XA0300145 IAEA-CN-90/16

MANAGEMENT OF RADIOACTIVE WASTE AT NOVI HAN REPOSITORY

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Abstract.

The Novi Han Repository is the only existing repository in Bulgaria for the disposal of radioactive waste from nuclear applications in industry, medicine and research. The repository was constructed in the early sixties according to the existing requirements. It was operated by the Institute for Nuclear Research and Nuclear Energy for more than thirty years without any accident or release of radioactivity to the environment, but without any investment for upgrading. As a consequence, the Bulgarian Nuclear Safety Authority temporarily stopped the operation of the repository in 1994. The measures for upgrading the Novi Han Repository, supported by the IAEA under TC Project BUL/4/005 "Increasing Safety of Novi Han Repository", are presented in this paper. They comprise: assessment of radionuclide inventory and future waste arisings, characterisation of disposal vaults, characterisation of the site, safety assessment, upgrading of the monitoring system, option study for the selection of treatment and conditioning processes and the development of a conceptual design for low and intermediate level waste processing and storage facility, immediate measures for improvement of the existing disposal vaults and infrastructure, construction of above-ground temporary storage structures, and resuming the operation of the Novi Han Repository. The necessary activities for re-licensing of the Novi Han Repository, construction of a waste processing and storage facility and a disposal facility for spent sealed sources are discussed.

1. Introduction

The Novi Han Radioactive Waste Repository is the only national radioactive waste disposal site in Bulgaria. The repository accepts radioactive waste generated from nuclear applications in industry, medicine, research and education. The facility was constructed according to a modified Russian design (type TP-4891) and commissioned in 1964. It was specially built for the needs of the Institute of Physics with their research reactor IRT-2000 and other institutions in the country that use sources of ionizing radiation and generate radioactive waste. The site was selected after site selection procedure according to site selection criteria that reflected the legal basis "Temporary sanitary roles of protection of the soil, water and air from radioactive substances" [1]. In 1959, the government appointed (by its decree No. 1287) the Physical Institute of the Bulgarian Academy of Sciences, whose legal successor is now the Institute for Nuclear Research and Nuclear Energy, as the central authority for the collection and disposal of radioactive waste from nuclear applications.

The Novi Han Repository was operated more than thirty years without any accident or release of radioactivity to the environment, but also without any investment for upgrading. As a consequence the Committee on the Use of Atomic Energy for Peaceful Purposes temporarily stopped the operation of Novi Han Repository in October 1994 until measures for improvement of the facility are undertaken.

In 1995 INRNE initiated a programme for upgrading the Novi Han Repository and developed an implementation plan. The activities are supported by the Bulgarian Academy of Sciences, the Committee on Use of Atomic Energy for Peaceful Purposes, the International Atomic Energy Agency with Model Technical Project BUL/4/005 "Increasing Safety of Novi Han Repository" for the period 1997–2000, and the Bulgarian Government with financing from the state budget in 1998, and subsequently from the State fund "Safety and storage of radioactive waste".

2. Novi Han repository

2.1. Organization of the activities

The Institute for Nuclear Research and Nuclear Energy is the operator of the Novi Han Repository. The Novi Han Repository department consists of four divisions: Research and Development, Nuclear Safety and Radiation Protection, Operational Division, and Construction and Maintenance.

The collection, transportation, treatment and storage of radioactive waste, as well as the upgrading of the Novi Han Repository is financed by the State fund "Safety and storage of radioactive waste" through annual contracts. These annual contracts are based on long-term programme, which is included in the National Strategy on the safety of spent fuel and radioactive waste management, approved by the Government with Decision No.693 of the Council of Ministers from 9 November 1999. The State fund "Safety and storage of radioactive waste" is managed by a steering committee. An expert group of representatives from the Ministry for Energy and Energy Resources and the operators of waste management facilities (Novi Han Repository and Waste Processing and Storage unit at NPP Kozloduy) has been created to assist the steering committee until the establishment of state enterprise for radioactive waste management.

Control over the safety of radioactive waste management, radiation protection, physical protection and security is performed by the Inspectorate for the Safe Use Atomic Energy (ISUAE) at the Committee on the Use of Atomic Energy for Peaceful Purposes, National Center for Radiobiology and Radiation Protection, Ministry of Environment and Water, Ministry of Internal Affaires, and Civil Defense.

