

Vector Complex in the Chernobyl Exclusion Zone: 2010-status and perspectives - 10250

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ABSTRACT

The purpose, location and current status of Vector Complex are described. Total planned volume of radioactive waste for treatment, storage and disposal is 2386 thousand m³ including waste from the Chernobyl Exclusion Zone, decommissioning of Chernobyl NPP, operation and future decommissioning of the Ukrainian NPP's as well as radioactive waste and disused sealed radiation sources from the Ukrainian State Corporation Radon. Design characteristics, composition and basic interrelations between facilities of Vector Complex are discussed. Requirements for waste acceptance criteria are given. Long-term program for operation of Vector Complex is presented.

INTRODUCTION

During the accident at Unit-4 of Chornobyl NPP in 1986, about 3 MCi of long-lived radionuclides, predominately ⁹⁰Sr, ¹³⁷Cs and transuranic elements, was released to environment causing the radioactive contamination of sizeable territories outside of NPP. Decontamination works in the vicinity of Chornobyl NPP and in the most contaminated settlements of Ukraine produced about 3 million m³ of radioactive waste (RW). About 2.5 million m³ of these wastes are localized inside of the Shelter object and in the temporary storages within the Exclusion zone where habitation was prohibited in 1986 after urgent evacuation of local citizens and rural population. About 0.5 million m³ of wastes is stored outside the Exclusion zone in dumps. All these storages were built in the accident elimination period. They do not comply with the disposal requirements and are presenting radiological burden and potential hazard for current and future generations. The decision concerning the construction within the Exclusion zone of industrial complex for decontamination, transportation, treatment and disposal of RW from the territories contaminated after the accident on Chornobyl NPP (code name "Vector") was approved in 1988. It was prescribed that Vector Complex must consist of sufficient number of near-surface storages and treatment facilities for reliable isolation of all RW generated during the accident elimination. The site for Vector Complex construction (160 hectares located 20 km west to the Chornobyl NPP) corresponding to the general requirements for operation of near surface RW disposals was selected and officially approved in 1991. Demand for Vector Complex construction was proved by the Government of Ukraine after USSR disintegration. In accordance with the decision, Vector Complex has to be constructed in two scheduling queues. First queue (Vector-1) intended for disposal of Chornobyl origin short-living (SL) RW in near-surface storages (150 thousand m³ in concrete containers and 380 thousands m³ in bulk). Second queue (Vector-2) is intended for treatment and near-surface storage/disposal of different types of RW generated in Ukraine. The rated capacity of Vector Complex, estimated as annual entry of 50 thousand m³ of RW for treatment and storage/disposal, will be achieved after commissioning of facilities for processing of Chornobyl origin RW. The client, licensee and operator of Vector Complex is Technocentre – specialized state enterprise (SSE) organized in 1996 and committed for scientific and technical support of designing, construction and operation of Vector Complex. The general designer of Vector Complex is Scientific and Technical Centre KORO. Construction of Vector-1 was licensed and started in 1997. Infrastructure of Vector Complex (construction funded by state program of RW management in Ukraine) and first near-surface 22-compartment storage for disposal of 50 thousand m³ of SL RW (construction funded by EU TACIS program) were commissioned in 2008. License for filling of two compartments of this storage with conditioned solid RW (drums and reinforced concrete containers), generated during the decommissioning of Chornobyl NPP, was issued in 2009. At present, construction of two new types of disposal facilities is close to be completed, and their commissioning is expected in 2010. One of them is intended for disposal of RW in standard (unified) reinforced concrete containers placed in four stacks (4668 containers total) on damp-proof multilayer platform with dimension 174m x 32 m. Another one is intended for disposal of RW in non-standard containers or in bulk. This is a cast-in-situ reinforced concrete 8-compartment structure (2 rows with 4 compartments, 1000 m³ each). These three storages are designed for disposal of 70 thousand m³ of Chornobyl origin RW. There are plans to build 21 near-surface storages with total RW volume of 200 thousands m³ till 2017. A life cycle of such storage includes the following stages: filling with RW, storage site banking, administrative control, regulatory control, exemption from the regulatory control (will be granted 300 years after the end of filling). However, not all types of Chornobyl origin RW fit the waste acceptance criteria for disposal in the Vector-1 storages. Specifically, high-level (HL) waste and long-lived (LL) waste (with activity concentration for transuranic elements in bulk more than 50 Bq/g, 100 Bq/g and 500 Bq/g for ²³⁹Pu, ²⁴¹Am and ²³⁸Pu correspondingly) cannot be disposed in the near-surface storages of Vector Complex. Therefore, construction of new types storages for long-term retention (period from 50 until

