out using observation bore-holes, located in HPZ, with the purpose of:

a) supervision over operator's (SevRAO) activity according to the sampling schedule made by the External Dosimetry Service (EDS); and

b) observation of radionuclide migration from SNF&RW repositories into underground waters.

Water sampling in SA is performed from observation boreholes (if any), in the area of possible repository impact.

Control frequency is 4 times in a year using boreholes located near contamination sources (50-100 m) and once in a year in boreholes, distant from contamination sources. Gross alpha and beta activity, as well as specific activity of major dose-forming radionuclides (^{90}Sr, ^{137}Cs, and ^{60}Co) and that of ^{3}H (as reference radionuclide specifying contaminant component migration) are determined in samples.

All water samples must be subjected to radiation control to confirm compliance with intervention levels established in NRB-99 for water.

5.4.9. Air control in HPZ is carried out in the stationary observation point, located in one of selected check points and in the background checkpoint.

In order to determine common air contamination, aspiration method of sampling is applied using aspiration installation providing approximately 400 m^3/h air infiltration rate (through FPP-15 filter). Exposition duration is 1 week.

Sedimentation method using open canisters is applied for precipitation collection (dry aerosols and atmospheric precipitation - rain, snow). Filter paper is fixed at the bottom of such canister. There are at least 3 canisters at the site. Exposition duration is 1 week. In case of the canister overflow, it is replaced under condition of exposition duration keeping.

After 1-week exposition, samples are subjected to gamma spectrometry analysis with the purpose of quantitative determination of common air and precipitation radionuclide composition. After that, gross α- and β- activity is measured [7].

If 1-week sample activity is lower than gamma spectrometer sensitivity, such samples are combined (into one) to determine content of gamma emitting radionuclides in 1-month exposition sample. In background points of 1-month exposition, ^{90}Sr and ^{137}Cs are also determined.

If a value of gross alpha and beta activity of long-lived radionuclides in atmospheric precipitation exceed average background values 10 and 5 times respectively, ^{90}Sr, ^{137}Cs are determined in 1-month exposition check points. ^{90}Sr, ^{137}Cs specific activity values in common air samples are used for calculation of annual inhalation radionuclide intake [16].

5.4.10. FMBA territorial body establishes frequency of dose rate measurement and environmental media sampling frequency in HPZ and SA; these values are: at least monthly in HPZ, and at least twice in a year in SA.

5.4.11. Foods sampling is carried out in settlements and in their vicinity.

To examine radionuclide intake with foods, such foodstuffs are used, which form a basis of dietary intake of the local population - milk, meat, fish, potato, wild berries, mushrooms etc. Both local (forestry products, fish, and molluscs) and imported foods, which go to the population by centralized sale, are subjects of examination. Food sampling and examination is carried out according to the Guidelines MUK 2.6.1.1194-03 «Radiation monitoring. Strontium-90 and Cesium-137. Foodstuffs. Sampling, analysis and hygienic assessment» [14].

Samples of local foods are collected in places of fishing, samples of wild berries and mushrooms - in places of their popular gathering, samples of imported foods - in food bases or in shops.

Frequency of sampling is once in a year: wild berries and mushrooms - in harvest period, fish – at the second half of summer.

Sampling frequency of imported foods is established depending upon the nature of foodstuff and its contribution into dietary intake of the local public. Samples from the firm supplier are collected once in a year. As arrival, single samples are collected from a new supplier of the main foods. Minimum amount of samples, collected in checkpoints is: milk - 4 samples, meat (beef, pork, mutton) - 1 sample of each type, fish (carcass) - 1 sample of each type of predominant food fishes, potato - 2 samples, vegetables, wild berries and mushrooms - in 2 samples of the most used in the particular region.

With the purpose of monitoring, specific activity of the main dose-forming radionuclides (^{90}Sr, ^{137}Cs) is determined in foods samples [10-13, 16].

All foods must be subjected to radiation control to confirm compliance with the authorized regulations [17].

5.4.12. In order to assess radionuclide intake by the public via dietary intake, data collection is performed relating to average per capita intake of the particular foods (kg/day, kg/year), taking account the food structure of the public from the particular region. Here, one should recognize that the structure of the public food is an intake of some independent foodstuffs, categorized into 9 principal food groups:

- bread and bakery produce,
- milk and dairy produce,
- potato,
- vegetables as well as melons and gourds,
- fruits and berries,
- meat and meat foods,
- fish and fish foods,
- wild berries,
- mushrooms.

Examination of the public food structure is carried out on the base of housekeeping budget study, implemented by Rosstat, for the following age groups of the population: 1 - 2 years, 2 - 7 years, 7 - 12 years, 12 - 17 years and adults (more than 17 years).

The data obtained are used in the course of the public internal dose calculations.

5.4.13. Radionuclide contents are determined by gamma-spectrometry, beta-spectrometry and radiochemical methods using certified and approved measuring tools and methodologies, with the relevant certificate on metrological attestation.

5.4.14. The sample mass calculation suitable for analysis.

The sample mass, collected for analysis, depends both upon tasks under solving – control or monitoring, and upon sensitivity of the equipment applied (Annex A).

When non-exceeding of the current regulations is under control, the lower boundary of measurement range must be set in terms of minimum value of the established regulation (H).

During monitoring, the lower boundary of measurement range (A_{mea}) is set in terms of magnitude of average background level of radionuclide contents in the environmental media near SevRAO STS and adjacent areas.

MMA value of the equipment used is set in the course of metrological attestation of the instrument for measurement error at least 50% at confidence probability P = 0.95 [16].

Current external and internal doses are calculated on the base of radiation monitoring results.

As a rule, the controlled parameter regulation at routine operation of the facility is more than average radionuclide content value in the environmental media. Therefore, mass of sample collected during the environmental monitoring will be more than that for purpose of control. Thus, when sampling environmental media in the check point for the purpose of simultaneous control and monitoring, one must proceed from the sample mass (volume) needed for monitoring analysis.

6. Arrangement of radiation control during SNF&RW removal from the STS area

6.1. Selection of radiation situation check points during SNF&RW removal from the STS area

6.1.1. During SNF&RW removal from STS HPZ territory, selection of radiation situation check points in HPZ of STS is carried out according to either Program of Control elaborated by the laboratory of external dosimetry or «Schedule of environmental radiation control» of the facility. Check points are also used for sampling performance, set in HPZ in the course of control under conditions of routine operation (Para 5.2). As necessary, additional check points can be set on the outer HPZ boundary.

6.1.2. In SA, check points remain for control purpose, which had been set in the course of the routine operation (Para 5.2), and background check point. Control is performed with the purpose to specify the extent and dynamics of the facility impact on the adjacent area during SNF&RW removal.