2.2. Description of the waste

Radioactive wastes generated in industry, medicine, research and education are accepted in the Novi Han Repository. They belong to Category I, II and III according to the existing regulation [2]. Liquid radioactive wastes of three groups are accepted for temporary storage awaiting treatment and conditioning.

General waste acceptance criteria are established, based on the existing legislation. Detailed criteria are under development, which cover each step of waste management at Novi Han Repository – acceptance of waste, transportation, treatment and conditioning, temporary storage and disposal, as well as exempt levels.

2.3. Description of the Novi Han Repository

The Novi Han Repository is located at Losen Mountain at an altitude of 920 m above sea level on a 13-16% north-northeast slope. The distance to the capital Sofia is 35 km, and to the nearest village Novi Han 6.5 km. The site covers an area of 42 500 m^2. It consist of two areas separated with an additional fence. The administrative building, security control, monitoring facilities and workshops are situated in the first area. The second area hosts the disposal and storage facilities, radiochemical facilities and decontamination facility.

The restricted areas and supervised areas are established according to the legal regulatory requirement [2,3]. They extend radially 1 km and 5 km from the site respectively:

- Concrete vault for disposal of low and intermediate level solid wastes, which consist of three separate cells with a total volume of 237m^3;
- Concrete vault for disposal of biological wastes - three separate cells with a total volume of 80 m^3;
- Special concrete vault for disposal of spent sealed radiation sources - 1 m^3;
- Concrete trench for disposal of solid radioactive waste, which consists of eight separate units with a total volume of 200 m^3;
- Temporary storage structure for low level spent sealed sources, smoke detectors and static electricity eliminators, which consist of 7 full size metal transport containers with a total volume of 238 m^3;
- Temporary storage structure for spent sealed sources, which consists of four reinforced concrete structures with a total volume of 60 m^3;
- Temporary storage structures for powerful spent sealed sources from irradiators, each reinforced concrete structure stores the sources from one irradiation device with activity in the order of $7 \cdot 10^{13}$ Bq;
- Temporary storage structure for radioactive waste that could be released from institutional control, which covers an area of 80 m^3, covered with a temporary roof.

Liquid wastes are temporarily stored in four stainless steel tanks, 12 m^3 each, in a hydro-insulated underground concrete structure.

All disposal units are near-surface engineered multibarrier disposal facilities. The following barriers retard the migration of radionuclides from the disposal vaults to the environment: reinforced concrete, stainless steel lining, hydroinsulation and the geological barrier (clayey phyllite-schists). The waste form itself is not considered as a barrier.

3. Upgrading of the Novi Han Repository

INRNE's programme and implementation plan for upgrading of the Novi Han Repository were supported by the IAEA under the Model Technical Project BUL/4/005 "Increasing Safety of Novi Han Repository". The main tasks and achievements of the programme for upgrading the Novi Han Repository are discussed below.

3.1. Identification of radionuclide inventory

The radionuclide inventory of the Novi Han Repository, as well as the inventory of each separate disposal vault, is identified based on existing documentation for the period of operation of the repository. Spent sealed radiation sources represent the majority of the disposed matter [4]. Currently the vault has 67.9 TBq. The radionuclide inventory is governed mainly by ^{137}Cs (84.11%) and ^{60}Co (14.49%). ^{192}Ir, which contributes to the majority of the activity originally disposed in the spent sources disposal vault, has decayed to insignificant levels of activity. Small amounts of long-lived radionuclides ($5.97 \cdot 10^{11}$ Bq ^{226}Ra, $1.82 \cdot 10^{11}$ Bq ^{239}Pu and $2.40 \cdot 10^{10}$ Bq ^{241}) are disposed. The activity disposed in the vaults for solid waste, biological waste and the trench is low compared to the sealed sources disposal vault. The figures are $7 \cdot 10^{12}$ Bq, $1.72 \cdot 10^{11}$ Bq and $1.11 \cdot 10^{12}$ Bq respectively. Currently the activity of the vault for solid waste is governed mainly by ^{137}Cs (63.31%), ^{60}Co (15.01%), ^{90}Sr (11.42%), ^{14}C (5.28%) and 3H (3.77%); ^{144}Ce, ^{65}Zn, ^{134}Cs, ^{106}Ru, ^{204}Tl, ^{55}Fe contribute to 1.21% of the inventory. The figures for the vault for biological waste and the trench are similar.