100 years) of such waste is planned in the Vector-2. The possibility for retrieval of waste packages from these storages for further disposal in the geological repository is pre-designed. In addition, construction of the Vector-2 will meet main challenges of RW management for all types of RW accumulated in Ukraine including RW at NPP and RW generated during use of radioactive materials and sealed radiation sources (SRS) in science, medicine and industry. Currently operating RW are stored at NPP sites, and all other RW – in the storages of specialized enterprises of the Ukrainian State Corporation (USC) Radon. Construction of Centralized storage for disused SRS is included in the Vector-2. The British government funds design of the Centralized storage. Before 2017, at last, construction and commissioning of the interim storage for vitrified HL waste expecting back from Russia after processing of the Ukrainian NPP spent nuclear fuel is stipulated by the national program of radioactive waste management in Ukraine [1].

DESIGN CHARACTERISTICS OF VECTOR COMPLEX

Designed productivity of Vector Complex must ensure acceptance, treatment, storage and disposal of 2386 thousand m³ of solid RW, i.e. all RW of Ukraine (not including RW to be returned from Russian Federation after reprocessing of spent nuclear fuel of Ukrainian NPP's) during 50 years.

Calculated amounts of RW that may be received from major suppliers are given in Table 1:

Table 1. Calculated Volumes of RW, Expected for Treatment, Disposal and Storage at Vector Complex

	RW type and category	RW supplier			
		Chornobyl Exclusion Zone	Chornobyl NPP	NNEGC ENERGOATOM a	Ukrainian State Corporation Radon
		thousand m ³			
1	Short-living (total)	459	310	51,5	
1.1	Without treatment	330	305	40,6	4,8
1.2	For pressing	9	5	5	
1.3	For incineration	120	0,2	3,8	
2	Long-living (total)	1071	257	132	
2.1	Without treatment	770	257		
2.2	For pressing	21	-		
2.3	For incineration	280	-		
4	High-level	-	84	13,164	0,2 b
5	TOTAL (round)	1530	651	197	5

a State Enterprise National Nuclear Energy Generating Company ENERGOATOM integrating all Ukrainian NPPs.

b volume of disused sealed radiation sources (an estimate).

Reduction of total activity of RW due to natural radioactive decay during long-term period (up to 100 years) will not lead to significant reduction of volumes of SL RW. Volumes of LL RW of Chornobyl origin may even increase, because part of SL RW may be reclassified into LL RW due to accumulation of americium-241 (in 100 years, alpha-activity of transuranium elements in Chornobyl waste will be doubled [2]). So, technological facilities and storages of Vector Complex during term of their operation must envisage incineration of 404,000 m³ of RW, pressing of 42,000 m³ of RW, disposal of 690,000 m³ of SL RW, storage of 1,272,000 m³ of LL RW and 100,000 m³ of HL RW.

COMPOSITION OF VECTOR COMPLEX

Site of Vector Complex is situated in the Exclusion Zone at the distance of 1 km from Buryakivka disposal site and 20 km from Chornobyl NPP within the borders of so-called "western trace" of Chornobyl contamination. Site area is 160 ha, ground water is located at depth of 18-21 m. In the region of site location, density of radioactive contamination in 1986 reached 290 Ci/km² for cesium-137, 140 Ci/km² for strontium-90, 3.2 Ci/km² for plutonium isotopes, 1.7 Ci/km² for americium-241. Due to this reason, without comprehensive decontamination, this territory is unsuitable for habitation. Hydrogeological characteristics of site are practically the same for all objects, located on site of Vector Complex.

Objects of Vector Complex are located on site, divided into "conditionally clean" and "conditionally contaminated" zones.

"Conditionally clean" zone include following objects:

- fire station for two vehicles (commissioned);
- water intake well (commissioned);
- water deironing station (commissioned);
- covered parking with fuel station and trestle (commissioned);
- administrative building with canteen and aid post (to be commissioned in 2010);
- information and analytical centre (planned in second turn of Vector Complex).

On the border between "conditionally clean" and "conditionally contaminated" zone, following objects are arranged:

- checkpoint with radiation monitoring (commissioned);
- checkpoint for staff (commissioned);
- physical security system (to be commissioned in 2010);
- sanitary checkpoint with laboratory (to be commissioned in 2010);
- checkpoint for builders (planned in second turn of Vector Complex).