6.2. Selection of controlled radiation parameters

6.2.1. In addition to radiation control (compliance with regulations), established by the facility regulation, during SNF&RW removal from STS territory, the environmental monitoring is performed in the course of periodical surveillance.

6.2.2. The main parameters under surveillance in HPZ are as follows:

- gamma dose rate and alpha and beta fluence density in situ;
- radionuclide contents in atmospheric precipitation and in common air.

6.2.3. Selection of main dose-forming radionuclides, surveillance of which in the environmental media is necessary during SNF&RW removal, is carried out according to the facility regulation, established in the design documentation (^{90}Sr, ^{60}Co, ^{137}Cs, $^{239, 240, 238}$Pu) [18].

6.2.4. The main parameters under control in SA are those, being specified during routine operation in accordance with Para 5.3.2, 5.3.3 of the present ***MU***.

6.3. Requirements for the environmental radiation control and monitoring performance during SNF&RW removal from STS territory. The extent and frequency of examination

6.3.1. In the course of SNF&RW removal from STS territory, gamma dose rate and alpha-beta fluence density are under control in check points established by the facility regulation.

In SA, control is performed in sampling points of soil, atmospheric air and precipitation, seawater, as well as in sampling points of local foods and drinking water. Gamma dose rate is also measured along the route of SNF&RW containers transportation from the industrial site to the storage site, from which containers will be conveyed to the destination place. The measurement frequency is at least once in a week.

If release composition changes or gamma background is detected to be excess, the measurements are performed daily during the whole removal period in all check points, including background one.

In order to identify initial data on beta-gamma dose fields in selected checkpoints (Para 5.2 of the present ***MU***) with the purpose of operative assessment in case of excess contamination, permanent dose control is arranged using set relevant dosimeters. Such control frequency is once in a month.

6.3.2. The environmental radiation control and monitoring (soil, vegetation, superficial and underground waters, including those from the marine offshore waters, etc.) within STS territory is performed, during SNF&RW removal, according Para 5.4 of the ***MU.*** Control frequency is established depending upon gamma background level change.

6.3.3. Volume of all collected environmental media samples must ensure determination of controlled radionuclide specific activities at the level of natural background at the particular area (Para 5.4.13).

6.3.4. Reference levels of dose-forming radionuclide contents for water, bottom sediments and seaweeds, soil and vegetation are established in compliance with the authorized dose limits. The reference levels are calculated according to the guidelines developed properly for this, which, guidelines, accounts real levels of the environmental parameters at the facility.

6.4. Statistic treatment of the results

To detect reliable background excess by controlled environmental parameters, statistical analysis is necessary of control results. Statistic treatment of the surveillance results is carried out according to techniques given in «Guidance on arrangement of environmental control in the region of the NPP location» and «Guidelines on sanitary control over radioactive substance contents in environmental media». [7, 15]

The criterion of the excess global background is:

for external gamma dose rate (N) - fivefold excess standard deviation (σ)

$$N > N + 5\sigma \qquad (1)$$

where N - average gamma background value, μSv/h(mR/h);

for alpha and beta activity of long-lived radionuclides in atmospheric precipitation and air (P,p) - respectively, tenfold and fivefold excess background value (P_b,p_b)

$$P > 10\ P_b;\ p > 5\ p_b \qquad (2)$$

where P, p - respectively, average values for radioactive precipitation and atmospheric air, Bq/m^2, Bq/m^3;

for alpha and beta activity of long-lived radionuclides in natural waters - fivefold excess average background activity concentration ($C_{b)}$

$$C > 5\ C_b \qquad (3)$$

where C - average activity concentration value, Bq/l;
during radioisotope analysis of soil, water and common air samples (A) - threefold excess average global background value (A_b).

$$A > 3(A_{ф}) \qquad (4)$$

where A - average specific activity value for soil, precipitation, common air and water, Bq/kg, Bq/m^2, Bq/m^3, Bq/l, respectively.

7. Arrangement of control during radiological accidents

7.1**.** Control during design basis and beyond design basis radiological accidents is arranged having in mind possible emergency situations, considered at the design stage, and according to the guidelines establishing a procedure of control arrangement in the particular emergency situation [18].

7.2. The main exposure pathways in this period are:

- external exposure due to precipitation in situ- ^{60}Co, ^{134}Cs and ^{137}Cs, ^{90}Sr + ^{90}Y;
- internal exposure due to air contamination caused by radionuclide re-suspension from the land surface – Pu, Cs , ^{90}Sr+^{90}Y isotopes;
- ingestion intake via wild berries and mushrooms, as well as sea fish eating – ^{137}Cs, ^{90}Sr+^{90}Y.

7.3. Selection of radiation situation check points, the extent and frequency of examinations in case of radiological accidents, is performed in compliance with the Regulation developed at the facility, which, Regulation, establishes a procedure of control implementation in the particular emergency situation.

7.4. Long-lived radionuclides are important for long-term dose forming. These are: $^{134,137}Cs$, $^{238,241}Pu$, ^{90}Sr and ^{60}Co isotopes.

8. Public effective dose assessment

8.1. Public effective dose assessment during STS routine operation

Public annual effective doses under condition of routine STS operation are assessed according to rules established for certification of territories [19] (Annex B).

At that, contribution is evaluated of internal dose due to local foods into the public total internal dose.

8.2. Effective dose assessment within HPZ and SA during SNF&RW discharge

8.2.1. During SNF&RW discharge, external effective dose is evaluated in terms of both gamma dose rate measurement results at the open area in HPZ and SA, and annual effective internal dose due to inhalation intake at SNF&RW discharge. (Annex C)

8.2.2. Average annual (committed) effective internal dose due to foods is evaluated in terms of radionuclide intake by the local public via foods of local manufacturing [19].

8.3. Current dose assessment after the accident on the base of radiation control results [20]

Current external and internal public doses in HPZ and in SA during radiological accidents are evaluated according to the guidelines, which establish both control procedure and dose calculation taking possible types of accidents and scenarios of emergency situation development into account.

As necessary, a decision is made about personal dose monitoring (PDM) performance of external exposure to the critical population groups. The public PDM is implemented in terms of 5 mSv committed annual dose, dynamics of photon dose rate change, or 0.6 μSv/h average dose rate values during the first two days after the accident. If MFD dosimeters (set in situ) show that doses of low-energy photon and beta radiation at 7 mg/cm^2 depth are more than 4 times higher than gamma doses, the critical population groups are provided with skin dosimeters for measurement doses for the skin and for the lens of eye.

9. Information about radiation situation

9.1. Results of environmental radiation control and monitoring must be analyzed periodically (at least once in a year) to simplify development of actions aimed at occupational and public dose reduction and at mitigation of consequences of SNF&RW STS environmental impact.

9.2. The state authorities, radiation safety regulatory bodies and individuals, community corporations and mass media must have an access to information about radiation situation at SNF&RW STS and about actions taken for its improvement.