3.2. Characterization of the disposal vaults

According to the original design, the lifetime of the repository was to be ten years. Each of the disposal vaults has free capacity. Part of the task was assigned to the engineering organization, which recovered the drawings of the disposal facilities on the basis of the original documentation. Figure 1 gives the design of the disposal vault for biological waste. The vault for solid waste and the engineered trench are of similar construction. Only the trench has a drainage system.

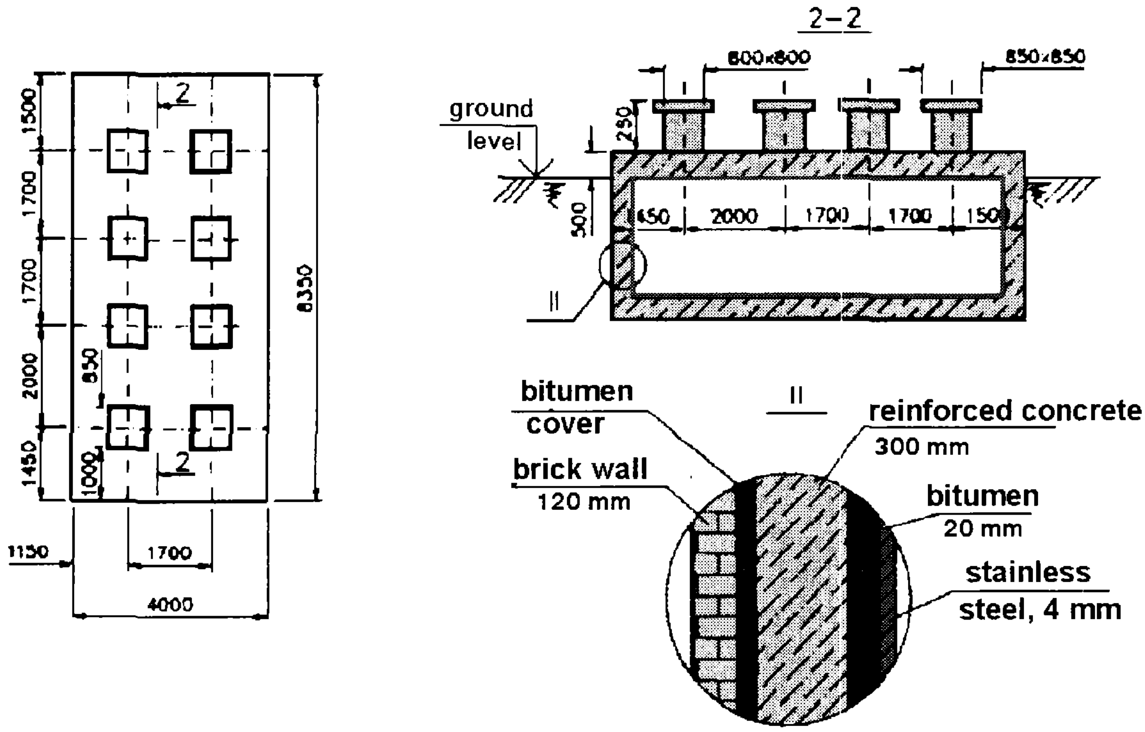

Figure 1: Disposal facility for biological waste

The underground parts of the disposal facilities are in good shape and no water is found inside the disposal structures. Leakage of radionuclide outside the vaults has not been observed.

The disposal vault for spent sealed sources is a typical RADON type bore-hole disposal facility of shallow depth. It consists of an underground reservoir with a capacity of 1 m^3 connected with a surface loading socket through a curved (serpentine like) loading channel (Fig. 2). The underground reservoir is under the ground level at a depth 5.5 m. It is constructed from a reinforced concrete 300 mm thick with stainless steel type 1X18H9T lining with a thickness 3 mm. Five led layers each 10 mm thick are placed between the underground reservoir and the surface to prevent the operators from the exposure. Sealed sources enter the underground reservoir through the serpentine like loading channel. There is also a pipe for temperature control ending at the upper part of the repository.

