PRELIMINARY STUDIES FOR THE DECOMMISSIONING OF THE REACTOR COMPARTMENTS OF THE FORMER PALDISKI MILITARY NUCLEAR SITE AND FOR THE ESTABLISHMENT OF A RADIOACTIVE WASTE REPOSITORY

TASK 2 INTERIM REPORT

COLLECTION OF DATA AND OVERVIEW OF NATIONAL AND INTERNATIONAL REQUIREMENTS

Revision No.: 06

CPV Code: 73210000-7

Consultant’s Contract Number: NR 33/ EKS0101-09

Client: AS A.L.A.R.A.

Registration Number: PLD-DOC-005/EN

Date of development: 03 November, 2015

Archive Number: PLD-DOC-005/EN

Euroopa Liit
Ühtekuuluvusfond

Eesti tuleviku heaks

APPROVAL SHEET

		NAME	SIGNATURE	DATE
CONTRACTOR	**REVIEW**	**E.BABILAS** PROJECT MANAGER		2015-12-30
		S. MOTIEJŪNAS, TECHNICAL EXPERT		2015-12-30
		E. UŠPURAS TECHNICAL EXPERT		2015-12-30
		M. MARTINKEVICH CONTRACTS MANAGER		2015-12-30
APPROVAL	**POSITION**	**M. KOŽENEVSKIJ** “EKSORTUS” DIRECTOR		2015-12-30
SUBCONTRACTOR	**DEVELOPER**	**FCNRS**		2015-12-30

		NAME		DATE
SUBCONTRACTOR	AUTHOR, POSITION	**T.F. MAKARCHUK** HEAD OF THE DEPARTMENT, JSC FCNRS		
		A.N. LOKHOV MANAGER OF THE DEPARTMENT, JSC FCNRS		
		A.A. KVAR EXPERT, JSC FCNRS		
		V.Y. KITAYEVA CHIEF SPECIALIST, JSC FCNRS		
		N.V. TITOV EXPERT, JSC FCNRS JSC NIPTB ONEGA		
		R.A. NIZANUTDINOV EXPERT, JSC FCNRS JSC NIPTB ONEGA		
		A.A. DANILIN EXPERT, JSC FCNRS JSC NIPTB ONEGA		
		YU.YU. KOSVINTSEV MAIN SPECIALIST, JSC FCNRS		
		A.F. MIRZIN HEAD OF NRS DEPARTMENT, JSC FCNRS		
		S.V. SEMENOVYIH EXPERT, JSC FCNRS		
		A.V. DEMIN HEAD OF DESIGN DEPARTMENT DP-1, JSC ATOMPROEKT		
		V.V. KASHEEV HEAD OF DEPARTMENT, JSC ATOMPROEKT		
		V.V. MEYER HEAD OF DEPARTMENT, JSC ATOMPROEKT		
		V.A. DMITRIYCHUK HEAD OF SECTION, JSC ATOMPROEKT		
		T.V. SHIDLOVSKAYA LEADING ENGINEER-DESIGNER, JSC ATOMPROEKT		
		YU.M. SIMANOVSKIY MAIN SPECIALIST, JSC ATOMPROEKT		
		A.V. PAUTE COMPLIANCE SUPERVISOR, JSC ATOMPROEKT		

TABLE OF CONTENTS

DESIGNATIONS AND ABBREVIATIONS

AC	Activated Crud
CFW	Control-Free Waste
CERS	Comprehensive engineering and radiation survey
D	Decommissioning
DCP	Donkey Centrifugal Pump
EDR	Exposure Dose Rate
eH	Oxidation-reduction potential (ORP)
ES	Energy Stand
EU	European Union
EURATOM	European Atomic Energy Community
EW	Exempt Waste
GSG	General Safety Guide
HLW	High Level Waste
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste
IP	Industrial Packaging
IWPT	Iron-Water Protection Tank
LB	Left Board (Portside)
LILW	Low- And Intermediate Level Waste
LLW	Low-Level Waste
LRW	Liquid Radioactive Waste
LSA	Low Specific Activity
LTS RC	Long-Term Storage Of Reactor Compartments
MCP	Main Circulating Pump
MTS	Main Technological Section
N	Navy
NF	Nuclear Facility

NM	Nuclear Maintenance
NORM	Naturally Occurring Radioactive Material
NPS	Nuclear-Powered Submarine
NPU	Nuclear Power Unit
NS	Nuclear Submarine
Partition-off	part of the space bounded by the wall, usually designed for the individual machines, equipment, instrumentation and so on. (Russian – «выгородка»)
PPE	personal protective equipment (Russian - "средства индивидуальной защиты")
PS	Port Side
RC	Reactor Compartment
RHF	Radiation-Hazardous Facility
RV	Reactor Vessel
RW	Radioactive Waste
RWDF	Radioactive Waste Disposal Facility
RWLTS	Radioactive Waste Long-Term Storage Point
SB	Starboard
SCO	Facility With Surface Contamination
SG	Steam Generator
SNF	Spent Nuclear Fuel
SRW	Solid Radioactive Waste
SSG	Specific Safety Guide
SSR	Specific Safety Requirements
SSS	Steam Supply System
TC	Training Center
VLLW	Very Low-Level Waste
VSLW	Very Short Lived Waste

INTRODUCTION

This work was executed under terms of the research Contract No.33 / EKS0101-09 as of 17 September 2014 between AS A.L.A.R.A. and UAB EKSORTUS «Preliminary studies for the decommissioning of the reactor compartments of the former Paldiski military nuclear site and for the establishment of a radioactive waste repository».

The aim of work performance is to:

- review and analyze the available data concerning the reactor compartments of the former Paldiski military nuclear site and the establishment of a radioactive waste repository;
- review IAEA, the European Union, the Estonian Republic and the Russian Federation regulations, relating to the area of decommissioning of the NS reactor compartments, which shall be observed upon making decisions on decommissioning of the reactor compartments of the former Paldiski military nuclear site;
- review the documents of the IAEA, European Union, Republic of Estonia and Russian Federation, regulating radioactive waste disposal, eliciting requirements to the radioactive waste disposal, which shall be observed under making decisions on the permanent radioactive waste disposal generated under decommissioning of the reactor blocks of the former Paldiski military facility.

CHAPTER 1

COLLECTION AND ANALYSIS OF THE AVAILABLE DATA CONCERNING THE REACTOR COMPARTMENTS AND OTHER RELATED ASPECTS

1.1 ORIGIN, OPERATION AND DECOMMISSIONING OF REACTOR STAND UNITS OF THE FORMER TRAINING CENTER OF NAVAL FORCE OF THE RUSSIAN FEDERATION IN THE PAKRI PENINSULA

In the late 1960s a training center of Naval Force of Russia was built at the territory of the Pakri Peninsula near the city of Paldiski (Estonia) for nuclear powered submarine crews training under the conditions maximally close to the real life. The main facility of the training center was a functional ground stand, simulating the nuclear power unit (NPU) of the first generation nuclear powered submarine (installation 346A). Except the nuclear compartment the stand included all necessary control, command and logistic equipment assembled in the compartments of the section by form and sizes fit the casing of actual nuclear-powered submarine. The stand was situated in the main technological section, surrounded by the buildings and constructions securing the safety of the stand in case of probable emergencies, as well as by the buildings and constructions used for formed radioactive waste management. The nuclear reactor and all logistic infrastructure were put into operation in 1968 and functioned trouble-free. In 1980 installation 346A was reconstructed: steam generators were replaced with more perfect ones and nuclear fuel was replaced by the fresh one. Unloaded nuclear fuel after relevant cooling was transported to the Russian Federation for processing.

Later, in 1983 main technological section was extended by means of attaching to it of an additional surface prototype of nuclear power unit of the second generation nuclear powered submarine (installation 346B). The stand was located in the compartments complying by shape and sizes with the actual compartments of a nuclear powered submarine of the second generation. Both stands functioned trouble-free till 1989, when they were stopped finally due to the political situation in the Soviet Union and a question of their decommissioning came up. No accidents related to the emergency aggravation of radiation situation in the main technological section were revealed during the entire period of operation of both installations. No technogeneus pollution of environmental objects such as soil, vegetation, groundwater, and etc., as well as of surrounding areas was observed for the period of long-term observations. The data of radiation independent studies carried out by the US experts in summer of 1995 confirmed satisfactory radiation environment at the site itself and at the surrounding area [1].

1.2 PRINCIPAL TECHNICAL SPECIFICATION OF ENERGY STANDS

Reactor stands were the analogs of nuclear power facilities of nuclear-powered submarine situated in the ground conditions and serving to train specialists on control of the reactor facilities.

Technical specification of stands and stages of operation are given in Table 1.

Table 1: Technical specification of stands and stages of operation

Stand	346A	346B
Reactor type	PWR/BM-A	PWR/BM-4
Heat power, MW	70	90
Outside sizes of a stand, m: Length Diameter	 50 7.5	 50 9.5
Operational stages of a stand: commissioning final shutdown total operating time of a stand, hr fuel recharging	 10/04/1968 January 1989 20281 1980	 10/02/1983 December 1989 5333 -
Final unloading	July – September 1994	

Both installations were situated inside the main technological section in the general stand hall with the length of 180, width of 18 and height of 22 m, which was equipped with two bridge cranes with the lifting capacity of 50 t each. In the last years the lifting capacity was limited to 30 tons by the Technical supervision authority of the Republic of Estonia.

1.3 ARRANGEMENT OF WORKS ON DECOMMISSIONING OF ENERGY STANDS OF THE FORMER TRAINING CENTER OF THE RUSSIAN FEDERATION IN PALDISKI CITY IN THE REPUBLIC OF ESTONIA

In July 1994 an intergovernmental agreement was concluded between the Russian Federation and the Republic of Estonia under which the territory of the training center together with all the constructions were transferred into ownership of the Republic of Estonia. Whereas all facilities should be put to the stable safety condition, i.e. a question of decommissioning of radiation hazardous facility came up.

Arrangement and works performance on safe long-term storage of the former training center of Naval Force of the Russian Federation was entrusted to GI VNIPIET (Lead Institute of the All-Russia Science Research and Design Institute of Power Engineering Technology).

At the first stage the spent nuclear fuel of both reactors was unloaded in September 1994 and transported to Russia for processing under the documentation of GI VNIPIET and in accordance with the Agreement. After this operation the former training center stopped being a nuclear hazardous facility but the radiation danger was remaining because of equipment and waste presence having high radioactive pollution. At the same time for development of the documentation on decommissioning of the facility in Paldiski the Russian party formed a working group consisting of the specialist of the following enterprises:

- Research and development institute GI VNIPIET;
- Design and engineering bureau CDB ME “Rubin” (Central Design Bureau for Marine Engineering);
- Research and development institute NIKIET;
- Experimental design bureau for mechanical engineering OKBM.

The specialists from PO «Sevmash» were involved at the stage of dismounting works of compartments adjacent with the reactor compartment and dismounting of non-radioactive equipment of the reactor compartments.

GI VNIPIET developed a preliminary concept of the reactor stands decommissioning. In the Concept three options for reactor compartments decommissioning were proposed and studied with evaluation of complexity, durability and cost of practical works performance:

1 Disposal of reactor compartments at the place of their installation. Duration of works was evaluated as 4 – 6 years;
2 Disposal of reactor compartments in a new constructed near-surface repository of radioactive waste in the territory of the Pakri peninsula. Duration of works was evaluated as 5 – 8 years;
3 Preparation and placement of reactor compartments for long-term controlled storage with the term up to 50 years. Duration of works was evaluated as 1 - 1.5 year.

The concept was studied by the Estonian party with involvement of the IAEA experts. The 3rd option was chosen as the most acceptable for the owners of constructions because of the least cost and term of execution with consideration of compliance of all safety measures [1].

1.4 EQUIPMENT CONFIGURATION AND RADIOLOGICAL CHARACTERISTICS OF REACTOR STANDS 346A AND 346B

A certain amount of radioactive waste was placed in the reactor compartments and fixed with concrete during 1995. Lists of these wastes were compiled in September 1995 and given to the Estonian authorities when transferring ownership of the site. It is understood that most of the radioactive wastes stored in reactor compartment 1 are low level (rags, metallic wastes, tools etc.), with surface contamination. These wastes are located principally on the third floor of the reactor compartment. The total weight of such wastes in RC1 (346A) is thought to be around 15 tons.

However, about 100 radioactive sources (used for calibrating radiological measurement equipment) were also entombed in concrete poured into the compartment within five or so containers (at the present moment it is not possible to indicate the exact location of sources), and comprise:

• neutron sources: Pu-238, Be-7, Cf-252
• γ-radiation sources: Co-60
• β-radiation sources: Na-22, Cl-36, Sr-90/Y-90, Cs-137, Tl-204
• α-radiation sources: Pu-239

Plutonium and cesium sources ranged from a few kBq to a few MBq. The total activity of the radioactive sources that were on site and might have been placed into RC1 was about 4.4 TBq in 1995 (mainly Co-60). All these sources are located inside shielding containers (Tables 2-4). For neutron sources and some γ-radiation sources, the container is constructed of special paraffin and/or lead. For β-radiation and α-radiation sources, the container is of plastic or wood. Most sources were placed into the U-shaped first-floor room where the main equipment of the first loop is located, and in the second floor area containing the motors and pumps, before these spaces were grouted with concrete. However, some sources could also have been placed in concrete poured onto the reactor vessel lid [1].

Table 2: List of ionizing radiation sources

№	Denomination of isotope, material, source	Activity (by passport)	Date of a passport issue (certificate) by manufacturer**
1	Fast neutron source Pt-Be ИБН-87 based on Pu-238	$5.0x10^7$ neutron/sec	March 1980
2	Co-60 gamma-source of the 2nd grade ГИК-2-14	$1.02x10^{10}$ Bq	January 1987
3	Co-60 gamma-source of the 2nd grade ГИК-2-14	$1.02x10^{10}$ Bq	January 1987
4	Pu-239, 9 $1/100cm^2$	3.62 Bq	February 1991
5	Pu-239, 9 $1/100cm^2$	16.2 Bq	February 1991
6	Pu-239, 9 $1/100cm^2$	44.3 Bq	February 1991
7	Pu-239, 9 $1/100cm^2$	158 Bq	February 1991
8	Pu-239, 9 $1/100cm^2$	447 Bq	February 1991
9	Pu-239, 9 $1/100cm^2$	1580 Bq	February 1991
10	Pu-239, 9 $1/100cm^2$	4380 Bq	February 1991
11	Pu-239, 9 $1/100cm^2$	17100 Bq	February 1991
12	Pu-239, 9 $1/100cm^2$	40000 Bq	February 1991
13	Pu-239, 9 $1/100cm^2$	412 Bq	February 1991
14	Pu-239, 9 $1/100cm^2$	1490 Bq	February 1991
15	Pu-239, 9 $1/100cm^2$	4300 Bq	February 1991
16	Pu-239, 9 $1/100cm^2$	16500 Bq	February 1991
17	Pu-239, 9 $1/100cm^2$	40000 Bq	February 1991
18	Pu-239, 9 $1/100cm^2$	176000 Bq	February 1991
19	Pu-239, 9 $1/100cm^2$	424000 Bq	February 1991
20	Pu-239, 9 $1/100cm^2$	1470000 Bq	February 1991
21	Pu-239, 9 $1/100cm^2$	416 Bq	April 1991
22	Pu-239, 9 $1/100cm^2$	40.6 Bq	April 1991
23	Pu-239, 9 $1/100cm^2$	3.61 Bq	April 1991
24	Pu-239, 9 $1/100cm^2$	450 Bq	April 1991
25	Pu-239, 9 $1/100cm^2$	1040 Bq	April 1991
26	Pu-239, 9 $1/100cm^2$	2670 Bq	April 1991
27	Pu-239, 9 $1/100cm^2$	2590 Bq	April 1991
28	Pu-239, 9 $1/100cm^2$	2890 Bq	April 1991
29	Pu-239, 9 $1/100cm^2$	4280 Bq	April 1991
30	Pu-239, 9 $1/100cm^2$	4370 Bq	April 1991
31	Pu-239, 9 $1/100cm^2$	4390 Bq	April 1991
32	Pu-239, 9 $1/100cm^2$	11200 Bq	April 1991
33	Pu-239, 9 $1/100cm^2$	43500 Bq	April 1991
34	Pu-239, 9 $1/100cm^2$	247 Bq	April 1991
35	Pu-239, 9 $1/100cm^2$	253 Bq	April 1991
36	Pu-239, 9 $1/100cm^2$	235 Bq	April 1991
37	Pu-239, 9 $1/100cm^2$	110 Bq	April 1991

№	Denomination of isotope, material, source	Activity (by passport)	Date of a passport issue (certificate) by manufacturer**
38	Pu-239, 9 1/100cm^2	706 Bq	April 1991
39	Pu-239, 9 1/100cm^2	1760 Bq	April 1991
40	Pu-239, 9 1/100cm^2	1760 Bq	April 1991
41	Pu-239, 9 1/100cm^2	1740 Bq	February 1991
42	Pu-239, 9 1/100cm^2	1770 Bq	February 1991
43	Pu-239, 9 1/100cm^2	87 Bq	March 1990
44	Pu-239, 9 1/100cm^2	137 Bq	March 1990
45	Pu-239, 9 1/100cm^2	395 Bq	March 1990
46	Pu-239, 9 1/100cm^2	929 Bq	March 1990
47	Sr-90 chlorous	$0.6x10^{-3}$ Bq	November 1991
48	Sr-90+Y-90 alloy 1; 40; 160 cm^2	7460000 Bq	April 1991
49	Sr-90+Y-90 alloy 1; 40; 160 cm^2	744000 Bq	April 1991
50	Sr-90+Y-90 alloy 1; 40; 160 cm^2	73500 Bq	April 1991
51	Sr-90+Y-90 alloy 1; 40; 160 cm^2	7410 Bq	April 1991
52	Sr-90+Y-90 alloy 1; 40; 160 cm^2	739 Bq	April 1991
53	Sr-90+Y-90 alloy 1; 40; 160 cm^2	3020002 Bq	April 1991
54	Sr-90+Y-90 alloy 1; 40; 160 cm^2	505000 Bq	April 1991
55	Sr-90+Y-90 alloy 1; 40; 160 cm^2	270000 Bq	April 1991
56	Sr-90+Y-90 alloy 1; 40; 160 cm^2	68 Bq	April 1991
57	Sr-90+Y-90 alloy 1; 40; 160 cm^2	207 Bq	April 1991
58	Sr-90+Y-90 alloy 1; 40; 160 cm^2	290 Bq	April 1991
59	Sr-90+Y-90 alloy 1; 40; 160 cm^2	302 Bq	April 1991
60	Sr-90+Y-90 alloy 1; 40; 160 cm^2	528 Bq	April 1991
61	Sr-90+Y-90 alloy 1; 40; 160 cm^2	553 Bq	April 1991
62	Sr-90+Y-90 alloy 1; 40; 160 cm^2	727 Bq	April 1991
63	Sr-90+Y-90 alloy 1; 40; 160 cm^2	1910 Bq	April 1991
64	Sr-90+Y-90 alloy 1; 40; 160 cm^2	3250 Bq	April 1991
65	Sr-90+Y-90 alloy 1; 40; 160 cm^2	5660 Bq	April 1991
66	Sr-90+Y-90 alloy 1; 40; 160 cm^2	5590 Bq	April 1991
67	Sr-90+Y-90 alloy 1; 40; 160 cm^2	20600 Bq	April 1991
68	Sr-90+Y-90 alloy 1; 40; 160 cm^2	26000 Bq	April 1991
69	Sr-90+Y-90 alloy 1; 40; 160 cm^2	1960000 Bq	April 1991
70	Sr-90+Y-90 alloy 1; 40; 160 cm^2	53800 Bq	April 1991
71	Sr-90+Y-90 alloy 1; 40; 160 cm^2	27900 Bq	April 1991
72	Sr-90+Y-90 alloy 1; 40; 160 cm^2	6680 Bq	April 1991
73	Sr-90+Y-90 alloy 1; 40; 160 cm^2	5290 Bq	April 1991
74	Sr-90+Y-90 alloy 1; 40; 160 cm^2	4770000 Bq	April 1991
75	Standard spectrometric source «ОСГИ» beta-activity type	10^5 decay per second	
76	Standard spectrometric source «ОСГИ» beta-activity type from II sources	10^5 Bq	November 1991
77	Cf-252	$1.7x10^7$ neutron/sec	March 1980
78	Na-22 chlorous	600000 Bq	
79	Tl-204	$0.5x10^{-3}$ Bq	November 1991
80	Co-60 ГИК-2-18	$5.11x10^{11}$Bq	January 1987
81	Co-60 ГИК-2-18	$5.11x10^{11}$Bq	April 1980

№	Denomination of isotope, material, source	Activity (by passport)	Date of a passport issue (certificate) by manufacturer**
82	Co-60 ГИК-5-2	$3.16x10^{12}$Bq	March 1987
83	Pu-Be source of ИБН-87 type	$4.85x10^{7}$neutron/sec	July 1987
84	Standard spectrometric source alpha emission (ОСИАИ)	38400 Bq	November 1989
85	Standard spectrometric source alpha emission (ОСИАИ)	4180 Bq	November 1989
86	Standard spectrometric source alpha emission (ОСИАИ)	35000 Bq	November 1989
87	Standard spectrometric source alpha emission (ОСИАИ)	39400 Bq	November 1989
88	Standard spectrometric source alpha emission (ОСИАИ)	44200 Bq	July 1991
89	Standard spectrometric source alpha emission (ОСИАИ)	3940 Bq	July 1991
90	Standard spectrometric source alpha emission (ОСИАИ)	38400 Bq	July 1991
91	Standard spectrometric source alpha emission (ОСИАИ)	37400 Bq	July 1991
92	Pu-239	1060 Bq	March 1990
93	Pu-239	4020 Bq	March 1990
94	Pu-239	10700 Bq	March 1990
95	Pu-239	41000 Bq	March 1990
96	Pu-239	3.59 Bq	March 1990
97	Pu-239	40.3 Bq	March 1990
98	Pu-239	403 Bq	March 1990
99	Pu-239	660 Bq	March 1990
100	Pu-239	4 Bq	February 1988
101	Pu-239	39 Bq	February 1988
102	Pu-239	445 Bq	February 1988
103	Pu-239	700 Bq	February 1988
104	Pu-239	117 Bq	February 1988
105	Co-60 ГИК-2-7	$3.4x10^{8}$Bq	January 1987
106	Cs-137 nitrate	$0.5x10^{-3}$ Bq	November 1991
107	Co-60 type ЗК-0 (solution)	$0.5x10^{-3}$ Bq	November 1991

** "alloy 1" – ionizing radiation sources material which incorporates the radionuclides (in Russian – «Сплав 1»)*

*** the passport issue date corresponds to the production date. Some of the sources were delivered to the Paldiski site after the reactor shutdown (1989). The dates of the passports issue are based on the sources passports list provided by ALARA AS (the copies of the sources passports are unavailable).*

Table 3: List of solid radioactive waste placed into reactor compartment of Unit 1 (346A)

No.	Description	Weight [kg]	Quantity [item]	Surface dose rate γ [μSv/h], 1995	Contamination β [Bq/cm^2], 1995
1	Container for transportation of spent fuel sleeves	6000		1.7	8
2	Bag with industrial trash and rags	40		0.3	1.7
3	Bag with boots and PVC film	50		0.3	1.7
4	Bag with boots, plastic, protective clothes, etc.	30		0.3	3.4
5	Bag with industrial trash.	15		0.3	25
6	Stand for transport rod's sleeves	110		1.7	5
7	Companion ladder	130		1.7	5
8	Support for transport container (item No. 1)	260		1.7	5
9	Device for turning off reactor lid nuts.	60		1.7	2.5
10	Pipes of the 2nd,3^{d} loops and draining systems		5	2.8	15
11	Mooring rings		5	2.3	5
12	Compensating grids driving gears		170	2.3	3.3
13	Driving gears (small)		12	2.3	1.7
14	Air filter	200		0.3	16.7
15	Leading gears	1500		0.6	50
16	Cross-arm	500		2.3	66.7
17	Saucer	500		0.3	2
18	Saucer with ropes	150		0.9	2.7
19	Lodgement with pipes, valves armature.	300		0.3	16.7
20	Valves	100		0.3	5
21	Steel and lead container (for overload) in the transport cask (waterproof) with 5 Co-60 sources	1200		5700	
22	Paraffin container with 5 neutron sources	400		5.0x10^{7}n/sec	**-**
23	Laboratory container with 1 Co-60 source	350		0.3	
24	Wooden box with flat Pu-239 and Sr-90 control sources	60		0.4	
25	Box (wooden) with 50 smoke detectors	25		0.3	**-**

Table 4: Characteristics of radioactive sources that were on site and had or might have been placed into reactor compartment of Unit 1 (346A)

№	Type of wastes	Type of container	№ of container	Isotopic composition	Radiation type	Specific Activity	Number of wastes	Total Activity of containers with sources (as calculated by the Site Radiation Safety Unit in 1994-1995)
1	Solid	Paraffin container	10	Fast neutrons source plutonium-beryllium, IBN-87, with Plutonium 238	neutrons	$5.0x10^7$n/s	01	$8.8x10^{10}$ Bq (estimate)
2	Solid	Steel and lead container (for overload) in the transport cask (waterproof).	04	Cobalt-60 γ-sources category 2, GIK-2-14	gamma	$1.02x10^{10}$Bq	02	$1.04x10^{10}$Bq
3	Solid	Wooden box	-	Pu-239 91/100cm^2	alpha		43	2,554x10^{6}Bq
4	Solid	Metallic box	-	Cl Sr-90 act.5mk	beta	$6x10^5$ Bq	01	$6x10^5$ Bq
5	Solid	Wooden box	—	Strontium-90+Ittrium-90 1; 40 ; 160cm^2	beta		27	1,9x10^7 Bq
6	Solid	Plastic box		Spectrometric control sources γ-radiation (SSERG) type B	gamma	10^5 desint/s	01	10^5 desint/s
7	Solid	Plastic box	-	SSERG type B	gamma	10^3 Bq	11	$1.1x10^6$ Bq
8	Solid	Paraffin container	10	Californium-252	neutrons	$1.7x10^7$n/s	01	$1.5x10^8$ Bq (estimate)
9	Solid	Metallic box	-	NaCl-22	beta gamma	$6x10^5$ Bq	01	$6x10^5$ Bq
10	Solid	Metallic box	-	Tallium-204	beta gamma	$5x10^5$ Bq	01	$5x10^5$ Bq
11	Solid	Steel and lead container / Paraffin container	04, 10	Cobalt-60 GIK-2-18	gamma	$5.1x10^{11}$ Bq	01	$5.1x10^{11}$ Bq
12	Solid	Steel and lead container / Paraffin container	04, 10	Cobalt-60 GIK-2-18	gamma	$5.1x10^{11}$Bq	01	$5.1x10^{11}$ Bq
13	Solid	Steel and lead container / Paraffin container	04, 10	Cobalt-60 GIK-2-18	gamma	3.16xl0^{12} Bq	01	3.16xl0^{12} Bq
14	Solid	Paraffin container	10	Source PuBe	neutrons	$4.86x10^7$ n/s	01	$8.5x10^{10}$ Bq

				type IBN-87				(estimate)
15	Solid	Plastic box	-	SSEAR	alpha			2,409x10^5 Bq
16	Solid	Wooden box	-	Pu-239	alpha		13	5,92x10^4 Bq
17	Solid	Steel and lead container (for overload) in the transport cask (waterproof).	04	Cobalt-60 GDC-2-7	gamma	3.4x10^8 Bq	01	3.4x10^8 Bq
18	Solid	Metallic box		Cesium-137 nitrate	beta, gamma	5x10^5 Bq	01	5x10^5 Bq
19	Solid	Metallic box		Cobalt-60 Type ZK-0 (solution)	gamma	5x10^5 Bq	01	5x10^5 Bq

1.4.1 Key Process Equipment In Reactor Compartment Of Stand 346A

Stand 346A was fitted with a VM-A nuclear power unit complete with all necessary equipment to ensure long-term, fail-free and safe operation of the energy stand. List of key equipment components and their weight and size characteristics are summarised in Table 5.

In addition to equipment components listed in the Table there are also equipment components belonging to circuits 3 and 4, in particular circulating pumps CP-21 and CP-23 (two in each), which only have minimum radioactive contamination and are installed on the second floor of the pump well. In terms of their weight and size, they are close to heat exchanger VP2-1-0, only somewhat shorter.

Table 5: Key circuit equipment of stand 346A

Equipment	Number	Overall dimensions, mm	Weight, t
1 Reactor vessel VM-A	1	2100x2100x4295	30
2 Steam generator chamber	8	800x940x2300	21.6
3 Main Circulation Pump GCEN-146	1	L—2150; H-2150	4.6
4 Aux. Circulation Pump VCEN-147	1	L – 850 H -1870	1.8
5 Pressuriser	6 bottles	L – 620 H- 3550	1.185x6 (7.2)
6 Activity filter	2	350x550x1800	0.565x2 (1.13)
7 Refrigerator HGCEN-601	1	405x700	0.3
8 Refrigerator HGCEN-146M	1	400x1200	0.115
9 Refrigerator XVCEN-147M	1	300x1200	0.052
11 Heat exchanger VP2-1-0	1	500x1510	0.45
12 Iron-water protection tank	1	2300x2300x3200	52
13. Piping (primary circuit)	3	180x17	0.2
	34.2	140x15	1.6
	9.4	108x11	0.25
	42	83x9	0.706
	7.0	89x9	0.13
	44.0	28x4	0.105
	20.0	15x2,5	0.015
14. Piping (secondary circuit)	29	83x4	0.226
	18.5	36x3	0.045

	30	22x2.5	0.037
	8.0	219x7	0.293
	12	108x6	0.181
	26	108x5	0.330
15. Piping (circuit 3)		63x6.5 34x4.5 22x3.5 16x3	
16. Piping for storage and SG rinsing		32x3.5 16x3	
17. Steam connections piping		194x10 127x14	

Materials used for key circuit equipment:

Reactor vessel and pressuriser - alloyed steel with internal surfacing of stainless steel;

Steam generator - body of steel grade 20, internal tubing of titanium alloys;

Main and auxiliary pumps in the primary circuit - body of alloyed steel with internal surfacing, scroll of stainless steel;

Refrigerator of activity filter - internal tubing of cupro-nickel;

Refrigerator of main and auxiliary pumps in primary circuit - body of alloy MNZH5-1;

Activity filter - stainless steel.

Pump well according to the design is fitted with various pipelines with diameters ranging from 180 to 15 mm which interconnect all available equipment. Considering the amount of installed equipment, piping and cabling, in pump rooms on the 1st and 2nd floors there is very little space left, making the rooms difficult to visit. Further difficulties are created by concrete poured into those rooms.

REACTOR

The reactor (or its metal) is considered as SRW intended for unconditional disposal. The reactor may be leaky in the seams for welding the reactor head to the reactor vessel and for welding the plugs in the reactor head because of inspection being performed through "external examination" only.

STEAM GENERATOR

The steam generator of the PG-14T type consists of 8 cylindrical chambers connected in pairs into 4 sections (Figure 1). The overall dimensions of one chamber are 786 mm diameter and 2300 mm height. All pipelines connected to the chamber are made of 1Cr18Ni9Ti stainless steel.

Three legs welded to each chamber are attached to the ship bases using M24 studs.

The primary water goes above from the reactor to the SG chamber via an 83x9 mm tube and inside the chamber via coils of 18x2.5 mm titanium alloy tubes. The primary water is discharged from the chamber below over an 83x9 mm tube.

The secondary water is supplied to the SG chamber below over a 36x3 mm tube and discharged as steam via an 83x4 mm tube.

A primary water sample has shown the volumetric activity of 1443 Bq/l.

A secondary water sample has shown the volumetric activity of 4.07 Bq/l.

Samples were taken for analysis in September 1994 (the reactor was shut down in January 1989).

The non-discharged secondary water amount is ~ 1000 L.

All the samples were taken from the circuits directly before the removal of water (excluding removal of trapped water). Circuit water measurements were made by the Paldiski Facility Radiation Safety Unit in approximately 1993.

The gamma radiation dose rate (on the above date of measurement, 1994) on the SG cylindrical chamber surface was <0.3 mSv/h.

The steam generator may be decontaminated when a part of the primary circuit tubes are cut for the reactor disconnection and connection of the system with a special pump, a tank for injection of chemical agents, a heater for solutions, etc.

The potential SG decontamination does not have sense because of the low activity of corrosion depositions that have been accumulated on the primary circuit tube inside during 7107 hours.

The radioactivity values are as follows (major radionuclides Co-60, Fe-55, Ni-59, Ni-63):

- after reactor shutdown (in 6 months) - 2.9×10^{11} Bq (over the entire SG surface),
- In 2001 – 1.95×10^{11} Bq,
- In 2015 – 1.36×10^{11} Bq,
- In 2039 – 8.3×10^{10} Bq.

The SG is accessible via a manhole at the fore end of the RC left board (portside) corridor. The steam generator at the RC preservation moment was leak tight.

The weight of the SG-14T with pipelines is 21600 kg.

REACTOR COOLANT PUMP

The GTsEN-146 pump (Figure 2) was intended for the circulation of the primary water. The overall dimensions are 1250 mm diameter and 2150 mm height. All parts contacting the primary circuit are made of 1Cr18Ni9Ti stainless steel. The pump stator is separated from the primary circuit by a Nichrome alloy jacket. The pump body and the scroll (lower portion) are made of 08Cr19Ni12V stainless steel. The scroll flange is made of steel 20.

The pump is attached to the story 2 floor using 12 studs M28.

The pump weight is 4600 kg.

AUXILIARY REACTOR COOLANT PUMP

The VTsEN-147P pump (Figure 3) is auxiliary and its location in the pumping enclosure is similar to that of the GTsEN pump. Its differences from the GTsEN are smaller capacity and dimensions. The overall dimensions are 850 mm diameter and 1870 mm height. All parts contacting the primary circuit are made of 1Cr18Ni9Ti stainless steel.

The pump stator is separated from the primary circuit by a Nichrome alloy jacket. The pump body is made of CrNiTiV steel and the scroll (pump lower portion) is made of 0Cr18Ni10Ti stainless steel.

The pump is attached to the story 2 floor using 11 studs M24.

The pump weight is 1800 kg.

PRESSURIZER

A pressurizer is installed only in the special fore enclosure in the RC of stand 346A. It is intended for compensating the primary circuit volume increase during heating-up.

The pressurizer (Figure 4) consists of 6 steel cylinders with the capacity of 340 liters each. The overall dimensions (assembly 13) are 620 mm diameter and 3190 mm height. The Inside of the cylinders is clad with a thin-wall jacket (the thickness of 3 mm) of stainless steel.

One of the cylinders (assembly 14) (Figure 5) has a special tube with a flange for installation of a level gage and the level gage upper portion is capped with a lead plug protruding over the height from the fore SCS enclosure floor. The gap between the cylinders is filled with carboryte bricks (contain boron carbide,B_4C , protection from neutrons). The overall dimensions (assembly 14) are 620 mm diameter and 3550 mm height.

The cylinders are installed with the support (plate) on the foundation and fastened with 4 studs M20. From the top the cylinders are pressed against the enclosure wall with yokes.

The weight of one cylinder is 1185 kg.

RADIOACTIVITY FILTER

The radioactivity filter (Figure 6) is intended for purifying the primary water of fission product activity and corrosion products through their absorption by sorbents. The primary water delivered to the radioactivity filter is cooled in the KhGTsEN-601 chiller to prevent the sorbents from caking. To protect the radioactivity filter from external heat sources, it has a jacket cooled by the tertiary water.

The overall dimensions are 346 mm diameter and 1790 mm height.

The RC of stand 346A has two filters installed in the rear reactor enclosure. Each filter is attached via a support flange using 10 studs M28.

The material of the filter body, jacket and connected tubes is 1Cr18Ni9Ti steel. The radioactivity filter weight is 565 kg.

KHGTSEN-601 CHILLER

This chiller (Figure 7) is intended for cooling the primary water delivered to the radioactivity filter for purification. The primary water was cooled by circuit 4 with its characteristics on stand 346A are similar to those of the tertiary circuit. The overall dimensions are 405 mm diameter and 1100 mm height.

The chiller is installed on a special support on the pumping enclosure story 1 using 7 studs M20. The KhGTsEN weight is 300 kg.

KHGTSEN-146 M AND KHVTSEN-147 M CHILLERS

These chillers (Figures 8 and 9) are intended for cooling the primary water delivered for cooling the pump rotor bearing. The primary water was cooled by circuit 4 with its characteristics on stand 346A similar to those of the tertiary circuit. Structurally, the chillers are U-shaped, and differ in dimensions only. The overall dimensions are 346 mm diameter and 1200 mm height (for KHGTSEN-146 M) and 240 mm diameter and 1200 mm height (for KHGTSEN-147 M). The chillers are located on the pumping enclosure story 1 and are attached via brackets each using 4 studs M16.

The weight of the KhGTsEN-146M is 114 kg and the weight of the KhVTsEN-147M is 52kg.

HEAT EXCHANGER VP 2-1-0

The VP 2-1-0 heat exchanger (Figure 10) is intended for the tertiary water cooling with the circuit 4 water. The overall dimensions are 450 mm diameter and 1510 mm height.

Two heat exchangers are installed on the story 1 of the pumping enclosure near its fore partition.

The heat exchanger is attached to the base using 6 bolts M16 and to the partition using yokes.

The weight of one heat exchanger is 450 kg.

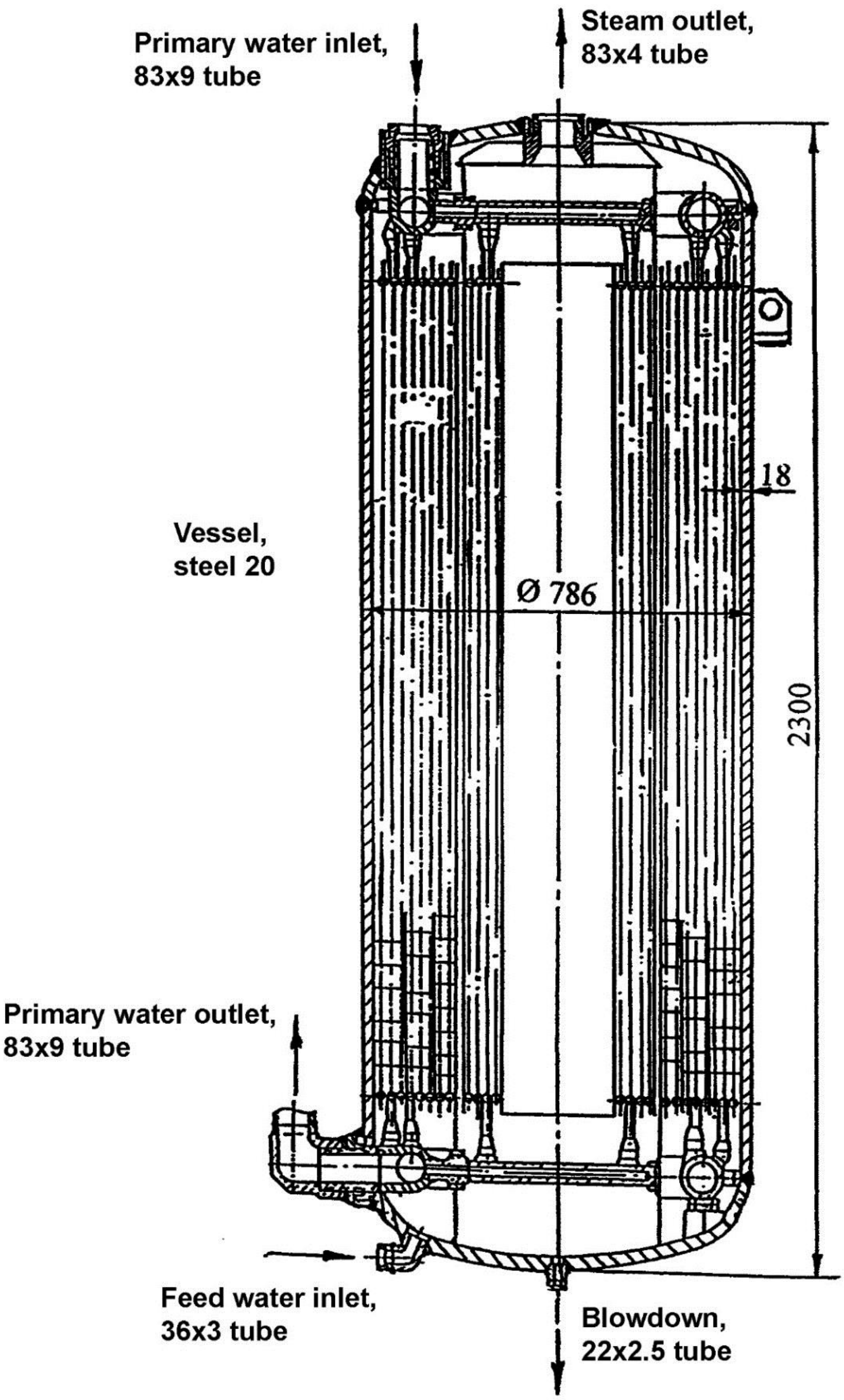


Figure 1. PG-14T steam generator chamber

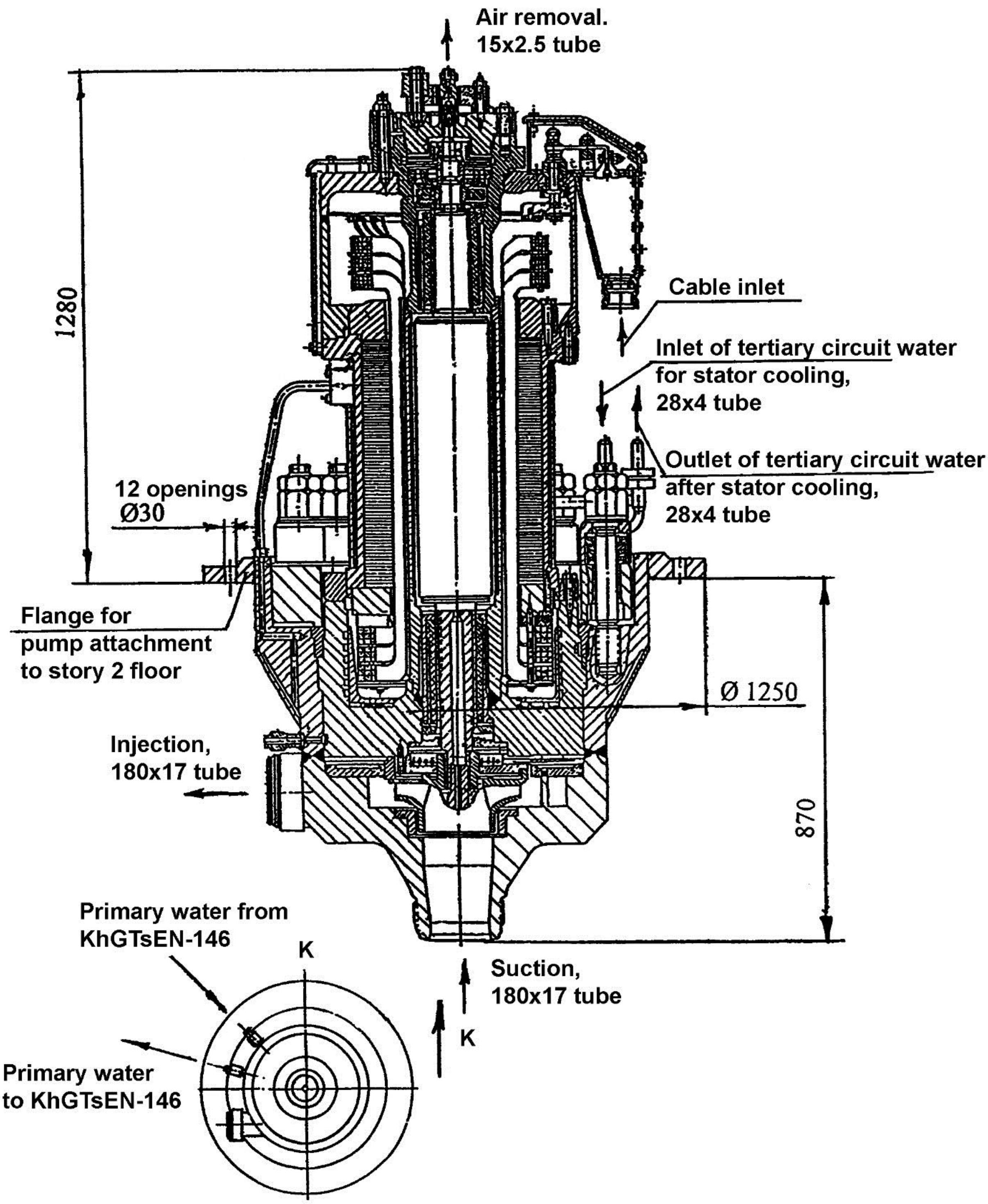


Figure 2. Reactor coolant GTsEN-146 pump

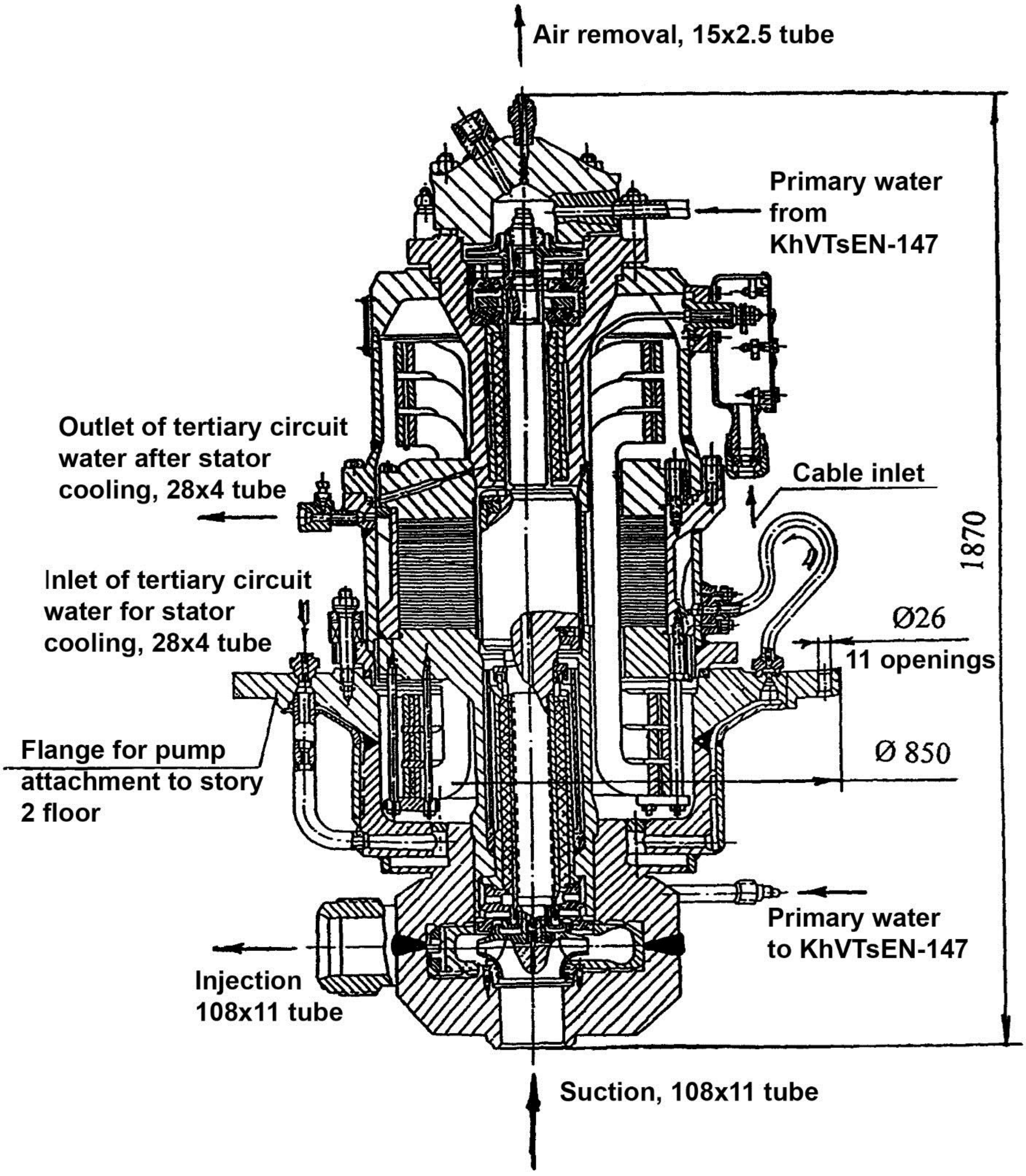


Figure 3. Auxiliary reactor coolant VTsEN-147P pump

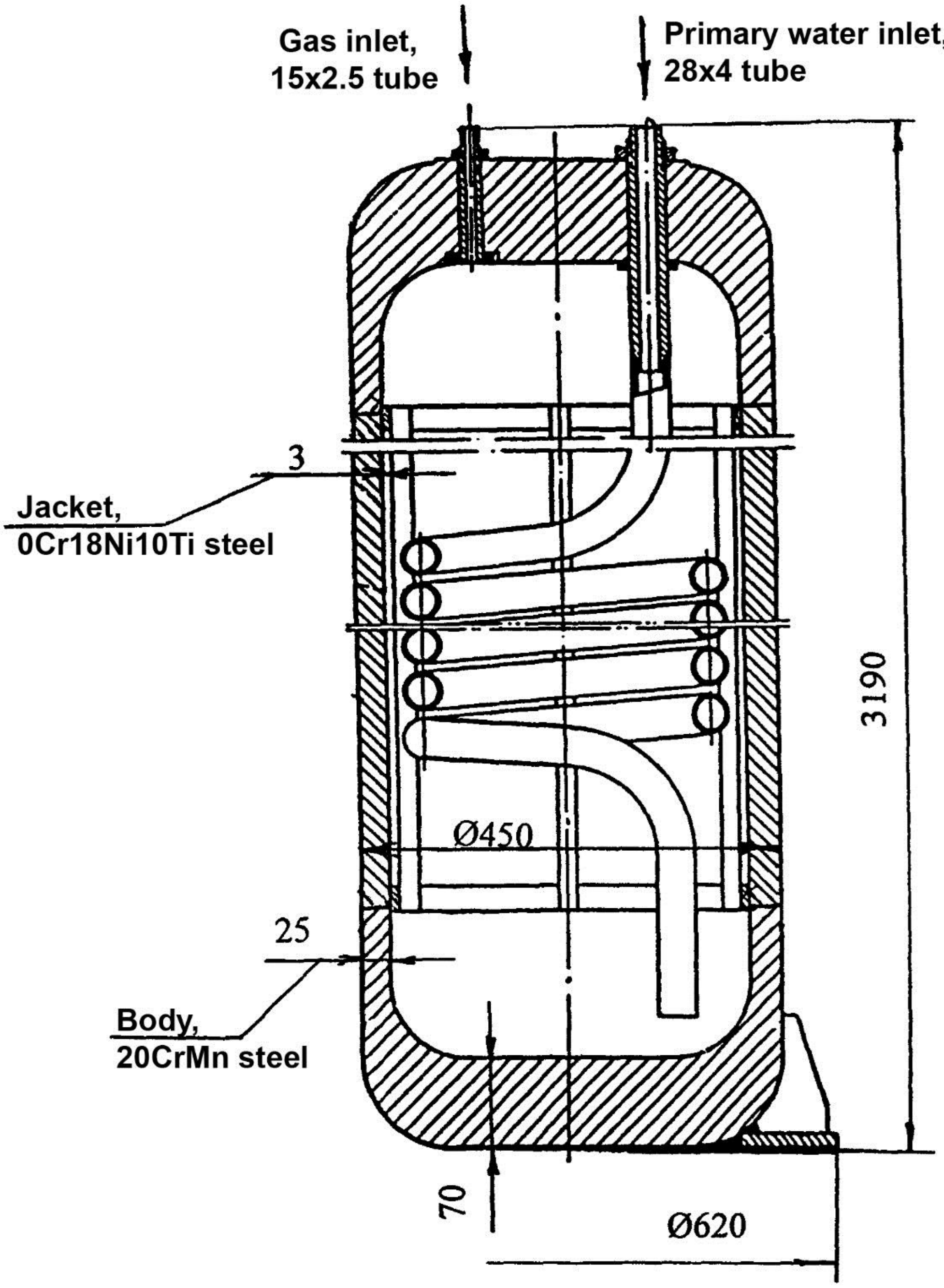


Figure 4. Pressurizer (cylinder), assembly 13

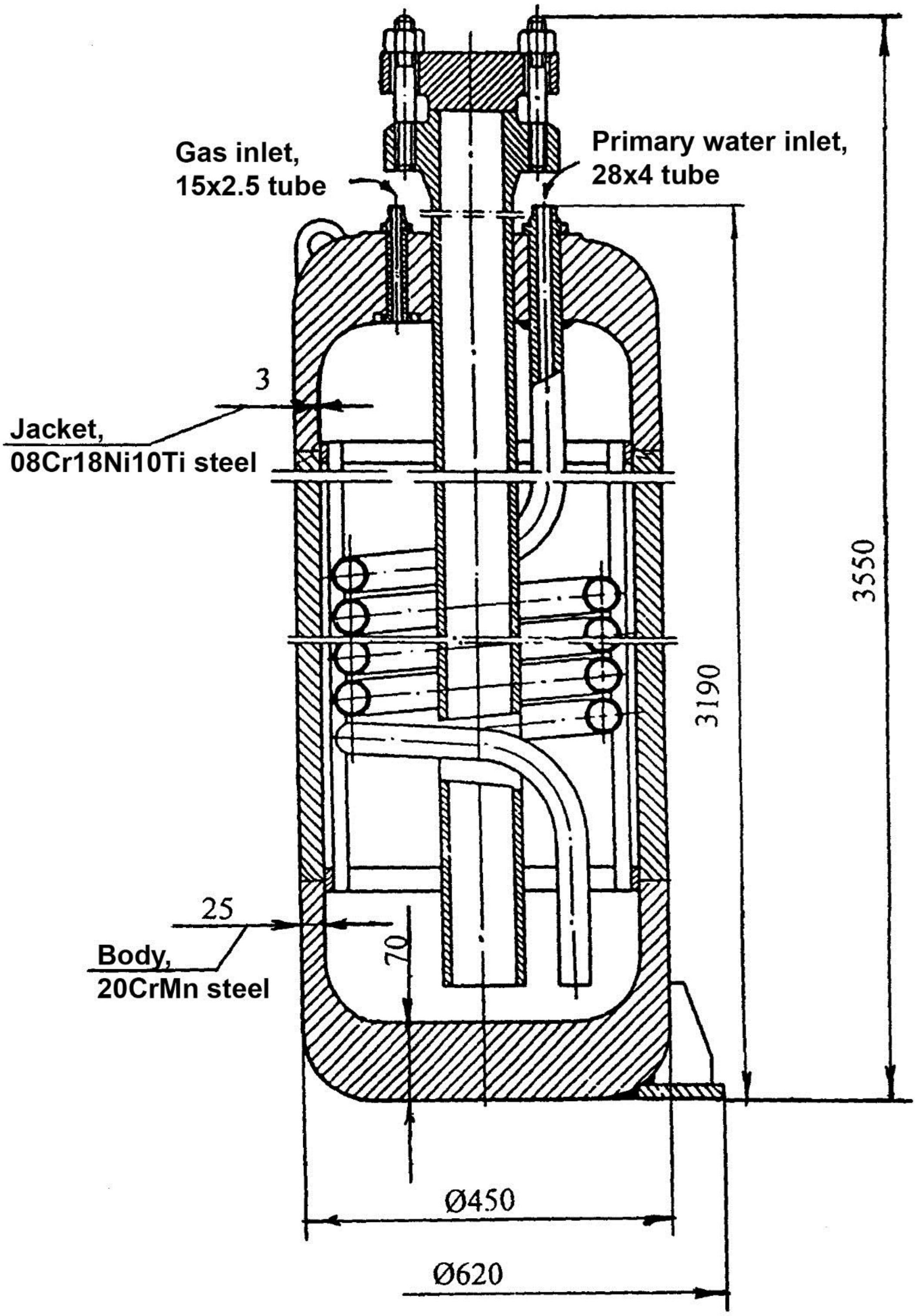


Figure 5. Pressurizer (cylinder), assembly 14

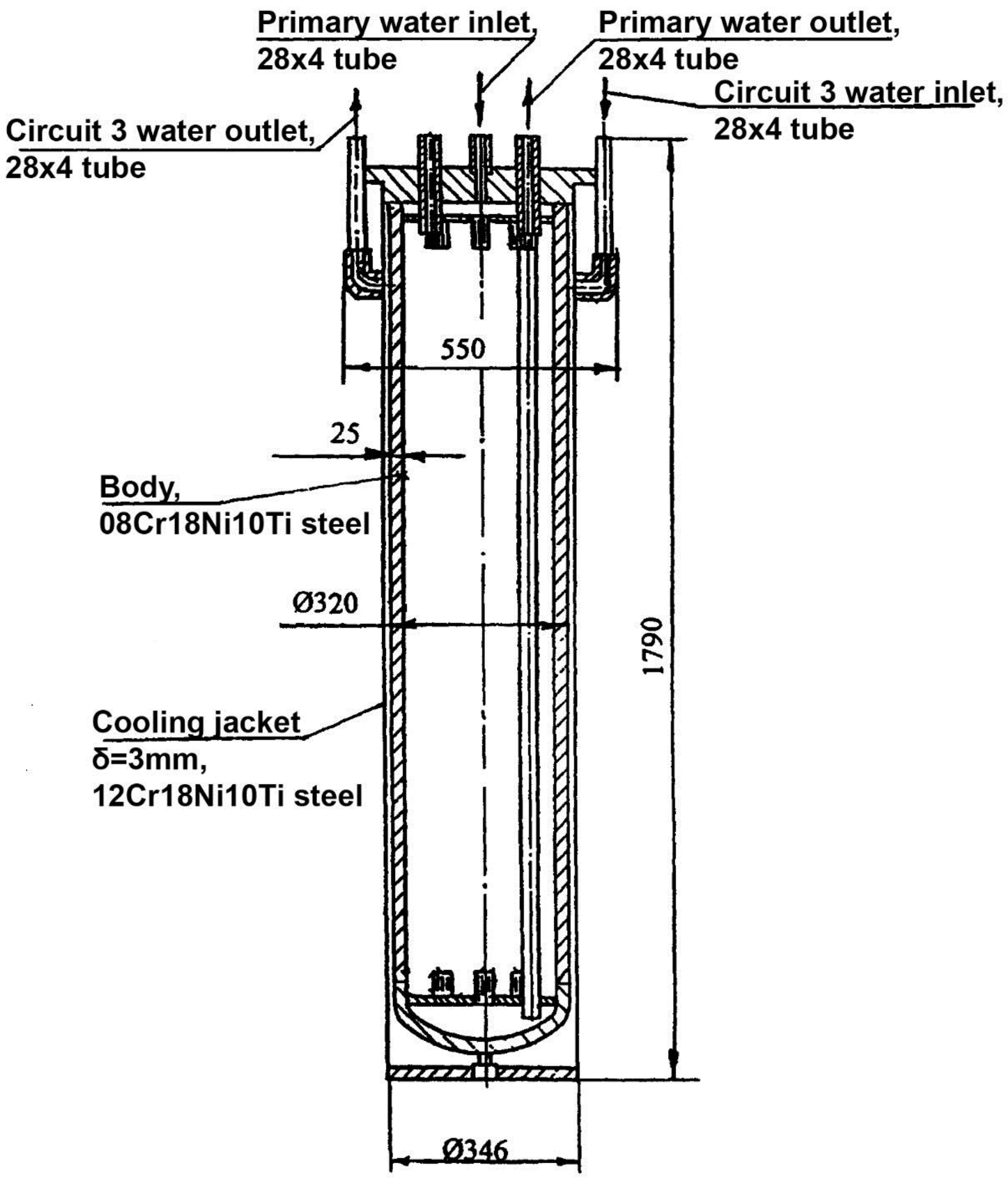


Figure 6. Radioactivity filter

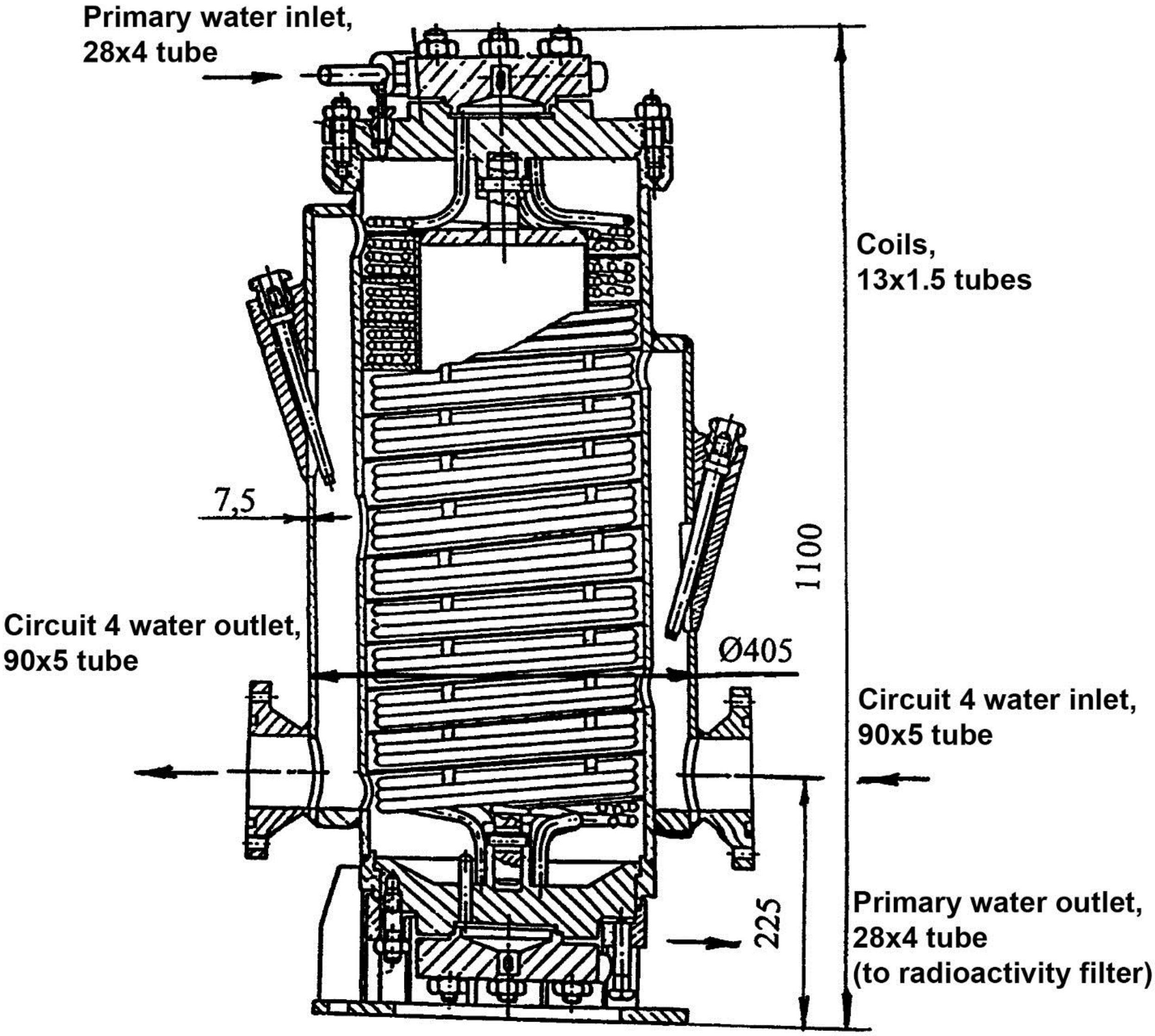


Figure 7. KhGTsEN-601 chiller

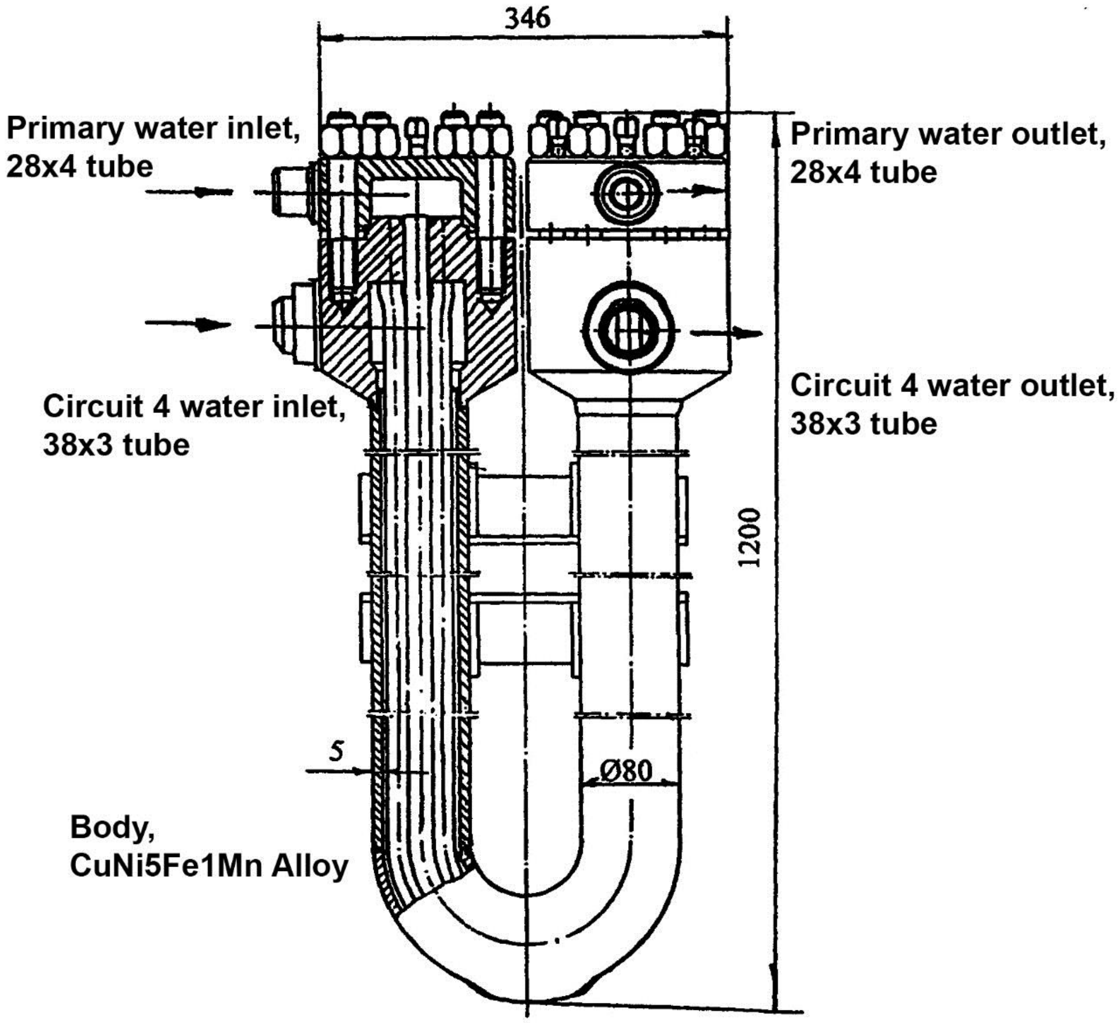


Figure 8. KhGTsEN-146M chiller

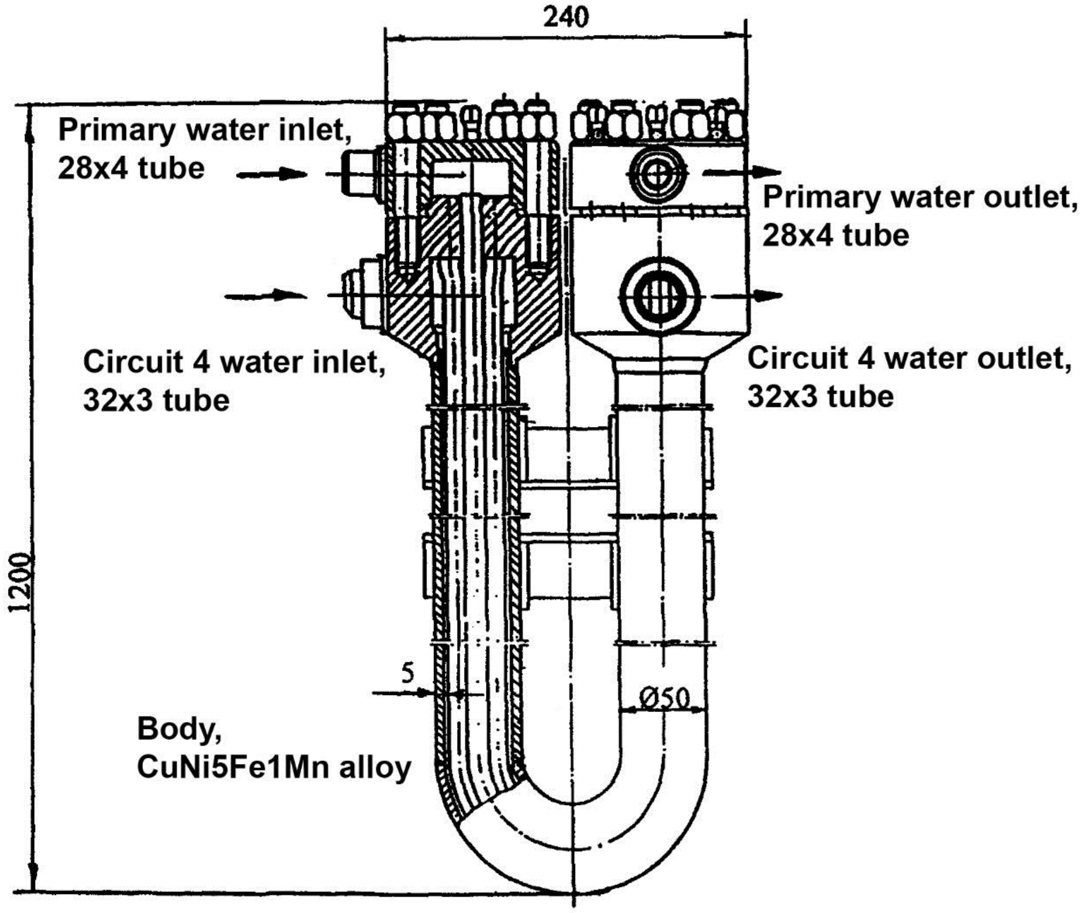


Figure 9. KhVTsEN-147M chiller

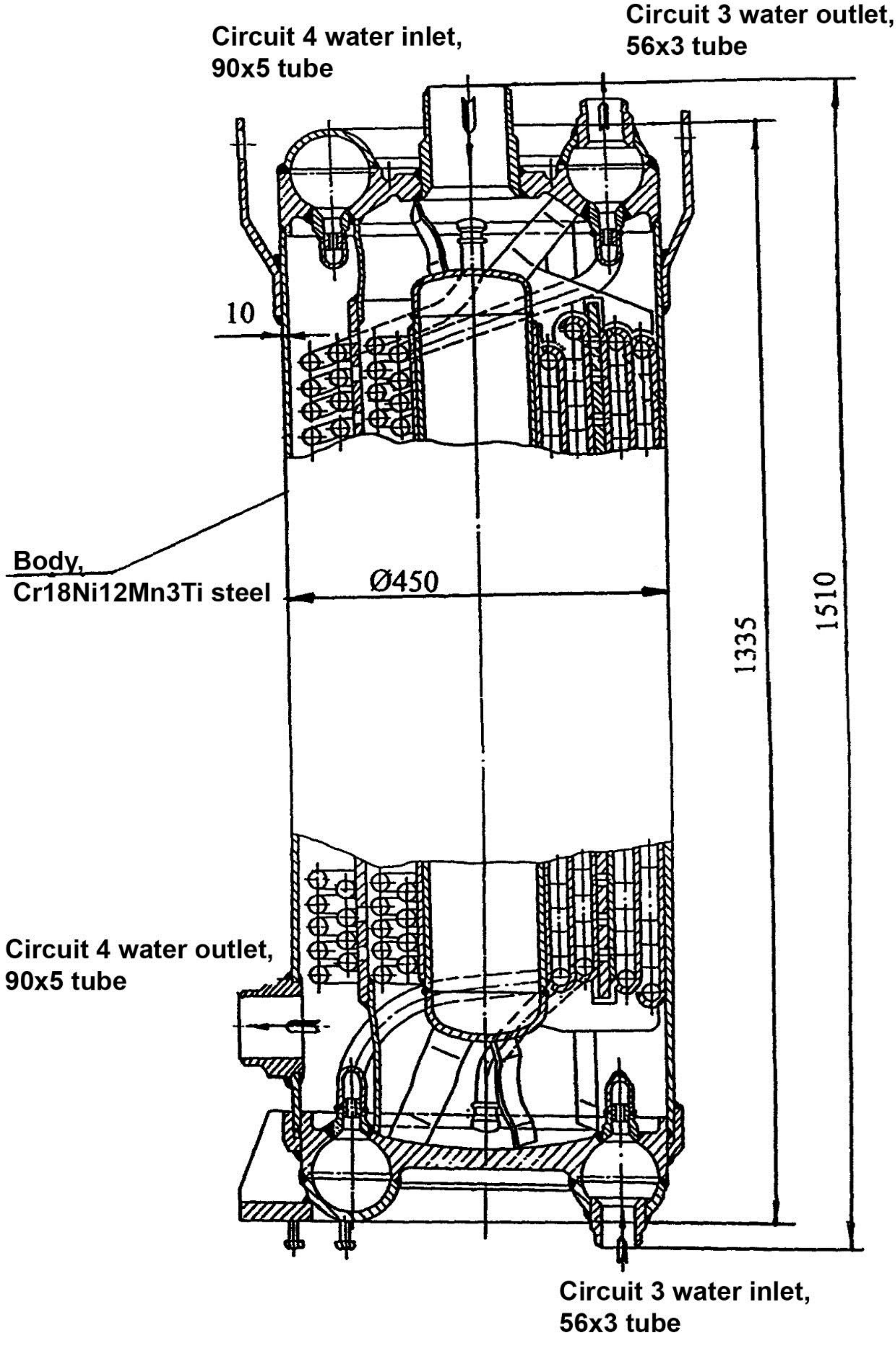


Figure 10. Circuits 3-4 VP 2-1-0 heat exchanger

PIPELINES OF THE MAIN SSS CIRCUITS

Primary circuit

The components of the primary circuit (reactor, steam generator, pumps with chillers, radioactivity filters with a chiller, pressurizer, valves) (Figure 11) are connected by 180x17, 140x15, 108x11, 89x9, 28x4 and 15x2.5 tubes. The length of the tubes and the weights are presented in Table 6.

Table 6: The length of the tubes and the weights (primary circuit)

Tube dimension (outer diameter x wall thickness), mm	Length (m)	Weight (kg)
180x17	3	200
140x15	34.2	1600
108x11	9.4	250
83x9	42	706
89x9	7.0	130
28x4	44.0	105
15x2.5	20.0	15

All tubes are made of 1Cr18Ni9Ti stainless steel.

Secondary circuit

The components of the secondary circuit (steam generator of 8 chambers, feed water header, steam collector, valves) are connected by 83x4, 36x3, 22x2.5, 108x6 and 108x5 tubes. The length of the tubes and the weights are presented in Table 7.

Table 7: The length of the tubes and the weights (secondary circuit)

Tube dimension, mm	Length (m)	Weight (kg)
83x4	29	226
36x3	18.5	45
22x2.5	30	37
219x7	8.0	293
108x6	12	181
108x5	26	330

All tubes are made of 1Cr18Ni9Ti stainless steel except the 219x7 tube made of steel 20. This tube runs from the steam collector to the rear partition over the fore enclosure story 2.

Practically all the tubes of the secondary circuit are located within SG partition-off at the portside.

The steam collector and the feed water header are located at story 2 of the pumping enclosure that is grouted together with equipment and different SRW placed in the compartment before grouting.

The steam generators are accessible through a manhole in the portside corridor.

<u>Tertiary circuit</u>

The tertiary circuit cools the reactor coolant pump stators, radioactivity filter and IWS tank. A TsN-21 pump is responsible for water circulation. The TsN-21 pumps (the second pump is standby) are installed on the pumping enclosure story 2. The tertiary water is delivered to the IWS tank and goes back to the heat exchanger of circuits 3 and 4 (VP 2-1-0) via 56x3 tubes running along the portside in the very bottom between the reactor and the SG. The rest of the tubes are rather small; their dimensions are 28x4, 25x2.5, 20x2.5,16x3.

The last tertiary water sample (prior to drying) has volumetric activity of 4.07 Bq/l. In accordance with the experts opinion of JSC “Atomproekt” these tubes are extremely hard to dismantle because of their location - along the portside at the very bottom between the reactor and the SG (both reactor and SG are radioactive).

<u>Fourth circuit</u>

The circuit 3 and 4 water quality on stand 346A was similar - twice distilled water.

The circuit 4 water was not active. The circuit 4 water cooled chillers KhGTsEN-601, KhGTsEN-146 M, KhGTsEN-147 M and heat exchanger VP ВП 2-1-0. A TsN-23 pump is responsible for water circulation. The TsN-23 pumps (the second pump is standby) are installed on the pumping enclosure story 2. The rest of the tubes (90x5, 38x3 and 32x3) are located on the pumping enclosure story 1. The rest of the tubes are 55x3 and 14x2.5.

The pumps of circuits 3 and 4 were grouted.

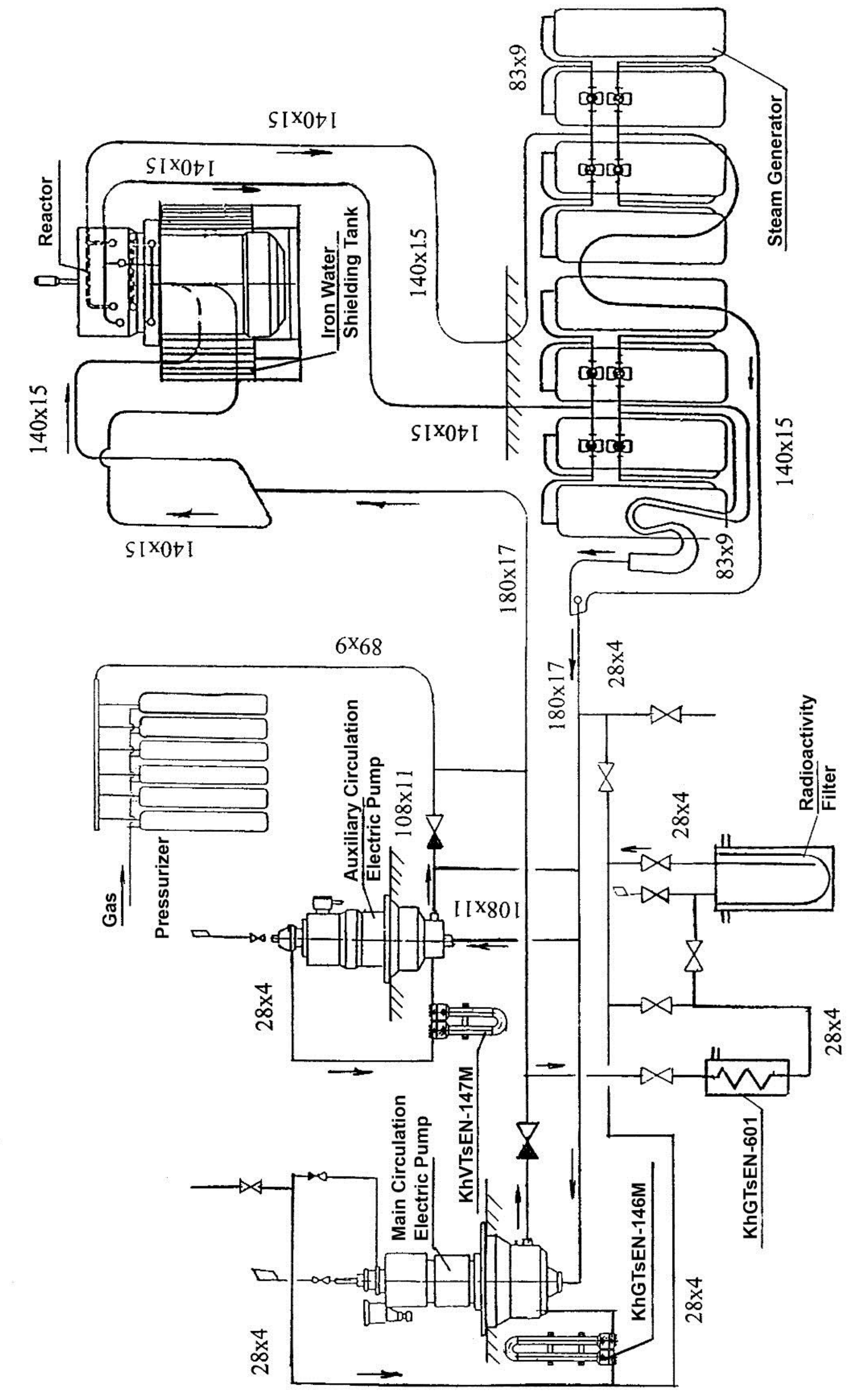


Figure 11. Layout of primary circuit pipelines

1.4.2 Radiological conditions at the energy stand 346A after reactor final shut-down

The stand nuclear units were operated in accordance with a training programme, and their operating conditions only envisaged running at 20 ÷ 40% of nominal reactor power, with rather frequent complete shut-downs. No considerable abnormalities or accident situations have been recorded. No cases of fuel element breach were registered either. As consequence, coolant radioactivity in the primary circuits of both units was kept low, as well as contamination of internal surfaces in the primary circuit equipment. Coolant samples collected from the primary circuit of 346A stand prior to draining registered volumetric activity of 1.4 kBq/l. Radiological conditions during stands operation were normal. After the final shut-down of the reactors in 1994, a radiological survey of internal reactor rooms was undertaken, with the survey results in attended rooms on 346A stand registering the following ambient dose equivalent rate values, in μSv/h:

- in 3rd floor through hallway – up to 0.12;
- in the reactor well – 1.1;
- on reactor lid – 1.9;
- on hatch lid of steam generator well – 8.