Annex A. Sample mass calculation with the purpose of analysis

The sample mass collected for further analysis, depends upon tasks solved – control or monitoring - and upon sensitivity of instrumentation used.

When non-exceeding of the current regulations is under control, the lower boundary of measurement range must be set in terms of minimum value of the established regulation (H).

Ability of this value (H) measurement depends upon minimum measurable activity (MMA) of the equipment used and upon mass of the sample analyzed.

MMA value of the equipment used is set in the course of metrological attestation of the instrument for measurement error at least 50% at confidence probability P = 0.95 [16].

The needed sample weight mass (m) (area, volume) kg (m^2, m^3) for analysis in the course of control is calculated in terms of (MMA) of the equipment used and minimum regulation value, established for one of radionuclides under identification ($H_{No.1}$) in the analyzed sample.

$$m = MMA / H_i \quad (5)$$

where H_i - established regulation of i – radionuclide content in air, water, foods, etc., Bq/kg(l), Bq / m^2, Bq / m^3.

MMA - minimum measurable activity of the equipment used, Bq;

m – the sample mass (volume), needed for analysis during control, kg, l, m^3.

In the course of monitoring, the lower boundary of measurement range (A_{mea}) is established in terms of average background level of radionuclide contents in the environmental media near SevRAO STS location or at adjacent area

$$m = MMA / A_{mea} \quad (6)$$

where A_{mea} – average value of radionuclide contents in air, water, foods, etc. at the territory under surveillance, Bq/kg(l), Bq / m^2, Bq / m^3,

MMA - minimum measurable activity of the equipment used, Bq

m – the sample mass (volume), needed for analysis during control, kg, l, m^3.;

Annex B. Public effective dose assessment at routine STS operation

The public annual effective dose assessment at routine STS operation is carried out according to the rules, established for certification of territories [19].

1. Average annual individual effective external dose ($E_{1,bac}$) for the public from the particular settlement is evaluated on the base of annual gamma dose rate measurements outdoors in SA. The following equation is used for assessment:

$$E_{1,\,bac} = d \cdot 10^{-3} \cdot 8800 \cdot (H_{out} \cdot \alpha_{out} + H_{in} \cdot \alpha_{in}) \text{ , mSv} \qquad (7)$$

where: 8800- amount of hours per year, h;

10^{-3} - conversion factor μSv into mSv;

H_i – average gamma dose rate value outdoors («out») and indoors (in dwellings and in public buildings) («in»)

d – dose factor, digital magnitude of which equals:

1.0 - if H_i – equivalent (ambient) gamma dose rate, in μSv /h;

0.7 - if H_i – absorbed gamma dose rate, in μGy/h;

0.0061 - if H_i – exposure gamma dose rate, in μR/h;

α_i - time quota of people staying indoors («in») and outdoors («out»).

2. Average annual (committed) effective internal dose ($E_{2,\,bac}$) is evaluated on the base of radionuclide intakes of the local public via foods both of local production and imported:

$$E_{2,\,bac} = 10^{3} \cdot \sum_{k}[\, dk_k \cdot (\sum_{n} M_n \cdot A_{kn})], \text{ mSv} \qquad (8)$$

where:

dk_k - dose factor for k-th radionuclide ingestion (via foods) intake, according to Annex A-2 of NRB-99, Sv/Bq;

M_n - annual n-th foodstuff intake, kg/year;

A_{kn} - annual specific activity of k-th radionuclide in n-th foodstuff, Bq/kg.

Internal dose due to local foods is determined according (2), where

$M_{n,}$ - annual n-th local foodstuff intake, kg/year;

A_{kn} - annual specific activity of k-th radionuclide in n-th local foodstuff, Bq/kg.

Then, contribution is evaluated of internal dose due to local foods into total public internal dose.
Total average annual individual effective dose (E_{bac}) is determined as a sum of individual external and internal doses:

$$E_{bac} = (E_{1,bac} + E_{2,\,bac}), \text{ mSv} \qquad (9)$$

Annex C. Effective dose assessment for the personal group B and for the public in HPZ and in SA of STS during SNF&RW discharge

1. In the course of SNF&RW discharge, effective external dose is evaluated on the base of gamma dose rate measurements outdoors in HPZ and in SA (Annex B Para 1).

2. Annual effective internal dose due to inhalation intake during SNF&RW discharge was evaluated using equation [18, 19]:

$$E_{inh}=(\tau_{out} + k \cdot \tau_{in}) \cdot k_1 \cdot V \left(\sum_i d_{i,inh} \cdot q_i\right) \qquad (10)$$

where: V– annual volume of air inhaled, m^3/year;

q_i – annual specific activity of i –th radionuclide in near-land air layer, Bq/m^3;

$d_{i,inh}$ – dose factors for inhalation intake of i –th radionuclide, mSv/Bq.

τ_{out} and τ_{in} – time quota, spent outdoors and indoors, respectively, relative units (generally, τ_{out} = 0.2 and τ_{in} = 0.8);

k – ratio between radionuclide air concentrations indoors and outdoors (generally k = 0.3);

k_1 – coefficient identifying time quota of staying within contaminated area. Generally k_1=1 under condition of permanent living within contaminated area, and k_1=0.2 under condition of temporary staying there.

3. Average annual (committed) effective internal dose (E_2) is evaluated in terms of radionuclide intakes by the local population via local foods (Annex B, Para 2).

Annex D. References

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15. Guidelines on sanitary control over radioactive substance contents in the environmental media. A.N. Marej, A.S.Zykova ed. Moscow, 1980.

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Annex E (Obligatory)

Arrangement of the environmental radiation monitoring in the operational area of the Federal state unitary enterprise "Northern federal enterprise for radioactive waste management" of the Federal Atomic Energy Agency

Guidelines

MU ______2007__

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Annex 6 The Operational Radiological and Medical Criteria for Initiation of Emergency Protective Actions in the Case of Radiation Emergency at Sevrao Facilities

State system of sanitary epidemiological regulation of Russian Federation

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2.6.1. IONIZING RADIATION, RADIATION SAFETY AND PROTECTION

THE OPERATIONAL RADIOLOGICAL AND MEDICAL CRITERIA FOR THE INITIATION OF EMERGENCY PROTECTIVE ACTIONS IN THE CASE OF RADIATION EMERGENCY AT THE SevRAO FACILITIES

Methodical recommendations

Legal edition

Federal Medical – Biological Agency

Moscow 2008

1. The operational radiological and medical criteria for the initiation of emergency protective actions in the case of radiation emergency at the SevRAO facilities. (MR P 2.6.1. …): Methodical recommendations. – M., Federal Medical – Biological Agency, 2008.
2. Developed by the creative group, including: Savkin M.N. (leader), Grachev M.I., Klochkov V.N., Pushkareva S.G., Titov A.V., Frolov G.P., Shinkarev S.M. (FSUE-SRC – Institute of Biophysics), Alexeeva V.R. (Territorial Agency -120 FMBA of Russia), Kazakov A.V. (Medical Sanitary Unit -120).
3. Recommended for approval by the Sub-commission for the special regulation of the Commission for the state sanitary epidemiological regulation (protocol No.1 of 2008).
4. Approved by the Deputy Head of State Chief Medical Officer on facilities and sites serviced, VV Romanov, 2007.
5. First entering into force.