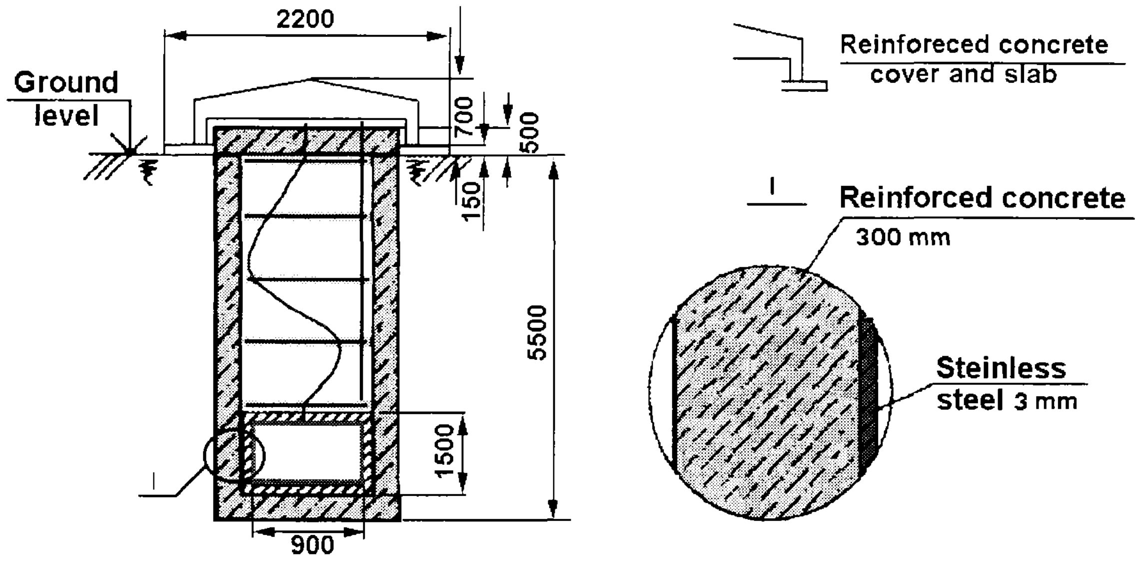

Figure 2: Bore-hole disposal facility for spent sealed sources

Any leakage of radionuclides from this repository was not observed during the ongoing monitoring programme.

Observation of the bore-hole disposal facility was made by an IAEA Expert mission [5]. The in-situ control covers: generation of radiolytic hydrogen, radon gas generation, temperature inside the repository, presence of water inside the repository, dose rate measurement at the surface, loading channel and inside the repository, contamination control at the surface, loading channel and inside the repository, design parameters control and in-situ television control with radiation tolerant television system.

The in-situ observation shows that the disposal vault is in a normal condition. No water or radiolysis gas generation is detected. The presence of ^{222}Rn, together with the absence of water show the repository is leak proof. The analysis of sample from the repository, together with the visual examination indicate on beginning of corrosion damage of some sources.

3.3. Characterization of the site

A geological study of the Novi Han Repository site was made by the Geological Institute of the Bulgarian Academy of Sciences [6]. The study includes characterization of the meteorology, lithostratigraphy of Losen mountain (based on existing records of deep drillings), lithology of the site (based on three shallow investigation bore-holes from 15 to 25m deep, as well as on existing data from six bore-holes 250-790 m deep, drilled in the area from 80 to 1500 m from the site), tectonics and hydrogeological settings. The site survey shows:

- phyllite-schist formation with a variable thickness from 300-500m to more than 800 m builds the repository site;
- there is no evidence for hazardous atmospheric phenomena;
- the site is not endangered by flooding and gully erosion;

- there are no landslides and rock falls in the repository region, which could be an eventual hazard and there are no conditions for evolution of such processes;
- the geological strata has safe bearing capacity, thus providing a safe suitable foundation base for the disposal vaults;
- the repository area is not endangered by subsidence or significant settlement of the soil base;
- the rocks in the region represent a low water bearing and low permeable formation.

Additional investigations are performed in 2002 to clarify the complex tectonic structure and to provide data for the safety assessment and for construction of new facilities on the site.