"Conditionally contaminated" zone include following objects:

- specially equipped subsurface storage for solid RW (Lot-3) (commissioned);
- washing facility for vehicles (commissioned);
- site for standby of specialized technique (commissioned);
- building for preparation of containers for disposal (building 20) (to be commissioned in 2010);
- storages for SL RW disposal of SRW-1 type (to be commissioned in 2010);
- storages for SL RW disposal of SRW-2 type (to be commissioned in 2010);
- Centralized Storage for Disused Sealed Radiation Sources (CSDSRS) (being designed);
- technological building (planned in second turn of Vector Complex);
- storages for SL RW disposal of SRW-2-1 type (planned in second turn of Vector Complex);
- LL RW storages of SRW-3 type (planned in second turn of Vector Complex);
- HL RW storages of SRW-4 type (planned in second turn of Vector Complex);
- building for temporary stockpiling of RW (planned in second turn of Vector Complex).

Engineering and life supporting infrastructure of Vector complex (electricity and water supply, fire protection, telecommunications, physical security system, radiation and environment monitoring, first-aid-post, personnel and staff premises, canteen, check-points, car-washing facility, roads etc.) is completed.

BASIC INTERRELATIONS BETWEEN FACILITIES AT VECTOR COMPLEX

All disposal facilities are located on the surface and belong to mound-type storages. Total area of storages is equal to 15% of total area of the site. After filling of part of the storage with waste or after completion of operation, the storages are dyked (covered with multilayer waterproofing ground shield from the sides and from above).

SRW-1 and Lot-3 storages are intended for container disposal. Type of container is defined by the design of appropriate storage and may be changed for optimization of radiation, operational and economical showings according to the established procedure. Storages of SRW-2 and SRW-2-1 types are intended both for disposal of loose or large-size RW in bulk and for disposal of RW in metal (or any non-standard) containers (packages) of various types. Number of storages (of certain type and total) is the designed one. On base of practices of operation of storages of the start-up complex and taking into account actual characteristics and expected streams of RW, decisions about construction of storages of certain type will be made.

All facilities for storage belong to subsurface type storages. They are intended for storage of RW during 50 – 100 years in containers. Type of container is defined by the design of appropriate storage and may be changed for optimization of radiation, operational and economical showings according to the established procedure.

Basic characteristics of the disposal and storage facilities are given in Table 2.

Table 2. Basic Characteristics of RW Disposal and Storage Facilities

Storage	RW type	Purpose	Period, years	RW volume, thousand m ³	Number of storages a			RW total, thousands m ³
					Start-up	Vector-1	Vector-2	
SRW-1	SL	disposal	300	9.8	1	15		156.8
SRW-2	SL	disposal	300	9.42	1	39		376.8
SRW-2-1	SL	disposal	300	18.0			10	180.0
Lot-3	SL	disposal	300	50.2	1			50.2
SRW-3	LL	storage	50-100	13.0			90	1170.0
SRW-4	HL	storage	50-100	3.5			28	98.0

a Number of storages for start-up and Vector-1 defined by design, for Vector-2 – predicted by the feasibility study.

Interrelations between main objects are shown in Fig.1 and are realized by material (band arrows) and informational (standard arrows) flows. Informational flows connect all objects of Vector Complex with informational and analytical centre. To do this, the design envisages appropriate digital communication lines. In Fig.1, only the part of informational flows related to accounting of RW and monitoring systems in the "conditionally contaminated" zone, is shown.