УТВЕРЖДАЮ
Approved

Заместитель руководителя Федерального медико-биологического агентства, Главный государственный санитарный врач по обслуживаемым организациям и обслуживаемым территориям

_______________ В.В. Романов

"24" ______ 2008 г.

Enforcement data: from the moment of the approval

2.6.1. Ionizing radiation, radiological safety

THE OPERATIONAL RADIOLOGICAL AND MEDICAL CRITERIA FOR THE INITIATION OF EMERGENCY PROTECTIVE ACTIONS IN THE CASE OF RADIATION EMERGENCY AT THE SevRAO FACILITIES

Methodical recommendations

MR 2.6.1…

I. Scope

1.1 Present Methodical recommendations determine the procedure of calculation and the numerical values of the operating radiation levels for decision making regarding protection of the personnel and the public in the case of the radiation emergency at the SevRAO facilities and medical-sanitary criteria and urgent actions.

Methodical recommendations can also be used during the emergency planning for other enterprises, which have the sites of temporary storage of RAW and SNF.

1.2 Methodical recommendations are intended to be used for the services of the enterprises of the SevRAO facilities, responsible for emergency planning and reaction, the services of urgent medical aid, Territorial Agency #120 and Medical Sanitary Unit #120 FMBA.

II. Normative references

Federal law «About radiation safety of the public» from January 9, 1996, #3-FZ (Collection of laws of Russian Federation, 1996, #3, p. 141);

Federal law «About sanitary-epidemiological prosperity of the public» from March 30, 1999, #52-FZ (Collection of laws of Russian Federation, 1999, #14, p. 1650);

Federal law «About atomic energy utilization» from November 21, 1995, #170-FZ (Collection of laws of Russian Federation, 1995, #48, p. 4552; 1997, #7, p. 808);

Federal law "About the protection of the public and territories from the extraordinary situations of natural and technogenic nature" (Collections of laws of the Russian Federation, 1994, #35 ст. 3648);

Statement on the common state system of the warning and liquidation of the extraordinary situations. Approved by the decision of the government of the Russian Federation November 5, 1995 #1113

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III. General considerations

3.1 Operational radiological levels (criteria) are established for the purpose to provide common and adequate radiation protection of the personnel and the public in case of a radiological emergency. The basis for this response is data on monitoring the radiological situation in sanitary shelter zone (SSZ) and surveillance zone (SZ) in case of appearance of the contingency situation.

3.2 In order to determine in advance an appropriate measurable surrogate quantity for the operational criterion, at least three requirements were identified to be met. This surrogate quantity shall be: prompt and easily measurable, representative, important with respect to dose assessment; the quantity shall characterize the leading factor of radiation impact.

For the sites of temporary storage of radioactive wastes and nuclear fuel (RAW and SNF) of SevRAO the ambient dose equivalent satisfies these requirements.

3.3 The dose criteria are basis for decision making by the emergency response. Depending on radiological situation and accordingly to “Statement on the common state system of the warning and liquidation of the extraordinary situations” there are three statuses of the system of emergency response: routine preparedness, alert, emergency conditions. The values of operational radiological levels for the selection of the status indicated are given in the section IV of these recommendations.

3.4 With the substantiation of operational radiological levels the categories of the irradiated persons (personnel of group A, personnel of group B, population) and zoning of industrial area and territory, which is adjacent to the sites of temporary storage of RAW and SNF are taken into account. In accordance with the sanitary classification in the regime of normal operation two zones are separated in SSZ:

- zone of controlled entrance: working premises where sources of exposures are managed and radiation impact is possible to personnel of category A
- zone of free entrance – auxiliary rooms and offices, where sources of exposures are not managed under normal conditions and, as a rule, radiation impact to the personnel is excluded. The working sites of the personnel of category B are in this zone.

Four zones are separated for the operational zoning of territory under planning of emergency protective actions, substantiation of limitations to the period of work conducting, applying of measures and means of individual protection of emergency personnel: Low hazard (A), Middle hazard (B), Hazard (C) and Very hazard (D).

The values of the ambient dose equivalent on the boundaries of the zones indicated are given in section V of these recommendations.

3.5 Operational radiological levels for the protection of the public are given in section VI and are calculated on the basis of the criteria for making of urgent decisions in the initial period of the radiation emergency (the averted dose exceeds level A – Table. 6.3 NRB-99).

3.6 In addition to the operational radiological criteria aimed at decision making regarding introduction of the protective actions, these methodical recommendations include medical-sanitary criteria to be used as criteria to include or not include a person (victim or the witness of emergency) in the complex of diagnostic, therapeutic, preventive and rehabilitative actions.

3.7 All the measures of medical actions differ by the tempo of their realization and include:

- *special* measures – actions, whose immediate fulfilment is necessary for the rescuing of the life of the victim

- *urgent* measures - actions, which ensure the maintenance of health or decrease damage of victim's health

Both special and urgent measures cannot be put off to the following stage of medical aid

- *delayed* measures - actions, whose fulfilment does not have strict time parameters, and which can be put off to the following stage of medical aid

3.8 Medical-sanitary criteria for the beginning of the first medical aid special and urgent actions in the radiation emergencies are the most important. Timely application of the special and urgent measures can rescue the victim's life and decrease the damage to victim's health. But these measures in view of their specific character can be invasive and have individual contra-evidence to their application.

3.9 The urgent measures include also therapeutic and prophylactic measures applied to the persons who received excessive irradiation (external or internal), but who have no direct danger for their life at the time of observation.

3.10 Delayed measures, as a rule, bear preventive and rehabilitative character, and they are connected with the evaluation of the emergency irradiation in the absence of the symptoms of defeat and forecasts of their development.

3.11 Medical-sanitary criteria are given in sections VII–IX of these methodical recommendations. The recommendations regarding the use of medical-sanitary criteria in pre-hospital and first physician's aid are given in the applications.

IV. Criteria to announce various statuses of emergency at the facilities

4.1. In case of radiological-hazardous situation or radiological emergency the following statuses of the system of emergency response should be announced "Alert" or "Emergency conditions", respectively.