Background exposure dose rate values lay within 0.11 to 0.14 μSv/h.

Calculated dose rates for 2015 (μSv/h, peak values, based on Co-60, Ni-59, Ni-63, Fe-55):

- 3rd floor hallway ≈0.024;
- central area ≈ 0.13
- near open hatch to steam generator well ≈ 1.72;
- on reactor lid along axis ≈ 0.78;
- reactor control rods well ≈ 0.0007;
- steam generator well ≈ 64;
- pumping room, 2nd floor, near auxiliary pump VCEN-147 ≈ 0.74;
- near the pumps – ≈ 0.16 (Note: during reactor compartment preparation for long-term storage, the pump room was poured with concrete);
- pump room 1st floor, near primary circuit pipeline ≈ 65;
- on pressure hull above the reactor – ≈ 0.0015;
- on pressure hull below (room 140): beneath reactor along centre line plane – ≈ 185; near front wall ≈1.1; along PS (port side) ≈51.7; along SB (starboard) ≈169.5;
- beneath stern - along centre line plane ≈8.3; along PS ≈0.6; along SB ≈17.8; peak near stern ≈ 0.8; peak near stern reactor control rods well ≈5.9; beneath pump room ≈0.1 (room poured with concrete).

Said exposure dose rates are computational as of 2015, and by the end of the design storage life they will drop naturally down to natural background (0.1 – 0.15 μSv/h), expect rooms where exposure dose rate may actually increase. Such rooms include:

- steam generator well ≤ 20 μSv/h;
- pump room (1st floor) ≤ 20 μSv/h;

– pressure hull in room 140 (beneath reactor) ~ 3.2 μSv/h.

On 346A stand, the space in front of the iron-water protection tank was provided with concrete blocks during stand construction to improve radiation shielding. Calculations have determined that the concrete will become activated as a consequence of being hit by neutrons emitted from the reactor to the depth of ~ 0.5 m from the wall of the iron-water protection tank. Its specific activity build-up over the period of operation and computed as of 2015 may be as high as ≈ 5 kBq/kg. Radionuclide composition by activity, (%): Fe-55 – 20.9; Co-60 – 3.5; Eu-152 – 72.0; Eu-154 – 3.6. Materials used for the control rods absorbers at 346A power plant – special alloy with Europium (Eu) which was used as the neutron resonance absorber (n, γ - absorber).Those materials are with the big neutron absorption cross section and do not produce new neutrons during the neutrons trapping.

According to the Technicatome report TA-247836 Ind. A [1] concrete samples collected from beneath the reactor compartment in 1994 were analysed in 2001 and demonstrated that specific activity of samples (peak values) does not exceed 0.29 Bq/g. Radionuclide composition by activity, (%): Eu-152 – 62; Co-60 – 12; Cs-137 – 5; K-40 – 18. Co-60 and Eu-152 formed as a result of neutrons emanating from the reactor hitting the trace impurities present in concrete, and Cs-137 as a result of surface contamination or leaks, while K-40 represents radioactivity naturally present in construction materials.

In accordance with the general approach used in the Russian Federation based on the statistic data of operational experience of water-pressured reactor units, the majority of induced radioactivity (up to 99 %), disregarding nuclear fuel, tends to concentrate in the reactor vessel because reactor pressure vessel is under neutron flux [22]. Second most radioactive piece of equipment is iron-water protection tank (protects other equipment from neutron flux), which accumulates about 1 %, with the balance of equipment in the primary circuit accountable for fractions of a percent of total radioactivity of nuclear power unit.

1.4.3 Activity of primary circuit equipment of stand 346A [1]

The assessment of the equipment radionuclides activity for the years 2015 and 2039 rests on the data of the previous measurements and calculations which is assumed as basic. In 1994 JSK NIKIET specialists performed experimental and computational studies to determine the accumulated activity in the RC structures. Stand 346A was examined and samples of concrete and metal were collected from the structures of the sarcophagus and RC for the immediate measurement of their activity. The sampling was done only for the physically accessible structures and components, the measurements of the samples were made by the means of the local laboratory of the facility Radiation Safety Unit. For the rest of the components of the RC structures and especially those operated in high neutron fields, the accumulated radioactivity was determined by calculations. The radioactivity of corrosion products on the surface of the components flowed over by the primary coolant, was also determined by calculations. Calculation procedures were confirmed on the basis of the experimental data of operating facilities of the similar characteristics. To determine the accumulated activity in the SSS equipment and materials, the following calculations were conducted:

- calculation of neutron fields in materials of structures, equipment and shielding;
- calculation of the induced activity of materials of the main structures;
- calculation of the corrosion products accumulated in the primary circuit equipment.

Calculations were performed on the basis of 346A stand actual operation mode:

- work beginning: 1968;
- work completion: 29.01.1989;
- the stand operated for two lifetime periods:
  - lifetime period 1- 1968 - 1977, power generation of 280 000 MWh;
  - lifetime period II - June 1981 - January 1989, power generation of 190 540 MWh;
- the average reactor power for the operation period: 20 - 40% of the nominal value (the calculations took into account the number of startups during each year of operation and the average power level during the startup time).

To obtain the distribution patterns for neutron fluxes, ANISN and DOT-III codes were used that implemented the solution of the transport equation by discrete ordinates method with regard for dispersion anisotropy for single- and two-dimensional geometries respectively. The energy spectrum of neutrons was divided into 12 groups.

Based on the actual operation mode and calculated neutron fields, there were performed calculations of the induced activity of materials using SAM code that used the constant library for activation reactions of chemical target elements in the neutron energy range of 14.7 MeV to thermal energy.

To calculate the activity of corrosion products, RAPK-6 code was used that implemented the solution by Runge-Kutta method of the differential equations system describing the process of generation, transport and accumulation of corrosion products and their activity in the nuclear power facility circuit. The reactor operation during the second lifetime period only was considered in calculating the accumulation of active corrosion products in the 346A stand SSS primary circuit. It is explained by the fact that most of the active corrosion products accumulated during the first lifetime period operation was removed during primary circuit decontamination between lifetime periods, during unloading of spent reactor cores and replacement of the SG chambers.

Results of induced activity calculations (extrapolation basing on the IAEA nuclear data for half-lives and decay branching fractions for activation products) for structural materials of key circuit equipment, are summarised in Table 8, based on the initial data for the calculations of radionuclides activity made by NIKIET in 2001 [1]

Table 8: Induced activity of radionuclides in key equipment for different cooling periods (T) after reactor shut-down. Bq

Radionuclide	T-12 years (2001)			T – 26 years (2015)			T – 50 years (2039)		
	Reactor	Iron-water protection tank	Nuclear power unit as a whole	Reactor	Iron-water protection tank	Nuclear power unit as a whole	Reactor	Iron-water protection tank	Nuclear power unit as a whole
Fe-55	9,21E+13	9,92E+11	9,32E+13	8.4 E+10	4.7E+09	8.5E+10	1.96 E+08	11 E+6	1.99 E+08
Co-60	1,21E+14	1,34E+12	1,22E+14	4.5E+12	5.0E+10	4.6E+12	1.93 E+11	2.12 E+09	1.95 E+11
Ni-59	1,17E+12	1,37E+10	1,19E+12	1.2E+12	1.4E+10	1.2E+12	1.17 E+12	1.37 E+10	1.19 E+12
Ni-63	9,33E+14	1,10E+12	9,47E+13	7.8E+13	9.2E+11	7.9E+13	6.66 E+13	7.81 E+11	6.73 E+13
Total	3,08E+14	3,44E+12	3,12E+14	8.4E+13	9.9E+11	8.5E+13	6.81 E+13	7.99 E+11	6.88 E+13

In other equipment components of the nuclear power unit, induced activity is within $1x10^3 \div 10^6$ Bq.

Activity of corrosion products on internal surfaces in the primary circuit of 346A stand is summarised in Table 9.

Table 9: Corrosion products activity in the primary circuit, Bq

Equipment title	T – 12 years (2001)	T – 26 years (2015)	T – 50 years (2039)
1 Reactor and primary circuit	2,77 E+11	1.7 E+11	6.79 E+10
2 SG	2,44 E+10	1.5 E+10	5.98 E+09
3 PR	1,26 E+09	7.5 E+09	3.09 E+08
4 GCEN-146	3,90 E+08	2.3 E+08	9.58 E+07
5 VCEN- 147	3,12 E+08	1.9 E+08	7.66 E+07
6 HGCEN-601	7,22 E+08	4.3 E+08	1.77 E+08
7 HGCEN-146M	4,17 E+08	2.5 E+08	1.02 E+08
8 XVCEN-147M	1,56 E+08	9.3 E+07	3.83 E+07

Average specific surface activity of corrosion products on internal surfaces of the primary circuit equipment and pipelines is $3.9x10^4$ and $9.6x10^3$ Bq/cm^2 after 12 and 50 years of cooling, respectively.

For example, although steam generators primarily have surface contamination on primary circuit side of their tubing, this causes outer surfaces of steam generator cylinder to register exposure dose rates up to 300 µSv/h.

In order to identify whether non-fixed contamination is present on outer surfaces of equipment and pipelines, smear samples were collected in 1994 from such surfaces in the reactor compartment. The samples were taken using the acidic smear method, with gauze tampons soaked in a weak solution of nitric acid. A total of 17 smears were collected from outer surfaces, including equipment and pipelines in the primary circuit (primary and auxiliary circulation pumps and their connection piping). Control measurements of collected smear samples demonstrated that their β – activity levels were within background. This essentially demonstrates that there is no non-fixed contamination present on the surfaces of examined equipment.

According to calculations, build-up of long-lived radionuclides activity in the materials of stand 346A, disregarding nuclear fuel, measured ~ 312 TBq. Radionuclide composition as of 2001 was as follows (%): Co-60 – 39.2; Fe-55 – 30.0; Ni-59 – 0.3; Ni-63 – 30.3.

As cooling time increases before the start of dismantling operations in the reactor compartment, exposure of involved personnel will decrease approximately in proportion to the drop in Co-60 activity, which is the main dose-contributing radionuclide in this composition. The contribution of Cs-137, which is present in corrosion products on internal surfaces in the primary circuit, is insignificant.

Technicatome & BNFL (2000) report [1] that about 360 liters of water remains in the primary cooling circuit of reactor 346A, with a total inventory of 2.2 MBq l^{-1} at the time of shutdown in 1989. The main radionuclides were Cs-137, Co-60, Sr-90 and tritium. The presence of Cs and Sr radionuclides in the cooling water (only) is explained by the operating features of PWR type reactors. The steam generators were replaced in 1980, apparently in order to test a new type of steam generator made of titanium alloy. According to information supplied by VNIPIET and reported in Technicatome & BNFL (2000), the reason for changing the steam generators was not a leakage from the primary part to the secondary part of the steam generators, which would have resulted in contamination diffusing into the secondary circuits. After drainage of all the circuits it was estimated that about 1000 liters remain in the secondary circuit (within the steam generators), with very low levels of contamination (approx. 4 Bq l^{-1}). The third and fourth coolant circuits were used for auxiliary equipment and are believed to contain no contamination. About 6 liters of water remains in the fourth circuit. According to the previous data there is no information about water remains in third circuit. The third circuit is believed to have no water remains. In the above paragraph shows activity prior to drying.

Table 10: Radioactive inventory of residual cooling water for 2005, 2015 and 2039 (346A)

Radionuclide	Total activity, Bq		
	Reactor Compartment 1		
	2005 *	2015	2039
H-3	4.28E+06	2.44E+06	6.32E+05
Co-60	2.73E+06	7.33E+05	3.12E+04
Sr-90	5.19E+06	4.08E+06	2.29E+06
Cs-137	5.23E+06	4.15E+06	2.39E+06

** Input data*

Overview of stand 346A reactor compartment (cross and lengthwise sections) prepared for long-term storage (shield cover built, concrete poured inside) is illustrated by Figure 18.

Detailed description related to the measurements, sampling, techniques, instrumentation etc. is presented within Technicatome report «Collection and Analysis of Information Regarding the Design and Content of the Reactor Compartments of Russian Nuclear Submarines that are being stored in Estonia» [1] and assumed as sufficient and reliable data to some extent for the tasks of the current preliminary studies for the decommissioning of the RCs.

1.4.4 Key process equipment of stand 346B [1]

The second-generation nuclear power units (346B) were designed in consideration of the first-generation unit's weaknesses. In view of this, the nuclear power unit design layout was changed. Its scheme remained loop but configuration and size of the primary circuit were significantly reduced. There was taken an approach of “pipe-in-pipe” configuration and primary circuit pumps “hanging” on the steam generators. The quantity of the big-diameter piping of the main equipment (primary circuit filter, pressurizers, etc.) was reduced. The majority of the primary circuit piping (big and small diameter) were positioned within the premises under the biological shielding. The plant automation and instrumentation systems and remote-controlled fittings (valves, shutters, stoppers etc.) were significantly changed.

Stand 346B is fitted with power unit VM-4 complete with all necessary equipment to ensure long-term, fail-free and safe operation of the power unit in all design-basis conditions of operation and in case of operational abnormalities.

List of key equipment components and their weight and size characteristics are summarised in Table 11.

Table 11: Key equipment components of stand 346B nuclear power unit

Equipment	Number	Unit weight, t	Overall dimensions, mm
1 Reactor	1	50.4	2550x2550x4660
2 Steam generator - primary circuit pump	5	14.2	1440x1550x4485
3 Pressuriser	3 bottles	2.0	795x795x2826
4 Primary circuit filter	1	1.98	800x800x2075
5 Primary circuit filter refrigerator	1	2.78	800x800x2130
6 Shield tank	1	66.18	2565x4860x6140
7 Electric cool-down pump	1	0.75	545x566x1135
8 Shielding blocks (concrete, lead, thermal insulation), lining of carbon steel	30	up to 1.27	475x1450x1850
9. Pining of circuit 3			63x6.5 34x4.5 22x3.5 16x3
10. Piping for storage and SG rinsing			32x3.5 16x3
11. Steam connections piping			194x10 127x14

Main equipment components of the reactor unit, such as reactor vessel, steam generator shell, pressuriser, filter and refrigerator case are made of alloyed carbon steel with internal stainless steel surfacing in contact with the primary circuit coolant. Protective tank shell and caissons are made of alloyed steel, except reactor caisson, which is made of stainless steel. All pipelines and valves in the primary circuit are made of stainless steel.

Concrete blocks placed during rig construction with the objective of improving radiation shielding also tend to develop induced radioactivity as a consequence of being hit by neutron flux, especially those blocks closest to the reactor vessel. Total averaged accumulated radioactivity of concrete blocks was computed in 2015 to be ~ 2 MBq, with the following radionuclide composition (%): Fe-55 – 50.0; Co-60 – 36.6; Ni-63 – 14.0.

<u>The filter cooler</u> (Figures 12 and 13) is a vertical house-tube heat exchange assembly with an integrated recuperator, two-sectional coil tube system of the cooler on cooling fluid.

The filter cooler consists of the following key units:
- casing 1
- cover 2 with connecting pipes for inlet-outlet of heat exchange fluids
- cooler 3
- recuperator 4
- support 5

Casing 1 is made of heat-resistant chrome-molybdenum steel with anti-corrosion surfacing on the internal surface, with ultimate strength of 568 MPa.

Cover 2 is made of stainless steel of 18-8 type with ultimate strength of 490 MPa.

Tube systems of cooler-recuperator are made of corrosion stainless steel of 18-8 type with ultimate strength of 549 MPa.

Support 5 is made of carbon steel with ultimate strength of 441 MPa.

The overall dimensions of the filter cooler are 750 mm diameter 2130 mm height.

<u>The filter</u> (Figures 14 and 15) is a welded vessel consisting of the following key units:
- casing 1
- cover 2 with connecting pipes for fluids supply and removal
- support 3
- housing 4

All elements are made of corrosion-resistant stainless steel of 18-8 type with ultimate strength of 490 MPa.

Overall dimensions of the filter are 748 mm diameter 2075 mm height.

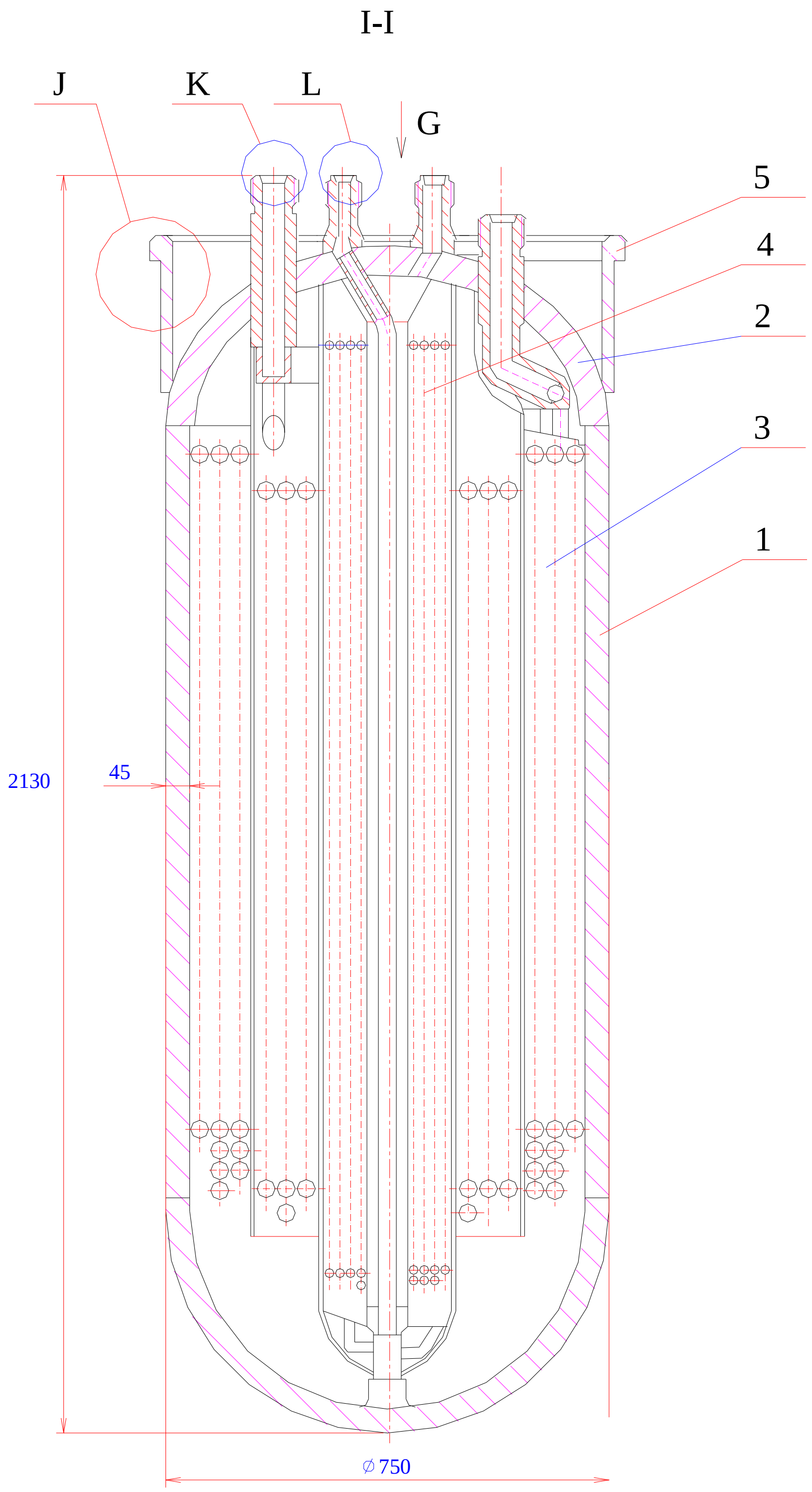
<u>The pressurizer</u> (Figures 16 and 17) is a welded vessel consisting of the following key units:
- casing 1

- cover 2 with connecting pipes for fluids supply and removal
- neck 3
- support 4

Casing 1 and cover 2 are made of heat-resistant chrome-molybdenum steel with anti-corrosion surfacing on the internal surface, with ultimate strength of 569 MPa.

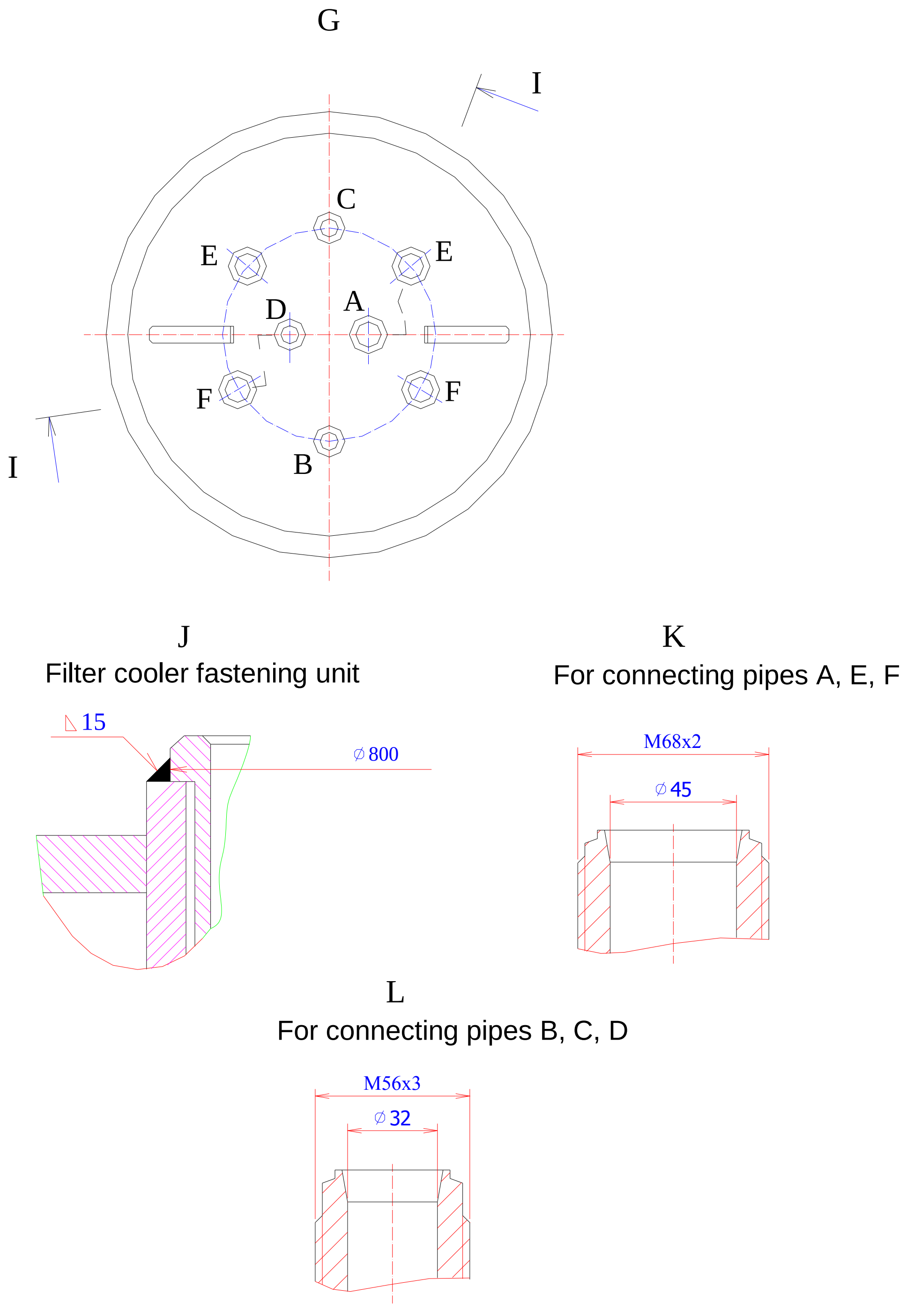
Other units are made of corrosion-resistant stainless steel of 18-8 type with ultimate strength of 490 MPa.

Overall dimensions of the pressurizer are 750 mm diameter 2826 mm height.



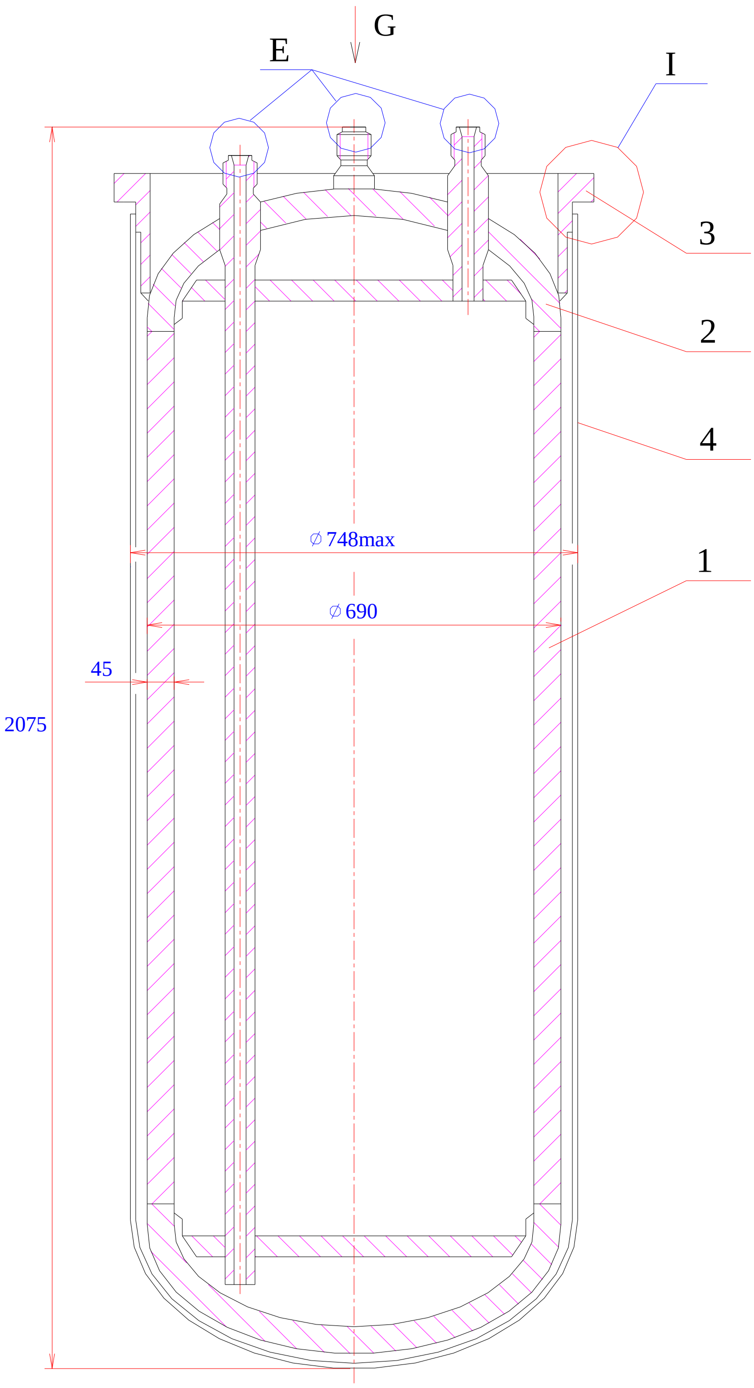
1 - casing; 2 - cover; 3 - cooler; 4 - recuperator; 5 - support.

Figure 12.Filter cooler.



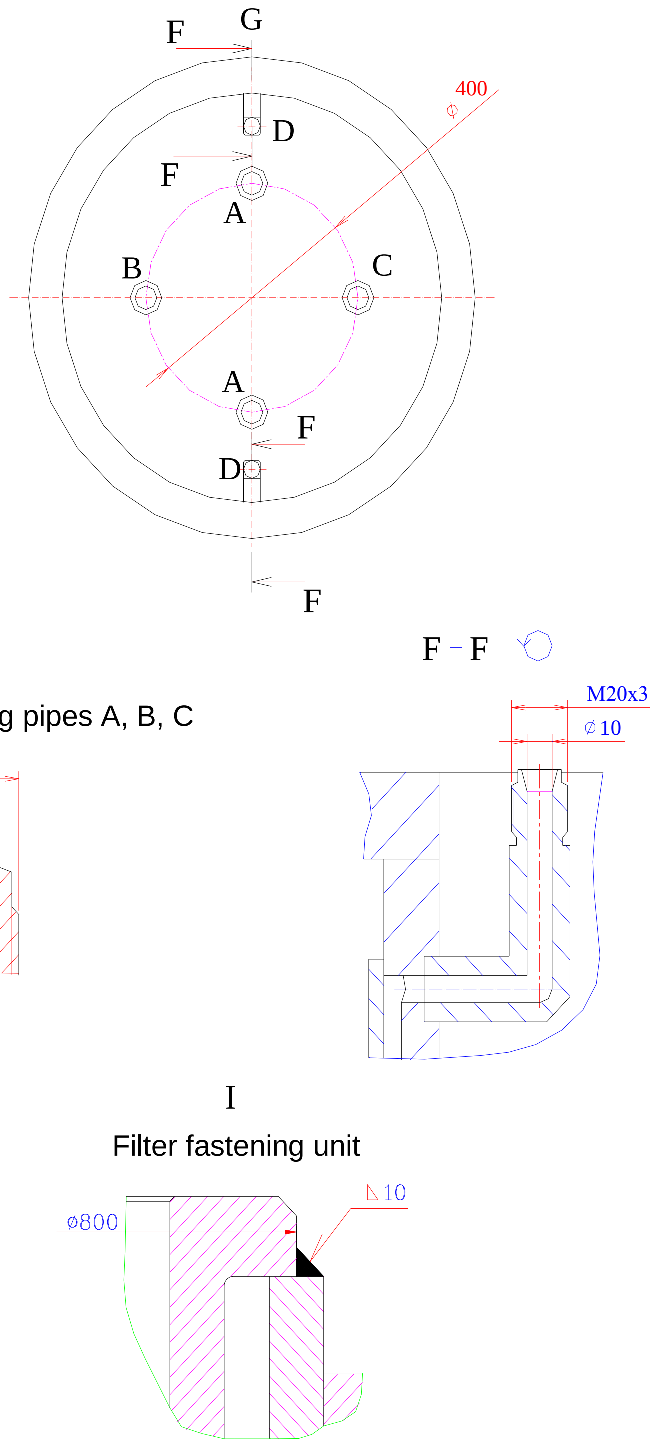
A - recuperator inlet; B - cooler outlet; C - recuperator inlet after filter;
D - recuperator outlet; E - III circuit inlet; F - III circuit outlet.

Figure 13. Arrangement of filter cooler connecting pipes.



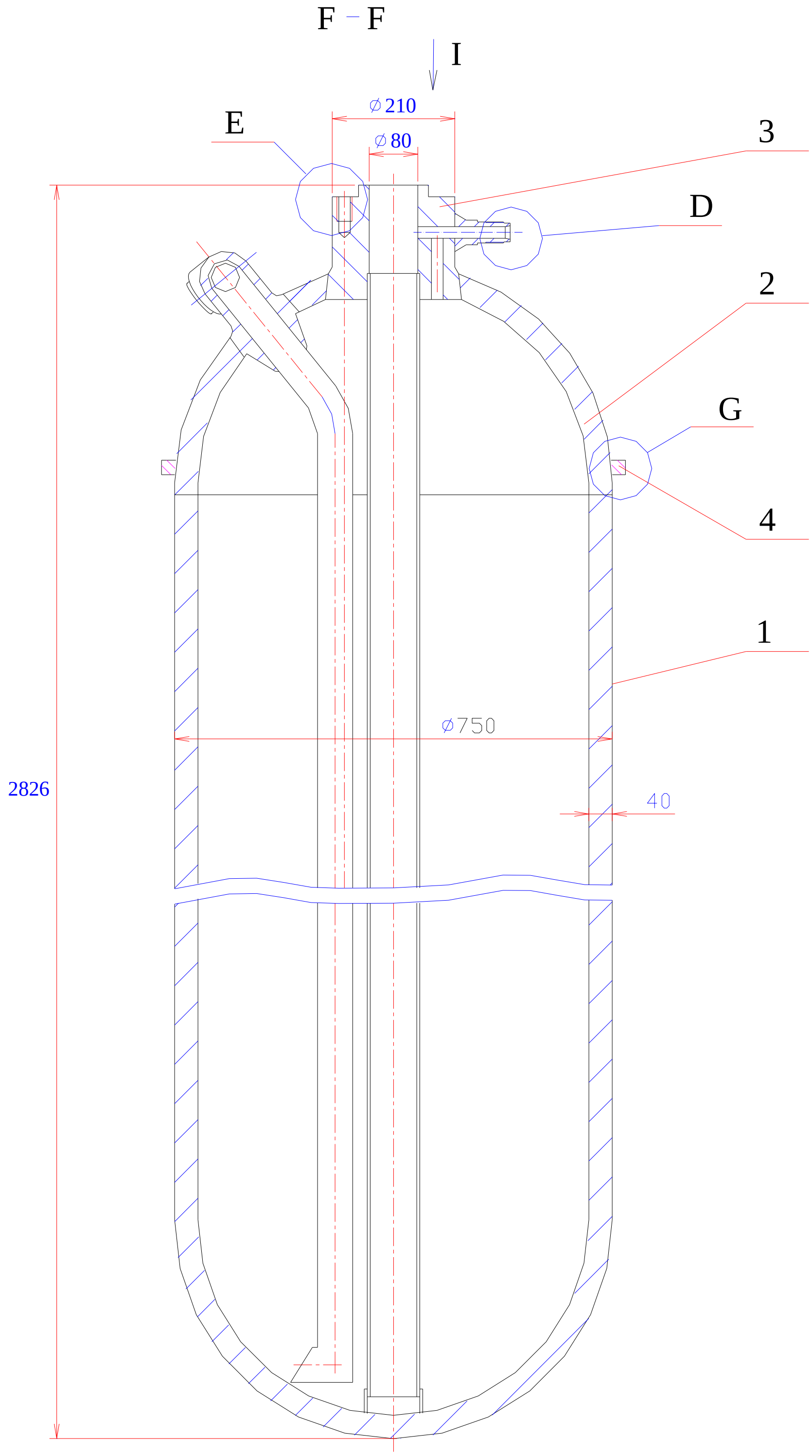
1 - casing; 2 - cover; 3 - support; 4 - housing.

Figure 14. Filter



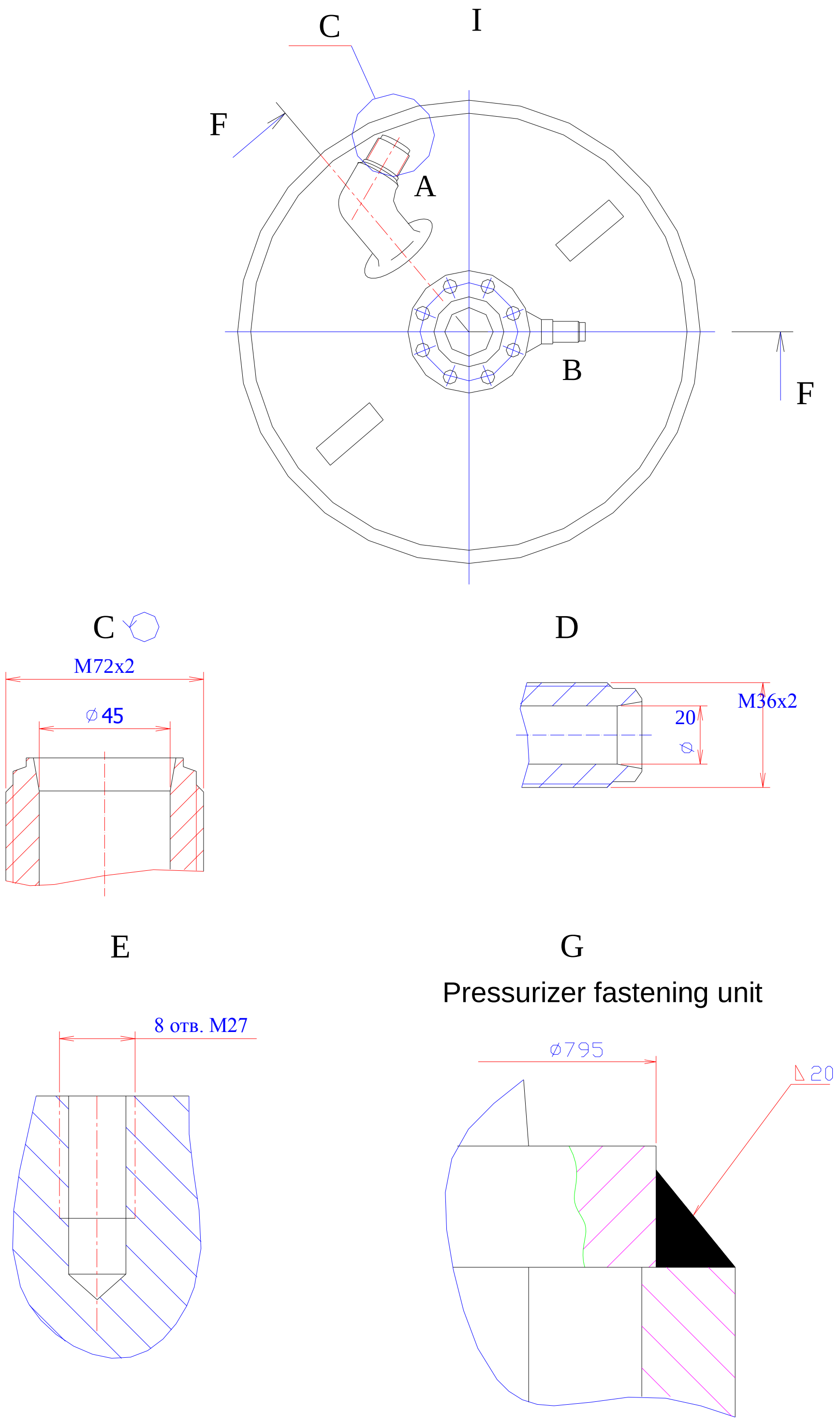
A - water inlet; B - water outlet; C - loading-unloading; D - III circuit inlet-outlet.

Figure 15. Arrangement of filter connecting pipes.



1 - casing; 2 - cover; 3 - neck; 4 - support.

Figure 16. Pressurizer.



A - water inlet-outlet; B - gas inlet-outlet.

Figure 17. Arrangement of pressurizer connecting pipes.

1.4.5 Radiological conditions and radioactivity of equipment of reactor stand 346B [1]

The second reactor stand (346B) was only in operation for a relatively short period of time (1983 to 1989). During this period, the reactor unit actually ran for only 5,333 hours at 20 – 40% of nominal power. No noticeable deviations in stand operation were recorded. Radiological conditions in work rooms of the stand were normal and stable. Coolant activity in the primary circuit remained at a minimum. There has been no noticeable build-up of activated corrosion products on internal surfaces in the primary circuit. Hence, radiological conditions in attended rooms of the stand were only slightly different from natural background levels. A radiological survey conducted in 1994 returned the following ambient dose equivalent rate values (μSv/h): instrument well - 0.2; reactor lid – 0.23; second floor near pump motors – 0.9. Background exposure dose rate values lay within 0.11 to 0.14 μSv/h.

Induced activity levels in equipment exposed to neutron flux emanating from the reactor are low compared to similar equipment of stand 346A.

In 1995 JSK NIKIET specialists performed collection of samples of concrete and metal from the structures of the sarcophagus and RC of the stand 346B for experimental and computational studies of the accumulated activity determination. The sampling was done only for the physically accessible structures and components, the measurements of the samples were made by the means of the local laboratory of the facility Radiation Safety Unit. For the most of the components of the RC structures the accumulated radioactivity was determined by calculations. The specialists from JSC «Afrikantov OKBM» performed calculations of induced activity in the primary circuit equipment accumulated over the operational time of the reactor taking into account the natural decay of radionuclides basing on the same methods and techniques as for 346A stand. The extrapolation calculations for 26 and 50 years of cooling after the final shut-down are summarized within Table 12 and based on the aforementioned measurements and results which are assumed as the basic data.

Table 12: Activity and radionuclide composition for stand 346B equipment, for 26 and 50 years of cooling

Equipment	Radionuclide	Activity, Bq		
		Cooling time, years		
		T-10 (1999)	T-26 (2015)	T-50 (2039)
Reactor	Fe-55	7,03 E+13	3.6E+11	8.37E+08
	Co-60	4,4 E+13	5.4E+12	2.3 E+11
	Ni-59	1,5 E+13	1.5 E+11	1.5 E +11
	Ni-63	1.7 E+13	1.4 E+13	1.2 E+13
	Nb-94	1.4 E+10	1.4 E+10	1.4 E+10
	Eu-152	1.2 E+13	5.1 E+12	1.5 E+12
	Eu-154	1.1 E+13	3.3 E+12	4.8 E+11
	Total	**1.6 E+14**	**2.9 E+13**	**1.5 E+13**
Steam generator	Fe-55	5,2 E+9	8.1 E+7	1.9 E+5
	Co-60	2.8 E+9	3.3 E+8	1.4 E+7
	Ni-59	1,5 E+7	1.5 E+7	1.5 E+7
	Ni-63	1,8 E+9	1.3 E+9	1.1 E+9
	Total	**9.7 E+9**	**1.7 E+9**	**1.2 E+9**
	Fe-55	3.7 E+9	4.7 E+7	1.1E+5
	Co-60	1.6 E+9	1.9 E+8	8.1 E+6

Equipment	Radionuclide	Activity, Bq		
		Cooling time, years		
		T-10 (1999)	T-26 (2015)	T-50 (2039)
Filter refrigerator	Ni-59	8.6 E+6	8.5 E+6	8.5 E+6
	Ni-63	1.0 E+9	9.2 E+8	7.8 E+8
	Total	**6.2 E+9**	**1.2 E+9**	**7.8 E+8**
Pressuriser	Fe-55	7.0 E+8	9.4 E+6	2.2 E+4
	Co-60	3.7 E+6	3.5 E+6	1.5 E+5
	Ni-59	2.3 E+5	2.3 E+5	2.3 E+5
	Ni-63	2.6 E+7	2.2 E+7	1.9 E+7
	Total	**7.0 E+8**	**3.6 E+7**	**1,9 E+7**
Ion-exchange filter	Fe-55	3.1 E+8	4.0 E+6	9,3 E+3
	Co-60	1.7 E+8	1.8 E+7	7,8 E+5
	Ni-59	8.1 E+5	8.1 E+5	8,1 E+5
	Ni-63	1.1 E+8	9.2 E+7	7,8 E+7
	Total	**6.0 E+8**	**1.2 E+8**	**7,8 E+7**
Primary circuit pump	Fe-55	2.1 E+8	3.2 E+6	7,4 E+3
	Co-60	1.0 E+8	1.2 E+7	5,2 E+5
	Ni-59	5.6 E+5	5.5 E+5	5,5 E+5
	Ni-63	6.7 E+7	6.1 E+7	5,2 E+7
	Total	**3.7 E+9**	**7.7 E+7**	**5,2 E+7**
Cool-down pump	Fe-55	3.7 E+7	1.8 E+6	2,5 E+3
	Co-60	1.5 E+7	1.7 E+6	7,4 E+4
	Ni-59	9.3 E+4	9.3 E+4	9,3 E+4
	Ni-63	1,1 E+7	9.6 E+6	8,1 E+6
	Total	**6.3 E+7**	**1.2 E+7**	**8,1 E+6**
Shield tank	Fe-55	1.4 E+12	4.1 E+10	9,5 E+7
	Co-60	1.0 E+11	1.2 E+10	5,2 E+8
	Ni-59	4.1 E+9	4.1 E+9	4,1 E+9
	Ni-63	4.1 E+11	3.5 E+11	3,0 E+11
	Nb-94	3.3 E+8	3.3 E+8	3,3 E+8
	Total	**2.8 E+12**	**4.1 E+11**	**3,1 E+11**
Concrete shield blocks (closest to reactor)	Fe-55	5.6 E+6	1.6 E+5	3,7 E+2
	Co-60	4.1 E+6	4.9 E+5	2,1 E+4
	Ni-59	1.6 E+4	1.5 E+4	1,5 E+4
	Ni-63	1.6 E+6	1.4 E+6	1,2 E+6
	Total	**1.1 E+7**	**2.1 E+6**	**1,2 E+6**
Reactor unit as a whole		**1.1 E+14**	**2.9 E+13**	**1.5 E+13**

Activity of radionuclides accumulated in structural materials as a consequence of exposure to neutrons and internal surface contamination of the primary circuit equipment creates elevated levels of exposure dose rate. Exposure dose rate levels on stand 346B equipment as computed by OKBM are summarised in Table 13.

Niobium (Nb) was used as the alloying agent within the cover of the reactor fuel elements (1-2.5%) to prevent the fuel-element cladding inconsistent deformation in gamma-neutron field. Due to the neutron activation of the Nb-93 natural isotope the small presence of Nb-94 was traced within the equipment of the reactor stands (not in the water).

As the Table 12 indicates, there is no C-14 radionuclide (β – source with Eβ - 0.156 MeV, T1/2 5730 years) in the list of radionuclides produced as a result of neutron radiation of NPP construction materials. Indeed, in that time, the generation of radionuclides was not considered in the reactor vessel metal due to its low content and absence of tendency to its dissemination in the environment. According to IAEA – TECDOC – 938, the content of the radiocarbon produced in the general balance of induced activity in constructive materials of Russian nuclear submarine NPPs is no more than 0.01% ÷ 0.001% of the total induced activity. If we convert this data into the average specific activity, we will obtain C-14 content in the reactor vessel metal: $3.7 \cdot 10^4 \div 9.3 \cdot 10^5$ Bq/kg (data is averaged for 10 nuclear submarine reactor vessels). In our case, power generation of vessels was relatively small, so the accumulation of C-14 was even smaller. Furthermore, the same IAEA materials show that the C-14 content in the balance of induced activity is somewhat 10 times less than that of Ni-59 produced, that has a significantly longer half-life (75,000 years) and that defines radioactive waste storage to be maintained until full decay of radionuclide.

The radionuclide content has no fission fragments and actinides, which is explained by their almost full absence. Operation of these NPPs was not accompanied by emergency destruction of fuel assemblies, so there was no contact of heat carrier with fuel composition. Specific activity of stand 346 A 1st circuit heat carrier before its discharge was 1.4 kBq/kg, and was generally defined by radionuclides of activation origin. Stand 346 B 1st circuit heat carrier had even smaller activity. This data differs from TECDOC-938 data, as the given publication describes reactor units, which active zone contained emergency fuel assemblies with damaged fuel-element cladding, so the activity of fission products was two times more than the activity of activated corrosion products.

Table 13: Estimated peak exposure dose rate for stand 346B equipment for various cooling times after reactor shut-down, in μSv/h.

Equipment title	Cooling time, years		
	T-10 (1999)	T-26 (2015)	T-50 (2039)
1 Reactor	$4{,}0 \times 10^5$	2.4×10^3	200.0
2 Steam generator	$4{,}0 \times 10^2$	5.7	0.2
3 Filter refrigerator	$9{,}0 \times 10^2$	13.0	0.5
4 Pressuriser	$2{,}0 \times 10^2$	2.8	0.1
5 Ion-exchange filter	$5{,}0 \times 10^2$	7.2	0.26
6 Primary circuit pump	$3{,}0 \times 10^3$	44.0	1.6
7 Cool-down pump	$2{,}0 \times 10^2$	2.8	0.1
8 Shield tank (reactor caisson)*	$3{,}6 \times 10^6$	52.1×10^3	1.9×10^3
9 Concrete shield blocks (closest to reactor)	$\leq 1{,}0 \times 10^2$	4.3	1

** Expose dose rate from shielding tank is higher because of its dimensions (as a radiation source)*

Considering the short time of stand 346B reactor operation, exposure dose rate levels on the reactor vessel and its surrounding structure are relatively low. At the end of the design-basis cooling period (50 years), reactor vessel exposure dose rate will decrease by a further two orders of magnitude, meaning that the residual γ- activity will no longer be a major obstacle to the performance of dismantling operations on reactor compartment equipment, i.e. they will not require the use of complex robotics, and may be performed by already available hardware with the use of relatively light shields and specialised ventilation equipment to clean airborne radioactivity out of work zone air.

The materials with the big neutron absorption cross section and which do not produce new neutrons during the neutrons trapping are used as absorbers. Europium (Eu) is the neutron resonance absorber (n, γ - absorber) and this material was used within the control rods of the 346B nuclear power plant. During the period of the 346B power plant operation its control rods never lost sealing or showed leakages so the remained water is free of Eu radionuclide.

VNIPIET surveyed the accessible area inside RC of 346B in 1994. Information summarized by Technicatome & BNFL (2000) [1] indicate dose rates in the range 0.14 to 2.5 µSv h^{-1} prevailed generally, although around the reactor and IWS shield the dose rate reached tens of Sv h^{-1}. Technicatome & BNFL (2000) also report that about 600 l of water remains in the primary cooling circuit of reactor 2, with a total inventory of 1 MBq l^{-1} at the time of shutdown in 1989. The main radionuclides were Cs-137, Co-60 and Sr-90. The presence of Cs and Sr radionuclides in the cooling water of the primary circuit is explained by the operating features of PWR type reactors, so, after the removal of the water from the reactor and circuit only the traces of Cs-137 and Sr-90 could be detected on the internal surfaces of the reactor and primary circuit tubes. There was no known leakage from the primary part to the secondary part of the steam generators during the operation of reactor 2 and there is no recorded contamination in the secondary circuit. The third and fourth coolant circuits were used for auxiliary equipment and are believed to contain no contamination. Volumes of water remaining in the second, third and fourth circuits are not recorded.

Table 14: Radioactive inventory of residual cooling water for 2005, 2015 and 2039 (346B)

Radionuclide	Total activity, Bq		
	Reactor Compartment 2		
	2005*	2015	2039
H-3	-	-	-
Co-60	1.59E+05	4.27E+04	1.82E+03
Sr-90	3.03E+05	2.38E+05	1.34E+05
Cs-137	3.05E+05	2.42E+05	1.39E+05

** Input data*

In any case, it would be sensible to begin complete dismantling of the reactor compartment with stand 346B, where key equipment components have at least an order of magnitude lower values of radionuclide contamination as compared to those on stand 346A and accordingly, their exposure dose rates are correspondingly lower by about the same rate.

1.5 OPERATIONS CARRIED OUT TO PREPARE STANDS 346A AND 346B FOR LONG-TERM STORAGE

The engineers of CDB ME “Rubin” prepared and implemented a project aimed at fully dismantling adjacent compartments which do not contain radioactively contaminated equipment, after which there remained two reactor compartments, one from each stand, which were subject to de-commissioning as radioactively hazardous facilities [1].

The hull structures and the equipment of the auxiliary compartments of both stands, uncontaminated with radiation, were dismantled and transferred to the Estonian side.

Subsequently, the engineers of CDB ME “Rubin” created a design aimed at preparing reactor compartments for long term storage for a period of no less than 50 years given seismic impacts maximally possible for this particular region.

Concurrently, GI VNIPIET developed a project for protection shelters for the reactor compartments, which were capable of withstanding natural and man-made disasters, including earthquakes up to 7 points according to MSK-64, the dropping of heavy objects on them and other unfavorable factors.

Projects solutions in respect of preparation of the reactor compartments for long term storage and erection of protection shelters were reviewed by experts at a special meeting with IAEA in May 1995 and were approved.

The nuclear power units, installed in the reactor compartment shells were prepared pursuant to the project and placed for long term, controlled storage for a period of 50 years.

Prior to this, all the accumulated radioactive solid wastes were removed from the building which, after they had been appropriately processed, were deposited in concrete containers and put in temporary storage for radioactive wastes. All the reactor compartment systems were emptied in respect of circuits 1, 2, 3 and 4, compressed gases and process liquids were removed from the equipment, sorbents were unloaded from coolant purification filters. All the tanks, reservoirs and the hold were dried out, however, in view of special design features of the equipment and pipelines in circuits 1, 2, 3, 4, there remained an irremovable amount of water (reactor vessel, steam generators, circuits 1, 2 and 3) in the quantity of ~ 1370 liters in the nuclear power unit of Stand 346A (include 360 liters of borated water in the primary circuit) and in the quantity of ~ 2280 liters in the nuclear power unit of Stand 346B (include 600 liters of borated water in the primary circuit).

Both for 346A [26] and 346B [27]: operating mechanisms (OM) and instrumentation of control and protection system (CPS) were dismantled in 1994 and could have low level surface contamination (control rods are still within the reactor pressure vessels but control rods which had been removed from 346A reactor during fuel change had been placed into solid waste storage facility and were later retrieved by AS ALARA, packed within shielded containers and stored in interim storage), all of the sorbents were removed from the filters of the circuits 1 and 2, the part of equipment and components over the biological protection were dismantled and removed from RC; stream generation plant’s equipment and piping located below standard and supplementary biological protection within the RC are braced in accordance with the operational state.

As calculations made by the engineers showed, multiple cycles of water freezing and thawing in the pipe-work and the equipment during the period of long term storage (50 years) are not expected to result in causing the systems to leak.

The reactor units were prepared for long term storage:

- the reactor was dried out and is currently under atmospheric pressure;
- the reactor was closed with the cover welded to the shell;
- actuators of the control and protection system were removed;
- all the holes in the reactor in the systems of the 1st circuit were plugged with welded plugs;
- some of the equipment and structures located above the biological shield were unloaded from the reactor compartment;
- in the reactor compartment shells, all the holes were tightly sealed with welds, air-tightness of the compartments was tested by blowing pressurized air;
- the atmosphere of the reactor compartment was dried up and a stock of moisture desiccants was left inside;
- duration of safe storage for the math-balled reactor compartments is no less than 50 years without subsequent re-activation of the nuclear power plant;
- the reactor compartments placed for long term storage do not require any service, control or supply of utilities throughout the entire period of storage;
- visits to the reactor compartments during the storage period are not foreseen;
- radiation safety of the reactor compartments during the period of storage is ensured by design measures and for that purpose three security barriers were created: air tightness of the equipment and the 1st circuit systems; tightly sealed reactor compartment shell; erection of reinforced concrete shelter around the reactor compartment designed for natural and man-made disasters.

Due to existence of solid radioactive wastes, left after doing repair work and re-loading the solid radioactive wastes on Stand 346A, it was decided to deposit these wastes in the reactor compartments before concreting. The above mentioned wastes comprised cut off pipe sections, fittings, tools, small size parts, re-loading equipment, containers, jackets for spent nuclear fuel assemblies, as well as spent sealed sources (control and calibration ones) together with protection containers and other radioactive wastes, referred, mainly, to the category of low radioactive wastes and some sources classified as the category of medium radioactive wastes.

Extraction of those waste from concrete is complicated by the presence of the sealed sources of ionized irradiation in standard containers, including:

- Drum-type transfer container in package with gamma radiation sources, Co-60 (05 pcs.) weighing 1,200 kg;
- Paraffin container with neutron radiation sources (5·107 n/s), 5 pcs., weighting 400 kg;
- Container with cobalt gamma radiation source 60 (01 pcs.), weighing 350 kg;
- Box with control and reference sources of beta and alpha radiation weighing 60 kg;
- Fire detectors with integrated alpha radiation sources ADI, each 2.1×10^7 Bq (50 pcs.) weighing – 25 kg.

The majority of the shielding containers with sources of ionized irradiation were placed within U-shape room at the first level which contained the main equipment of the primary circuit, and within the room at the second level which contained pumps and motors. Then, the rooms were grouted with the concrete. Supposedly, some of the shielding containers with sources of ionized irradiation were placed within the concrete which was poured on the reactor vessel lid [24].

Furthermore, the wastes poured with concrete also include organic wastes in bags: rags, overshoes, film, brushes, etc., with total weight of about 140 kg.

RC 346B includes metallic wastes (tools, loading equipment, electrical equipment, etc.) There are no sealed sources in loaded wastes and only one air filter weighing about 200 kg represents organic wastes.

Radioactive wastes, with a mass of ~ 15 tons, were put on the 1st and 2nd floors of the non-pass-through premises of the reactor compartment, Stand 346A, and approximately 10 tons on the premises of Stand 346B. Subsequently, the deposited radioactive wastes were grouted in with concrete laid inside the compartments.

The RC wastes placed for long term storage have the following mass and dimension characteristics set out in Table 15.

Table 15: Mass and Dimension Characteristics of RCs

Reactor Compartment Shell:	346A	346B
Diameter of Transverse Sections, m	7.5	9.5
Length, m	15.3	12.3
Width, m	8.08	10.8
Height, m	8.8	11.1
Shell Thickness, mm	27	20
Thickness of End Bulkheads, mm	10	12
Mass, tons	855	950
Protection Shelter:	346A	346B
Length, m	16.9	13.5
Width, m	10.4	12.3
Height, m	12.4	13.0
Wall Thickness, m	0.4	0.4
Weight of radioactive wastes with reinforced concrete shelter, t	~1,570	~1,650

To ensure additional protection for the equipment of the nuclear power unit, concrete was laid inside the reactor compartment:

- on Stand 346A [26]: onto the reactor lid at forward apparatus partition-off – 4.7 m^3, into U-shaped partition-off 17.65 m^3, onto the lid of the U-shaped partition-off – 7.5 m^3, onto the hatch of the portside steam-generator partition-off – 0.9 m^3, total ~ 30.75 m^3 (weight 67,650 kg);
- on Stand 346B [27]: onto the lid of iron-water protection tank – 9.0 m^3, onto the floorings of the upper premises of the apparatus partition-off – 31.0 m^3, onto the

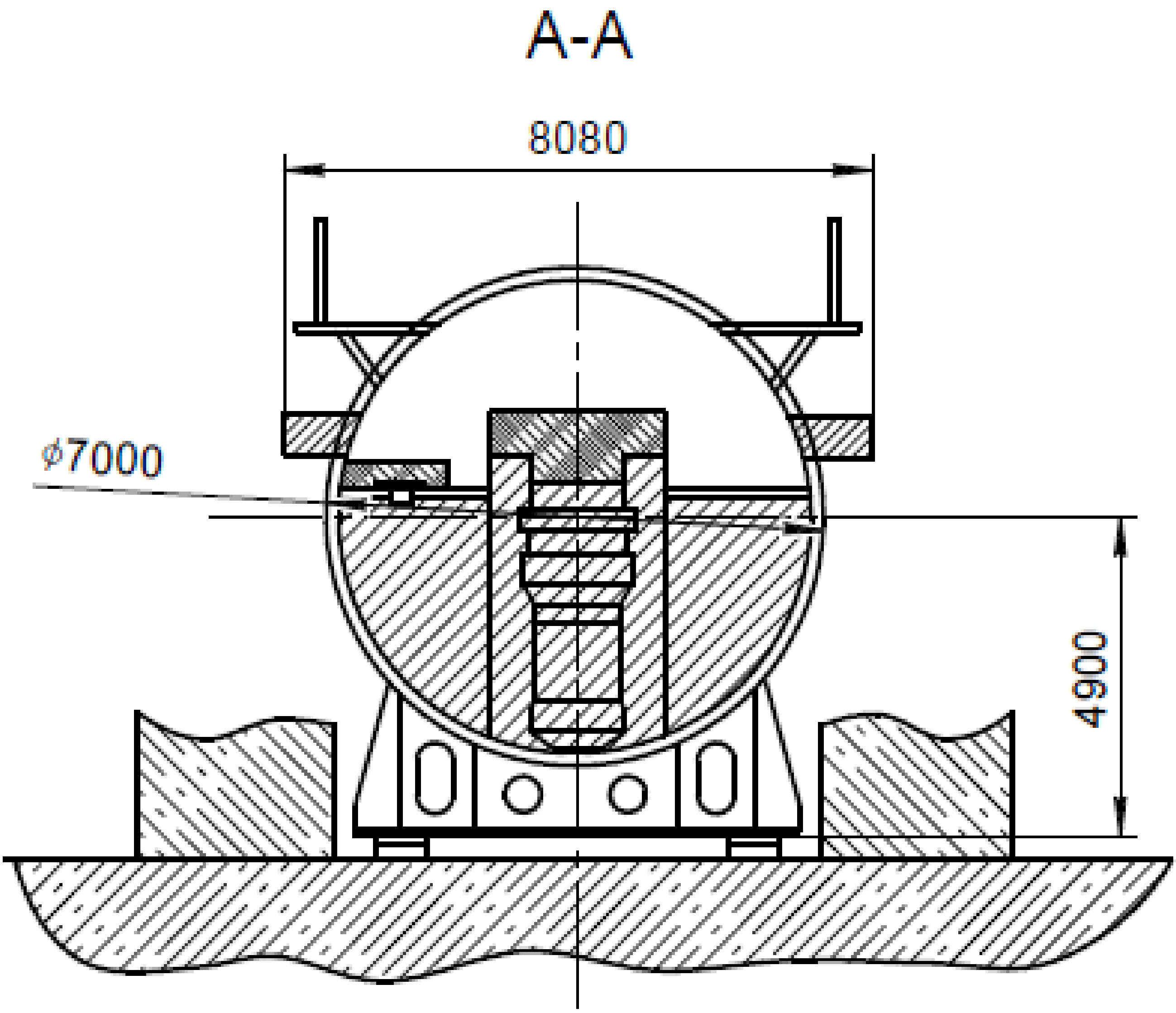
hatches of the starboard and portside pump partition-off – 1.2 m^3, total ~ 41.25 m^3 (weight – 90,700 kg).

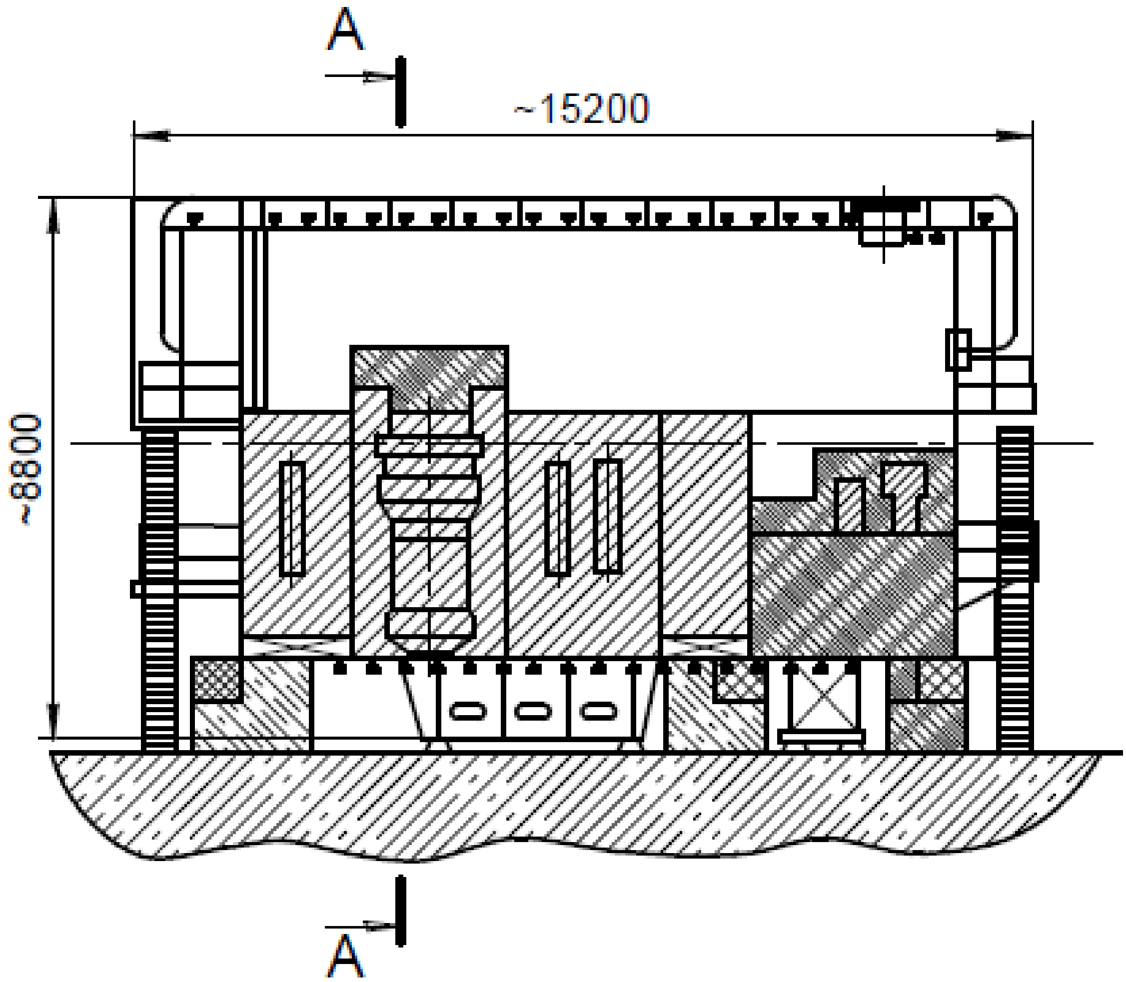
At the same time, radiation monitoring was made of the external surfaces of the building structures of the process hall of the main technological section with a view to identifying contaminated areas and eliminating them. Local contaminated areas of outside surfaces were decontaminated to allowable levels in the locations where such contamination had been detected.

Figures 18-20 show longitudinal and transverse sections of the reactor compartments of Stand 346A and Stand 346B, in accordance with the project for the reactor compartments installed in the shelters and prepared for long term storage.

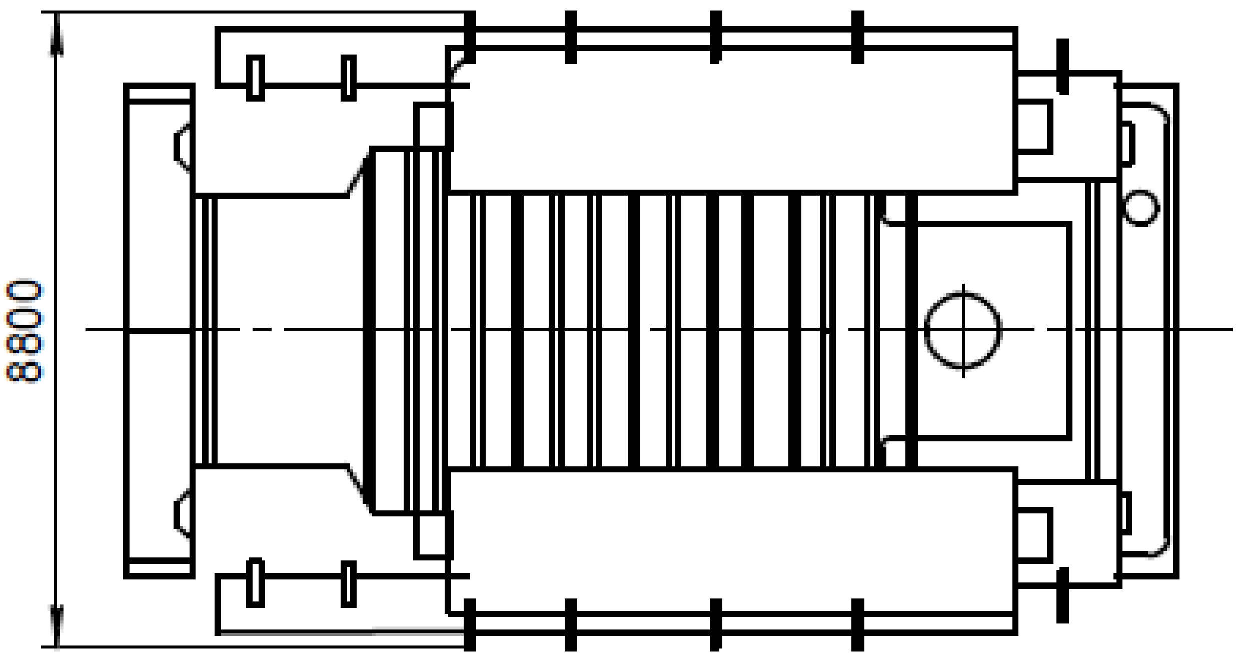
The implemented project for placement of the reactor compartments of Stand 346A and Stand 346B for long term storage, including the safety precautions undertaken, was considered by a special meeting with the IAEA in May 1995 and was approved.

Figure 18 (a, b, c). Reactor Stand 346A



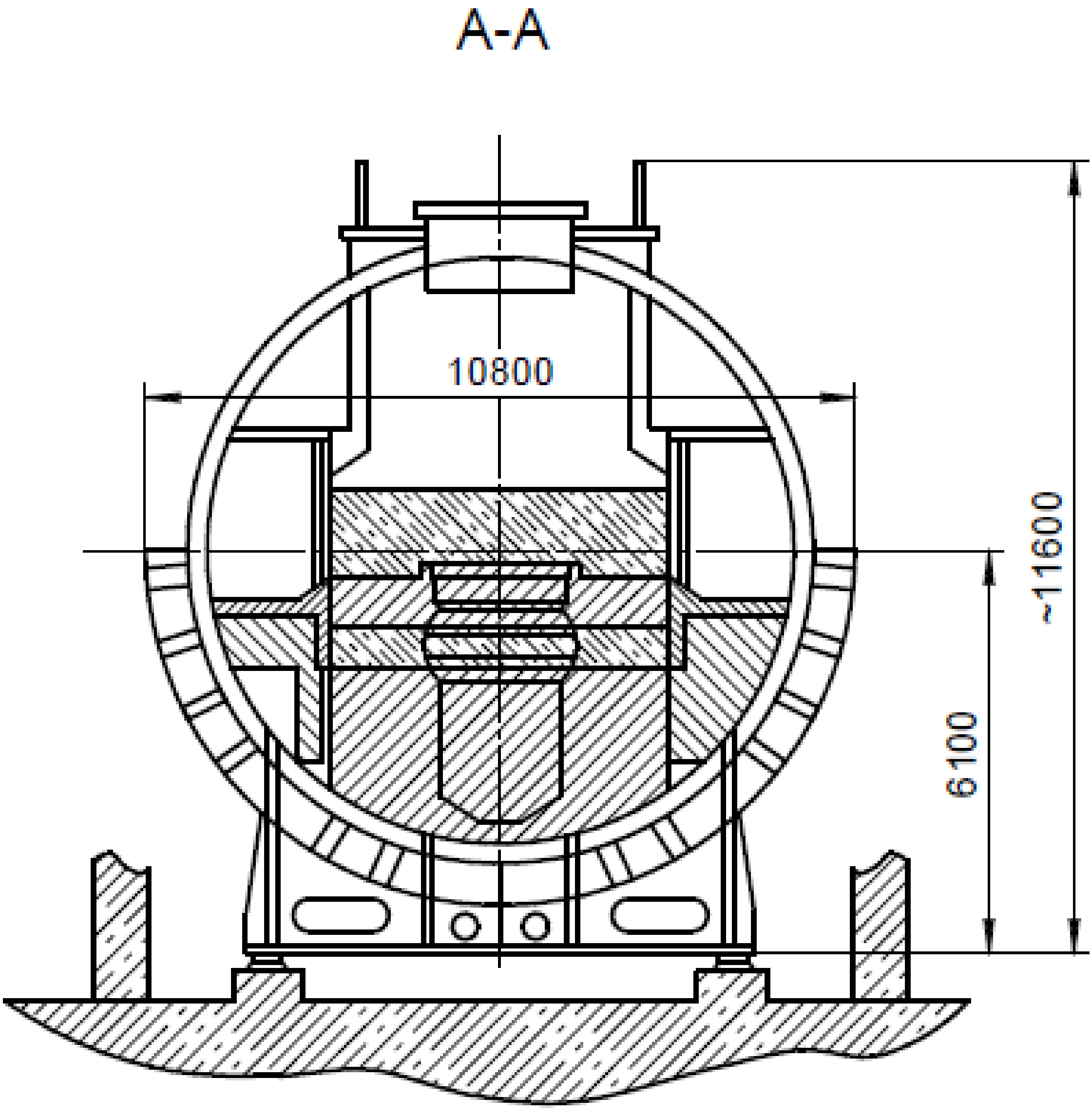


A
~15200
~8800
A



8800

Figure 19 (a, b, c). Reactor Stand 346B



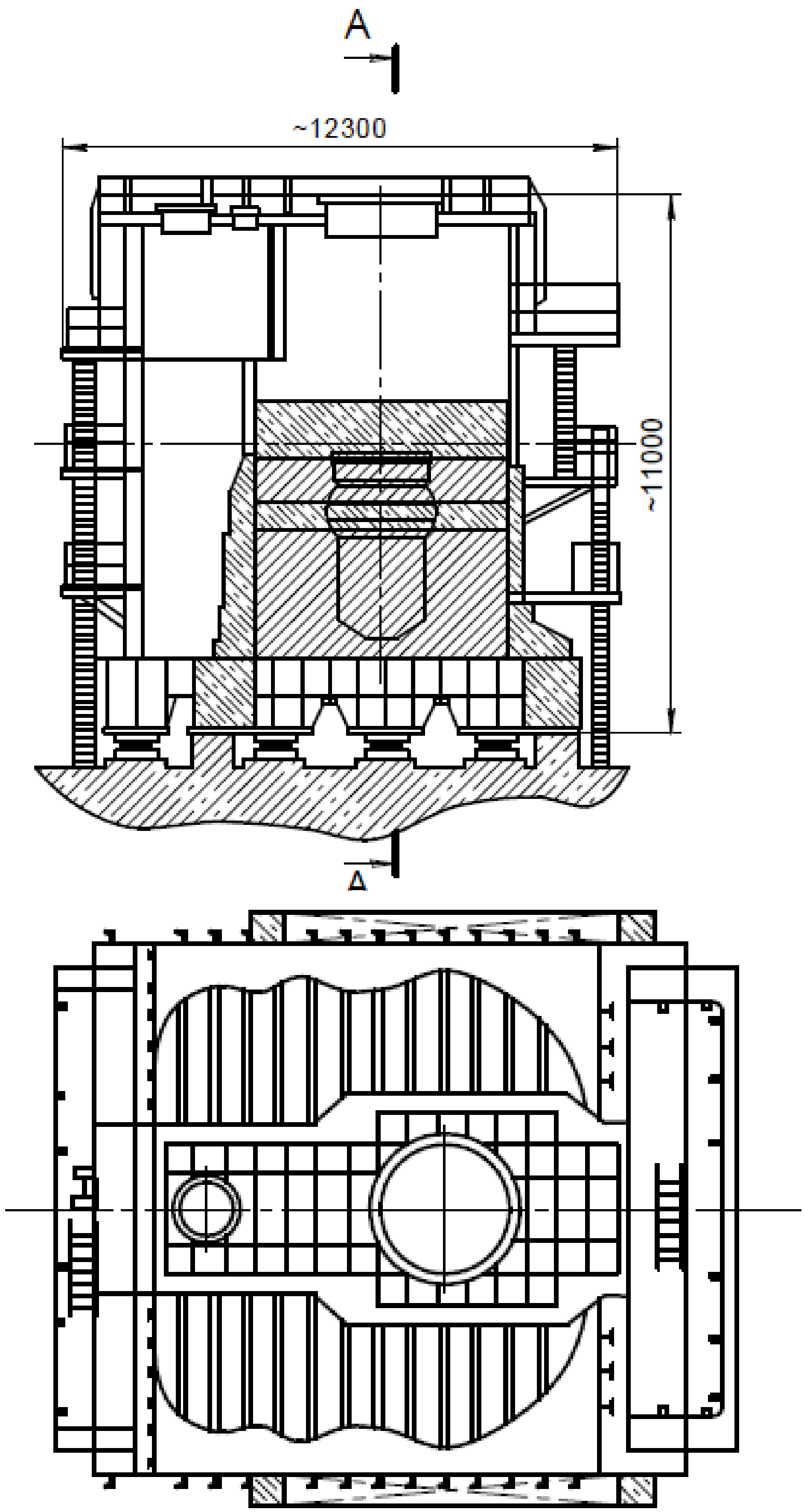
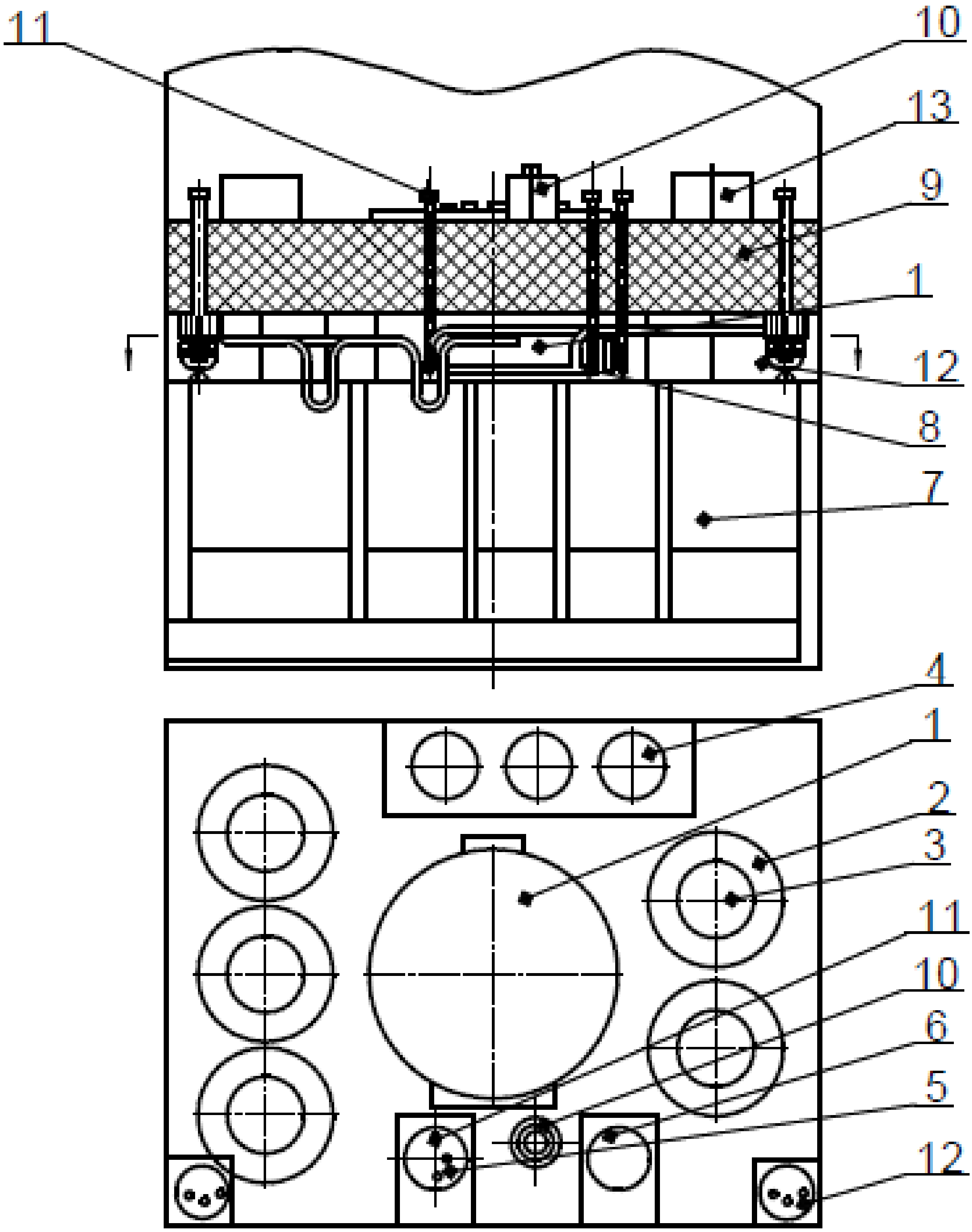
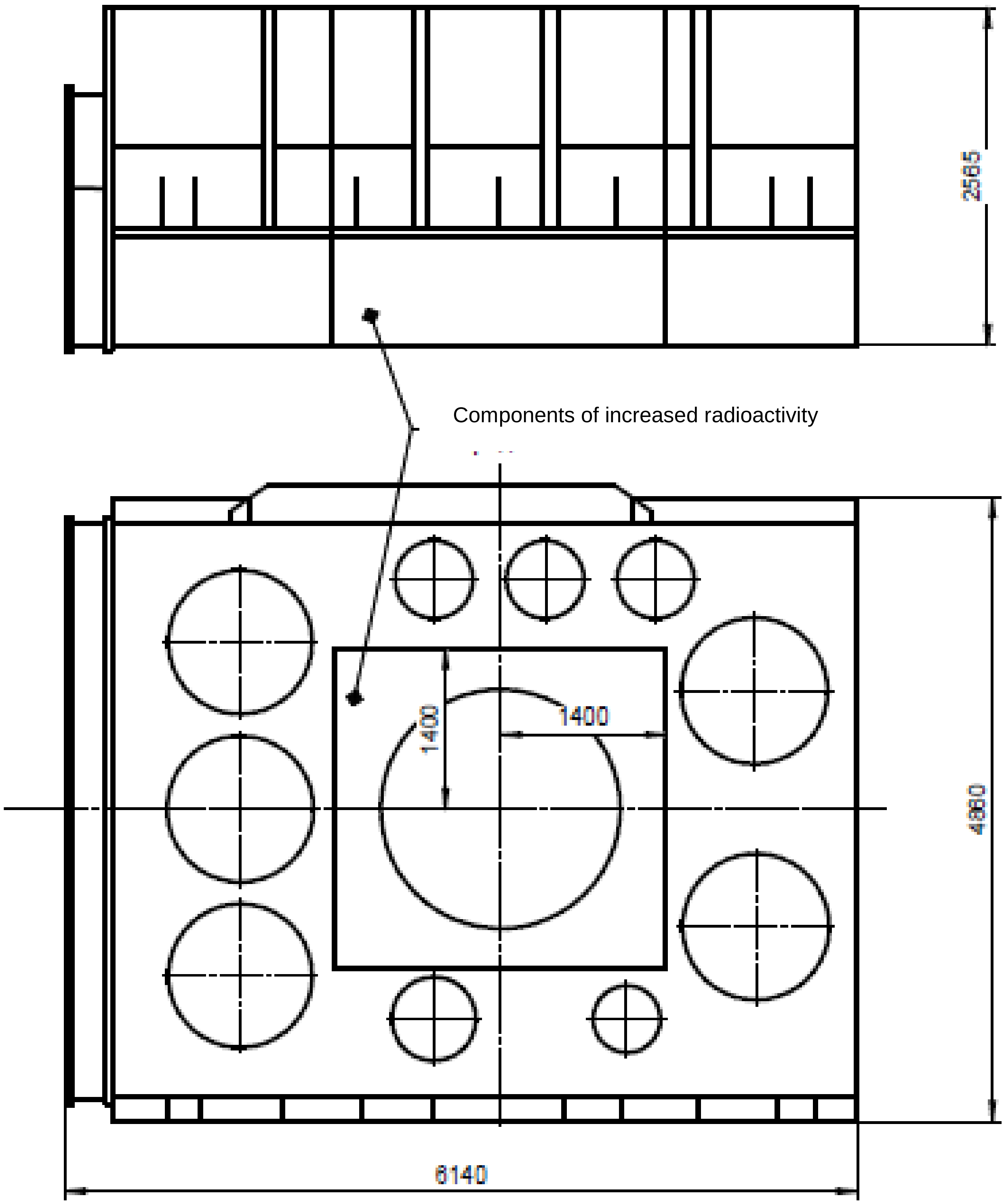

A
~12300
~11000
A

Figure 20 (a, b). Scheme of components and equipment



1 reactor; 2 steam generator; 3 primary circuit pump; 4 primary circuit pressurizer filter refrigerator; 5 valve unit; 6 primary fluid filter; 7 shield tank; 8 primary pipings; 9 bioshield; 10 cool-down pump;

11 primary circuit valves; 12 valve unit; 13 - primary circuit pump



1.6 RADIOLOGICAL SITUATION IN THE REACTOR COMPARTMENT AREA BEFORE PLACEMENT FOR LONG TERM STORAGE

Before erecting reinforced concrete shelters around the reactor compartments, during 1995, a radiological check-out was made of the external surfaces of the reactor compartments. Only calibrated, validated instruments were used for the inspection [1]. The test results yielded the following readings of ionization exposure rate in :

Power Stand 346A

- external surfaces of transverse bulkheads of the reactor compartment (bow and stern) 0.11 - 0.14 μSv/h, which corresponds to the level of natural environment;
- on top of the reactor compartment over the bow partition-off 0.11 - 0.14 μSv/h;
- on top of the reactor compartment on the removable sheet (over the reactor partition-off) 0.12 - 0.17 μSv/h;
- on the bottom of the reactor compartment on the surface of the shell, directly underneath the reactor (along the vertical axis) 4800 μSv/h;
- on the bottom of the reactor compartment, ~ 1.5 m from the reactor centerline towards port and starboard 440 - 1340 μSv/h;
- on the bottom of the reactor compartment, ~ 1.5 m from the reactor centerline towards bow and stern 21 - 28 μSv/h;
- on the bottom of the reactor compartment, ~ 2.0 m from the reactor centerline towards stern 3.0 - 11.0 μSv/h;
- on the bottom of the reactor compartment, ~ 1.5 m from the reactor centerline towards bow up to 22.0 μSv/h.