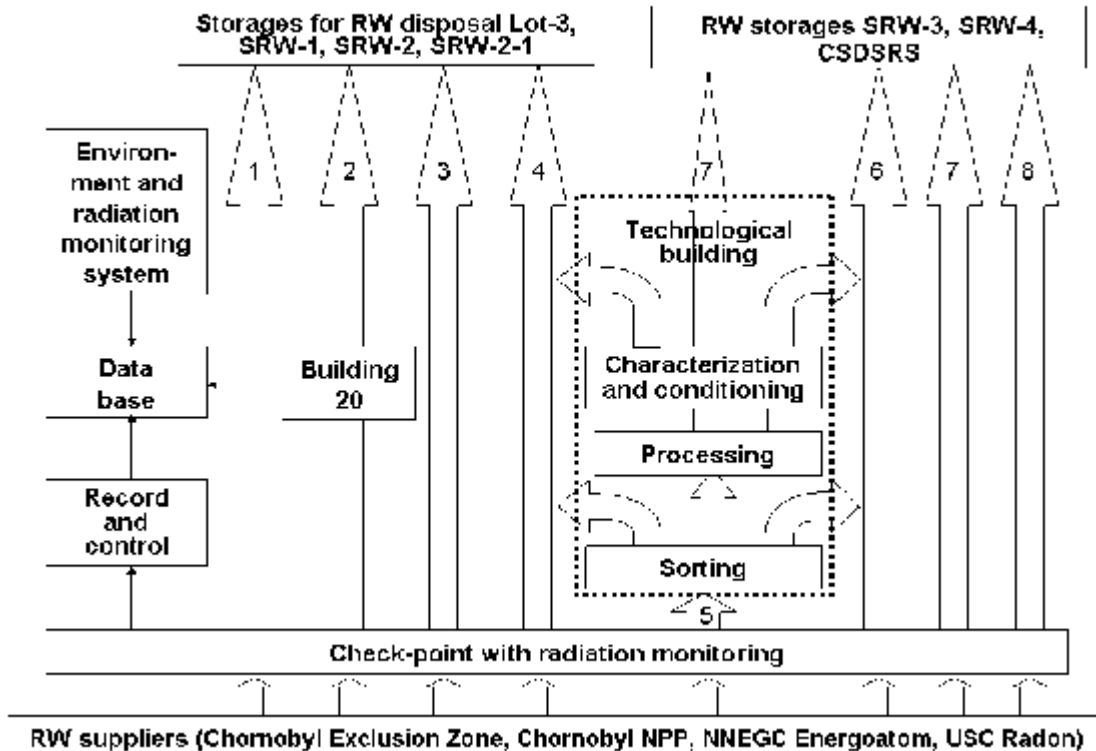


Fig. 1 Process layout for RW management at Vector Complex

Material flows of RW in Fig.1 are numbered and shown by wide arrows. They correspond to following technological processes:

1. transportation of conditioned SL RW (in casks and containers) by container carrier of the ChNPP [3] from checkpoint with radiation monitoring for disposal in specially equipped subsurface storage of solid RW (Lot-3);
2. transportation of packages with RW by container carrier of the supplier (or SSE Technocentre) from checkpoint with radiation monitoring to building 20, unloading, preparation of containers for disposal, loading of containers into vehicles of SSE Technocentre and transportation for disposal of conditioned SL RW (in containers) in subsurface storage for solid RW of SRW-1 type;
3. transportation of large-size and non-conditioned SL RW by vehicles of the supplier (or SSE Technocentre) from checkpoint with radiation monitoring for disposal (in bulk) in subsurface storage for solid RW of SRW-2 type;
4. transportation of conditioned SL RW by vehicles of the supplier (or SSE Technocentre) for disposal of conditioned SL RW (in containers) in subsurface storage for solid RW of SRW-2-1 type;
5. placement of RW in building 20a (technological building) for sorting, treatment, characterization and conditioning to ensure compliance with the requirements of criteria for disposal of SL RW in storages of SRW-2-1, SRW-1 or SRW-2 types, or criteria for storage of LL RW in storages of SRW-3 type, or criteria for storage of HL RW in storages of SRW-4 type;
6. transportation of packages with conditioned LL RW by vehicles of the supplier (or SSE Technocentre) for storage in containers in subsurface storage for solid RW of SRW-3 type;

7. transportation of packages with conditioned HL RW by vehicles of the supplier (or SSE Technocentre) for storage in containers in subsurface storage for solid RW of SRW-4 type;
8. transportation of packages with disused SRS by vehicles of the supplier (or SSE Technocentre) for storage and (or) treatment of disused SRS in the centralized storage facility for disused SRS.

WASTE ACCEPTANCE CRITERIA FOR VECTOR COMPLEX

Criteria for acceptance of RW for each object, intended for RW management, are worked out on base of Ukrainian documents and IAEA recommendations, taking into account international practices. The basis for definition of acceptance criteria is the results of safety analysis for relevant type of storage or technological process. Justification is carried out on base of multibarrier concept, based on successive consideration of:

- site characteristics;
- radiation safety requirements;
- basic design solutions;
- characteristics of RW to be received at relevant object;
- established terms of administrative control.

Taking into account the fact, that, at the moment, there is no reliable information on radiation characteristics of RW, and issues of use of territory of the Exclusion Zone in 300 years are not solved, to define RW acceptance criteria, concept of restricted release of RW from regulatory control is accepted. According to the normative documents, restricted release is possible in case of non-exceeding of reference level B of potential irradiation (1mSv/year) and reference level of current irradiation (10 µSv/year).

At the moment, there are developed and agreed by the regulatory authorities RW acceptance criteria for the first two compartments of the specially equipped subsurface storage for solid RW. For SRW-1 and SRW-2 storages, acceptance criteria for disposal are now passing expert examination. Acceptance criteria will be adjusted at regular intervals on base of operational practices of Vector Complex.

LONG-TERM PROGRAM FOR OPERATION OF VECTOR COMPLEX

According to the Strategy for RW Management in Ukraine, feasibility study for the second turn of Vector Complex, and experience of implementation of state programs for RW management in Ukraine, operation of Vector Complex will probably consist of three periods.