4.2. Announcement "Alert" means switch of the system of emergency response from status of "Routine preparedness" to the status "Alert" (see Bullet 3.1). Operational radiological levels (criteria) to announce "Alert" were derived on the basis of the main dose limits regarding effective dose to the personnel and the public.

SSZ-zone of controlled entrance20 mSv / 1700 h per year = 12 $\mu Sv\ h^{-1} \approx 10\ \mu Sv\ h^{-1}$;

SSZ - zone of free entrance 5 mSv / 2,000 h per year = 2.5 $\mu Sv\ h^{-1} \approx 2\ \mu Sv\ h^{-1}$;

At the borderline of SSZ .25mSv / 8,800 h per year = 0.4 $\mu Sv\ h^{-1} \approx 0.5\ \mu Sv\ h^{-1}$.

(here 0.25 – shielding factor).

4.3. "Emergency conditions" is announced if a radiological emergency is identified.

It is reasonable to settle

The operational criteria to announce "Emergency conditions" have been settled to be the rate of effective dose that is different for various zones and for various groups of people as follows:

for personnel of group A on the basis of the criterion for sheltering of 20 mSv during the first day;

for personnel of group B on the basis of the criterion for sheltering of 5 mSv during the first day;

for the public on the basis of the level A criterion of 5 mSv during the first 10 days.

4.4. The numeric values of the operational radiological criteria are given in Table 1. Those values are conservative and they have been rounded with following increments 1-2-5-10.

Table 1. *Criteria to announce various statuses of emergency at the facilities.*

Purpose: adequate and timely introduction of Emergency plans to provide radiation protection to the public.

Conditions	Ambient dose equivalent, $\mu Sv\ h^{-1}$		
	Zone of controlled entrance of SSZ	Zone of free entrance of SSZ	SZ
Alert	10	2	0.5
Emergency conditions	500	200	20

V. Operational radiological criteria for zoning of territories under planning of emergency protective actions

5.1. Delineation of the zones to implement emergency protective actions to mitigate the consequences of a radiological emergency is carried out on the basis of the projected effective dose criteria given in Table 2.

Table 2. *Criteria for urgent zoning under planning of emergency protective actions.*

Purpose: Justification of limitations regarding duration of work, measures, and means of individual protection of the emergency workers.

Zone	General characteristics. Conditions of work	Ambient dose equivalent, μSv h-1
Low hazard (A)	Work without exceeding the main dose limits during 1,700 h	<10
Middle hazard (B)	Work is possible without exceeding the main dose limits under restriction of duration of the work and application of protective measures	$10 - 5 \times 10^3$
Hazard (C)	Work in conditions of planned elevated exposure	$5 \times 10^3 - 2 \times 10^4$
Very hazard (D)	Irradiation is possible with potentially hazard dose. Work is allowed only in case of time restriction and application of protective measures	$> 2 \times 10^4$

5.2. For the personnel involved in emergency protective actions the main radiation pathways are:

- external exposure from radionuclides deposited on the ground surface;
- internal exposure from inhalation intake of airborne aerosols due to resuspension of radionuclides from the ground surface.

5.3. Calculated estimates showed that for all design basis emergencies the main contribution to the dose to the personnel involved in emergency protective actions will be provided from external exposure of ^{137}Cs and internal exposure from inhaled ^{137}Cs and $^{90}Sr+^{90}Y$.

If a working day is 6 hours then the value of the coefficient between the ambient dose equivalent (mSv h^{-1}) and the effective dose (mSv d^{-1}) is equal to 0.13 (Sv h^{-1}) per Sv.

VI. Operational radiological criteria for the protection of the population

Table 3. *Operational criteria for radiation protection of the public.*

Purpose: Indices for decision making regarding introduction of emergency protective actions in the initial phase of radiological emergency.

Protective action	Operational criterion, mSv h^{-1}	
	Fall of aircraft	Self-sustained chain reaction
Sheltering	0.1	$1 \cdot 10^{-2}$
Evacuation	1	1

VII. Medical-sanitary criteria and the first medical aid special actions

Table 4. *Criteria and the first medical aid special actions in the radiation emergencies*

Purpose: Special actions are carried out for the persons (by persons) located in the zone of emergency, where the radiological situation and other factors (not of radiation nature) present danger to the life (Zone D, Table 2).

#	Medical-sanitary criteria	Necessary actions
1.	- the exposure rate exposure in the zone of radiation emergency is more than 0,3 Gy/min *or* - the exposure rate, and the time of the stay and evacuation from the zone make it possible to forecast emergency irradiation with dose exceeding 1 Sv	- accept B-190* (3 tablets), wash down with 100 ml of the water - immediate evacuation into the safety zone - repeat accept of B-190 *If it is possible rapidly (during 1-2 minutes) to leave hazardous zone, B-190* must be accepted immediately after its leaving.*
2.	- the danger for the life not of radiation nature (fire, smoke-screening, the possibility of caving constructions, action of the toxic means and others) appears in the zone of radiation emergency	- immediate evacuation to the safe zone
3.	victim has: - the burning of the clothes - the disturbance of respiration (asphyxia) - the massive external haemorrhage	- the extinguishing of the burning clothes - cleaning the cavity of mouth and the restoration of the pass ability of the respiratory tract - the elimination of haemorrhage (plait, tight bandage) - evacuation from the hazardous zone
4.	- the exposure rate in the zone of radiation emergency is more than 0,3 Gy/min + the spontaneous chain reaction	- accept B-190* (3 tablets), wash down with 100 ml of the water - immediate evacuation to the safe zone - after leaving a hazardous zone accept inside 1 tablet of iodide potassium 0,125 g, wash down with 100 ml of the water

*) B-190 - the radioprotective medicine of special action. The treatment with medicine 60 min after irradiation and more lately is not effective.

VIII. Medical-sanitary criteria and the first medical aid urgent actions

Table 5. *Criteria and the first medical aid urgent actions with the radiation emergencies*

Purpose: Urgent actions are carried out for the persons (by persons) located in the zone of emergency, where the radiological situation is abnormal (Zone C or D - Table 2).