Power Stand 346B

- external surfaces of the transverse bulkheads of the reactor compartment (bow and stern) 0.11 - 0.14 μSv/h, which corresponds to the level of natural environment;
- on top of the reactor compartment, on the surface of the shell, throughout its entirety 0.12 - 0.14 μSv/h;
- on the bottom of the reactor compartment, on the surface of the shell, directly underneath the reactor (along the vertical axis) 2.2 μSv/h;
- on the bottom of the reactor compartment, ~ 1.5 m from the reactor centerline towards port and starboard 2.2 μSv/h;
- on the bottom of the reactor compartment, ~ 2.0 m from the reactor axis towards bow 0.1 μSv/h;
- on the bottom of the reactor compartment, ~ 1.0 m from the reactor axis towards stern 0.76 μSv/h.

Thus, it can be seen that the highest radioactivity on the reactor compartment shells is typical of the spot directly under the reactor, 1.5 - 2.0m in diameter, on the remaining surface of the shell, ionization radiation rate approaches environmental levels. Ionization radiation rate under the reactor of Stand 346B has a much smaller value due to design reinforcement of the biological shield and shortened energy yield.

A more detailed description of the design and the makeup of the compartments, is given in the input data document Report “Collection and analysis of information regarding the design and content of the reactor compartments of Russian Nuclear Submarines that are being stored in Estonia” Technicatome [1].

1.7 WORK CARRIED OUT BY AS ALARA ON THE SHELTERS OF THE REACTOR COMPARTMENTS AFTER 1995

The main hall of the main technological section (MTS) where the reactor compartments are located for storage in reinforced concrete shelters was left unheated after preparation the compartments for long term storage.,. The shells of the reactor compartments, during the winter, are cooled down to sub-zero temperatures and with the onset of the warm season of the year, moisture begins to condense on them, which leads to their sweating. This results in forming a condensate on the surface of the reactor compartment and this causes damage to the lacquer and paint coats on the shells and speeds up corrosion of the shell external surfaces.

For the purpose of eliminating undesirable processes, the engineers of AS ALARA, in the early 2000s, decided to install ventilation with heated air into the shelters of the reactor compartments. For this purpose, they made door openings in the reinforced concrete walls of the shelters, installed ventilation equipment and air heaters, necessary control and measuring instrumentation as well as automation, which allows automatic actuation of the system during such periods when air moisture reaches dew point. Availability of the above system allows pre-determined air moisture level to be maintained inside the shelters and moisture condensation on the reactor compartment shells with following corrosion will be avoided [1]. For improving of storage conditions of RCs were installed a monitoring system on the reactor compartments for the purpose of detecting possible spills and the main building surrounding the reactors was renovated, thereby making it more weather-proof. Those works were done 2005-2008. As the coating of the shells of RCs were damaged AS A.L.A.R.A. re-painted shells 2014.

1.8 DATA COLLECTION PROCEDURE AND ASSESSMENT OF THE NEED FOR FURTHER INFORMATION AND ADDITIONAL SURVEYS

Initial data from reports, operating documents data, reports of Technicatome Company, etc. [1, 17-20] were used in the work. Data on design and weight as well as dimensional characteristics of basic equipment of power stands, data on the arrangement of equipment inside reactor compartments (RC), data on the design accumulated activity in the equipment, were taken from reports of reactor stands developers – ATOMPROJECT AO, NIKIET AO, OKBM AO and Rubin CKB MT. The credibility of this data is apparent, and no additional confirmation is required. This data is enough to develop options for reactor compartment decommissioning and assess the volume and radioactivity of wastes produced.

From the point of view of obtaining additional data, the information on the design and location of the radioactive waste disposal facility to be erected is of great importance, as this information defines design peculiarities of containers for radioactive waste disposal after the reactor compartment decommissioning and the distance of transportation from the loading place to the disposal facility. This data is one of the most crucial in determining the cost of works for handling radioactive wastes being produced during decommissioning.

To select the location of the radioactive waste disposal facility, additional deep geological, hydrological, environmental and other surveys are required, which is a very time-consuming and expensive task. Additional surveys for RC decommissioning are required especially for the option of decomposing RCs into small fragments. Initially, it was planned to dispose of RCs without decomposing them into individual components. But currently, it is considered more reasonable to decompose RCs into individual components. In this case, it is necessary to find ways for crushing concrete and remove concrete poured into reactor compartments from the circuit equipment, metallic and non-metallic RWs, including containers with radiation sources that are also laid into containers before their final closure.

As for the assessment of storage items, environmental impact in preparing for long term storage and storage of power stands, surveys were undertaken together with foreign specialists in the field of assessing environmental impact from the RC operation and preservation, which show no significant consequences for the surrounding territory from the activities performed. During the RCs storage almost no above-level emissions and discharges of radioactivity into the environment occurred.

The environmental protection during RC dismantling and preparation of RWs for disposal shall be provided in the design for these activities, which is to be developed 5 year prior to the start of such activities. The same project shall define a technology of works and necessity of additional surveys and developments with determination of cost. It is reasonable to interact with specialists of other countries who have practical experience in decommissioning of reactor plants, such as Germany, Sweden, Russia etc.

Due to the uncertainties in data and partial lack of reliable data for the decommissioning planning, it is recommended to provide for the corresponding inventory databases, which are required for the following steps. In view of the unavailability of the operational history and data the possible way to form the abovementioned databases could be done through the corresponding investigations, as it is stipulated in the international practice and in the Russian Federation (the corresponding engineering and radiological investigations at the pre-decommissioning stage are denominated as the Comprehensive engineering and radiation survey – CERS). Such a survey seems to be essential for the further steps in decision making and for the stages of pre-design, EIA, Feasibility Study, design and dismantling. It is assumed that it would be reasonable to divide CERS into several phases:

- First, it is recommended to perform engineering survey of the MTB structures and stack to verify their current condition and determine how it could affect the decommissioning process (e.g. based on the engineering survey conclusions - MTB could be used as a shelter during the dismantling process after corresponding stabilization works (if needed) or demolished prior to the RCs dismantling if the strength properties will not comply with the requirements);
- Second, as far the design life-time period of the sarcophagi ends in 2045, it seems reasonable to perform engineering survey of the sarcophagi structures and external structures of the RCs to obtain data for the beginning of the decommissioning stage. Based on the results of engineering survey of the sarcophagi structures, recommendations for the stabilization measures

will be given (if needed). In case of the decision to extend the storage period the additional surveys on geology, hydrogeology, wind and snow loads, etc. will be needed for calculations and safety justifications;

- Third, it is recommended to perform engineering survey of the existing waste storage within the MTB;

These surveys could be performed in several stages or simultaneously.

- Forth, it is recommended to perform radiation survey of the RCs (including survey of the internals) to obtain actual data to be used as the basic data for the EIA, FS and design stage. It seems reasonable to perform this survey as much closer as possible to the starting point of the dismantling stage (depends on the decision on the safe storage to be extended or not);

- Fifth, it is recommended to perform survey of the site, including radiation survey (and also geological, hydrogeological, seismic etc. for the case of Paldiski site selection for disposal facility construction).

Considering the preparation of the decommissioning EIA, the aforementioned surveys will provide the basic data for the EIA to be performed. In view of this engineering and radiation survey could constitute the preliminary part of the EIA to form the basic data.

For the purpose of the EIA of the facility at the current state the engineering survey seems to be essential and the data for the assessment related to the radiological issues could be input both through radiation survey or existing data. EIA of the facility needs full characterisation of RW stored at the site.

At the current moment it is recommended to consider the possibility to add to the existing monitoring procedure the measurement of pH in the water wells and constructions condition monitoring.

The main parameters required for the further steps are following below.

CERS of the MTB shall consist of an engineering and a radiation survey and be performed by a commission set up (appointed) by the utility.

The results of CERS of the MTB shall provide the basis for justification of the preferred option for facility decommissioning and development of a decommissioning design based on the selected option.

CERS of the MTB shall include:

– design documentation review (if available);

– review of operating documentation for the RC (if available); obtain data on the status of structures, systems and components: constructions at the site (MTB), including the storage with containers with solid RW, structural elements of the MTB and sarcophagi, systems and its components in the MTB, e.g. system for lifting and handling, electricity supply, water supply, drainage, liquid waste collection, ventilation, special ventilation, laboratories, radiation monitoring system, sanitary access control point, rainwater collection etc. - in order to perform decommissioning safety assessment and justify their use for decommissioning purposes (these information should be specified within CERS program in accordance with the CERS statement of work). Also, recording of the existing on-site and off-site monitoring boreholes;

- analysis of radiological conditions in restricted-access rooms and other rooms of MTB;
- analysis of physical protection arrangements for radioactive substances and radwaste during various stages of MTB decommissioning;
- performance (if necessary) of calculations and research work, e.g. corresponding calculations if there is no design, calculations of building structures taking into account design accidents including the fall of the aircraft/flying object, fire, seismic impacts and other natural factors for the reconstructed MTB (these information should be specified within CERS program in accordance with the CERS statement of work).

Scope, methods and timeframes for the survey shall be identified by MTB decommissioning programme and detailed in the CERS technical specification.

Engineering investigation

a) The engineering investigation of the MTB shall be performed in order to obtain information about the technical status of systems (components) and structures of the MTB.

Results of the engineering investigation shall contain:

- actual status assessment of structures, systems (components) of the MTB at the time of the survey;
- list of technical and mass and dimension characteristics of equipment, facilities and systems (components);
- list and characteristics of handling and transport machinery;
- list and characteristics of ventilation and cleaning systems;
- list and characteristics of fire protection systems;
- information about potential placement of required additional equipment for the performance of dismantling work.

Radiological investigation

a) The radiological investigation shall be performed in order to obtain information about radiation conditions, as well as quantities, volumetric (specific) and total activity of contained radwaste, its aggregate state and radionuclide composition.

b) Information about radiological conditions shall include data regarding both dose rates of gamma-radiation and levels of radioactive contamination on surfaces in rooms of the installation, concentrations of radioactive aerosols and gases in room air on the installation, as well as on infrastructure facilities, used for the purposes of MTB decommissioning, as well as data regarding the concentrations of radioactive aerosols and gases in the sanitary-protection zone atmosphere surrounding the location of decommissioning the MTB.

c) Results of the radiological investigation shall contain:

- list of rooms on the MTB, infrastructure facilities at the site that became radioactively contaminated, indicating area, type of surface and covers, activity levels at surfaces that became radioactively contaminated;
- information about the quantities of liquid waste in collection system at the MTB (pumps, tanks etc.), their specific and integrated activity;
- information about quantities of solid waste their specific and integrated activity, radionuclide and chemical compositions.

d) After completion of radiological investigation in rooms of MTB, the following shall be identified:

- zone and boundaries of radioactive contamination on the MTB;
- levels of surface contamination with radioactive substances on systems (components) and structures MTB.

Requirements applicable to means used for the performance of comprehensive engineering and radiation survey of MTB

a) CERS of the MTB shall be performed using design, engineering and operating documentation, which shall have appropriate registration numbers to confirm their relevance to the surveyed facility.

b) CERS shall be performed using metrological certified hardware (instruments, tools) and following procedures that are approved as appropriate.

1.9 NEED FOR ADDITIONAL STUDIES: THE COMPREHENSIVE ENGINEERING AND RADIATION SURVEY (CERS)

RC plants are radiation-hazardous facilities. The comprehensive engineering and radiation survey (CERS) is required to choose the RC decommissioning option and subsequent decommissioning solutions. For the particular case of the Paldiski facility decommissioning CERS is necessary in view of the lack of the facility operational documentation and history records on surveys and monitoring.

CERS is a set of measures required to develop RC decommissioning design and aimed at obtaining the data on the engineering and technical condition of buildings, structures and equipment, as well as on the radiation situation inside the RC, on volumetric and surface radioactive contamination of rooms and equipment, quality and volume of radioactive waste.

The CERS is currently understood as a residual radioactivity inventory and investigation of durability and stability of buildings, structures and systems, it is assumed to be a permanent process started at the operating stage and continued after the shutdown up until reaching a planned final state after the selected decommissioning option is implemented. As applied to the Paldiski facility the principal CERS task is to assess actual radiation and technical state of the facility and its radiological and non-radiological hazards due to the lack of data accumulated. Based on the study results a report shall be prepared on the facility state where the information and the data obtained during the survey shall be documented. Besides, since the facility is removed from operation and is in the long-term storage, special attention shall be given to the engineering part of the survey in the course of the CERS.

CERS of the Paldiski facility, comprising engineering and radiation surveys, shall be carried out by the committee appointed by the operator.

The CERS results shall serve as an informational base to justify the facility decommissioning option and to develop the decommissioning project for the option preferred.

CERS shall comprise:

- review of the design documentation and compliance analyses of the solutions actually implemented on the facility being decommissioned to design solutions;
- analysis of the facility operating documentation on the condition of building structures, systems and equipment to justify their usage for the decommissioning purposes;
- analysis of radiation situation indoors and outdoors;
- instrumental examination of building structures, system and equipment condition;
- design and research activities if required.

During the CERS of the facility being decommissioned the committee shall analyze the information available as well as specify and systemize the information relevant for the decommissioning, comprising:

- data contained in design materials on the materials chemical composition of equipment, biological shielding, building structures;
- data on the technical condition of systems, equipment and structures to justify their possible usage during the whole decommissioning period;
- data on restrictions during the decommissioning activities;
- data on RC operation related to repairing and replacement of system and equipment components and periods of repairs;
- data of operational and technical documentation on accidents occurred during the operating period and their consequences.

The scope methods and periods of the CERS shall be specified in the decommissioning program and depend on the decommissioning option preferred, technical means for the survey, equipment and systems availability for the survey, scope of the information needed to develop the decommissioning project and shall be given in detail in the requirements specification for the CERS.

Engineering survey

The engineering survey shall be carried out to obtain detailed information on the technical condition of the facility and is a part of the CERS.

In the general case the engineering survey shall be aimed at obtaining the data having the following structure.

Survey of buildings and structures.

The survey results shall comprise:

- description of the facility and its structures;
- full list of rooms and equipment with respect to zoning naming each room;
- assessment of the actual state of building structures at the moment of the survey indicating their residual lifetime;
- schematic diagrams of power, heat, gas, air and water supply systems;
- circuits and characteristics of connections between the areas.

Survey of rooms.

The survey results shall comprise the following:

- characteristics of the room (dimensions; room category; explosion and fire safety class; electrical safety class; air changes per hour; characteristics of floor, ceiling and walls coating, characteristics and types of openings);
- list and technical specifications of equipment, plants, systems and utilities (weight, dimensions etc);
- list and specifications of hoisting and transport equipment;
- list and specifications of ventilation systems;
- list and specifications of fire control systems;

- data on possible placement of required additional equipment to carry out dismantling as well as data on additional openings required to carry out dismantling;
- data on the actual condition of equipment, plants and system at the moment of the survey and on their residual lifetime.

Radiation survey

The principal objective of the radiation survey is to obtain data on the radiation situation, residual contamination of equipment, systems and building structures, as well as data on the volume, aggregate state and nuclide composition of radioactive waste required to assess radiation exposure of employees (personnel) during the decommissioning activities.

The information on the radiation situation shall comprise the following data:

- gamma dose rates, alpha and beta flux density, concentration of radioactive aerosols and gases in the air;
- gamma dose rates outdoors, levels of radioactive contamination of building external surfaces, concentration of radioactive aerosols and gases in the atmosphere.

The results of the radiation survey shall reflect the following:

- list of layout items that have radioactive contamination, indicating their area, surface and coating type, radionuclide composition and their activity;
- volumes of radioactive waste accumulated, their specific and integral activity, radionuclide and chemical composition;
- data on radwaste storages occupancy;
- gamma dose rates and maps of radiation fields;
- contamination of equipment, utilities, building and shielding structures with fission products and other radionuclides.

The following shall be determined after the radiation survey:

- zones and boundaries of radioactive contamination;
- areas of control access;
- levels of equipment, systems, building structures surface contamination with radioactive substances;
- levels of radionuclide contamination of materials, equipment and structures in depth from the external surface;
- volumes and nuclide composition of radioactive deposits inside the equipment.

Requirements for the means used to carry out CERS of the MTB unit.

The survey shall be carried out using design, technical, engineering and operational documentation on the facility.

The instrumental examination of the facility state shall be carried out using metrological certified devices and based on approved techniques.

1.10 INDICATIVE ANALYSIS OF RADIOACTIVE WASTE VOLUMES, INCLUDING OPERATION AND DECOMMISSIONING OF POSSIBLE NPP IN THE ESTONIAN REPUBLIC

Based on the analysis of some existing nuclear power plants, this section gives indicators of formation volumes of radioactive wastes during the operation and decommissioning of a possible nuclear power plant in the Estonian Republic with water-cooled reactor plants of approximate capacity 1,000 MW.

The modern international practices give favor to the construction of the multi-unit nuclear power plants with water-cooled reactors compared to the single-unit ones. The current approach of the multi-unit nuclear power plant (NPP) construction (e.g. two power units) proved to be more economic efficient due to the usage of the corresponding infrastructure and systems for several units and provides opportunity to reduce the costs of each unit by up to 30%. Furthermore, the multi-unit approach ensures the continuing power supply for the NPP-dependent regional consumers in the case of the scheduled maintenance shut-down of a unit. The task of the present report does not include detailed studies and justification for the international practice of the multi-unit NPP approach. The following analysis of the waste qualities has been made for the single-unit NPP with a reactor plant of approximately 1 000 MW capacity.

1.10.1 Description of RW produced during NPP operation

As a basis of handling WSs at the NPP, the concept of temporary organized storage of conditioned RWs is assumed. The storage technology and the storage facility design shall ensure the necessary level of radiation safety, extraction of located wastes and their transfer to further storage or disposal beyond the NPP site.

During the NPP operation, the following radioactive wastes are produced:

- Liquid radioactive wastes (LRWs) as the result of maintaining water chemical conditions, equipment and premises decontamination, etc.
- Solid radioactive wastes (SRWs) as the result of LRWs processing, personal protection equipment, repairs and scheduled works, etc.

<u>LRW handling</u>

The selection of engineering solutions for systems where LRWs are produced shall be conditioned by the need to minimize LRWs in order to reduce the volume of radioactive wastes transferred for storage and/or final disposal. The reduction of yearly influent of LRW for processing is defined by the assumed design solutions:

- Separate collection and processing of LRW streams with respect to their chemical and isotopic content;
- Applying non-reactive technologies – full/partial abandoning of regeneration of filters for low-salt high-active waters;
- Applying low-waste methods of decontamination with intermediate transformation of solutions, reduction of chemical component concentration, reduction of volumes of LWRs produced by decreasing the number of processing cycles and stages;

- Using special units and mobile modules that allow abandoning the routing of steam and decontamination solutions pipelines within the station;
- Treatment of potentially non-active and low-active waters by using ion-selective non-organic sorbents intended for extracting Cs-137, Co-60 isotopes and other radionuclides, with further no-control of purified salty and condensed waters.

The basis of LRW processing shall be the concentration method (evaporation, electro dialysis, separation, etc.) that ensures the volume reduction coefficient (up to 103) and production of small amount of LRW – radioactive salty concentrates (bottom residue, bottom residue concentrate).

For LRW conditioning, the following methods can be selected:

- Cementing of the salty bottom residue;
- Dehydration of ion exchange resins (IER);
- Dehydration of birch activated carbon (BAC);
- Dehydration of titanium mechanic sorbents;
- Dehydration of ion-selective sorbents;

Cementing of heterogeneous radioactive wastes with further location and initial conditioning in the following primary packages:

- Reinforced concrete non-return shielding containers (NRSC);
- Steel drums 200 or 100 L in volume;
- Steel drums 200 or 100 L in volume with no-extractable stirrer.

Solidified LRW in primary packages are transported into the solid waste storage facility of the NPP. Packages with wastes shall be located on the floor of the solidified wastes storage facility.

The primary package shall ensure radiation and process safety at all handling stages of solidified LRW.

<u>SRW handling</u>

Separate system for handling SRWs of different types shall be provided at the NPP. For each type of wastes, the following is provided: methods for collection, temporary storage, packing, transportation, conditioning and storage. Necessary premises and equipment for RW handling is provided, the scope and methods of radiation monitoring are defined.

To reduce final volumes of SRWs, the following conditioning methods are assumed: grinding, incineration and pressing.

A source of operational HAWs are: wastes produced during the replacement of assemblies of intra-reactor detectors and detecting units; wastes from cutting surveillance specimen. These wastes are collected into special metallic capsules, loaded into protective containers, transported into the NPP solid radioactive waste storage facility and located in guiding pipes of the highly active waste storage compartment. Highly active wastes are stored during the whole NPP's operational period.

Large-size non-processed SRWs generated as a result of repairs, for which containers cannot be provided, are removed from the place of generation in accordance with all the safety rules (sealing, coating with accumulating composition, shrouding) to prevent propagation of radionuclides into the environment, and are transferred to the NPP SRW storage where they are located in a separate premise during the whole NPP's operational period. If necessary, an individual program for handling such RWs is developed, and additional storage location are provided on the NPP site.

Description of radioactive wastes produced during NPP decommissioning

The volume and morphological composition of the radioactive waste generated during the decommissioning of the power units with pressurized water reactor plants (VVER, PWR) depend on the following stages:

- direct operation is accompanied by steady accumulation of radioactive waste of different morphology and activity; the intensity of its processing, the amount of secondary radioactive waste, the quality of recycled waste and putting it for temporary and long-term storage are of great influence here.

- final shutdown of the reactor plant (discharge of spent fuel from the core, storage and removal from the power unit, NPP site) and preparing the power unit for decommissioning (or preservation and long-term storage under supervision); it is characterized by the moving of basic waste streams generated during normal operation of the plant to a stable state (solidification of liquid and bulk radioactive waste, etc.), processing is performed by regular radioactive waste management systems (complexes and installations), removal of accumulated waste to the long-term storage / disposal facility site;

- decommissioning of the power unit shall take into account the most effective use of the new additional radioactive waste management systems (complexes and installations) and the existing radioactive waste management systems at the NPP site. Dismantling and fragmentation of equipment and building structures shall be performed in decreasing order of activity, that is highly active equipment (reactor core and internals, CPS, reactor, neutron in-core measurement channel, then piping and equipment of the primary circuit) is decommissioned first, then intermediate level waste (part of the equipment of the primary, secondary and third circuits, water cooling system, filtering elements, filters, waste management systems), and finally building structures are dismantled (usually LLW and VLLW).

Regardless of morphology and activity, radioactive waste, shall be transferred to a stable state and placed into the appropriate transport (protective) containers and packages, providing further transfer of radioactive waste to the long-term storage / disposal facilities.

Induced activity of structural and shielding materials from PWR nuclear plants

Systematized data analysis of space-and-time distribution of induced activity in PWR reactor structures gives evidence of the following general patterns for formation of induced activity:

1. Among reactor internals, the highest specific activity is naturally observed in the basket and shield structures, which are located closer to the core with high neutron fluxes than any other internals.

2. The contribution made by various radionuclides toward the total induced activity of materials varies considerably depending on cooling time after reactor shut-down. For instance, for a reactor vessel during its first few years after shut-down, the biggest contributor toward total activity is Fe-55. Considerable contributions toward specific activity during this time are also made by Co-60 and Ni-63.

3. Time dependencies of specific activity in concrete structures are more complex, as a large number of impurities and 'trace' elements contribute heavily toward the formation of induced activity. Total activity of serpentine concrete is dominated by tritium, formed from lithium by the Li -6(n,), H-3 reaction, with trace amounts of lithium present in concrete. During the first years of cooling, Fe-55and Co-60 are also important contributors.

As time passes, however, their contribution toward total activity tends to decrease, with radiation emitted largely defined by Co-60, Eu-152 and Eu-154. As cooling time increases further, the importance of Co-60 drops, while the contribution of the more long-lived Eu-152 and Eu-154 grows. A similar pattern of induced activity time-dependence is also observed in regular concrete. Full activity of serpentine concrete is approximately an order of magnitude higher than that of regular concrete.

4. The material that makes the heaviest contribution toward total activity is steel of the reactor internals. Its activity for all considered cooling times remains predominant, and with short cooling periods it exceeds vessel steel activity.

5. Over 95 % of full activity of a finally shut-down reactor installation is determined by the activity of reactor internals steel and reactor vessel steel. Chemical composition of said structures is strictly controlled according to the provisions of applicable technical specifications. Fluctuations in chemical composition of concrete structures of the reactor installation as a consequence of variations in impurities and trace elements present bear practically no impact on the full - radioactivity of the reactor installation.

6. As every NPP unit is unique in its characteristics, operational history, components, chemical composition of materials, etc., the general approach is that independent calculation of induced activity in structural and shielding materials must be performed for each specific power unit at the moment of decommissioning.

Radwaste and reusable materials during decommissioning

Available experimental and analytical studies of shut-down NPP units allowed for an assessment of the amounts of radioactive waste (radwaste) to be generated and its aggregate state, as well as classification by type and level of activity. Radioactive waste is generated by radioactive contamination and activation during plant operation. Additionally, a certain quantity of waste is also generated during the decommissioning process. Only a small amount of those materials bears high levels of specific activity. These primarily include activated materials in near-core areas, reactor internals and reactor vessel, whose activity contributes more than 99 % of full activity.

As radioactive waste with induced activity cannot be decontaminated, it must be entirely sent to disposal. Its volume, however, accounts for only a few percent (2—3 %) of the total volume of radioactive waste.

The balance of waste is mainly represented by surface-contaminated materials (reinforced concrete and metals), which have low and intermediate levels of radioactive contamination. Low and intermediate-level waste is treated using appropriate processes (decontamination, re-melting, removal of heavily contaminated fragments, etc.) and sent for storage or released for re-use. Waste is to be segregated and classified of waste by type, size, material, etc. during the preparatory or initial stages of plant decommissioning. During the same period, the waste is to be pre-divided into the following streams:

- waste for disposal;
- waste for processing followed by disposal;
- waste for processing followed by on-site storage;
- waste for processing followed by re-use;
- waste for processing followed by re-use after a period of interim storage.

Waste types on shut-down NPPs

According to preliminary assessment, the following fall into the low-level solid waste category:

- circuits process equipment;
- turbine room metal structures;
- construction waste (concrete, plaster, re-bar);
- plasticate coats;
- thermal insulation, electric cabling, electric equipment, cabinets and panels;
- non-accounted components and structures;
- secondary waste.

High-level waste generated during plant decommissioning shall obligatorily be sent into long-term storage in stationary storage facilities and eventually disposed of in deep geological repositories.

High-level waste represents a formidable problem during plant operation. This problem also remains during management of high-level waste generated as a consequence of plant decommissioning.

According to estimates, the following fall into the high-level waste category:

- reactor vessel;
- internals;
- part of activated reactor shield.

It should be noted that considerable quantities (tens and hundreds of thousands of tons) of reinforced concrete and metal structures generated by dismantling of plant buildings could be released for re-use provided that they undergo through measurements of residual radioactivity. Otherwise, major problems could be posed by the need by dispose of huge quantities of non-radioactive or low-level waste. Various re-use scenarios for released materials are possible. For example, concrete waste could be used as coarse and fine filler material for production of new concrete to be used for construction of roads, utilities, buildings, etc.

After decontamination and remelting, metals could provide a resource for fabrication of metals structures, re-bar and for other applications.

Volume of RW generation at NPP with PWR reactor

The modern standard designs of reactor plants, the project documentation of which has been approved and the stations where these reactor plants are located are already under construction, commissioning or operation, shall serve as the basis for calculations of the volume of radioactive waste generated during operation. These designs are currently the following:

- VVER (Russian design, developed by the State Atomic Energy Corporation Rosatom) Belarus NPP (Belarus, construction), Leningrad NPP-2 (Russia, construction), Kudankulam NPP (India, 2 power units in operation), Akkuyu (Turkey, construction of 4 power units), Smolensk NPP-2 (Russia, design completion), Kursk NPP -2 (Russia, design completion), Novovoronezh NPP-2 (Russia, construction);
- AP-1000 (developed by Westinghouse EC) - Vogtle-3, 4 (USA, construction), Sanmen NPP, Haiyang NPP (China, construction).

The RW volume shall be confirmed by the existing equipment and processing technologies generated during operation and decommissioning of nuclear power plants. At the same time, it is only possible after selecting the NPP supplier, determining the reactor and related systems, and obtaining full technical documentation from the supplier/developer.

Estimated volume of RW during operation NPP with PWR reactor AP-1000

Data on the rated annual volume of waste generated by AP-1000 is shown in Table 16.

Table 16: Summary of the rated annual volume of conditioned (solid) radioactive waste from the power unit with AP-1000 reactor plant under normal operation [21].

Name	Class of radioactive waste	Normal volume, m^3	Maximum volume m^3
Waste ion-exchange resins	ILW (Intermediate level waste)	7.8	15.6
Birch activated carbon (moist)	ILW (Intermediate level waste)	0.6	1.1
Filter-cartridge	ILW (Intermediate level waste)	0.2	0.4
Compressible paper, clothing, plastic, PVC, PPE, etc.	LLW (Low level waste)	135	206
Non-compressible: metal fragments, glass, wooden fragments	LLW (Low level waste)	6.6	10.6
Waste ion-exchange resins	LLW (Low level waste)	3.9	7.7
Birch activated carbon (moisture-free)	LLW (Low level waste)	0.3	3.3
Different materials	LLW (Low level waste)	1	2
Total, m^3/year:		155.4	246.7

Accordingly, the total amount of conditioned radwaste over the entire period of operation of one unit fitted with AP-1000 reactor would be expected at approximately (at least) - 9,324 m^3 with the design duration of operating life of 60 years.

NPP site usually includes a waste storage facility for temporary (not less than the life of the station) storage of conditioned RW with account for marginal calculated values of its generation. When calculating the structural volume of the storage facility, it is recommended to use the margin for unforeseen circumstances in the case of excessive radioactive waste formation.

<u>Estimated volume of RW during NPP decommissioning with PWR reactor AP-1000</u>

The basic approach to determine the volume, composition and activity of the radioactive waste generated during decommissioning of NPPs is a statistical approach. However, due to the fact that the current number of decommissioned stations is limited by the small number of power units of the 1st and 2nd generation, which do not correspond to each other in power, constructive and other solutions, this statistic has considerable differences. The technology used during the decommissioning process also undergone significant changes and determine much more efficiency compared to the technologies used during the implementation of projects for decommissioning nuclear power plants in the European Union, the Russian Federation, Japan and the United States.

For AP-1000 reactor, the total amount of conditioned radioactive waste generated in accordance with the design when decommissioning one power unit will be the following [21] (Table 17):

Table 17: The total amount of conditioned radioactive waste generated during decommissioning

Activity	Volume, m^3	Weight, tons
LLW (Low level waste)	2911,937	2316,10
ILW (Intermediate level waste)	3151,707	2540,66
HLRW	13,740	124,00
Total:	6077,384	4980,76

Radwaste generation during operation and decommissioning of a power plant with AP-1000 unit

Thus, the total amount of conditioned radioactive waste expected to be generated during operation and decommissioning of a power plant with AP-1000 unit is (at least) - 15,401.5 m^3.

Actual verified quantity of radwaste to be generated during plant operation and decommissioning can only be identified after selection of plant supplier, type of reactor and auxiliary systems, and receipt of the full set of documentation from the supplier/designer.

Radwaste generation during operation and decommissioning of a Russian-design VVER power plant

Expected annual generation of conditioned RW of all categories with the account of its processing under normal operation of Russian design NPP with reactor VVER-1000:

The average annual amount of operational radioactive waste per power unit (net):

- very low level (flammable) solid RW 8 m^3 (4.9 m^3)
- low-level (flammable) solid RW 32 m^3 (4 m^3)
- intermediate-level solid RW 5 m^3
- high-level solid RW 0.5 m^3
- Bulky irreclaimable solid RW 5 m^3
- Solidified LRW 33 m^3

Total: 83.5 m^3

Accordingly, the total amount of conditioned radwaste over the entire period of operation of a unit fitted with VVER-1000 reactor would be expected at approximately (at least) – 5010 m^3 with the design duration of operating life of 60 years.

For VVER-1000 reactor, the total amount of conditioned radioactive waste generated in accordance with the design when decommissioning of one power unit will be the following:

- intermediate-level and low-level RW 2050 m^3
- high-level RW 85 m^3

Total: 2135 m^3

Thus, the total amount of conditioned radioactive waste expected to be generated during operation and decommissioning of a VVER-1000 unit power plant is (at least) - 7145 m^3.

1.10.2 Waste amount generated during decommissioning of rigs 346A and 346B for various decommissioning options

Table 18 summarizes the quantities of radioactive and non-radioactive waste estimated to be generated during the decommissioning of rigs 346A and 346 B for various decommissioning options.

Table 18: Waste amounts to be generated during decommissioning of rigs 346 A and 346 B

Waste designation	Waste weight, kg	
	Rig 346 A	Rig 346 B
Whole disposal of radwaste (options C and D)		
ILW radioactive waste within reactor compartments volume	920000	1040000
Waste from sarcophagi disassembly (non-radioactive)	650000	610000
Total of radwaste	920000	1040000
Total of non-radioactive waste	650000	610000
Dismantling with fragmentation into large pieces (option A)		
ILW radioactive waste from dismantling of primary circuit equipment	115000	210000
Waste from dismantling of reactor compartments (cleared and non-radioactive)	740000	740000
Radioactive waste from cutting concrete with radwaste inside the compartments (category ILW for blocks of containers with ionizing radiation sources, LLW, VLLW for other concrete blocks)	65000	90000
Waste from sarcophagi disassembly (non-radioactive)	650000	610000
Total of radwaste	180000	300000
Total of non-radioactive waste	1390000	1350000
Dismantling with fragmentation into small pieces (option B)		
ILW radioactive waste from dismantling of primary circuit equipment	115000	210000
Waste from dismantling of reactor compartments (cleared and non-radioactive)	740000	740000
Radioactive waste separated from concrete inside the compartments (category ILW for blocks of containers with ionizing radiation sources, LLW, VLLW for other concrete blocks)	15000	10000
Concrete	50000	80000
Waste from sarcophagi disassembly (non-radioactive)	650000	610000
Total of radwaste	130000	220000
Total of non-radioactive waste	1440000	1430000

As evident from Table 18, radioactive waste generation is minimized during decommissioning of reactor compartments following option B. However, as mentioned above, the performance of work following this option is associated with higher exposure, demands the involvement of more equipment and systems for decontamination of the waste, and generates greater quantities of secondary waste.

Option A exceeds option B in terms of radwaste generation by some 50-80 t. From the perspective of the total amount of waste, this quantity is not vastly greater than that of the other option.

1.10.3 Waste from Paldiski facility [28-29]

For the assessment within the framework of the Task 4 it is necessary to take into consideration the existing and estimated future waste quantities in the Estonian Republic and at the Paldiski site. According to the Minister of the Environment Regulation No. 8 "Radioactive waste classification, recording, handling and transfer of radioactive waste acceptance criteria", wastes from the decommissioning of the reactor compartments are classified as low and medium active short-term and long-term waste.

Waste stored at the Paldiski site

At the Paldiski site there were accumulated the waste from the site decommissioning performed activities, from Tammiku facility and all other institutions and companies operating in Estonia (so-called institutional wastes). These wastes are located in the storage facilities and controlled access are at MTB, generally within concrete and metal containers, the exterior dimensions 1.2x1.2x1.2 m (capacity 1 m^3, waste package volume 1.728 m^3).

Metal Containers

Metal containers stored at the Paldiski site include concrete waste generated during the decommissioning (117 pieces, with total capacity of 202.176 m^3).

The waste in containers requires more detailed characterization to determine what isotopes are represented there, and to assess the maximum possible activity figures. That cemented waste is originally related to the reactor compartments.

The waste in metal containers are classified as short-term low- and medium– level.

Paldiski interim storage of contaminated metals

Paldiski metal wastes are stored in 17 sea containers. According to the former smelting requirements it was cut into a maximum of 2 m lengths. The exceptions are some NORM - waste that does not minimize the lengths of contaminated fragments. General indication of the waste is given in Table 19 below (dose rates on the surface at the distance of 1 m).

Table 19: Surface Dose Rates, metal containers stored at Paldiski

The container number and type of waste	Dose rate surface μ Sv/h	Dose rate 1 m distance, μ Sv/h	Dose rates date of establishment
Container No. 1 RV steel	0.5	0.1	23/03/2012
Container No. 2, black metal	0.7	0.1	22/03/2012
Container No. 3, stainless steel	1.3	0.2	21/03/2012
Container No. 4, black metal	0.3	0.1	23/03/2012
Container No. 5, black metal	9.5	2.3	22/03/2012
Container No. 6, stainless steel	0.6	0.1	21/03/2012
Container No. 7, black metal	0.7	0.3	22/03/2012
Container No. 9 stainless steel	0.5	0.1	22/03/2012
Container No. 10, black metal	0.5	0.3	21/03/2012
Container No. 11, black metal	3.5	2.1	23/03/2012
Container No. 14, stainless steel	2.6	0.8	21/03/2012
Container No. 15, stainless steel	0.5	0.1	22/03/2012
Container No. 16, lead and aluminum	0.9	0.7	23/03/2012
Container No. 17, black metal	0.4	0.1	23/03/2012
Container No. 18, NORM	1.5	0.4	23/03/2012
Container No. 19, stainless steel	0.4	0.1	22/03/2012
Container No. 28, copper	0.6	0.1	23/03/2012

Stainless steel (SS) – resistant to various corrosive effects. Corrosion resistance is achieved by the addition of chromium which forms on the surface the chromium oxide layer which prevents corrosion on the surface thereof, and the transmissibility in the material;

The black metal to carbon steel - an alloy with the main component iron and other elements (sulfur, phosphorus, etc.) up to 2.14% carbon.

Dose rate measurement was carried out of the container wall, shielding the waste turn to each other (distance factor). However, since the container does not contain a shielded radiation sources, there were performed estimates of the data on the basis of general activity level of the waste, containers 5, 3, and 11 are likely to have a slightly higher activity waste. NORM container showed the presence of Ra-226 and Cs-137 within different types of waste.

Surface material-specific activity measurements showed: ferrous metals in containers 10 and 4, lead, aluminum in a container 16, and the NORM waste in a container 18. Components were measured as large open surfaces (cut surfaces of the pipes, the large interior surfaces of the vessels, etc.). Mobile gamma Synodys 100 was used to determine the composition of isotopes, to determine the isotope from the surface-specific activity of 3-5 Bq / cm^2 (depending on the isotope). For complex geometries (eg. small diameter pipes) estimates were made on surface-specific activities. For final storage/disposal of waste is definitely needed additional measurements (geometry suitable detectors, etc.). Details of the maximum dose rate levels are presented in Table 20.

Table 20: Waste metal pieces measuring results

Type of waste	Part No.	β+ γ of pollution, Bq / cm ^{2}	Pollution α Bq / cm ^{2}	Notifications
Black Metal	1	0.7	-	Container No. 4
Black Metal	2	3.8	-	Container No. 4
Black Metal	3	0.6	-	Container No. 4
Black Metal	4	3.2	-	Container No. 4
Black Metal	1	33	-	Container No. 10
Black Metal	2	9	-	Container No. 10
Black Metal	3	22	-	Container No. 10
Black Metal	4	37	-	Container No. 10
Lead & aluminum	1	12	-	Container 16
Lead & aluminum	2	29	-	Container 16
Lead & aluminum	3	35	-	Container 16
Lead & aluminum	4	40	-	Container 16
NORM	1	-	2	Container 18
NORM	2	-	6	Container 18
NORM	3	-	15	Container 18
NORM	4	-	10	Container 18

The results uncertainty: ± 20% β + γ emission of pollutants and ± 30% for α.

The vast majority of waste are pipes and valves. The surface specific activity of a material is up to 15 Bq/cm^2 and the estimated average specific activity of the surface - 8-10 Bq/cm^2. The average thickness of the material in temporary storage is about 3 mm - 1 cm, the steel density is about 7900 kg/m^3.The material average specific activity are from 0.33 to 0.43 Bq/g. NORM waste metals weight is about 8.5 tons (approximately 8 m^3), and they are stored in a sea container. Metal volume / weight ratio is not proportional because the pieces are not allocated regularly.

The measurements showed minimal surface contamination of 0.6 Bq / cm^2 and a maximum of 40 Bq/cm^2. Measurements depend on shielding effect (for example, the wall of the container nearest to the contaminated side of the piece facing the center of the container, and the thickness of the piece of metal itself serves as a shield). The conclusion for the obtained values can be interpreted that in some places it could be relatively large differences in real specific activities. For example, the level of pollution in the container No.4 was 0.6-3.7 Bq/cm^2 and in the container No.10 was 9-37 Bq/cm^2.

Metal waste quantity with low active short-lived isotopes (half-life of up to 30.2 years) at Paldiski storage facility was estimated of 182 tons (volume of 235 m^3 or 16 sea containers). Approximately 92% of such waste originating from Paldiski decommissioning operations. There were various sewer pipes, pipes and ventilation ducts and HVAC elements. The remaining 8% of the waste were from decommissioning operations and from storage at Tammiku. Based on previous studies at Paldiski site [12], the dominant radionuclides of the decommissioning waste were Cs-137, Co-60 and Sr-90. The identified isotopes for the Tammiku waste were Cs-137 and Sr-90 presence.

Categories and amounts are shown in Table 21.

Table 21: Metal waste with a half-life up to 30.2 years

Material	Weight, tons	Capacity, m^3	The number of containers, pcs
Carbon Steel	90	126	7
Stainless steel	76	95	7
Copper	11	11	1
Aluminum, lead,	5	3	1

The waste-specific surface activity were within the range of 10 - 40 Bq / cm^2.

Table 22: Paldiski metal waste activity levels

Material	Specific activity *	The surface-specific activity of,
	Bq/g	Bq/cm ^{2}
Carbon Steel	0.03 to 1.56	0.6 to 37
Lead	0.35 to 1.18	12-40
Copper	0.02 to 1.38	0.6 to 37
Stainless steel	0.3 to 1.54	0.6 to 37
Aluminum	1.08 to 3.60	12-40
NORM wastes	0.33 to 0.43	8-10

** Calculations of the specific activity on the surface were based on the specific activity, an average thickness considered - 3 mm, densities of the materials: Steel 7900 kg/m^3, stainless steel 8030 kg/m^3, Pb 11,300 kg/m^3, aluminum 3700 kg/m ^{3} and copper 8930 kg/m ^{3}.*

Concrete Containers

Conditioned waste is stored within concrete containers as well as some other waste (eg smoke detectors, spent sealed sources, icing detectors sources, etc.). There are waste from Paldiski decommissioning operations (1995-2008), from Tammiku and from other agencies and corporations.

In total there are 146 concrete containers with the total volume of 257.472 m^3.

Table 23: Concrete containers

The contents of the container	The number of containers	Volume, m^3	Description
Cs-137, sealed sources	11	19.008	characterized
Co-60, sealed sources	5	8.640	characterized
Sr-90, sealed sources	5	8.640	characterized
Pu-239, sealed sources	1	1.728	characterized
Am-241 sealed sources	1	1.728	characterized
U-238, sealed sources	2	3.456	characterized
Neutron (Pu-Be)	2	3.456	characterized
Sources for Verification (with different isotopes)	1	1.728	characterized
Ra-226, sealed sources	1	1.728	characterized
sealed sources, half-life up to 13	1	1.728	characterized
Unidentified sealed sources of Tammiku	10	17.280	simple isotope determination
Alfa contaminated metals	1	1.728	simple isotope determination
One source containers	7	12.096	simple isotope determination
Sources of beta Tammiku	2	3.456	difficult to characterize
Tammiku boxes and pipes	3	10.368	difficult to characterize
Concreted, Paldiski	85	146.880	difficult to characterize
Concreted, Tammiku	7	12.096	difficult to characterize
Sillamae NORM drill core	1	1.728	requires the characterization laboratory tests
TOTAL	146	257.472	

Characterized sources are located in 30 containers. They are from institutions and enterprises, generally sealed sources most of which are located in shielding containers. Waste from Tammiku (2008-2011) consists merely of identified sealed sources (smoke detectors, icing detectors, Cs-137 and Co-60 sealed sources). Tammiku sources were studied by spectrometer Synodys H100, and the activity was determined by the dose rate at 1 m distance according to the management of radioactive waste ALARA internal regulations KO-15. Most of the containers contain only one isotope.

Tammiku waste from unknown sources (10 containers) are likely to be shielding containers with Cs-137 and Co-60 sealed sources.

Alfa active isotopes (1 container) are from Tammiku metal waste (Ra-226 have been identified).

Seven containers include only one source. Those are spent sealed sources, without screening and without shielding containers. An orphan source and five boxes are from repository Tammiku with a high dose rate closed-source. Containers provide additional shielding (eg. The source is located in the middle of the container / metal tube surrounded by sand). The sources are planned for further treatment to reduce volumes. Detecting of isotop(es) by spectrometry is relatively simple, it is considered reasonable to keep these sources within a single container for additional screening.

Containers with beta sources (2) contain unknown sources, specific identification is not available.

Tammiku high activity radioactive sources with metal boxes and S-tube (3 containers) are characterized as of so-called "hot cell" or shielding chamber.

Regarding cemented waste from Paldiski decommissioning operations (85 containers), it can be assumed that this waste is similar to the concreted waste in metal containers.

Tammiku waste containers, covered with concrete (7) - uncharacterized waste. In particular, that is concreted waste, contaminated sand. Preliminary measurements can only trace strong presence of β-active isotopes, likely to be widely used in scientific institutions ^{90}Sr, and there is no α contamination.

Waste from the Sillamäe facility - drill core from NORM waste disposal site (1 container) could be characterized by gamma spectrometry.

Waste in concrete containers is classified as follows:

198.72 m^3 or 77% - short-term low- and medium- active;
13.82 m^3 or 5.4% - long-term low- and medium- active;
1.728 m^3 or 0.7% NORM waste;
43.204 m^3 or 16.9% of unknown, uncharacterized waste.

The latter group of waste (by its origin, dose rates, etc.), generally is low - and intermediate-level waste of the short term, but still needs more accurate characterization.

Sea Containers (waste in the controlled access area)

In the controlled access area of the main building in Paldiski site there are stored metal sea containers and 200 l metal drums which generally contain cemented waste.

Sea containers waste characterization and quantities are shown in Table 24.

Table 24: Sea containers waste

Waste characterized	Package	Waste origin	Number of containers, pcs	Total volume, m^3	Total mass, tons
Contaminated metal, artificial nuclides	-	Paldiski site	15	224.0	171.0
Contaminated metal, NORM	-	Institutions and enterprises	1	8.0	8.5
Crushed concrete	Big bag	Paldiski site	5	165.6	103.5
TOTAL			22	397.6	283.0

Scrap metal pollution level (2012) was from 0.6 to 40 Bq / cm^2. Metal with low active short-lived isotopes (half-life of up to 30.2 years) within Paldiski storage facility are about 171 tons (volume of 224 m^3 or 15 sea containers). Approximately 92% of that waste is from Paldiski decommissioning operations. Generally - pipeline tubes, pipes and ventilation ducts and HVAC elements. The remaining 8% of the waste were from Tammiku - decommissioning waste with predominant radionuclides of Cs-137, Co-60, Sr-90.

NORM waste - 8.5 tons (approximately 8 m^3) stored in a sea container.

Paldiski waste generated during the decontamination of concrete is stored in sea containers within in "big bags" or "in bulk" Volume - 165.6 m^3. There are no data on the specific activity of the material and the corresponding analyzes have not been done. Additional information: α contamination of concrete surfaces is not found, possibly it is only β and γ active isotopes.

Overall, it is clear that all sea containers require additional characterization of the waste is deposited.

Sea containers, the waste classification:

389.6 m^3 or 98% - short-term low- and medium- active waste;
8 m^3 or 2% NORM waste.

Waste in 200 l metal drums

In the control access area of the main building there are stored 200 l metal drums which contain generally compressible waste, waste wood, small size metal, cemented waste, etc. 200 l drums are for low-level waste, in accordance with the ALARA waste containers compliance indicator - a 200 liter drum surface dose may not be greater than 50 μSv/h.

In total there are 446 items, and 362 items are filled with waste from Tammiku.

Table 25: 200 liter metal drums

contents	number of pieces	total quantity in m^3
Soft compressible	182	36.4
Wood	41	8.2
Sawdust	1	0.2
Metal	49	9.8
Concreted	141	28.2
Stainless scrap	2	0.4
Dust	2	0.4
Beta sources, foil	1	0.2
^{226} R	2	0.4
Alfa contaminated soft compressible waste	4	0.8
Alfa contaminated metal	11	2.2
Alfa contaminated wood	2	0.4
Asbestos	8	1.6
TOTAL	446	89.2

All 200 liter drums need additional characterization. 81% of the drums are from Tammiku.

The type of waste in 200 l metal drums are as follows:

85.4 m^3 or 95.7% short-term low- and medium- active waste ;
3.8 m ^{3} or 4.3% long-term low- and medium- active waste .

Liquid Waste

Liquid waste in marginal quantities is stored in glass and plastic containers which in turn is placed within absorbent material (sawdust) packed into 200 l drums. In particular, that is Tammiku waste in the amount of 250 liters. Is likely to remain below the clearance levels of waste activities. In addition, the waste still stored in Tammiku - very small amounts of C-14(0.4 liter - 2,47 GBq), and H-3(0.9 liter - about 10 GBq).

Liquid waste is classified into:

99.5% uncharacterized waste;
0.16% long-term low- and medium- active waste;
0.36% short-term low- and medium- active waste.

Paldiski waste

Four containers in with a total capacity of 8.5 m^3 contain control rods (activity of 3.5 TBq), eight steam generators with a total capacity of 10 m^3 and activity of 0.9 GBq. In addition, in cooling pools adjacent space is stored 55 HEPA filters - 0.9 GBq with volume 20 m^3. Each filter element is placed within a wooden box within cast concrete.

The type of waste - low and medium level waste, but more precise characterization is not possible whether there is a short- or long- term waste.

Based on the work carried out in 2009. "Assessment of radioactive waste", the summary includes sealed sources which activities are based on the sources passports or the dose is determined by the rate and distance.

Table 26: Paldiski stored activity as 2009

Isotope	Activity, Bq	%
Sr-90	6.20E+14	68.89
Co-60	1.11E+14	12.35
Cs-137	1.56E+14	17.29
Pu-238	1.25E+13	1.39
Pu-239	1.95E+11	0.02
U-2 38	5.30E+07	0.00
Am-241	1.60E+11	0.02
Kr-85	2.77E+10	0.00
Ra-226	4.91E+09	0.00
Ni-63	1.09E+09	0.00
Fe-55	6.66E+07	0.00
Pm-147	1.08E+07	0.00
Ru-106	8.28E+06	0.00
Ir-192	1.05E+01	0.00
Eu-152	3.62E+04	0.00
Ti-204	2.52E+04	0.00
Ba-133	3.02E+06	0.00
Na-22	8.22E+02	0.00
U-234	2.19E+03	0.00
Cd-109	2.57E+02	0.00

Th-228	6.40E+00	0.00
H-3	2.85E+11	0.03
I-125	4.08E+09	0.00
TOTAL	9.00E+14	100

The largest part of waste activity represents Sr-90 isotope (about 68.9%), and the following isotopes Cs-137 (17.3%), Co-60 (12.3%). Other isotopes - U-238 up to 1.39%.

High-activity radioactive sources (HAS) are located in 16 concrete containers. Co-60 and Cs-137 sources are mostly stored in separate containers, but some are stored together for the purpose of saving space. Sr-90 and Pu-238 sources are located in separate containers.

Table 27: HAS Inventory

Isotope	Total activity, Bq	Number of sources	The number of containers
Co-60	1.17E+14	61	6
Sr-90	5.11E+14	37	3
Cs-137	1.46E+14	350	12
Pu-238	1.13E+13	17	2

From Tammiku site decommissioning process there are 2 concrete containers in Paldiski containing metal boxes with unshielded sealed sources. There are also 1 concrete container with S-tube. All 3 containers are classified as uncharacterized waste with significant activity. Most probably they contain sources listed in Tammiku site inventory (table 28).

Table 28: Tammiku site inventory- on the basis of total activity

Isotope	Activity (01.01.2000), Bq	Activity (11.10.2013), Bq
H-3	1.63E + 12	7.51E + 11
Co-60	4.26E + 11	6.89E + 10
Cs-137	1.70E + 13	1,23E + 13
Eu-152, Eu-154	8.90E + 10	4,32E + 10
Cr-85	1.30E + 10	5,30E + 09
Sr-90	4.69E + 13	3.37E + 13
C-14	2.70E + 12	2.70E + 12
Ni-63	1.40E + 09	1.27E + 09
Ra-226	4.26E + 11	4.23E + 11
Pu-239	7.10E + 11	7.10E + 11
Am-241	7.10E + 10	6.94E + 10

TOTAL		5.08E + 13

From characterized HAS 96.3% are intermediate-level short-lived waste and 3.7% intermediate-level long-lived wastes.

Summary of radioactive waste stored at Paldiski site

It must be noted that the large portion of the waste is uncharacterized. From waste existing in Paldiski interim storage facility and the control area (985 m^3) only 51.84 m^3 or about 5.3% are characterized. In particular, the characterization needed for low and very low-level waste. Since most of the sources have been characterized, it can be assumed that at least 90% of the activity is characterized.

Table 29: The existing waste types and quantities

Type of waste	Quantity, m^3	% of total waste
Low and intermediate-level short-lived waste	875.9	44.9%
Low and intermediate-level long-lived wastes	17.6	0.9%
NORM wastes	23.7	1.2%
Low and intermediate-level waste, the waste uncharacterized	1032.0	53.0%
TOTAL	1949.2	

Low and intermediate-level waste is uncharacterized (1032 m^3) can be considered as short-lived waste.

988.5 m^3 (95.7%) are from the Paldiski site (incl. Reactor sections, control rods, steam generators and filters), particularly short-lived isotopes (<30 years);

39.7 m^3 of waste from the storage and Tammiku sources in shielding container - Cs-137 and Co-60 sources;

3.8 m^3 of waste (beta sources) from Tammiku repository. Most likely those contain Sr-90.

Because the waste is still uncharacterized the conclusions are based on indirect estimates.

Short-lived waste is not reflected in the Table 29.

CONCLUSION

In the late 1960s a training center of Naval Force of Russia was built at the territory of the Pakri Peninsula near the city of Paldiski (Estonia) for nuclear powered submarine crews training. In 1968 first nuclear reactor stand (346A) was commissioned. In 1980 installation was reconstructed: steam generators were replaced with more perfect ones and nuclear fuel was reloaded. Second reactor stand (346B) was commissioned 1983.

Both reactors were shut down in 1989 and under the intergovernmental agreement between the Russian Federation and the Republic of Estonia in 1994 the territory of the training center together with all the constructions were transferred into the ownership of the Republic of Estonia. Prior to the transfer, all facilities were put to the stable safety condition. Spent nuclear fuel of both reactors was unloaded 1994 and transported to Russia. There were performed all necessary works on the reactors and compartments conservation. In order to provide safe long-term storage of the reactor compartments there were constructed concrete shelters around RC (sarcophagi). Conducted activities ensured placement of reactor compartments for long-term controlled storage with the term up to 50 years (2045).

In stand 346A:

- Reactor type VM-A, vessel volume ca 18 m^3 and weight 30 tons;
- dose contributors Co-60, Fe-55, Ni-59, Ni-63;
- total activity of nuclear power unit $1,5x10^{14}$ Bq (2015);
- total amount of water remains about 1370 l (360 liters of water in the primary cooling circuit with a total inventory of 2.2 MBq/l (1989) and ca 1000 l secondary cooling circuit with activity 4,07 Bq/l (1994)). The main radionuclides Cs-137, Co-60, Sr-90 and H-3;
- there is no non-fixed contamination present on outer surfaces of equipment and pipelines inside RC;
- about 100 sealed sources with total activity ca 4,4 TBq (1995) and 14 tons solid LLW were put inside stand (rags, tools, metallic waste etc.) and covered with concrete;
- reactor compartment was filled with concrete up to second floor, totally 30,75 m^3 of concrete were poured inside RC;
- after the final shut-down of the reactors a radiological survey of internal reactor rooms was undertaken;
- according to calculations, build-up of long-lived radionuclides activity is ca 312 TBq (2001). Radionuclide composition as of 2001 was following (%): Co-60 – 39.2; Fe-55 – 30.0; Ni-59 – 0.3; Ni-63 – 30.3;

In stand 346B:

- Reactor type VM-4, vessel volume ca 30,3 m^3 and weight 50,4 tons;
- dose contributors Co-60, Fe-55, Ni-59, Ni-63; Nb-94;
- total activity of nuclear power unit $2,9x10^{13}$ Bq (2015);
- total amount of water remains about 2280 l (600 liters of water in the primary cooling circuit with a total inventory of 1 MBq/l (1989) and ca 1680 l in 2^{nd}, 3^{rd} and 4^{th} loop. The main radionuclides Cs-137, Co-60, Sr-90;

- volumes and activities of water remaining in the second, third and fourth circuits are not recorded;
- about solid metallic LLW were put inside stand (tools, loading equipment, electrical equipment etc.) and covered with concrete;
- reactor compartment was filled with concrete up to second floor, totally 41,25 m^3 of concrete were poured inside RC;

Other important facts:

- no accidents related to the emergency aggravation of radiation situation in the main technological section were revealed during the entire period of operation of both installations. No technogeneous pollution of environmental objects such as soil, vegetation, groundwater etc., as well as of surrounding areas was observed for the period of long-term observations;
- before erecting reinforced concrete shelters around the reactor compartments, during 1995, a radiological check-out was made of the external surfaces of the reactor compartments. The highest radioactivity on the reactor compartment shells was spotted directly under the reactor, 1.5-2.0 m in diameter. On the remaining surface of the shell, ionization radiation rate approaches environmental levels. Ionization radiation rate under the reactor of stand 346B has a much smaller value due to design reinforcement of the biological shield and shortened energy yield.

Collected data is sufficient to develop options for reactor compartments decommissioning and assess the volume and radioactivity of wastes produced. During the RCs storage almost no above-level emissions and discharges of radioactivity into the environment has been detected.

During indicative analysis of radioactive waste volumes, including operation and decommissioning of possible NPP in the Estonian Republic was considered 1000 MW PWR reactor. Prototype reactor was AP-1000 from Westinghouse (USA) and VVER-1000 as alternative (Russia).

Next presumptions were made:

- nuclear fuel will be leased and returned later to producer. Only operational and decommissioning waste will be managed in Estonia;
- reactor will be commissioned 2030;
- operational period of reactor 60 years.

Estimated total amount of conditioned radioactive waste expected to be generated during operation and decommissioning of a power plant with AP-1000 unit is at least 15 401,5 m^3. Estimated amount of conditioned radioactive waste from VVER-1000 is 7145 m^3.

Four decommissioning options were considered during assessment of waste arising from Paldiski RC decommissioning:

A - dismantling with fragmentation into large pieces;
B - dismantling with fragmentation into small pieces;

C and D – disposal as one piece (entombment and near surface disposal).

Options C and D were considered only as alternatives because those options are not internationally accepted for disposal.

Estimated radioactive waste amounts generated from Paldiski reactors decommissioning are following:

Concept A – ILW and LLW radioactive waste 455 tons, non-radioactive waste 2765 tons;
Concept B – ILW and LLW radioactive waste 325 tons, non-radioactive waste 2895 tons;
Concepts C and D – ILW and LLW radioactive waste 1960 tons, non-radioactive waste 1260 tons;

Existing radioactive waste amount stored in Paldiski site interim storage facility and at control area are 985 m^3.

For Paldiski facility its recommended comprehensive engineering and radiation survey (CERS) prior to decommissioning as there is lack of the facility operational documentation and history records on surveys and monitoring. CERS task is to assess actual radiation and technical state of the facility and its radiological and non-radiological hazards. CERS results have to be available before environmental impact assessment report. The CERS results shall serve as an informational base to justify the facility decommissioning option and to develop the decommissioning project for the option preferred. Inside CERS will be done both engineering survey and radiological survey.

.

REFERENCES

1. Collection and Analysis of Information Regarding the Design and Content of the Reactor Compartments of Russian Nuclear Submarines that are being stored in Estonia» Technicatome, 09.10.2001.

2. Evaluation of Management Routes for the Paldiski Sarcophagi. Task 3 – Evaluation of Dismantling Strategies, Final Report, Technicatome, 2001.

3. Evaluation of Management Routes for the Paldiski Sarcophagi. Task 2 – Drawing up of Dismantling Options, Technicatome, 2001.

4. Safe Long-term Storage of the Paldiski Sarcophagi and Related Dismantling Activities – Technical Assistance for Environmental Impact Assessment Studies, Geological and Hydrogeological Final Report, European Commission, 2004.

5. Historical Survey of Nuclear Non-Proliferation in Estonia 1946-1995, Estonian Radiation Protection Centre, 2003.

6. Radioaktiivsete jäätmete inventuur seisuga Paldiski objekt, AS A.L.A.R.A., 2014.

7. Paldiski endise tuumaallveelaevnike õppekeskuse tuumaobjekt – üleandmine Eestile ja saastusest puhastamine, AS A.L.A.R.A., 2005.

8. Drawing up and Evaluation of Management Strategies for Radioactive Waste in Estonia, Final Report, 2002.

9. Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, Estonian National Report, Radiation Safety Department, Environmental Board, Estonia, 2014.

10. National Radiation Safety Development Plan 2008-2017, The Ministry of the Environment, Estonia, 2008.

11. Dissertation, 2011. Studies of the irradiation characteristics of permanently shut down VVER reactor units (State Commission for Academic Degrees and Titles 05.14.03, PhD in Technical Sciences Ye.A. Zhurbenko).

12. Bylkin B.K., Davydova G.B., Zhurbenko Ye.A. Radioactive waste by NPP reactor units decommissioning. Nuclear power, 2011, v.110, issue 3.

13. Technical Reports Series No. 401 – IAEA.

14. Disposal of radioactive wastes (Elsevier, 01.06.2009).

15. http://www.nukemgroup.com

16. The research report « Preliminary studies for the decommissioning of the reactor compartments of the former Paldiski military nuclear site and for the establishment of a radioactive waste repository: collection and analysis of the data concerning the reactor compartments, determination of the possibility of the reactor compartments decommissioning», JSC «ATOMPROEKT», 2015.

17. Atomic Energy, Volume 80, Issue 6, 1996.

18. NIKIET report (Contract No 9001054/1), Moscow, 2001.

19. Report of the Experimental Design Bureau of Machine Building (Contract No 901054/0), Nizhny Novgorod, 1999.

20. IAEA – TECDOC – 938.

21. UKP-GW-GL-023, Westinghouse Electric Company LLC.

22. B. K. Bylkin, G. B. Davydova, Ye. A. Zhurbenko. Radioactive waste during dismantling NPP reactor plants. Nuclear Energy, 2011, Volume 110, Issue 3, pages 171-172.

23. B. K. Bylkin, I. A. Yengovatov. Decommissioning of reactor plants. FPBEIHE "MGSU". Moscow, 2014.

24. Consortium AGRIFOR Consult, Draft Final Report, Safe Long-Term Storage of the Paldiski Sarcophagi & Related Dismantling Activities – Technical Assistance for Environmental Impact Assessment Studies, 2004.

25. Consortium AGRIFOR Consult, Geological and Hydrogeological Final Report, Safe Long-Term Storage of the Paldiski Sarcophagi & Related Dismantling Activities – Technical Assistance for Environmental Impact Assessment Studies, 2014.

26. 346A Facility Passport “У346А-906-100ПС”, 1995.

27. 346B Facility Passport “У346В-906-100ПС”, 1995.

28. Radioaktiivsete jäätmete käitlemise tegevuskava eelnõu ajakohastamine, ALARA AS, Paldiski 2013.

29. Looduslikke ja tehislikke radionukliide sisaldavate metallijäätmete käitlemise metoodika, ALARA AS, Paldiski 2012.

30. Engineering –geological modelling of the Sillamae radioactive pond area, Hardi Thorn, 2008

CHAPTER 2

OVERVIEW OF INTERNATIONAL AND NATIONAL RECOMMENDATIONS AND LEGAL ACTS ON THE DECOMMISSIONING OF REACTOR SECTIONS

2.1 REACTOR COMPARTMENTS MANAGEMENT IN COUNTRIES WITH NUCLEAR SUBMARINE FLEET

As of today NSs are operated in such countries as the USA, UK, France, Russia and China. However, there are few publications in the mass media of these countries on the issues associated with the management of the RCs decommissioned from the Navy. This can be attributed to a high level of information sensitivity of this subject. There are individual publications on the situation within this sphere in the United Kingdom, the United States and Russia; as for other countries, there are only seldom and odd bits of information.

It is known that in the USA, following decommissioning from the Navy, NSs are sent to the coastal bases for defueling. After the floating storage during an extended period, NSs are to be dismantled at a shipyard, with the RC to be cut from them. Then, the adjacent compartments that do not contain radioactive components will be dismantled and the RCs with reactor equipment and contaminated equipment are prepared for long-term storage and placed in specially equipped trenches located in the Nevada desert on strong reinforced-concrete foundations. The RCs are, in general, delivered to the desert by a waterborne transport route, and a higher capacity transporter is used on the last land transportation leg. Thus, by now, several dozens of former NS reactor compartments have been placed there. The US first nuclear-powered submarine – the Nautilus – has been converted into a museum and is exhibited for public.

The RCs storage in trenches is expected to last for 70 to 100 years, (moreover, the US experts assume that the stored RCs could provide sealing for the radioactive materials over a period up to 600 years), after which they are supposed to be completely disassembled, with non-decontaminable metal to be segregated. The further operations with radioactive metal is still unclear, today it is supposed to be placed for final disposal in special casks in deep underground repositories practically forever, in full compliance with national regulatory documents pertaining to radiation protection. Non-radioactive metal is to be re-used in the industry.

In the United Kingdom and France the RCs of decommissioned NSs are also cut from the hull, transported and placed for storage in specially built reinforced-concrete vaults supposedly for a period of 70 or more years. Further on the RCs are supposed to be entirely dismantled, in the same way as in the USA, (still unclear and not proved), and metal to be generated is expected to be segregated into streams to be disposed of and re-used. The disposal is supposed to be performed in deep underground RW repositories.

Over 200 NSs have been decommissioned in Russia so far. The NS to be dismantled was first defueled, then a three-compartment unit was cut from the NS hull (the RC being in the center between two adjacent compartments on sides), non-contaminated equipment was dismantled from a three-compartment unit and then the unit was placed for interim floating storage. At the present, the RCs are being cut from the NSs, prepared for long-term storage and placed onto specially equipped reinforced-concrete pads out-of-doors (long-term storage site, LTS). The RCs are no longer placed for floating storage, and previously existing three-compartment units are being cut to form single-compartment ones and shipped to the LTS. There are two LTS for RCs: in the North-Western and Far Eastern regions of Russia. The RCs are planned to be stored for 70 to 100 years, to be followed by entire disassembly of the compartments, metal segregation into streams to be re-used and disposed of; the latter to be emplaced into a deep underground RW repository. Several dozens of RCs have been placed on the LTS by now.

As can be seen, in all the countries having NSs, the approach to decommissioning is approximately identical: RC cutting from the NS hull, preparation for long-term storage (50 – 100 years), followed by planned complete disassembly of the RC and segregation of contaminated and non-contaminated metal. In case of any surface contamination decontamination can be carried out in order to release the decontaminated metal from regulatory control, if residual contamination levels conform to the applicable regulatory documents of this country.

Radioactive metal in shielded casks is supposed to be disposed of in deep underground RW repositories.

Analysis of the regulatory documents is influenced by the factor that the current status of the Paldiski facility has been specified as radiation hazardous facility. In principle, for the purposes of this work we can be guided by the documents issued by the EU and Radiation Protection series documents issued by IAEA on a regular basis.

2.2 OVERVIEW OF THE IAEA STANDARDS FOR DECOMMISSIONING

2.2.1 Decommissioning of Facilities, IAEA General Safety Requirements, part 6 (GSR PART 6), 2014

The IAEA publication ”Decommissioning of Facilities, General Safety Requirements, Part 6 (GSR Part 6)” [1] was issued in 2014 and is the document of the Safety Requirements category in the IAEA Safety Series.

The objective of this IAEA publication [1] is to establish the general safety requirements to be met during planning for decommissioning, during conduct of decommissioning actions and during termination of the authorization for decommissioning.

This publication applies to nuclear power plants, research reactors, other nuclear fuel cycle facilities, including predisposal waste management facilities, facilities for processing naturally occurring radioactive material (NORM), former military sites, and relevant medical facilities, industrial facilities, and research and development facilities.

This publication [1] consists of 9 sections.

Safety requirements for decommissioning and references to relevant paragraphs in the publication [1] are given in Table 30.

Table 30: Safety requirements for radioactive waste management prior to disposal.

Description of the safety requirement	Requirement definition	Ref. No of parag in GSR, Part 6 [1]
Requirement 1: Optimization of protection and safety in decommissioning	Exposure during decommissioning shall be considered to be a planned exposure situation and the relevant requirements of the Basic Safety Standards [2] shall be applied accordingly during decommissioning.	2.1 – 2.3
Requirement 2. Graded approach in decommissioning	A graded approach shall be applied in all aspects of decommissioning in determining the scope and level of detail for any particular facility, consistent with the magnitude of the possible radiation risks arising from the decommissioning.	2.4 – 2.5
Requirement 3. Assessment of safety for decommissioning	Safety shall be assessed for all facilities for which decommissioning is planned and for all facilities undergoing decommissioning in compliance with [3].	2.6 – 2.7
Requirement 4. Responsibilities of the government for decommissioning	The government shall establish and maintain a governmental, legal and regulatory framework within which all aspects of decommissioning, including management of the resulting radioactive waste, can be planned and carried out safely. This framework shall include a clear allocation of responsibilities, provision of independent regulatory functions, and requirements in respect of financial assurance for decommissioning.	3.2
Requirement 5. Responsibilities of the regulatory body for decommissioning	The regulatory body shall regulate all aspects of decommissioning throughout all stages of the facility's lifetime, from initial planning for decommissioning during the siting and design of	3.3

Description of the safety requirement	Requirement definition	Ref. No of parag in GSR, Part 6 [1]
	the facility, to the completion of decommissioning actions and the termination of authorization for decommissioning. The regulatory body shall establish the safety requirements for decommissioning, including requirements for management of the resulting radioactive waste, and shall adopt associated regulations and guides. The regulatory body shall also take actions to ensure that the regulatory requirements are met.	
Requirement 6. Responsibilities of a licensee for decommissioning	The licensee shall plan for decommissioning and shall conduct the decommissioning actions in compliance with the authorization for decommissioning and with requirements derived from the national legal and regulatory framework. The licensee shall be responsible for all aspects of safety, radiation protection and protection of the environment during decommissioning.	3.4
Requirement 7. Integrated management system for decommissioning.	The licensee shall ensure that its integrated management system covers all aspects of decommissioning.	4.1 – 4.7
Requirement 8. Selecting a decommissioning strategy.	The licensee shall select a decommissioning strategy that will form the basis for the planning for decommissioning. The strategy shall be consistent with the national policy on the management of radioactive waste.	5.1 – 5.5
Requirement 9. Financing of decommissioning.	Responsibilities in respect of financial provisions for decommissioning shall be set out in national legislation. These provisions shall include establishing a mechanism to provide adequate financial resources and to ensure that they are available when necessary, for ensuring safe decommissioning D.	6.1 – 6.5
Requirement10. Planning for decommissioning.	The licensee shall prepare a decommissioning plan and shall maintain it throughout the lifetime of the facility, in accordance with the requirements of the regulatory body, in order to show that decommissioning can be accomplished safely to meet the defined end	7.1 – 7.8

Description of the safety requirement	Requirement definition	Ref. No of parag in GSR, Part 6 [1]
	state.	
Requirement 11. Final decommissioning plan.	Prior to the conduct of decommissioning actions, a final decommissioning plan shall be prepared and shall be submitted to the regulatory body for approval.	7.9 – 7.16
Requirement 12. Conduct of decommissioning activities.	The licensee shall implement the final decommissioning plan, including management of radioactive waste, in compliance with national regulations.	8.1 – 8.5
Requirement 13. Emergency response arrangements for decommissioning.	Emergency response arrangements for decommissioning, commensurate with the hazards, shall be established and maintained, and events significant to safety shall be reported to the regulatory body in a timely manner in compliance with [4].	8.6
Requirement 14. RW management in decommissioning.	Radioactive waste shall be managed for all waste streams in decommissioning in compliance with [5-7].	8.7 – 8.10
Requirement 15. Completion of decommissioning actions and termination of the authorization for decommissioning.	On the completion of decommissioning actions, the licensee shall demonstrate that the end state criteria as specified in the final decommissioning plan and any additional regulatory requirements have been met. The regulatory body shall verify compliance with the end state criteria and shall decide on termination of the authorization for decommissioning.	9.1 - 9.7

2.2.2 Safety Assessment for the Decommissioning of Facilities Using Radioactive Material, IAEA Safety Guide No. WS-G-5.2

This safety guide “Safety Assessment for the Decommissioning of Facilities Using Radioactive Material, IAEA Safety Guide No. WS-G-5.2” [8] was adopted in 2008 and contains the recommendations on safety assessment in the course of the decommissioning of facilities using radioactive material.

The objective of this Safety Guide [8] is to provide recommendations for the development and review of safety assessments for decommissioning activities; to assist regulators, operators and supporting technical specialists in the application of a graded approach to the development and review of safety assessments.

The Safety Guide [8] provides guidance for a regulatory framework in which a safety assessment is prepared as part of the decommissioning plan for a facility. However, it is recognized that various approaches are in use internationally, for example, where safety assessments are documented in a stand-alone document, where they are integrated into the decommissioning plan, or where safety assessments are used to support the decommissioning plan but are not subject to separate regulatory controls. This Safety Guide [8] provides guidance that can be used irrespective of how safety assessments are addressed or the safety assessment process is addressed in a national regulatory framework.

The guidance [8] is intended for application in the development or review of safety assessments prepared in support of decommissioning strategies, plans or activities.

This Safety Guide [8] provides guidance on a systematic methodology for the evaluation of radiological consequences for workers, the public and the environment of planned activities and of potential accidents during decommissioning. It applies to all types of facilities, such as nuclear power plants, research reactors, nuclear fuel cycle facilities, research laboratories and medical facilities as well as above ground supporting facilities (e.g. storage facilities).

This publication [8] consists of 6 sections.

In compliance with paragraph. 2.1 [8] an appropriate safety assessment should be performed:

- To support the selection of the decommissioning strategy, the development of a decommissioning plan and associated specific decommissioning activities;
- To demonstrate that exposures of workers and of the public are as low as reasonably achievable (ALARA) and do not exceed the relevant limits.

In accordance with para 2.3 [8] the safety assessment for decommissioning should:

- Document how regulatory requirements and criteria are met to support the authorization of the proposed decommissioning activities;
- Include a systematic evaluation of the nature, magnitude and likelihood of hazards and their radiological consequences for workers, the public and the environment for planned activities and for accident conditions;
- Quantify the systematic and progressive reduction in radiological hazards to be achieved through the conduct of the decommissioning activities;
- Identify the safety measures, limit controls and conditions that will need to be applied to the decommissioning activities to ensure that the relevant safety requirements and criteria are met and maintained throughout the decommissioning;
- Where relevant, demonstrate that the institutional controls applied after decommissioning will not impose an undue burden on future generations;
- Provide input to on-site and off-site emergency planning and to safety management arrangements;

- Provide an input into the identification of training needs for decommissioning and of competences for staff performing decommissioning activities.