First period (8 years).

- Commissioning of start-up complex of the first turn.
- Commissioning of 23 storages SRW-1 and SRW-2 type of the first turn (220,000 m³).
- Commissioning of one storage of SRW-2-1 type (18,000 m³).
- Commissioning of three storages of SRW-3 type (39,000 m³).
- Commissioning of one storage of SRW-4 type (3,500 m³).
- Commissioning of technological building and facilities for RW treatment.
- Commissioning of the centralized storage for disused SRS.
- RW acceptance from Chernobyl NPP and Chernobyl Exclusion Zone.
- RW acceptance from Ukrainian State Corporation Radon.
- RW acceptance from NNEGC ENERGOATOM.
- Dying of storages for disposal of SL RW.
- Reaching the design capacity of 47,700 m³ per year.

Second period (30 years).

- Dying of storages for disposal of SL RW.
- Commissioning of 33 storages of SRW-1 and SRW-2 type (315,000 m³).
- Commissioning of 9 storages of SRW-2-1 type (162,000 m³).
- Commissioning of 87 storages of SRW-3 type (1,131,000 m³) for storage of LL RW.
- Commissioning of 27 storages of SRW-3 type (97,000 m³).
- Acceptance of RW from all suppliers.
- Completion of acceptance of all accumulated RW.

Third period (50 years).

- Decommissioning of facilities for long-term storage of RW.
- Commissioning of new RW storages.
- Acceptance of RW, to be generated as a result of routine use of nuclear power, for disposal.
- Transfer of RW from storage facilities to geological repository.

CLIENT, LICENSEE AND OPERATOR

The Client for construction of first and second turns of Vector Complex is State Specialized Enterprise – Centre for Treatment and Disposal of Mixed Hazardous Waste "Technocentre" (SSE Technocentre), subordinate to the Ministry of Emergencies of Ukraine. SSE Technocentre is a part of the Ukrainian State Corporation Radon (USC

Radon), SSE Technocentre was appointed as an operator of the storages for RW disposal. According to the requirements of the legislation and normative documents, SSE Technocentre carries out directly or orders:

- research, engineering and technological activities in field of RW management;
- design and development activities in field of RW management;
- designing of storage and disposal facilities;
- construction of storage and disposal facilities;
- transportation of RW packages from suppliers to Vector Complex;
- acceptance, incoming control and accounting of RW, that come to Vector Complex;
- decontamination of specialized vehicles, containers and equipment;
- placement of RW in disposal facilities;
- placement of LL and HL RW in storage facilities;
- RW treatment at the facilities of the technological building;
- sorting and fragmentation of non-conditioned RW in storage facilities;
- conditioning of RW of the Exclusion Zone after sorting;
- arrangement of conditioned LL and HL RW in storage facilities;
- arrangement of SL RW in disposal facilities after treatment;
- operation of storage and disposal facilities;
- shutdown of disposal facilities;
- dyking of shut-down disposal facilities;
- decommissioning of storage facilities;
- transfer of RW to geological repository;
- ensuring radiation safety;
- radiation monitoring at all stages of RW management on site;
- radiation protection of staff and environment;
- monitoring of site and environment;
- physical security of RW storages;
- fire protection of objects;
- life support of staff on site;
- safety analysis of RW treatment, storage and disposal at all stages of life cycle of every storage;
- periodical reassessment of safety of storages for RW disposal and reporting by the results of reassessment of storage safety;
- obtaining licenses and other permitting documents and observance of their requirements.

SSE Technocentre has licenses for designing, construction and operation of subsurface storages for RW disposal, and for operation of ionizing radiation sources. In future, it is planned to obtain licenses for transportation, treatment and storage of RW.

CONCLUSION

Construction and development of Vector Complex is the strategic element of radioactive waste management system in Ukraine. Location of Vector Complex within the most contaminated part of the Chernobyl Exclusion Zone has several advantages: 1) remote location from permanent residence; 2) prohibition on building of apartment houses on this territory; 3) site is in close proximity to main source of radioactive waste; 4) the main stream of waste transport is within the abandoned Chernobyl Exclusion Zone. All these features ensure very small impact of Vector Complex operation on the population and environment. Acceptance of radioactive waste will start in 2010. Designing, building, commissioning and licensing of new facilities will take place simultaneously with operation of current facilities. Long-term program of construction and operation of Vector Complex spans dozens of years. Plan until 2017 is defined by the Nationwide environment-oriented program of radioactive waste management in Ukraine, approved by the Parliament of Ukraine.

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