#	Medical-sanitary criteria	Necessary actions
1.	- the contamination of clothing, skin and mucous membranes of the victim > 20 000 the beta particle/(sm^2 min) and/or > 200 alpha particle /(sm^2 min)	- put on to the victim the equipment of individual protection of the respiratory organs - deliver to the point of the radiological check and sanitary treatment - complete sanitary treatment and the changing of clothes - accept ferrocin (2 tablets), wash down with 100 ml of the water
2.	- having injury victim was found on the territory with the level of contamination >20 000 the beta particle/(sm^2 min) and/or >200 alpha particle/(sm^2min) *or* - the contamination of clothes and skin around the wound >2000 the beta particle/(sm^2 min) and/or >20 alpha particle /(sm^2 min) *or* - the same conditions, but wound is located on the extremity	*Wounds must be considered to be contaminated with radioactive materials*. - put on to the victim the equipment of individual protection of the respiratory organs - shut the wound with the airtight bandage - deliver victim into the radiological checkpoint - complete sanitary treatment and the changing of clothes - deliver victim into the medical point of enterprise for the treatment of wound not later, than after 40 minutes from the moment of the injury - put on to the victim the equipment of individual protection of the respiratory organs - put plait on the struck extremity higher than wound (don't squeeze artery) - ensure the venous blood loss (100-150 ml) for cleaning of the wound - remove plait, shut wound with dry napkins and airtight pressure bandage - deliver victim to the radiological checkpoint - complete sanitary treatment and the changing of clothes - deliver victim to the medical point of enterprise for the treatment of wound not later, than after 40 minutes from the moment of the injury
3.	- the work of personnel of emergency rescue formation in the zone of controlled entrance is planned	- verify the security of the personnel: by first-aid kits, bag of medical instructor, by the stretchers - accept ferrocin (2) (2 tablets on 0,5) and riboxin (12 tablets on 0,2) - put on the equipment of individual protection of the respiratory organs
4.	- the work of personnel of emergency rescue formation in the zone of controlled entrance with the	- verify the security of the personnel: by first-aid kits, bag of medical instructor, by the stretchers - accept ferrocin (2) (2 tablets on 0,5) and riboxin (12

	spontaneous chain reaction is planned	tablets on 0,2) - put on the equipment of individual protection of the respiratory organs - accept inside 1 tablet of iodide potassium 0,125 g, wash down 100 ml of the water, once leaving from the hazardous zone

IX. Medical-sanitary criteria and delayed medical actions

Table 6. *Criteria and the first medical aid delayed actions with the radiation emergencies*

Purpose: delayed actions are carried out for the persons (by persons) located in the zone of emergency, where the radiological situation is abnormal (zone B or C, Table 2).

#	Medical-sanitary criteria	Necessary actions
1.	- the contamination of clothing, skin and mucous membranes of the victim <20 000 but >200 the beta particle/(sm^2 min) and/or <200 but >2 alpha particle/(sm^2min)	- put on to the victim the equipment of individual protection of the respiratory organs - deliver victim into the radiological checkpoint - complete sanitary treatment and the changing of clothes
2.	- the wound in victim which has the contamination of clothes and skin <2000 but >200 the beta particle/(sm^2 min) and/or <20 but >2 alpha particle /(sm^2 min)	- put on to the victim the equipment of individual protection of the respiratory organs - shut the wound with the airtight bandage - deliver victim into the radiological checkpoint - complete sanitary treatment and the changing of clothes - the treatment of wound is delayed till the entering in to local medical unit of FMBA
3.	- data of the individual radiation monitoring testify about the above-norm irradiation, the symptoms of primary reaction for the irradiation be absent	- medical examination for the evaluation of the status of health and exception of unfavourable influence on the health of the factors of the radiation emergency
4.	- data of the individual radiation monitoring exclude above-norm irradiation, but there are symptoms, similar to the primary reaction for the irradiation (nausea, the vomiting etc)	
5.	- the witness of emergency or a participant in the emergency reaction turns himself for medical aid with the complaints of the health status or on the fact of participation in the emergency	

ANNEX

Recommendations for the local medical unit #120 of FMBA regarding the selection of the measures for medical intervention in radiation emergencies

1. Criteria of actions on the pre-hospital and first physician's aid to victims in the possible accidents on the objects of the SevRAO facilities

The pre-hospital medical aid to victim is carried out by medical personnel of medical point of enterprise (nurse) and by team of "fast and urgent medical aid" of MSU of FMBA (nurse and physician).

Victims may enter medical point of enterprise without assistance or be evacuated to medical point by emergency teams of the objects of SevRAO facilities.

With the entering of victims the medical personnel must conduct medical triage [1] for determining the volume of the necessary medical aid. After this, the measures of pre-hospital and first physician's medical aid are carried out. Then victims are bound for profile medical units. Priority and direction of hospitalization depend on the form of injury and severity of the state of the victims. Victims with the radiation injuries will be hospitalized in MSU of FMBA.

The need of protective (anti-radiation) measures with the transport of victims is determined by the presence and the degree of the contamination of victims by radioactive materials.

The enumeration of the measures of the first physician's aid which is determined by the expected medical consequences of possible emergencies on the objects of SevRAO facilities is represented in Table 4.4.

Basic requirements for habits and knowledge of the medical personnel of medical point, teams of "fast and urgent medical aid" and the medical personnel of the receiving department of MSU 120 of FMBA are based on the protocols [2] of rendering pre-hospital and first physician's aid with the different defeats and the clinical situations.

The list of the criteria of choosing and beginning of pre-hospital and first physician's aid actions [2] is represented in Table 1.

Table 1.*Criteria and the pre-hospital and first physician's aid actions with the radiation emergencies*

#	Medical-sanitary criteria	Necessary actions
1.	five or more victims enter the medical point of enterprise	- managing near the medical point of enterprise the triage area with radiological checkpoint. *With a smaller quantity of victims the triage is completed in the medical point of enterprise.*
2.	some victims have a contamination of clothes, skin, wounds and/or the mucous membranes > 200 the beta particle/(sm^2 min) and/or > 2 alpha particle/(sm^2 min)	- medical staff works in the equipment of individual protection, the individual radiation monitoring is carried out - separate "clean" and "dirty" zones in the medical point of enterprise - the victims enter to the MSU of FMBA by two flows (contaminated and not having pollution), through the different entrances and into the different accommodations of MSU's receiving department - the work of radiological checkpoint for the victims and the medical staff is managed
3.	victim has indications for urgent and	- the elimination of asphyxia (including tracheotomy)

	special aid: - the disturbance of respiration (asphyxia) - the massive external haemorrhage - the cessation of heart, respiration - shock as a result of different reasons - uncontrollable vomiting	- the stoppage of the external haemorrhage - mechanical ventilation of lungs, the external massage of heart, the defibrillation - antishock therapy, the anesthetization - antiemetics *Special medical aid must begin before the radiometric monitoring and the sanitary treatment of the victim. Medical staff works in the equipment of individual protection.*
5.	Glazing and sprinkling of body with the highly active solutions	Urgent complete sanitary treatment of the contaminated sections of body and mucous surfaces.
6.	Victim has symptoms of the radiation injury - the repeated vomiting - local oedema and the erythema of the skin	 - ondansetron 4 mg im or iv up to 5 times in a 24 hour period - abundant irrigation by the aerosol of "Lioxazol" - shut injured area by bandage, repeat irrigation through the bandage
	other symptoms of the radiation injury	
	- according to the data of the individual radiation monitoring the dose of irradiation exceeds 1 Gy *or* - repeated vomiting, which was initiated during two hours after the irradiation	**) on the actions - see commentary at the end of the table*
7.	*Contamination of wounds by the radioactive materials i.e.* - victim was found on the territory with contamination level > 20 000 the beta particle/(sm^2 min) and/or >200 alpha particle /(sm^2min) *or* - contamination of clothes and skin around the wounds > 2000 the beta particle/(sm^2 min) and/or > 20 alpha particle /(sm^2 min) + injury occurred less than 60 minutes before and/or contamination by the soluble compounds of the radionuclide, victim in stable state	- special treatment of wounds (removal of foreign bodies, the abundant washing of wound by sterile solution, the aseptic bandage) - the selection of wash waters and surgical dressing for the radiometric study - cephalosporin 1 g im - the complete sanitary treatment