Section 3 [8] contains the following subsections:

- graded approach (paras 3.1 – 3.5 [8]);
- hazards during decommissioning (paras 3.6 – 3.10 [8]);
- defense in depth (paras 3.11 – 3.13 [8]);
- safety functions (paras 3.14 – 3.16 [8]);
- optimization (paras 3.17 – 3.19 [8]);
- long-term safety (paras 3.20– 3.23 [8]);
- engineering analysis (paras 3.24 – 3.26 [8]);
- material management (paras 3.27 – 3.29 [8]);
- uncertainties (paras 3.30– 3.31 [8]);
- management system (paras 3.32 – 3.34 [8]);
- staffing for decommissioning (paras 3.35 – 3.38 [8]).

Section 4 [4] contains a description of steps in the course of safety assessment development.

The safety assessment process is shown in Figure 21.

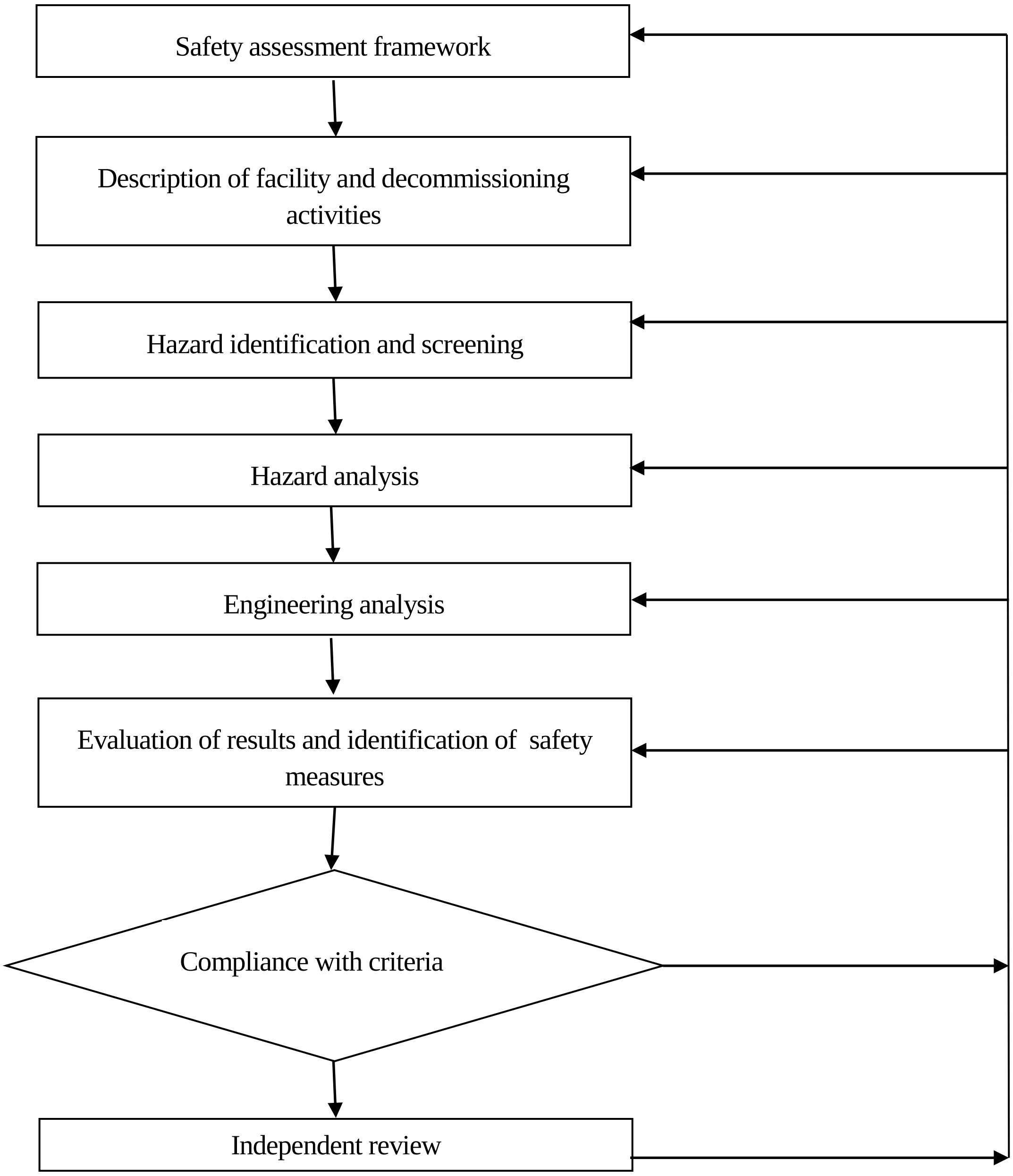


Figure 21. The safety assessment process

Section 5 [8] gives recommendations in the area of the regulatory review of the safety assessment, use of a graded approach by the regulatory body, conduct of the regulatory review.

2.3 THE EUROPEAN UNION LEGAL FRAMEWORK

A significant quantity of nuclear waste generated in the territory of the European Union sets for the Member States a task of mutually beneficial cooperation in this field, in particular, in the field of the development of uniform general principles on nuclear facility decommissioning in the EU territory. The main purpose of the documents publication on this subject is to minimize potential damage to the environment. The objective of the European legislation harmonization is to establish a uniform process of managing the decommissioning of nuclear facilities in the EU territory. The presence of Soviet-design reactors in EU whose operation is discontinued at the moment, is a factor that increases the needs in the development of both national programs on the nuclear facility decommissioning and a uniform Concept of the European Union. The standardization of technical procedures allows reducing the risks affecting the environment and decreasing the cost of decommissioning.

Important aspects of financing also need elaboration. The funds available in the Member States have national peculiarities and do not meet the uniform EU standards. In addition, their amount is commonly insufficient to ensure the fulfillment of all safety requirements in a proper manner. The said factors give evidence of the necessity to establish a single reserve fund for decommissioning in Estonia.

Directives and recommendations of the European Commission with regard to decommissioning are given below:

- EURATOM Treaty, Chapter 3, Article 37 [9];
- Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste [10];
- Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment Text with EEA relevance [11];
- Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation [12].
- Commission Recommendation of 24 October 2006 on the management of financial resources for the decommissioning of nuclear installations, spent fuel and radioactive waste (2006/851/Euratom) [13].
- In Directive 2014/52/EU [11] decommissioning is considered as an integral part of the industrial process, requiring the conduct of an environmental impact assessment.

Articles 3, 4 and 5 Council Directive 2013/59/Euratom[12] describe the principles of the authorization and accountancy of waste to be taken into account during the decommissioning of nuclear installations. The Directive gives recommendations on criteria of safe processing of metals generated as a result of nuclear facilities dismantling. These recommendations were developed in the expert community in accordance with the requirements of the Treaty establishing the European Atomic Energy Community (EURATOM Treaty) [9].

The Republic of Estonia faced the problems associated with the Soviet legacy, including the necessity to update the national regulatory base in compliance with the European standards and IAEA recommendations.

As it is mentioned in art. 5 Council Directive 2011/70/Euratom [10] each Member State develops national regulatory framework for RW management in compliance with the European standards.

A similar integrated document was issued in the form of Recommendations - Commission Recommendation of 24 October 2006 on the management of financial resources for the decommissioning of nuclear installations, spent fuel and radioactive waste (2006/851/Euratom) [13]. The document specifies the character of cost estimates that should be site-specific and based upon best available estimates. If during implementation the decommissioning project proves to be more expensive than the approved cost estimates, the operator should cover the additional expenses. Nevertheless, it is the State that shall control the status and sufficiency of the funds. Financial resources from the decommissioning funds should be used only for the purpose for which they have been established; all commercial non-sensitive information should be publicly available.

Certain recommendations for the Republic of Estonia resulting from the analysis of the European Union legal framework:

- Initiate proposals to the European Commission regarding the establishment and maintenance of a unified decommissioning fund and the development of the management procedure for this fund;

- Assess the Paldiski site decommissioning costs and consider a possibility of fund raising (as the facility of the historical legacy the Paldiski decommissioning could be fully or partially funded through the budget);

- Establish a national plan on decommissioning of radiation hazardous facilities;

- Draw public attention to the issue of choice of a decommissioning scenario, to be followed with the organization of a public hearing.

2.4 OVERVIEW OF THE RUSSIAN RECOMMENDATIONS AND REGULATORY ACTS FOR DECOMMISSIONING OF THE REACTOR COMPARTMENTS.

Large-scale activities are in progress at present associated with the dismantling of nuclear submarines and surface vessels with nuclear installations (NPFs), as well as nuclear maintenance ships decommissioned from the Navy of the Russian Federation (RF Navy).

The decommissioning of a hazardous nuclear and radiological facility (NHRF) aims at the facility release from regulatory supervision and control, and represents a package of safety arrangements implemented following the NHRF final shutdown. The objectives of the measures are to prevent the NHRF use for it's designed purpose and to ensure safety of the staff (personnel), public and the environment until the facility is brought into a final condition as identified in the decommissioning plan/ design.

Decommissioning shall be assessed against the following factors:

- duration of decommissioning;
- expected collective dose for the staff and population;
- expected volume of radioactive waste;
- need in establishment of the additional infrastructure;
- technology complexity and necessity of new equipment development;
- expected environmental impact;
- need in labour resources;
- cost of the facility decommissioning option.

The main issues of safety ensuring during the preparation for decommissioning and decommissioning of a hazardous radiological facility will be:

- nuclear safety in the course of SNF management during the preparation for decommissioning;
- radiation safety of the personnel and population;
- environmental safety.

Considering this, the design documentation shall contain, first of all, the following data:

- complete description of the situation at the facility;
- data on the current and planned uses of the facility;
- data on the scope of the contaminated environment and areas that require remediation;
- description of the procedure and technology proposed for the remediation, justification of their applicability;
- follow-up measures (long-term inspection and cleaning system operation, monitoring programs etc.);
- protection measures for the environment and employees' health in the course of works (arrangement of segregation into “clean” and “contaminated” areas with the security system, arrangement of washing the vehicle tires, establishment of sites for temporary storage of contaminated soil and materials, partial or complete safe-keeping, medical check-up of the personnel, plan of actions in case of an emergency situation etc.);
- schedule of carrying out all stages of works including decontamination, high-level expense rates and the work arrangement plan;

– a list of required approvals and permissions/ licenses.

The system of the Russian Federation legislative acts is built on a three-tier hierarchical principle:

1. International level:

- international treaties of the Russian Federation (conventions) – voluntary obligations.

2. Federal level:

- federal laws of the Russian Federation – the main documents in the legislative system;
- regulatory legal acts (decrees, regulations) of the RF President and regulatory legal acts (regulations, resolutions) of the RF Government; and
- mandatory statutory regulations of the federal executive bodies.

The public authorities responsible for the management of nuclear power uses can also issue regulatory documents that establish specific ways of the implementation of safety requirements, principles, criteria, standards and rules.

3. Industrial level:

- departmental legal regulations mandatory for companies and organizations subordinate to the authority that issued them (including the industrial standards, norms, rules, instructions, regulations and orders).

Table 31 contains the principles of the subject structuring of the legal framework in the sphere of the comprehensive dismantling of decommissioned nuclear naval facilities and environmental remediation of the supporting infrastructure. The subject structuring of the legal framework is stipulated by the combination of standards pertaining to international practices of safe nuclear power uses, as well as, civil, administrative, nuclear, ecological, sanitary and hygienic, land and legal standards [15].

Table 31: The subject structuring of the regulatory documents.

1. International practices of safe nuclear power uses and ensuring environmental safety with respect to comprehensive dismantling processes.
1.1. International treaties on the non-proliferation of nuclear weapons. 1.2. IAEA documents, forming the legal framework of safeguards. 1.3. Control of nuclear exports. 1.4. Accountancy, control and physical protection of nuclear material. 1.5. International practices of combating nuclear terrorism and illegal trafficking of radioactive material.

1.6. Nuclear ships and ensuring safe navigation. 1.7. Ensuring environmental safety. International ecological programs and initiatives. 1.8. Early notification of a nuclear accident or a radiation incident and rendering assistance in case of the nuclear accident. 1.9. Civil liability for nuclear damage.
2. Governmental management and regulation of safety in the sphere of the comprehensive NS dismantling.
2.1. The system of federal executive bodies that exercise governmental management and regulation of safety in the sphere of the comprehensive NS dismantling. 2.2. Separation of powers and coordination of activities safety in the area of the comprehensive NS dismantling between regulatory bodies. 2.3. Legal status of comprehensive dismantling facilities. 2.4. Licensing of the main activities in the sphere of the comprehensive NS dismantling. 2.5. Ensuring nuclear, radiation and environmental safety. 2.6. Ensuring industrial and fire safety. 2.7. State accounting and control of nuclear material, radioactive material and radioactive waste. 2.8. Physical protection of the comprehensive NS dismantling facilities. 2.9. Governmental control of the radiological situation in the territories where comprehensive NS dismantling takes place. 2.10. SNF and RW management. 2.11. Siting and construction of the comprehensive dismantling facilities. 2.12. Conduct of the state environmental expert review.
3. Technical, sanitary and hygienic requirements for the safe conduct of the safety comprehensive NS dismantling.
3.1. Safety requirements applicable at all stages of NS dismantling. 3.2. Safety requirements applicable to certain stages of NS dismantling.
4. Environmental remediation of lands and water bodies.
5. Informing of the authorities and population of the region in the course of hazardous radiological works. Public relations.

When developing of governmental safety regulations a focus was made on the radiation protection of the personnel, population and environment when using nuclear power for peaceful and defensive purposes. During a short period time a number of laws were developed, the regulatory safety authorities were established, the main Federal regulatory documents pertaining to health legislation were developed and are being developed.

The fundamental radiological and hygienic regulatory document is NRB-99/2010 [16]. This document defines the fundamental principles of ensuring radiation protection, in particular, “justification, standardization and optimization” that lay the basis for the management strategy in radiation protection. The OSPORB-99/2010 [17] and SPORO-2002 [18] sanitary rules were developed to work out a comprehensive approach in establishing permissible limits of radiation exposure to the body and assessing occupational exposures. 60 regulatory documents and 128 methodological documents ensuring the implementation of the regulatory documents were developed to further detail the national radiation protection standards [16-18].

The late 1980s and 1990s and 2000s saw large –scale decommissioning of the nuclear navy. Establishment of the regulatory and procedural framework on radiological and hygienic support to these activities was carried out in five directions:

- organization of radiation protection assurance at nuclear ship-building enterprises;
- organization of radiation protection assurance at infrastructure facilities;
- radiological and hygienic zoning;
- radiation control;
- forecast of the radiation accidents consequences, justification of the necessity of protective measures.

Documents [19-21] concern organization of radiation protection assurance at nuclear shipbuilding enterprises. These documents establish the main provisions for ensuring safe working conditions, environmental protection and health protection of the employees involved in the dismantling of nuclear submarines (NSs), NM vessels and surface ships with NIs.

In order to ensure radiation protection including arrangement of zoning and management of products resulting from the dismantling of first generation NSs a special document - methodical guidelines MU2.6.1.38-05 [22] - was developed.

The guidance [23] defines requirements for equipment, services, organization and performance of radiological monitoring control and ensuring radiation protection of the personnel, population and environment during unloading of fuel assemblies.

The guidance [24] establishes radiological and hygienic requirements for solid radioactive waste (SRW) emplaced for storage, requirements for radiation protection assurance and radiological monitoring in the course of SRW emplacement.

Approaches to sanitary and epidemiological control of radiation protection assurance are summarized in federal level documents that enabled to spread the established radiological and hygienic requirements on the enterprises being outside the nuclear industry and shipbuilding system and thus to ensure a uniform radiation protection irrespective of the form of their incorporation and departmental subordination [25,26].

Environmental remediation is an important task in addressing the nuclear legacy problem in the Russian Federation. In this regard the regulatory documents [27-29] were developed regulating sanitary, hygienic and organizational requirements for human protection against radiation exposures in the course of environmental remediation of the base territories. Besides, the documents [30,31,33,34] were prepared establishing the main requirements for radiological situation in the territory and facilities of spent nuclear fuel and radioactive waste interim storage sites and the territory of the observation area upon completion of remediation activities, and the criteria were established of radiological, hygienic and radio ecological assessment of lands contaminated with radionuclides as well as requirements for the determination of radionuclide content in the biota and requirements for the development of the system of standards for making decisions on further usage of transferred territories after their remediation.

In order to ensure safe remediation activities a guidance [32] was developed on ensuring radiation protection in the course of design and construction of SNF and RW safe management infrastructure.

In order to improve radiation protection of the personnel and population methodical guidelines [35-41] for nuclear shipbuilding companies were developed, taking into account:

- exposure conditions under normal operation and in emergencies;

- exposure constraints to the population under normal operation by the quota of the dose limit established with the consideration of the attained level; and

- impact of radiation-related and radiation-related factors on the environment and the health of the population health.

It should be noted that this analysis covers only regulatory and methodological support to the works connected with the dismantling of ships with NIs and nuclear maintenance (NM) ships, as well as issues of the remediation of former coastal technical bases and demonstrates that currently health legislation covers practically all aspects of radiation protection assurance in the course of elimination of the Russian Federation nuclear legacy.

2.5 LEGISLATIVE FRAMEWORK OF THE REPUBLIC OF ESTONIA CONCERNING DECOMMISSIONING OF RADIATION HAZARDOUS FACILITIES

** Detailed analysis of the legislative framework of the Estonian Republic with relation to the decommissioning and RW management issues is presented within Annex 1 of the present report “Assessment of the Legislation of the Estonian Republic”.*

Estonian policy for radioactive waste management is based on national legislation and international principles.

The Republic of Estonia has acceded to several international conventions on nuclear safety, in particular the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, as well as the Convention on Nuclear Safety, which was ratified in 2005.

In the context of radioactive waste management, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management is the most important document, which is aimed at protecting people and the environment from radioactive waste in the civilian sector and from dangers arising due to spent fuel management. The participants confirm in the preamble of the Convention that the state shall be responsible for ensuring safety in the process of spent fuel and radioactive waste management at the final stage. The Governments shall provide control over the use of radiation sources, including safe management of orphan sources. For this purpose, a legal and regulatory framework shall be created, an independent competent authority (regulatory body) shall be appointed as well as the necessary regulations shall be issued in addition to the Act. In addition to the commitments undertaken upon accession to the Convention, it is important to participate in the reporting meetings of the Convention participants and submit reports to them.

The Republic of Estonia, as EU Member State, shall ensure compliance with the standards, directives and other documents issued at the EU level. In the field of radioactive waste, there are more important documents as European Council Directives 96/29/EURATOM, 2013/59/EURATOM, 2003/122/EURATOM, 2009/71/EURATOM, 2011/70/EURATOM.

As far as the former nuclear site in Paldiski was the Training Center not directly covered by Directive 2009/71/EURATOM and 2014/87/EURATOM, Estonia should fulfill the requirements of these Directives at the general level. Safety ensuring is very important for Estonia, therefore the Directives requirements shall be considered as much as possible at decommissioning of the Paldiski site, while ensuring reasonable administrative barriers at the same time.

Directive 2011/70/EURATOM coincides with the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. This Directive establishes a European Community Framework Program for responsible and safe management of spent fuel and radioactive waste. Estonian national program is aimed at implementing the requirements of this Directive.

Appendix 1 (Table 45) shall provide the national regulations of the Republic of Estonia concerning decommissioning of radiological facilities that define the radioactive waste management activity and provide availability of occupational license to manage radioactive materials. There are no special regulations governing the decommissioning process of radiological facilities in the Republic of Estonia.

Table 45 provides a detailed analysis of 32 documents related to regulatory and legal framework of the Republic of Estonia with a view to dissemination of requirements covering the issue of decommissioning. The analysis revealed the documents with requirements sufficient to be used for decommissioning of Paldiski facility reactor compartments. These documents include Regulation # 110 [61], Environmental Monitoring Act; Regulation # 50 [62]; Regulation # 57 [63]; Regulation # 5 [64]; Road Transport Act; Industrial Emissions Act; Ambient Air Protection Act; Fire Safety Act.

The principles of radioactive waste control and obligations related to waste management in the Republic of Estonia are established in the Radiation Act [42]. More specific requirements for reducing the volume of waste and ensuring safe management of radioactive waste are defined in the regulations issued under the Act and in licenses for the use of radioactive materials issued by the Environmental Board and provided for organizations that generate or dispose waste.

The most important Regulations of the Government of the Republic of Estonia and the Minister of the Environment are as follows:

- Regulation # 163 of the Republic of Estonia as of April 30, 2004 “The Bases for Calculation of Exemption Values, and the Exemption Values for Radionuclides.” This Regulation shall establish the exemption values for radionuclides, i.e. activity and specific activity values. If these values are below the mentioned levels, it is not required to receive the license. The Regulation also provides the formula to calculate the exemption values for several radionuclides or mixture of radionuclides [55];

- Regulation # 193 of the Republic of Estonia as of May 17, 2004 “Effective Dose and Equivalent Dose Limits for the Lens of the Eyes, Skin and Extremities for Exposed Workers and Members of the Public.” This Regulation shall establish the effective and equivalent dose limits for exposed workers and civilians [48];

- Regulation # 243 of the Republic of Estonia as of July 8, 2004 “Procedure Specifications for Processing Documents of Import, Export and Transit of Radioactive Waste Based on Country of Origin and Destination.” This Regulation shall establish the procedure specifications for processing documents for radioactive waste import, export and transit [54];

- Regulation # 244 of the Republic of Estonia as of July 8, 2004 “Statutes for the Maintenance of the State Dose Register of Exposed Workers.” It shall establish the procedure for maintenance of the state dose register of exposed workers. The license owner for the use of radioactive materials should send to the Register the data on doses of exposed workers due to ionizing radiation [49];

- Regulation # 41 of the Ministry of the Environment as of April 29, 2004 “Time Limits for Proceedings to Issue, Amend or Revoke the Radiation Practice Licenses, the Specific Requirements for and Format of Applications for Radiation Practice.” The document shall define the procedure for consideration of the radiation practice licenses and the list of documents to be submitted along with the application for a license [55];

- Regulation # 86 of the Ministry of the Environment as of July 8, 2004 “Requirements for the Radiation Safety Training of Exposed Workers.” The Regulation shall define the requirements for the radiation safety training of exposed workers, the curriculum content as well as the frequency of training sessions [50];

- Regulation # 93 of the Ministry of the Environment as of July 14, 2004 “Intervention and Action Levels, and Emergency Exposure Guidance in a Radiological Emergency” shall establish the doses for the use of protective measures in the event of radiological emergency [56];

- Regulation # 113 of the Ministry of the Environment as of September 7, 2004 “Requirements for the Rooms Where the Radiation Sources Are Situated and for Labeling Thereof and for the Working Rules for the Performance of Radiation Practices” [57];

- Regulation # 8 of the Ministry of the Environment as of February 9, 2005 “The Classification of Radioactive Waste, the Requirements for Registration, Management and Delivery of Radioactive Waste and the Acceptance Criteria for Radioactive Waste“ [58];

- Regulation # 10 of the Ministry of the Environment as of February 15, 2005 “Clearance Levels for Radioactive Substances and Materials Contaminated with Radioactive Substances Resulting from Radiation Practices, and the Requirements for Their Clearance, Recycling and Reuse“ [59];

- Regulation # 45 of the Ministry of the Environment as of May 26, 2005 “The Procedure for Monitoring and Estimation of Effective Doses Incurred by Exposed Workers and Members of the Public, and the Coefficients for Calculating Radionuclide Ingestion and Inhalation Doses“ [60].

The main legal act of the Republic of Estonia in the field of nuclear and radiation safety, the Radiation Act [42], was adopted in 2004. This Act is based on the concepts and provisions established by the International Basic Safety Standards [43] and by Directive 2013/59/EURATOM [44]: optimization of protection and safety (ALARA principle), limitation of individual radiation doses, acceptance of justified and optimized works for prevention of emergencies, permission for execution of works related to radiation etc. In 2011, the Radiation Act [42] was partially amended with respect to definitions, principles, obligations of license owners and ensuring nuclear safety requirements at nuclear facilities. The problems related to the safe management of radioactive waste and emissions in Estonia are described in the Radiation Act, which is supplemented with regulations of the Republic Government and the Minister of the Environment. According to the Radiation Act [42], activities for radioactive waste management and decommissioning of radiological facilities shall be licensed. Within the license obtaining, the plan for safe decommissioning of the radiation source upon radiation use completion shall be presented indicating the procedure according to which the safe decommissioning of the source is to be provided in future. In case of moderate or high radiation activity risk, the plan shall be approved by a competent radiation expert.

In accordance with the Radiation Act, radioactive substances generated in the process of radioactive materials use may be exempted from compliance with the Radiation Monitoring Act requirements if they have such a low activity or concentration that their management and storage as radioactive waste is not mandatory in the context of radiation safety. The indisputable condition of such exemption is waste performance specification (improvement of radionuclide concentrations and activity). For this purpose, a system for characterization of other waste shall be created in addition to the sealed radiation sources and the required clearance procedures shall be developed. Besides, the waste clearance provides an opportunity to optimize the amount of radioactive waste subject to final disposal, which in turn means more efficient use of available funds.

In accordance with the requirements of the Act [42], a number of resolutions have been adopted since 2004 by the Government, the Minister of the Environment and the Minister of Internal Affairs. Some general safety principles of the hazardous nuclear and radiological facilities decommissioning are reflected in the Environmental Supervision Act [45], Emergency Act [46] and the Environmental Impact Assessment and Environmental Management System Act [47], Regulation No. 193 [48], Regulation No. 244 [49] and Regulation No. 86 [50] by the Minister of the Environment.

The general principles of securing radiation protection during decommissioning of hazardous nuclear and radiological facilities, lines for development of these principles and financing issues are defined within the National Radiation Safety Development Plan 2008 – 2017 [51], developed in accordance with the requirements of Radiation Act Chapter 2 [42]. The National Development Plan shows that there is an urgent need to develop the preparatory documents and perform studies for dismantling the reactor compartments. It is required to develop design documentation for the RW temporary storage facility. Also, it is required to develop design documentation for the RW disposal facility conforming to the proposed radioactive waste volumes, for which it is required to provide quantitative investigation for estimation of generated radioactive waste quantities.

The National programme for radioactive waste management [65] is developed in 2015. The need for the programme preparation is provided in the National Development Plan for Radiation Protection, approved by the Republic Government in 2008 and in the European Council Directive 2011/70/EURATOM on responsible and safe management of spent fuel and radioactive waste. NRSDP shall consider reduction of hazard related to radioactive waste and its management as one of the most important interim objectives.

2.6 GUIDELINES FOR AMENDING THE REGULATORY FRAMEWORK OF THE REPUBLIC OF ESTONIA TO THE EXTENT OF RADIATION HAZARDOUS FACILITY (RHF) DECOMMISSIONING

** Detailed analysis of the legislative framework of the Estonian Republic with relation to the RHF decommissioning is presented within Annex 1 of the present report “Assessment of the Legislation of the Estonian Republic” (Table 45).*

2.6.1 Recommendation on the development of regulatory documents regulating radiological facilities decommissioning

Table 45 gives the recommendations on introducing some changes into the regulatory base of the Republic of Estonia with respect to radiological facilities decommissioning.

Thus it is proposed to introduce some changes into the main document, Radiation Law, concerning:

- Provision of a legal basis for obtaining the license for stages of radiation materials handling, since the decommissioning after closing down may be implemented both as one continuous operation and as a series of discontinuous operations during a long time period;

- Specification of the requirements for the license application (the license application shall comprise, among other things, the following issues: fire protection and fire fighting for the whole site, optioneering of various decommissioning options considering wide range of issues with special emphasis on the balance between safety requirements and resources available at the moment of decommissioning etc.)

- Survey of residual radionuclides on the reactor site after the decontamination or dismantling completion to confirm the residual activity compliance with criteria established by the national regulator thus justifying achievement of the decommissioning objective;

- Provision of financial resources to cover expenses associated with safe decommissioning, including waste handling.

- Special attention shall be given to a possible contamination due to generation and release of dust and aerosols of radioactive liquids as well as to large amount of waste generated during the decommissioning.

The amendments shall be introduced into Regulation No. 10 Clearance Levels for Radioactive Substances and Materials Contaminated with Radioactive Substances Resulting from Radiation Practices, and the Requirements for Their Clearance, Recycling and Reuse and into the Waste Act since large amounts of metal waste subject to clearance are generated during the decommissioning.

A possibility to unite regulations that concern exception and exclusion shall be discussed to introduce changes into Regulation No.10 since a unified approach is used to the regulations mentioned in the Basic Safety Standards Directive of EURATOM (EURATOM BSS). The Regulation shall be updated based on requirements and recommendations received from the EURATOM BSS. There shall be instructions available to handle metal waste after the exception.

The changes related to the following points are recommended to be introduced into the Waste Act:

- Special conditions for decontaminated metal waste. The Act shall stipulate a possibility to determine those special conditions.

- Taking into account non-radiological hazards accompanying the decommissioning process and occurred during decontamination, metal cutting etc.,

- Requirement for inventory taking of all hazardous chemicals available in the facility to be decommissioned. Special attention shall be paid to hazardous materials, e.g. asbestos, to prevent harm to health.

The Chemicals Act on the whole cover the decommissioning needs, but special attention shall be paid to contamination possible due to generation and release of dust and aerosols of radioactive liquids as well as to large amount of waste generated during the decommissioning activities.

The other documents specified in Table 45 give recommendations for changes concerning general issues of radiation safety assurance with respect to any stage of RW handling.

More detailed analysis of recommendations given to introduce changes into the legal base of Estonia with respect to radioactive waste handling is presented in Table 43.

Table 43 gives the analysis of the list of Estonian regulations in the same scope as for radiological facilities decommissioning. The list of documents that shall remain unchanged is similar to the list of documents for decommissioning.

The amendments comprising the following data are proposed to be introduced into the Radiation Law with respect to radioactive waste handling:

- The Law shall clearly determine legal, technical and financial liabilities of companies taking part in radioactive waste handling up to its final disposal;

- There is a need for an Operator audit program helping to identify whether program and plans for LLW and ILW handling up to its final disposal comply with respective requirements and to confirm that procedures cover certain types of activities and the program is properly implemented;

- Recommendations to choose the most suitable option of preliminary cleaning, reprocessing and conditioning of radioactive waste in case if a disposal facility is not available, as well as suppositions on possible disposal options.

- The state shall provide required information to the public and take part in spent fuel and radioactive waste handling, but at the same time duly consider the requirements for the safety and usage of official information.

The following amendments are proposed to be introduced into Regulation No. 8: changing the radioactive waste classification taking into account the classification proposed by the IAEA, introducing waste acceptance requirements, introducing changes concerning the list of factors for the safety assessment in RW handling based on IAEA guidelines.

2.6.2 Schedule for development and release of regulatory documents of the republic of Estonia legal framework

For resolution of regulatory issues for decommissioning of the RHF, a schedule needs to be developed for actions to be taken to bring the regulatory framework of the Republic of Estonia to compliance with the IAEA requirements and recommendations, including such justifications as concepts and scientific research work.

In order to ensure compliance of the regulatory system in the Republic of Estonia, a number of acts have to be issued (government decrees, ministry decrees, regulations, safety guides) to govern relations that occur during decommissioning of RHF.

The work to produce the schedule shall be organised and supervised by the Ministry of Environmental Protection. Preliminary estimates show that harmonisation of the regulatory framework in the Republic of Estonia with the IAEA requirements and recommendations would take 4 to 6 years

2.6.3 Conclusions

Due to an obvious need for reactor compartments decommissioning at the Paldiski facility in the future, the Republic of Estonia shall continue developing the direction of radiation safety assurance during radiological facilities decommissioning using the experience of countries experienced in NPS decommissioning as a guide. A respective normative base shall be used during practical implementation of reactor compartments decommissioning to ensure safety and comply with EU and IAEA requirements.

The current legislation of the Republic of Estonia does not provide precise responsibility subdivision during radioactive waste handling. The responsibilities and liabilities of participants shall be determined. Besides some legislative acts enforced in the European Union impose additional liabilities on the Republic of Estonia and those liabilities shall be stipulated in the Estonian legal base to ensure their fulfillment.

Directive 2011/70/EURATOM came into effect in 2011 establishing responsible and safe management of radioactive waste and spent fuel in the European Union imposing each EU Member State to prepare a national program and submit it to the Council describing waste collection and removal arrangements in the member state as well as measures taken to the waste for its final disposal. The action plan comprises the description of the state policy on radioactive waste, existing unnecessary inventory, technical solutions for waste treatment and disposal (final disposal), time periods for actions, resources etc.

2.7 LIST OF REQUIREMENTS AND GUIDELINES FOR ASSESSMENT OF RC DECOMMISSIONING POSSIBILITIES

Key parameters for identification of a list of activities required for decommissioning and waste disposal shall be prepared within the framework of reporting documentation for Stage 3 "Identification of Potential Options for Reactor Compartments Decommissioning", which will suggest decommissioning options for the reactor compartment, describe key processes involved with the option, estimate labour demands and complexity of the work effort and propose key mechanisation methods, as well as estimate the quantities of waste expected to be generated by reactor compartments decommissioning. During Stage 3, options will be considered for preparation and dismantling of the reactor compartment with the objective of separating radioactive components from non-radioactive to maximise reduction of RW generation.

Non-radioactive metallic waste will be re-used as scrap metal, with radioactive pieces should be processed, packaged into containers and sent to long-term storage or disposal in a newly-built RW storage facility or disposal facility. The ultimate objective of dismantling and waste processing is minimisation of quantities of waste to be sent to final disposal. Various methods will be employed to reduce the volume of RW: fragmentation of large pieces of equipment; compaction of compressible waste; decontamination of equipment that is free of induced activity; incineration of organic waste etc. It is obvious that RW can be processed using existing facilities or can be transported to other countries for processing, for example, decontamination of certain types of equipment, incineration and melting of solid wastes, etc.

The major requirements for the assessment of the decommissioning possibilities are the following:

Political decision of the Republic of Estonia and conformation from European Union about the commencement of activities of the Paldiski RCs decommissioning;

Technical capabilities for RC decommissioning scenarios implementation: reference technologies, equipment, machinery, remote controlled equipment and other parameters;

Safety assurance – application of ALARA principle;

Compliance with the principle of minimization of RW generation through application of the technical regulations on collection, separation, fragmentation, processing and treatment of RW and packaging of RW in accordance with the waste acceptance criteria;

Environmental impact of the RCs dismantling activities;

Economic indicators: schedule, investment and operating expenditures, source of finance, labour force availability etc.;

Availability of free areas for receiving and storage of demolition waste from uncontaminated structures;

Availability of the infrastructure for RW packages storage and disposal;

Availability of the infrastructure for hazardous non-radioactive waste management;

Availability of the infrastructure and logistics for transportation of the various types of wastes.

CONCLUSION

The review and analysis of normative documents of the IAEA, European Union and Russian Federation regulating nuclear and radiological facilities decommissioning issues have been carried out within the framework of the Subtask.

The focus in the majority of documents is placed on the back end of hazardous nuclear and radiological facilities. It is vitally important to make such facilities (in this case – reactor compartments of the Paldiski site) radiologically safe and ensure environmental protection and safety of the population, as well as relieve the future generations from the nuclear legacy burden. The major issues in the course of the decommissioning are radiation protection assurance, treatment of radioactive waste to be generated and its final disposal.

International legal and regulatory framework prescribes that attention should be paid to the identification of the after-effects from decommissioning activities on the human health and environment.

IAEA recommendations and EURATOM Directives are based on the priorities of the population protection against hazardous exposure. The development of the decommissioning and RW management option in the EU Member State should be performed in a consensual and consultative environment and take into account the interests of the other Member States. However, the development of an individual decommissioning strategy is available for every Member State.

32 documents of the Republic of Estonia (state recommendations and regulations of the Republic of Estonia) related to nuclear and radiological facilities decommissioning defined as a part of radioactive waste management actions thus requiring the license for activities associated with radioactive materials have been analyzed within the scope of the Subtask.

The analysis revealed the following:

- There are no special regulations regulating radiological facilities decommissioning in the Republic of Estonia;
- The following documents shall remain unchanged: Regulation No.110 [61], Environmental Monitoring Act; Regulation No.50 [62]; Regulation No.57 [63]; Regulation

No.5 [64]; Road Transport Act; Industrial Emissions Act; Ambient Air Protection Act; Fire Safety Act;

- With respect to the documents analyzed the recommendations are given for changes concerning general issues of radiations safety assurance and any stages of radioactive waste handling.

Since the decommissioning is determined as a part of radioactive waste management activities, the requirements for RW management cover decommissioning as well.

The amendments related to the following points are proposed to be introduced into the main document, the Waste Act:

- Provision of a legal basis for obtaining the license for stages of radiation materials handling, since the decommissioning after closing down may be implemented both as one continuous operation and as a series of discontinuous operations during a long time period;
- Specification of the requirements for the license application (the license application shall comprise, among other things, the following issues: fire protection and fire fighting for the whole site. The optioneering of various decommissioning options shall be developed considering wide range of issues with special emphasis on the balance between safety requirements and resources available at the moment for decommissioning etc.)
- Survey of residual radionuclides on the reactor site after the decontamination or dismantling completion to confirm the residual activity compliance with criteria established by the national regulator thus justifying achievement of the decommissioning objective;
- Provision of financial resources to cover expenses associated with safe decommissioning, including waste handling.
- Special attention shall be given to a possible contamination due to generation and release of dust and aerosols of radioactive liquids as well as to large amount of waste generated during the decommissioning.

The changes are to be introduced into Regulation No.10 and into the Waste Act since large amount of metal waste will be generated during the decommissioning.

The changes are to be introduced into legislative and regulatory base of the Republic of Estonia due to planned activities on RW handling and updated legal base of the EU and IAEA.

Being the EU Member State the Republic of Estonia shall ensure alteration based on rules, directives and other documents issued at the EU level. The EU Directives 96/29/ EURATOM, 2013/59/ EURATOM, 2003/122/ EURATOM, 2009/71/ EURATOM, 2011/70/ EURATOM are the most important documents in the sphere of radioactive waste.

Due to an obvious need for reactor compartments decommissioning at the Paldiski facility in the future, the Republic of Estonia shall continue developing the direction of radiation safety assurance during radiological facilities decommissioning using the experience of countries experienced in NPS decommissioning as a guide.

To develop amendments to some part of regulations regulating the activities on reactor compartments decommissioning at the Paldiski facility it would be appropriate to engage experts from one of the countries experienced in NPS operation and decommissioning.

The amendments introduced into legislative and regulatory base of the Republic of Estonia shall be sufficient to develop design documentation on reactor compartments decommissioning at the Paldiski facility and carry out activities on the dismantling of RC building structures and equipment based on design documents and respective licenses for the right to activities.

REFERENCES

1. Decommissioning of Facilities, IAEA Safety Standards Series Part 6 (GSR Part 6), IAEA, Vienna, 2014.

2. Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna, 2014.

3. Safety Assessment for Facilities and Activities, IAEA Safety Standards Series No. GSR Part 4, IAEA, Vienna, 2009.

4. Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-R-2, IAEA, Vienna, 2002.

5. Disposal of Radioactive Waste, IAEA Safety Standards Series No. SSR-5, IAEA, Vienna, 2011.

6. Predisposal Management of Radioactive Waste, IAEA Safety Standards Series No. GSR Part 5, IAEA, Vienna, 2009.

7. Regulations for the Safe Transport of Radioactive Material, 2012 Edition, IAEA Safety Standards Series No. SSR-6, IAEA, Vienna, 2012.

8. Safety Assessment for the Decommissioning of Facilities Using Radioactive Material, IAEA Safety Standards Series No. WS-G-5.2, IAEA, Vienna, 2008.

9. Treaty establishing the European Atomic Energy Community (EURATOM Treaty)/

10. Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste.

11. Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment Text with EEA relevance.

12. Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation.

13. Commission Recommendation of 24 October 2006 on the management of financial resources for the decommissioning of nuclear installations, spent fuel and radioactive waste (2006/851/Euratom).

14. Aspects of ensuring nuclear and radiation safety in the course of dismantling radiological facilities decommissioned from the Russian Federation Navy; Cooperation between the State Supervision Authority for Nuclear and Radiation Safety of the Russian Federation Ministry of Defense and the Norwegian Radiation Protection Authority, Report, 2013.

15. Legal and Regulatory Support to Safety Assurance in the Course of Decommissioning of Russian Nuclear Fleet Hazardous Nuclear and Radiological Facilities, A.I. Ioyrysh, A.A. Kozodubov, V.G. Markarov, Moscow, 2008.

16. SanPin 2.6.1.2523-09 Radiation Protection Standards (NRB-99/2009).

17. SP 2.6.1.2612-10 Principal Sanitary Rules for Radiation Protection (OSPORB-99/2010).

18. SP 2.6.6.1168-02 Sanitary Rules for Radioactive Waste Management (SPORO-2002).

19. R2.6.6.37-02 Hygienic Standards Established in the Course of NS Dismantling Activities.

20. MU2.6.1.4-05 Radiation Protection Assurance in the Course of Dismantling Nuclear Submarines.

21. R2.6.1.62-04 Radiation and Hygienic Requirements for the Dismantling of Nuclear Maintenance Ships.

22. MU2.6.1.38-05 Radiation Protection Assurance in the Course of Dismantling First Generation Nuclear Submarines.

23. R2.6.1.35-02 Radiation Protection Assurance in the Course of Spent Fuel Assemblies Unloading from Nuclear Submarines to Be Dismantled (RBV-2002).

24. R2.6.6.42-02 Radiological and Hygienic Requirements for Solid Radioactive Waste Emplacement in the Reactor Compartments of Nuclear Submarines to Be Dismantled.

25. Sanitary Rules for Radiation Protection Assurance in the Course of Comprehensive Dismantling of Nuclear Submarines (SPU-2006).

26. Sanitary Rules for Ensuring Safe Working Conditions at Nuclear Shipbuilding Enterprises (SP PAS-2006).

27. Methodical Guidelines MU 2.6.1.58-02 Criteria and Methods of Assessment of the Condition of Radionuclide-Contaminated Lands Adjacent to NS Bases.

28. Methodical Guidelines MU 2.6.6.22-05 Radiation Protection Assurance in the Course of Coastal Technical Bases Remediation.

29. R 2.6.1.25-07 Criteria and Standards of Remediation of Territories and Facilities Contaminated with Technogenic Radionuclides, Federal State Unitary Enterprise ”Northern Federal Radioactive Waste Management Company, Federal Atomic Energy Agency”.

30. MU 2.6.1.37-07 Organization of Radiological Monitoring of the Biota in the Area of Activities of the Federal State Unitary Enterprise ”Northern Federal Radioactive Waste Management Company”, Federal Atomic Energy Agency.

31. R 2.6.1.29-07 Hygienic Requirements for Radiation Protection of the Personnel and Public in the Course of Planning and Organizing Activities with SNF and RW, FSUE ”SevRAO”.

32. MU 2.6.5.05 - 08 Peculiarities of the ALARA Principle Application in the Course of SNF and RW Management, FSUE ”SevRAO”.

33. Guidance R 2.6.1.42-03 Radio ecological Safety Assurance in Interim Floating Storage Facilities for the Reactor Compartments of Dismantled Nuclear Submarines .

34. Guidance R 2.6.6.57-04 Radiological and Hygienic Requirements for Long-Term Storage Facilities for Single-Compartment Reactor Units of Nuclear Submarines under Dismantling.

35. Methodical Guidelines MU 2.6.1.52-03 Radiological and Hygienic Areas of Nuclear Shipbuilding Enterprises. Operation Conditions and Justification of Boundaries.

36. Methodical Guidelines MU 2.6.1.36-02 Sanitary Protection and Observation Areas of Nuclear Shipbuilding Enterprises. Operation Conditions and Justification of Boundaries.

37. R2.6.1.55-04 Organization of Personal Dosimetry Control of the Personnel at Nuclear Shipbuilding Enterprises and Population in the Observation Area.

38. MU 2.6.1.32-01 Radiological Monitoring of Metal Scrap Generated during Dismantling of Nuclear Submarines and Methodical Guidelines for Radiological and Hygienic Requirements for the Radiological Monitoring System at Long-Term Storage Facilities for Single-Compartment Reactor Units.

39. MU 2.6.1.61-04 Determination of Individual Effective and Equivalent Doses and Organization of Exposure Control to Personnel at Nuclear Shipbuilding and Ship-Repair Enterprises.

40. MU 2.6.1.56-04 Assessment of Impact from Hazardous Radiological Works Carried Out by Nuclear Shipbuilding Enterprise on the Environment and Population.

41. MU 03-98 Radiological Survey of Nuclear Submarines during their Handover from the Navy for Dismantling.

42. Radiation Act, enforced in 1 May 2004, as amended in 22 February 2005, 10 May 2006, 7 December 2006, 24 January 2007, 18 December 2008 and 15 June 2009, 16 September 2009, 27 October 2011, 19 February 2014, 19 June 2014.

43. International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources Safety Series No. 115 IAEA, Vienna 2014.

44. Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom.

45. Environmental Supervision Act, enforced in 06 June 2001, as amended in 16 June 2002, 13 November 2002, 11 December 2002, 17 December 2003, 14 April 2004, 21 April 2004, 13 April 2005, 12 October 2005, 08 February 2007, 27 January 2011, 10 October 2012, 25 August 2013, 19 February 2014, 19 June 2014.

46. Emergency Act, enforced in 15 June 2009, as amended in 26 November 2009, 5 May 2010, 21 October 2010, 27 January 2011, 08 December 2011, 13 June 2012, 17 October 2012, 19. February 2014, 13 February 2014, 19 February 2014 and 07 May 2014.

47. Environmental Impact Assessment and Environmental Management System Act, passed 22 February 2005, as amended in 7 December 2006, 21 February 2007, 19 June 2008, 18 December 2008, 27 January 2010, 26 October 2010, 06 December2011 and 19 February 2014.

48. Regulation No. 193 of 17 May 2004: Effective Dose and Equivalent Dose Limits for the Lens of the Eyes, Skin and Extremities for Exposed Workers and Members of the Public.

49. Regulation No. 244 of 8 July 2004, as amended in 15 January 2009 and 01 August 2011: Statutes for the Maintenance of the State Dose Register of Exposed Workers.

50. Regulation No. 86 of 8 July 2004, as amended in 21 January 2009: Requirements for the Radiation Safety Training of Exposed Workers.

51. National Development Plan for Radiation Protection 2008-2017, the Ministry of the Environment, Tallinn, 2008.

52. The research report «Preliminary studies for the decommissioning of the reactor compartments of the former Paldiski military nuclear site and for the establishment of a radioactive waste repository: collection and analysis of the data concerning the reactor compartments, determination of the possibility of the reactor compartments decommissioning», JSC «ATOMPROEKT», 2015.

53. Regulation No. 163 of 30 April 2004, as amended in 11 February 2010: The Bases for Calculation of Exemption Values, and the Exemption Values for Radionuclides

54. Regulation No. 243 of 8 July 2004, as amended in 15 January 2009 and 10 December 2009: Procedure Specifications for Processing Documents of Import, Export and Transit of Radioactive Waste Based on Country of Origin and Destination

55. Regulation No. 41 of 29 April 2004, as amended in 31 May 2006, 21 January 2009 and 04 March 2014: Time Limits for Proceedings to Issue, Amend or Revoke the Radiation Practice Licenses, the Specific Requirements for and Format of Applications for Radiation Practice Licenses, and the Format of Radiation Practice Licenses

56. Regulation No. 93 of 14 July 2004: Intervention and Action Levels, and Emergency Exposure Guidance in a Radiological Emergency

57. Regulation No. 113 of 7 September 2004, as amended in 31 May 2006: Requirements for the Rooms Where the Radiation Sources Are Situated and for Labelling Thereof and for the Working Rules for the Performance of Radiation Practices.

58. Regulation No. 8 of 9 February 2005, as amended in 21 January 2009: The Classification of Radioactive Waste, the Requirements for Registration, Management and Delivery of Radioactive Waste and the Acceptance Criteria for Radioactive Waste.

59. Regulation No. 10 of 15 February 2005, as amended in 21 January 2009: Clearance Levels for Radioactive Substances and Materials Contaminated with Radioactive Substances Resulting from Radiation Practices, and the Requirements for Their Clearance, Recycling and Reuse

60. Regulation No. 45 of 26 May 2005, as amended in 21 January 2009: The Procedure for Monitoring and Estimation of Effective Doses Incurred by Exposed Workers and Members of the Public, and the Coefficients for Calculating Radionuclide Ingestion and Inhalation Doses

61. Regulation No. 110 of 27 August 2004, as amended in 21 January 2009: The Requirements for the Results of Individual Monitoring of Outside Workers, and for Formalizing Such Results, and for the Standard Format for the Dose Chart of Outside Workers

62. Regulation No. 50 of 30 July 2002, as amended in 21 August 2003, 15 May 2008 and 26 March 2010 and 23 May 2013: Establishment of National Environmental Monitoring Stations and Areas.

63. Regulation No 57 of 6 May 2010: Procedure of Notification of the Ministry of the Interior of An Emergency or of the Impending Risk of the Occurrence of An Emergency

64. Regulation No 5 of 18 February 2010, as amended in 13 April 2010 and 09 November 2010: The Guidelines for Preparing an Emergency Risk Assessment.

65. National programme for radioactive waste management, Ministry of the Environment, Republic of Estonia, Tallinn, 2015.

CHAPTER 3

OVERVIEW OF INTERNATIONAL AND NATIONAL RECOMMENDATIONS AND LEGAL ACTS ON THE DISPOSAL OF RADIOACTIVE WASTE

3.1 REVIEW OF THE IAEA SAFETY STANDARDS FOR RW DISPOSAL

Requirements to radioactive waste disposal are detailed in the following IAEA documents:

– Disposal of Radioactive Waste, IAEA Specific Safety Requirements No.SSR-5, 2011;

– Near Surface Disposal Facilities for Radioactive Waste, Specific Safety Guide No.SSG-29, 2014

– Geological Disposal Facilities for Radioactive Waste. Specific Safety Guide No. SSG-14.

After 50 years of storage, the waste generated in the course of Paldiski reactor units decommissioning does not contain radioactive waste of HLW category that require disposal in geological formations. Proceeding from the above, the analysis of IAEA documents specifying requirements to the RW disposal in deep geological formations and management of radioactive waste of HLW category prior to their disposal is not provided.

3.1.1 Disposal of radioactive waste, IAEA specific safety requirements NO.SSR-5, 2011

IAEA Publication “Radioactive waste disposal. Specific safety requirements” No. SSR-5 [1] was issued in 2011 and it is a document of the category “Safety requirements” in the IAEA Nuclear Security Series [1].

The purpose of publication No. SSR-5 [1] consists in stating the tasks and criteria of disposal of all types of radioactive waste and establishing the requirements based on the principles, represented in the material [2], which shall be fulfilled under radioactive waste disposal.

This publication [1] contains requirements to the radioactive waste disposal of all types by its placement into the purpose-designed facilities upon condition of imposing constraints and using the means of control with regard to the radioactive waste disposal, as well as operation and closure of the facilities. The document states the requirements in order to ensure confidence in radiological safety of the radioactive waste disposal, and also the facility for disposal during its operation and especially after its closure. The basic safety purpose – human protection and environment protection from negative effect of the ionizing radiation. It is achieved by establishing the requirements, including organizational and regulating requirements, to selection and assessment of the site and design of the disposal facility and to its construction, operation and closing.

The document [1] consists of 6 sections, the section “Addition” and appendices, which gives the classification of radioactive waste in accordance with the approach specified in the Addition. In 2014 the new document of the IAEA Nuclear Security Series “Standards Classification of Radioactive Waste for protecting people and the environment. General Safety Guide No. GSG-1” [2] was issued. The review of this document is given in section within the present report.

In the sections of publication [1] “Introduction” and “Human protection and environment protection” general information, concepts and purpose of safe disposal are stated. In sections ”Safety requirements under planning of radioactive waste disposal”, “Requirements applicable to development, operation and closure of the disposal facility”, ”Safety assurance” and ”Existing disposal facilities” safety requirements for disposal facilities are stated. These requirements include 26 clauses, which are applied to all types of disposal and disposal facilities.

The recommendations for fulfillment of these requirements are represented in the IAEA safety guides, each of which considers the specific type of disposal, in particular, in the documents of 2014 “Geological disposal facilities for radioactive waste. Specific safety guide” No. SSG-14 [3], “Near surface disposal facilities for radioactive waste. Specific safety guide” SSG-29 [4].

The main provisions of the sections of the publication No. SSR-5 [1] are presented below in Table 32.

Table 32**:** Safety requirements during radioactive waste disposal [1].

Description of safety requirement	Requirement comment	Item No of publication No. SSR-5 [1]
Requirement 1. State responsibility	This requirement corresponds to the basic safety concepts [5] and text of Joint Convention [79]. Special attention shall be paid to the project for radioactive waste disposal, especially for the development of long-lived waste disposal facility taking into account a relatively long period of time required for the development of such facilities. The state shall clearly allocate the types of responsibility for radioactive waste disposal facilities at the stages of site selection, designing, construction, operation and abandonment.	3.6-3.7
Requirement 2. Regulatory body responsibility	The regulatory body shall specify regulatory requirements to the development of RWDF and shall introduce	3.8-3.11

<table>
<tr><th>Description of safety requirement</th><th>Requirement comment</th><th>Item No of publication No. SSR-5 [1]</th></tr>
<tr><td></td><td>requirements compliance procedures at different stages of licensing process. It should be checked that the requirements being established are understandable both to the waste producers and to the waste disposal facility operator.</td><td></td></tr>
<tr><td>Requirement 3.Operator responsibility</td><td rowspan="3">The operator of radioactive waste disposal facility shall bear responsibility for the safety of RWDF. The operator shall carry out safety assessment and perform all the required types of activity at all the stages of the RWDF lifecycle: assessment of site for RWDF arrangement; designing, construction, operation and abandonment of the radioactive waste disposal facility, if necessary, supervision of RWDF abandonment. The maximum extent of safety shall be provided at all specified stages by passive methods, such as shielding and containment of radioactive waste with the use of package material.</td><td>3.12-3.16</td></tr>
<tr><td>Requirement 4. Importance of providing safety in the process of development and operation of the disposal facility</td><td>3.17-3.20</td></tr>
<tr><td>Requirement 6. Understanding of the disposal facility and safety confidence</td><td>3.26 -3.31</td></tr>
<tr><td>Requirement 7. Multiple safety functions</td><td>The safety of RWDF shall be provided by means of multiple safety functions performance: using engineering and technical as well as physical barriers, such as shape of waste, package of waste, place and method of waste disposal. The serviceability of these physical barriers shall be ensured by means of various physical and chemical processes as well as different means of in-service monitoring. General serviceability of the disposal system shall not be overly dependent on a single safety function.</td><td>3.35-3.38</td></tr>
<tr><td>Requirement 8. Containment of radioactive waste</td><td>The engineering and technical barriers, including waste shape and package shall be designed, while the background medium shall be selected in the way to ensure containment of radionuclides related to waste. The RWDF designing</td><td>3.39-3.42</td></tr>
</table>

Description of safety requirement	Requirement comment	Item No of publication No. SSR-5 [1]
	shall ensure minimization of radionuclides emissions. The containment shall be provided until radioactive disintegration results in significant reduction of risk related to waste.	
Requirement 9. Isolation of radioactive waste	The disposal facility shall be situated, designed and operated in the way to ensure measures aimed at isolation of radioactive waste from people and accessible biosphere. The isolation at the facilities for near-surface disposal shall be provided by means of its arrangement and designing as well as through the use of operational and in-house monitoring tools.	3.43-3.47
Requirement 10. Monitoring and supervision of passive safety features	The purpose of monitoring and supervision is not to measure radiological parameters but to ensure continuous implementation of safety functions. The passive safety features (barriers) for disposal of medium-level radioactive waste shall be robust enough to exclude any need for repair and modernization. It is necessary to provide independence from the active measures of institutional control (see requirement 22). Regarding facilities for near-surface waste disposal, the measures on monitoring and supervision may include restriction of access for people and animals; inspection of physical conditions; retention of due maintenance potential as well as implementation of monitoring and supervision as a method of testing performance indexes compliance with the established standards (i.e. degradation test).	Para. 3.48
Requirement 11. Step-by-step development and assessment of disposal facilities	The RW disposal facilities shall be developed, operated and abandoned in steps. Every step shall be supported, if necessary, by iterative assessments of the site, design options, construction, operation and control, as well as	4.2-4.11

Description of safety requirement	Requirement comment	Item No of publication No. SSR-5 [1]
	functioning and safety of a disposal system.	
Requirement 12. Preparation, approval and use of safety case and disposal facility safety assessment	Preparation and updating the safety case and auxiliary safety assessment shall be effected by an operator, if necessary, at every stage of development, operation and abandonment of the disposal facility. The safety case and auxiliary safety assessment shall be submitted to the regulatory body for approval.	4.12-4.14
Requirement 13. Content of safety case and safety assessment	The safety case for the disposal facility safety shall comprise a description of all corresponding safety aspects both during operation and after abandonment, including construction works (excavation, disposal facility encapsulation and abandoning). It is necessary to give consideration to staff and public radiation exposure both during normal operation and in emergency situations. In the course of assessing safety after abandoning it is necessary to consider events affecting the disposal system, including low-probability events.	4.15-4.22
Requirement 14. Documenting of safety case and safety assessment	The composition and structure of documentation comprising safety case and auxiliary safety assessment depends on the stage reached within the implementation of disposal facility design and national requirements.	4.23 -4.25
Requirement 15. Determining characteristics of site for disposal facility	The characteristics of site for disposal facility shall be determined at the level of detail sufficient for supporting general idea of both site characteristics and the results of its evolution in the course of time. In the course of site selection, it is necessary to demonstrate the availability of due geological, geomorphological or topographic stability (corresponding to the facility type) as well as characteristics and processes, which help ensure safety.	4.23 -4.25
Requirement 16. Design of	The design of RWDF shall ensure the RW	4.30 -4.32

Description of safety requirement	Requirement comment	Item No of publication No. SSR-5 [1]
disposal facility	containment by means of engineering-and-technical barriers, which may minimize the risks related therewith, may be chemically and physically compatible with the background geological formation and/or environment on the surface and may provide such safety characteristics after abandonment, which complement the background medium characteristics. Designing of its engineering and technical barriers shall be effected to ensure safety during the operation period.	
Requirement 17. Construction of disposal facility	The RWDF construction shall be carried out in accordance with design documentation. General requirements to conducting construction activities excluding any excessive disturbance of the background medium (underlying rocks and ground-water conditions) were presented. The construction works shall be performed in a way to ensure safety during the operation period.	4.33 -4.34
Requirement 18. Operation of disposal facility	The disposal facility shall be operated during operational period such that after the facility is abandoned the safety-important functions provided for in the safety case shall be retained. The active safety control shall be continued until the disposal facility remains not abandoned, and it may cover a durable period after waste placement and up to final facility abandonment.	4.35 -4.37
Requirement 19. Abandonment of disposal facility	The disposal facility shall be abandoned so that to ensure safety functions provided for in the safety case as important ones in the period after facility abandonment. The safety after disposal facility abandonment will depend on the performance of a number of activities and providing design characteristics, which may include a backfilling and sealing or closing the disposal facility. The abandonment may be	4.38 -4.41

Description of safety requirement	Requirement comment	Item No of publication No. SSR-5 [1]
	delayed within a period after finishing the waste placement, e.g., in order to provide monitoring for assessing aspects related to safety after abandonment or due to the reasons related to public acceptance.	
Requirement 20. Acceptability of waste at the disposal facility	The packages of waste and unpacked waste accepted for placement at the disposal facility shall meet the criteria, which are fully compatible with disposal facility safety case during operation and after abandonment as well as developed on its basis.	5.1 -5.3
Requirement 21. Programs of monitoring at disposal facility	The program of monitoring shall be effected, if it is a part of safety case, before the beginning and during construction and operation of the disposal facility and after its abandonment. This program shall be compiled so that to make the acquisition and updating information required for the needs of providing protection and safety possible. It is necessary to acquire information for confirming conditions required for ensuring the safety of employees and public representatives and environment protection during facility operation. It is also necessary to perform monitoring in order to confirm absence of any conditions, which might have reduced safety after facility abandonment.	5.4 -5.5
Requirement 22. Period after abandonment and in-house monitoring facilities	The plans shall be prepared for a period after facility abandonment covering issues of in-house monitoring and measures for providing availability of information on the disposal facility. An official authorization of radioactive waste disposal facility shall be issued based on the plan.	5.6 -5.14
Requirement 23. Reviewing state system of nuclear material management	--	5.15 -5.19
Requirement 24. Requirements regarding measures on	The measures shall be taken in order apply a comprehensive approach to	5.20 -5.21

Description of safety requirement	Requirement comment	Item No of publication No. SSR-5 [1]
providing physical nuclear safety	providing safety and physical nuclear safety at the RW disposal facility.	
Requirement 25. Control systems	Management system with respect to disposal facility shall provide for preparation and retention of documentary evidences to prove that a required quality of data has been reached; that the components have been supplied and are used according to applicable technical characteristics; that the waste packages and the unpacked waste correspond to the established requirements and criteria; and that they are properly arranged at the disposal facility.	5.20 -5.21
Requirement 26. Existing disposal facilities	-	6.2-6.3

3.1.2 Near surface disposal facilities for radioactive waste. Specific safety guide NO.SSG-29, 2014

The IAEA publication "Near surface disposal facilities for radioactive waste. Specific Safety Guide" No.SSG-29 [4] was issued in 2014 and is a Safety Requirements document of the IAEA Safety Standards Series.

The purpose of this Safety Guide [4] is to provide guidance and recommendations for the prestart period, operation, closure and regulatory control of near surface disposal of radioactive waste, which ensure meeting the safety requirements set out in SSR-5 [1].

This Safety Guide [4] provides general guidance for the design, construction, operation, closure and closed near surface radioactive waste disposal facilities, which are intended for the disposal of VLLW and LLW. This Safety Guide does not apply to intermediate-level waste (ILW), which does not decay to a safe level in several hundred years or high-level waste (HLW).

Transportation of waste to near surface disposal facilities shall be carried out in accordance with the requirements of the Regulations for the Safe Transport of Radioactive Material. IAEA Safety Standards Series No.SSR-6, 2012 edition.[7]

The document [1] consists of 8 sections. Section 2 provides an overview of the concepts of near surface disposal. Section 3 provides a description of the legal and institutional infrastructure. Section 4 sets out security issues during the development and operation of a near surface disposal facility. Section 5 provides a description of the security strategy and the preparation of safety assessment. Section 6 provides the guidance for phased development, operation and closure of the near surface disposal facility. Section 7 provides a description of security safeguards and agreements on Section 8 with the existing treatment facilities. Annexes I and II provide additional information and guidance on the location of near surface treatment facilities, particularly regarding the data requirements.

SSR-5 [1] establishes 26 safety requirements, which apply to near-surface disposal of radioactive waste. For convenience and traceability, the text of each SSR-5 [1] requirement is quoted in this Safety Guide and is accompanied with recommendations.

The safety requirements with an indication of clauses from publications Nos. SSR-5 [1], SSG-14 [3] and SSG-29 [4], which disclose these requirements and provide recommendations for near surface radioactive waste disposal facilities and disposal facilities in geological formations, are provided in Table 33.

3.1.3 Geological disposal facilities for radioactive waste. Specific safety guide No. SSG-14

The IAEA publication "Geological disposal facilities for radioactive waste. Specific Safety Guide" No. SSG-14 [3] was issued in 2011 and is a Safety Requirements document of the IAEA Safety Standards Series.

The purpose of this document is to provide guidance and recommendations on the development and regulatory control of geological radioactive waste disposal facilities, which will ensure compliance with the safety requirements set out in SSR-5 [1].

The scope of the document is safe development of underground disposal facilities. This does not apply to disposal facilities in boreholes. Disposal of radioactive waste in pre-existing workings can be considered, but it requires meeting the same safety requirements set out in SSR-5 [1].

This document considers the problems associated with the development of geological disposal facilities after the site has been selected. It should be noted that the development covers a range of activities from the initial conceptual design and site selection through to the confirmation of the site for the construction of the treatment facility. General recommendations regarding the technical and scientific aspects of development are provided in the Annex I.

Transportation of waste to geological disposal facilities shall be carried out in accordance with the "Regulations for the Safe Transport of Radioactive Material". IAEA Safety Standards Series No.SSR-6, 2012 edition. [7]

SSR-5 [1] establishes 26 safety requirements that apply to geological disposal of radioactive waste. For convenience and traceability the text of each SSR-5 [1] requirement is quoted in this Safety Guide and is accompanied with recommendations.

The safety requirements with an indication of clauses from publications Nos. SSR-5 [1], SSG-14 [3] and SSG-29 [4], which disclose these requirements and provide recommendations for near surface radioactive waste disposal facilities and disposal facilities in geological formations, are provided in the Table 33.

Table 33: Safety Requirements with an indication of clauses of publications Nos. SSR-5 [1], SSG-14 [3] and SSG-29 [4]

Name of the safety requirement	Numbers of clauses of IAEA standards		
	№ SSR-5	№ SSG-29	SSG-14
Requirement 1. Responsibility of the state	3.6-3.7	3.2-3.5	3.3-3.4
Requirement 2. Responsibility of the regulatory authority	3.8-3.11	3.6-3.10	3.3-3.4
Requirement 3. Responsibility of the operator	3.12-3.16	3.11-3.15; 4.1-4.2	3.8-3.13; 4.1-4.2
Requirement 4. The importance of safety assurance during the design and operation of a disposal facility	3.17-3.20	4.5-4.17	4.3-4.7
Requirement 5. Passive safety facilities of the disposal facility	3.21-3.25	4.43 -4.46	4.17-4.18; 5.1-5.5
Requirement 6. Awareness of the disposal facility and confidence in safety	3.26-3.34	5.34-5.38	5.25-5.26
Requirement 7. Multiple safety functions	3.35-3.38	4.35 -4.42	4.13-4.16
Requirement 9. Isolation of radioactive waste	3.39-3.42	4.18-4.26	
Requirement 10. Supervision and control of passive safety facilities	3.43-3.47	4.27 -4.34	4.10-4.12
Requirement 11. Phased development and assessment of disposal facilities	3.48; 4.1	4.47 -4.51	6.65-6.66
Requirement 12. Preparation, approval and use of safety justification and safety assessment of the disposal facility	4.2-4.11	6.1-6.5	6.1-6.3
Requirement 13. The content of safety justification and safety assessment	4.12-4.14	5.2 -5.11	5.6-5.7
Requirement 14. Documentation of safety justification and safety assessment	4.15-4.22	5.12 -5.27	5.8-5.19
Requirement 15. Characterization of the site for the disposal facility	4.23 -4.25	5.28 -5.33	5.20-5.24
Requirement 16. Disposal facility design	4.26 -4.29	6.6 -6.18	6.4-6.24
Requirement 17. Construction of the disposal facility	4.30 -4.32	6.19 -6.28	6.25-6.35
Requirement 18. Operation of disposal installation	4.35 -4.37	6.47 -6.61	6.47-6.55
Requirement 19. Decommissioning of disposal installation	4.38 -4.41	6.62 -6.73	6.56-6.59
Requirement 20. Waste acceptability at the disposal installation	5.1 -5.3		6.36-6.41
Requirement 21. Monitoring programs at the disposal installation	5.4 -5.5	7.1 -7.5	6.60-6.64
Requirement 22. Period after decommissioning and institutional control means	5.6 -5.14	7.6 -7.15	6.67-6.68
Requirement 23. Examination of	5.15 -5.19	7.16 -7.17	6.69-6.74

governmental system of nuclear material accounting and control			
Requirement 24. Requirements for the arrangements for physical nuclear safety	5.20 -5.21	7.18 -7.19	6.75-6.76
Requirement 25. Control systems	5.22 -5.26	7.20 -7.33	6.77-6.84
Requirement 26. Existing disposal installations	6.2 -6.3	8.1 -8.10	6.85-6.92

3.2. OVERVIEW OF THE IAEA SAFETY REQUIREMENTS FOR PREDISPOSAL MANAGEMENT OF RADIOACTIVE WASTE

Requirements for predisposal management of radioactive waste are specified in the IAEA documents:

- Predisposal management of radioactive waste. IAEA Safety Standards Series, No.GSR, Part 5, 2010 [8];
- Predisposal management of low- and intermediate-level radioactive waste. Security Guide. IAEA Safety Standards Series. WS-G-2.5, 2005 [9];
- Predisposal management of high-level radioactive waste. Security Guide. IAEA Safety Standards Series, No. WS-G-2.6, 2003 [10];

3.2.1 Predisposal management of radioactive waste, IAEA general safety requirements part 5, 2010

The IAEA publication "Predisposal management of radioactive waste. General Safety Requirements" No. GSR, Part 5 [8] was issued in 2010 and is a Safety Requirements document of the IAEA Safety Standards Series.

The purpose of the IAEA publication "Predisposal management of radioactive waste. General Safety Requirements" No. GSR, Part 5 [8] is to establish the requirements that shall be met during predisposal management of radioactive waste on the basis of the principles specified in ref. [2]. These requirements include both mandatory and recommended requirements.

The document [8] is applicable to the predisposal management of radioactive waste of all types and covers all stages of managing this waste (from its generation to disposal), including processing (pre-treatment, treatment and conditioning), storage and transportation. Such waste may generate as a result of commissioning, operation and decommissioning of nuclear installations, use of radionuclides in medicine, industry, agriculture, research and education, processing of materials containing natural radionuclides and rehabilitation of contaminated sites.

The document structure [8] is similar to the structure of publications on disposal of radwaste. The issues of human health and environment protection are considered in Section 2 of this publication. Section 3 examines the requirements in terms of the duties related to predisposal management of radioactive waste. The requirements regarding the basic approaches to predisposal management of radioactive waste and the elements of this management are set out in Section 4. Section 5 establishes requirements for the safe design and operation of facilities for predisposal management of radioactive waste and for safe operations. The Annex contains the results of the discussion regarding the compliance of the safety requirements set out in this publication with the fundamental safety principles [2].

The document [2] sets out the safety requirements relating to predisposal management of radioactive waste. B. The specified requirements and the clauses of the publication revealing their contents are listed in Table 34.

Table 34: Safety requirements for predisposal management of radioactive waste.

Name of the safety requirement	Wording of the requirements	Numbers of clauses of publication No.GSR, Part 5 [8]
Requirement 1: a legal and regulatory framework	The Government provides an appropriate national legal and regulatory framework, within which it is possible to plan and safely implement radioactive waste management activities.	3.4
Requirement 2: a national policy and strategy for radioactive waste management	To ensure effective management and control of radioactive waste, the government ensures the development of a national policy and strategy for radioactive waste management. The policy and strategy shall be appropriate to the nature and volume of radioactive waste in the state, and shall specify the required regulatory control and take into account relevant social factors.	3.5-3.6.
Requirement 3: responsibility of the regulatory authority	The regulatory authority sets the requirements for the development of radioactive waste management facilities and kinds of activities, and introduces compliance procedures at various stages of the licensing process.	3.7.-3.10.
Requirement 4: responsibility of the operator	Operators shall be responsible for the safety of facilities or radioactive waste predisposal management activities. The operator shall perform safety assessments and develop a safety justification, as well as ensure that all necessary activities for selecting the site, design, construction, commissioning, operation, shutdown and decommissioning are conducted in accordance with the legal and regulatory requirements.	3.11-3.18
Requirement 5: requirements for	Measures are taken to ensure the use of an integrated approach to safety and physical safety in	3.19-3.20

Name of the safety requirement	Wording of the requirements	Numbers of clauses of publication No.GSR, Part 5 [8]
physical safety measures	predisposal management of radioactive waste.	
Requirement 6: interdependence	Interdependence of all stages of predisposal management of radioactive waste, as well as the impact of the expected disposal option is properly taken into account.	3.21-3.23
Requirement 7: control systems	Control systems apply to all stages and elements of predisposal management of radioactive waste.	3.24
Requirement 8: generation and control of radioactive waste	All radioactive waste is determined and controlled. Generation of radioactive waste is kept as low as reasonably practicable.	4.6-4.9
Requirement 9: characterization and classification of radioactive waste	Characteristics and classification of radioactive waste are determined at various stages of predisposal management of radioactive waste in accordance with the requirements established or approved by the regulatory authority.	4.10-4.12
Requirement 10: processing of radioactive waste	….Processing of radioactive waste is based on proper consideration of characteristics of waste and requirements imposed by the various stages of their management (pre-treatment, treatment, conditioning, transportation, storage and disposal). Waste packages are designed and manufactured so that radioactive material can be properly maintained under normal operation and accident conditions that may arise when handling waste, during its storage, transportation and disposal.	4.13-4.18
Requirement 11: storage of radioactive waste	Waste shall be stored in such a way to ensure the possibility of its inspection, monitoring, retrieval and preservation in a condition suitable for further handling. Due accounting shall be ensured depending on the expected period of storage, and, as far as possible, passive safety features shall be applied. In particular, in the case of long-term storage, measures shall be taken to prevent degradation of the external waste containment.	4.19-4.23
Requirement 12: radioactive waste acceptance criteria	Waste packages and unpackaged waste suitable for processing, storage and/or disposal shall meet certain criteria in accordance with the safety justification.	4.24-4.25

Name of the safety requirement	Wording of the requirements	Numbers of clauses of publication No.GSR, Part 5 [8]
Requirement 13: preparation of safety justification and auxiliary safety assessment	The operator shall prepare safety justification and auxiliary safety assessment. In the case of phased development or in the case of modification of the facility or activity, the safety justification and the related auxiliary safety assessment are reviewed and updated, as required.	5.3-5.4
Requirement 14: the content of safety justification and auxiliary safety assessment	The safety justification of a facility for predisposal management of radioactive waste shall include a description of how all aspects of site safety, design, operation, shutdown and decommissioning, as well as management control measures meet the regulatory requirements.......	5.5-5.7
Requirement 15: documentation of the safety justification and auxiliary safety assessment	The safety justification and the related auxiliary safety assessment shall be documented with the details and quality sufficient to confirm safety, to justify the decisions made at each stage and to enable conducting an independent review and approval of the safety justification and safety assessment....	5.8-5.10
Requirement 16: periodic safety review (survey)	The operator shall conduct periodic safety reviews (surveys) and perform any safety upgrades requested by the regulatory authority after these reviews. The results of the periodic safety review shall be reflected in the updated version of the safety justification of the facility	5.11-5.12
Requirement 17: location and designing of facilities	Facilities for predisposal management of radioactive waste shall be placed and designed in such a way as to provide safety over the expected service life under both normal and emergency conditions, and during their decommissioning.	5.13-5.14
Requirement 18: construction and commissioning of facilities	Construction of facilities for predisposal management of radioactive waste shall be carried out in accordance with the project, which is described in the safety justification and approved by the regulatory authority. Commissioning of the facility is carried out to check that the equipment, structures and system elements, as well as the facility as a whole, properly operate.	5.15-5.18
Requirement 19:	Operation of facilities for predisposal management of	5.19-5.20

Name of the safety requirement	Wording of the requirements	Numbers of clauses of publication No.GSR, Part 5 [8]
operation of the facility	radioactive waste shall be carried out in accordance with national regulations and conditions prescribed by the regulatory authority...	
Requirement 20: shutdown and decommissioning of facilities	During the design stage, the operator shall develop an initial plan for shutdown and decommissioning of facilities for predisposal management of radioactive waste, and periodically update it throughout the period of operation. Decommissioning of a facility is based on the final decommissioning plan approved by the regulatory authority. Furthermore, the availability of sufficient financial resources for the implementation of shutdown and decommissioning are guaranteed [12]	5.21-5.23
Requirement 21: Accounting and control system for nuclear material	With regard to the facilities covered by the agreements on nuclear material accounting, the system of accounting and control of nuclear material shall be used during the design and operation of facilities for predisposal management of radioactive waste in such a way as not to jeopardize the safety of the facility	5.24
Requirement 22: existing facilities	In order to check compliance with the requirements, safety issues are reviewed at the existing facilities. Safety-related update is performed by the operator in accordance with the national policy and the requirements of the regulatory authority	5.25

3.2.2 Predisposal management of low and intermediate level radioactive waste, IAEA safety guide No. WS-G-2.5, 2005

The present Safety Guide “Predisposal Management of Low and Intermediate Level Radioactive Waste, IAEA Safety Guide No. WS-G-2.5” [9] contains the recommendations on the problems concerning the enforcement of safety requirements during the management of low and intermediate level radioactive waste before disposal that are formed at the enterprises of nuclear fuel cycle (excepting the enterprises engaged in extraction and processing of uranic and thorium ores), on the big research and pilot installations and enterprises on production of radioisotopes. Low- and Intermediate Level Waste (LILW) is considered to be radioactive waste, which level of radiological hazard is lower than in comparison with the high level waste but which is an object of regulatory control (i.e. that was not recognized as acceptable for release from the regulatory control).

The aim of the present Safety Guide [9] is to provide the regulating authorities and operators, whose activity results in the formation of the radioactive wastes or who carry out management of wastes, with recommendations on following the principles and requirements specified in [8] for LILW management before disposal.

LILW management before disposal includes all steps or types of activity on waste management from formation of primary waste to its placement into depository or at other site for final disposal, or by releasing it from regulatory control. It may include pre-treatment, processing, conditioning, decommissioning, storage, preparation works on transportation as well as any types of activity related to abovementioned, such as characterizing of primary wastes, wastes form and packages with waste at the relevant stages of processing before transfer of packages of waste to the depository or release of regulatory control (1.7 [9]).

Pre-treatment can include collection of wastes, sorting, control of chemical composition and deactivation. Processing includes operations of change of characteristics of radioactive wastes that were directed to improve the safety level and/or economic indicators. The main aims for processing are the following: volume decrease, extraction of radionuclide and change of waste composition. Conditioning of low and intermediate level waste consists of the operations that allow transferring the radioactive waste into the form useful for further actions like handling, transportation, storage and disposal. These operations can include waste containment, waste emplacement in containers or use of additional packages. Storage means waste emplacement in the plant, which secures insulation of waste, environmental protection and monitoring. It is an intermediate stage in waste management that provides the possibility for extraction of waste in future for release from the regulatory control, processing and/or disposal.

Management of LILW before disposal can be fulfilled on a separate special dedicated installation or on a separate site within bigger installation operated for other purposes. In the present Safety Guide a term “installation” refers to both of them, and the term “operator” refers to operating company or operator of installation designed for waste management, or to the producer of wastes, who is also engaged in waste management before disposal.

In addition to radiological hazard LILW can have additional non-radiological hazard caused by its physical, chemical or pathogenic features that should be considered when handling the waste before disposal (paragraph 1.8-1.10 [9]).

Radioactive waste management includes decommissioning before disposal. The term “decommissioning” refers to both a process of decommissioning itself and management of wastes resulted from this decommissioning (before disposal). Recommendations on waste management caused by decommissioning are included in the present Safety Guide (п.1.13 [9]).

Waste characterization and acceptance criteria

It is necessary to make characterization (determine features and characteristics) of LILW at various stages of management before its disposal in order to get some information concerning the characteristics of waste that will be used for product quality control and technological process control and therefore to simplify further steps in the process of safe processing and final disposal of LILW (4.10 [9]).

Required data concerning the characteristics and methods of data collection will be different depending on LILW type and form (liquid or solidified LILW). When processing various flows of waste the characterization can be fulfilled by sampling and analysis of chemical, physical and radiological properties of wastes. Quality of waste packages can be defined by nondestructive and rarely destructive methods. But to avoid excessive radiation of personnel it is allowed to use indirect methods of characterization, instead of sampling and check of packages or additionally, that are based on control of process and information concerning the process itself. The methods of waste characterization during waste processing are recommended to be agreed in the regulating authority in the frames of official permit issuing process (4.11 [9]).

It is required to ensure that the important aim of LILW management before disposal should be getting of such waste packages, which can secure safety at fulfillment of handling, transportation, storage and disposal. In particular, LILW should be conditioned in order to provide enforcement of requirements of acceptability for disposal. To secure the sufficient guarantee that conditioned waste can be accepted for disposal in case of possible absence of any established specific requirements, it is necessary as much as possible to provide the variants of LILW management in future and the requirements of waste acceptability accordingly. Accomplishment of requirement of waste acceptability can be achieved if to use a transportation package which will be in compliance with the specific conditions at the site of storage and LILW characteristics as well as with engineering components of installation for disposal. Typical properties and characteristics are listed in Annex II that should be considered for waste packages at LILW management before disposal (4.12 [9]).

The program on development of conditioning process should be provided to ensure the acceptability of waste packages for disposal. The program is subject to be approved by the regulating authority. It will be secured that the parameters chosen for waste characterization and for process control ensure availability of necessary properties of waste packages (4.13 [9]).