3.4. Safety assessment

Radiological consequences from the disposal of radioactive waste in the Novi Han Repository are determined for relevant scenarios, selected from a comprehensive list of features events and processes, developed for the Novi Han Repository [7,8]. The main scenarios are leaching scenario, Pu capsules scenario and intrusion scenario (construction and residence). Results are obtained for the whole repository and for individual disposal vaults. The peak doses are lower than 1 mSv/y. Based on the results for the intrusion scenario, an institutional control period of 300 years is proposed.

3.5. Upgrading of the monitoring and controls system

The environmental monitoring programme covers the Novi Han Repository site, the restricted area and the supervised area. Based on the experience of monitoring during 30 years of operation of the Novi Han Repository and the site characterization, the monitoring programme is upgraded [9]. The sampling programme is extended and additional methods and measurements are now included. Monitoring is performed of water sources (monitoring bore-holes, permanent and seasonal springs, surface running waters, drinking, household and irrigation water), soil, sediments, vegetation, food and air. The following analytical methods are used: gross beta, gross alpha, gamma spectrometry, liquid scintillation measurement of ^{14}C and ^{3}H, ^{90}Sr and ^{239}Pu determination, direct measurement of the dose rate with thermoluminescent dosimeters, direct measurement of the dose rate with portable surveillance monitors, permanent measurement of gamma background with automatic system SBN-90, automatic measurement of gamma background with six gas filled counters, permanently situated at the Novi Han Repository site, in situ gamma spectrometry. The sampling points and the points where in situ measurements are performed are fixed and marked with signs. Their positions are determined with GPS and the results are incorporated in a geographical information system.

The radiation protection programme covers the personnel dosimetric control and the control of the technological processes in order to assure the safety of the operators.

3.6. Option study and conceptual design of a new waste processing and storage facility.

The option study is aimed to select treatment and conditioning processes for the radioactive waste from nuclear applications [10]. It is made on the basis of the existing information of the different waste streams, regulatory requirements and best practices. Conceptual design for a new waste processing and storage facility is developed [11]. The study is taken into account in the feasibility study for reconstruction and modernization of the Novi Han Repository.

Table 1. RAW stored in temporary storage facilities at Novi Han Repository site in 2000.

Radionuclide	Sealed sources Number	Total activity, Bq	Description
Am^{241}	6043	$7,85.10^{13}$	Smoke detectors, Sealed sources
Pu^{239}	26418	$3.91.10^{11}$	Smoke detectors
Cs^{137}	1888	$1,96.10^{12}$	Sealed sources, evidence material
Co^{60}	259	$1,0.10^{10}$	Sealed sources
Kr^{85}	7911	$3.61.10^{11}$	Smoke detectors, Sealed sources
Sr^{90}	446	$8,9.10^{10}$	Sealed sources
Ra^{226}	163	$3,17.10^{9}$	Sealed sources
C^{14}	53	$2,97.10^{9}$	Sealed sources
Ba^{133}	7	$3,72.10^{8}$	Sealed sources
Cf^{252}	4	$9,1.10^{7}$	Sealed sources
Tl^{204}	19	$2,0.10^{10}$	Sealed sources
$U^{235,238}$	8	$9,84.10^{5}$	Sealed sources
Pm^{147}	13	$4.99.10^{10}$	Sealed sources
Pu-Be. Am-Be Ra-Be	40	1,96 n/sec	Neutron sources
Pu^{239}	275	$1,95.10^{11}$	Neutralizators (plates)
Pu^{238}	712	$4,0.10^{11}$	Smoke detectors and sealed sources
Cd^{109}	47	$2,4.10^{9}$	Sealed sources
Ce^{144}	4	$8.5.10^{6}$	Sealed sources
Co^{57}	12	$1,46.10^{6}$	Sealed sources
Na^{22}	16	$6.45.10^{6}$	Sealed sources
Fe^{55}	20	$2.0.10^{10}$	Sealed sources
Cd^{109}	46	$7.0.10^{7}$	Sealed sources
Eu^{152}	5	$0.1.10^{9}$	Sealed sources

The total number of spent sealed sources is 22 017, the total activity being $1,59.10^{12}$ Bq. These figures do not include powerful spent sources from an irradiation facility with a total activity of $6.27.10^{13}$ Bq, for which a special waste storage container was constructed. Small amounts (3.6 m^3) of solid and liquid (bellow 0.1 m^3) were collected as well. Details are given in Table 2.