	- injury occurred more than 60 minutes before or contamination by the insoluble compounds of the radionuclide victim in stable state	- shut wound with dry napkins and hermetic bandage (it is possible to use medical glue with the shallow wounds of small area) - cephalosporin 1 g im - the complete sanitary treatment - surgical treatment of wound in MSU of FMBA
	- unstable state of victim	-the treatment of wounds is conducted after the stabilization of the general state of the patient
8.	- the inhalation/ingestion of the fission products of nuclear fuel >1 maximum annual entering	- rinse mouth and throat - wash stomach, - accept of salt purgative (sulphate of magnesium 25g) - accept ferrocin (1,0 g three times a day – for two days)
	- the inhalation/ingestion of the radioactive cesium in the quantity of > 2,5 maximum annual entering	- rinse mouth and throat - wash stomach (in such cases by the suspension of ferrocin 1 g/l) - accept of salt purgative (sulphate of magnesium 25g) - accept ferrocin (2-4 g/day for 5-10 days)
	- emergency with the spontaneous chain reaction	- potassium iodide 0,125 g inward once (if it did not accept in the stage of first aid) *Potassium iodide should be administered by mouth as soon as possible after the accident (≤ 6 hours)*
9.	- sending the victim into the hospital	inform the hospital about the state of that victim, is there the need in additional sanitary treatment of the victim and the use of the equipment of individual protection for the medical personnel

*) Commentary

Guidance “Sanitary-hygienic and treatment-prophylactic management in case of radiation emergencies.” [1] recommend to introduce interleukin-1 beta (betaleukine) in dose 2 mg sc once in the first 2 hours after irradiation, if victim has:

- repeated vomiting, which was begun during 2 hours after irradiation (the primary reaction, characteristic for the irradiation in the dose > 2 Gy),

or

- according to the data of individual radiation monitoring victim has irradiation in the dose more than 1 Gy.

Carry out this recommendation in the prehospital stage is difficult, because results of individual radiation monitoring usually are not known for two hours after irradiation, and because before the introduction of betaleukin it is necessary to collect the victim’s blood for a cytogenetic study. This action may be difficult to carry out at the medical point of enterprise in case of a large quantity of the victims.

That is why the decisions about betaleukin’s introduction in the first 2 hours after irradiation must be accepted by the medical personnel of the medical point of enterprise or MSU of FMBA, taking into account the local possibilities of implementation of recommendations.

2. The most important measures of the medical intervention with the entering of victims with the radiation emergencies to MSU-120

Recommendations on medical actions with radiation emergency presented in the appropriate clinical guidelines [1, 2, 3, 4, 5, 6]. Below are presented the most significant actions on confirmation of the fact of the emergency irradiation of the victim and of estimation of its severity. In addition, there is a description of the erroneous actions of personnel which renders medical aid to victim, which we observe most frequently during trainings.

Confirmation of the emergency irradiation of the victim

Each fact of the action of irradiation on the man must be confirmed and evaluated. It is possible to confirm the fact of radiation exposure by the methods of physical and biological dosimetry.

Physical dosimetry

Statement and estimation of irradiation by the methods of physical dosimetry is carried out by the service of radiation safety of enterprise. Medical workers should have had ideas about the possibilities and accessibility of these methods, used some of them in their own clinical practice [3, 6].

Below we present the enumeration of the methods of the physical dosimetry, which can be used with the radiation emergency in zone of interest of MSU # 120.

Methods of physical dosimetry:

- dose estimates derived from the personnel dosimeters (if available). Results can be obtained in 1- 6 hours and later
- radiometric measurements of clothes and skin. Data are available at the time of the measurements
- radiometric measurements of blood, urine, faeces, with the subsequent estimation of activity of incorporated radionuclides. Preliminary results can be available in 2-3 days
- study of the tooth enamel of victim and objects of his clothes by using the method of the electron paramagnetic resonance. Information about the radiation doses can be obtained during several days
- measurements by whole-body counter. Information about the content of the gamma - radionuclides in person’s body in the clinically significant range of doses will be available immediately after the measurement. Prior to the measurement the patient must pass complete sanitary treatment and not have the residual contamination of the skin
- assessment of doses based on the data of the map of exposure rates in the zones of emergency and the routes of the victim (where victim was located, with whom, at what period, movement relatively to the source of irradiation). The confirmation of the fact of irradiation by other methods is required.

Biodosimetry

- the documentation of prodromal symptoms in first 24 hours after irradiation. Vomiting is the most important symptom of prodromal faze. After irradiation with dose less than 1 Sv the prodromal symptoms never appear. But the absence of vomiting does not exclude irradiation in dose as large as 2 – 4 Sv.
- the documentation of initial erythema in first 24 hours after irradiation and registration of it’s dynamic during the first week. The duration of the initial erythema’s presence depends on the dose of local irradiation
- the calculation of absolute lymphocyte count in peripheral blood through the first week after irradiation. After subtotal irradiation (gamma/gamma-neutron) in dose more than 1 Sv we see rapid reduction of absolute lymphocyte count in peripheral blood. If the lymphocyte count is less than $1000/mm^3$ during the first 24 hours after irradiation, the dose of irradiation is much more than 2 Sv. Reduction in absolute lymphocyte count will constantly stay through the whole cytopenia period of ARS and may be the symptom of irradiation in the concealed emergency. It is difficult to evaluate

dose of irradiation with the reduction of absolute lymphocyte count in victims with thermal burns and viral infection.
- the chromosome-aberration cytogenetic bioassay, primarily the lymphocyte dicentrics assay, remains the gold standard for biodosimetry. The results can be obtained from a few hours – up to 3-5 days after blood collection. Cytogenetic markers will stay during some years.

Exception of the unjustified medical intervention in the process of medical aid for the victims with the radiation emergency

There is a description of the erroneous actions of personnel, which renders medical aid to victim, which we observe most frequently during trainings.