Technical requirements for conditioned LILW are set in order to ensure that the waste packages satisfy the relevant acceptability criteria for transportation, storage and disposal. Specifications for waste packages are defined to secure the compliance of final product (waste package) with the acceptability criteria applied, in particular, for disposal. Radiological characteristics of waste (concentration of radionuclides, activity and dose rate) are the most important and are defined at early stage. Other technical requirements for packages can be divided into the following four groups: chemical and physical features, mechanical characteristics, holding power and stability. Feature “stability” refers to the property of packages to keep radionuclides within long period of time (Annex II [9]).

Technical requirements for waste packages according to Annex II [9] are given below.

Chemical and physical properties

Chemical and physical characteristics of waste form include:

a) chemical composition;
b) density, porosity, water and gas permeability;
c) waste homogeneity and its compatibility with matrix;
d) thermal stability;
e) percentage content of bound water, discharge from water pores (exudation) at compressive stress, shrinkage and consolidation;
f) leachability and corrosion rate.

Chemical and physical characteristics of containers include:

a) container material;
b) porosity, water and gas permeability;
c) specific heat conductivity;
d) solubility and corrosion in corrosive atmosphere or liquids such as water or brines;
e) quantity of interstice in container (it should be minimum);
f) characteristics of shut-off and sealing units;
g) sensitivity to temperature change.

Mechanical properties

Mechanical properties of waste form include tensile strength, compression strength and stability of geometrical dimensions.

Mechanical properties of waste packages include behavior of packages at mechanical (static and impact) or thermal loads.

Holding capacity

Holding capacity of waste packages defines:

a) diffusion and leachability of radionuclides in aqueous media;
b) gas yield at normal atmospheric conditions or in depository environment;
c) tritium diffusion at normal atmospheric conditions or in depository environment;
d) ability to fix and to keep radionuclides;
e) water and gas tightness of sealing units of packages.

Stability

Stability of waste packages defines:

a) behavior during cyclical temperature changes;

b) sensibility to higher temperatures and behavior in case of fire;
c) behavior in conditions of long radiation influence;
d) sensibility of matrix to contact with water;
e) resistance to influence of microorganisms.

Processing of LILW

Processing of LILW includes operations on pre-treatment such as waste collection, sorting, chemical composition control and deactivation.

The first stage in pre-treatment of LILW is selection of waste of radioactive materials and if necessary wastes sorting depending on radiological, physical, chemical or pathogenic properties. LILW containing mostly short-lived radionuclides should not be mixed with long-lived waste. While sorting the waste, the possibility for its release from regulatory control, recycling or discharge to environment either immediately or by expiration of decay period should be considered (5.10 [9]).

To simplify further processing and to improve safety the solid LMIW should be sorted in accordance with the general strategy of waste management and with taking into consideration the actual installations. Sorting provided includes division into:

a) burning and non-burning components, if burning is possible;
b) pressed and non-pressed components, if compacting is possible;
c) metallic or non-metallic components, if remelting is possible;
d) components with fixed (non-taken) or non-fixed (taken) surface radioactive pollution, if deactivation is possible.

When sorting it is necessary to pay special attention to materials and objects that are of ignition alloy, highly explosive, chemically active or have other hazardous properties, or which contain free liquid or compressed gases (paragraph 5.11 [9]).

LILW management, especially sorting and pre-treatment is fulfilled in order to minimize the quantity of radioactive waste which should be processed, stored and disposed. It is necessary to use, how it is possible from practical point of view, such options of management as permitted discharges, disposal, reversed waste collection, recycling and release from material regulatory control in accordance with the conditions and criteria established by regulating authority. In relevant cases it is necessary to use deactivation and/or sufficiently long-term period of storage during which radioactive decay occurs in order to make it possible to release waste materials from regulatory control (paragraph 5.15 [9]).

Before conditioning of large-size waste or waste having non-standard sizes for this operation (for example, in case of conditioning of worn parts and devices) it is possible to use fragmentation or dismantling and other methods for reduction of sizes. Usually for this purpose they use cutting with high temperature flame, various methods of sawing, hydraulic cutting, abrasive and PTA cutting. When choosing a method and operating the equipment it is required to examine the methods for preventing spreading of pollution in the form of particles (paragraph 5.24 [9]).

Direct conditioning without pretreatment should be considered for non-burning and non-pressed solid waste, for which equalizing until the decay or deactivation is not applicable. Re-melting of metallic scrap constituting LILW which leads to homogenization of radioactive material and its accumulation in the slag can be considered as a method providing the ability for authorized reuse of material or its removing from the regulatory control (paragraph 5.25 [9]).

Conditioning

Conditioning of LILW consists of operations which result in getting the waste packages suitable for safe management, transportation, storage and disposal. Conditioning can include immobilization of liquid or dispersed waste, location of waste into container and ensuring (if necessary) the transport package (5.31 [9]).

It should be ensured that the waste packages resulting from conditioning meet the applicable acceptability criteria. Therefore, it is required to consult with the regulating authority and companies conducting or planning to provide services of transportation and storage, as well as with the operators of facilities for storage and disposal when making decisions concerning the required type of pretreatment, processing and conditioning (5.32 [9]).

Requirements to solid LILW should be set in every specific case. Characteristics of the waste form listed above are applied for many types of solid LILW. Some of these characteristics (in particular, homogeneity and low porosity) are not used for definite types of solid LILW (5.34 [9]).

It should be considered that definite metals such as aluminum, magnesium and zirconium can react to, for example, alkaline water of cement mixture or water diffusing from cement matrix with formation of hydrogen. It should pay attention to the content of chelating agents, organic liquids or oils, as well as to salt content of liquid waste (5.35 [9]) when conditioning.

It is required to secure compatibility between the wastes and containers for it. Depending on waste characteristics and management method, transportation and storage the container can be necessary also as protection from direct radiation. When selecting the material for container and its outer coating it is required to pay attention to convenience for deactivation performance. If container initially was designed without considering the relevant requirements and does not comply with acceptability criteria for transportation, storage or disposal an extra container or unit load will be required in order to fulfill these criteria. It is required to pay attention to compatibility of waste package and unit load considering technical requirements to the acceptability of wastes (5.36 [9]).

In case of considerable delay in taking a decision concerning the admissible method for disposal it is required to ensure that the container will keep integrity within entire period of storage until disposal as well as it is required to secure (5.37 [9]):

a) possibility for its extraction by termination of storage period;
b) possibility for its location into container, if necessary;
c) possibility for its transportation and handling on the disposal installation;
d) performance required in the conditions of disposal.

3.3 OVERVIEW OF IAEA SAFETY STANDARDS ON CLASSIFICATION OF RADIOACTIVE WASTE AND ITS TRANSPORTATION

3.3.1 Classification of radioactive waste, IAEA General Safety Guide No. GSG-1, 2009

IAEA Publication «Classification of Radioactive Waste for protecting people and the environment, IAEA General Safety Guide No. GSG-1» [2] was issued in 2009.

The purpose of this Safety Guide [2] is to define the general classification scheme of radioactive waste based primarily on long-term safety considerations and thus, indirectly, on the issues of waste disposal. This Safety Guide, along with other IAEA safety standards relating to radioactive waste, will promote the development and implementation of appropriate waste management strategies and facilitate the exchange of views and information within and among countries. As provided in the publications devoted to the requirements of safe management of radioactive waste prior to and during disposal, [9, 1], waste disposal is the last stage of radioactive waste management.

This Safety Guide [2] provides guidance on the classification of the whole series of radioactive waste: from spent nuclear fuel at the stage when it is considered to be radioactive waste, through to waste with such low activity concentration levels that there is no need to handle or manage it as radioactive waste. This Safety Guide [2] applies to spent closed sources when they are deemed to be waste, as well as waste containing naturally occurring radionuclides. The recommendations contained in this Safety Guide [2] apply to waste from all sources, including waste generated at facilities and as a result of relevant activities, waste generated in the current conditions, and waste that may originate from accidents.

The document consists of two sections, an appendix and three annexes. The radioactive waste classification scheme is set out in Section 2. The Appendix reveals issues of general scope and target functions of the radioactive waste classification schemes. It specifies the purpose and limitations of the classification scheme described in this Safety Guide, as well as explains the approach taken in the development of the radioactive waste classification scheme. The Appendix also examines the criteria of waste handling and waste management operations, which are taken into account in determining the classes of waste. Annex I describes the development of the IAEA safety standards in terms of radioactive waste classification. Annex II deals with different goals and approaches to the classification of waste, as well as qualitative and quantitative methods of waste classification. Annex III describes various types of radioactive waste and demonstrates the use of the waste classification scheme developed in this Safety Guide in respect of these types of radioactive waste.

In accordance with the approach set out in the Appendix [2], six classes of waste were singled out and used as the basis for the classification scheme:

1) Exempted waste [2] (EW): waste that meets the criteria for withdrawal of regulatory control, exemption from regulatory control or withdrawal of regulatory control for the purpose of radiation protection.

2) Very short-lived waste (VSLW): waste that can be stored for decay for a limited period of time (up to several years), and then be withdrawn from regulatory control in accordance with the procedure for uncontrolled disposal, use or dumping approved by the regulatory body. This class includes waste containing mainly radionuclides with a very short half-decay period, which are frequently used for medical and research purposes.

3) Very low-level waste (VLLW): waste that does not necessarily meet the criteria of EW, but which does not require a high level of containment and isolation and, therefore, is suitable for disposal in near surface disposal facilities (trenches backfilled with earth) with limited regulatory control. Earth backfill disposal trenches may also contain other hazardous waste. Typical waste attributable to this class includes soil and rubble with low activity concentration levels. Concentrations of long-lived radionuclides in VLLW are generally very limited.

4) Low-level waste (LLW): waste exceeding the level of regulatory control withdrawal, but with a limited amount of long-lived radionuclides. Such waste requires robust isolation and containment for up to several hundred years; it is suitable for disposal in near-surface facilities with engineering barriers. This class includes a very wide range of waste. LLW may include short-lived radionuclides with higher activity concentration levels, as well as long-lived radionuclides, but only with relatively low levels of activity concentration.

5) Intermediate-level waste (ILW): waste that, due to its content, especially which of long-

[2] The term "exempted waste" was taken from the previous classification scheme in order to maintain consistency; however, immediately after withdrawal of regulatory control such waste is no longer deemed radioactive waste.

lived radionuclides, requires a greater degree of localization and isolation than it is provided for by the criteria for near-surface disposal. Nevertheless, ILW does not need the provision nor needs only limited provision of heat dumping during storage and disposal. ILW may contain long-lived radionuclides, in particular alpha-emitting radionuclides that do not decompose to a level of activity concentration which is acceptable for near-surface disposal for the period of institutional control measures implementation. Thus, this class waste requires disposal at great depths, from tens to hundreds of meters.

6) High-level waste (HLW): waste with sufficiently high levels of activity concentration to generate a significant amount of heat in the process of radioactive decay or waste with a large amount of long-lived radionuclides that must be taken into account when designing the disposal facility for such waste. Disposal in stable deep geological formations, generally at a depth of several hundred meters or more from the surface is the commonly recognized option for HLW disposal.

It is impossible to provide clear distinction between LLW and intermediate-level waste (ILW) as the limits for the acceptable level of activity concentration will vary between individual radionuclides or groups of radionuclides. Acceptability criteria for near-surface disposal of waste depend on the factual aspects of the facility design and plan (for example, engineering barriers, duration of institutional control, factors pertaining to a particular site). Restrictions on the activity concentration level of long-lived radionuclides in individual waste packages can be supplemented by restrictions regarding the average activity concentration levels or simple operational methods, such as placement of waste packages with higher levels of activity concentration in individual selected locations within the disposal facility . Suitability of facilities for disposal of a certain physical amount of waste shall be demonstrated as part of the Safety Case for the facilities.

The design options for LLW disposal facility may vary from simple to more complex engineering structures, and may also include disposal at various depths, usually from surface level to 30 meters deep. The options depend on safety evaluations and national practices and are subject to approval by the regulatory body.

In many countries the institutional control is considered reliable within the period of approximately up to 300 years….

In earlier classifications, low-level waste was defined as radioactive waste that does not require shielding during normal handling and transport. Radioactive waste for which shielding is required, but only slight cooling or no cooling at all is needed, was classified as intermediate-level waste. For differentiating between these two waste classes, radiation dose rate of 2 mSv/h was usually used. Radiation dose rate is not used for differentiation between waste classes in the current classification, which is primarily based on long-term safety criteria. Nonetheless, this remains an issue to be considered during waste handling and transport, as well as for the purposes of radiation protection during operation of waste processing facilities and repositories, but does not necessarily have to be the decisive factor for long-term safety of the repository.

3.3.2 Regulations for the safe transport of radioactive material, IAEA specific safety requirements NO.SSR-6, 2012

IAEA publication "Regulations for the Safe Transport of Radioactive Material, IAEA Specific Safety Requirements No.SSR-6" was issued in 2012 and is a document of "Safety Requirements" category in IAEA safety standards series [7].

The aim of the present Rules [7] is to establish the requirements that should be fulfilled to secure safety and protection of people, property and environment from radiation effect during transportation of radioactive material. This protection is achieved by application of the following:

a) measures for holdup of radioactive contents;
b) control for outer levels of radiation;
c) criticality prevention actions;
d) prevention of damage resulting from heat release.

Fulfillment of these requirements is provided, firstly, by application of differentiated approach to the limits of packages contents and transportation means, as well as to the regulatory characteristics of package structures depending on a hazard constituted by radioactive contents. Secondly, they are fulfilled by establishment of requirements concerning structure and operation of packages as well as by maintenance of package sets as well considering the nature of radioactive contents. At last, the requirements are fulfilled by obligatory application of measure of administration control including procedures of approval by competent authorities, when necessary.

When transporting radioactive materials, the safety of people and protection of property and environment is achieved by observance of the present Rules [7]. Confidence in such observance is achieved by means of control systems and programs of enforcement of Rules.

The present Rules [7] are applied to transportation of radioactive material by all types of surface, water or air transport including transportation related to use of radioactive material. Transportation includes all operations and conditions related to movement of radioactive material and comprise this process, in particular designing, production, maintenance and repair of packing set, as well as preparation, loading, sending, transportation, including transit storage, discharge and unloading in final destination of cargos of radioactive materials and packages. Differentiated approach is applied in the present Rules when establishing regulatory characteristics in accordance with which these characteristics reflect three general levels of difficulty of transportation conditions:

a) general transportation conditions (without any incidents);

b) normal transportation conditions (insignificant accidents);
c) accident conditions of transportation.

The present rules do not cover:

a) radioactive materials that are an integral part of transportation means;

b) radioactive materials, moved within some institution to which the relevant safety rules are applied and are valid in this institution when movement does not suppose any use of general-duty motor roads or railway roads;

c) radioactive materials implanted or inserted into the human organism or animal with the purpose of diagnostics or medical treatment;

d) radioactive material inside the body or on the body of human who is subject to transportation for medical treatment as this human was exposed to casual or intended entering of radioactive material or pollution effect;

e) radioactive materials in consumer goods allowed by regulating authority for use after sale of them to the end user;

f) natural materials and ores containing natural radionuclides, which could be processed provided that specific activity concentration of such material does not exceed more that in 10 times of value specified in Table 2, or calculated in accordance with paragraphs 403 a) and 404-407 [7]. Calculation of activity concentration should be done in accordance with paragraph 405 [7] for natural materials and ores containing natural radionuclides which are not in secular equilibrium;

g) non-radioactive solid objects with radioactive substances on any surfaces in the quantities not exceeding the limit specified in paragraph 214 [7].

The present Rules [7] do not provide such control measures as route choice or provision of physical protection that can be established under the causes that are not connected with radiation safety. Any such control measures should take into consideration the radiation and non-radiation hazards without deviation from safety standards prescribed by the present Rules.

It is necessary to take reliable measures for provision of preservation of radioactive material during transportation to the intent that prevent stealing or damage and for exclusion of relevant weakening of control over the material (see Annex I).

The relevant rules of transportation of hazardous cargos are applied in respect of radioactive materials related to additional risk as well as in respect of transportation of radioactive material together with other hazardous cargos in addition to the present Rules.

Section II [7] is provided in the structure of this publication where definitions of terms are given, which are necessary for the purposes of the present Rules; Section III [7] describes general regulations; Section IV [7] contains the activity limits and restrictions in respect to the materials used when describing the present Rules; Section V [7] describes the requirements and measures of control when transporting; Section VI [7] contains the requirements to radioactive materials, packing sets and packing; Section VII [7] describes the requirements to the tests; Section VIII [7] contains the requirements in respect to approval and administration control.

The requirements for radioactive waste packages are given below, which can be in demand when forming the packing for transportation and disposal of waste formed when decommissioning of reactor compartment in Paldiski.

- 409 [7] Materials with LSA are included in one of three groups:

a) LSA-I

b) LSA-II

i) water with tritium concentration up to 0.8 TBq/l;

ii) or other materials in which the activity is distributed over the entire volume and set average specific activity does not exceed 10^{-4} A_2/g for solid and gaseous substances and 10^{-5} A_2/g for liquids.

c) LSA-III

Solid materials (for example, jointed wastes and activated substances), excluding powders meeting the requirements specified in paragraph 601 [7], where:

i) radioactive material is distributed by entire volume of solid material or group of solid objects or, generally, evenly distributed in solid compact jointing material (such as concrete, bitumen and ceramics);

ii) radioactive material is relatively insoluble or structurally contains in relatively insoluble matrix and therefore even when disrupting the packing set, the leakage of radioactive material in calculation per packing as a result of leaching in case of being in water during seven days will not exceed 0.1 A_2;

iii) set average specific activity of solid material without any protective material does not exceed 2 x 10 $^{-3}$ A_2/g.

– 521 [7]. Materials with LSA and SCO excepting the cases listed in paragraph 520 [7] should be packed according to Table 5[8]. The data from Table 5 [8] are given in Table 35 of the present report.

Table 35: Requirements for industrial packaging for materials with LSA and SCO

Radioactive contents	Type of industrial packaging	
	Exclusive use	Non-exclusive use
LSA-I Solid substance [3] Liquid	Type IP-1 Type IP-1	Type IP-1 Type IP-2
LSA -II Solid substance Liquid and gas	Type IP-2 Type IP-2	Type IP-2 Type IP-3
LSA-III SCO -II	Type IP-2 Type IP-1 Type IP-2	Type IP-3 Type IP-1 Type IP-2
[a] In the conditions specified in paragraph 520 the material LSA-I and SCO-I can be transported unpacked.		

The requirements to packaging type IP-2

– 624 [7]. Packaging certificated as type IP-2 should be designed so as to meet the requirements for Type IP-1 specified in paragraph 623 [7], and, in addition, being subject to tests specified in paragraphs 722 [7] and 723 [7], it should prevent:

a) leakage or dispersion of radioactive contents;

b) increase by more than 20% of maximal level of radiation on any outer surface of packaging.

The requirements to packaging type IP-3

– 625[7]. Packaging certificated as type IP-3 should be designed, so as to meet the requirements for Type IP-1, specified in paragraph 623 [7], and, in addition, the requirements specified in paragraphs 636-649 [7] (requirements to packaging type A).

3.4 LEGISLATIVE FRAMEWORK OF THE EUROPEAN UNION

As the Republic of Estonia is a member state of the European Union, it is covered by the requirements of EURATOM documents, which entails the need for detailed analysis of not only series of IAEA standards but also EURATOM Directives in the radioactive waste management and control of its transportation.

3.4.1 Overview of EURATOM directives in the management of radioactive waste

According to Directive No. 2011/70/EURATOM [13], establishing Community framework with respect to spent fuel and radioactive waste, the member states of EU should develop national programs on radioactive waste management that further will be reformed by political decisions into national law. Similar plan was developed and published in 2008 in the Republic of Estonia and it is advisory in nature.

Directive No. 2011/70/ EURATOM [13] recommends publishing separate legal acts in case of utilization of nuclear facility on the basis of comprehensive analysis directed to most complete securing of safety. Expert estimations (with attraction of independent international specialists) and public discussions should play an essential role in publishing of statutory acts.

Directive No. 2011/70/EURATOM [13] establishes the necessity for member state to have clear national policy in the field of radioactive waste management; to create national programs on disposal of radioactive waste including the plans for construction of radioactive waste storage facilities. The data on situation concerning the radioactive waste in the country should be accessible for general public. National legislation should be reviewed by the member state every decade. Export of radioactive waste out the EU is possible only under very strict regulated conditions.

Directive No. 2006/117/EURATOM [14], regulating transportation of radioactive waste and spent fuel, establishes that the responsibility for choice of policy in the field of transportation of radioactive waste and spent nuclear fuel in full is born by country of origin of waste. The member states of the EU have to cooperate in deciding the problem of safe management of radioactive waste and spent nuclear fuel, searching the most suitable way to escape the residual products resulted from operation of nuclear facilities. In case of making a decision concerning the removal of waste to other country it is required to conclude agreements in order to improve the efficiency of radioactive waste management and to secure high level of safety. Any transportation should be legal and under a contract in accordance with the applicable procedure with attaching the standard forms of documents established by EURATOM. There are a number of export restrictions.

Polluted territory should be regularly inspected for the purpose of influence on environment in accordance with Directive 2013/59/EURATOM [15]. Definitive strategy concerning the management of polluted territory should be made on the basis of inspections. All polluted equipment should be inspected for the purpose of possible harm to the environment. In all cases the research should include radiation exposure survey. Waste intended to be further processed or disposed should be taken into consideration and taken under control.

3.4.2 Main conclusions in the EURATOM directive concerning radioactive waste management

On the basis of conducted content analysis of EURATOM Directives related to management of radioactive waste it is reasonable to recommend to carry out reorganization of regulatory and legal framework of the Republic of Estonia related to radioactive waste management. As the national legislation is in the exclusive competency of member states of the EU, so it is possible to talk about independency and individuality of documents excepting complete compliance with the EURATOM recommendations and standards related to radioactive waste management and radiation safety. Making decisions concerning the final stage of fuel cycle should be based, first of all, on ethic component in non-burden of future generations by heritage of nuclear waste.

The problem concerning disposal of radioactive wastes is described in clause 11 of Directive 2011/70/EURATOM [13], where it is stated that the problem of disposal of radioactive wastes should be described in National plan of member state. In Euratom Treaty[2] , clause 37, it is said that each member state should submit a plan for disposal of radioactive waste to the European Commission. Studying this plan in the expert community the Commission makes a resume concerning the consequences of realization of this plan in respect of possible radiological pollutions. Clause 37 calls upon to secure a radiation protection of all member states. Therefore the evaluation of pollutions is conducted not only in respect of a country, which is an author of disposal plan.

Therefore the problem of national disposal should be studied at local regional level with further approval of expert community of the European Commission.

Publication of new regulatory acts and their introduction into the entire structure of legal framework of the Republic of Estonia is a very important step which results in formation of national policy related to safe waste management. Any amendments should not be accepted without having no evidence base, and should include economical budget analysis certifying the availability of sufficient quantity of budget funds for practical implementation of adopted standards.

Therefore when developing national regulatory and legal documents in the Republic of Estonia related to management of radioactive waste it is required to follow the EURATOM Directives:

- Council Directive 2011/70/EURATOM of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste [13];

[2]The Treaty establishing the European Atomic Energy Community (Euratom) (1957)

- Council Directive 2013/59/EURATOM of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation [15],

- Council Directive 2006/117/EURATOM of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel [14].

3.4.3 Basic findings with respect to directives of EURATOM on transportation of radioactive wastes

Provisions pertaining to export of radioactive wastes to the third country are laid down in Directive 2011/70/Euratom [13], Article 4:

Radioactive wastes are to be disposed by the EC member-country, where they have been produced before the moment an agreement between EC member countries or a third country comes into effect taking into account a criterion established by the European Commission in accordance with Article 16 (2) of Directive 2006/117/Euratom.

Before sending to the third country the EC member-country exporting the nuclear wastes and spent fuel is obliged to inform the European Commission on the content of such an agreement and take reasonable measures to confirm that:

a) the destination country has closed a corresponding agreement with the European Commission comprising regulations on management of nuclear fuel and radioactive wastes or is the party of the Single Convention on safe management of the nuclear wastes and spent fuel ("Single Convention");

b) the destination country has available corresponding programs for providing high level of safety on management of nuclear wastes and spent fuel equivalent to the provisions of this Directive;

c) before the moment of sending nuclear wastes and spent fuel to destination country the provisions on the disposal facilities of the destination country will be effective and governed on the basis of the rules on management of nuclear wastes and programs of the given state on the disposal thereof.

3.5 JOINT CONVENTION ON THE SAFETY OF SPENT FUEL MANAGEMENT AND ON THE SAFETY OF RADIOACTIVE WASTE MANAGEMENT

Joint Convention on the safety of spent fuel management and on the safety of radioactive waste management [79] is the first legal document directly aimed at the solution of these issues on a global scale. Document [79] was opened for signing on September 29, 1997, but became effective on June 18, 2001.

Joint Convention [79] is applicable to safety of management of SNF and RW produced as a result of operating nuclear reactors as well as to emissions of liquid or gaseous radioactive materials from nuclear installations into environment.

Document purposes [79]:

- attain and maintain high level of safety at management of SNF and RW through consolidation of national measures and international cooperation in the field of safety;
- ensure that effective protective means from potential threat are available at all stages of SNF and RW management so that to protect community and environment from harmful effect of ionizing radiation now and in future;
- prevent accidents with radiological consequences and mitigate consequences thereof in case they take place at any stage of SNF or RW management.

Joint Convention [79] consists of 44 Articles and 7 Chapters:

- Chapter 1 – Objectives, definitions and field of application.
- Chapter 2 – Safety during SNF management.
- Chapter 3 – Safety during RW management.
- Chapter 4 – General directions for ensuring safety.
- Chapter 5 – Other provisions.
- Chapter 6 – Meetings of participating countries.
- Chapter 7 – Conclusive provisions.

Chapter 2 [79] comprises general safety requirements; safety requirements to the facilities being designed and existing facilities for SNF management; requirements to location, designing and construction, operation of facilities on SNF management; requirement to assessing facility safety; requirements to SNF disposal.

Chapter 3 [79] gives a description of general safety requirements; safety requirements to the existing and preserved facilities for RW management; requirements to location, designing and construction of a facility on RW management; requirement to assessing facility safety; basic measures after facility closure.

Recommendations and requirements in the sphere of legislative and regulatory environments of the states, establishment of a governing authority, licensee's obligations, human and financial resources, quality control, radiation protection during operation, readiness to emergency situations and decommissioning are comprised by Chapter 4 [79].

Chapter 5 [79] comprises provisions on trans-border trafficking and closed sources withdrawn from service.

Chapters 6-7 [79] describe an order of adopting Convention [79] by the participating countries.

Chapter 5, Article 27 of Joint Convention on the safety of spent fuel management and on the safety of radioactive wastes management [79] governs the trans-border trafficking of radioactive wastes. Any displacements shall be approved by the state authorities and in that case only, when the destination country meets standards with respect to administrative management and technical potential with respect to SNF and RW management. The state, in which territory the wastes have been produced, shall take care of the possibility of returning them to its own territory in case the transportation is not going to take place for the reasons beyond their reasonable control. The purpose of suchlike measures is to ensure safety. No license can be obtained for transportation of wastes for further storage or disposal to a place located to the south from 60 degree of southern latitude.

3.6 OVERVIEW OF THE RUSSIAN FEDERATION RECOMMENDATIONS AND STATUTORY ACTS ON DISPOSAL OF RADIOACTIVE WASTE.

Principal aim for management of radioactive waste (RW) is its safe insulation securing the radiation safety for human and environment within the entire period of potential hazard of radioactive waste.

Proceeding from this purpose the system of statutory regulation of safety in case of management of radioactive waste should regulate the requirements to provision of safety: at different stages of preparation of radioactive waste for its long-term storage and/or disposal including its collection and sorting in accordance with adopted classification, processing, conditioning, storage and transportation; when disposing the radioactive waste.

Technical and organizational events on management of radioactive waste till its disposal should be implemented on the basis of the results of analysis of its characteristics and acceptability criteria (quality criteria) of radioactive waste for storage and/or disposal.

Three-staged hierarchy structure of regulatory safety control system, presented on Fig.22, is developed on the basis of system approach and in accordance with the legislation of the Russian Federation, IAEA regulatory documents and recommendations, including the documents [41-54]. The documents of the first and the second level refer to federal standards and rules, documents of the third level excluding the documents [47, 50] are advisory in nature. The last group can be added with regulatory documents of control authority in the field of use of nuclear power, standards and other documents, for example documents [55-58].

A number of requirements referring to securing the safety in case of management of radioactive waste are specified in the federal standards and rules defining the general provisions on securing the safety for the facilities of nuclear power use but which do not compose the structure mentioned above, including the requirements of the documents [59-61].

The Ministry of Health of the Russian Federation has developed the documents regulating the management of radioactive waste including the documents [62-66].

The aims and principles of securing the safety in case of management of radioactive waste, given in the documents [41-66], in accordance with the legislation of the Russian Federation, IAEA regulatory documents and recommendations are the following:

Aims of safety securing

- securing of reliable protection for workers (staff) and population from radiation effect of radioactive waste beyond the levels stated by the standards of radiation safety;
- prevention of emissions (discharge) to environment in the quantity exceeding the acceptable emissions (discharge);
- securing of reliable isolation of radioactive waste from environment, protection of present and future generations, biological resources against radioactive effect beyond the levels stated by the standards of radiation safety.

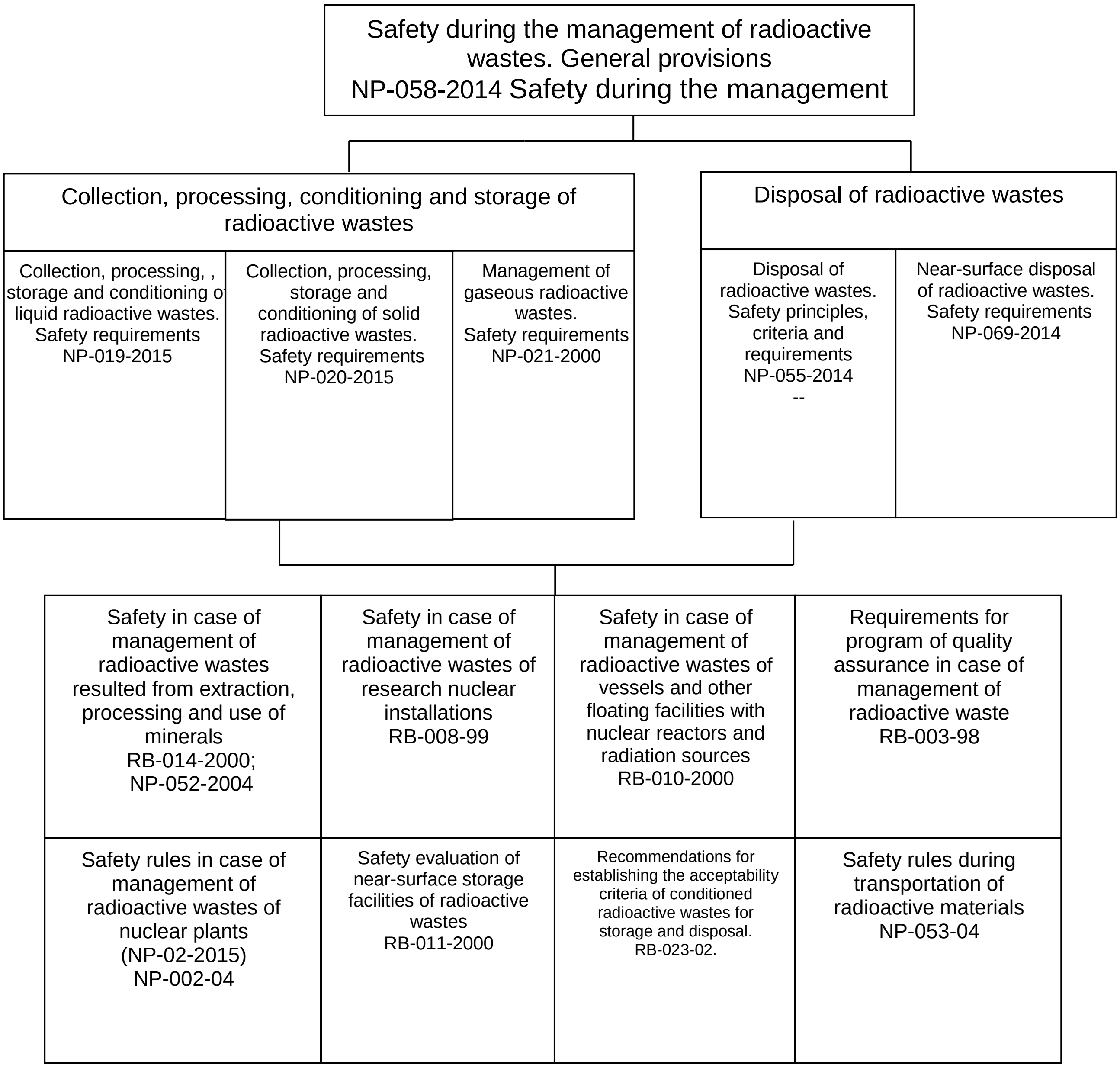


Fig.22. Structure of system of normative documents regulating the safety in case of management of radioactive waste

Safety principles:

- provision of acceptable level for protection of workers (staff) and population from radiation effect from radioactive waste in accordance with the principles of substantiation, rate setting and optimization (principle of human health protection);

- provision of acceptable level of protection for environment from harmful radiation effect of radioactive waste (principle of environmental protection);

- accounting of interconnection between the stages of radioactive waste formation and management (principle of interdependency of stages of forming of radioactive waste and management);

- non-exceedance of predictable levels of irradiation of future generations caused by disposal of radioactive waste, acceptable levels of irradiation of population established in regulatory documents (principle of protection of future generations);

- non-assignment of baseless burden on future generations related to the need for safety in case of management of radioactive wastes (principle of non-assignment of excessive burden on future generation);

In 2011 the Federal Law “On radioactive waste management and of amendments to certain legislative acts of the Russian Federation” (No. 190-FZ) [67] entered into force in the Russian Federation. Federal Law [67] governs the relations in the field of radioactive waste management and is not applied in the field of the spent nuclear fuel.

The Law [67] consists of 42 (forty two) clauses and 8 (eight) chapters. Brief overview of chapters is given below.

Chapter 1. General provisions (scope of the present Federal Law; legal regulation of relations in the field of radioactive waste management; the basic concepts used in this Federal Law; classification of radioactive waste; powers of the Government of the Russian Federation in the field of radioactive waste management; powers of the federal executive bodies in the field of radioactive waste management; powers of public authorities of the Russian Federation, the powers of local authorities in the field of radioactive waste management; Federal standards and rules governing the management of radioactive waste; ownership of radioactive waste and storage facilities of radioactive waste).

Chapter 2. Unified state system for radioactive waste management (purpose, operation principles and structure of unified state system of radioactive waste management; creation of the unified state system of radioactive waste management; requirements for disposal of radioactive waste; safety requirements of facilities for radioactive waste disposal; requirements to the companies engaged in radioactive waste management; state accounting and control of radioactive waste; registration requirements of radioactive waste and storage facilities of radioactive waste; radiation control during radioactive waste management).

Chapter 3. Institutional and legal framework for radioactive waste management (powers and functions of government authority in the field of radioactive waste management; powers and functions of the state regulation of safety in the regulation of radioactive waste management; national operator for radioactive waste management; general requirements for the companies which activity causes the formation of radioactive waste; the financial provision for management of radioactive wastes).

Chapter 4. Management of radioactive waste formed before the date of entering into force of the present Federal Law (initial registration of radioactive waste and determination of places for its location; requirements for management of accumulated radioactive waste and facilities for its storage).

Chapter 5. Management of certain types of radioactive wastes and requirements for certain types of activity of radioactive waste management (management of radioactive waste to be disposed; management of specific radioactive waste and requirements to storage facilities; management of radioactive waste, resulted from extraction and processing of uranium ores, and with very low level radioactive waste; management of materials with a high content of natural radionuclides formed during the implementation of activity that does not relate to the use of nuclear energy on mining and processing of mineral and organic raw materials with a higher content of natural radionuclides; management of spent sealed sources of ionizing radiation; management of liquid radioactive waste and of gaseous radioactive waste; features of import of radioactive wastes to the Russian Federation and export from the Russian Federation).

Chapter 6. Responsibility for violation of the requirements in the management of radioactive waste (types and basis of liability for violation of the requirements in the management of radioactive wastes; compensation for damage caused as a result of violations of the requirements in the management of radioactive wastes).

Chapter 7. Amendments to the certain legislative acts of the Russian Federation.

Chapter 8. Concluding provisions (transfer of ownership to the disposal facilities of radioactive waste; validity of regulatory legislative acts of the Russian Federation adopted before the date of entering into force of the present Federal Law and licenses issued before the date of entering into force of the present Federal Law; procedure of entering into force of the present Federal Law).

The system for management of radioactive waste was defined in accordance with the Law [67]:

- obligatory disposal of all radioactive waste;
- disposal facilities for radioactive waste should be only federal and inter-regional (operated by national operator);
- activity on disposal of radioactive waste is a natural monopoly (tariffs are set by the government);

Ownership of accumulated radioactive waste is reserved for the government till publication of the Law.

A number of the RF Government Resolutions and Decrees, specified on Fig. 23, were published according to Chapter 2 of the present Law [67] to build up the unified national system for radioactive waste management.

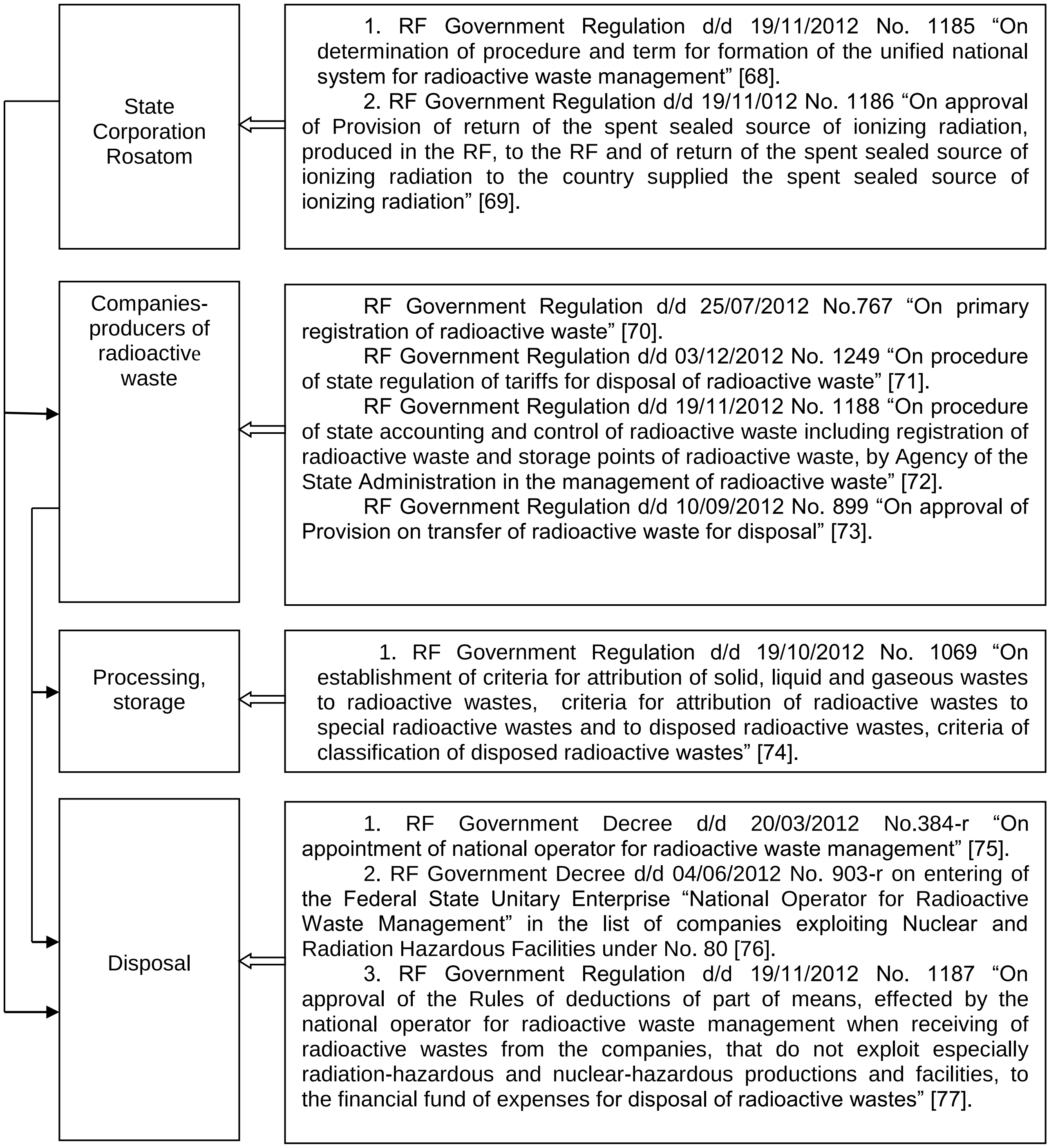


Fig.23. RF Government Decrees and Resolutions for formation of governmental system for radioactive waste management

3.7 LEGISLATIVE FRAMEWORK OF THE REPUBLIC OF ESTONIA

** Detailed analysis of the legislative framework of the Estonian Republic with relation to the RW management, transportation and disposal issues is presented within Annex 1 of the present report "Assessment of the Legislation of the Estonian Republic" (Tables 43, 44, 46).*

The establishment of national requirements of the Republic of Estonia is greatly influenced by the legislation of the EU, IAEA and the international conventions.

In 1992, the Republic of Estonia acceded to the International Atomic Energy Agency (hereinafter referred to as the IAEA).

The Republic of Estonia has joined a number of international conventions in the field of radiation safety, in particular, Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, as well as the Convention on nuclear safety, which was ratified in 2005.

The Republic of Estonia, as EU member state, shall provide the compliance with the rules, directives and other documents issued at EU level. The European Council Directives 96/29/EURATOM, 2013/59/EURATOM, 2003/122/EURATOM, 2009/71/EURATOM, 2011/70/EURATOM are more important instruments in the field of radioactive waste.

The state legislative and regulatory acts of the Republic of Estonia related to the subject of the radioactive waste disposal as one of the stages of radioactive waste management are presented in appendix 1 (Table 46). There are no special normative acts governing the final phase of the radioactive waste management in the Republic of Estonia.

A detailed analysis of the legislative framework of the Republic of Estonia in the field of RW and their transportation is presented in appendix 1 "Evaluation of legislation of the Republic of Estonia" (Tables 43, 44).

The main legal act of the Republic of Estonia in the field of nuclear and radiation safety is the Radiation Act [17] adopted in 2004. The Act is based on the concepts, regulations and limitations defined by the main International safety standards [5] and the EURATOM Directives [13-15], such as: optimization of protection and safety (ALARA principle), the limitation of individual radiation doses, acceptance of the proved and optimized works on prevention of emergency situations, permission to carry out works related to radiation etc. General principles of safety specified in the Radiation Act are also applied to the radioactive waste management, including the radioactive waste disposal. In 2011 the Radiation Act [17] according to the requirements of the directive 2009/71/EURATOM [16] was partially amended, relating to definitions, principles, responsibilities of licensees and ensuring the nuclear safety requirements at the nuclear facilities. Currently, the new version of the law has been prepared. The proposed date of coming into effect - 2015.

Radiation Act [17] established the principles of radioactive waste management and the obligations associated with waste management in the Republic of Estonia. More specific requirements to reduce the waste and to ensure the safe radioactive waste management are determined by normative acts on the basis of the law, as well as in the use of radioactive material license issued by the Environment Council and provided by organizations that form or dispose the waste. Since 2004, there were adopted 18 Government Regulations, Minister for the environment and the Minister of Internal Affairs [18-39] of the Republic of Estonia as required by the Law [17].

The most important normative acts of the Government of the Republic of Estonia and the Minister for the environment are: Regulations No. 163 as of 30.04.2004 [21]; No. 193 as of May 17, 2004 [22]; No 243 as of July 8, 2004 [23]; No. 244 as of July 8, 2004 [24]; No. 41, as of April 29, 2004 [27]; No. 86 as of July 8, 2004 [28]; No. 93 as of July 14, 2004 [29]; No. 113, as of September 7, 2004 [31]; No. 8 as of February 9, 2005 [33]; No. 10 as of February 15, 2005 [34]; No. 45 as of May 26, 2005 [35] A brief description of these regulations are given in section 2.6.

Law [17] consists of 75 paragraphs and 9 chapters that cover the following issues:

- the basic principles of radiation safety, organizing activities for radiation protection, obligations arising from international agreements, State planning for radiation protection (stages/phases of training, coordination and approval of the National development plan for radiation protection);

- licensing of works associated with radiation (requirements, conditions and procedure for obtaining the licenses, license revocation, amendment of the license);

- obligations of licensees (basic obligations of licensees, requirements for quality system and for radiation safety specialists, safety requirements when working with radioactive sources, when transporting the substances containing radioactive materials, guidance materials on radiation safety);

- ensuring the radiation safety (protection of the population and personnel, limited doses to the personnel and the population, ensuring the radiation safety in the workplace, categories of employees exposed to radiation, age restrictions, a dosimeter, individual control, medical personnel examination, elevated natural radioactive background, radiation requirements for medical purposes and in emergency situations);

- ensuring the radiation safety during radiation accidents (principles of intervention during radiation accident, action in the event of prolonged radiation effect, evaluation of the release rate during the radiation accidents, observation over the persons involved in the post-accident clean-up);

- radioactive waste and emissions (general requirements for the radioactive waste management and radioactive emissions, transfer of the radioactive waste, requirements for import, export and transportation of the radioactive waste, commissioning of the facilities for the radioactive waste management, safety assurance during the decommissioning of the facilities for the radioactive waste management).

- responsibility (mislicensing, transportation of the radiation sources containing the radioactive substances and transportation of radioactive waste without licenses, supervision over the radiation safety);

According to the Radiation Act (§ 63) after the closure of the radioactive waste disposal, the Department of the environment shall without any limitation of the period store the documents on-site storage of the radioactive waste, a plan for the storage and the inventory of the radioactive waste. Also in accordance with the established procedure the radiation level monitoring, control of the restriction of access shall be organized and the works to prevent emergency situations shall be carried out if on the basis of data of monitoring or after survey it was defined that the radioactive materials have got into environment.

The specific terms and conditions of the closure of the storage locations are defined in the license for work with the ionizing radiation sources.

Some general principles of the radioactive waste management, decommissioning and disposal of objects are reflected in environmental control Act [18], the Law on emergency situations, [19] and the Law on environmental impact assessment and management system [20].

In 2009, the Regulation of the Ministry of the environment # 8 as of February 9, 2005 “The Classification of Radioactive Waste, the Requirements for Registration, Management and Delivery of Radioactive Waste and the Acceptance Criteria for Radioactive Waste" [33] entered into force.

The Resolution was issued in accordance with the "Radiation Act" § 58, clause 5 and 6.

The Resolution [33] covers the following issues:

- radioactive waste management (collection, processing and storage of the radioactive waste (§ 4); treatment and conditioning of the waste (§ 5); RW storage at the manufacturer (§ 6); storing waste and prepare them for disposal (§ 7); long-term safety assessment requirements when RW disposal (§ 8); assessment of the radiation safety; lists the source events of the emergencies, which shall be considered when performing the radiation safety assessment after the closure of the facilities for the disposal; physical protection of the radioactive waste).
- questions concerning conditioning of the radioactive waste, including radioactive waste packaging requirements according to the follows items (§ 11):

  1) mechanical properties of packaging;
  2) physical properties of RW packaging (weight, dimensions, heating capacity, temperature, radioactivity);
  3) chemical properties of RW packaging;
  4) biological properties of the waste packaging
  5) content of the fissile materials;

6) packaging identification code assignment.

According to the Resolution [33] a licensor for the RW handling shall maintain control of the packaging according to RW requirements 1) -6) three years after receipt of the package and then every 10 years.

There is a list of controlled parameters of RW packaging in § 12 [33]:

1) weight;
2) free fluid content:
3) total activity, Alpha and beta emitting radionuclides:
4) maximum specific activity of radionuclides in RW packaging;
5) maximum surface contamination of the packaging;
6) maximum dosage rate at the surface of the package and at a distance of 1 m from the package.

– delivery of the radioactive waste and the requirements for RW registration and for reporting documents.

According to paragraph 3 of Chapter 1 of this Resolution [33] the radioactive waste are classified according to the following characteristics:

1) activity and specific activity;

2) half-life period;

3) type of radiation;

4) radiant energy.

The following nomenclature of the radioactive waste and the way of their storage are given in the appendix of the document [33]:

Table 36. Nomenclature and RW storage

Type	RW description	Storage
1. Decontrolled waste	Activity levels are equal to or below the levels that are based on an annual dose for the population according to cl. 7 § 17 "Radiation Protection Act"	There are radiological restrictions in accordance with the “Waste Act" (RT I 2004, 9, 52; 30, 208)
2.Waste radioactive materials of the natural origin	Natural radionuclides (Th-232 and U-238 and decay products, which belong to the radioactive materials of natural origin, activity levels of which are greater than levels, based on an annual dose	Temporary storage

	for the population according to cl. 7 § 17 "Radiation Protection Act"	
3.Short-lived radioactive waste	Radioactive waste with a half-life period of less than 100 days and activity levels equal to or below the levels based on an annual dose for the population according to cl. 7 § 17 "Radiation Protection Act" under the control of up to 5 years	Temporary storage
4.Low and medium-active short-lived radioactive waste	Limited concentrations of the long-lived radionuclides (less than 4000 Bq/g in the individual waste packages and on the average of 400 Bq/g for all packages)	Temporary storage and disposal
5. Low and medium-active long-lived radioactive waste	Radioactive waste with a half-life period of more than 30 years, bulk power density of less than 2 kW/m3 and concentrations of long-lived radionuclides is higher the limits for short-lived waste.	Temporary storage and disposal
6.High-level radioactive waste	The bulk power density is above 2W/m3 and concentrations of the long-lived radionuclides is higher the limits for short-lived waste	Disposal

The Environmental Impact Assessment and Environmental Management System Act was passed in 2005.

This Act provides legal grounds and procedure for the assessment of likely environmental impact, organisation of the environmental management and audit scheme and legal grounds for awarding the eco-label in order to prevent environmental damage and establishes liability for violation of the requirements of this Act.

The purpose of environmental impact assessment is to:

- make, on the basis of the results of environmental impact assessment of the proposed activity, a proposal regarding the choice of the most suitable solution for the proposed activity, which makes it possible to prevent or minimise damage to the state of the environment and to promote sustainable development;

- provide information to the decision-maker on environmental impact of the proposed activity and its reasonable alternatives, and the possibilities to prevent or minimise negative environmental impact;

- allow the results of environmental impact assessment to be taken into account in development consent proceedings.

The purpose of strategic environmental assessment is to:

- contribute to the integration of environmental considerations into the preparation and adoption of strategic planning documents;
- provide for a high level of protection of the environment;
- promote sustainable development.

The Act comprises 5 chapters and 71 paragraphs. A summary of the chapters is given below.

Chapter 1. General provisions: scope of application of the Act, purpose of environmental impact assessment (EIA) and strategic environmental assessment

Chapter 2. EIA.

Division 1. EIA of proposed activity: environmental impact; significant environmental impact; supervisor of environmental impact assessment; initiation of and refusal to initiate EIA; EIA programme; expert; license for EIA; publication of EIA programme; taking account of results of public display and public consultation regarding EIA programme; approval of and refusal to approve EIA programme; notification of approval of EIA programme; EIA report; publication of EIA report and taking account of results of publication of report; approval of EIA report, determination of environmental requirements and refusal to approve report; grant of development consent and refusal to grant development consent; ex-post evaluation of EIA; specifications for EIA related to preparation of building design documentation, termination of mining of mineral resources, landfill closure, activities affecting Natura 2000 sites, activities in transboundary context.

Division 2. Strategic environmental assessment of strategic planning document: strategic planning document; strategic environmental assessment (SEA); right to carry out SEA; initiation of and not requiring SEA; SEA programme; publication of SEA programme; supervisor of SEA; approval of and refusal to approve SEA programme; SEA report; publication of SEA report; approval of or refusal to approve SEA report; taking account of results of SEA; notification of adoption of strategic planning document; specifications for strategic environmental assessment in Natura 2000 site; strategic environmental assessment in transboundary context resulting from implementation of strategic planning document.

Chapter 3. Organisation of environmental management and audit scheme and awarding of ecolabels.

Division 1. Organisation of voluntary environmental management and audit scheme;

registration of organisations and competent body; accreditation of environmental verifier; promotion of environmental management and audit scheme.

Division 2. Awarding ecolabel to products; state fee for review of application for use of ecolabel and use of ecolabel.

Chapter 4. Liability: violation of requirements for EIA and SEA; violation of conditions for use of Community environmental management system and environmental audit system logo and Community eco-label; proceedings.

Chapter 5. Implementing provisions: implementation of the Act; entry into force of the Act.

The Law on environmental impact assessment and environmental management system [20] governs activities related to the radioactive waste management and spent nuclear fuel, with significant effects on the environment, including:

- construction, dismantling or decommissioning of NPP or other nuclear facilities (except the research facilities for the production and conversion of fissionable and fertile materials), whose maximum power does not exceed 1 MW of continuous thermal load;
- production or enrichment of the nuclear fuels, nuclear reprocessing or handling irradiated nuclear fuels or radioactive waste;
- construction of the complex for temporary storage or disposal of the irradiated nuclear fuels or radioactive waste;

EIA procedure includes the program and report. The EIA report consists of the following sections:

- alternatives and influencing project parameters;
- references to other projects and plans;
- environmental impacts of the construction and operation;
- impact of transport and transportation;
- impact of land use, social heritage, landscape, buildings and structures;
- impact on soil, hard-rock and groundwater;
- impact on the air quality;
- noise and vibration impact;
- impact on the vegetation, animals and objects of protection;

- impact on people;
- social impact assessment and regional economics;
- transboundary impact.

In accordance with the requirement of Chapter 2 of the Radiation Act [17] in 2008 a National development programme in the field of radiation safety for 2008-2017 was developed. [40]. This document defines the direction of radiation safety and contains the necessary general principles and measures for radiation safety, including the definition of RW disposal, decommissioning the objects, as well as requirements for implementation and adequate financing.

The national program [40], points out that there is an urgent need to develop preparatory documents and research for reactor blocks dismantling. It is necessary to develop the design documentation for the installation of RW temporary storage. Also it is necessary to develop a design documentation for the facility of the final RW disposal of the relevant volumes of anticipated RW, for which it is necessary to conduct quantitative research on counting the number of formed RW.

In 2015, a National program was worked out on the radioactive waste management [86], The need for the preparation of the program is envisaged in the national work plan for the radiation safety, approved by the Government of the Republic in 2008 and in 2011 in the European Union Directive/70/EURATOM on the responsible and safe management of spent fuel and radioactive waste

The program [86] presents the interim targets for the radioactive waste management, activities and expected results up to 2050. The document also describes the responsible agencies and program expenditures.

The program defines deadlines to establish facilities for the disposal of the waste arising from the decommissioning of Paldiski's reactor blocks, a regulatory body responsible for the disposal is specified. According to the program [86] the interim storage and permanent radwaste disposal was organized by the Ministry of Economy. The State is obliged to form a regional policy, to establish the requisite legislation and to organize management, temporary_storage and ultimate disposal. The ultimate nuclear waste disposal site in Estonia shall be determined by the year 2040. The results of preliminary researches, which are to be completed in 2015, play an important role in choosing the concept of the ultimate disposal and decommissioning of the reactor blocks of the former training center in Paldiski. Then environmental impact assessment shall be conducted for the purpose of clarification the location of the storage and other waste storage conditions. The ultimate disposal planning and applying for the licenses to use radioactive materials shall take place in 2027-2037, and construction - in 2037-2040. After that it is possible to start decommissioning the reactor blocks. New site for the ultimate disposal shall be ready by the year 2040, when the storage time is reached for the reactor blocks (50 years, the exploitation ended in 1989).

The program [86] states that the construction of the ultimate disposal shall be preceded by a thorough updating of legislation, since the existing legal framework is insufficient for the construction of a site for ultimate disposal. It is necessary to amend the legislation relating to planning and construction, with a view to establishing requirements for construction of the site for ultimate disposal in addition to Radiation control law and regulations issued on the basis thereof.

The national program on the radioactive waste management [86] is a documented source, which, in addition to the aforesaid, presents an overview of the legislative documents and directions for their supplementing. Since the radioactive waste management is of interest to various interest groups (both domestically and internationally), the program is a good tool to communicate with them, for example, dissemination of information to the interest groups, notification of the current situation and of future plans ...

The program is regularly reviewed and updated by taking into account the technological innovations and results of the investigations, as well as the recommendations of the experts, the best lessons learned from the best practices. In accordance with Directive 70/2011/EURATOM, the national framework program, competent regulatory body, National program and procedure of its application shall regularly undergo re-evaluation of at least once in ten years, to achieve a high level of the safety standards for the spent fuel and radioactive waste management.

3.8 RECOMMENDATIONS ON INTRODUCING CHANGES INTO REGULATORY FRAMEWORK OF ESTONIAN REPUBLIC WITH RESPECT TO DISPOSAL AND TRANSPORTATION

** Detailed analysis of the legislative framework of the Estonian Republic with relation to the RW disposal issues is presented within Annex 1 of the present report “Assessment of the Legislation of the Estonian Republic” (Table 46).*

Having studied a reasonably large number of the existing regulatory documents issued by the IAEA, European Commission, Russian Federation and Republic of Estonia (Sections 3.1 to 3.7 above) with respect to regulatory control of radwaste final disposal, a need has been identified for improvements to the existing legal provisions and regulatory requirements in the field of safety assurance based on scientific, technical and organisational principles, criteria and requirements for safety assurance when placing radwaste for final disposal in the Republic of Estonia. The provisions must be responsive to the current status of science and technology and today’s view of safety, recommendations by the International Commission on Radiological Protection, IAEA and EU.

Table 46 gives recommendations for amendments to be introduced to the legal framework in the Republic of Estonia with regard to the final disposal of radioactive waste.

This analysis resulted in the identification of documents that contain sufficient requirements for radioactive waste disposal. Such documents include Regulation # 110 [30], the Environmental Monitoring Act; Regulation # 50 [37]; Regulation # 57 [26]; Regulation # 5 [39]; the Road Transport Act; the Industrial Emissions Act; the Ambient Air Protection Act; the Fire Safety Act.

Part of the documents indicated in Table 46 provide recommendations for modifications to be made concerning general aspects of radiation safety concerning every stage of radwaste management. A more detailed analysis of recommendations for amendments to the legal framework in the Republic of Estonia with regard to radioactive waste management is given in Table 43. A brief overview of changes in terms of general provisions of radioactive waste management is given in Chapter 2.6.

Final disposal is the final stage in radioactive waste management process. Therefore, all radiation protection principles and all requirements for radioactive waste management are applicable to this stage.

However, there is a number of special requirements suggested for incorporation into the legal and regulatory framework in the Republic of Estonia.

For instance, the principal document – the Radiation Act [17] – is suggested to be amended to reflect the following:

- definition of the regulator's role in the planning, designing, building and operational stages of the radioactive waste management site;
- definition of legal, technical and financial responsibilities for organisations involved in radioactive waste management activities in the course of radioactive waste disposal;
- definition of clear juridical, technical and financial responsibilities for organisations involved in the establishment of radioactive waste management facilities including all types of disposal ones;
- incorporation of options for waste disposal planning and implementation into the national policy;
- division of the activities at different stages of the disposal facility operation: pre-operational, operational and post-operational periods;
- the operator's responsibilities with respect to preparation of the commissioning report; requirements for information that this report should provide;
- requirements for planning of the disposal facility shutdown (elaboration of shutdown solutions must be mandatory when such disposal facilities are designed);
- provision of the public with information concerning radioactive waste management, while having due regard to security and confidentiality issues;
- identification of specific requirements to the license owner who practices radioactive waste disposal activities;
- guidelines and details pertaining to studies and identification of site characteristics during the building period and following its shutdown;
- any other issues associated with final disposal.

Regulation # 163 [21] needs updating so that the assessment of doses to members of the public shall take into account pathways resulting from the disposal or recycling of solid residues. Member States may specify dose criteria lower than 1 μSv per year for specific types of practices or specific pathways of exposure.

Regulation # 41 [27] is recommended to provide more information for the licensing for radioactive waste management activities.

The following information should be covered in case of changing. The indicative list of information for license applications of the new EURATOM Basic Safety Standard (EURATOM BSS) is basically covered in the current legislation, but the aims of the safety assessment might be defined in more detailed way. Adequate defence in depth has to be ensured by demonstrating that there are multiple safety functions, that the fulfilment of individual safety functions is robust and that the performance of the various physical components of the disposal system and the safety functions they fulfil can be relied upon, as assumed in the safety case and supporting safety assessment. The long term safety of a disposal facility for radioactive waste is required not to be dependent on active institutional control. The intent of surveillance and monitoring is not to measure radiological parameters but to ensure the continuing fulfilment of safety functions.

Amendments should be made to Regulation # 8 [33] concerning:

- review of the classification of the radioactive waste taking into account the classification proposed by IAEA;
- development of the waste acceptance criteria for radioactive waste as part of the design process of the disposal facility;
- corrective actions to be carried out, should a waste package not meet the specifications or the waste acceptance requirements;
- possibility to amend the list of the factors for safety assessments of radwaste management based on IAEA recommendations;
- need for considering alternative options for waste disposal, if human intrusion were expected to lead to a possible annual dose of more than 20 mSv to those living around the disposal site.

The Environmental Impact Assessment and the Environmental Management System Act requires to be supplemented with the following:

- the listing of the activities should be defined so that it would be easier to understand that activities fall under the current act and which are not;
- consideration has to be given to locating the disposal facility away from significant known mineral resources, geothermal water and other valuable subsurface resources. This is to reduce the risk of human intrusion into the site and to reduce the potential for use of the surrounding area to be in conflict with the facility.
- the requirement of getting the approval from European Commission should be taken into consideration.

The Building Code. The legislation should address clearly that in case of the application for the building disposal facility, the approved EIA is a prerequisite.

Table 44 in the Annex contains recommendations for amending the legal framework in the Republic of Estonia with regard to radioactive waste transportation. The majority of the documents do not need to be revised. This analysis resulted in the identification of documents that contain sufficient requirements for radioactive waste disposal. Such documents include Regulation # 110 [30], the Environmental Monitoring Act; Regulation # 50 [62]; Regulation #57 [63]; Regulation #5 [64]; the Road Transport Act; the Industrial Emissions Act; the Ambient Air Protection Act; the Fire Safety Act.

Part of the documents indicated in Table 44 provide recommendations for modifications to be made concerning every stage of radwaste management it has been recommended that modifications should be made with respect to general aspects of radiation protection concerning every stage of radwaste management.

It is recommended that changes associated with radioactive waste transportation proper should be made to the following documents: the Radiation Act [17]; Regulation # 163; Regulation # 86; Regulation #8; Regulation # 243 General Part of the Environmental Code Act.

Currently the Radiation Act [17] lists under the activities which need radiation protection license only export and import. Even though this is the open list, it would be much clearer if the transportation inside the country were listed as well. The current requirements coming both from Radiation Act and from the legislation defining the Dangerous Good Transportation, might cause some duplication and misunderstanding. These requirements should be more coherent.

The current Act provides the very overall requirement for the radiation practice license owner to provide the security of the radioactive material. This should be elaborated, possibly providing more detailed information in the relevant regulation.

The following amendments are recommended:

- Regulation # 163: In case of the transportation of the exempt material, there is no need to follow the Radiation Act.
- Regulation # 86: For the transportation workers there is need to get training in the transportation of dangerous goods.
- Regulation # 8: In case of the transportation of the RW, these scenarios have to be included in the safety assessments as well
- Regulation # 243: Where radioactive waste or spent fuel is shipped for processing or reprocessing to a Member State or a third country, the ultimate responsibility for the safe and responsible disposal of those materials, including any waste as a by-product, shall remain with the Member State or third country from which the radioactive material was shipped

General Part of the Environmental Code Act: In case of the transportation of radioactive material the Environmental Board has to be included in the inspection process.

3.8.1 Recommendations on introducing changes into Radiation Law

In order to govern relations in the field of radioactive wastes management in case of disposing them, it is necessary to specify general requirements for providing safety of disposal by introducing changes into the effective Radiation law or issue of the new law. The effective law shall be appended by the Section (Chapter) on the location of RW disposal facility(ies) comprising the following main provisions:

3.8.1.1 Decisions on the place of location and on building disposal facility(ies)

- shall be taken by the State government bodies of the Estonian Republic in accordance with the land legislation, urban development legislation, legislation on environmental protection of the Estonian Republic and taking into account findings of expert evaluations conducted by the public organizations.

3.8.1.2 Basic requirements to safety of planned for location and building of disposal facility(ies)

- Location and building of disposal facility(ies) shall be effected on the basis of rules and regulations in the field of nuclear power utilization and rules and regulations in the field of environmental protection taking into account requirements of urban activity legislation.
- Decision on the location and building disposal facility(ies) shall be taken with due account of:
  - demands for them for solving economic tasks of the Estonian Republic and its separate districts;
  - availability of conditions necessary for arrangement of specified facilities meeting the rules and regulations in the field of nuclear power utilization;
  - absence of threat to the safety of disposal facility on the part of civil or military objects located nearby;
  - possible social and economic consequences of arranging these facilities of nuclear power utilization for industrial, agricultural, social and cultural and general development of the region.
- Documents on assessing radiation impact of the disposal facility(ies) on the environment are to be submitted by the relevant authority of nuclear power utilization management or by Operator as part of the design documentation of the given facilities

of nuclear power utilization for state expert review in accordance with legislation of the Estonian Republic on the urban development activity.

- In case of construction, reconstruction, overhaul of the disposal facilities the State construction supervision will be effected by the body of executive power authorized for rendering State construction supervision in accordance with legislation of the Estonian Republic on the urban development activity.

3.8.1.3 Establishing sanitary protection zone and observation zone

- Special territories are to be established for the sake of protecting people in the area - sanitary protection zone and observation zone.
- Control of radiation situation shall be effected in the sanitary protection zone and observation zone.
- Dimensions and boundaries of the sanitary protection zone are to be determined in the sanitary protection zone design in accordance with the rules and regulations in the field of nuclear power utilization, which is to be coordinated with the authorities of Health Board supervision and are to be approved by the bodies of local self-government of municipal districts.
- In the sanitary protection it is prohibited zone to locate residential and public buildings, child welfare institutions as well as health-related institutions not related to functioning of disposal facility(ies), public catering facilities, industrial objects, auxiliary and other structures and objects not envisaged by the approved sanitary protection zone design.
- Utilization of existing objects and structures located in the sanitary protection zone for the economical purposes in case of changing profile of using them is permissible as advised by the Operator by the permission of state authorities of safety governing.
- Necessity of establishing the observation zone, its dimensions and boundaries are to be determined in the design on the basis of safety characteristics of the nuclear power utilization facilities and are to be coordinated with the authorities of state sanitary and epidemiological supervision.
- Introduction of restrictions for economic activity in accordance with legislation of the Estonian Republic is possible in the observation zone by the authorities of state sanitary and epidemiological supervision.

- Damages caused by the establishment of sanitary protection zone and observation zone will be compensated by the Operator in accordance with legislation of the Estonian Republic.

- Sanitary protection zone and observation zone can be limited by the territory boundaries of object, building, premises for some nuclear power utilization facilities in accordance with safety characteristics of these facilities.

3.8.1.4 Acceptance to operation and putting into operation disposal facility(ies)

- acceptance to operation disposal facility(ies) will be effected in complex with the objects of production and household purpose envisaged in the design of indicated nuclear power utilization facilities.

- putting into operation disposal facility(ies) will be effected in case of availability of permissions (licenses) with the Operators issued by the relevant bodies of state governing safety for operation thereof.

3.8.2 Recommendations on development of regulatory documents specifying RW deposition

In furtherance of provisions of regulatory framework of the Estonian Republic it is necessary to develop documents in accordance with hierarchy structure of regulatory documents of the EU legislation and take into account the recommendations of the IAEA, which are recommended to comprise the following provisions:

3.8.2.1 Principles, criteria and basic safety requirements

3.8.2.1.1 The purpose of ensuring safety at RW disposal is a reliable isolation thereof ensuring radiation safety of a human being and environment for the whole period of potential threat from RW.

3.8.2.1.2 The following principles of providing safety shall be observed at RW disposal:

- optimization – radiation effect related to RW disposal shall be maintained at possibly low and accessible level taking into account economic and social factors;

- multi-barrier feature - longstanding safety of RW disposal in the period after closing radwaste disposal facility shall be ensured by application of the system of safety barriers in the way of propagating ionizing radiation and radioactive substances into environment; disturbed integrity of one of safety barriers or a probable external event of natural or man-induced origin shall not entail reduction of level of a longstanding safety of RW disposal system;

- protection of future generations – predicted levels of exposure to radiation of future generations due to RW disposal shall not exceed permissible levels of people's exposure to radiation established by the statutory and regulatory enactments;

- any individual of future generations shall be protected against harmful effect of disposed of RW just as any individual of the present generation;

- non-imposition of an excessive burden on the future generations - RW disposal shall be effected so that not to impose an unfounded burden associated with a necessity of providing safety in the course of RW management on the future generations.

3.8.2.1.3 Methods of RW disposal can be divided into:

- near-surface RW disposal - RW disposal in the structures located above ground surface, at the same surface with ground surface or below the ground surface at the depth down to hundred meters from the ground surface;

- underground RW disposal - RW disposal in the structures located at the depth exceeding one hundred meters from the ground surface;

3.8.2.1.4 Depending on the method of RW disposal the RW disposal facilities can be divided into:

- near-surface RW disposal facilities (hereinafter referred to as the near-surface RWDF);

- underground RW disposal facilities (hereinafter referred to as the underground RWDF);

3.8.2.1.5 Class of RW prepared for disposal shall be set before the moment of transferring them for disposal in accordance with the requirements of regulatory and statutory enactments in the field of using nuclear power and is to be indicated in a certificate for RW package (RW batch) forwarded for disposal according to the requirements of rules and regulations in the field of nuclear power utilization.

3.8.2.2 Providing safety at selecting disposal site

3.8.2.2.1 In the course of the disposal facility site selection will be necessary to investigate phenomena, processes and factors of natural and man-induced origin characteristic for the area of supposed location.

3.8.2.2.2 Tectonic, seismic, geological-hydrogeological, engineering-geological, hydrographical, geomorphological and climatic conditions of the disposal site location shall meet the requirements of the regulatory and statutory enactments, including rules and regulations in the field of nuclear power utilization, and construction rules and regulations specifying carrying out of activities on the arrangement of objects of nuclear power utilization and establishing requirements to keeping record of external effects of natural and man-induced origin on the objects of nuclear power utilization. In the course of selecting the disposal site it is necessary to investigate and evaluate conditions of the disposal location, which can influence the disposal safety, and the disposal influence on the population and environment.

3.8.2.2.3 The following territories are not suitable for radioactive waste disposal:

- at the territories, within which limits the disposal location is prohibited by the law, including environment-oriented legislation;
- at the sites located directly on the active faults or in the active geodynamical zones;
- at the sites, which seismicity is characterized by the intensity of maximum expected earthquake exceeding intensity 8 on the MSK-64 scale (approximately 6,2 on the Richter scale in accordance with ГОСТ30630.5.4-2013 / IEC60721-2-6:1990);
- at the territory subject to effect of active volcanoes and at the territory of manifestation of active mud volcanoes.

3.8.2.2.4 The site is suitable for the disposal facility location, if a possibility of ensuring safe RW disposal in the period of potential RW threat is substantiated taking into account natural phenomena, processes and factors of natural and man-induced origin. Selection of the disposal facility location site shall be grounded in the safety report (SAR of the disposal facility) with due account of studies and investigations results in the area of supposed location and results of evaluating disposal facility safety.

3.8.2.2.5 In the course of selecting disposal facility site it is necessary to justify a possibility of providing safe RW transportation.

3.8.2.2.6 In the course of selecting the disposal site it is necessary to set the boundaries of sanitary protection zone and observation zone according to the requirements of regulatory documents.

3.8.2.2.7 The site for location of underground repository shall be selected taking into account the following requirements:

- enclosing rocks shall be represented by one of the potentially suitable types (crystalline magmatic or metamorphic rocks, including granites, foliated granites, tuffs, preferentially of the basic or ultrabasic composition; rock salt or anhydrite; clays), shall feature a sufficient volume, occur at the acceptable depth and feature favorable physical and mechanical properties, uniform structure and low fracture porosity;

- it is reasonable to locate a site in the areas not exposed to intensive tectonic activities;
- working rock mass shall not comprise lenses of brines, beds of permeable rocks;
- rock massif shall not comprise water-bearing formations, lenses of subterranean waters or fracture-porosity zones, through which inflow of water is possible into mine workings and flooding thereof.

3.8.2.2.8 In case of availability of alternative variants of sites for locating underground the disposal facility, which meet the foregoing requirements, precedence shall be given to those sites, which geological conditions satisfy one or several additional requirements:

- subterranean waters feature recovering character, faintly alkaline reaction and low mineralization;
- active fault are absent within the site limits;
- low thermal flux;
- water-resistant and water-bearing beds not suitable for water supply are located above the expected depth of building the RWDF structures;
- revealed and(or) probable hydraulic connection passages of the supposed level of RWDF location with the daylight surface, above- and underlying water-bearing beds are absent, including those not suitable for water supply.

3.8.2.3 Providing safety at designing and building of the disposal facility

3.8.2.3.1 The RWDF design shall establish and substantiate the following on the basis of results of assessing the disposal facility safety:

- radionuclide composition of RW emplaced at the disposal facility;
- permissible cumulative activity of disposed RW;
- total and specific activity of radionuclides in package of RW (average and maximum) disposed at the disposal facility;

– permissible quantity (volume) of RW placed into the disposal facility and RW stored on a temporary basis at the disposal facility site.

3.8.2.3.2 Disposal facility design shall specify RW acceptability criteria for disposal, including requirements to physical and chemical RW properties and RW packages, including requirements to containers (structural materials, weight, dimensions, design, mechanical properties).

3.8.2.3.3 Disposal facility design shall provide for technical means and organizational provisions ensuring control of compliance of RW arriving for disposal with the established acceptability criteria for disposal in this facility.

3.8.2.3.4 Methods and scope of incoming inspection of RW arriving for disposal shall be established and substantiated in disposal facility design.

3.8.2.3.5 Disposal facility design shall provide for technical means and organizational provisions for safe management of all RW arriving for disposal, including:

– control of process parameters of the systems;

– carrying out transportation and processing operations;

– temporary storage of RW packages;

– deactivation of equipment and premises;

– radiation control in the disposal facility premises, at its site, within sanitary protection zone and observation zone established for this disposal facility;

– monitoring RW disposal system;

– management of RW generated during disposal facility operation;

– repair and maintenance of RW systems and equipment;

– keeping record of arriving RW and places of location thereof in disposal facility.

RWDF design shall provide for technical means and organizational provisions aimed at preventing violation of boundaries and conditions for safe operation, design accident events and limiting consequences thereof.

It is necessary to provide for technical means and (or) organizational provisions for restricting probable consequences of off-design accident events, if they are not excluded owing to internal properties of self-protection of systems (elements) of RWDF.

3.8.2.3.6 Disposal facility design shall specify and justify the following:

- composition, protective and isolating properties of safety barriers, control methods of the protective and isolating properties thereof;
- reliability of engineering safety barriers;
- minimal time limits, within which every safety barrier preserves properties required for ensuring safety without outside interference;
- measures for protecting engineering barriers against damages during operation and closure and after closure in the period of RW disposal system monitoring.
- possible changes of protective and isolating properties of safety barriers shall be taken into account in the scenarios of evolution of RW disposal system.

The RW disposal system evolution scenario implies one of the possible progressions of the events, phenomena and factors of natural and man-induced origin interrelated with each other, physical and chemical processes determining RW disposal system evolution, migration of radionuclides into environment and levels of a human-being exposure to radiation.

The materials of safety barriers shall be selected in such a way that the interaction between elements of different barriers and RW does not bring about the unpredictable aggravation of protective and isolating properties of barriers.

3.8.2.3.7 Engineering barriers of underground and near-surface disposal facility shall be protected against destruction related to undeliberate intervention of a human-being.

Engineering barriers of near-surface disposal facility shall be protected against destruction related to life and activities of plants and animals.

3.8.2.3.8 Design shall justify the disposal facility tolerance to external effects of natural and man-induced origin characteristic for a site selected for disposal facility location and (or) to possible internal effects emerging as a result of accidents.

3.8.2.3.9 Disposal facility design shall specify and substantiate the disposal facility equipment service life as well as period of its operation.

3.8.2.3.10 Design shall envisage provision of disposal facility fire safety, including categorization of buildings, structures and premises with respect to fire hazard in accordance with requirements of regulatory and statutory enactments establishing fire safety requirements.

Disposal facility fire safety in the period after its closure shall be ensured by the use of non-flammable structural materials for manufacturing engineering barriers, which is to be substantiated by the fire and engineering calculations in disposal facility design.

3.8.2.3.11 Disposal facility design shall provide for technical means and organizational provisions for location of RW packages through a targeted method – in a particular disposal facility place with an identifiable particular location place (including number of a cell, compartment, section, chamber, and place in a stockpile). Place of location of every RW package shall be registered in a system of RW keeping record in disposal facility.

3.8.2.3.12 Disposal facility design shall take into account processes taking place in the structural disposal facility materials and in RW packages in the course of disposal facility normal operation and design accident events, such as corrosion, creeping, fatigue, shrinkage, ageing, changes caused by the effect of ionizing radiation, other possible processes, which can bring about a change of protective and isolating properties of safety barriers.

3.8.2.3.13 The design shall determine order and basic technical solutions and organizational measures on disposal facility closure (disposal facility closure concept), give evaluation of radiation effect at disposal facility closure and of the closed disposal facility on the employees (personnel), population and environment.

3.8.2.4 Safety assurance during radioactive waste repository operation

3.8.2.4.1 In order to identify the need for implementation of technical and organisational measures aimed at assurance of safety of employees (personnel) and members of the public as well as safety of the radioactive waste repository system, any operating (or mothballed) radioactive waste repositories shall undergo reviews of their current safety level as well as assessment of long-term safety of the radioactive waste repository system.

Resulting from the analysis required justified measures shall be identified aimed at assurance that the provisions of codes and regulations will be met.

During radioactive waste repository operation on the basis of a permit (licence) covering a period longer than 10 years, in accordance with the provisions of codes and regulations applicable to use of nuclear power, periodic safety assessments of the radioactive waste repository shall be performed. Periodic safety assessments of the radioactive waste repository shall be performed in accordance with a programme developed and approved by the utility organisation.

3.8.2.4.2 The utility organisation shall incorporate its divisions responsible for safe operation of the radioactive waste repository, and provide the radioactive waste repository with the necessary financial, material and technical resources.

3.8.2.4.3 The radioactive waste repository shall be staffed with workers (personnel) who possess the necessary qualifications and permissions to work unsupervised issued as appropriate by the utility organisation. The system of selection and training of workers (personnel) for the radioactive waste repository shall aim to achieve, control and maintain their level of qualifications sufficiently high to ensure safe operation of the radioactive waste repository, as well as be able to take action to mitigate the consequences of an accident.

The workers training system shall include promotion of safety culture among employees (personnel).

3.8.2.4.4 The utility organisation shall on the basis of documentation furnished by the developers of equipment, technological processes and design ensure production of operational documentation for the radioactive waste repository.

The operating documentation shall describe the rules and key methods employed to ensure safe operation of the radioactive waste repository, operating modes, requirements applicable to the sequence of performance of operations related to safety, limits and conditions of safe operation, specific instructions to employees (personnel) on how to act during normal operation and operational abnormalities, including pre-accident conditions, as well as employee (personnel) actions to ensure safety in design-basis and beyond-design accidents.

8.2.4.5 In order to ensure that the systems (components) and equipment of the radioactive waste repository remain operational, as well as to preclude any dangerous failures, the systems shall undergo technical maintenance, repairs, tests and checks. Such activities shall be performed following the appropriate manuals (programmes, schedules, process charts), developed by the utility organisation on the basis of design provisions, and shall be documented. During technical maintenance, repairs, tests and checks on systems (components) and equipment, conditions shall be observed as prescribed by the operational documentation in order to ensure safety of the radioactive waste repository.

3.8.2.4.6 During radioactive waste repository operation, information about failures in systems (components) and equipment, as well as inappropriate human actions shall be collected, processed, analysed, systematised and stored.

3.8.2.4.7 The following shall be ensured during radioactive waste repository operation:

- efficient management of all activities associated with operation and maintenance of the radioactive waste management systems aimed at prevention of accidents;
- minimised generation of secondary radioactive waste both in terms of volume and total radioactivity;
- prevention of uncontrolled discharges and releases;
- safe management and disposal of any secondary radioactive waste generated by radioactive waste repository operation;
- physical protection of the radioactive waste repository, as well as radioactive waste accounting and tracking.