Table 2. Spent sources and RAW collected and stored at Novi Han Repository during 2001.

Radionuclide	Type	Number	Activity, Bq
^{241}Am	Smoke detectors & spent sources	8087	$9.57.10^{10}$
^{226}Ra	Spent sources	22	$1.02.10^{9}$
^{239}Pu	Smoke detectors, spent sources, neutralizators, neutron sources	12080	$1.40.10^{10}$
^{238}Pu	Smoke detectors	21	$5.46.10^{6}$
^{85}Kr	Smoke detectors & spent sources	1532	$4.35.10^{10}$
^{60}Co	Spent sources	61	$1.56.10^{9}$
^{137}Cs	Spent sources	150	$1.44.10^{12}$
^{147}Pm	Spent sources	1	$9.96.10^{8}$
^{55}Fe	Spent sources	1	0.007
^{109}Cd	Spent sources	1	0.2
^{232}Th	Spent sources	14	$1.78.10^{8}$
Unknown	Spent sources	47	-
^{60}Co	36 spent sealed sources from irradiator	1	$6.27.10^{13}$ Bq
^{134}Cs, ^{137}Cs, ^{90}Sr, ^{60}Co, ^{14}C, ^{54}Mn, ^{241}Am, ^{238}U	Solid waste	3.6 m^3	< $7.1.10^{4}$ Bq/kg
^{134}Cs, ^{137}Cs, ^{90}Sr, ^{60}Co, ^{14}C	Liquid waste	0.1 m^3	< $3.7.10^{5}$ Bq/L

3.7. Direct measures for improvement of the safety

The measures for improvement of the safety are financed by the budget in 1998 and subsequently by the State fund Safety and Storage of Radioactive Waste. They cover recommendations of the regulators as well technological needs. The measures include improvement of the Novi Han Repository and organizational measures. The last includes new organizational structure of the Novi Han Repository Department and quality assurance. Some of the important activities are given below:

- Repair and improvement of the existing disposal vaults. This includes repair of the concrete of the above ground parts of the disposal facilities, new hydro-inusulation and new lids. New heavy protective cover is installed over the disposal vault for spent sealed sources (Fig. 2);

- Repair and improvement of the building, complete refurbishment of the electrical supply and reserve electrical supply, water supply, specialized sump water collection and ventilation systems, decontamination facility;
- Improvement of the fire-fighting system and the physical protection;
- Improvement of the security and personnel access control;
- Improvement of the infrastructure;
- Reliable communications and new transport vehicles for the personnel and for transport of RAW;
- Construction of above ground structures for temporary storage of spent sealed sources, low level waste, and very low active waste, which could be released from institutional control.

4. Operation of the Novi Han Repository

The routine activities for collection, transportation and storage of radioactive waste at the Novi Han Repository are resumed from 2000 as a consequence of the upgrading measures. Radioactive wastes with radionuclide inventory given in Table 1, that has been stored in the Central Storage Facility of INRNE since 1994, are transported to the Novi Han Repository and stored in the temporary storage structures specially constructed for this purpose. The activities are performed under the license issued by the ISUAE in order to fulfill the Council of Ministers' Decision No.332/1999. The temporary storage of new incoming waste is also licensed. During 2001 more than 170 contracts with consignors of radioactive waste are signed and the radioactive wastes are transported and stored in the facilities of the Novi Han Repository.

5. Future plans

The Novi Han Repository will be re-licensing during 2002 according to the programme developed by INRNE and CUAEPP. An IAEA Workshop on upgrading measures for re-licensing is planned for 2002. Based on the INRNE's programme for reconstruction and modernization, the technical control system for incoming radioactive waste/sealed sources will be commissioned in 2003. A facility for conditioning and storage of low and intermediate level waste and a facility for conditioning and storage of high level spent sealed sources are planned to be operational in 2006. The option for utilization of a deep shaft for construction of a bore-hole disposal facility for spent sealed sources is under investigation.

Acknowledgement

The authors wish to acknowledge the IAEA for the support given to INRNE under technical project BUL/4/005.

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