Pre-hospital aid and aid in the receiving department of MSU of FMBA

- *the error:* to render medical aid to victim before radiometric inspection for the exception of external contamination and without sanitary treatment, if victim does not need aid for vital indications, or antiemetics because of uncontrollable vomiting, or analgesics for pain control
- *the error:* rejection of the medical aid to the victim before radiometric inspection of external contamination and sanitary treatment, in cases of the vital indications, or indications for analgesics or antiemetics
- *the error:* the work of medical personal without the means (equipments) of individual protection, besides the cases, when the external contamination of victims is excluded
- *the error:* the use of betaleukin in the medical point of enterprise if there are no absolute indications and possibilities to carry out other recommendations (see commentary to table .4.)
- *the error:* absence of careful documentation of the time of onset of every episode of vomiting and the introduction of antiemetics
- *the error:* prophylaxis against vomiting
- *the error:* the formal inspection of the skin, illegible description of all regions of hyperemia and rash in the medical documentation
- *the error:* the large volume of the laboratory studies of victims in the receiving department, that makes it necessary to assign on the work a large quantity of the medical personal, which may be contaminated. In the receiving department only blood count and differential and studies, which require because of the vital indications, must be carried out.
- *the error:* the fulfillment of primary surgical treatment of the wound/burn before the radiation monitoring of the region of the wound/burn
- *The error:* the fulfilment of primary surgical treatment of contaminated with the radioactive materials wound in the receiving department independently of the level of the contamination.
  Primary surgical treatment of wound must be done in receiving department in such cases: level of the contamination of wound >2,5 maximum annual entering, or level of the contamination of the skin around the wound >2000 the beta particle/(sm^2 min) and/or > 20 alpha particle /(sm^2 min). In victims, who have the smaller level of contamination, primary surgical treatment must be done in the operating room of the surgical department
- *the error:* the utilization of the surgical used dressing and napkins without their preliminary radiological study
- *the error:* the hospitalization of victims, that have external or internal contamination into any department besides the special “dirty” department, which accomplishes work under the regular radiation monitoring of patients and medical personnel
- *the error:* to leave without the medical observation in the first twenty-four hours after the emergency (to let go home) the persons with the above-norm irradiation according to the data of individual radiation monitoring, but without the symptoms of primary reaction for the irradiation. Short hospitalization is necessary for the exception of late primary reaction and to collect the victim’s blood for a clinical and cytogenetic study, and biological materials for a radiological study.

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- *the error:* to enlarge the volume of the examination of victims (in comparison with that indicated in the recommendations) without the individual clinical indications
- *the error:* the designation of the treatment of radiation injury without strict indications (for example, vitamins, immunoglobulin, the component of the blood). The indications for the beginning of treatment and its volume are presented in the appropriate clinical recommendations [1, 2, 3, 5, 6].
- *the error:* refuse the urgent surgical procedures, which are necessary for victim (for example, osteosynthesis and other) because of concomitant irradiation
- *the error:* the use of medical procedures on decorporation (for example, bronchial- alveolar lavage, hemosorption, plasmaferesis and other) in cases of the internal contamination with radioactive isotopes in a quantity <100 maximum annual entering
- *the error:* the utilization of biological material (urine, faeces) without their preliminary radiological study
- *the error:* the collecting of the first samples of urine and faeces for a radiological study already after the beginning of the specific therapy by complexone, for example, by Pentacin
- *the error:* hospitalization for more than 1-3 days of victims, not having the signs of general irradiation in the dose >1 Sv (on primary reaction and lymphopenia), either the primary erythema of the skin or the internal contamination with radioactive isotopes in a quantity >2,5 maximum annual entering. Medical observation of such victims can be continued in outpatient regime.
- *the error:* the direction of the witness of emergency into the specialized radiological medical department only on the fact of participation in the emergency, (i.e. without the signs of radiation injuries or substantiated forecast of their development). Exception: the direction is explained by the necessity of scientific studies, the victim does not object it
- *the error:* to consider that all changes in the health status during 3 months from the emergency (for example, cytopenia) are the manifestations of irradiation, especially, if there is no clear confirmation of emergency irradiation in the clinically significant range of doses. For example, cytopenia can be caused by the medicines, alcohol, by virus infection and others
- *the error:* to consider person disabled through the period of the medical observation after irradiation in spite of the absence of any complaints
- *the error:* to leave without prolonged observation the witnesses of emergency with the radiation dose from 50 to 200 mSv and >200 mSv and don’t include them in medico- dosimetric register

Recommendations for the local medical unit #120 of FMBA regarding the selection of the measures for medical intervention in concealed radiation emergencies

With the undoubted radiation emergency the actions of medical personnel are organized by the chief of MSU #120 in accordance with criteria described above and with “The instruction to medical personnel of medical unit #120 about therapeutic, prophylactic and hygiene measures in the initial period of radiation emergency with different types of radiation emergencies taking into account of ways and factors of the radiation exposure”.

The determination of the measures for the intervention in the case of concealed radiation emergencies is more difficult. Taking into account the small number of victims with this scenario, the measures for medical intervention can be coordinated in each specific case with the expert establishments.

Table 2 describes the clinical symptoms and the syndromes, which require including the possibility of the unregistered radiation exposure of person in a differential- diagnostic list of patient with complaints and the changes in the health’s status of unclear nature.

Table 2. *Symptoms and syndromes which require excluding concealed radiation emergency*

#	Clinical symptoms and syndromes	Differential diagnosis
1	The patient is examined because of fever and/or bleeding, there is pancytopenia in peripheral blood. Bone marrow exam revealed aplasia of hemopoiesis, but no signs of acute leukaemia.	Differential diagnosis include: aplastic anemia, autoimmune pancytopenia, PNH, MDS and chemo or radiation-induced aplasia. Focus attention on absolute lymphocyte count in peripheral blood. Cytogenetic examination is absolutely necessary.
2	Vomiting, diarrhoea, +/- fever, +/- the level of leukocyte and platelets are low,	Differential diagnosis may include severe primary reaction on irradiation. But, first of all, it is necessary to sink about intestinal infection (typhoid fever, the virus infection); the results of bacteriological examination may help to make correct diagnosis. Focus attention: nonconformity of the severity of vomiting and diarrhoea (intensive diarrhoea with only mild vomiting) and simultaneous appearance of vomiting, diarrhoea and cytopenia – does not correspond with primary reaction on irradi
3	Skin and soft tissue injuries, which require to exclude radiation burns	
	Local skin and soft tissue injuries (erythema, dense oedema, pain). No thermal or chemical action in anamnesis. Dark hyperaemia of unknown origin, skin rash, desquamation, repeated blistering	Differential diagnosis may include phlegmon, erysipelas, thrombophlebitis (phlebitis), erythema nodosum, etc. But it is necessary to remember about gamma-irradiation burn. It is necessary to remember about beta-irradiation burn *Epilation of the hair around the injury and onycholysis – may be the symptoms of the radiation burns*

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