3.8.2.4.8 The following measures shall be undertaken during radioactive waste repository operation:

- protection of employees (personnel) and members of the public against radiation impacts of radioactive waste;
- prevention of radioactive contamination in rooms and site of the radioactive waste repository.

3.8.2.4.9 Plans shall be developed and ready for use to take action to protect employees (personnel) and members of the public in case of accident on the radioactive waste repository in accordance with the provisions of codes and regulations applicable to use of nuclear power.

3.8.2.4.10 The utility organisation shall ensure continuous supervision of all activities important for safety of the radioactive waste repository, and send to the state nuclear power regulator periodic reports describing the safety status of the radioactive waste repository as requested by the regulator.

3.8.2.4.11 The utility organisation shall inform in a timely manner the state nuclear power regulator about any safety breaches during radioactive waste repository operation.

3.8.2.4.12 The utility organisation shall record and store information as required for closure of the radioactive waste repository, including design and operational documentation, as well as the following information:

- about changes to process flows on the radioactive waste repository;
- about completed renovations (upgrades) on the radioactive waste repository;
- levels of radioactive substances contamination on the surfaces of systems, components, rooms prior to the start of activities to close the radioactive waste repository, as well as site where the radioactive waste repository is located;
- about the amounts and radionuclide composition of radioactive waste generated during operation and stored on the site of the radioactive waste repository, its characteristics and locations at the radioactive waste repository;
- about the amount of buried radioactive waste, its radionuclide composition and specific activity levels;
- about the total and available holding capacity of radioactive waste repository structures;
- about any accidents on the radioactive waste repository that have caused releases of radionuclides beyond the radioactive waste repository structures and resulted in radioactive contamination of systems, components, rooms, civil structures and the environment.

3.8.2.4.13 The utility organisation shall ensure that the systems (components) of the radioactive waste repository will remain operational until its closure or ensure that they can be replaced once beyond their service lives.

3.8.2.4.14 During operation of the radioactive waste repository, the utility organisation shall provide collection, documentation and storage of information important for safety assurance during closure of the radioactive waste repository.

3.8.2.4.15 During operation of the radioactive waste repository, current planning for its closure shall be on-going through periodic reviews and updating of its design documentation and corresponding chapters of the safety analysis report that contain key technical solutions and organisational measures related to closure of the radioactive waste repository (radioactive waste repository closure concept and long-term safety assessment).

3.8.2.4.16 Prior to commissioning of the radioactive waste repository it shall be staffed with workers (personnel) who possess the necessary qualifications and permissions to work unsupervised issued as appropriate.

3.8.2.4.17 Prior to commissioning of the radioactive waste repository it shall undergo pre-commissioning and integrated testing of systems (components) that shall confirm that the systems (components) and equipment of the radioactive waste repository are built and function in accordance with the design, and any identified flaws have been rectified.

3.8.2.4.18 Prior to the start of radioactive waste repository operation, plans shall be developed and made available for measures to protect employees (personnel) and members of the public in case of accident on the radioactive waste repository.

3.8.2.4.19 During operation of the radioactive waste repository, provisions shall be made for acceptance and receipt examination of radioactive waste in order to verify that any incoming radioactive waste meets the acceptance criteria for disposal on the radioactive waste repository.

Radioactive waste packages (or batches) shall be accepted on the basis of review of their declared data, visual and instrument-aided examination of incoming radioactive waste packages (batches), including in particular verification of the following:

- availability and completeness of supporting documentation;
- integrity of radioactive waste packages;
- availability, contents and visual accessibility of labelling on radioactive waste packages;
- exposure dose rate on the outer surfaces (or a certain distance away from the surfaces) of radioactive waste packages (non-packaged radioactive waste);
- radioactive contamination on outer surfaces of radioactive waste packages.

During radioactive waste acceptance, it shall be made sure that the labelling on radioactive waste package meets the declared data and the declared data meet the criteria of radioactive waste acceptability for disposal on the radioactive waste repository, with actual characteristics of radioactive waste packages (batches) being in line with design-specified declared data and radioactive waste acceptance criteria for disposal on the radioactive waste repository. Methods and extent of examination to check whether the actual characteristics of radioactive waste packages (batches) meet their declared data and/or acceptance criteria for disposal on the radioactive waste repository shall be established by the design of the radioactive waste repository depending on the category of incoming radioactive waste and its properties, as well as the handling process of radioactive waste packages (non-packaged radioactive waste) on the radioactive waste repository.

In case it is established that the radioactive waste package (batches) does not meet the declared data or acceptance criteria for disposal on the radioactive waste repository, the radioactive waste package (batch) shall be either returned to the sender radioactive waste, or if acceptable to the radioactive waste repository utility undergo additional processing to be prepared for disposal in accordance with applicable acceptance criteria. The radioactive waste repository utility shall identify the methods and procedures for handling radioactive waste packages (non-packaged radioactive waste) that do not meet the acceptance criteria for disposal on the radioactive waste repository, and sequence of their preparation for disposal or return to sender, if necessary.

3.8.2.4.20 A system shall be put in place for accounting and records-keeping of documentation related to radioactive waste management and disposal on the radioactive waste repository, including accounting and tracking of radioactive waste packages (non-packaged radioactive waste), their amounts, characteristics, individual numbers, as well as disposal locations on the radioactive waste repository.

Accounting shall be made on the basis of data contained in certificates for radioactive waste packages (batches), data collected from receipt examination during acceptance and identified specific locations of radioactive waste disposal on the repository.

Certificates for radioactive waste packages (batches) and accounting data with disposal locations of radioactive waste packages (non-packaged radioactive waste) on the radioactive waste repository shall be kept as permanent records.

3.8.2.4.21 Radioactive waste shall be transported within the repository site in accordance with the transport process chart following routes identified in the repository design.

3.8.2.4.22 As the disposal compartments (modules, sections, chambers, cells) of the radioactive waste repository are filled with radioactive waste packages (non-packaged radioactive waste), they shall undergo preservation in accordance with the technical solutions built into the design of the radioactive waste repository.

3.8.2.5 Safety assurance during closure of the radioactive waste repository

3.8.2.5.1 The utility organisation shall exercise systematic planning of activities to close the radioactive waste repository during all stages of the repository life cycle that precede closure. The design of the radioactive waste repository shall include initial planning of its closure, with current planning continuing during repository operation. The results of closure activities planning shall be reflected in the radioactive waste repository design (and safety justification report).

3.8.2.5.2 Organisational and technical measures implemented during operation (renovation, upgrading) of the radioactive waste repository shall be undertaken with due consideration of the forthcoming repository closure activities.

3.8.2.5.3 Before expiration of the design (specified) service life of the radioactive waste repository, the utility organisation shall ensure development of a programme (plan) of repository closure or conduct an assessment to determine whether repository operation can be extended in accordance with the provisions of codes and regulations applicable to use of nuclear power.

3.8.2.5.4 Radioactive waste repository closure activities shall be performed in accordance with the repository closure programme (plan) and closure design, developed on the basis of the selected closure option.

3.8.2.5.5 Choice of closure option for an in-operation radioactive waste repository shall be made on the basis of the following factors:

- specifics of the radioactive waste repository: method of radioactive waste disposal, technical and process solutions adopted in the radioactive waste repository design;
- radioactive waste repository site conditions: radioactive waste repository resistance to external natural and man-caused impacts; characteristics of repository site, region, and local environment, which may influence the dissemination and accumulation of radioactive substances during and after closure of the radioactive waste repository;
- quantity and characteristics of radioactive waste available on the radioactive waste repository, its radionuclide composition, specific (volumetric) and total radioactivity, and period of potential hazard;
- actual status of the radioactive waste repository and safety barriers;
- radiation consequences of accidents that have occurred during operation of the radioactive waste repository;

– availability of design and operational documentation for the radioactive waste repository;

– availability of methods, means and processes for decontamination and dismantling of equipment, pipelines, structures and facilities of the radioactive waste repository, as well as methods, means and processes for preservation of radioactive waste repository storage cells;

– usability of existing systems, components, structures and facilities (for example, lifting cranes, handling and transport equipment, ventilation systems, radiation monitoring systems, radioactive waste management systems) during repository closure;

– potential radiation impact from radioactive waste repository closure operations on employees (personnel), members of the public and the environment;

– safety assessment results of the radioactive waste repository, including a calculated prediction for assessment of long-term safety of the radioactive waste repository system, assessment results for exposure doses (risks) for employees (personnel), members of the public and impact upon the environment from a closed-down radioactive waste repository;

– results of radiation monitoring during radioactive waste repository operation, including observations results of radionuclides dissemination out of the repository and into the environment;

– possibility of providing physical protection for the closed-down radioactive waste repository and the radioactive waste it accommodates.

3.8.2.5.6 The programme (plan) of repository closure for the selected closure option shall identify key measures to prepare for closure and close the radioactive waste repository, sequence, conditions and expected schedule of performance, including the timeframes for a comprehensive engineering and radiation survey (hereinafter called CERS) of the radioactive waste repository, sequence and target timeframes for various stages of repository closure, as well as brief characterisation of the expected status of radioactive waste repository after completion of the individual stages of closure.

The programme (plan) of repository closure shall be developed on the basis of design and operational documentation for the repository. The programme (plan) of repository closure shall be updated following CERS completion on the radioactive waste repository.

CERS of the radioactive waste repository shall be performed to collect input data for development of the repository closure design and shall cover organisational and technical measures aimed at acquiring information characterising the engineering (technical) status of the radioactive waste repository, quantity of available radioactive waste, its characteristics and locations, as well as information required for assessment of radiological impact upon the employees (personnel), members of the public and the environment during and after the performance of radioactive waste repository closure activities.

3.8.2.5.7 The repository closure programme shall be completed prior to the end of radioactive waste acceptance to the radioactive waste repository.

3.8.2.5.8 Before the start of radioactive waste repository closure operations, the utility organisation shall ensure completion of preparatory activities in accordance with the closure programme (plan), including:

- CERS on the radioactive waste repository and production of summary report within the extent necessary to improve the repository closure programme and justify safety of associated closure operations;
- decontamination of buildings, structures, facilities, equipment, pipelines, systems and components to the extent necessary for the performance of closure operations;
- management of radioactive waste accumulated on the radioactive waste repository over its period of operation and generated as a consequence of preparations for closure;
- training of employees (personnel) for the performance of closure operations on the radioactive waste repository.

3.8.2.5.9 On the basis of data collected during CERS, and analysis of repository design and operational documentation, during preparations for closure the utility organisation shall ensure development of documentation required for repository closure, including the following:

- post-CERS updated radioactive waste repository closure programme;
- repository closure design for the selected option of repository closure, developed with consideration of repository CERS results;
- process regulations for the performance of radioactive waste repository closure activities;

- operation manuals for systems and components that will be needed for the performance of closure operations on the radioactive waste repository;

- action plans to protect employees (personnel) and members of the public in case of accident on the radioactive waste repository during closure;

- accident-response and consequences mitigation plans for radioactive waste repository under closure;

- quality assurance programme during repository closure;

- safety justification report for the selected option of repository closure.

3.8.2.5.10 Design solutions for radioactive waste repository closure shall aim to bring it to a condition so that it will remain safe for as long as the radioactive waste it holds will remain potentially hazardous.

3.8.2.5.11 The repository closure design shall describe and justify the selected closure option and corresponding design solutions for radioactive waste repository closure.

3.8.2.5.12 The repository closure design shall describe the sequence, technical means and organisational measures in support to repository closure for the selected closure option, including:

- description of repository closure stages;

- process and sequence of work performance during each stage of repository closure;

- methods and means for radiation safety assurance, including implementation of the optimisation principle;

- methods and means for radiation monitoring on the radioactive waste repository system during and after repository closure;

- methods and means of fire safety assurance;

- measures to ensure physical protection of the radioactive waste repository and radioactive waste it holds;

- methods and means for management of radioactive waste generated during repository closure;

- measures to ensure radioactive waste tracking and accounting;

- measures to ensure records-keeping and storage;
- description of transport and handling operations in radioactive waste repository rooms and on the site, as well as process chart for transport within the radioactive waste repository site;
- description of final state of the radioactive waste repository after completion of its closure;
- justification of necessary human, financial and material resources.

3.8.2.5.13 For each stage of repository closure the design shall contain:

- work performance process;
- number of employees (personnel) required for work performance;
- measures to ensure radiation safety at the workplaces;
- extent, means and methods of radiation monitoring, including individual dosimetry of employees (personnel), radiation monitoring on the radioactive waste repository, within the sanitary protection zone and observation zone identified for this particular radioactive waste repository, and corresponding technical means to effect that monitoring;
- assessment of individual exposure doses of employees (personnel) for each activity and collective dose of personnel exposure for each work stage on the basis of information about radiological conditions;
- methods and means aimed at minimising personnel exposure during work performance;
- volume, activity and radionuclide composition of generated radioactive waste, as well as methods of its processing, conditioning, transport and disposal locations;
- measures to minimise discharges and releases of radionuclides into the environment;
- description of radioactive waste repository status on completion of each stage of closure.

3.8.2.5.14 Repository closure design shall make the following provisions:

- preservation of filled cells (compartments, chambers, sections) of the radioactive waste repository;

- decontamination, dismantling, disassembly or reassignment of structures, civil structures, systems and equipment, designed for radioactive waste acceptance and temporary placement on the radioactive waste repository;

- radiation monitoring and status monitoring of the radioactive waste repository system during a pre-determined period of time;

- dismantling and disassembly of systems and equipment designed for radiation monitoring and status monitoring of the radioactive waste repository system after the end of radiation and status monitoring.

3.8.2.5.15 The repository closure design shall make provisions for methods and means of surfaces decontamination of equipment, pipelines, rooms, structures and facilities of the radioactive waste repository.

3.8.2.5.16 The repository closure design shall make provisions for methods and means for dismantling of equipment, pipelines, structures and facilities. The methods and means of dismantling envisaged by the design shall be reliable and simple for operation and technical maintenance.

3.8.2.5.17 The repository closure design shall make provisions for radiation monitoring in rooms and on the site of the radioactive waste repository, within the sanitary protection zone and observation zone identified for this particular radioactive waste repository. Radiation monitoring may be performed using the radiation monitoring system provided for radioactive waste repository operation. If necessary, the closure design shall envisage upgrades to that system to better suit the specifics of activities to be performed during each stage of repository closure.

3.8.2.5.18 The to-be-closed radioactive waste repository shall be staffed with workers (personnel) who possess the necessary qualifications and permissions to work unsupervised issued as appropriate.

3.8.2.5.19 During repository closure, the utility organisation shall provide collection, processing, analysis, systematisation and storage of information about any abnormalities, as well as communicate it promptly to interested organisations as appropriate.

3.8.2.5.20 In accordance with the provisions of the Russian legislation the utility organisation shall ensure collection and storage of documentation related to radioactive waste repository closure and important to safety information about the closed radioactive waste repository and the radioactive waste it holds, including design, as-built, operational and accounting documentation, key monitoring results of the radioactive waste repository system and information regarding measures undertaken to ensure safety of the closed-down radioactive waste repository.

3.8.2.5.21 After repository closure the utility organisation shall perform periodic radiation and status monitoring of the radioactive waste repository system, including:

- status verification of engineered and natural safety barriers, enclosures and warning signs;
- host rock status monitoring;
- environmental monitoring.

3.8.2.5.22 Repository closure design shall envisage performance of the following activities:

- preservation of filled cells (compartments, chambers, sections) of the radioactive waste repository;
- decontamination and dismantling of structures, civil structures, systems and equipment that only need to function during radioactive waste repository operation;
- status monitoring of the radioactive waste repository system.

3.8.2.5.23 Preservation of cells (compartments, chambers, sections) in the radioactive waste repository includes performance of the following activities:

- dismantling of handling and processing equipment;
- dismantling of temporary civil structures (for example roofs, canopies) and auxiliary systems (for example ventilation, sewer, water supply);
- filling any empty space (voids) between radioactive waste packages (non-packaged radioactive waste) using a buffer material, if necessary, as well as other activities to bring the cells (compartments, chambers, sections) of the radioactive waste repository to their final condition as envisaged by the closure design.

The scope and sequence of work performance to preserve the cells (compartments, chambers, sections) in the radioactive waste repository once it stops receiving packaged and non-packaged radioactive waste shall be determined and justified in the repository closure design.

3.8.3 Recommendations for the development of regulations that govern acceptance criteria for conditioned radioactive waste for its storage and disposal

** Detailed analysis of the legislative framework of the Estonian Republic with relation to the RW management and disposal issues is presented within Annex 1 of the present report "Assessment of the Legislation of the Estonian Republic" (Tables 43, 46).*

The criteria for RW acceptance for the disposal/storage usually formed on the quantitative and/or qualitative basis and may include criteria introduced for operational as well as for safety reasons. The criteria may be specified by the regulatory body, or by a disposal/storage facility developer/operator and approved by the regulatory body. For the case of the introduction of the acceptance criteria by the Regulatory body it could be recommended to advance the regulative documents of the Republic of Estonia in accordance with the EU requirements and taking into account the IAEA guidelines. In view of this it is recommended that the documents could contain the following provisions:

3.8.3.1. General provisions

3.8.3.1.1 Any removed radioactive waste to be handed over for disposal shall meet the acceptance criteria for disposal as identified by the codes and regulations of the Republic of Estonia.

Criteria for radioactive waste acceptability for disposal are identified in order to ensure safe disposal of a particular class of radioactive waste and determine the requirements sufficient for handover to the national radioactive waste management operator.

3.8.3.1.2 Radioactive waste to be disposed of in a particular radioactive waste repository shall meet acceptance criteria for disposal in that particular repository as identified in accordance with the provisions of applicable codes and regulations.

Criteria of radioactive waste acceptability for disposal in a particular radioactive waste repository are identified in order to implement radioactive waste acceptance criteria for disposal (introduced by the Regulatory body) and repository safety assurance and determine the requirements sufficient for radioactive waste disposal in this particular radioactive waste repository.

Acceptance criteria for radioactive waste disposal in a particular repository shall be determined and identified by the national radioactive waste management operator.

3.8.3.1.3 The organisation whose operations result in the generation of radioactive waste shall use its in-house or specialised subcontractor resources to make sure that the radioactive waste meets the acceptance criteria for disposal and that observation of radioactive waste acceptance criteria is confirmed as required by codes and regulations.

3.8.3.1.4 Any radioactive waste to be handed over for disposal shall come with a certificate ('passport'). The radioactive waste certificate shall be produced by the organisation whose operations result in the generation of radioactive waste, or organisation that conditioned the radioactive waste (produced radioactive waste package), in accordance with the provisions of codes and regulations.

3.8.3.1.5 The national radioactive waste management operator shall ensure radioactive waste acceptance in accordance with the provisions of codes and regulations that govern the handover and acceptance of radioactive waste for disposal.

3.8.3.1.6 During acceptance of radioactive waste for disposal the national radioactive waste management operator shall verify it in accordance with the provisions of codes and regulations applicable to use of nuclear power that govern safety during radioactive waste disposal.

3.8.3.1.7 Activities associated with the development and identification of criteria for radioactive waste acceptability for disposal in a particular radioactive waste repository, making sure the radioactive waste meets the acceptance criteria, confirming that it meets the acceptance criteria and producing a certificate covering the radioactive waste sent to disposal shall be a quality assurance activity and be performed in accordance with the quality assurance programme during radioactive waste management.

3.8.3.2 General disposal acceptance criteria for radioactive waste

3.8.3.2.1 General acceptance criteria for disposal of solid radioactive waste identify requirements that apply to physical and chemical properties of radioactive waste and radioactive waste packages of various classes to be handed over for disposal.

3.8.3.2.2 Qualitative and quantitative values of controlled parameters in general acceptability criteria for disposal of various classes of radioactive waste shall be determined by the regulations of the Republic of Estonia.

3.8.3.2.3 Specific activity of radionuclides in a package (batch) of radioactive waste shall be identified and shall meet the criteria for assigning the package (batch) of radioactive waste to a particular class, as determined by regulations, and provisions that govern safety during radioactive waste disposal.

Specific activity of radionuclides in a package (batch) of radioactive waste is determined by averaging its activity across the mass of the contents of package (batch), including the mass of the matrix material, but excluding the mass of the container (over pack) and its components.

3.8.3.2.4 Absorbed dose rate on the outer surface and/or at a certain distance from the surface of the radioactive waste package (non-packaged radioactive waste) and level of radioactive contamination (both removable and fixed) of the radioactive waste package shall be restricted to limits set in accordance with codes and regulations.

3.8.3.2.5 The following kinds of waste shall not be accepted to a radioactive waste repository:

- explosive, including when heated or caused by impact or friction;
- spontaneously combustible;
- such that emit when in contact with water, air and other substances combustible or explosive (spontaneously flammable, flammable or volatile) gases;
- reactive with water, air and other substances followed by explosion, inflammation or release of a significant amount of heat;
- such that emit when in contact with water, air and other substances toxic gases and aerosols;
- such that contain infective (pathogenic) materials (substances).

3.8.3.2.6 Radioactive waste placed into one package, as well as non-packaged radioactive waste shall be chemically and physically compatible with each other, with the matrix material (if any), as well as with contacting materials of the container and other safety barriers of the radioactive waste repository. Their interaction shall not cause deterioration of mechanical, isolating and shielding characteristics of the radioactive waste package and/or contacting safety barriers.

3.8.3.2.7 Generation of gases in the radioactive waste as a consequence of corrosion, radiolysis, biochemical decomposition of organic substances included in the radioactive waste, as well as other radiochemical, chemical and biological processes shall not cause generation of combustible and explosive mixes, formation of excessive pressure inside the radioactive waste package capable of causing it to deform, breach and release radionuclides into the environment in excess of limits identified in accordance with codes and regulations applicable to use of nuclear power.

3.8.3.2.8 The content of corrosion-active substances in radioactive waste package (batch) shall be restricted so as to ensure that chemical and physical-chemical impacts from corrosion-active substances upon structural materials of the container and other safety barriers of the radioactive waste repository does not cause deterioration of mechanical and isolating characteristics of radioactive waste packages and/or contacting other safety barriers relative to limits identified in accordance with codes and regulations applicable to use of nuclear power.

3.8.3.2.9 The content of complexing agents that can form water-soluble compounds with radionuclides (complex compounds) that are hyper-mobile shall be excluded or restricted so as to keep the release of radionuclides from the radioactive waste package within limits identified in accordance with codes and regulations.

3.8.3.2.10 The content of organic rotting, decomposing and biologically active substances in radioactive waste package (batch) shall be restricted so as to make sure that their decomposition and biological degradation do not reduce structural stability of the radioactive waste package and/or repository cell relative to limits identified in accordance with codes and regulations applicable to use of nuclear power.

3.8.3.2.11 The content of chemically toxic substances in radioactive waste package (batch) shall not exceed limits identified in accordance with the regulations applicable to sanitary and epidemiological protection of the public, environmental protection and other codes and regulations.

3.8.3.2.12 The content of non-bound liquid in the radioactive waste package shall be restricted and kept within limits identified in accordance with codes and regulations of the Republic of Estonia. Radioactive waste humidity shall not cause release of non-bound liquids in excess of identified limits.

3.8.3.2.13 Heat release from radioactive contents of the radioactive waste package shall not cause deterioration of mechanical, shielding and isolating characteristics of the radioactive waste package relative to limits identified in accordance with codes and regulations.

3.8.3.2.14 Generally acceptable for disposal are non-flammable and not-easily-flammable kinds of radioactive waste. Combustible radioactive waste may be accepted for disposal if it is packaged into appropriate containers (over packs), with the resulting radioactive waste package meeting the fire resistance requirements identified in the radioactive waste repository design in accordance with the provisions of codes and regulations.

3.8.3.2.15 The content of spontaneously flammable and easily flammable substances in radioactive waste package (batch) shall not exceed 1% of the weight of the package content (batch), provided that they are evenly distributed across the volume of the package (batch).

3.8.3.2.16 Powder-like dispersed radioactive waste that can be easily dissipated shall be converted into a form that restricts its ability to disseminate, and/or packaged so as to ensure that its radiation impact upon employees (personnel), members of the public and the environment as a consequence of radioactive substances release from the radioactive waste package (non-packaged radioactive waste) in normal radioactive waste repository operation and operational abnormalities is kept within limits identified in regulations.

3.8.3.2.17 Radioactive waste shall be disposed of in a structurally stable form. The form of radioactive waste and/or radioactive waste package shall retain in disposal conditions its physical shape, size structure and mechanical properties within the design-identified limits.

3.8.3.2.18 Solidified (grouted) radioactive waste, its physical-chemical form and the post-solidification (grouting) compound (matrix material with radioactive waste inclusions) shall meet the safety requirements applicable to processing and conditioning of radioactive waste.

3.8.3.2.19 Disposal of radioactive waste that is not incorporated in a matrix (such as non-processable solid radioactive waste, non-fragmentable pieces of contaminated equipment, compressed radioactive waste, fragmented metallic radioactive waste, dehydrated ion-exchange resins, molten salts) may be permitted on the condition that the radioactive waste package to be disposed of meets the requirements identified by radioactive waste acceptability criteria for disposal in a particular radioactive waste repository.

3.8.3.2.20 Some kinds of radioactive waste may be disposed of without prior grouting and/or in non-packaged form on the condition that this method of radioactive waste disposal is envisaged by the radioactive waste repository design and that the radioactive waste meets the general acceptance criteria established for non-packaged radioactive waste, as well as acceptance criteria for disposal in this particular radioactive waste repository.

3.8.3.2.21 Very low-level radioactive waste may be disposed of on the radioactive waste repository located within the same site as the repository for particularly hazardous waste where it was generated, if the radioactive waste meets the general acceptance criteria identified for non-packaged class 4 radioactive waste, and acceptance criteria for disposal in this particular repository.

Radioactive waste generated as a consequence of mining and processing of mineral and organic resources with elevated levels of natural radionuclide content may be disposed of on the radioactive waste repository originally designed for disposal of other kinds of radioactive waste, on the condition that the to-be-disposed-of radioactive waste meets the general acceptance criteria identified for this class of radioactive waste, and acceptance criteria for disposal in this particular repository.

3.8.3.2.22 Radioactive waste generated as a consequence of uranium ores mining and processing may be disposed of on the radioactive waste repository located within the same site as the uranium mining and processing facilities where the radioactive waste was generated, provided that the radioactive waste meets general acceptance criteria and acceptance criteria for disposal in this particular radioactive waste repository.

3.8.3.3 Requirements for packages of radioactive waste for disposal and for containers (shipping packages)

3.8.3.3.1 Radioactive waste package has to restrict emission of radiation and radioactive substances beyond the radioactive waste package so that the combination of protection and insulation properties of the radioactive waste package and other safety barriers of the disposal facility ensured implementation of established by sanitary rules and regulations of radiation, safety requirements for restriction of radiation and other impact on the employees (personnel), public and the environment during the period of the potential risk from the disposed radioactive waste.

3.8.3.3.2 Radioactive waste packages of all classes when handling at normal operation of the disposal facility must maintain integrity and restrict emission of radiation and radioactive contents by limits established according to the requirements of the rules and regulations of the Republic of Estonia.

Radioactive waste packages also have to withstand impacts and loads that may arise at handling under condition of violation of normal operation of the disposal facility (excluding accidents) without deformations otherwise they will no longer meet the established requirements for mechanical insulation and protection characteristics.

3.8.3.3.3 Radioactive waste packages must not be subject to spontaneous combustion.

3.8.3.3.4 Mechanical characteristics of the radioactive waste packages must guarantee performance of transportation operations including stockpiling if it is provided for by transportation flow chart of the dispose facility.

3.8.3.3.5 If protection and mechanical characteristics of a radioactive waste package do not ensure safety requirements at handling at the disposal facility, the package of radioactive waste must be placed in additional container (shipping package) ensuring implementation of the established safety requirements at handling the package.

3.8.3.3.6 Radioactive waste packages during a period determined in the Radioactive Waste Disposal Facility Project must maintain the structural stability, mechanical and insulation characteristics under condition of the disposal facility taking into account radioactive, mechanical, chemical, thermal and biological loads and impacts that may arise at the disposal facility.

The radioactive waste packages must be radiation resistant and maintain mechanical and insulation characteristics at projected integral absorbed dose of radiation within the limits..

Radioactive waste packages must be resistant to action of temperature specific to the environmental conditions, and maintain mechanical and insulation characteristics at forecasted temperature actions, including temperature cycling actions within the limits established by the norms and rules. The packages of heat generating radioactive waste must be resistant to temperature actions due to heat generation by radioactive waste.

Radioactive waste packages must be biologically resistant and maintain within the established limits the structural stability, mechanical and insulation characteristics at action of bacterial, fungus and microorganisms causing rotting and other destroying processes.

3.8.3.3.7 Radioactive waste packages must maintain its efficiency (mechanical and insulation characteristics) until closing the disposal facility.

3.8.3.3.8 Integrity of the radioactive waste packages must be maintained until isolation of the radioactive waste disposal cell. The period for maintaining the integrity, mechanical and insulation characteristics of radioactive waste packages after isolation of the disposal cell and after closing the disposal facility is established in the Disposal Facility Project based of assessment of safety of the disposal facility.

3.8.3.3.9 Radioactive waste packages containing nuclear hazardous fissionable nuclide must satisfy the nuclear safety requirements.

3.8.3.3.10 Performance of established requirements for mechanical, protection and insulation characteristics of radioactive waste packages is ensured at the cost of combination of the properties of elements of radioactive waste packages, including the contents of radioactive waste packages, form of the package of radioactive waste package and container (shipping package).

3.8.3.3.11 Mass-dimensional characteristics of packages of radioactive waste (geometric dimensions, weight, volume and structure) shall comply with lifting capacity of mechanisms and layout solutions of the disposal facility.

3.8.3.3.12 Containers (shipping packages) intended for manufacture of radioactive waste packages for disposal subject to compliance assessment in terms of legislation of the Republic of Estonia.

3.8.3.3.13 Construction materials of the containers (shipping packages) intended for manufacture of packages of radioactive waste must be resistant to radiation, corrosion, thermal loads due to the properties of the radioactive contents and conditions of disposal of the radioactive waste at the radioactive waste disposal facility.

3.8.3.3.14 Structure of the containers (shipping packages) designed for manufacture of radioactive waste packages shall provide the possibility of handling with the radioactive waste package at the disposal facility directly or remotely depending of accepted process of handling with the radioactive waste package at the disposal facility.

3.8.3.3.15 Structure of the containers (shipping packages) designed for disposal of the radioactive waste which can release gases must provide exit of gaseous substances from the radioactive waste packages thereat exit of the radionuclides from the radioactive waste packages shall be limited to the extent established in accordance with these rules and regulations.

3.8.3.3.16 Each package of radioactive waste for disposal must be marked. Marking (marking label) must contain basic information about the package of the radioactive waste necessary for its identification and transfer for disposal:

- radiation precaution sign;
- individual number (identification code) of the radioactive waste package including the mark of the manufacturer (supplier) of the radioactive waste package;
- indication of the radioactive waste class;
- dose rate at the surface, total activity of the radioactive waste package;
- date of loading of the radioactive waste;
- net and gross weight of the radioactive waste package.

3.8.3.3.17 Marking of the radioactive waste package must be clear and legible, visible, if necessary available for electronic reading from the distance determined by the process of loading.

3.8.3.3.18 Marking of the radioactive waste package must be resistant to influence of climatic factors, difficult-to-remove at handling and informative till the planned moment of isolation of the disposal cell where the package of radioactive waste is disposed.

3.8.3.4 Requirements for development and standard-setting for admissibility of radioactive waste for disposal in a certain disposal facility

3.8.3.4.1 For each radioactive waste disposal facility there must be established standards for admissibility of radioactive waste for disposal at the given disposal facility including admissible quantitative and qualitative values of regulated indices according to the following list:

1) Characteristics of radioactive contents of the package (batch) of solid radioactive waste:

- type of radioactive waste and their physical form;
- radiation characteristics - radionuclide composition, specific activities and total specific activities:
  - long-lived radionuclides;
  - transuranic radionuclides;
  - alpha-emitting radionuclides (excluding transuranic radionuclides);
  - beta/gamma-emitting radionuclides;
  - tritium;
- general activity of a package (batch) of radioactive waste – contents and (or) concentration of nuclear-hazard fissionable nuclides;
- physical and chemical properties:
  - morphological (chemical) composition;
  - content of corrosion-active substances;
  - content of complexing agents;
  - content of chemically toxic substances;
  - content of infection (pathogen) agents;
  - content of organic rotting, biologically active degradable substances;
  - content of flammable, self igniting substances;
  - content of oxidizing substances;
  - reactivity;

  - burning quality;
  - ability to explode;
  - content of free liquid including organic;
  - heat release;
  - gas generation.

2) Characteristics of radioactive waste form:

- mechanical strength;
- physical properties, including homogeneity, porosity, density, gas and water permeability;
- resistance to leaching;
- radiation, thermal and biological resistance.

3) Characteristics of container (shipping package):

- mechanical strength;
- chemical and physical properties of construction material:

  - chemical composition;
  - porosity, density, gas and water permeability;
  - chemical resistance;
  - corrosion resistance to exposure to contacting environment;
  - radiation resistance ;
  - resistance to thermal loads and thermal cycles,
  - frost resistance;

- protective properties (provision of biological protection);
- insulation properties (tightness, diffusion permeability by separate radionuclides);
- durability (retention of mechanical, protection and insulation properties);
- fire-resistance;
- mass and dimensions parameters;
- structure;
- damage tolerance (allowable dimensions of chips, cracks, dents).

4) Characteristics of radioactive waste packages:

- mechanical strength ;
- insulating properties (tightness, radionuclides release rate);
- radiation resistance;
- resistance to thermal loads and thermal cycles;
- fire-resistance;

– radiation characteristics:

  - o equivalent dose rate at the surface and at certain distance;
  - o surface contamination of external surface;

– mass and dimensions parameters;
– damage tolerance (allowable dimensions of chips, cracks, dents);
– marking.

The list of criteria of acceptability of radioactive waste for disposal at certain disposal facilities and admissible values of regulated indices must be established and proved in the Disposal Facility Project and in the safety assessment report (hereafter - Safety Assessment Report) on the disposal facility taking into account conditions of disposal of radioactive waste and special characteristics of the Disposal Facility Project.

3.8.3.4.2 Criteria of acceptability of radioactive waste for disposal at a certain disposal facility shall be developed based on general criteria of acceptability of radioactive waste, requirements of normative legal acts in the field of nuclear energy, sanitary and epidemiological welfare of population and environment, as well as results of safety assessment of the disposal facility.

3.8.3.4.3 The criteria of acceptability of radioactive waste for disposal at a certain disposal facility are developed at the stage of design and construction of the disposal facility involving companies performing design of the disposal facility.

3.8.3.4.4 The criteria of acceptability of radioactive waste for disposal at a certain disposal facility shall be installed for each individual disposal facility designed for disposal of radioactive waste.

3.8.3.4.5 Changes of quantitative and qualitative indices of criteria of acceptability of radioactive waste for a certain disposal facility against the values established by general acceptability criteria shall be substantiated in the project and Safety Assessment Report for a particular disposal facility.

3.8.3.5 Confirmation of compliance of radioactive waste with criteria of acceptability for disposal

3.8.3.5.1 Methods and means of bringing radioactive waste to conformity with criteria of acceptability for disposal, among them methods and means for reprocessing and conditioning of radioactive waste, including manufacture of radioactive waste packages, as well as procedure, volume, methods and means of control of characteristics of radioactive waste for their compliance with acceptability criteria shall be established in design and (or) operational documentation of the company which activity results in generation of radioactive waste or specialized company on handling radioactive waste, performing conditioning of radioactive waste.

3.8.3.5.2 Compliance of radioactive waste to acceptability criteria for disposal is confirmed by experimental (instrumentation) and (or) calculation methods under condition that they are based on results of preliminary direct and (or) indirect measurements of values of controlled parameters of the process.

Ensuring of compliance with the parameters of radioactive waste to criteria of acceptability by means of compliance to established requirements for the processes (in particular, sorting, reprocessing, and conditioning of radioactive waste) shall be documented in operational documentation. In the operational documentation shall be shown that at performance of the process according to the established requirements and in compliance with the quality assurance program on handling the radioactive waste, the reprocessed (conditioned) radioactive waste meet the acceptability criteria.

3.8.3.5.3 Characteristics and properties of radioactive waste sent for disposal shall be determined in scope and within the accuracy, which allow confirming compliance with the criteria of acceptability of radioactive waste for disposal.

3.8.3.6 Requirements for radioactive waste certificate

3.8.3.6.1 Correspondence of radioactive waste transferred for disposal (radioactive waste packages, batches of solid radioactive waste, and batches of liquid radioactive waste) to criteria of acceptability for disposal shall be confirmed by documents and reflected in certificate for package (batch) of radioactive waste in compliance with the requirements of norms and regulations.

3.8.3.6.2 Certificate shall be executed for each package (batch) of radioactive waste for disposal.

3.8.3.6.3 Certificate for package (batch) of radioactive waste shall contain information on main characteristics of package (batch) of radioactive waste and confirm compliance of given package (batch) of radioactive waste to established criteria of acceptability for disposal.

3.8.3.7 Example of criteria of acceptability of radioactive waste

In the Table 37 below are given criteria of acceptability of radioactive waste for disposal as example.

Table 37: General criteria of acceptability of radioactive waste for disposal

General criteria of acceptability of radioactive waste class 1	
Regulated parameter	Value (requirement)
Requirements for radioactive contents	
Ability to explode	Not allowed
Content of flammable or spontaneously combustible substances	Not over 1% of the weight of the radioactive content
Content of substances that react with water with emission of flammable or self-flammable gases	Not allowed
Emission of toxic gases, aerosols and fumes at interaction with water, air or other substances	Not allowed
Presence of infectious (pathogenic) agents	Not allowed
Requirements for package of radioactive waste	
Specific activity of radionuclides in package of radioactive waste	According to criteria established for the given class of radioactive waste by laws and regulations
Non-fixed surface contamination of the outer surface of radioactive waste package: beta-emitting radionuclides; alpha-emitting radionuclides	 Not over 10^4 particles/(cm^2 x min); not over 2 x 10^2 particles/(cm^2 x min)
Mechanical strength of radioactive waste packages: compression strength	 Not less than 10 MPa
Saving of insulation ability of radioactive waste package	Not less than 1000 years
Thermal resistance of radioactive waste package	Saving of structure, strength and insulating properties at temperature up to 450 °C
Radiation resistance of radioactive waste packages	Saving of strength not less than 20% of established one at radiation dose up to 10^8 Gy for beta/gamma radiation 10^{19} alpha-decay/см^3
Thermal resistance of radioactive waste package	Not over 2 kW/m^3
General criteria of acceptability of radioactive waste class 2	

Regulated parameters	Value (requirement)
Requirements for radioactive contents	
Ability to explode	Not allowed
Content of flammable or spontaneously combustible substances	Not over 1% of the weight of the radioactive content radioactive waste packages
Content of substances that react with water with emission of flammable or self-flammable gases	Not allowed
Emission of toxic gases, aerosols and fumes at interaction with water, air or other substances	Not allowed
Content of infectious (pathogenic) agents	Not allowed
Contents of complexing agents	Not over 1% of the weight of the radioactive content radioactive waste packages
Contents of free liquid	Not over 3% of the weight of the radioactive content radioactive waste packages
Requirements for package of radioactive waste	
Specific activity of disposed radioactive waste	According to criteria established for the given class of radioactive waste by laws and regulations
Non-fixed contamination of the outer surface of radioactive waste package: beta-emitting radionuclides; alpha-emitting radionuclides	 Not over 1 x 10^4 particles/(cm^2 x min); not over 2 x 10^2 particles/(cm^2 x min)
Mechanical strength: compression strength	Not less than10 MPa
Saving of insulation ability of radioactive waste package	Not less than1000 years
Radiation resistance radioactive waste packages	Saving of strength not less than 20% of established one at radiation dose up to 10^6 Gy or predicted dose
Thermal resistance of radioactive waste package	Not over 100 W/m^3
Resistance of radioactive waste package to thermal cycles	Saving of strength and insulation properties after 30 cycles of freezing and thawing (-40.. + 40°C)

General criteria of acceptability of radioactive waste class 3	
Regulated parameters	Value (requirement)
Requirements for radioactive contents	
Ability to explode	Not allowed
Content of flammable or spontaneously combustible substances	Not over 1% of the weight of the radioactive content radioactive waste packages
Content of substances that react with water with emission of flammable or self-flammable gases	Not allowed
Emission of toxic gases, aerosols and fumes at interaction with water, air or other substances	Not allowed
Content of chemically toxic agents	Not allowed to bury radioactive waste referred to hazard class I (extra-hazardous) according to criteria of hazardous waste classified as hazardous for environment, which are established by regulatory legal acts in the field of environment protection
Content of infectious (pathogenic) agents	Not allowed
Contents of complexing agents	Not over 1% of the weight of the radioactive content radioactive waste packages
Contents of free liquid	Not over 3% of the weight of the radioactive content radioactive waste packages
Requirements for package of radioactive waste	
Specific activity of disposed radioactive waste	According to criteria established for the given class of radioactive waste by laws and regulations
Rate of absorbed dose at the surface of radioactive waste package	Not over 10 mGy/h
Non-fixed (removed) surface contamination: beta-emitting radionuclides; alpha-emitting radionuclides; transuranic radionuclides	 Not over 2 x 10^3 particles/(cm^2 x min); not over 2 x 10^1 particles/(cm^2 x min); not over 2 x 10^1 particles/(cm^2 x min)
Mechanical strength radioactive waste packages: compression strength	Not less than the requirements established by rules regulating safety during transportation for radioactive material packages type A; not less than5 MPa

Saving of insulation ability of radioactive waste package	Not less than 100 years
Radionuclides release rate from package (mass activity fraction released from radioactive waste package, per year)	Not over 10^{-2}/year for tritium; not over 10^{-3}/year for beta/gamma-radiation radionuclides, excluding tritium; not over 10^{-4}/year for alfa-radiation radionuclides
Resistance to thermal cycles of radioactive waste packages	Saving of strength and insulation properties after 30 cycles of freezing and thawing (-40... + 40 °C)
Radiation resistance of radioactive waste package	Decrease of strength not over than 20% of established limit at radiation dose 10^6 Gy or predicted dose
<u>General criteria of acceptability of packed radioactive waste class 4</u>	
Regulated parameters	Value (requirement)
Requirements for radioactive contents	
Ability to explode	Not allowed
Content of flammable or spontaneously combustible substances	Not over 1% of the weight of the radioactive content radioactive waste packages
Content of substances that react with water with emission of flammable or self-flammable gases	Not allowed
Emission of toxic gases, aerosols and fumes at interaction with water, air or other substances	Not allowed
Content of chemically toxic agents	Not allowed to bury radioactive waste referred to hazard class I (extra-hazardous) according to criteria of hazardous waste classified as hazardous for environment, which are established by regulatory legal acts in the field of environmental protection
Content of infectious (pathogenic) agents	Not allowed
Contents of complexing agents	Not over 1% of the weight of the radioactive content radioactive waste packages
Requirements for package of radioactive waste	
Specific activity of radionuclides in package of radioactive waste	According to criteria established for the given class of radioactive waste by laws and regulations
Rate of absorbed dose at the surface of	Not over 2 mGy/h

radioactive waste package	
Non-fixed (removed) surface contamination radioactive waste packages: beta (gamma)-radiation radionuclides; alpha-emitting radionuclides; transuranic radionuclides	 Not over 2 x 10^3 particles/(cm^2 x min); not over 2 x 10^1 particles/(cm^2 x min); not over 2 x 10^1 particles/(cm^2 x min)
Saving of insulation ability of radioactive waste package	before disposal
General criteria of acceptability of unpacked radioactive waste class 4	
Regulated parameters	Value (requirement)
Ability to explode	Not allowed
Content of flammable or spontaneously combustible substances	Not over 1% of weight of radioactive waste batch
Content of substances that react with water with emission of flammable or self-flammable gases	Not allowed
Emission of toxic gases, aerosols and fumes at interaction with water, air or other substances	Not allowed
Flammability	Non-flammable and fire resistant radioactive waste are allowed
Content of chemically toxic agents	Not allowed to bury radioactive waste referred to hazard class I (extra-hazardous) and II (highly hazardous) according to criteria of hazardous waste classified as hazardous for environment, which are established by regulatory legal acts in the field of environmental protection
Content of infectious (pathogenic) agents	Not allowed
Specific activity of radioactive waste	According to criteria established for the given class of radioactive waste by laws and regulations
Rate of absorbed dose at the surface of radioactive waste	Not over 2 mGy/h
General criteria of acceptability of radioactive waste class 6 generated during production and processing of uranium ore	
Regulated parameters	Value (requirement)

Ability to explode	Not allowed
Content of flammable or spontaneously combustible substances	Not allowed
Content of substances that react with water with emission of flammable or self-flammable gases	Not allowed
Content of chemically toxic agents	Not allowed to bury radioactive waste referred to hazard class I (extra-hazardous) and II (highly hazardous) according to criteria of hazardous waste classified as hazardous for environment, which are established by regulatory legal acts in the field of environmental protection
Content of infectious (pathogenic) agents	Not allowed
Flammability	Allowed nonflammable and fire resistant radioactive waste
Rate of absorbed dose at the surface	Not over 2 mGy/h
Specific activity	In accordance with rules and regulations in the field of nuclear energy, regulating safety in the near-surface disposal of radioactive waste
<u>General criteria of acceptability of liquid radioactive waste class 5</u>	
Regulated parameters	Value (requirement)
Ability to explode	Not allowed
Content of flammable or spontaneously combustible substances	Not allowed
Content of substances that react with water with emission of flammable or self-flammable gases	Not allowed
Content of infectious (pathogenic) agents	Not allowed
Specific activity of liquid radioactive waste	According to criteria established for the given class of radioactive waste by laws and regulations
Total salt content	Not over 450 g/ dm^3
Content of organic acid salts	Not over 150 g/dm^3
Content of nitrates, sulphates and chlorides of sodium	Not over 350 g/dm^3
Content of fine suspended solid particles	Not over 0,1 g/dm^3

3.8.4 Schedule of development and issuance of normative documents of legal framework of the republic of Estonia

To address the issues on preparation of radioactive waste for disposal it is necessary to develop a schedule for bringing the legal framework of the Republic of Estonia in compliance with EU Directives and the IAEA requirements and recommendations.

This schedule should include detailed description of the stages of development, coordination, approval and adoption by the public authorities of the Republic of Estonia of amendments to the law on radiation, government regulations, decrees of ministry regulating relations in the field of disposal of radioactive waste.

When developing the schedule it is necessary to consider that the schedule must include substantiating documents in the form of concepts and research work.

According to the hierarchical structure of regulatory documents of the Republic of Estonia after amendments to the existing law on radiation or after adoption of new law it is necessary to develop regulations (government regulations, decrees of ministry, procedures, safety guides) regulating relations in the field of disposal of radioactive waste.

At the initial stage of development of the schedule under condition of lack of information when it is difficult to predict the time, the best variant is to develop an indicative schedule. With work progress in is necessary to perform detailing of the schedule taking into account data entry on labor and financial resources necessary for development and enactment of new regulations.

Organization of work on development of the schedule must be overseen by the Ministry of Environment protection. According to preliminary estimate bringing the legal framework of the Republic of Estonia in conformity with the IAEA recommendations will take from 4 to 6 years.

3.8.5 Findings

Active development of the area associated with ensuring national radiation protection and radioactive waste management is currently under way in the Republic of Estonia. The objective of creating a national system is to give legal effect to internationally recognized principles, criteria, provisions and mechanisms of their implementation in order to efficiently regulate matters related to radiation safety including the experience in radioactive waste collection and disposal as well as decommissioning of hazardous radiation installations.

One of directions in ensuring national radiation safety is improvement of legal and regulatory framework. The need for making amendments to the legal and regulatory framework in the Republic of Estonia is stipulated by the plans of radwaste management activities and updates to the EU and IAEA's legal framework.

The National Development Plan for Radiation Protection 2008-2017 [40] and the national programme for radioactive waste management [86] identify the timeframes for decommissioning the rector compartments at the Paldiski site and construction of the radioactive waste repository. Implementation of these activities will mandatorily require updating the applicable legislation. The programme [86] states that construction of the final disposal facility/ repository should be preceded by thorough updating of the legislation, as the existing legal framework is insufficient for the building of the final disposal site. In addition to the Radiation Act and regulations issued on its basis, changes should be made to legislation concerning planning and erection of facilities in order to establish requirements for the construction of a final disposal site.

The existing Estonian Law does not provide for a clear allocation of responsibilities for radioactive waste management. The roles and responsibilities of entities involved must be determined. Besides, a number of regulations that came into effect in the European Union, in their turn, impose additional obligations on the Republic of Estonia., and such obligations should also be reflected in the Estonian legal framework for the purposes of their implementation.

In 2011, Council Directive 2011/70/EURATOM entered into force, establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste. This Directive requires that each EU Member State is obliged to prepare and provide the Council with a national programme that would describe waste collection and disposal arrangement in the Member State as well as steps to be undertaken for waste management from generation to final disposal. The action plan includes the description of the national policy on radioactive waste, the existing obsolete inventory, technical solutions for waste treatment and disposal (final disposal), and timeframes for actions, resources etc.

In 2013, Council Directive 2013/59/EURATOM entered into force, laying down basic safety standards for protection of the health of workers and the public against the dangers arising from exposure to ionising radiation. This Directive should be adopted by Member States by the end of 2018.

It would be adequate to involve experts from countries that possess experience in the design and operation of repositories for the purposes of developing amendments to part of regulatory documents that regulate activities associated with the final disposal of radwaste.

Amendments to be made to the legal and regulatory framework in the Republic of Estonia must be sufficient for siting a near-surface radwaste repository, development of the design documentation for such a radioactive waste repository and safety assurance during operational and post-operational periods.

3.9 LIST OF REQUIREMENTS AND RECOMMENDATIONS TO BE TAKEN INTO CONSIDERATION DURING DEVELOPMENT OF THE ASPECTS OF DISPOSAL (DISPOSAL) OF RADIOACTIVE WASTE

** Detailed analysis of the legislative framework of the Estonian Republic with relation to the RW management, transportation, decommissioning and disposal issues is presented within Annex 1 of* *the present report "Assessment of the Legislation of the Estonian Republic" (Tables 43, 44, 45, 46).*

During development of the concept for disposal of radioactive waste produced at decommissioning of reactor compartments of Paldiski, along with the principles of radwaste handling stated in the legislative base of the Republic of Estonia, it is necessary to refer on IAEA documents (WS-G-2.5, 2005;; № SSR-5, 2011, SSG-29. 2014) and the Directives of the European Union in the field of radioactive waste management)

3.9.1 Requirements and recommendations for radioactive waste conditioning for the subsequent disposal

The sections of the report contain general requirements for RW conditioning before their disposal and the list of characteristics of waste and containers/packages required to be analyzed to ensure compliance with acceptance criteria for transportation, storage or disposal. Technical specifications for the waste packages are determined so that to ensure compliance of the final product (waste package) with applicable acceptance criteria, in particular for disposal. For reasonable assurance that the conditioned waste can be accepted for disposal at possible absence of any specific requirements established, it is necessary to provide for, as far as possible, the variants of waste handling in future and related requirements for waste acceptability. Fulfillment of waste acceptability requirements can be achieved using additional package (transport package), which will comply with transportation and technological part for management within the storage area and RW characteristics, as well as engineering systems of disposal facility. The disposal packages may not comply with acceptance criteria for transportation of packages. Application of dual purpose containers/packages is often economically inadvisable. It is true especially for waste characterized by sufficiently high activity. Characteristics of containers/packages that need to be taken into account differ for metal and reinforced concrete containers.

3.9.1.1 Waste acceptance criteria for disposal

General acceptance criteria for solid RW to be disposed establish requirements for RW packages (RW batch) subject to disposal, namely for:

Characteristics of radioactive contents of RW packages including RW forms, characteristic of RW batches;

Characteristics of RW package.

Radiological characteristics of waste (concentration of radionuclides, activity and dose rate) are the most important and determined at early stage.

In terms of physical-chemical form, the conditioned radioactive waste coming for disposal shall not contain the following:

Substances capable of explosion, including when being heated or initiated by impact or friction;

Flammable substance or capable of spontaneous combustion;

Substances reacting with water with emission of inflammable or flammable gases;

Infective (pathogenic) agents;

Substances emitting toxic gases, aerosols and fumes in contact with water, air or other substances;

Free liquid (limitation is imposed).

Incombustible and low combustible RW are accepted for disposal.

Metal waste that will be generated at cutting of steel structures of reactor meets the general requirements of the acceptance criteria and does not require additional verification of compliance to these criteria.

When choosing container for SRW, the following shall be considered:

Corrosion resistance, radiation resistance, configuration (geometry) – for metal container;

Density, porosity, water permeability, gas permeability, frost resistance, radiation resistance, microbial resistance, mould-growth resistance, fire resistance, configuration (geometry) – for reinforced concrete container;

Other characteristics that determine insulating capacity of container.

An important objective of SRW handling before disposal shall be obtaining of waste packages that can provide safety in handling, transportation, storage and disposal.

The methods and means of bringing the RW in compliance with acceptable criteria of disposal, including the methods and means of re-processing and conditioning of RW, and including manufacture of RW package, as well as the procedure, volume, methods and means of control of RW characteristics in terms of compliance to acceptance criteria shall be established in design and (or) operational documentation of the company from whose activities there were generated RW or specialized company on handling of RW who performs conditioning of RW.

3.9.1.2 Procedure of acceptance of waste for disposal

RW compliance with acceptance criteria for disposal is confirmed by experimental (instrumental) and (or) calculation methods provided that they are based on results of preliminary direct and (or) indirect measurements of the values of controlled parameters of the process.

Ensuring of RW parameters compliance with acceptable criteria by meeting the established requirements for processes performance (in particular, RW sorting, re-processing, conditioning) shall be fixed in operational documentation.

In the operational documentation there shall be shown that in performance of the process according to the established requirement and in compliance with the quality assurance program on RW handling, the processed (conditioned) RW meet the acceptance criteria.

Characteristics and properties of the RW sent for disposal shall be determined in scope and accuracy allowing to confirm fulfillment of acceptance criteria of RW for disposal.

Compliance of the RW (RW packages, SRW batches) sent for disposal to the RW acceptance criteria for disposal shall be confirmed by documents and reflected in the technical documentation for package of RW (SRW batch).

Certificate shall be executed for every package of RW (SRW batch) to be disposed.

The certificate shall contain basic characteristics of RW (SRW batch) package and certify compliance of the given package of RW (SRW batch) to the established acceptance criteria for disposal.

3.9.2 Requirements and recommendations for development of solutions for arrangement of disposal facility.

When developing solutions on arrangement of disposal facility at the stages of conceptual and forward design and at the stage of area review resulting in selection of one or several places of possible points of disposal in compliance with the appendices 1, 2 SSG-29. 2014 and 1 SSG-14, 2014, the following factors shall be considered:

- Expected type and quantity of waste, time of disposal;
- Identification of the place of location of potential site is performed in two stages:

a) Regional phase of mapping and investigation in order to identify the area with potentially suitable places (it is performed step-by-step based on geographical, geological and hydrogeological data of the previous investigations, historical data);

b) Selection of one or more potential places for further detailed evaluation considering social and political criteria, considering national instructions and laws. The presence of national parks, monuments, for example, refer to such criteria.

Preliminary analyses of waste generated from decommissioning of reactor compartments approximately in 50 years of storage after shutdown of reactors shows that due to radionuclide decay the waste from cutting of reactor and shielding tank characterized by the highest activity refer to intermediate-level waste which radionuclide composition is due to long-lived radionuclides, where the main is Ni-63. According to IAEA [3] classification the intermediate-level waste (ILW / CAO) containing long-lived radionuclides are not acceptable for near- surface disposal and require to be disposed of at greater depth ranging from dozens to several hundred meters.

Taking into account high disposal cost, the EU directive 2011/70 [13] provides for the EU countries a possibility to cooperate in construction of shared radioactive waste repositories. Currently, as far as there is no spent nuclear fuel at the Paldiski facility - the obligation on implementation of the directive provisions related to the spent nuclear fuel does not apply to Estonia.

Based on the foregoing the following are the requirements for selection of the place for arrangement of the facilities for disposal and near-surface disposal.

Suitability of the place for arrangement of the facility for a disposal shall be evaluated considering the following conditions:

- Availability of mineral resources;
- Geology of the place of disposal;
- Hydrogeological characteristics at the site and surroundings;
- Geochemistry of ground water and geological environments;
- Geomechanical conditions, tectonics and seismicity;
- Surface processes;
- Meteorology;
- Events resulting from human activities;
- Transportation logistics;
- Land-use;
- Density of the population;
- Environmental protection;
- Social conditions.

Geology of the place of the disposal facility shall make isolation of waste and restrict release of radionuclides into biosphere. The geological information shall include identification of approximate geological structure and stratigraphy, possibly with depth, thickness and lateral extent of surface formation and surrounding units.

The hydrogeological characteristics of the space. In case of insufficient information on hydrogeological maps at the stage of review of the region the analyzed information should include:

- Data on existing and expected main types of water use;
- Identification of main points of handling;
- Evaluation of the ground water flow rate.

Geochemistry of the ground water and geological environments shall help to restrict the release of radionuclides from the disposal facility and should not significantly reduce the durability of the designed barriers. The preference should be given to the places where the geochemistry conditions ensure sorption, precipitation and co-precipitation of radionuclides which could migrate from the disposal facility.

When considering possible chemical interactions within the disposal facility the following shall be evaluated:

- Corrosive effect of the ground water on designed barriers;
- The processes of conditions affecting the solubility and sorption of the radionuclides;
- eH and pH factor of the ground water;
- The processes or conditions involving the presence of natural colloids and organic materials;
- Potential of gas development in the disposal system.

Information required for evaluation of the potential movement of the radionuclides within the biosphere shall include description of the on-site geochemical and hydrochemical conditions, surrounding geological and hydrogeological units and ways of potential flow of the ground water.

This information is unlikely to be available at the stage of review of selection of the places for the disposal facility. However it should be collected as a part of the investigation program performed during characterization of the site and stages of confirmation of the site.

Tectonics and seismicity

The site should be located in the area of low tectonic and seismic activity, so that the disposal facility is not exposed to danger.

The areas of low seismic activity should be selected during the analysis. The preference should be given to the areas or places where the potential for adverse tectonic, volcanic or seismic events is low enough.

Surface processes

The surface processes such as flooding, landslides or erosion should not be so intensive or frequent to impact the disposal facility safety. At the stage of the site there should be evaluated the flood probability. Potential sites should be showed on map. The surface geological processes such as erosion, landslides or slope should be evaluated in terms of their frequency and ability to impact the disposal facility safety.

Meteorology

At the stage of the site selection the data on extreme weather conditions which could have a negative impact on safety to the facility shall be mapped at national or regional level.

Events resulting from human activities

The site of disposal should be located so that the activities of the current and/or future generations could not impact the disposal facility insulating capacity. There shall be evaluated the sites in close vicinity to main dangerous facilities, airports or transport routes carrying over significant amounts of dangerous materials. In addition the sites or places shall be evaluated in terms of valuable geological resources or potential future resources including ground water.

At the stage of the site selection the known valuable geological resources including ground water shall be mapped as a part of the process of determining the area of interest.

Transportation logistics

The site shall be located so that transport communication allowed transportation of RW with minimum risk for the population. Parameters including radiation exposure and possibility of accident due to transportation of waste to the place of disposal shall be considered.

Land using

Land use and land ownership in the area of supposed arrangement of the disposal facility shall be evaluated considering use of land in the vicinity to supposed place of disposal.

Distribution of population

Attention shall be paid to avoiding the areas with high density of population. The preference should be given to the sites remote from the highly populated areas. Also, the availability of the infrastructure and work force should be taken into consideration.

At the stage of the site selection on large-scale maps there should be shown main population centers and regions with high density of population as distance function.

Environment protection

Near the disposal facilities there should be met the environment protection requirements. Possible negative impacts on the environment from the near surface disposal facilities include:

- Environment impact resulting from construction and operation of disposal facility;
- Impact on the population;
- Impact on water supply;
- Impact on endangered species.

To assess potential impact on environment the types, the information shall include the following:

- Location of national parks and areas with historical monuments and archeological results;
- Existing resources of surface and ground waters and their quality;
- Existing surface and water vegetation and wildlife, especially endangered species.

CONCLUSION

The conducted overview and analysis of IAEA, European Union, Russian Federation and Republic of Estonia's regulatory documents that regulate final disposal of radioactive waste (Sections 3.1 to 3.7 above) have demonstrated the need for improvements to the existing legal provisions and regulatory documents in the Republic of Estonia in terms of incorporating requirements for ensuring safety of radwaste disposal. The provisions of Estonian regulations must be responsive to the current status of science and technology and today's view of safety, as well as recommendations by the International Commission on Radiological Protection, IAEA and EU.

Thirty-two Estonian documents have been analysed under this subtask.

This analysis resulted in the identification of documents that contain sufficient requirements for radioactive waste disposal. Such documents include Regulation # 110 [30], the Environmental Monitoring Act; Regulation # 50 [37]; Regulation # 57 [26]; Regulation # 5 [39]; the Road Transport Act; the Industrial Emissions Act; the Ambient Air Protection Act; the Fire Safety Act.

Part of documents analysed provide recommendations for modifications to be made concerning general aspects of radiation safety concerning every stage of radwaste management.

Final disposal is the final stage in radioactive waste management process. Therefore, all radiation protection principles and all requirements for radioactive waste management are applicable to this stage.

However, there is a number of special requirements suggested for incorporation into the legal and regulatory framework in the Republic of Estonia.

For instance, the principal document – the Radiation Act [17] – is suggested to be amended to reflect the following:

- definition of the regulator's role in the planning, designing, building and operational stages of the radioactive waste management site;
- definition of legal, technical and financial responsibilities for organisations involved in radioactive waste management activities in the course of radioactive waste disposal;
- definition of clear juridical, technical and financial responsibilities for organisations involved in the establishment of radioactive waste management facilities including all types of disposal ones;
- incorporation of options for waste disposal planning and implementation into the national policy;
- division of the activities at different stages of the disposal facility operation: pre-operational, operational and post-operational periods;

- the operator’s responsibilities with respect to preparation of the commissioning report; requirements for information that this report should provide;

- requirements for planning of the disposal facility shutdown (elaboration of shutdown solutions must be mandatory when such disposal facilities are designed);

- provision of the public with information concerning radioactive waste management, while having due regard to security and confidentiality issues;

- identification of specific requirements to the license owner who practices radioactive waste disposal activities;

- guidelines and details pertaining to studies and identification of site characteristics during the building period and following its shutdown;

- any other issues associated with final disposal.

One of the main regulations – Regulation # 8 [33] should be changed with regard to:

- review of the classification of the radioactive waste taking into account the classification proposed by IAEA;
- development of the waste acceptance criteria for radioactive waste as part of the design process of the disposal facility;

- any other issues associated with the acceptance of waste for final disposal and safety assessment for the purposes of final disposal.

The need should be noted for accounting doses to members of the public and dose pathways resulting from the disposal or recycling of solid residues. A recommended dose limit for specific types of exposure in a Member State is 1 μSv per year.

Development of national legal and regulatory documents in the Republic of Estonia with regard to radioactive waste management and disposal, should be based on the EURATOM Directives and IAEA standards and recommendations.

The indicative list of information for license applications of new EURATOM BSS is basically covered in the current legislation, but the aims of the safety assessment might be defined in more detailed way. Also adequate defence in depth has to be ensured by demonstrating that there are multiple safety functions, that the fulfilment of individual safety functions is robust and that the performance of the various physical components of the disposal system and the safety functions they fulfil can be relied upon, as assumed in the safety case and supporting safety assessment. The long term safety of a disposal facility for radioactive waste is required not to be dependent on active institutional control. The intent of surveillance and monitoring is not to measure radiological parameters but to ensure the continuing fulfilment of safety functions.

The issue of new and addenda to the existing legal and regulatory acts at the level of National Laws (in terms of legislation elaboration with regard to the tasks of decommissioning hazardous radiation facilities, radioactive waste management including final disposal and establishment of a unified national system for radioactive waste management), Government regulations (with regard to the identification of radioactive waste classification criteria; radioactive waste and storage facility registration, accountancy and control system; provisions of radioactive waste transfer for storage and disposal; regulation of tariffs and contributions for radioactive waste storage and disposal), regulations by Ministries (with regard to the specification of principles, criteria and safety requirements for radioactive waste collection, management, treatment, conditioning, transport, storage and final disposal including the establishment of waste acceptance and quality assurance criteria), and their incorporation into an integrated structure of the Estonian legal and regulatory framework is a vital step that entails the formation of the national policy with respect to ensuring safety of radioactive waste management. Any changes should be made only with reliance on the evidence base and must include comprehensive economic analysis that should confirm the availability of sufficient (budget) funds for the practical implementation of standards to be adopted.

.

REFERENCE LIST

1. Disposal of Radioactive Waste, IAEA Specific Safety Requirements No. SSR-5, 2011.

2. Classification of Radioactive Waste, IAEA General Safety Guide No. GSG-1, 2009.

3. Geological Disposal Facilities for Radioactive Waste, IAEA Specific Safety Guide No. SSG-14, 2014.

4. Near Surface Disposal Facilities for Radioactive Waste, IAEA Specific Safety Guide No. SSG-29, 2014.

5. International Basic Safety Standards for Protection against Ionizing Radiation and for the Safe Management of Radiation Sources, series of publications on safety No. 115, IAEA, Vienna (1997) (at the stage of revision).

6. INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, the 2007 Recommendations of the International Commission on Radiological Protection, Publication 103, Elsevier (2007).

7. Regulations for the Safe Transport of Radioactive Material, IAEA Specific Safety Requirements No.SSR-6, 2012.

8. Predisposal Management of Radioactive Waste, IAEA General Safety Requirements Part 5, 2010.

9. Predisposal Management of Low and Intermediate Level Radioactive Waste, IAEA Safety Guide No. WS-G-2.5, 2005

10. Predisposal Management of High Level Radioactive Waste, IAEA Safety Guide No. WS-G-2.6, 2003.

11. Decommissioning of facilities, where radioactive material is used, Series of IAEA Safety Standards No. WS-R-5, IAEA, 2007.

12. Storage of Radioactive Waste, IAEA Safety Guide Safety Standards WS-G-6.1, 2008.

13. Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste.

14. Council Directive 2006/117/Euratom of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel.

15. Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom.

16. Council Directive 2009/71/Euratom of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations.

17. Radiation Act, enforced in 1 May 2004, as amended in 22 February 2005, 10 May 2006, 7 December 2006, 24 January 2007, 18 December 2008 and 15 June 2009, 16 September 2009, 27 October 2011, 19 February 2014, 19 June 2014

18. Environmental Supervision Act, enforced in 06 June 2001, as amended in 16 June 2002, 13 November 2002, 11 December 2002, 17 December 2003, 14 April 2004, 21 April 2004, 13 April 2005, 12 October 2005, 08 February 2007, 27 January 2011, 10 October 2012, 25 August 2013, 19 February 2014, 19 June 2014.

19. Emergency Act, enforced in 15 June 2009, as amended in 26 November 2009, 5 May 2010, 21 October 2010, 27 January 2011, 08 December 2011, 13 June 2012, 17 October 2012, 19. February 2014, 13 February 2014, 19 February 2014 and 07 May 2014

20. Environmental Impact Assessment and Environmental Management System Act, passed 22 February 2005, as amended in 7 December 2006, 21 February 2007, 19 June 2008, 18 December 2008, 27 January 2010, 26 October 2010, 06 December2011 and 19 February 2014

21. Regulation No. 163 of 30 April 2004, as amended in 11 February 2010: The Bases for Calculation of Exemption Values, and the Exemption Values for Radionuclides

22. Regulation No. 193 of 17 May 2004: Effective Dose and Equivalent Dose Limits for the Lens of the Eyes, Skin and Extremities for Exposed Workers and Members of the Public

23. Regulation No. 243 of 8 July 2004, as amended in 15 January 2009 and 10 December 2009: Procedure Specifications for Processing Documents of Import, Export and Transit of Radioactive Waste Based on Country of Origin and Destination

24. Regulation No. 244 of 8 July 2004, as amended in 15 January 2009 and 01 August 2011: Statutes for the Maintenance of the State Dose Register of Exposed Workers

25. Regulation No. 92 of 1 July 2010: Order of Informing of the Public about the Immediate Danger for Arising of the Emergency Situation, about the Emergency Situation and about the Management of the Emergency Situation and the Requirements to the Forwarded Information

26. Regulation No 57 of 6 May 2010: Procedure of Notification of the Ministry of the Interior of An Emergency or of the Impending Risk of the Occurrence of An Emergency

27. Regulation No. 41 of 29 April 2004, as amended in 31 May 2006, 21 January 2009 and 04 March 2014: Time Limits for Proceedings to Issue, Amend or Revoke the Radiation Practice Licenses, the Specific Requirements for and Format of Applications for Radiation Practice Licenses, and the Format of Radiation Practice Licenses

28. Regulation No. 86 of 8 July 2004, as amended in 21 January 2009: Requirements for the Radiation Safety Training of Exposed Workers

29. Regulation No. 93 of 14 July 2004: Intervention and Action Levels, and Emergency Exposure Guidance in a Radiological Emergency

30. Regulation No. 110 of 27 August 2004, as amended in 21 January 2009: The Requirements for the Results of Individual Monitoring of Outside Workers, and for Formalizing Such Results, and for the Standard Format for the Dose Chart of Outside Workers

31. Regulation No. 113 of 7 September 2004, as amended in 31 May 2006: Requirements for the Rooms Where the Radiation Sources Are Situated and for Labelling Thereof and for the Working Rules for the Performance of Radiation Practices.

32. Regulation No. 127 of 12 October 2004, as amended in 21 January 2009: The Format of Activity Licenses of Qualified Experts and Applications Therefore and the Procedure for the Issue, Extension, Suspension and Revocation of Activity Licenses.

33. Regulation No. 8 of 9 February 2005, as amended in 21 January 2009: The Classification of Radioactive Waste, the Requirements for Registration, Management and Delivery of Radioactive Waste and the Acceptance Criteria for Radioactive Waste.

34. Regulation No. 10 of 15 February 2005, as amended in 21 January 2009: Clearance Levels for Radioactive Substances and Materials Contaminated with Radioactive Substances Resulting from Radiation Practices, and the Requirements for Their Clearance, Recycling and Reuse

35. Regulation No. 45 of 26 May 2005, as amended in 21 January 2009: The Procedure for Monitoring and Estimation of Effective Doses Incurred by Exposed Workers and Members of the Public, and the Coefficients for Calculating Radionuclide Ingestion and Inhalation Doses

36. Regulation No. 13 of 20 May 2014: Statute of the Environmental Board.

37. Regulation No. 50 of 30 July 2002, as amended in 21 August 2003, 15 May 2008 and 26 March 2010 and 23 May 2013: Establishment of National Environmental Monitoring Stations and Areas.

38. Regulation No 15 of 8 June 2010: The Guidelines for Preparing An Emergency Plan.

39. Regulation No 5 of 18 February 2010, as amended in 13 April 2010 and 09 November 2010: The Guidelines for Preparing an Emergency Risk Assessment.

40. National Development Plan for Radiation Protection 2008-2017, The Ministry of the Environment, Tallinn, 2008.

41. Safety during radioactive waste management. General Provisions NP-058-04. M.: Rostechnadzor, 2004.

42. Collection, processing, storage and conditioning of liquid radioactive wastes. Safety Requirements NP-019-2015. M.: Gosatomnadzor of Russia, 2000.

43. Collection, processing, storage and conditioning of solid radioactive wastes. Safety Requirements NP -020-2015. M.: Gosatomnadzor of Russia, 2000.

44. Management of gaseous radioactive wastes. Safety Requirements NP-021-2015. M.: Gosatomnadzor of Russia, 2000.

45. Disposal of radioactive wastes. Principles, criteria and principle safety requirements NP-055-2014. M.: Rostechnadzor, 2014.

46. Near-surface disposal of radioactive wastes. Safety Requirements NP-069-14. M.: Rostechnadzor, 2006.

47. Safety rules during temporary storage of radioactive wastes resulted from extraction, processing and use of minerals NP-052-04. M.: Rostechnadzor, 2004.

48. Safety during management of radioactive wastes resulted from extraction, processing and use of minerals RB-014-2000. M.: Gosatomnadzor of Russia, 2001.

49. Safety during management of radioactive wastes of research nuclear installations RB-008-99. M.: Gosatomnadzor of Russia, 1999.

50. Safety rules during management of radioactive wastes of nuclear plants NP-002-15. M.: Gosatomnadzor, 2004.

51. Safety provision during management of radioactive wastes of vessels and other floating facilities with nuclear reactors and radiation sources RB-010 -2000. M.: Gosatomnadzor of Russia, 2000.

52. Requirements for the program of quality assurance during management of radioactive wastes RB-003-98. M.: Gosatomnadzor of Russia, 1998.

53. Safety assessment of near-surface storage facilities of radioactive wastes RB-011-2000. M.: Gosatomnadzor of Russia, 2000.

54. Recommendations for establishment of acceptability criteria of conditioned radioactive wastes for storage and disposal RB-023-02. M.: Gosatomnadzor of Russia, 2002.

55. Safety rules during transportation of radioactive materials (NP-053-04), Resolution as of October 4, 2004 No.5, Federal Service for Environmental, Technological and Nuclear Supervision.

56. GOST R 52037-2003. Near-surface landfills for disposal of radioactive waste. General requirements. M.: State Committee for Standardization and Metrology of the Russian Federation, 2003.

57. Technical requirements for designing of depositories for packages of solid and solidified radioactive wastes in reinforced concrete protective last-trip containers of NZK-150-1.5P type RD EO 0356-02. M.: Rosenergoatom, 2002.

58. Requirements for report on safety justification of storage facilities of radioactive waste as related to accounting of external effects PNAE G-14-038-96. M.: Gosatomnadzor of Russia, 1996.

59. General safety provisions of nuclear stations NP-001-97. M.: Gosatomnadzor of Russia, 1997.

60. 121. General safety provisions of nuclear fuel cycle facilities (OPB OYaTC) NP-016-2005. M.: Rostechnadzor, 2005.

61. Main rules for accounting and control of radioactive substances and radioactive wastes in a company NP-067-05. M.: Rostechnadzor, 2005.

62. Radiation Safety Standards (NRB-99/2009), SanPiN 2.6.1.2523-09. M.: Chief State Medical Officer of the Russian Federation, 2009.

63. Principal Sanitary Radiation Safety Rules (OSPORB-99/2010). M.: Chief State Medical Officer of the Russian Federation, 2010.

64. Sanitary Rules of Radioactive Waste Management (SPORO-2002), SP 2.6.6.1168-02. M.: Chief State Medical Officer of the Russian Federation, 2002.

65. Hygienic requirements for design of enterprises and installations of nuclear industry (SPP PUAP-2003) SanPin 2.6.1.07-03. M.: Chief State Medical Officer of the Russian Federation, 2003.

66. Sanitary Rules and Hygienic Standards SanPin 2.6.1.24-03 "Sanitary rules of design and operation of nuclear stations (SP AS-03)". M.: Ministry of Health of the Russian Federation, 2003.

67. Federal Law d/d 11/07/2011 “On radioactive waste management and of amendments to certain legislative acts of the Russian Federation” (No. 190-FZ)

68. RF Government Regulation d/d 19/11/2012 No. 1185 “On definition of procedure and term for formation of single national system for radioactive waste management”

69. RF Government Regulation d/d 19/11/012 No. 1186 “On approval of Provision of return of spent sealed source of ionizing radiation, produced in the RF, to the RF and of return of spent sealed source of ionizing radiation to the supplying country of spent sealed source of ionizing radiation”

70. RF Government Regulation d/d 25/07/2012 No.767 “On primary registration of radioactive waste”

71. RF Government Regulation d/d 03/12/2012 No. 1249 “On procedure of state regulation of tariffs for disposal of radioactive waste”

72. RF Government Regulation d/d 19/11/2012 No. 1188 “On procedure of state accounting and control of radioactive waste including registration of radioactive waste and storage facilities of radioactive wastes, by Agency of the State Administration in the management of radioactive waste”

73. RF Government Regulation d/d 10/09/2012 No. 899 “On approval of Provision on transfer of radioactive waste for disposal”

74. RF Government Regulation d/d 19/10/2012 No. 1069 “On establishment of criteria for attribution of solid, liquid and gaseous waste to radioactive waste, criteria for attribution of radioactive waste to special radioactive wastes and to disposed radioactive wastes, criteria of classification of disposed radioactive wastes”

75. RF Government Decree d/d 20/03/2012 No.384-r “On appointment of national operator for radioactive waste management”

76. RF Government Decree d/d 04/06/2012 No. 903-r on entering of the Federal State Unitary Enterprise “National Operator for Radioactive Waste Management” in the list of companies exploiting Nuclear and Radiation Hazardous Facilities under No. 80

77. RF Government Regulation d/d 19/11/2012 N 1187 “On approval of Rules of deductions of part of means, effected by the national operator for radioactive waste management when receiving of radioactive waste from the companies, that do not exploit especially radiation-hazardous and nuclear-hazardous producing units and facilities, to the financial fund of expenses for disposal of radioactive waste”

78. The research report «Preliminary studies for the decommissioning of the reactor compartments of the former Paldiski military nuclear site and for the establishment of a radioactive waste repository: collection and analysis of the data concerning the reactor compartments, determination of the possibility of the reactor compartments decommissioning»», JSC «ATOMPROEKT», 2015.

79. Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

80. Law on procedure of work of Riigikogu, Eestikeelne kehtiv seaduse tekst asub, adopted on 11.02.2003, entered into force on 17.03.2003.

81. Status and actual problems of safety regulatory control at handling radioactive waste, R.B. Sharafutdinov, O.N. Ushanova, A.V. Talitskaya and others, nuclear and radiation safety, No 4, 2007 г.

82. Concept on formation of structure of regulatory documents system regulating provision of safety at handling radioactive waste/ E.E. Kovalev, V.T. Khrusch, S.G. Chukhin and others// Nuclear power. 1998. No 4. T. 84. Edition 4. p. 369-378.

83. R.B. Sharafutdinov. Several aspects of systematic approach to regulation of safety at handling radioactive waste// Issues of radiation safety. 2002. №2. p.3-19

84. IAEA SAFETY STANDARDS. Application of the Concepts of Exclusion, Exemption and Clearance. SAFETY GUIDE No. RS-G-1.7, 2004.

85. Application of the Concepts of Exclusion, Exemption and Clearance. Safety Guide. IAEA Safety Standards Series RS-G-1.7. IAEA, Vienna, 2006.

86. National programme for radioactive waste management, Ministry of the Environment, Republic of Estonia, Tallinn, 2015.

4. INPUT DATA FOR THE TASK 4 RELATED TO THE ESTABLISHMENT OF THE DISPOSAL FACILITY

4.1 GEOLOGICAL AND HYDROGEOLOGICAL CONDITIONS, CLIMATE

4.1.1 Regional Geology

Estonia is situated on the stabile crystalline basement of the Baltic shield. On the Pakri peninsular these crystalline rocks are comprised primarily of granito-gneiss which is found at depths of approximately 200 m below the surface or 160 m below sea level (bsl) in the southern part of the peninsular and approximately 180 m bsl in the central part of the peninsular. The general trend of the surface of the crystalline basement is however, a gently sloping surface to the south.

The climate of this region is transitional from west-European to east-European continental. Winter is not severe, and summer is cool. Precipitation averages 560 mm a^{-1}, with snowfall around 170 mm a^{-1}. The average annual temperature is +5.3°C and the average annual relative humidity is 86%. The area is generally flat and the site has a 1% inclination to the Gulf of Finland.

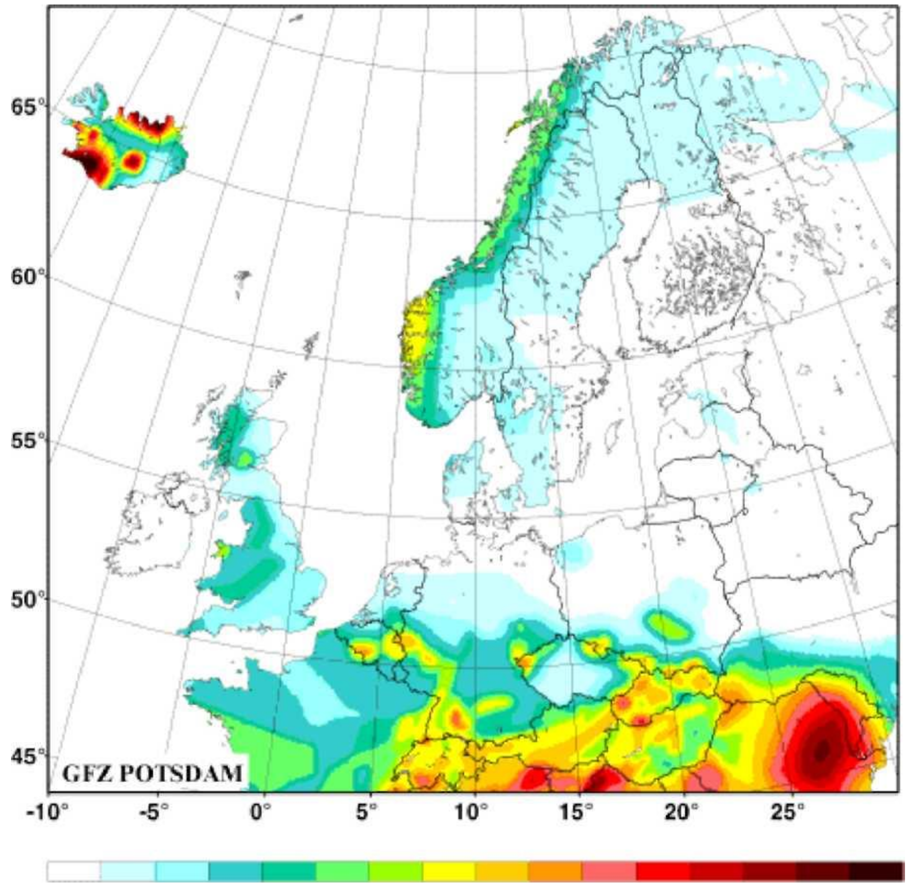


Figure 24. Peak horizontal acceleration map with a 90% probability of non-exceedance in 50 years

4.1.2 Tectonic and seismicity

The western and northern parts of Estonia have been subject to modest tectonic activity, with moderate earthquakes recorded in 1670, 1827, 1881 and 1976 (estimated intensities ranged from 3 to 6 on the MSK-64 scale, approximately 2.8 – 4.3 on the Richter scale in accordance with GOST 30630.5.4-2013/IEC60721-2-6:1990). In 1992 the Global Seismic Hazard Assessment Program was established with support by the United Nations Decade for Natural Destruction Reduction. One of the results of this program, which terminated in 1999, was the compilation of a global seismic hazard map. Figure 24 shows a section of one of these maps covering northern Europe. The hazard is on the map expressed as peak ground acceleration expected at 10% probability of exceedance in 50 years. As can be seen from Figure 24 it is estimated that there is only a probability of very low accelerations (< 0.2 m/s^2) in the northern part of Estonia within a 50 year period.

4.1.3 Stratigraphy

The general geology of the Pakri region can be described using the lithological logs of at least 15 wells that have been established in the area. Two wells in particular are of interest in describing the stratigraphy of the area, the so called Põllküla core from the southern part of the peninsular, from the central part of the peninsular. Both of these wells penetrate the sedimentary rocks to the crystalline basement.

Investigations by the Geological Survey of Estonia and others, indicate a predominantly horizontally bedded geology without tectonic folding, some erosion surfaces are encountered but no structural discontinuities.

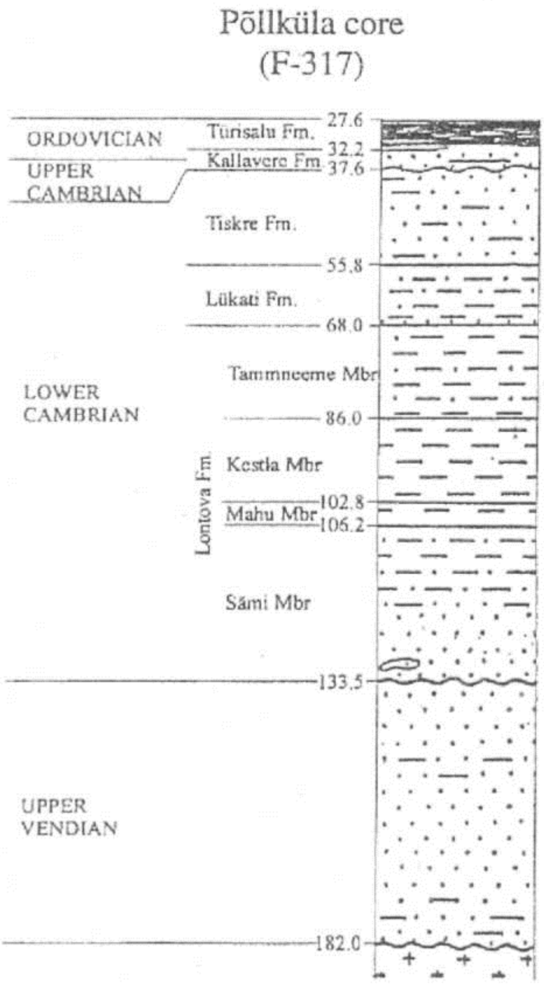


Figure 25. Stratigraphy in the Põllküla core

Using the Põllküla core and well, the stratigraphy can be described as follows. On this crystalline base rests sandstones interbedded with clay and siltstone of earliest Cambrian or Vendian age. These deposits have a thickness of approximately 100 meters. Lower Cambrian clays and siltstones that comprise the Lontova Formation of up to 50 meters in thickness overlie the sandstones. These deposits are exposed along parts of the coast east of the city of Tallinn. At a depth of approximately 50-55 meters below the surface of the peninsular Cambrian sandstones overlie the Lower Cambrian clays. These sandstones have thicknesses of approximately 25-30 meters.

The uppermost approximately 25 meters of bedrock is exposed along the south-western coast of the peninsular and have been the subject of almost continuous study since the area again became accessible. The base of the section is formed by the siltstones of the Lower Cambrian Tiskre Formation. Over these, a basal conglomerate is interpreted to form the boundary to Upper Cambrian and Ordovician, the Kallavere Formation. This formation consists of shales, siltstones and sandstones. On the Paldiski peninsular the sandstones are overlain by glauconitic sandstones and shales of Ordovician age with thicknesses up to approximately 5 meters. Limestone and carbonates of Silurian and Ordovician age overlie the glauconitic sandstones and form the uppermost pre-quaternary rocks on the peninsula. These carbonates have thicknesses of up to approximately 20 meters. The stratigraphy of the peninsular is illustrated in Figure 25, which illustrates the geology as found in the Põllküla core.

Quaternary deposits lie on the Silurian carbonates of the peninsular and rarely exceed 1-2 meters in thickness. In large areas of the peninsular pre-quaternary deposits occur within 1 meter of the surface. Mapping of these deposits was carried out in 1997-98. The deposits consist primarily of marine and lacustrian clays, silts and sands. The marine deposits are interpreted to be formed during the Litorina and Yoldia transgressions. Extensive deposits of peat are also found in the northern and south-western parts of the peninsular. The channels have been eroded into the bedrock to depths of up to approximately 80 - 100 meters and are oriented north-west to south-east. Glacial melt water deposits fill the channels, and it is assumed at present that glacial or glacial melt water activity formed the channels, possibly during Weichsel.

4.1.4 Geophysical Investigations

Geophysical investigations have been carried out on the Pakri peninsular in connection with an investigation of the impact to the environment of the former military bases. The aim of these investigations was to determine if steeply dipping fracture zones in the carbonate rocks could be identified. The method employed was electrical resistivity surveying and involved 18 resistivity traverses totaling 35.6 km and 15 resistivity depth soundings.

Fracture zones were identified in traverses in the study as narrow low resistivity anomalies. It is reported in the study that anomalies occurred with a frequency of between 0.1 and 2 km. The position of the geophysical investigations and the anomalies interpreted in the investigation are illustrated on Figure 27. A linier interpretation of a possible correlation between the anomalies has not been attempted in the study.

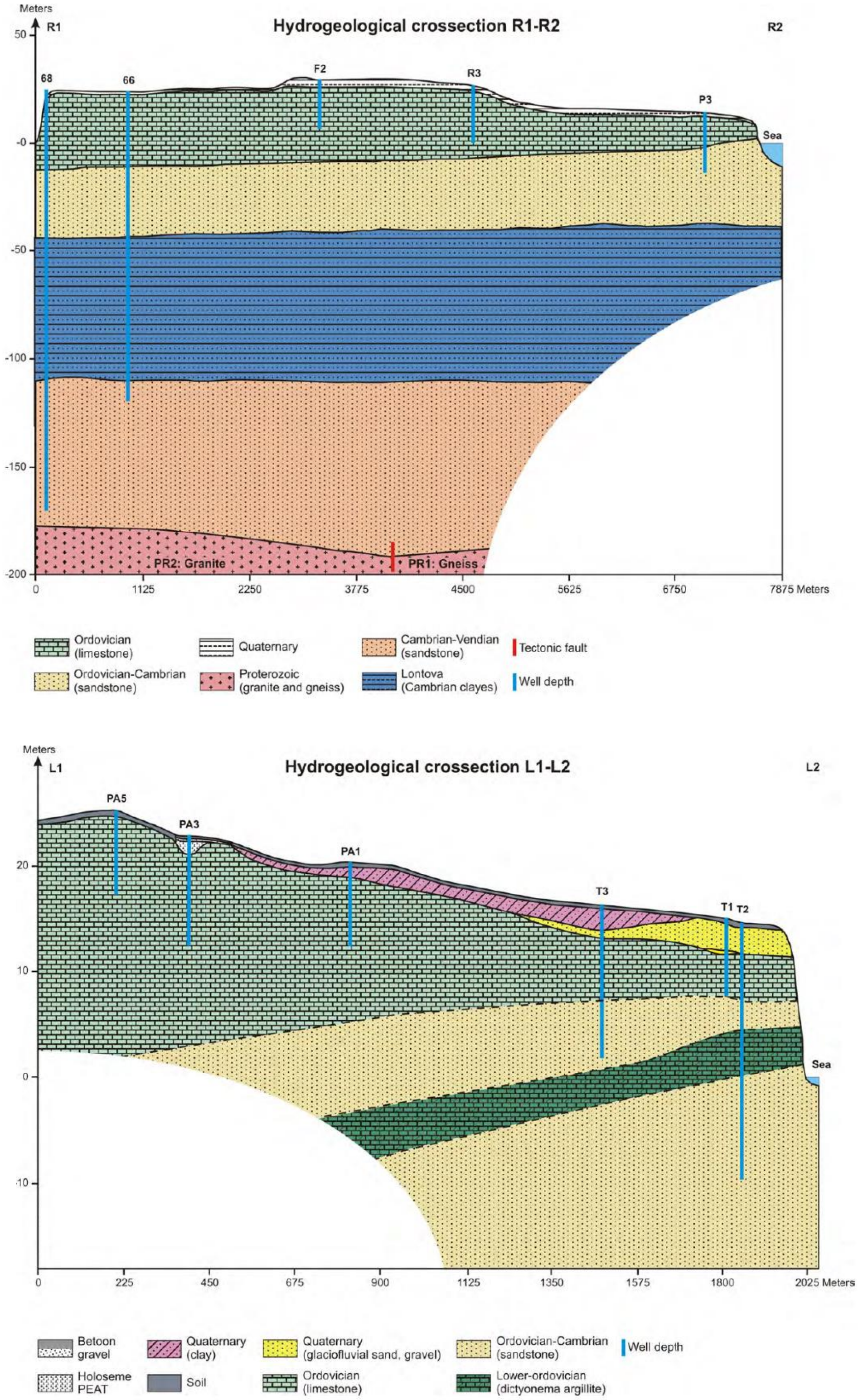


Figure 26. Hydrogeological cross section

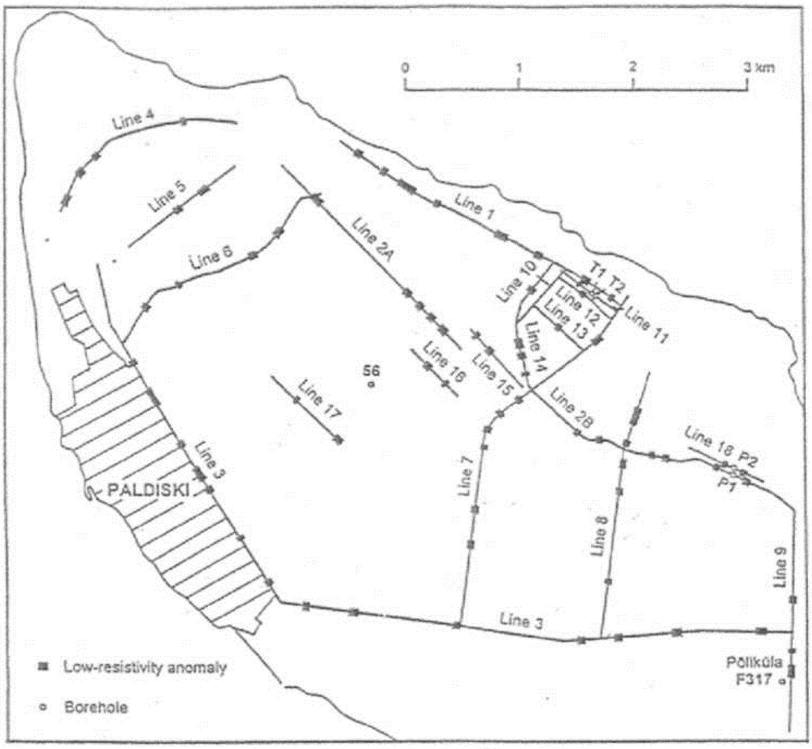


Figure 27. Position of resistivity traverse lines and anomalies

4.1.5 Geology and disposal

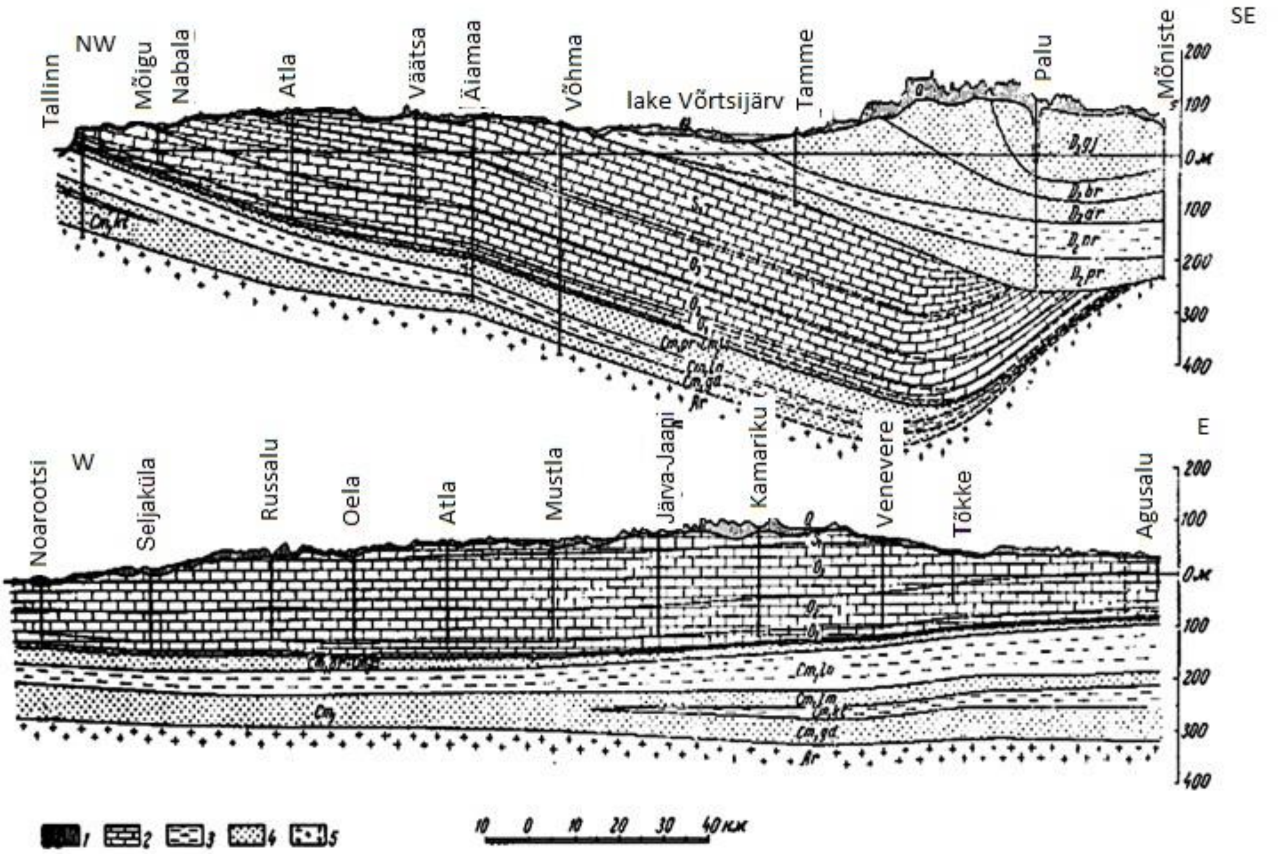
When a decision on a repository construction is to be taken, one of the key issues is to assess the options and select its geographical location. The main criterion for selecting the facility location should be minimisation of impact from radwaste to be placed in the repository, on the environment and population in the area. The most promising area with regard to the safety of the proposed construction site needs to be selected based on comparing the following alternative characteristics:

- geological and hydrogeological conditions that will ensure reliability of natural barriers;
- minimum required land allocation that will determine a potential sanitary protection area;
- remoteness from surface water courses and water intake structures;
- minimum population density and the degree of remoteness from big cities;
- any protected areas, such as national parks;
- any natural resources.

A brief overview of the geological map of the Republic of Estonia is given below [4].

The basement of Estonia is located, in terms of structural geology and tectonics, in the southern slope of the Fennoscandian/ Baltic Shield, is predominated with Precambrian crystalline rocks covered with several hundred metres of Palaeozoic sedimentary strata. The sedimentary rocks originate from the Cambrian, Ordovician, Silurian and Devonian geological periods. The surface of the latter is aerial and covered with a generally thin layer of Quaternary sediments.

Monoclinal folding is characteristic of Palaeozoic sedimentary strata due to southern to south-eastern inclination of the crystalline basement surface (Figure 28).



1-quaternary deposits; 2-limestone and dolomites; 3-clay rock; 4-sandstone; 5-crystalline rock (metamorphic and igneous)

Figure 28. Geological sections through Estonia from north-west (NW) to south-east SE and from West to East

The layers are inclined in the southern and south-eastern directions under an angle of 0°15' on average. The direction and angle of inclination change in the very southeast of Estonia, within the Lockno Elevation, only. This type of Palaeozoic sedimentary strata determines the character of their outcrops; they can be traced in latitude strips: strips of older strata are exposed in the north while newer ones are located in the south.

Against the background of the Palaeozoic sedimentation mass there can be seen tectonic disturbances stretched in the northeast and detected in several locations across North-eastern

Estonia as a system of joints and faults ranging to 20m that are supposed to stretch further, in the south-western direction. The phenomenon of the so-called hypogeum karst is connected to the latter.

The Cambrian sediments are located directly on the washed-out surface of the crystalline basement, forming the lower, early Palaeozoic terrigene mass of the area in question. The Cambrian sediments are dispersed across entire Estonia under the Ordovician, Silurian, Devonian and Quaternary sediments. The upper Cambrian strata 30 to 40m thick are exposed in the north of Estonia only where they are accessible for study purposes whereas their overall thickness varies between 150 and 240m. The outcrops of the intermediate and lower Cambrian strata occur on the bottom of the Gulf of Finland and have been reached only via a significant number of boreholes in the northern part of the Republic. In the centre and south of Estonia these sediments have been reached via four boreholes only (Äiamaa, Võhma, Väimela and Võru). Their outcrops occur only in a narrow pre-glint strip of the Gulf of Finland shore and near the basis of the glint. According to data available, the thickness of the Cambrian strata in the area in question ranges between 99m and 244m growing thinner from the east to the west and from the north to the south: Narva — 244 m, Viivikonna — 222 m, Jõhvi — 215 м, Tallinn — 155 to 165 m, Võhma — 117 m, Võru — 99 m.

The overall thickness of the Cambrian sediments is mostly caused by clayey suites in the central part of the cross-section (Figure 29).

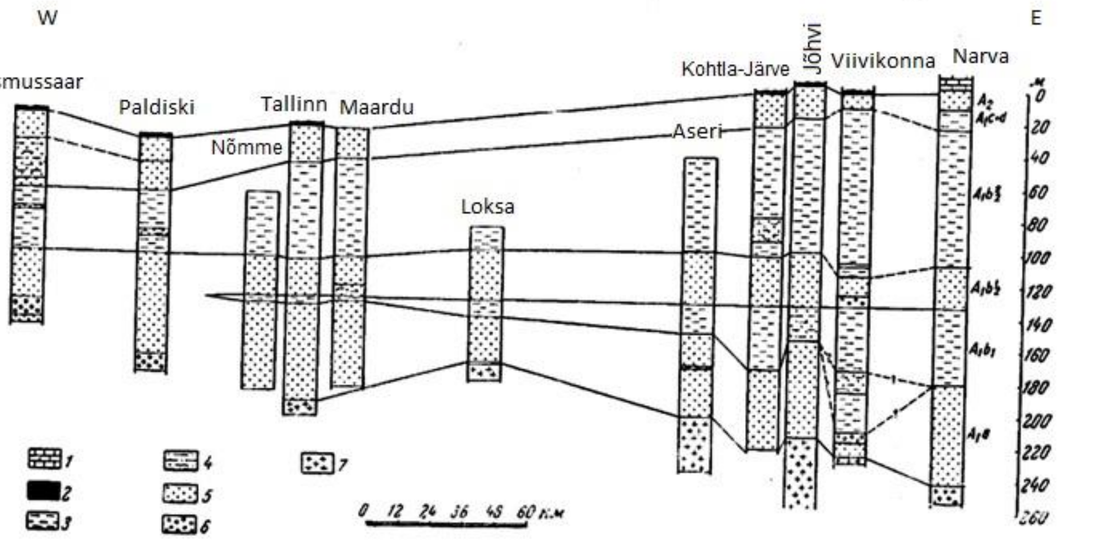


Figure 29. Schematic section of Cambrian in North Estonia (according to drilling data)
1-limestones (Ordovician); 2-dictyonema oil shale (Ordovician); 3-clays; 4-sandy clay and siltstones; 5-sandstones and sands; 6-coarse sandstones, gravelstones and pudding-stone; 7-Pre-Cambrian rocks

The lower and upper boundaries of the Cambrian strata are rather clearly marked in Estonia. The former is a highly washed-out surface of the crystalline basement and is marked by a sharp difference between the Precambrian and Cambrian rocks. The upper boundary is less distinct as it lies in the mass of identical petrographic composition, between Tiskre (fucoid) and Pakerort (obolus) sandstones. However, the traces of washaway and a layer of bibbley-rock as well as occurrence of obolide fauna in the upper layers of the Ordovician Pakerort aquifer make this boundary very clear.

For many decades the stratigraphical subdivision of the Cambrian strata in Estonia has been confined to four complexes: the lowermost sandstones and bibbley-rock, ‘blue clays’, Eophyton and fucoid sandstones.

In the cross-section of the Väimela borehole the entire suite is represented with multicoloured lamellar clays. Thus, the peculiarity of the cross-section in the area of the Lokno Elevation (Russia) is the presence of multi-coloured kaolinite clays in its top that denotes halmyrolysis or weathering.

The thickness of the Lomonosov suite in Estonia is quite permanent and ranges between 20 to 30m. A rather consistent thickness in the area between Narva and Tallinn allows making an assumption that the sediments of this suite also occur in the Paldiski area. However, due to the absence of lowermost clays there these sediments have not been identified yet. The thickness of the Lomonosov suite drastically decreases in the area of the Lokno structure.

When selecting the repository construction site, it is reasonable to consider the areas with the outcrops of the Cambrian sediments, such as **Narva, Viivikonna, Jõhvi, Võhma and Võru.** Recommendations for the identification of promising geological formations have been made based on comparison between isolation properties of the rocks forming the geological cross-section of the sites. The rocks with lower water permeability (clays and loamy clays) were considered the most promising ones, since water permeability is the factor that predominantly determines the properties of the environment that can contain radionuclides and prevent spread of radioactive contamination.

Further assessments of a possibility for the repository location in the areas above require detailed surveys to explore geological, hydrogeological and geographical characteristics as well as social and administrative conditions of a possibility to locate the radwaste repository.

4.1.6 Site Geology

The geology of the Pakri site can be illustrated from 8 wells that have been established on the site. The position of these wells is shown on Figures 30-32. Under approximately 0.3 meters organic loam or top soil predominantly sand and gravel deposits are found in thicknesses up to 1.7 meters. In one well (PA7) peat is found to 2 meters below the surface. In all wells carbonate rocks, limestone and/or dolomites, are found between 0.3 m and 2 m below the surface.

The 8 wells on the site are all approximately 12 meters in depth, and none of these wells have penetrated the carbonate rocks.

Soil samples from the site have been collected and analyzed in connection with an investigation of an oil spill, the samples were analyzed for oil products and metals.

4.1.7 Regional and Site Hydrogeology [5]

A number of studies have been carried out on groundwater on the Pakri. In these studies at least three groundwater aquifers have been identified on the peninsula. The uppermost aquifer is unconfined and associated with the carbonates of Silurian and Ordovician age. Glauconitic sandstone and shales form the base of this aquifer. Below this aquifer, the Ordovician – Cambrian sandstones form the second aquifer below the surface. This aquifer is in part confined. The Lower Cambrian clays form the base of this aquifer. The lowermost and confined aquifer is the sandstone of Vendian – Lower Cambrian age.

<u>The Uppermost carbonate aquifer</u>

Groundwater flow in this aquifer is assumed to be towards the coast with a groundwater divide running the length of the peninsula in a position that is identical with the surface water divide (Finnish Environment Institute 1998). Groundwater north of this divide is assumed to flow northward to the Bay of Lahepere. Hydraulic conductivity of this aquifer has been estimated (Finnish Environment Institute 1998) and determined (Kink et al. 2002). However it is also noted that the carbonate rocks of the aquifer are fissured and observations from the quarry in the northwestern part of the peninsula indicate that groundwater flow is predominantly in these dissolution fissures and bedding planes of the rocks. This secondary permeability is expected to be orders of magnitude greater than the primary permeability of the carbonates and can therefore effect flow directions. If, as expected, the predominant groundwater flow is through fissures and bedding planes it can also be expected that exchange of chemical constituents and absorption of possible contaminants in the water to the rock matrix will be reduced.

Groundwater levels have been monitored in some wells intermittently since 1995, and systematically since 2001 (Kink et al. 2002) and results indicate mean levels of approximately 21 m to 22 m above sea level. Groundwater levels vary up to approximately 3 m, and it has been noted (Finnish Environment Institute 1998) that the water table varies with precipitation.

A static 2-dimensional groundwater model of this aquifer has been constructed to determine variations in groundwater level on the northern part of the peninsula (Finnish Environment Institute 1998). However, due to the assumptions it was necessary to make in the construction of the model, we do not believe that the model gives a realistic interpretation of actual conditions. Chemical analyses of predominantly macro-ions have been carried out on water from a number of wells. It is expected that the number and variation of these analyses are sufficient to characterize groundwater from this aquifer.

The position of the Pakri site is adjacent to and north of the estimated groundwater divide. The position of the divide is however very uncertain (Finnish Environment Institute 1998). The position of wells used to monitor flow or contaminant levels in groundwater from the site should therefore be based on investigations designed to determine site specific flow directions.

8 wells have been established on the investigation site in connection with an investigation of an oil spill, and a number of these have subsequently been used in connection with further investigations and monitoring (Maves AS 1999a,b,c). The wells are screened in this aquifer. The

wells are numbered PA1 to PA 8; subsequent investigations have renamed these wells R1 to R8. The position of the wells is illustrated on Figures 30-32.

Test pumping has been carried out in a number of wells on the site (Raukas & Kink 1996a), however, hydraulic connection between the wells has not been investigated. As secondary permeability can be an important factor in groundwater flow in this aquifer it is recommended that test pumping involving 2 or more wells on the site is implemented in at least 3 wells. Figures 30-32, it is assumed that there is hydraulic connection between wells and contours of the groundwater table are illustrated. The contours are based on interpolation of measured levels in wells and indicate possible variations in flow direction. Flow direction is towards the north-west, and flow direction is towards the north. The spacing of the contours also indicates that there can be variations in groundwater flow rates.

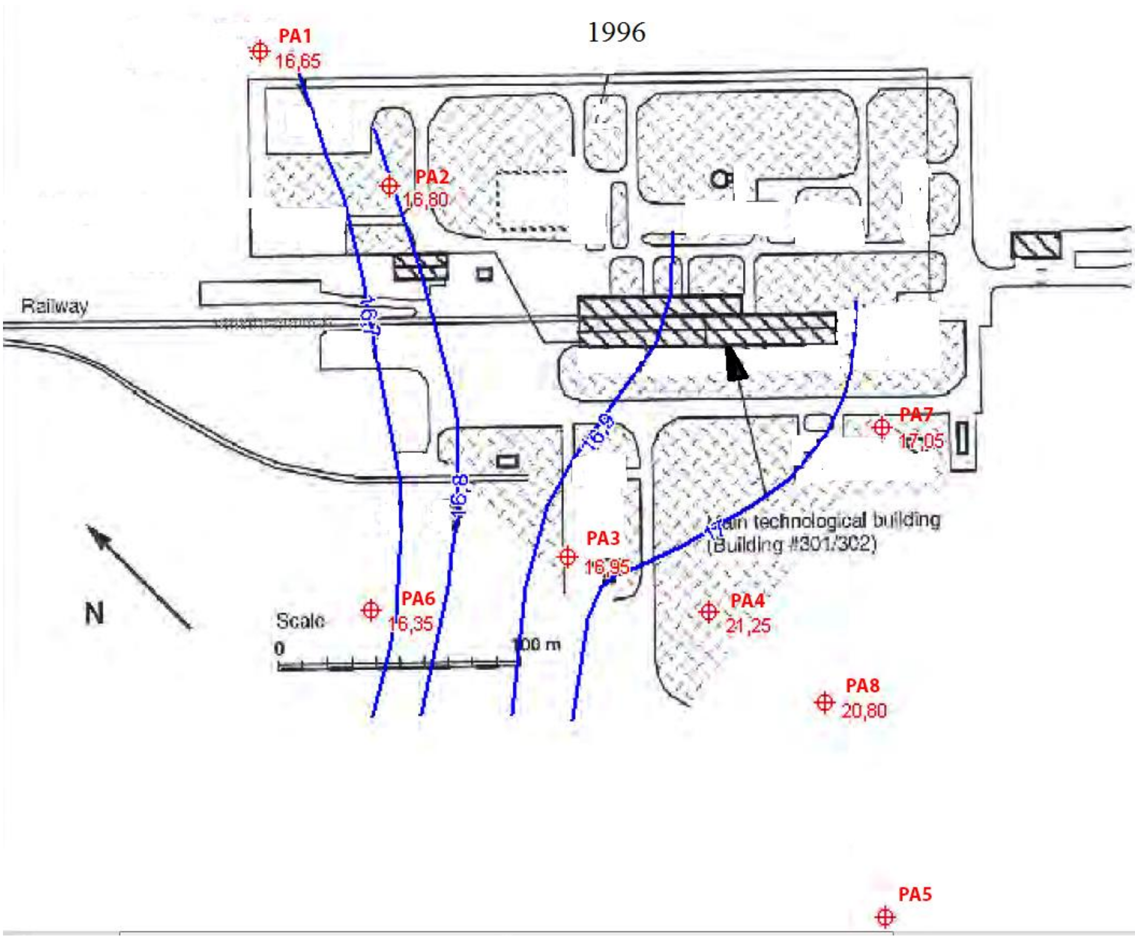


Figure 30. Upper Aquifer, Groundwater contours: 1996.

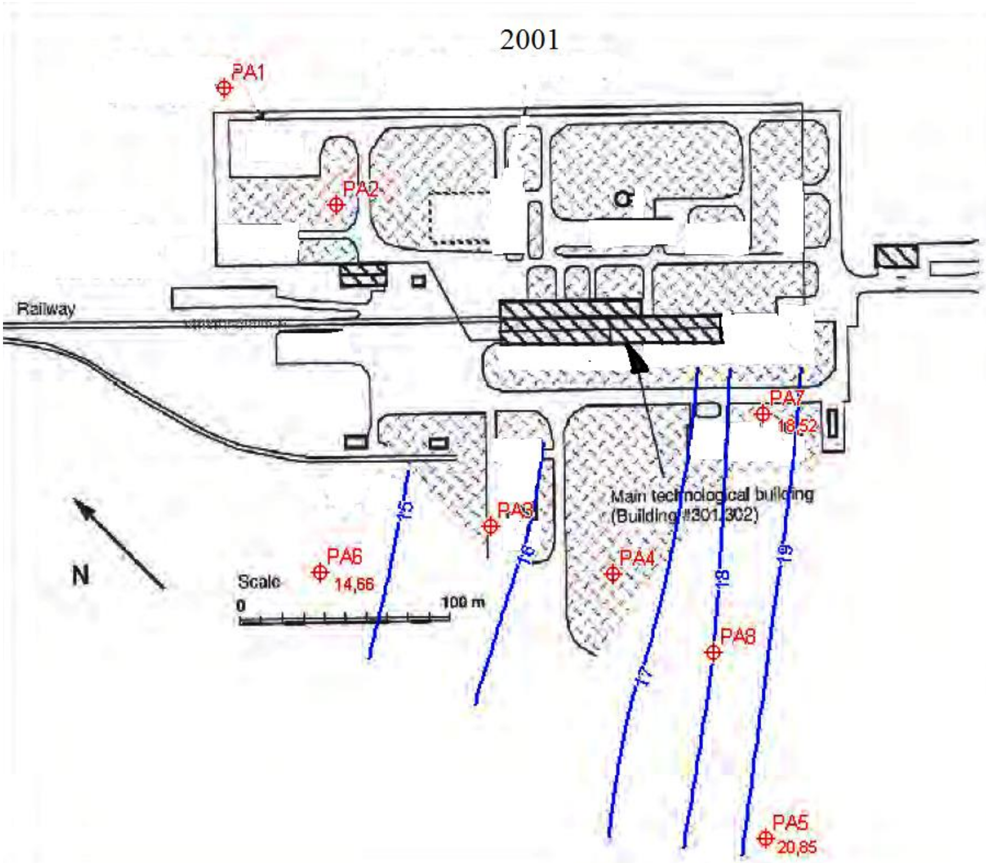


Figure 31. Upper Aquifer, Groundwater contours: 2001.

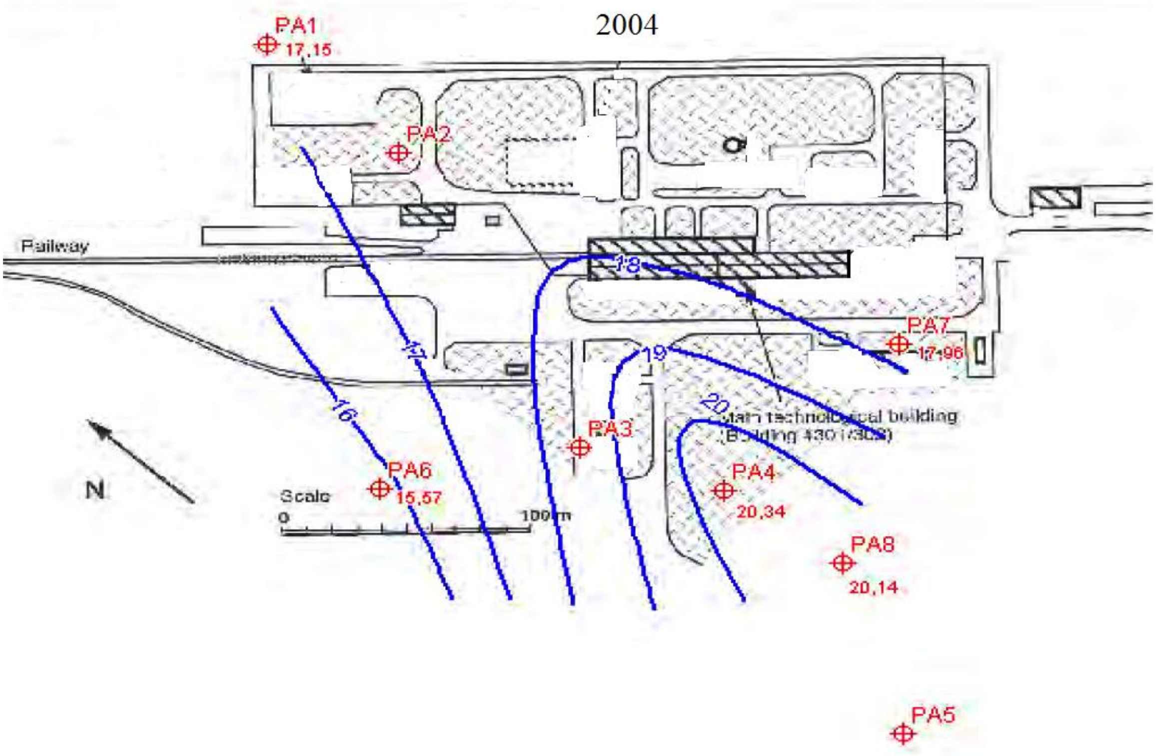


Figure 32. Upper Aquifer, Groundwater contours: 2004.

The Ordovician-Cambrian sandstone aquifer

Well logs indicate that only 2 wells on the Pakri Peninsular have screens in this aquifer. These wells are T2, which is placed north of the investigation site, and P3 that is place southwest of the investigation site near a landfill area. Measurements of groundwater levels in well T2 for the period 1996 to 2001 are reported in Kink et al. (2002). The results indicate that groundwater levels fluctuate around 1.2 to 1.4 m above sea level, with highest levels occurring in the period March to May and lowest levels in November. The hydraulic conductivity of the aquifer has been estimated in both wells (Kink et al. 2002), and there is a variation of several orders of magnitude indicating lateral heterogeneous conditions in the aquifer. The chemical composition of groundwater from this aquifer has been determined (Raukas & Kant 1996a). A vertical hydraulic gradient exists from the upper aquifer to this aquifer; consequently if transport through the overlying greensand aquitard is possible, waterborne pollutants could be transported to this aquifer. No information has been available regarding tests to determine whether transport through this aquitard does occur. It is therefore recommended that tests are carried out to determine if this second aquifer is a so-called leaky aquifer. The position of well T2 is expected to be downstream of the investigation site and if tests are carried out it is recommended that this well be used.

The Vendian-Lower Cambrian aquifer

The lowermost aquifer is the sandstone of Vendian–Lower Cambrian age. The base of this aquifer is approximately 180 m bsl and is formed by the crystalline basement. The aquifer is confined by Lower Cambrian clays occurring at approximately 80 m bsl, the confining clays are up to 50 m in thickness. This aquifer has regional extent but thins to the south and west (Valner 1993). Natural groundwater levels in this aquifer are approximately at sea level (Lithostratigraphic log 1963), but intensive use of this aquifer for consumption has lowered the piezometric surface considerably (Valner 1993). Investigations of water in the aquifer have shown that values range from -1.8 to -2.2% indicating an age for the water of approximately 10,000 years (Valner 1993). This result indicates that the aquifer is only marginally vulnerable to potentially polluting activities on the land surface. However, erosion north and south of the Pakri peninsular has reduced or removed the protective clay covering of the aquifer creating the possibility for access by seawater. This aquifer is monitored continuously following drinking water standards and the Geological Survey of Estonia have found no indication of saltwater intrusion.

4.1.8 Groundwater

It is understood that groundwater samples are collected quarterly from a three boreholes located on site, with analysis for H-3, Sr-90, Co-60 and Cs-137.

Data for the period March 2008 to June 2014 (data given by ALARA) indicate that sampling was regularly. All samples have positive determinations for H-3 and Sr-90. In addition, from the gamma spectrometry, Cs-137 and Co-60 are reported specifically, and Cs-137 and Co-60 have been observed above the limits of detection.

Concentrations of all detectable radionuclides are moderately low and show evidence of site contamination (Figures 33-39). Thus, reported levels of tritium vary from about 3 to 6.1 Bq l^{-1}. For comparison, background levels of tritium in lakes, rivers and tap water from the area around Sellafield (where some diffuse contamination might be anticipated) are less than 10 Bq l^{-1} (BNFL 2002) and, in more remote regions of the UK, background levels of H-3 are typically less than 2 Bq l^{-1} (FSA & SEPA 2002) [25].

Figure 33. Concentration of H-3 in groundwater (Bq/l) boreholes #1, #6, #9

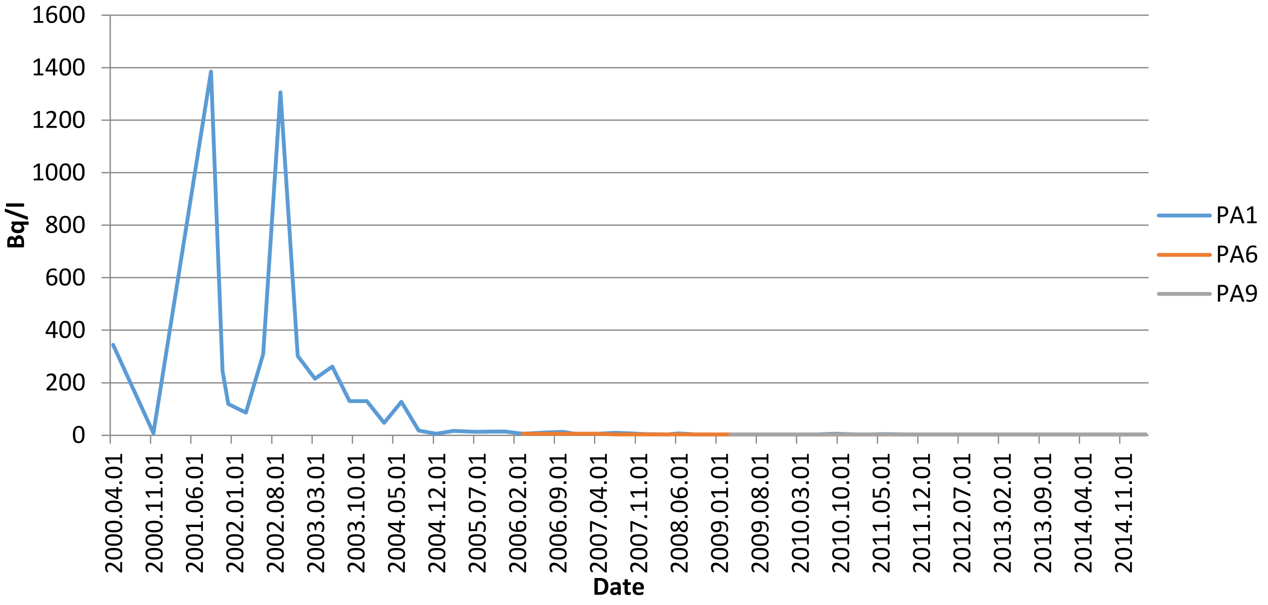


Figure 34. Concentration of H-3 in groundwater without high-end peaks,<20 Bq/l, boreholes #1, #6, #9

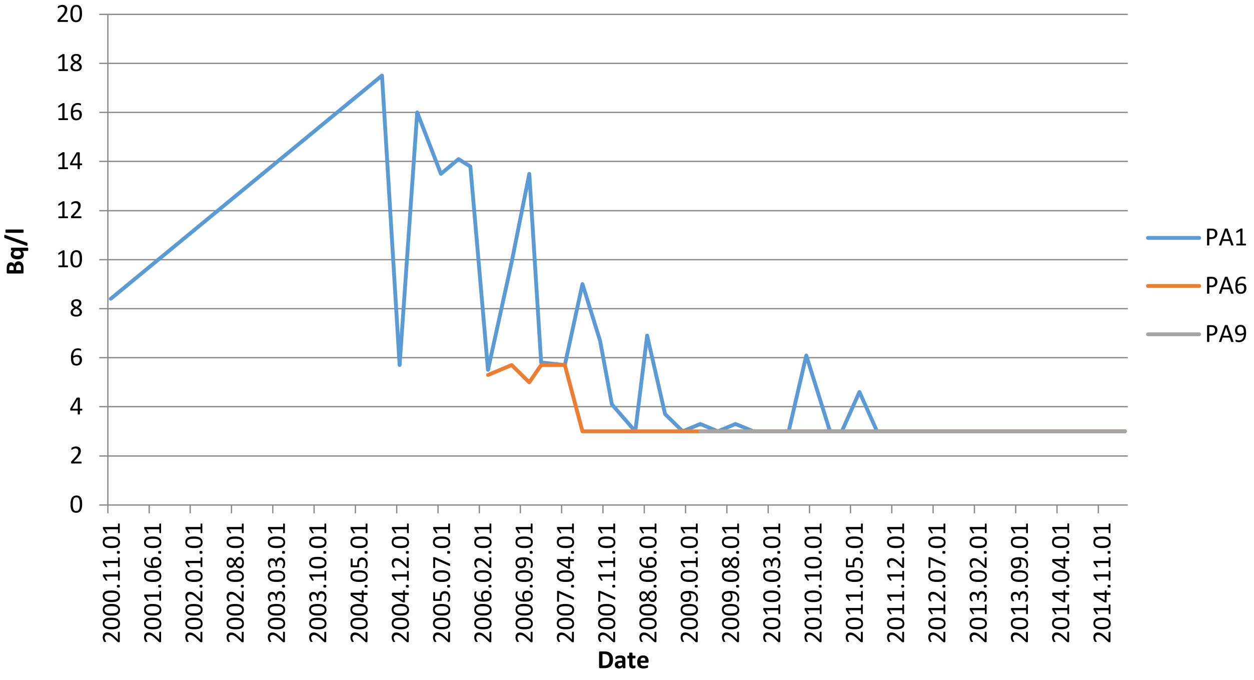


Figure 35. Concentration of Cs-137 in groundwater (Bq/l) boreholes #1, #6, #9

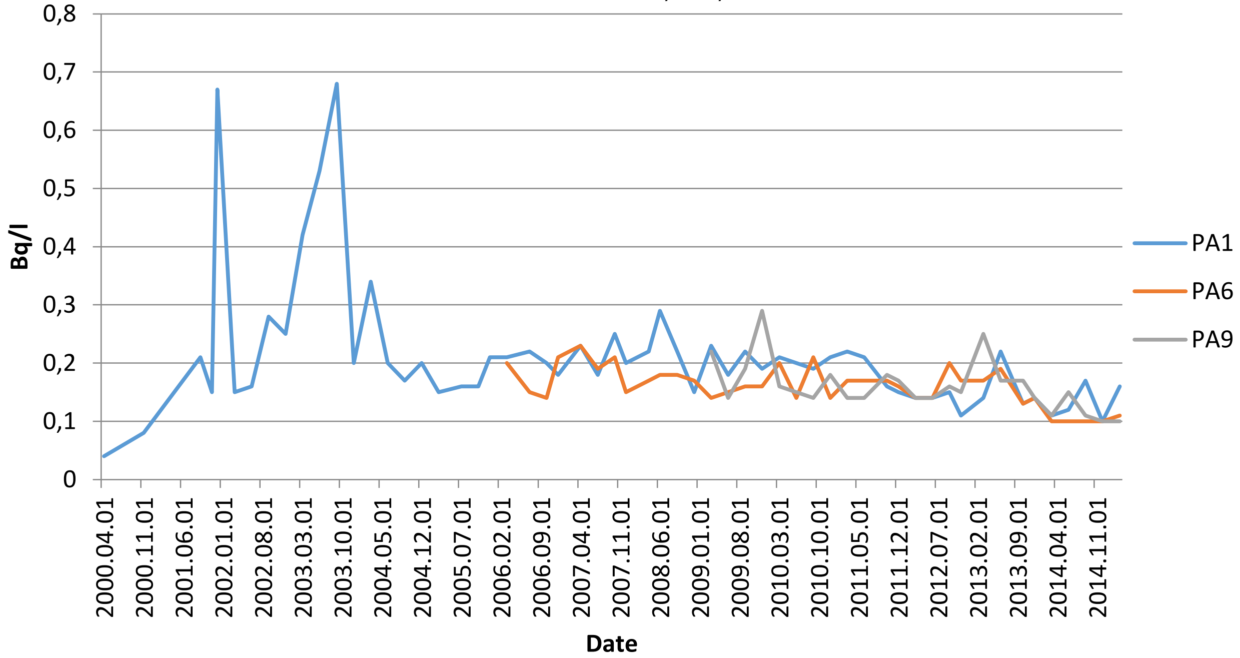


Figure 36. Concentration of Cs-137 in groundwater without high-end peaks, < 0,3 Bq/l, boreholes #1, #6, #9

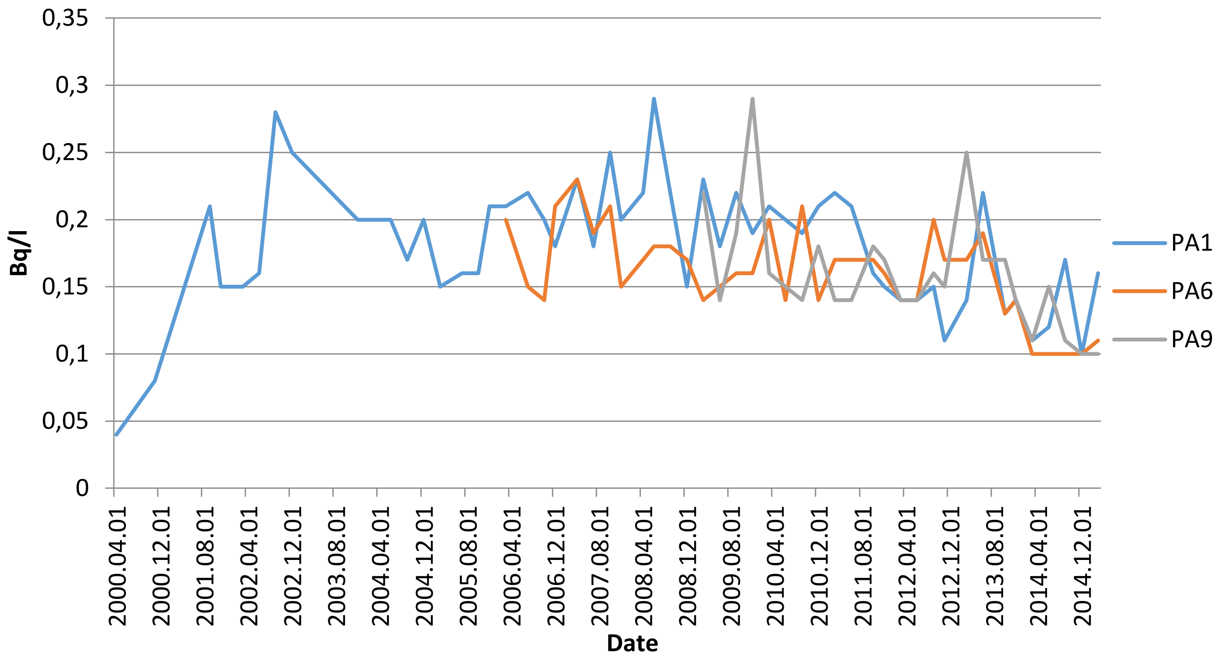


Figure 37. Concentration of Sr-90 in groundwater (Bq/l) boreholes #1, #6, #9

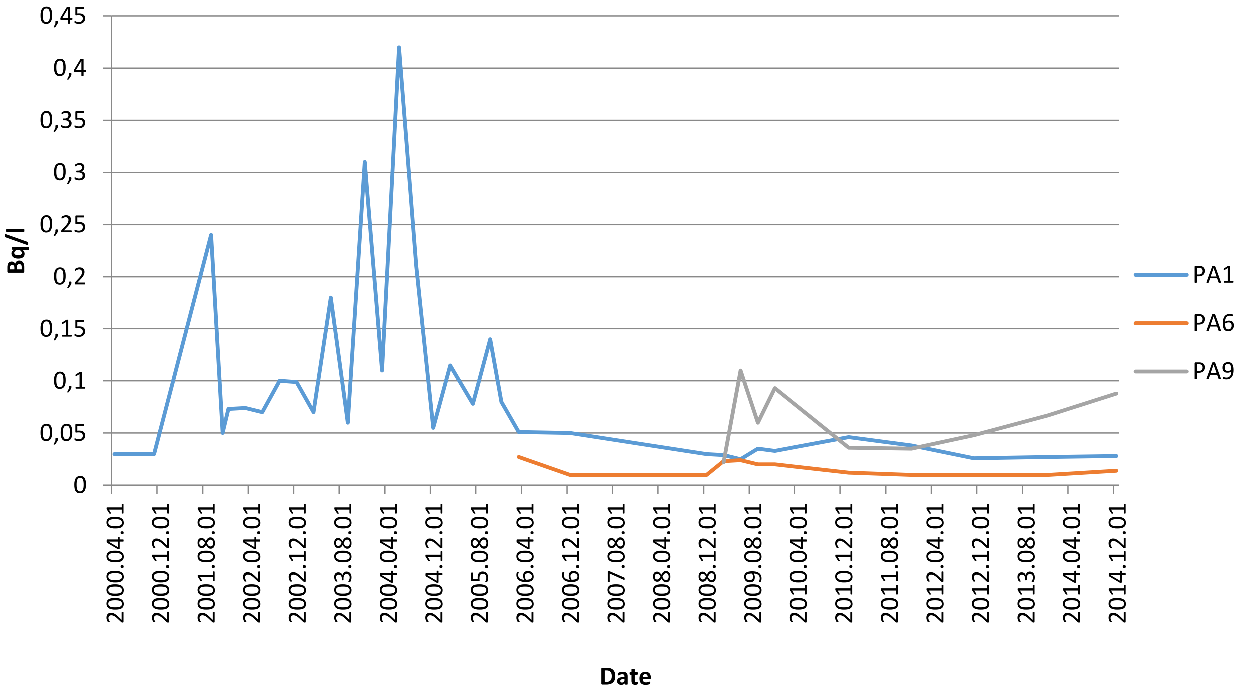


Figure 38. Concentration of Sr-90 in groundwater without high-end peaks, < 0,2 Bq/l, boreholes #1, #6, #9

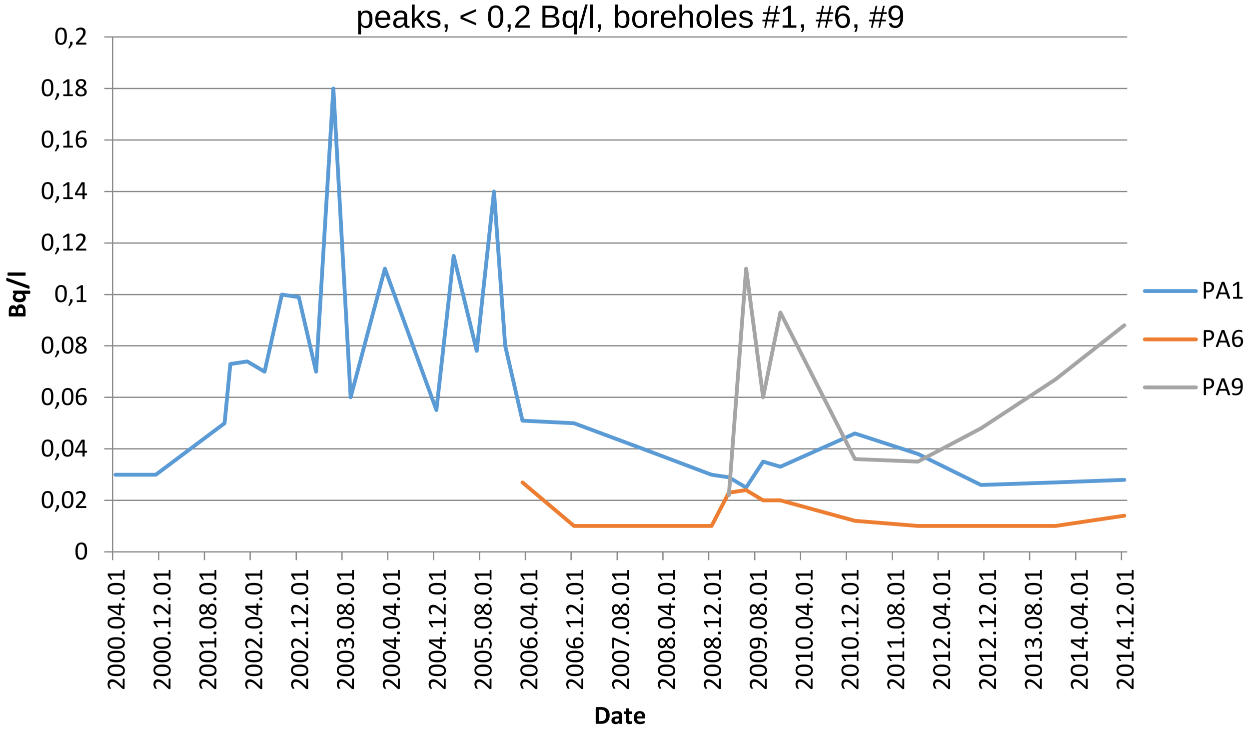
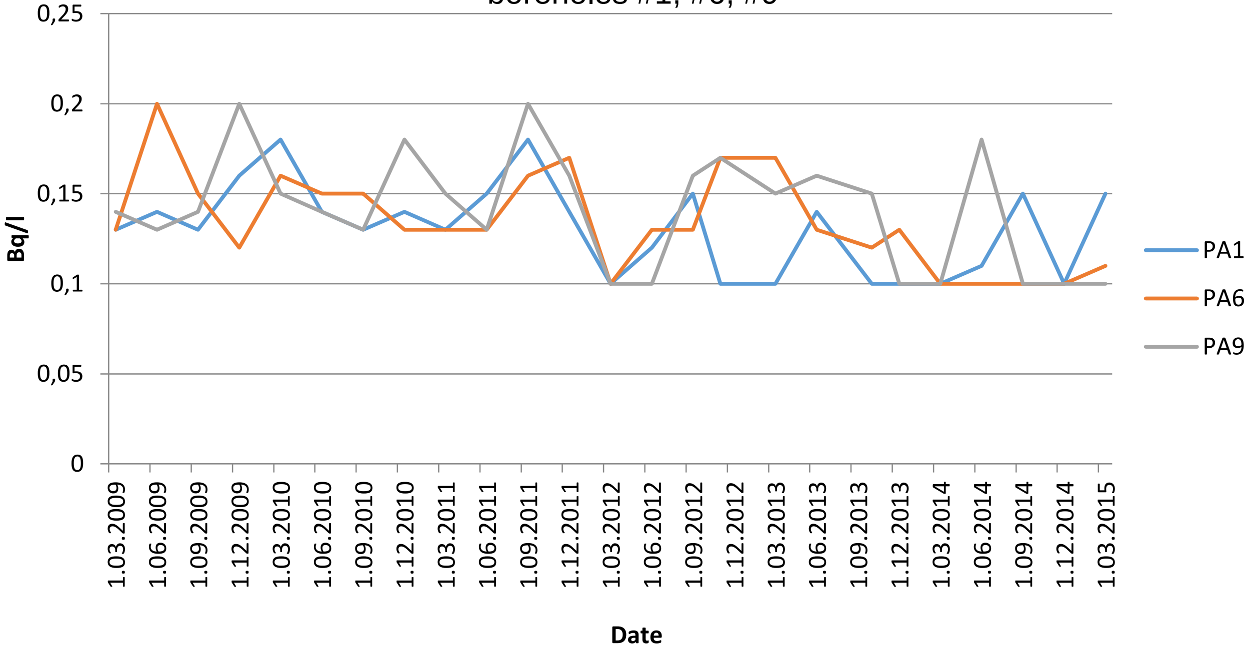


Figure 39. Concentration of Co-60 in groundwater (Bq/l) boreholes #1, #6, #9



Based on observations tritium concentrations may vary on a seasonal basis with peak concentrations. Reported levels of Sr-90 on the Paldiski site vary from about 0.01 to 0.11 Bq l^{-1} and Cs-137, taking positive determinations only (i.e. ignoring values reported as 'less than'), has varied from 0.1 to 0.29 Bq l^{-1} (see Figures 33-39). Again, comparisons with the UK suggest that background levels of Sr-90 and Cs-137 in regions of known environmental contamination are around 0.005-0.01 Bq l^{-1} and <0.02 Bq l^{-1}, respectively (BNFL 2002). In more remote regions, Sr-90 concentrations do not typically exceed 0.005 Bq L^{-1} in surface waters and Cs-137 is generally reported as <0.01 Bq L^{-1} (FSA & SEPA 2002).

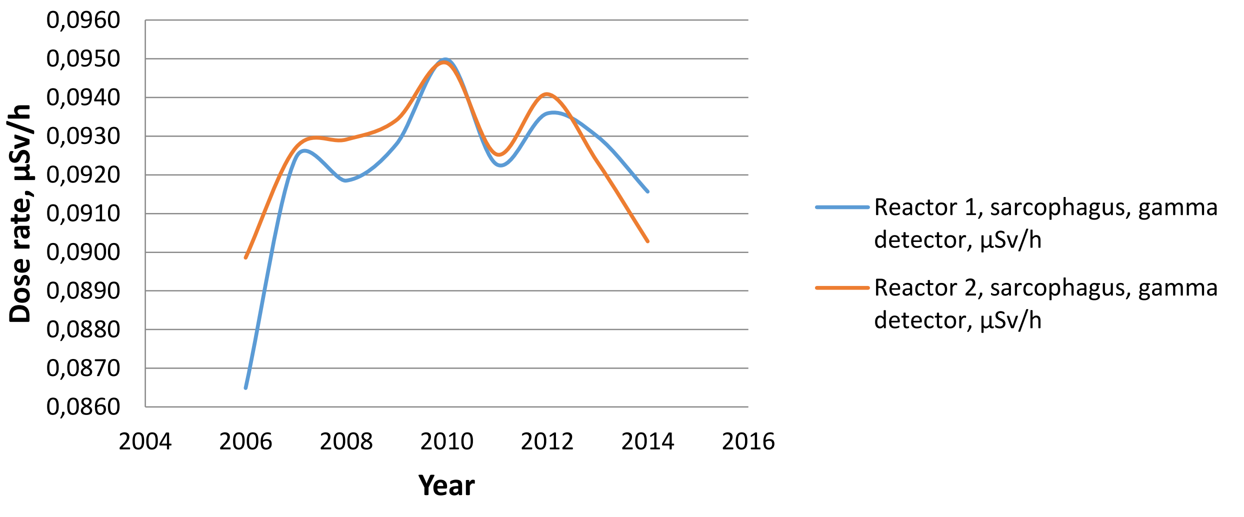
Reported levels of Co-60 on the Paldiski site vary from about 0.1 to 0.18 Bq l^{-1}..

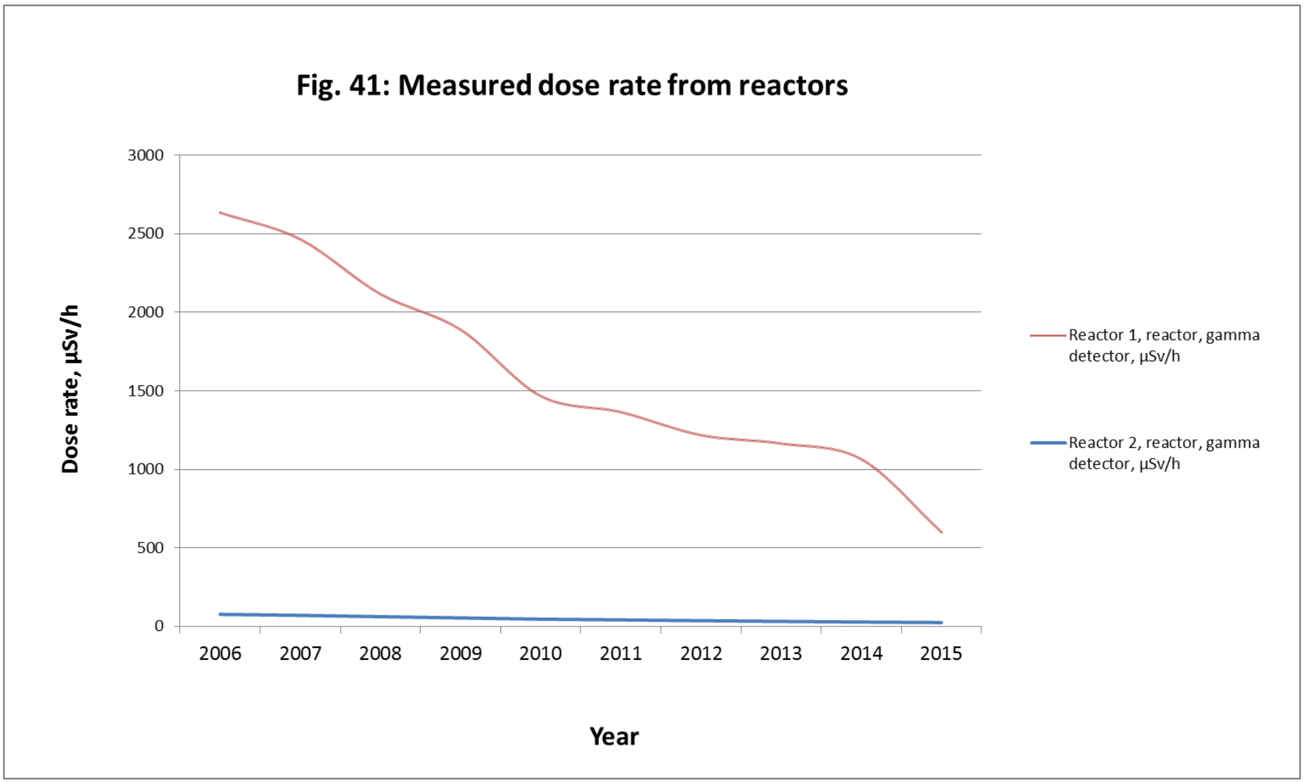
The data on concentration of the following radionuclides H-3, Cs-137, Sr-90, Co-60 in the ground water for the last 14 years and 6 years for Co-60 shows that its activities in the very low levels which does not exceed permissible levels. According to the international experience the same traces of Cs-137 and Sr-90 are monitored within the facilities of the similar character. Also, it should be taken into account, that due to the low levels of activities, the instrumental errors could be correspondent to measurement values.

4.1.9 Monitoring data

The following Figures 40-41 show the data for the gamma monitoring at the sarcophagi and from reactor in the RC. Analysis of data on dose rates shows that the surface of the sarcophagus have a stable low level of dose, indicating the absence of radionuclide release from the RC premises.

Figure 40. Measured dose rate from reactor sarcophagi





4.1.10 Other potential sites for the RW disposal

Two possible sites of the uranium legacy could be considered among the various opportunities for the further disposal facility location.

Sillamae site

The studies at Sillamäe (Figure 42) show that the environmental state and geodynamic situation of the waste depository are affected by five closely connected factors: geotectonic, hydrodynamic, slope processes, erosion and shore processes. Tectonic factors and the influence of glacier have created preconditions for the development of macro- and micro-fissures. For this reason, the Cambrian clay is more sensitive to technogenic influence and its strength is lower than that of the other similar clay stratum distributed on the North-Estonian coast.

The studies show that the coasts in the immediate vicinity of Sillamäe starting from Voka settlement in the west and extending as far as a small cape with accumulative gravel shore on the eastern border of the city is subject to very intensive wave action.

The stability of the dam was assessed using minimal strength parameters, which is in accordance with the world practice. The analysis of the results shows that the initial persistance of the slopes is not ensured. Based on bench marks movement, two kinds of slope processes were distinguished. On the one hand, there is a large-scale deep creep, which includes the depository and the underlying blue clay massif both in its northern and eastern part. On the other hand, there are local creeps in the dam body and related movement of under-slope bench marks.

The studies and measurements showed that before the sanitation work was started the depository's dam was unstable. This was caused by insufficient shear strength of the Cambrian clay under the dam. The problems related to the strength of blue clay and the impact of solutions filtrating from the dam on geotechnical properties of clays are not yet entirely clear. Alteration of clay's properties over time may adversely affect the stability of the dam.

The geotechnical parameters of the soils spread in the area of waste depository are analyzed during investigations. The strength of Lower Cambrian clay is the most important factor controlling the stability of the dam of the waste depository. In view of this, main attention focusses on the study of the properties of Lower Cambrian clay underlying the dam, and on its behavior (Table 38).

To assess the strength of clay soils, undrained stabilometer tests, one-axial compression tests and drained shear tests are mainly used. During the stabilometer tests and one-axial compression tests, undrained maximum shear strength Cur and the shear strength of creep limit Cuy is determined.

The general studies reveal a principal difference in the mechanical behavior of the angle of internal friction and cohesion in different clay soils. The cohesive component of shear strength reaches its maximum at relatively low pressure, while in the case of the angle of interior friction higher pressure is needed. The mechanical essence of the shear strength components is clearly different.

Table 38: Physical and mechanical properties of Lower Cambrian clay

Geol, index			Cm $_{1/n}$	CM$_{1/N}$	Cm$_{1/n}$
			Cambrian clay	*Cambrian clay*	*Cambrian clay*
Soil description			*weathered*	*fissured*	
Physical properties					
Natural water content	w_B		20	111	16
Liquidity limit	w_L	96	63	65	69
Plasticity limit	w_p	%	28	28	31
Plasticity index	I_p	%	35	37	38
Void ratio	E_n		0.56	0.55	0.55
Natural unit weight	P_n	kN/m^3	20.5	21.0	21.1
Dynamic sounding test (DOTH)					
Number of blows per 0,2 m	n	n/20cm	20	40	80
Mechanical properties					
Undrained shear strength (norm.)	C_{uf}	kPa	90	150	200
(design value 0,95% probability)			55	80	160
Drained shear strength (norm.)					
Angle of internal friction (norm.)	Φ^1	deg	27	26	
Cohesion (norm)	C^1	kPa	45	60	
Hudraulic conductivity (k)		m/day	10^{-6}	10^{-6}	10^{-6}

Figure 42. Sillamae waste depository and surroundings

Tammiku site geology and hydrogeology data should be received from the corresponding Estonian institution which accumulates data for the regional and local geology and corresponding investigations results. In case of the lack of data additional geological, hydrogeological and geophysical studies of the site will be needed.

4.2 ADDITIONAL RECOMMENDATIONS FOR A DISPOSAL SITE

Siting a radioactive waste disposal facility refers to the process of selecting a suitable location that must take into account technical and other considerations. Technical factors cover a long list: geology, hydrogeology, geochemistry, tectonics and seismicity, surface processes, meteorology, human-induced events, transportation of waste, land use, population distribution and environmental protection. Another key factor is public acceptance.

There are number of environments not suitable for waste disposal. These exclusion criteria could have various origins. Due to legal and environmental restrictions the following territories have to be excluded at the stage of negative screening:

- Protected territories, nature protection reservations, territories of European ecological network Natura 2000 and cultural heritage territories;
- Urban and recreation territories;
- Mining territories;

- Waterworks and inland water bodies;
- Air grounds, oil and gas pipelines protection zones;
- Military grounds and other military facilities;
- National border zone.

Few the technical requirements are different for repositories to be built above ground water table (Landfills and concrete vaults of NSR) and below it (tranches of NSR and IDR).

Technical/safety criteria

The site selected for waste repository has to fulfill number of geological, hydrogeological, topographical and hydrological requirements. Safety and durability of repository are mostly determined by stability of the soil and protection from ground or precipitation water impact. Stability should also remain during earthquake. The following areas have to be excluded due to technical and safety reasons:

- Highly compressible soils and physically or chemically unstable rocks;
- Seismic territories, presence of active tectonic faults and high liquefaction of the soil;
- Presence of mineral resources;
- Unstable slopes;
- Active erosion areas;
- Flooded areas.

Technical requirements for the site belong on a concept of repository. For a shallow facility (concrete vaults of NSR or Landfill) in the vadose zone (above the ground water table), the preferred host rocks are having low unsaturated moisture content, providing effective drainage for water percolating through the facility and ample sorption capacity limiting the spread of radionuclides. For facilities built in water saturated zone (tranches of NSR or IDR) the preferred environments are with not intensive underground water flow (small water pressure gradients and low water conductivity of the host rocks).

<u>Geotechnical stability.</u> The repository can be installed only in a geotechnically stable site. Repository deposition increases its barriers degradation risks. The risk depends on the mass of the repository and the soil compressibility. The bearing capacity of the soil has to be sufficient to eliminate a risk of failure due to soil settlement.

<u>Seismicity, tectonic activity, and dynamic soil liquefaction</u>. For installation of repository should be chosen the area expressing minimal seismic and tectonic activities. The maximum possible seismic activity should not be more than 7 points by MSK scale. Vibrations caused by seismic events may lead to liquefaction of soils and formation of fractures of concrete structures or the soil. It depends on the frequency and amplitude of earthquakes. Soil dynamic liquefaction ability should be small. Consideration of external events in the design is provided in the IAEI technical document [IAEA-TECDOC-1347].

<u>Hydrogeological properties</u>. The following hydrogeological characteristics should be fulfilled within the region of the repository: low ground water flow, insignificant hydraulic gradient, long

groundwater flow path till a discharge zones, large enough distance to the ground water discharge or water extraction points. For shallow repository the main criteria are the depth of occurrence of ground water and the possibility of flooding. For repository in saturated zone the main criteria are water permeability of the host media and intensity of water flow through it as well as long water flow distance to a discharge zone. The hydrological setting of the region should include:

- low ground water level,
- low groundwater flow,
- long flow paths,
- long distance to water discharge zone or wells.

Preference should be given to regions that could make characterizing or modeling of the hydrogeological system easy. Good dilution possibilities and possibilities to monitor the eventual effluents would be an advantage.

Mineral resources. The most important mineral resources in Estonia are oil shale, limestone, clay. The territories presenting potential for minerals presents great risk of increased human intrusion. Integrity of the repository could be damaged during exploration and mining activities.

Human activities. Human activities can affect the mechanical stability of large regions, examples being the reduction of the safety factor of slopes by excavation and dredging, and the creation of critical conditions for flooding and erosion by dam construction. Other examples are contamination of groundwater in industrial areas, by which very low or very high pH and Eh conditions caused. Industrial or military activities in the area, over-ground and air transport and other factors that could have impact upon the safety of a near surface repository should be evaluated.

Transport conditions. In order to reduce transportation costs and possibility of accidents preference should be given to sites located not fare from the main waste producer and having favorable transport infrastructure.

Social and economic criteria

Economic environment. The preferred sites being in sparsely populated territories, with no particular economic value. The area of the disposal facility should not be important for the local community economic or social development of the region. Construction of the repository must be acceptable to the local community and to the local and regional authorities. The repository should not have a negative impact on the area of long-term strategic development plans and aspirations on the local, municipal and regional levels. Repository installation should not cause or escalate conflicts between social, ethnic or interest groups.

Public acceptance. In industrialized democratic countries public attitude "not-in-my-backyard" can hinder siting of all types of industrial waste facilities, including radioactive waste management sites. This causes planners to focus great attention on societal factors during early phases of the siting process. In many cases due to positive public acceptance, the repositories are being co-located at sites where nuclear facilities already exist; for example, Centre de la Manche

(France), Drigg (UK), Rokkasho (Japan), Olkiluoto (Finland), Forsmark (Sweden), Mochovce (Slovakia), Ignalina (Lithuania).

4.3 MAIN TECHNICAL CHARACTERISTICS OF DISPOSAL FACILITY

The following factors shall be taken into account at various design stages and at the review stage during developing the solutions on siting the disposal facility resulted in choosing one or several possible disposal sites based on Appendices 1, 2 of SSG-29, 2014:

- Forecasted type and amount of waste, timing of disposal;
- Identification of a potential site fulfilled in two stages:

а) Regional phase of cartography or survey to identify regions with potentially suitable areas (to be carried out step-by-step based on geographical, geological and hydrogeological data of previous surveys, historical data);

б) Selection of one or more options for the further more detailed assessment considering social and political criteria, review of national directions and laws. The criteria comprise e.g. presence of national parks, monuments.

Solid RW resulted from stands 346A and 346B decommissioning may be subdivided into following groups:

- Waste which activity is due to the induced activity of reactor structural components;
- Waste which activity is due to corrosion products and fission products on the surfaces of the primary circuit structure and equipment;
- Nonradioactive waste of RC structures and biological shielding;
- Waste placed for storage into the reactor compartments before their putting in dead storage;
- Waste resulted from dismantling the concrete poured into rector compartments before the stands were put into dead storage;
- Waste resulted from dismantling the sarcophagi.

After the 50-year storage period a part of equipment has transferred from the RW category into a releasable materials category. The value of parameter C_i/(activity concentration)$_i$ - that is the criterion to rate the material as RW - was used to make a decision on categorizing the stand structures and equipment as RW on completion of this 50-year storage period. The values of specific activity concentration based on nuclides are taken in accordance with IAEA document No.

RS-G-1.7 regulating application of the concepts of exclusion, exemption and clearance. Further storage will not result into a significant reduction of the RW volume.

The data on RW generated during the RC dismantling having the highest activity are given in Table 39 below.

Table 39. List and characteristics of RW generated during the RC dismantling and having the highest induced activity

RW description	RW weight, kg	Specific activity, Bq/kg	RW category based on GSG-1 [2]	Radionuclides determining rating as RW	Disposal method
Stand 346A					
VM-A reactor (with internals and control rods)	30 000	2.3 E+09	ILW Long-lived	Co-60, Ni-59, Ni-63 (97.8%)	Near surface disposal at a depth from several tens to several hundreds of meters
IWS tank	52 000	1.6E+7	ILW Long-lived	Co-60, Ni-59, Ni-63	
Total:	82 000				
Stand 346B					
VM-4 reactor (with internals and control rods)	50 400	3.0E+08	ILW Long-lived	Co-60, Ni-59, Ni-63 Nb-94 Eu-152 Eu-154	
SG - primary circuit pump assembly	71 000	2.1E+04	LLW Short-lived	Co-60,	
Heat exchanger of the primary circuit cooling system filter	2 780	2.8E+05	ILW Long-lived	Co-60, Ni-63	
Primary circuit cooling system filter	1 980	3.9E+04	LLW Short-lived	Co-60	
Shield tank	66 180	4.6E+06	ILW Long-lived	Co-60, Ni-63 Nb-94	
Total:	**192 340**				

Table 40 shows the activity of corrosion products which accumulate in the equipment and piping of the first circuit during operation of the reactor plant of 346A stand. Comparing to the rather low induced activity of the primary circuit components shielded by the (due to the low flux of activating neutrons) the activity of the corrosion products located at the internal surfaces of these components may be significant to determine the total amount of activity of the circuit.

The main radionuclide determining the activity of construction materials and corrosion products after 50 years of storage is long-lived Ni-63. The IAEA document No. RS-G-1.7 limits Ni-63 activity concentration by 1E+05 Bq/kg for the exemption from under control. Table 40 shows the equipment of 346A stand to be categorized as RW. The total weight of this equipment – 22 067 kg. Data on the piping weight is not available. Because of their activity is determined by the long-lived radionuclides, piping should be categorized as medium level RW.

A similar picture on the corrosion products is observed for the equipment of the stand 346B, and it is possible to assume conservatively that all of the equipment of the stand B 346 categorised as RW referred to the medium level RW category.

Table 40: Activity of the primary circuit corrosion products (346A, Bq)

Zone, component	Weight, kg	Activity, Bq	Specific activity, Bq/kg
Reactor and primary circuit	30 000	6.79 E+10	2.26 E+06
SG	21 600	5.98 E +09	2.7 E +05
Pressurizer	7 200	3.09 E +08	4.34 E +04
Primary circulation pump GCEN-146	4 600	9.58 E +07	2.08 E +04
Auxiliary circulation pump VCEN-147R	1 800	7.66 E +07	4.25 E +04
Refrigerator HGCEN-601	300	1.77 E +08	5.9 E +05
Refrigerator HGCEN-146M	115	1.02 E +08	9.01 E +05
Refrigerator HGCEN-147M	52	3.83 E +07	7.36 E +05

Thus, after 50 years of storage after the shut-down the weight of the equipment contaminated with the long-lived radionuclides and, correspondingly categorized by the Estonian classification as medium level RW will amount to:

346A – 104 067 kg, 346B – 192 340 kg.

Considering the uncertainty of input data on weight of unaccounted structures and equipment activity, the RW weight is assumed to be 10% more: thus the RW weight shall be about 115 000 kg for stand 346A and 210 000 kg for stand 346B.

General denominative information on approximate indicative volumetric characteristics of RW is presented within the Report on the Task 3 “Determining the possibilities of decommissioning the reactor compartments” (Chapter 3 “Description and assessment of the waste to be generated in the course of the decommissioning works”) in accordance with the concepts, technologies and waste assessment covered within the scope of the Task 3.

Table 41 gives data on enlarged estimate of RW volume generated during RC decommissioning.

Table 41: volume of RW resulted of reactor stands dismantling (including sarcophagi)

Waste description	Waste weight, kg		Total weight, kg
	Stand 346A	Stand 346B	
ILW, LLW resulted from dismantling of RC primary circuit equipment	115 000	210 000	335 000
Waste resulted from RC dismantling (releasable and non-radioactive)	740 000	740 000	1 480 000
Radioactive waste separated from concrete inside the compartments (ILW for blocks containing IRS casks, LLW, VLLW for other concrete blocks)	15 000	10 000	25 000
Concrete	50 000	80 000	130 000
Waste resulted from the sarcophagi dismantling (nonradioactive)	650 000	610 000	1 260 000
Total RW	**130 000**	**220 000**	**350 000**
Total non-radioactive waste	**1 440 000**	**1 430 000**	**2 870 000**
Total weight of waste resulted from reactor stands dismantling (including the enclosure)	**1 570 000**	**1 650 000**	**3 220 000**

The amount of waste to be disposed depends on the decommissioning option preferred. If it will be decided to dispose the reactor stands as a whole, the waste volume would be determined by the RC volume based on their dimensions.

The volume of waste to be disposed in casks will be determined by the size of ready casks. The amount of waste to be loaded into a cask may be enlarged if cutting the waste. But the cask carrying capacity limitation shall be taken into account to define the number of casks required to load the waste. Bulk weight of cut metal is assumed not to exceed 2,000 kg/m^3.

According to the preliminary analysis of waste to be generated due to the reactor compartments decommissioning at the end of the 50-year storage period after the reactor shutdown, the waste resulted from the reactor and IWS tank dismantling are characterized by the highest activity due to the radionuclides decay and this waste is rated as medium level waste which radionuclide composition is determined by long-lived radionuclides among which Ni-63 is the main one. According to IAEA classification, intermediate level waste (ILW) comprising long-lived radionuclides shall be disposed at considerable depths, from some tens to some hundreds of meters.

Amount of secondary RW resulted from decommissioning the stands will also depend on the decommissioning option preferred, dismantling process used and duration of activities. The secondary waste comprises the following: overalls, PPE, abrasive material, consumables of dismantling equipment (e.g. filter cartridges, diamond grinding points, sabre saw blades, abrasive disks etc.). The volume of this waste (estimated based on an analogue) is about 25-30 m^3.

The total amount of conditioned radioactive waste expected to be generated during operation and decommissioning of a future power plant with AP-1000 unit is (at least) - **15 401.5** m^3 which should be posted in the calculation of the disposal facility capacity.

Also the existing stored RW in the Paldiski site (1949.2 m^3 – see table 30 of this report) should be posted in the calculation of the disposal facility capacity.

Thus, the capacity of the disposal facility should envisage the above various radwaste streams - approximately 17,700 m^3 in the case of realization of Concept B of Paldiski RC decommissioning.

CONCLUSION

In the framework of research carried out to collect input data for the implementation of Task 4 'Determining the possibilities of the disposal of radioactive waste' and Task 5 'Cost of radioactive waste management and planning' under these 'Preliminary studies for the decommissioning of the reactor compartments of the former Paldiski military nuclear site and for the establishment of a radioactive waste repository' the following tasks have been regarded as the priority ones:

Recommendations for the identification of suitable locations of a potential radwaste disposal site.

An indicative assessment has been made of the regional cartography/ mapping and studies in order to determine areas with potentially suitable locations based on geographic, geological and hydrogeological findings from previous surveys as well as historical data. Other factors that influence the siting of the disposal facility has been identified, such as the presence of mineral resources.

The following has been established as a result:

It was taken into consideration in the course of overview of archive data and the Client's data concerning geological, hydrogeological and weather conditions in the Republic of Estonia that the process of siting a radwaste disposal facility had to take into account technical and other considerations. Technical factors cover a long list: geology, hydrogeology, geochemistry, tectonics and seismicity, surface processes, meteorology, human-induced events, transportation of waste, land use, population distribution and environmental protection. Preliminary analysis has led to the recommendation of considering areas with the outcrops of the Cambrian sediments, such as Narva, Viivikonna, Jõhvi, Võhma and Võru when selecting the construction site for the radwaste disposal facility. Recommendations for the identification of promising geological formations have been based on the comparison between isolation properties of materials that form the geologic cross-section of the sites. Materials with lower water permeability (clays and loamy clays) are considered the most promising ones, since water permeability is the factor that predominantly determines the properties of the environment that can contain radionuclides and prevent spread of radioactive contamination.

Further assessments of a possibility for the disposal facility location in the areas above require detailed surveys to explore geological, hydrogeological and geographical characteristics as well as social and administrative conditions of a possibility to locate the radwaste disposal facility.

This section also contains the description of the areas:

Pakri peninsula where the Paldiski site is located and Sillamäe.

Data on the content of radionuclides in the groundwater for the last 7 to 14 years have been given for the Paldiski site. The concentrations of all radionuclides detected are moderately low and give indications of earlier activities on the site hosting two operating nuclear reactors.

These additional requirements for the siting of the radwaste disposal facility enable a more scrupulous approach to be followed to select specific areas during further stages of surveys and justifications. Such requirements include:

criteria of unsuitability to locate the radwaste disposal facility;

technical/ safety criteria;

social and economic criteria.

In order to identify what the radwaste disposal facility will look like, the rate of radwaste accumulation in 2015 has been estimated. The estimates cover both the radwaste currently being stored in Paldiski and the one to result from the RCs dismantling as well as the future NPP operation.

The quantities of waste to be placed for disposal depend on the preferred RCs decommissioning option to be selected (please refer to the Task 3 report).

Preliminary analysis of waste to be generated in the course of reactor compartments decommissioning after 50 years of storage following the shutdown of the reactors, shows that due to radionuclide decay, waste resulting from cutting the reactor and the iron-water protection tank and characterized with the highest radioactivity, will be eventually referred to as intermediate-activity waste whose radionuclide composition is stipulated with long-lived radionuclides, Ni-63 being the major one. In compliance with the IAEA GSG-1, 2014 4 classification, intermediate-level waste (ILW) that contains long-lived radionuclides, needs to be placed for disposal at considerable depths ranging between tens and hundreds meters. The weight of the 346A stand equipment is 104,067 kg, and the stand 346B one is 192,340 kg. Following 50 years of storage after the reactor shutdown all this equipment is contaminated with long-lived radionuclides and, consequently, refers to ILW according to the classification in the Republic of Estonia and IAEA.

Considering uncertainties in the input data with regard to the weight of non-estimated structures and activity of the equipment we will assume that the weight of radwaste of 10% bigger: thus, the weight of ILW will be up to ~115,000 kg for the 346A stand and up to ~ 210,000 kg for the 346B stand.

General denominative information on approximate indicative volumetric characteristics of RW is presented within the Report on the Task 3 “Determining the possibilities of decommissioning the reactor compartments” (Chapter 3 “Description and assessment of the waste to be generated in the course of the decommissioning works”) in accordance with the concepts, technologies and waste assessment covered within the scope of the Task 3.

The quantities of secondary radwaste to be generated in the course of decommissioning will also depend on the decommissioning option to be selected, dismantling technologies to be applied and the duration of activities. Secondary waste will comprise: work clothing, PPE, grinding

[4]Classification of Radioactive Waste, IAEA Safety Standards Series GSG-1, 2014

media, consumables for dismantling equipment (e.g., filter cartridges, diamond grinding cup wheel, blades for reciprocating saws, abrasive discs etc.). The quantity of such waste is estimated (based on similar activities) about 25 m^3 to 30 m^3.

Indicative total weight of radwaste to be generated in the course of RCs dismantling irrespective of the RCs decommissioning concept, is expected to reach approx. 350,000 kg, and approx. 400,000 kg if secondary waste is considered.

The total quantity of conditioned radwaste resulting from the future NPP (AP-1000 reactor) operation and decommissioning is forecast to amount to 15,401.5 m^3 as a minimum. This must be taken into account when the capacity of the disposal facility is calculated.

Besides, the design of the disposal facility capacity must consider 1,949.2 m^3 of existing radwaste currently stored at the Paldiski site.

Thus, the capacity of the disposal facility should envisage the above various radwaste streams - approximately 17,700 m^3.

Also, the capacity of the disposal facility should take into account the RW streams generated in the Republic of Estonia annually and single volume waste which is expected to be generated by the year of 2039. In accordance with the estimations presented within “National programme for radioactive waste management” [6], the average expected streams of the waste to be generated in the Republic of Estonia annually and by the year of 2039 are the following:

- Annually 0.27 m^3 low- and intermediate-level short-lived waste;
- Annually 0.06 m^3 low- and intermediate-level long-lived waste;
- Annually 10 m^3 cleared liquid waste;
- Annually 0.4 m^3 (contaminated metal) NORM waste;
- Annually 72.5 tonnes of Molycorp Silmet AS NORM waste (potential NORM waste);
- Annually 0,1 l low- and intermediate-level liquid waste;
- single large-volume concrete scrap from Tammiku decommissioning - 28 m^3;
- single large-volume of metal contaminated with NORM waste from Molycorp Silmet AS – 200 tonnes.

Thus, it is recommended to envisage the capacity of the disposal facility – approximately 2150 m^3 for the waste to be generated in the Republic of Estonia by the year of 2039 and for the later annual generation – about 85 m^3.

So, the recommended total capacity of the disposal facility should be not less than 23 000 cubic meters with consideration of about 9-10% reserve

REFERENCE

1. Radioaktiivsete jäätmete käitlemise tegevuskava eelnõu ajakohastamine, ALARA AS, Paldiski 2013.
2. Looduslikke ja tehislikke radionukliide sisaldavate metallijäätmete käitlemise metoodika, ALARA AS, Paldiski 2012.
3. Engineering –geological modelling of the Sillamae radioactive pond area, Hardi Thorn, 2008
4. USSR Geology, Vol. 28, Estonian SSR, A Geological Description and Natural Resources, Moscow, 1960.
5. Consortium AGRIFOR Consult, Geological and Hydrogeological Final Report, Safe Long-Term Storage of the Paldiski Sarcophagi & Related Dismantling Activities – Technical Assistance for Environmental Impact Assessment Studies, 2014.
6. National programme for radioactive waste management, Ministry of the Environment, Republic of Estonia, 2015.

5. SUMMARY

Based on the investigation carried out, as well as calculations, evaluations, data updating made in respect of Task 2 “Data Collection and Review” of the Contract on performance of “Preliminary Study for De-Commissioning the Reactor Compartments Located in the Territory of Former Military Base (Nuclear Power Use Facility in the city of Paldiski) and Construction of Radioactive Waste Storage Facility”, the following findings have been made:

1. The procedure of collection and assessment of the input data to accomplish Task 2 consisted:

- firstly, in obtaining the available documents, reports, explanatory notes, information containing investigation results, measurements of the state of the facility and the two reactor compartments from the Customer, i.e. the company ALARA;

- secondly, in using the experience, knowledge or expertise possessed by the professionals of the General Project Engineering Group that designed the training center of the Navy in the City of Paldiski, namely Atomproekt JSC;

- thirdly, in the technical visits made by the engineers of Eksortus, FCNRS JSC, Atomproekt JSC to the site of the former training center of the Navy in the city of Paldiski with a view to inspecting the condition of the site, the building, grouted reactor compartments of Stands 346A and 346B, adjacent premises, as well as the premises for intermediate storage of radioactive waste containers. During the visit, the engineers were briefed in detail on the history of the training center, including its aims and tasks, the background information relating to the operation of the nuclear-powered submarine prototype stands, key performance characteristics of the reactor plants, their operating periods, the decision on decommissioning and selection of the deferred decision concept, the time frame for conducting the moth-balling of the reactor compartments, the work done on the site and in the building of the reactor compartments (RC) for the purpose of improving safety. The engineers were also familiarized with the main process equipment available in the building where the reactor compartments are located, including instrumentation to control and take measurements to monitor the status of the premises including internal RCs;

- fourthly, in organizing projects and technical meetings, two meetings of the steering committee at which the Customer’s representatives gave a detailed presentation of the aims and tasks of the preliminary investigation. At the same time, on the part of the Contractor, a presentation was made of their vision for achieving the aims and tasks of the preliminary investigations as well as expected results. The Contractor set out the results of the investigations obtained which were commented on in detail by the representatives of the Customer.

The procedure of transmitting the input data from the Customer was carried out on the basis of the Contract provisions. The Contractor executed appropriate authorizations to transfer the information to the Customer, including the information to be accounted for, in due course, on the basis of the Contractual obligations. No confidential information, or limited disclosure information or classified information was used in the course of the present investigations.

Despite a number of limitations, the present report incorporates all the available collected information and the input data as at the middle of 2015.

2. For the purpose of conducting the investigation and on the basis of the collected information, a list was made of the available documents, investigation materials, radioactive checkouts, operational history, safety reports, reports on environmental impact assessment. The list is given in the section Reference on task 2.1.

3. Based on the experience, the requirements of the legislative and normative framework, a list of principal criteria for the decision to de-commission the two RCs to be made was established:

- political decision in view of the change in the status of the Republic of Estonia in 1992;
- ensuring safety for the personnel, population and environment;
- ensuring physical protection for the former training center in the city of Paldiski;
- complying with the requirements of the norms and regulations of the Russian Federation and IAEA.

More than two decades have elapsed since work was done to immediately de-commission the nuclear-powered submarine prototype stands and to moth-ball the reactor compartments. Proceeding from the experience, the condition of the building, its building structures, concrete structures around the reactor blocks, the data of control and monitoring as the key criteria for decision to be made regarding the dismantling of the moth-balled reactor compartments or continuation of their controlled storage, the facility ageing will result in:

- reduced level of safety for the personnel engaged in control and monitoring of the condition of the site where the reactor compartments are;
- negative impact of the site of the former training center in the city of Paldiski on the population and environment;
- cost of the work to be done in order to dismantle the reactor compartments and availability of financing;
- decision at the level of the Government of the Republic of Estonia regarding the place of storage/disposal of the radioactive wastes resulting from the dismantling of the reactor compartments and the radioactive waste containers stored in the building of the RC;
- other circumstances, for example, the need to vacate the site and rid it from the radioactive facility with aim of re-purposing it for another business application.

4. The results of acquisition of available information regarding state of reactor compartment, reactors and ancillary equipment as of the date of placing in durable storage thereof according to design documentation, data as of 1995, estimated data provided as a result of investigations carried out in 2001 have made it possible to submit the data pertaining to the design, radiation characteristics and radionuclide composition of the nuclear power plant equipment 346 A, including:

- technical characteristics and design of the systems of the main primary circuit: steam generators, main circulation pumps, pressure compensators, auxiliary circulation pump, heat exchangers, reactor heat carrier cleaning filters;

- engineering drawings determining internal configuration of every component of the primary circuit from those enumerated above, path length, material thickness, final configuration at every side of every blanked component (pipes dimensions, elbows lengths, blanks dimensions) and demonstrating the method of equipment attachment in the reactor compartments;
- complete data regarding pipes of the primary and secondary main circuits, which determine the path length, material types, thickness and weight;
- technical characteristics and design of the main equipment of the second, third and fourth circuits of the reactor heat carrier;
- radionuclide composition given for every part of the plant as of 2015, 2039 (50 years after shutdown) and 100 years after shutdown. The composition includes the long-lived and short-lived radionuclides. The calculation of induced radioactivity in stationary premises of compartment 346A as well as induced radioactivity of concrete placed in the compartment in the course of preservation operations has been performed. The data have been obtained in the way of calculations based on the results of the preceding investigations;
- assessments of the radiation dosage rate as of 2015, 2039 (50 years after shutdown) and 100 years after shutdown in the reactor compartment 346 A proceeding from the statistic data (e.g., preceding radiological cartography) and calculations using data on induced radioactivity and radionuclide composition. The radiation dosage rate average values have been provided for the main equipment units of the first circuit (average radiation dosage rate as of 2015 and scheduled in 50 and 100 years after shutdown).

The identical data are presented in the report for stand 346B as well.

5. The conducted analysis and calculations of quantity of the existing wastes available in the internal premises of the reactor compartment and being newly generated during reactor compartment dismantling have made it possible to refresh and update the data of the preceding investigations. The general amount of the existing radioactive wastes will equal 1949,2 m^3 according to assessment for 2015.

6. The conducted analysis of amount of radioactive wastes generation from the future operation of one NPP unit featuring capacity up to 1,000 MW-h has shown that the amount of radioactive wastes depends on the type of reactor plant as well as radioactive wastes generation from the dismantling of one NPP unit.

The total amount of conditioned RW over the entire period of operation of one unit with AP-1000 reactor would be expected at approximately (at least) - 9 324 m^3 with the design duration of operating life of 60 years. The total amount of conditioned radioactive waste expected to be generated during operation and decommissioning of a power plant with AP-1000 unit is (at least) 15 401,5 m^3.

The total amount of conditioned RW over the entire period of operation of a unit with VVER-1000 reactor would be expected at approximately (at least) – 5 010 m^3 with the design duration of operating life of 60 years. The total amount of conditioned radioactive waste expected to be generated during operation and decommissioning of a VVER-1000 unit of NPP is (at least) 7 145 m^3.

7. The used source data and the obtained results with respect to task 2 are true since they have been received from the reliable sources. All the calculations have been performed by the specialists of the factories possessing the relevant experience, certificates and licenses.

8. The analysis of necessity of additional data and unaccounted factors (uncertainties) has been carried out in the course of evaluating demand for additional information for taking future decisions for subsequent works such as designing, environment impact assessment procedure and other. Such works will include fulfillment of the integrated engineering radiation safety audit of the reactor compartment building, adjacent areas, premises and radioactive wastes storage. A detailed description of the requirements and scope of investigations and studies has been prepared within the report. The data acquired in the course of integrated engineering radiation safety audit will be used as the basis for performing design works on reactor compartment dismantling, preparation of report on the environment impact assessment procedure and measures on environment protection. It is not reasonable to carry out the environment impact assessment procedure without conducting the integrated engineering radiation safety audit.

9. The review of international and state recommendations and regulatory documents on the reactor compartment decommissioning has demonstrated a necessity for introducing changes into the legislative and regulatory environment for power nuclear reactors, which is described in detail within the present report.

10. The review of international and state recommendations and regulatory documents on the ultimate disposal has demonstrated a necessity for introducing changes into the legislative and regulatory environment for power nuclear reactors, which is described in detail within the present report.

11. Waste amount generated during decommissioning of rigs 346A and 346B for various decommissioning options are following (Table 42):

Table 42: Waste amount generated during decommissioning of rigs 346A and 346B for various decommissioning options

Waste designation	Waste weight, kg	
	Rig 346 A	Rig 346 B
Whole disposal of RW (options C and D)		
Total of RW	920 000	1 040 000
Total of non-radioactive waste	650 000	610 000
Dismantling with fragmentation into large pieces (option A)		
Total of RW	180 000	300 000
Total of non-radioactive waste	1 390 000	1 350 000
Dismantling with fragmentation into small pieces (option B)		
Total of RW	130 000	220 000
Total of non-radioactive waste	1 440 000	1 430 000

General denominative information on approximate indicative volumetric characteristics of RW is presented within the Report on the Task 3 “Determining the possibilities of decommissioning the reactor compartments” (Chapter 3 “Description and assessment of the waste to be generated in the course of the decommissioning works”) in accordance with the concepts, technologies and waste assessment covered within the scope of the Task 3.

The figure of generated RW amount could vary from about 50 to 80 tons depending on the decommissioning option presented within the report on the Task 3.

According to the Minister of the Environment Regulation No. 8 "Radioactive waste classification, recording, handling and transfer of radioactive waste acceptance criteria", wastes from the decommissioning of the reactor compartments are classified as low level short-term and medium level long-term radioactive waste.

Thus, proceeding from the conducted investigations regarding task 2, it can be acknowledged that the state of preserved reactor compartments is safe and reliable and will be kept unchanged within the nearest decades to come.

The current report and its results are the preliminary studies for the decommissioning of the reactor compartments and for the establishment of a radioactive waste repository, and composed as an indicative assessment for the decision making, so they should be clarified, updated and improved at the further stages of the preparation for the Paldiski reactor compartments decommissioning and development of a concept of the establishment of RW repository.

In order to maintain safety of the reactor compartments, it is necessary to provide continuous control and monitoring of the state of reactor compartment, building, adjacent area as well as maintenance and repair of the building and premises.

In case of adopting a decision on the beginning of works regarding final decommissioning of the former Navy training center in Paldiski town, first of all, it will be necessary to carry out the integrated engineering radiation safety survey and after that develop the design documentation and environment impact assessment procedure with the environment protection measures based on the acquired data.

It is overwhelmingly important to develop and put into effect the missing regulatory documents or append the existing legislative and regulatory documents for power nuclear reactors prior to beginning the design works on decommissioning and construction of RW final repository. Detailed analysis of the legislative framework of the Estonian Republic and needs in possible amendments is presented within Annex 1 of the present report “Assessment of the Legislation of the Estonian Republic”.

ANNEX 1 ASSESSMENT OF THE LEGISLATION OF THE ESTONIAN REPUBLIC

Table 43. Radioactive Waste Management

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
01	**Radiation Act**	Currently the radiation act is applicable only to radiation practices, so this does not allow to regulate anything that is not directly related to use/management of the sources/radioactive waste. This is the reason why for example the design phases of the radioactive waste management are not really included in the Radiation Act. Taking into account the requirements from the new EURATOM BSS, there will be need to change the application areas of Radiation Act anyway. The regulator needs to have a role in the planning and building stages of the RWM site as well. The Act should define clearly legal, technical and financial responsibilities for organizations involved in predisposal radioactive waste management activities. The Act includes the national radiation safety plan and its audits. However it should be clear that there is also need for operator's audit program, which could determine whether the program and plans for the predisposal management of LILW meet the applicable requirements and to confirm that certain activities are covered by the procedures and that the program is being implemented adequately. Process audits should be conducted for verifying that waste management processes are being conducted within specified parameters, in compliance with the procedures for safe operation and with the requirements established by the regulatory body in a license or an authorization of another type. There should be recommendation that to select the most appropriate type of pretreatment, treatment and conditioning for the radioactive waste when no disposal facility has been established, assumptions have to be made about the likely disposal option. The current practice is to divide the activities into different stages; however this should be reflected more clearly also in the legislation. Upon the completion of commissioning, a final commissioning	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste Council Directive 2006/117/EURATOM on the supervision and control of shipments of radioactive waste and spent fuel	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards General Safety Requirements Part 5 Predisposal Management of Radioactive Waste

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
		report is usually produced by the operator. The report has to document the as-built status of the facility, which, in addition to providing information to facilitate operation, is important when considering possible future modifications to the facility and its shutdown and decommissioning. The report has to describe all the testing and provide evidence of the successful completion of testing and of any modifications made to the facility or to procedures in commissioning. The financial guarantees to secure the disposal of the radioactive material in the interim storage. Current act provides the very overall requirement for the radiation practice license owner to provide the security of the radioactive material. This should be elaborated, possibly providing more detailed information in the relevant regulation. The country has to ensure of necessary public information and participation in relation to spent fuel and radioactive waste management while having due regard to security and proprietary information issues.		
02	Regulation # 163 The Bases for Calculation of Exemption Values, and the Exemption Values for Radionuclides	The regulation needs updating taking into account the requirements and recommendations coming from EURATOM BSS. It shall be demonstrated that workers should not be classified as exposed workers, and the following criteria for the exposure of members of the public are met in all feasible circumstances: — For artificial radionuclides: The effective dose expected to be incurred by a member of the public due to the exempted practice is of the order of 10 μSv or less in a year. — For naturally-occurring radionuclides: The dose increment, allowing for the prevailing background radiation from natural radiation sources, liable to be incurred by an individual due to the exempted practice is of the order of 1 mSv or less in a year. The assessment of doses to members of the public shall take into account not only pathways of exposure through airborne or liquid effluent, but also pathways resulting from the disposal or recycling of solid residues. Member States may specify dose criteria lower than 1 mSv per year for specific types of practices or specific pathways of exposure.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards RS-G-1.7 Application of the Concepts of Exclusion, Exemption and Clearance

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
		For the purpose of exemption from authorization, less restrictive dose criteria may be applied. The exemption values should be checked as well. The differentiating in the exemption values (any amount, activity concentration in moderate amounts).		
03	Regulation # 193 Effective Dose and Equivalent Dose Limits for the Lens of the Eyes, Skin and Extremities for Exposed Workers and Members of the Public	Some of the dose limits need updating. Currently the 5 year total limit for radiation worker is 100 mSv, but the updated version should be defined as annual maximum dose to the radiation worker 20 mSv. There is need to update also the equivalent dose limits. For example: the equivalent dose for the lens of the eye of radiation worker shall be 20 mSv in a single year or 100 mSv in any five consecutive years subject to a maximum dose of 50 mSv in a single year. Currently it is 150 mSv per year.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards
04	Regulation # 41 Time Limits for Proceedings to Issue, Amend or Revoke the Radiation Practice Licences, the Specific Requirements for and Format of Applications for Radiation Practice	As the regulation provides more information about the licensing procedure. Currently it covers the all radiation practices and provides very small differentiating between activities. It would be useful to provide more information for the licensing for radioactive waste management activities. In case of changing the coverage of the Radiation Act, these additional activities and their licensing needs have to been taken into account as well. The indicative list of information for license applications of new EURATOM BSS is basically covered in the current legislation, but the aims of the safety assessment might be defined in more detailed way.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards WS-G-2.5 Predisposal Management of Low and Intermediate Level Radioactive Waste
05	Regulation # 86 Requirements for the Radiation Safety Training of Exposed Workers	The regulation provides information about the requirements and about the topics to be involved in the trainings. The legislation needs amendments in order to include the system for recognition of the trainings and trainers.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards
06	Regulation # 93 Intervention and Action Levels, and Emergency Exposure Guidance in a Radiological Emergency	The new BSS defines that the Member State has to establishment of appropriate reference levels. The elements to be included in an emergency management system are following: 1. Assessment of potential emergency exposure situations and associated public and emergency occupational exposures; 2. Clear allocation of the responsibilities of persons and organizations having a role in preparedness and response arrangements;	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
		3. Establishment of emergency response plans at appropriate levels and related to a specific facility or human activity; 4. Reliable communications and efficient and effective arrangements for cooperation and coordination at the installation and at appropriate national and international levels; 5. Health protection of emergency workers; 6. Arrangements for the provision of prior information and training for emergency workers and all other persons with duties or responsibilities in emergency response, including regular exercises; 7. Arrangements for individual monitoring or assessment of individual doses of emergency workers and the recording of doses; 8. Public information arrangements; 9. Involvement of stakeholders; 10. Transition from an emergency exposure situation to an existing exposure situation including recovery and remediation.		
07	Regulation # 113 Requirements for the Rooms Where the Radiation Sources Are Situated and for Labeling Thereof and for the Working Rules for the Performance of Radiation Practices	The regulation provides only overall requirement for the security. However in order to build up the common understanding of the requirements, they should be elaborated in more detailed way. The requirements for marking HASS have to be more detailed as well. The manufacturer or supplier ensures that: (a) Each high-activity sealed source is identified by a unique number. This number shall be engraved or stamped on the source, where practicable. The number shall also be engraved or stamped on the source container. If this is not feasible, or in the case of reusable transport containers, the source container shall, at least, bear information on the nature of the source. (b) The source container and, where practicable, the source are marked and labeled with an appropriate sign to warn people of the radiation hazard. 2. The manufacturer provides a photograph of each manufactured source design type and a photograph of the typical source container. 3. The undertaking ensures that each high-activity sealed source is accompanied by written information indicating that the source is identified and marked in compliance with point 1 and that the markings and labels referred to in point 1 remain legible. The information shall	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
		include photographs of the source, source container, transport packaging, device and equipment as appropriate.		
08	Regulation # 8 The Classification of Radioactive Waste, the Requirements for Registration, Management and Delivery of Radioactive Waste and the Acceptance Criteria for Radioactive Waste	The classification of the radioactive waste should be reviewed, taking into account the classification proposed by IAEA. Mixing LILW streams should be limited to those streams that are radiologically and chemically compatible. If the mixing of chemically different waste streams is considered, an evaluation should be made of the chemical reactions that could occur in order to avoid uncontrolled or unexpected reactions, especially the unplanned release of volatile radionuclides or radioactive aerosols. It hast to be stated also that should a waste package not meet the specifications or the waste acceptance requirements, the nature of the non-conformance should be recorded as well as any decision taken to carry out appropriate corrective actions. The list of the factors for safety assessments of RWM can be amended based on IAEA recommendations.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste	General Safety Guide GSG-1 Classification of Radioactive Waste WS-G-2.5 Predisposal Management of Low and Intermediate Level Radioactive Waste
09	Regulation # 10 Clearance Levels for Radioactive Substances and Materials Contaminated with Radioactive Substances Resulting from Radiation Practices, and the Requirements for Their Clearance, Recycling and Reuse	It should be discussed if the clearance and exemption regulations could be united, as based the new EURATOM BSS these are approached together as well. The regulation needs updating taking into account the requirements and recommendations coming from EURATOM BSS. It shall be demonstrated that workers should not be classified as exposed workers, and the following criteria for the exposure of members of the public are met in all feasible circumstances: — For artificial radionuclides: The effective dose expected to be incurred by a member of the public due to the exempted practice is of the order of 10 μSv or less in a year. — For naturally-occurring radionuclides: The dose increment, allowing for the prevailing background radiation from natural radiation sources, liable to be incurred by an individual due to the exempted practice is of the order of 1 mSv or less in a year. The assessment of doses to members of the public shall take into account not only pathways of exposure through airborne or liquid effluent, but also pathways resulting from the disposal or recycling of solid residues. Member States may specify dose criteria lower than 1 mSv per year for	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards RS-G-1.7 Application of the Concepts of Exclusion, Exemption and Clearance

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
		specific types of practices or specific pathways of exposure. For the purpose of exemption from authorization, less restrictive dose criteria may be applied. The exemption values should be checked as well. The differentiating in the exemption values (any amount, activity concentration in moderate amounts).		
10	Regulation # 45 The Procedure for Monitoring and Estimation of Effective Doses Incurred by Exposed Workers and Members of the Public, and the Coefficients for Calculating Radionuclide Ingestion and Inhalation Doses	Update on radiation and tissue weighting factor values is needed. The monitoring requirements for RWM sites should be more elaborated in the regulation. There are requirements for record keeping, but it should be provided in more detailed way – for example who and on which conditions have right to access this data.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	
11	Regulation # 243 Procedure Specifications for Processing Documents of Import, Export and Transit of Radioactive Waste Based on Country of Origin and Destination	Where radioactive waste or spent fuel is shipped for processing or reprocessing to a Member State or a third country, the ultimate responsibility for the safe and responsible disposal of those materials, including any waste as a by-product, shall remain with the Member State or third country from which the radioactive material was shipped.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste Council Directive 2006/117/EURATOM on the supervision and control of shipments of radioactive waste and spent fuel Council Recommendation 2008/956/Euratom on criteria for the	

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
			export of radioactive waste and spent fuel to third countries	
12	Regulation # 244 Statutes for the Maintenance of the State Dose Register of Exposed Workers.	The information about the radiation workers in the dose registry should also include their health data.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	
13	Regulation # 110 The Requirements for the Results of Individual Monitoring of Outside Workers, and for Formalising Such Results, and for the Standard Format for the Dose Chart of Outside Workers	The current legislation covers the needs in RWM.		
14	**Environmental Monitoring Act**	The current legislation covers the needs in RWM. It should be useful to have the reference to the Radiation Act, as some regulations based on this act are providing some additional requirements for the monitoring activities.		
15	Regulation # 50 Establishment of National Environmental Monitoring Stations and Areas	The current legislation covers the needs in RWM.		
16	**Environmental Supervision Act**	There is a possibility provided to include other authorities additionally to the Environmental Inspectorate in the process of the supervision. In case of the RWM the Environmental Board has to be included in the inspection process.		
17	**Emergency Act**	The current legislation covers the needs in RWM.		
18	Regulation # 57 Procedure of Notification of the Ministry of the Interior of An Emergency or of	The current legislation covers the needs in RWM. Requirements for the Environmental Board, not related to the operator.		

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
	the Impending Risk of the Occurrence of An Emergency			
19	**Environmental Impact Assessment and Environmental Management System Act**	The current legislation covers the needs in RWM. However the listing of the activities could be defined so that it would be easier to understand which activities fall under the current act and which not.		
20	**General Part of the Environmental Code Act;**	There is a possibility provided to include other authorities additionally to the Environmental Inspectorate in the process of the supervision. In case of the RWM the Environmental Board has to be included in the inspection process.		
21	**Building Code;**	Currently the code lets the competent authority to decide about the need for Environmental Impact Assessment. However in case of the building license for RWM facilities it should be clearly stated that approved EIA is prerequisite. The legislation should address clearly that in case of the application for the building RWM facility, the approved EIA is prerequisite.	Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste	GSR Part 5 Predisposal Management of Radioactive Waste
22	**Planning Act;**	The act provides the option for the state to define special planning. Among the listed possibilities should be also disposal facility and even centralized storage facility. In the planning stage it should be already taken into account that predisposal radioactive waste management facilities shall be located and designed so as to ensure safety for the expected operating lifetime under both normal and possible accident conditions, and for their decommissioning.	Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste	GSR Part 5 Predisposal Management of Radioactive Waste
23	Regulation # 92 - Order of Informing of the Public about the Immediate Danger for Arising of the Emergency Situation, about the Emergency Situation and about the Management of the Emergency Situation and the Requirements to	The requirements to the forwarded information are very overall. Taking into account the EURATOM BSS annex, some recommendations for information to be provided to the affected members of the public in the event of an emergency 1. the members of the public actually affected in the event of an emergency shall rapidly and regularly receive: (a) information on the type of emergency which has occurred and, where possible, its characteristics (e.g. its origin, extent and probable development); (b) advice on protection, which, depending on the type of emergency, may: (i) cover the following: restrictions on the consumption of certain foodstuffs and water	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
	the Forwarded Information	likely to be contaminated, simple rules on hygiene and decontamination, recommendations to stay indoors, distribution and use of protective substances, evacuation arrangements; (ii) be accompanied, where necessary, by special warnings for certain groups of the members of the public; (c) announcements recommending cooperation with instructions or requests by the competent authority. 2. If the emergency is preceded by a pre-alarm phase, the members of the public likely to be affected shall already receive information and advice during that phase, such as: (a) an invitation to the members of the public concerned to tune in to relevant communication channels; (b) preparatory advice to establishments with particular collective responsibilities; (c) recommendations to occupational groups particularly affected. 3. This information and advice shall be supplemented, if time permits, by a reminder of the basic facts about radioactivity and its effects on human beings and on the environment.		
24	Regulation # 15 - The Guidelines for Preparing An Emergency Plan	It should be stated that for emergency preparedness the elements included in the plan should include: 1. Reference levels for public exposure; 2. Reference levels for emergency occupational exposure; 3. Optimized protection strategies for members of the public who may be exposed, for different postulated events and related scenarios; 4. Predefined generic criteria for particular protective measures; 5. Default triggers or operational criteria such as observables and indicators of on-scene conditions; 6. Arrangements for prompt coordination between organizations having a role in emergency preparedness and response and with all other EU Member States and with third countries which may be involved or are likely to be affected; 7. Arrangements for the emergency response plan to be reviewed and revised to take account of changes or lessons learned from exercises and events.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	
25	Regulation # 5 - The Guidelines	The current legislation covers the needs in RWM.		

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
	for Preparing An Emergency Risk Assessment			
26	**Occupational Health and Safety Act**	It is recommended that A-category workers would have gone through the medical control before starting the work. The current occupational health and safety act requires the medical controls, however these have to be done only by the end of the first month of the employment.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	
27	**Road Transport Act**	The current legislation covers the needs in RWM.		
28	**Industrial Emissions Act**	The current legislation covers the needs in RWM.		
29	**Chemicals Act**	The current legislation covers the needs in RWM.		
30	**Ambient Air Protection Act**	The current legislation covers the needs in RWM.		
31	**Waste Act**	The cleared waste will be managed accordingly to the requirements of the waste act and it would be valuable to have the special conditions for the cleared metal waste. The Act provides the possibility for defining these special conditions.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards
32	**Fire Safety Act**	The current legislation covers the needs in RWM.		

Table 44. Transportation

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
01	**Radiation Act**	Currently the radiation act lists under the activities which need radiation protection license only export and import. Even this is the open list, it would be much clearer if the transportation inside the country is listed as well. The current requirements coming both from Radiation Act and from the legislation defining the Dangerous Good Transportation, might cause some duplication and misunderstanding. These requirements should be more connected. Current act provides the very overall requirement for the radiation practice license owner to provide the security of the radioactive material. This should be elaborated, possibly providing more detailed information in the relevant regulation.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste Council Directive 2006/117/EURATOM on the supervision and control of shipments of radioactive waste and spent fuel	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards
02	Regulation # 163 The Bases for Calculation of Exemption Values, and the Exemption Values for Radionuclides	The regulation needs updating taking into account the requirements and recommendations coming from EURATOM BSS. It shall be demonstrated that workers should not be classified as exposed workers, and the following criteria for the exposure of members of the public are met in all feasible circumstances: — For artificial radionuclides: The effective dose expected to be incurred by a member of the public due to the exempted practice is of the order of 10 μSv or less in a year. — For naturally-occurring radionuclides: The dose increment, allowing for the prevailing background radiation from natural radiation sources, liable to be incurred by an individual due to the exempted practice is of the order of 1 mSv or less in a year. The assessment of doses to members of the public shall take into account not only pathways of exposure through airborne or	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards RS-G-1.7 Application of the Concepts of Exclusion, Exemption and Clearance

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
		liquid effluent, but also pathways resulting from the disposal or recycling of solid residues. Member States may specify dose criteria lower than 1 mSv per year for specific types of practices or specific pathways of exposure. For the purpose of exemption from authorization, less restrictive dose criteria may be applied. The exemption values should be checked as well. The differentiating in the exemption values (any amount, activity concentration in moderate amounts). In case of the transportation of the exempt material, there is no need to follow the Radiation Act.		
03	Regulation # 193 Effective Dose and Equivalent Dose Limits for the Lens of the Eyes, Skin and Extremities for Exposed Workers and Members of the Public	Some of the dose limits need updating. Currently the 5 year total limit for radiation worker is 100 mSv, but the updated version should be defined as annual maximum dose to the radiation worker 20 mSv. There is need to update also the equivalent dose limits. For example: the equivalent dose for the lens of the eye of radiation worker shall be 20 mSv in a single year or 100 mSv in any five consecutive years subject to a maximum dose of 50 mSv in a single year. Currently it is 150 mSv per year.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards
04	Regulation # 41 Time Limits for Proceedings to Issue, Amend or Revoke the Radiation Practice Licences, the Specific Requirements for and Format of Applications for Radiation Practice	As the regulation provides more information about the licensing procedure. Currently it covers the all radiation practices and provides very small differentiating between activities. The indicative list of information for licence applications of new EURATOM BSS is basically covered in the current legislation, but the aims of the safety assessment might be defined in more detailed way.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards
05	Regulation # 86 Requirements for the Radiation Safety Training of Exposed Workers	The regulation provides information about the requirements and about the topics to be involved in the trainings. The legislation needs amendments in order to include the system for recognition of the trainings and trainers. For the transportation workers there is need to get training in the transportation of dangerous goods.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards
06	Regulation # 93 Intervention and Action Levels,	The new BSS defines that the Member State has to establishment of appropriate reference levels. The elements to be	Council Directive 2013/59/EURATOM laying down	General Safety Requirements Part 3 Radiation

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
	and Emergency Exposure Guidance in a Radiological Emergency	included in an emergency management system are following: 1. Assessment of potential emergency exposure situations and associated public and emergency occupational exposures; 2. Clear allocation of the responsibilities of persons and organizations having a role in preparedness and response arrangements; 3. Establishment of emergency response plans at appropriate levels and related to a specific facility or human activity; 4. Reliable communications and efficient and effective arrangements for cooperation and coordination at the installation and at appropriate national and international levels; 5. Health protection of emergency workers; 6. Arrangements for the provision of prior information and training for emergency workers and all other persons with duties or responsibilities in emergency response, including regular exercises; 7. Arrangements for individual monitoring or assessment of individual doses of emergency workers and the recording of doses; 8. Public information arrangements; 9. Involvement of stakeholders; 10. Transition from an emergency exposure situation to an existing exposure situation including recovery and remediation.	basic safety standards for protection against the dangers arising from exposure to ionizing radiation	Protection and Safety of Radiation Sources: International Basic Safety Standards
07	Regulation # 113 Requirements for the Rooms Where the Radiation Sources Are Situated and for Labeling Thereof and for the Working Rules for the Performance of Radiation Practices	The regulation provides only overall requirement for the security. However in order to build up the common understanding of the requirements, they should be elaborated in more detailed way.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	
08	Regulation # 8 The Classification of Radioactive Waste, the Requirements for Registration, Management and Delivery of	The classification of the radioactive waste should be reviewed, taking into account the classification proposed by IAEA. In case of the transportation of the RW, these scenarios have to be included in the safety assessments as well.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Guide GSG-1 Classification of Radioactive Waste WS-G-2.5 Predisposal Management of Low and

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
	Radioactive Waste and the Acceptance Criteria for Radioactive Waste		Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste	Intermediate Level Radioactive Waste
09	Regulation # 10 Clearance Levels for Radioactive Substances and Materials Contaminated with Radioactive Substances Resulting from Radiation Practices, and the Requirements for Their Clearance, Recycling and Reuse	It should be discussed if the clearance and exemption regulations could be united, as based the new EURATOM BSS these are approached together as well. The regulation needs updating taking into account the requirements and recommendations coming from EURATOM BSS. It shall be demonstrated that workers should not be classified as exposed workers, and the following criteria for the exposure of members of the public are met in all feasible circumstances: — For artificial radionuclides: The effective dose expected to be incurred by a member of the public due to the exempted practice is of the order of 10 μSv or less in a year. — For naturally-occurring radionuclides: The dose increment, allowing for the prevailing background radiation from natural radiation sources, liable to be incurred by an individual due to the exempted practice is of the order of 1 mSv or less in a year. The assessment of doses to members of the public shall take into account not only pathways of exposure through airborne or liquid effluent, but also pathways resulting from the disposal or recycling of solid residues. Member States may specify dose criteria lower than 1 mSv per year for specific types of practices or specific pathways of exposure. For the purpose of exemption from authorization, less restrictive dose criteria may be applied. The exemption/clearance values should be checked as well. The differentiating in the exemption values (any amount, activity concentration in moderate amounts).	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards RS-G-1.7 Application of the Concepts of Exclusion, Exemption and Clearance
10	Regulation # 45 The Procedure for Monitoring and Estimation	Update on radiation and tissue weighting factor values is needed. There are requirements for record keeping, but it should be provided in more detailed way –	Council Directive 2013/59/EURATOM laying down basic safety	

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
	of Effective Doses Incurred by Exposed Workers and Members of the Public, and the Coefficients for Calculating Radionuclide Ingestion and Inhalation Doses	for example who and on which conditions have right to access this data.	standards for protection against the dangers arising from exposure to ionizing radiation	
11	Regulation # 243 Procedure Specifications for Processing Documents of Import, Export and Transit of Radioactive Waste Based on Country of Origin and Destination	Where radioactive waste or spent fuel is shipped for processing or reprocessing to a Member State or a third country, the ultimate responsibility for the safe and responsible disposal of those materials, including any waste as a by-product, shall remain with the Member State or third country from which the radioactive material was shipped.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste Council Directive 2006/117/EURATOM on the supervision and control of shipments of radioactive waste and spent fuel Council Recommendation 2008/956/Euratom on criteria for the export of radioactive waste and spent fuel to third countries	
12	Regulation # 244 Statutes for the Maintenance of the State Dose Register of Exposed Workers.	The information about the radiation workers in the dose registry should also include their health data.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to	

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
			ionizing radiation	
13	Regulation # 110 The Requirements for the Results of Individual Monitoring of Outside Workers, and for Formalising Such Results, and for the Standard Format for the Dose Chart of Outside Workers	The current legislation covers the needs in transportation.		
14	**Environmental Monitoring Act**	The current legislation covers the needs in transportation.		
15	Regulation # 50 Establishment of National Environmental Monitoring Stations and Areas	The current legislation covers the needs in transportation.		
16	**Environmental Supervision Act**	The current legislation covers the needs in transportation.		
17	**Emergency Act**	The current legislation covers the needs in transportation.		
18	Regulation # 57 Procedure of Notification of the Ministry of the Interior of An Emergency or of the Impending Risk of the Occurrence of An Emergency	The current legislation covers the needs in transportation.		
19	**Environmental Impact Assessment and Environmental Management System Act**	The current legislation covers the needs in transportation.		
20	**General Part of the Environmental Code Act;**	There is a possibility provided to include other authorities additionally to the Environmental Inspectorate in the process of the supervision. In case of the transportation of radioactive material the Environmental Board has to be included in the inspection process.		
21	**Building Code;**	The current legislation covers the needs in transportation.		

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
22	**Planning Act;**	The current legislation covers the needs in transportation.		
23	Regulation # 92 - Order of Informing of the Public about the Immediate Danger for Arising of the Emergency Situation, about the Emergency Situation and about the Management of the Emergency Situation and the Requirements to the Forwarded Information	The requirements to the forwarded information are very overall. Taking into account the EURATOM BSS annex, some recommendations for information to be provided to the affected members of the public in the event of an emergency 1. the members of the public actually affected in the event of an emergency shall rapidly and regularly receive: (a) information on the type of emergency which has occurred and, where possible, its characteristics (e.g. its origin, extent and probable development); (b) advice on protection, which, depending on the type of emergency, may: (i) cover the following: restrictions on the consumption of certain foodstuffs and water likely to be contaminated, simple rules on hygiene and decontamination, recommendations to stay indoors, distribution and use of protective substances, evacuation arrangements; (ii) be accompanied, where necessary, by special warnings for certain groups of the members of the public; (c) announcements recommending cooperation with instructions or requests by the competent authority. 2. If the emergency is preceded by a pre-alarm phase, the members of the public likely to be affected shall already receive information and advice during that phase, such as: (a) an invitation to the members of the public concerned to tune in to relevant communication channels; (b) preparatory advice to establishments with particular collective responsibilities; (c) recommendations to occupational groups particularly affected. 3. This information and advice shall be supplemented, if time permits, by a reminder of the basic facts about radioactivity and its effects on human beings and on the environment.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	
24	Regulation # 15 - The Guidelines for Preparing An Emergency Plan	It should be stated that for emergency preparedness the elements included in the plan should include: 1. Reference levels for public exposure; 2. Reference levels for emergency occupational exposure; 3. Optimized protection strategies for members of the public who may be	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to	

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
		exposed, for different postulated events and related scenarios; 4. Predefined generic criteria for particular protective measures; 5. Default triggers or operational criteria such as observables and indicators of on-scene conditions; 6. Arrangements for prompt coordination between organizations having a role in emergency preparedness and response and with all other EU Member States and with third countries which may be involved or are likely to be affected; 7. Arrangements for the emergency response plan to be reviewed and revised to take account of changes or lessons learned from exercises and events.	ionizing radiation	
25	Regulation # 5 - The Guidelines for Preparing An Emergency Risk Assessment	The current legislation covers the needs in transportation.		
26	**Occupational Health and Safety Act**	It is recommended that A-category workers would have gone through the medical control before starting the work. The current occupational health and safety act requires the medical controls, however these have to be done only by the end of the first month of the employment.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	
27	**Road Transport Act**	The current legislation covers the needs in transportation. However it would be useful to have the reference to Radiation Act and its requirements.		
28	**Industrial Emissions Act**	The current legislation covers the needs in transportation.		
29	**Chemicals Act**	The current legislation covers the needs in transportation.		
30	**Ambient Air Protection Act**	The current legislation covers the needs in transportation.		
31	**Waste Act**	The current legislation covers the needs in transportation.		
32	**Fire Safety Act**	The current legislation covers the needs in transportation.		

Table 45. Decommissioning

##	Document of the Estonian Legislation	Activities are not covered	Recommendation EU document	Recommendation IAEA document
01	**Radiation Act**	Decommissioning is defined separately as well as part of the radioactive waste management activities. Decommissioning is requiring radiation activity license. As decommissioning may be carried out in one continuous operation following shutdown or in a series of discrete operations over time, the act should provide the legal basis for licensing the stages. The licence application should include among others: Fire protection and suppression for the complete site, an evaluation of the various decommissioning options should be performed by considering a wide range of issues, with special emphasis on the balance between the safety requirements and the resources available at the time of implementing decommissioning, etc. At the completion of the decontamination or dismantling activities, a survey of the residual radionuclides at the reactor site should be performed to demonstrate that the residual activity complies with the criteria set by the national regulatory authority and the decommissioning objectives have been fulfilled. It shall be ensured that adequate financial resources to cover the costs associated with safe decommissioning, including management of the resulting waste, are available when necessary. Special attention must be given to the potential for contamination due to the production and release of dust and aerosols of radioactive liquids, and of large quantities of waste generated during decommissioning operations. The main concern is that currently Radiation Act lists most of the requirements as the requirements for the licence holder and this can cause some times misunderstandings.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste	WS-G-2.1 Decommissioning of Nuclear Power Plants and Research Reactors General Safety Requirements Part 6 Decommissioning of Facilities
02	Regulation # 163 The Bases for Calculation of Exemption Values, and the Exemption Values for Radionuclides	The regulation needs updating taking into account the requirements and recommendations coming from EURATOM BSS. It shall be demonstrated that workers should not be classified as exposed workers, and the following criteria for the exposure of members of the public are met in all feasible circumstances: — For artificial radionuclides: The effective dose expected to be incurred	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards

##	Document of the Estonian Legislation	Activities are not covered	Recommendation EU document	Recommendation IAEA document
		by a member of the public due to the exempted practice is of the order of 10 μSv or less in a year. — For naturally-occurring radionuclides: The dose increment, allowing for the prevailing background radiation from natural radiation sources, liable to be incurred by an individual due to the exempted practice is of the order of 1 mSv or less in a year. The assessment of doses to members of the public shall take into account not only pathways of exposure through airborne or liquid effluent, but also pathways resulting from the disposal or recycling of solid residues. Member States may specify dose criteria lower than 1 mSv per year for specific types of practices or specific pathways of exposure. For the purpose of exemption from authorization, less restrictive dose criteria may be applied. The exemption values should be checked as well. The differentiating in the exemption values (any amount, activity concentration in moderate amounts).		RS-G-1.7 Application of the Concepts of Exclusion, Exemption and Clearance
03	Regulation # 193 Effective Dose and Equivalent Dose Limits for the Lens of the Eyes, Skin and Extremities for Exposed Workers and Members of the Public	Some of the dose limits need updating. Currently the 5 year total limit for radiation worker is 100 mSv, but the updated version should be defined as annual maximum dose to the radiation worker 20 mSv. There is need to update also the equivalent dose limits. For example: the equivalent dose for the lens of the eye of radiation worker shall be 20 mSv in a single year or 100 mSv in any five consecutive years subject to a maximum dose of 50 mSv in a single year. Currently it is 150 mSv per year.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards
04	Regulation # 41 Time Limits for Proceedings to Issue, Amend or Revoke the Radiation Practice Licences, the Specific Requirements for and Format of Applications for Radiation Practice	As the regulation provides more information about the licensing procedure. Currently it covers the all radiation practices and provides very small differentiating between activities. It would be useful to provide more information for the licensing for radioactive waste management activities. In case of changing the coverage of the Radiation Act, these additional activities and their licensing needs have to been taken into account as well. The operating organization should submit to the regulatory body a description of: (a) the proposed surveillance and maintenance program for the buildings, structures and safety related operational systems;	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards WS-G-2.1 Decommissioning of Nuclear Power Plants and Research Reactors

##	Document of the Estonian Legislation	Activities are not covered	Recommendation EU document	Recommendation IAEA document
		(b) existing or new systems or program necessary for maintaining the installation under proper control, such as engineered barriers, ventilation, drainage and environmental/safety monitoring; (c) systems to be installed or replaced to carry out deferred dismantling; (d) the proposed frequency at which the above items would be reviewed; and (e) the number of staff needed and their qualifications, during any period of deferment. The decommissioning plan should specify the requirement for on-site and off-site monitoring during decommissioning. All radioactive materials that were present at the beginning of decommissioning should be properly accounted for, and their ultimate destination should be identified.		
05	Regulation # 86 Requirements for the Radiation Safety Training of Exposed Workers	The regulation provides information about the requirements and about the topics to be involved in the trainings. The legislation needs amendments in order to include the system for recognition of the trainings and trainers.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards
06	Regulation # 93 Intervention and Action Levels, and Emergency Exposure Guidance in a Radiological Emergency	The new BSS defines that the Member State has to establishment of appropriate reference levels. The elements to be included in an emergency management system are following: 1. Assessment of potential emergency exposure situations and associated public and emergency occupational exposures; 2. Clear allocation of the responsibilities of persons and organizations having a role in preparedness and response arrangements; 3. Establishment of emergency response plans at appropriate levels and related to a specific facility or human activity; 4. Reliable communications and efficient and effective arrangements for cooperation and coordination at the installation and at appropriate national and international levels; 5. Health protection of emergency workers; 6. Arrangements for the provision of prior information and training for emergency workers and all other persons with duties or responsibilities in emergency response,	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards

##	Document of the Estonian Legislation	Activities are not covered	Recommendation EU document	Recommendation IAEA document
		including regular exercises; 7. Arrangements for individual monitoring or assessment of individual doses of emergency workers and the recording of doses; 8. Public information arrangements; 9. Involvement of stakeholders; 10. Transition from an emergency exposure situation to an existing exposure situation including recovery and remediation.		
07	Regulation # 113 Requirements for the Rooms Where the Radiation Sources Are Situated and for Labelling Thereof and for the Working Rules for the Performance of Radiation Practices	The regulation provides only overall requirement for the security. However in order to build up the common understanding of the requirements, they should be elaborated in more detailed way.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	
08	Regulation # 8 The Classification of Radioactive Waste, the Requirements for Registration, Management and Delivery of Radioactive Waste and the Acceptance Criteria for Radioactive Waste	The classification of the radioactive waste should be reviewed, taking into account the classification proposed by IAEA.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste	General Safety Guide GSG-1 Classification of Radioactive Waste
09	Regulation # 10 Clearance Levels for Radioactive Substances and Materials Contaminated with Radioactive Substances Resulting from	Guidance on radiological criteria for the removal of regulatory control, appropriate decontamination and dismantling techniques and the reuse or recycling of materials can reduce the waste inventory. It should be discussed if the clearance and exemption regulations could be united, as based the new EURATOM BSS these are approached together as well. The regulation needs updating taking into	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards

##	Document of the Estonian Legislation	Activities are not covered	Recommendation EU document	Recommendation IAEA document
	Radiation Practices, and the Requirements for Their Clearance, Recycling and Reuse	account the requirements and recommendations coming from EURATOM BSS. It shall be demonstrated that workers should not be classified as exposed workers, and the following criteria for the exposure of members of the public are met in all feasible circumstances: — For artificial radionuclides: The effective dose expected to be incurred by a member of the public due to the exempted practice is of the order of 10 µSv or less in a year. — For naturally-occurring radionuclides: The dose increment, allowing for the prevailing background radiation from natural radiation sources, liable to be incurred by an individual due to the exempted practice is of the order of 1 mSv or less in a year. Management of the metal waste after clearance needs more guidance.	Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste	RS-G-1.7 Application of the Concepts of Exclusion, Exemption and Clearance WS-G-2.1 Decommissioning of Nuclear Power Plants and Research Reactors
10	Regulation # 45 The Procedure for Monitoring and Estimation of Effective Doses Incurred by Exposed Workers and Members of the Public, and the Coefficients for Calculating Radionuclide Ingestion and Inhalation Doses	Update on radiation and tissue weighting factor values is needed. The monitoring requirements for disposal sites should be more elaborated in the regulation. Requirement for a provision for performing a final confirmatory radiological survey at the end of decommissioning All potential initiating events through which harm could be caused should be considered in the process, in particular: (a) External initiating events: — Natural events such as adverse meteorological conditions (e.g. wind, snow, rain, ice, temperature, flooding, lightning), earthquakes or biological intrusion; — Human-made events such as aircraft accidents (with or without subsequent fires), explosions, fires, loss of electric power or other services, and human intrusion (mainly in cases where the facility is in a state of deferred dismantling). (b) Internal initiating events at the facility or on the site, such as fire, explosion, structural collapse, leakage or spillage, failure of ventilation, dropping of heavy loads and failure of protective measures (e.g. failure of shielding or of personal protective equipment). (c) Human induced initiating events, such as operator errors and violations, and misidentifications leading to the performance of incompatible activities. There are requirements for record keeping, but it should be provided in more detailed	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	WS-G-2.1 Decommissioning of Nuclear Power Plants and Research Reactors WS-G-5-2 Safety Assessment for the Decommissioning of Facilities Using Radioactive Material

##	Document of the Estonian Legislation	Activities are not covered	Recommendation EU document	Recommendation IAEA document
		way –for example who and on which conditions have right to access this data.		
11	Regulation # 243 Procedure Specifications for Processing Documents of Import, Export and Transit of Radioactive Waste Based on Country of Origin and Destination	Where radioactive waste or spent fuel is shipped for processing or reprocessing to a Member State or a third country, the ultimate responsibility for the safe and responsible disposal of those materials, including any waste as a by-product, shall remain with the Member State or third country from which the radioactive material was shipped.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste Council Directive 2006/117/EURATOM on the supervision and control of shipments of radioactive waste and spent fuel Council Recommendation 2008/956/EURATOM on criteria for the export of radioactive waste and spent fuel to third countries	
12	Regulation # 244 Statutes for the Maintenance of the State Dose Register of Exposed Workers.	The information about the radiation workers in the dose registry should also include their health data.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	
13	Regulation # 110 The Requirements for the Results of Individual Monitoring of Outside	The current legislation covers the needs in decommissioning.		

##	Document of the Estonian Legislation	Activities are not covered	Recommendation EU document	Recommendation IAEA document
	Workers, and for Formalising Such Results, and for the Standard Format for the Dose Chart of Outside Workers			
14	**Environmental Monitoring Act**	The current legislation covers the needs in decommissioning. It should be useful to have the reference to the Radiation Act, as some regulations based on this act are providing some additional requirements for the monitoring activities.		
15	Regulation # 50 Establishment of National Environmental Monitoring Stations and Areas	The current legislation covers the needs in decommissioning.		
16	**Environmental Supervision Act**	There is a possibility provided to include other authorities additionally to the Environmental Inspectorate in the process of the supervision. In case of the decommissioning the Environmental Board has to be included in the inspection process.		
17	**Emergency Act**	Fire protection and suppression for the complete site should be included in the decommissioning plan.		WS-G-2.1 (PO79) Decommissioning of Nuclear Power Plants and Research Reactors
18	Regulation # 57 Procedure of Notification of the Ministry of the Interior of An Emergency or of the Impending Risk of the Occurrence of An Emergency	The current legislation covers the needs in decommissioning.		
19	**Environmental Impact Assessment and Environmental Management System Act**	The current legislation covers the needs in decommissioning. However the listing of the activities could be defined so that it would be easier to understand that activities fall under the current act and which are not. Also the process has to take into account the requirement of getting the approval from European Commission.	Commission Recommendation 2010/635/Euratom on the application of Article 37 of the Euratom Treaty	
20	**General Part of the**	There is a possibility provided to include other authorities additionally to the		

##	Document of the Estonian Legislation	Activities are not covered	Recommendation EU document	Recommendation IAEA document
	Environmental Code Act	Environmental Inspectorate in the process of the supervision. In case of the decommissioning the Environmental Board has to be included in the inspection process.		
21	**Building Code**	Currently the code lets the competent authority to decide about the need for Environmental Impact Assessment, also for demolishing processes. However in case of the demolishing license in decommissioning process it should be clearly stated that approved EIA is prerequisite. The legislation should address clearly that in case of the application for the demolishing in framework of decommissioning, the approved EIA is prerequisite.	Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste	GSR Part 5 Predisposal Management of Radioactive Waste
22	**Planning Act**	Not relevant		
23	Regulation # 92 - Order of Informing of the Public about the Immediate Danger for Arising of the Emergency Situation, about the Emergency Situation and about the Management of the Emergency Situation and the Requirements to the Forwarded Information	The requirements to the forwarded information are very overall. Taking into account the EURATOM BSS annex, some recommendations for information to be provided to the affected members of the public in the event of an emergency 1. the members of the public actually affected in the event of an emergency shall rapidly and regularly receive: (a) information on the type of emergency which has occurred and, where possible, its characteristics (e.g. its origin, extent and probable development); (b) advice on protection, which, depending on the type of emergency, may: (i) cover the following: restrictions on the consumption of certain foodstuffs and water likely to be contaminated, simple rules on hygiene and decontamination, recommendations to stay indoors, distribution and use of protective substances, evacuation arrangements; (ii) be accompanied, where necessary, by special warnings for certain groups of the members of the public; (c) announcements recommending cooperation with instructions or requests by the competent authority. 2. If the emergency is preceded by a pre-alarm phase, the members of the public likely to be affected shall already receive information and advice during that phase, such as: (a) an invitation to the members of the public concerned to tune in to relevant communication channels; (b) preparatory advice to establishments	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	

##	Document of the Estonian Legislation	Activities are not covered	Recommendation EU document	Recommendation IAEA document
		with particular collective responsibilities; (c) recommendations to occupational groups particularly affected. 3. This information and advice shall be supplemented, if time permits, by a reminder of the basic facts about radioactivity and its effects on human beings and on the environment.		
24	Regulation # 15 - The Guidelines for Preparing An Emergency Plan	It should be stated that for emergency preparedness the elements included in the plan should include: 1. Reference levels for public exposure; 2. Reference levels for emergency occupational exposure; 3. Optimized protection strategies for members of the public who may be exposed, for different postulated events and related scenarios; 4. Predefined generic criteria for particular protective measures; 5. Default triggers or operational criteria such as observables and indicators of on-scene conditions; 6. Arrangements for prompt coordination between organizations having a role in emergency preparedness and response and with all other EU Member States and with third countries which may be involved or are likely to be affected; 7. Arrangements for the emergency response plan to be reviewed and revised to take account of changes or lessons learned from exercises and events. Fire protection and suppression for the complete site should be included in the decommissioning plan.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	WS-G-2.1 Decommissioning of Nuclear Power Plants and Research Reactors
25	Regulation # 5 - The Guidelines for Preparing An Emergency Risk Assessment	The current legislation covers the needs in decommissioning.		
26	**Occupational Health and Safety Act**	It is recommended that A-category workers would have gone through the medical control before starting the work. The current occupational health and safety act requires the medical controls, however these have to be done only by the end of the first month of the employment.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	
27	**Road Transport Act**	The current legislation covers the needs in decommissioning.		
28	**Industrial Emissions Act**	The current legislation covers the needs in decommissioning.		

##	Document of the Estonian Legislation	Activities are not covered	Recommendation EU document	Recommendation IAEA document
29	**Chemicals Act**	The current legislation covers the needs in decommissioning, however special attention must be given to the potential for contamination due to the production and release of dust and aerosols of radioactive liquids, and of large quantities of waste generated during decommissioning operations.		WS-G-2.1 Decommissioning of Nuclear Power Plants and Research Reactors
30	**Ambient Air Protection Act**	The current legislation covers the needs in decommissioning.		
31	**Waste Act**	The cleared waste will be managed accordingly to the requirements of the waste act and it would be valuable to have the special conditions for the cleared metal waste. The Act provides the possibility for defining these special conditions. The safety assessment may identify a number of significant non-radiological hazards during the decommissioning phase that are not normally encountered during the operational phase of a reactor. These include, for example, hazardous materials that may be used during decontamination, dismantling and demolition activities, and the lifting and handling of heavy loads. Most of these non-radiological hazards will be covered by regulations, but a good safety culture will help to ensure that such tasks are carried out safely. An inventory of all hazardous chemicals present in the installation should be conducted. Hazardous materials such as asbestos require special consideration to prevent harm to human health.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards WS-G-2.1 Decommissioning of Nuclear Power Plants and Research Reactors
32	**Fire Safety Act**	The current legislation covers the needs in decommissioning.		

Table 46. Disposal

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
01	**Radiation Act**	Currently the radiation act is applicable only to radiation practices, so this does not allow to regulate anything that is not directly related to use/management of the sources/radioactive waste. This is the reason why for example the design phases of the disposal facility are not really included in the Radiation Act. Taking into account the requirements from the new EURATOM BSS, there will be need to change the application areas of Radiation Act anyway. The regulator needs to have a role in the planning, designing and building stages of the RWM site as well. The Act should define clearly legal, technical and financial responsibilities for organizations involved in disposal radioactive waste management activities. Setting clearly defined legal, technical and financial responsibilities for organizations that are to be involved in the development of facilities for radioactive waste management, including disposal facilities of all types. Ensuring the adequacy and security of financial provisions for disposal facility. Member States, while retaining responsibility for their respective policies in respect of the management of their spent fuel and low, intermediate or high-level radioactive waste, should include planning and implementation of disposal options in their national policies. The current practice is to divide the activities into different stages, however this should be reflected more clearly also in the legislation. It is convenient to identify three periods associated with the development, operation and closure of a disposal facility: (i) the pre-operational period, (ii) the operational period and (iii) the post-closure period. Upon the completion of commissioning, a final commissioning report is usually produced by the operator. The report has to document the as-built status of the facility, which, in addition to providing information to facilitate operation, is important when considering possible future modifications to the facility and its shutdown and decommissioning. The report has to describe all the testing and provide evidence of the successful completion of	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste Council Directive 2006/117/EURATOM on the supervision and control of shipments of radioactive waste and spent fuel	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards Specific Safety Requirements SSR-5 Disposal of Radioactive Waste

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
		testing and of any modifications made to the facility or to procedures in commissioning. Current act provides the very overall requirement for the radiation practice license owner to provide the security of the radioactive material. This should be elaborated, possibly providing more detailed information in the relevant regulation. The country has to ensure of necessary public information and participation in relation to spent fuel and radioactive waste management while having due regard to security and proprietary information issues. Closure has to be considered in the initial design of the facility, and plans for closure and seal or cap designs have to be updated as the design of the facility is developed. More guidance and data for site investigation and site characterization. Also on the post-closure period.		
02	Regulation # 163 The Bases for Calculation of Exemption Values, and the Exemption Values for Radionuclides	The regulation needs updating taking into account the requirements and recommendations coming from EURATOM BSS. It shall be demonstrated that workers should not be classified as exposed workers, and the following criteria for the exposure of members of the public are met in all feasible circumstances: — For artificial radionuclides: The effective dose expected to be incurred by a member of the public due to the exempted practice is of the order of 10 μSv or less in a year. — For naturally-occurring radionuclides: The dose increment, allowing for the prevailing background radiation from natural radiation sources, liable to be incurred by an individual due to the exempted practice is of the order of 1 mSv or less in a year. The assessment of doses to members of the public shall take into account not only pathways of exposure through airborne or liquid effluent, but also pathways resulting from the disposal or recycling of solid residues. Member States may specify dose criteria lower than 1 mSv per year for specific types of practices or specific pathways of exposure. For the purpose of exemption from authorization, less restrictive dose criteria may be applied. The exemption values should be checked as well. The differentiating in the exemption	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards RS-G-1.7 Application of the Concepts of Exclusion, Exemption and Clearance

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
		values (any amount, activity concentration in moderate amounts).		
03	Regulation # 193 Effective Dose and Equivalent Dose Limits for the Lens of the Eyes, Skin and Extremities for Exposed Workers and Members of the Public	Some of the dose limits need updating. Currently the 5 year total limit for radiation worker is 100 mSv, but the updated version should be defined as annual maximum dose to the radiation worker 20 mSv. There is need to update also the equivalent dose limits. For example: the equivalent dose for the lens of the eye of radiation worker shall be 20 mSv in a single year or 100 mSv in any five consecutive years subject to a maximum dose of 50 mSv in a single year. Currently it is 150 mSv per year.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards Specific Safety Requirements SSR-5 Disposal of Radioactive Waste
04	Regulation # 41 Time Limits for Proceedings to Issue, Amend or Revoke the Radiation Practice Licences, the Specific Requirements for and Format of Applications for Radiation Practice	As the regulation provides more information about the licensing procedure. Currently it covers the all radiation practices and provides very small differentiating between activities. It would be useful to provide more information for the licensing for disposal activities. In case of changing the coverage of the Radiation Act, these additional activities and their licensing needs have to been taken into account as well. The indicative list of information for license applications of new EURATOM BSS is basically covered in the current legislation, but the aims of the safety assessment might be defined in more detailed way. Also adequate defense in depth has to be ensured by demonstrating that there are multiple safety functions, that the fulfilment of individual safety functions is robust and that the performance of the various physical components of the disposal system and the safety functions they fulfil can be relied upon, as assumed in the safety case and supporting safety assessment. The long term safety of a disposal facility for radioactive waste is required not to be dependent on active institutional control. The intent of surveillance and monitoring is not to measure radiological parameters but to ensure the continuing fulfilment of safety functions.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards Specific Safety Requirements SSR-5 Disposal of Radioactive Waste
05	Regulation # 86 Requirements for the Radiation Safety Training of Exposed Workers	The regulation provides information about the requirements and about the topics to be involved in the trainings. The legislation needs amendments in order to include the system for recognition of the trainings and trainers.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources:

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
			from exposure to ionizing radiation	International Basic Safety Standards
06	Regulation # 93 Intervention and Action Levels, and Emergency Exposure Guidance in a Radiological Emergency	The new BSS defines that the Member State has to establishment of appropriate reference levels. The elements to be included in an emergency management system are following: 1. Assessment of potential emergency exposure situations and associated public and emergency occupational exposures; 2. Clear allocation of the responsibilities of persons and organizations having a role in preparedness and response arrangements; 3. Establishment of emergency response plans at appropriate levels and related to a specific facility or human activity; 4. Reliable communications and efficient and effective arrangements for cooperation and coordination at the installation and at appropriate national and international levels; 5. Health protection of emergency workers; 6. Arrangements for the provision of prior information and training for emergency workers and all other persons with duties or responsibilities in emergency response, including regular exercises; 7. Arrangements for individual monitoring or assessment of individual doses of emergency workers and the recording of doses; 8. Public information arrangements; 9. Involvement of stakeholders; 10. Transition from an emergency exposure situation to an existing exposure situation including recovery and remediation.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards
07	Regulation # 113 Requirements for the Rooms Where the Radiation Sources Are Situated and for Labelling Thereof and for the Working Rules for the Performance of Radiation Practices	The regulation provides only overall requirement for the security. However in order to build up the common understanding of the requirements, they should be elaborated in more detailed way. The requirements for marking HASS have to be more detailed as well. The manufacturer or supplier ensures that: (a) Each high-activity sealed source is identified by a unique number. This number shall be engraved or stamped on the source, where practicable. The number shall also be engraved or stamped on the source container. If this is not feasible, or in the case of reusable transport containers, the source container shall, at least, bear information on the nature of the source. (b) The source container and, where	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
		practicable, the source are marked and labelled with an appropriate sign to warn people of the radiation hazard. 2. The manufacturer provides a photograph of each manufactured source design type and a photograph of the typical source container. 3. The undertaking ensures that each high-activity sealed source is accompanied by written information indicating that the source is identified and marked in compliance with point 1 and that the markings and labels referred to in point 1 remain legible. The information shall include photographs of the source, source container, transport packaging, device and equipment as appropriate.		
08	Regulation # 8 The Classification of Radioactive Waste, the Requirements for Registration, Management and Delivery of Radioactive Waste and the Acceptance Criteria for Radioactive Waste	The classification of the radioactive waste should be reviewed, taking into account the classification proposed by IAEA. Clear indications that part of the design process includes also development of the Waste Acceptance Criteria for Radioactive Waste. It hast to be stated also that should a waste package not meet the specifications or the waste acceptance requirements, the nature of the non-conformance should be recorded as well as any decision taken to carry out appropriate corrective actions. The list of the factors for safety assessments of RWM can be amended based on IAEA recommendations. If human intrusion were expected to lead to a possible annual dose of more than 20 mSv to those living around the site, then alternative options for waste disposal have to be considered.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste	General Safety Guide GSG-1 Classification of Radioactive Waste Specific Safety Requirements SSR-5 Disposal of Radioactive Waste
09	Regulation # 10 Clearance Levels for Radioactive Substances and Materials Contaminated with Radioactive Substances Resulting from Radiation Practices, and the Requirements for Their Clearance, Recycling and Reuse	It should be discussed if the clearance and exemption regulations could be united, as based the new EURATOM BSS these are approached together as well. The regulation needs updating taking into account the requirements and recommendations coming from EURATOM BSS. It shall be demonstrated that workers should not be classified as exposed workers, and the following criteria for the exposure of members of the public are met in all feasible circumstances: — For artificial radionuclides: The effective dose expected to be incurred by a member of the public due to the exempted practice is of the order of 10 μSv or less in a year. — For naturally-occurring radionuclides:	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards RS-G-1.7 Application of the Concepts of Exclusion, Exemption and Clearance

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
		The dose increment, allowing for the prevailing background radiation from natural radiation sources, liable to be incurred by an individual due to the exempted practice is of the order of 1 mSv or less in a year. The assessment of doses to members of the public shall take into account not only pathways of exposure through airborne or liquid effluent, but also pathways resulting from the disposal or recycling of solid residues. Member States may specify dose criteria lower than 1 mSv per year for specific types of practices or specific pathways of exposure. For the purpose of exemption from authorization, less restrictive dose criteria may be applied. The exemption values should be checked as well. The differentiating in the exemption values (any amount, activity concentration in moderate amounts).		
10	Regulation # 45 The Procedure for Monitoring and Estimation of Effective Doses Incurred by Exposed Workers and Members of the Public, and the Coefficients for Calculating Radionuclide Ingestion and Inhalation Doses	Update on radiation and tissue weighting factor values is needed. The monitoring requirements for RWM sites should be more elaborated in the regulation. There are requirements for record keeping, but it should be provided in more detailed way – for example who and on which conditions have right to access this data. The disposal site characterization program should identify the site conditions to be monitored in the pre-construction, construction and operational phases and should establish the required level of detail of measurement (e.g. accuracy and precision) to ensure a suitable baseline record of the original conditions of the site. This baseline record of the natural system would provide a reference against which the results of future site monitoring can be compared to determine any changes brought about by the construction and operation of the facility.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	Specific Safety Requirements SSR-5 Disposal of Radioactive Waste
11	Regulation # 243 Procedure Specifications for Processing Documents of Import, Export and Transit of Radioactive Waste Based on Country of Origin and	Where radioactive waste or spent fuel is shipped for processing or reprocessing to a Member State or a third country, the ultimate responsibility for the safe and responsible disposal of those materials, including any waste as a by-product, shall remain with the Member State or third country from which the radioactive material was shipped.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation Council Directive 2011/70/EURATOM establishing a	

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
	Destination		Community framework for the responsible and safe management of spent fuel and radioactive waste Council Directive 2006/117/EURATOM on the supervision and control of shipments of radioactive waste and spent fuel Council Recommendation 2008/956/Euratom on criteria for the export of radioactive waste and spent fuel to third countries	
12	Regulation # 244 Statutes for the Maintenance of the State Dose Register of Exposed Workers.	The information about the radiation workers in the dose registry should also include their health data.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	
13	Regulation # 110 The Requirements for the Results of Individual Monitoring of Outside Workers, and for Formalising Such Results, and for the Standard Format for the Dose Chart of Outside Workers	The current legislation covers the needs in disposal.		
14	**Environmental Monitoring Act**	The current legislation covers the needs in disposal. It should be useful to have the reference to the Radiation Act, as some regulations based on this act are providing some additional requirements for the monitoring activities.		
15	Regulation # 50	The current legislation covers the needs in		

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
	Establishment of National Environmental Monitoring Stations and Areas	disposal.		
16	**Environmental Supervision Act**	There is a possibility provided to include other authorities additionally to the Environmental Inspectorate in the process of the supervision. In case of the disposal the Environmental Board has to be included in the inspection process.		
17	**Emergency Act**	The current legislation covers the needs in disposal.		
18	Regulation # 57 Procedure of Notification of the Ministry of the Interior of An Emergency or of the Impending Risk of the Occurrence of An Emergency	The current legislation covers the needs in disposal.		
19	**Environmental Impact Assessment and Environmental Management System Act**	The current legislation covers the needs in RWM. However the listing of the activities could be defined so that it would be easier to understand that activities fall under the current act and which are not. Consideration has to be given to locating the disposal facility away from significant known mineral resources, geothermal water and other valuable subsurface resources. This is to reduce the risk of human intrusion into the site and to reduce the potential for use of the surrounding area to be in conflict with the facility. Also the process has to take into account the requirement of getting the approval from European Commission.	Commission Recommendation 2010/635/Euratom on the application of Article 37 of the Euratom Treaty	Specific Safety Requirements SSR-5 Disposal of Radioactive Waste
20	**General Part of the Environmental Code Act;**	There is a possibility provided to include other authorities additionally to the Environmental Inspectorate in the process of the supervision. In case of the disposal the Environmental Board has to be included in the inspection process.		
21	**Building Code;**	Currently the code lets the competent authority to decide about the need for Environmental Impact Assessment. However in case of the building license for disposal facilities it should be clearly stated that approved EIA is prerequisite. The legislation should address clearly that in case of the application for the building disposal facility, the approved EIA is prerequisite.	Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste	Specific Safety Requirements SSR-5 Disposal of Radioactive Waste

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
22	**Planning Act;**	The act provides the option for the state to define special planning. Among the listed possibilities should be also disposal facility and even centralized storage facility.	Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste	Specific Safety Requirements SSR-5 Disposal of Radioactive Waste
23	Regulation # 92 - Order of Informing of the Public about the Immediate Danger for Arising of the Emergency Situation, about the Emergency Situation and about the Management of the Emergency Situation and the Requirements to the Forwarded Information	The requirements to the forwarded information are very overall. Taking into account the EURATOM BSS annex, some recommendations for information to be provided to the affected members of the public in the event of an emergency 1. the members of the public actually affected in the event of an emergency shall rapidly and regularly receive: (a) information on the type of emergency which has occurred and, where possible, its characteristics (e.g. its origin, extent and probable development); (b) advice on protection, which, depending on the type of emergency, may: (i) cover the following: restrictions on the consumption of certain foodstuffs and water likely to be contaminated, simple rules on hygiene and decontamination, recommendations to stay indoors, distribution and use of protective substances, evacuation arrangements; (ii) be accompanied, where necessary, by special warnings for certain groups of the members of the public; (c) announcements recommending cooperation with instructions or requests by the competent authority. 2. If the emergency is preceded by a pre-alarm phase, the members of the public likely to be affected shall already receive information and advice during that phase, such as: (a) an invitation to the members of the public concerned to tune in to relevant communication channels; (b) preparatory advice to establishments with particular collective responsibilities; (c) recommendations to occupational groups particularly affected. 3. This information and advice shall be supplemented, if time permits, by a reminder of the basic facts about radioactivity and its effects on human beings and on the environment.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	
24	Regulation # 15 - The Guidelines	It should be stated that for emergency preparedness the elements included in the	Council Directive 2013/59/EURATO	Specific Safety Requirements

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
	for Preparing An Emergency Plan	plan should include: 1. Reference levels for public exposure; 2. Reference levels for emergency occupational exposure; 3. Optimized protection strategies for members of the public who may be exposed, for different postulated events and related scenarios; 4. Predefined generic criteria for particular protective measures; 5. Default triggers or operational criteria such as observables and indicators of on-scene conditions; 6. Arrangements for prompt coordination between organizations having a role in emergency preparedness and response and with all other EU Member States and with third countries which may be involved or are likely to be affected; 7. Arrangements for the emergency response plan to be reviewed and revised to take account of changes or lessons learned from exercises and events. In addition, emergency plans are required to be put in place for dealing with accidents and other incidents, and for ensuring that any consequent radiation doses are controlled to the extent possible, with due regard for the relevant emergency action levels	M laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	SSR-5 Disposal of Radioactive Waste
25	Regulation # 5 - The Guidelines for Preparing An Emergency Risk Assessment	The current legislation covers the needs in disposal.		
26	**Occupational Health and Safety Act**	It is recommended that A-category workers would have gone through the medical control before starting the work. The current occupational health and safety act requires the medical controls, however these have to be done only by the end of the first month of the employment.	Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation	
27	**Road Transport Act**	The current legislation covers the needs in disposal.		
28	**Industrial Emissions Act**	The current legislation covers the needs in disposal.		
29	**Chemicals Act**	The current legislation covers the needs in disposal.		
30	**Ambient Air Protection Act**	The current legislation covers the needs in disposal.		
31	**Waste Act**	The cleared waste will be managed accordingly to the requirements of the waste act and it would be valuable to have the special conditions for the cleared metal	Council Directive 2013/59/EURATOM laying down basic safety	General Safety Requirements Part 3 Radiation Protection and

##	Document of the Estonian Legislation	Activities are not covered or covered partly	Recommendation EU document	Recommendation IAEA document
		waste. The Act provides the possibility for defining these special conditions.	standards for protection against the dangers arising from exposure to ionizing radiation	Safety of Radiation Sources: International Basic Safety Standards
32	**Fire Safety Act**	The current legislation covers the needs in disposal.		