UDC: 621.039.75

THE NEAR-SURFACE DISPOSAL FACILITIES OF RADIOACTIVE WASTE: OPERATIONAL EXPERIENCE

Pron I. A., Konovalov V. Y.

The Federal State Unitary Enterprise «National Operator for Radioactive Waste Management»

Article received on 23 October 2018

The paper presents preliminary results of activities carried out by the National Operator on radioactive waste disposal in a near-surface disposal facility. It also summarizes the results of evaluations addressing the dose rate values measured at the surface of radioactive waste packages. The paper notes some regulatory aspects on the establishment of specific waste acceptance criteria for a particular near-surface disposal facility. It also discusses the challenges associated with the big variety of different sizes and characteristics of containers designed for radioactive waste disposal.

Keywords: *radioactive waste, near-surface disposal facility, waste acceptance criteria, container for radioactive waste, radioactive waste package, dose rate.*

In 2015, the first section of a near-surface disposal facility for radioactive waste (NSDF) was commissioned in Novouralsk being a restricted administrative unit. This disposal facility was designed for radioactive waste of Class 3 and 4 according to the classification system provided in the Government Resolution No 1069 of October 19, 2012 [1]. These RW classes should include solid or solidified waste containing short-lived radionuclides with a specific activity being not higher than the one of ILW, whereas the specific activity of long-lived radionuclides should be not higher than the one of LLW. Such waste is accepted for disposal in conditioned form (see provisions of the Federal Law No 190-FZ of July 11, 2011 [2]) emplaced into disposal containers.

Radioactive waste being disposed of in the NSDF shall comply with waste acceptance criteria for disposal: the general ones set in relevant provisions of Federal Norms and Rules in the field of atomic energy use Radioactive Waste Acceptance Criteria for Disposal [3] (NP-093-14) and particular ones set by the National Operator [2] the feasibility of which has been demonstrated in NSDF design documentation.

It should be noted that no formal standards on sizes and types of containers designed for RW disposal package manufacturing are currently available. As the result, some 20 groups of such containers can be identified according to their sizes and types. These are characterized by different weight, size, strength and other characteristics.

During NSDF design development, the abundance of container designs based on which the RW packages accepted for disposal shall be manufactured drives the decision suggesting that no automatic load-handling devices should be incorporated into these designs as their number should be no less than the number of the required container types. Introduction of such a big number of devices would have resulted in unreasonable costs associated with design, manufacturing, storage, installation/disassembly of lifting equipment.

Moreover, the abovementioned load-handling equipment could not even theoretically live the

Fig. 1. Hooking RW package using a semi-automatic capturing device [4]

entire intended lifespan, since certain types of containers are available in an amount ranging from several hundred to several thousand pieces with no plans calling for their further production.

All of the abovementioned facts resulted in the use of much simpler semi-automatic gripping tools: RW package gripping occurs in manual mode (Fig. 1), and the uncoupling after the RW package is placed in the repository — in the automatic one.

Application of such gripping tools was considered among the causes resulting in higher forecasted exposure dose. Relevant requirements on dose evaluations to be presented in design documentation developed for any RW disposal facility are set forth in OSPORB-99/2010 [5] and NP-055-14 [6]. This, along with other factors (applied input control technologies, RW loading), has required to establish a limit on the dose rate for RW packages accepted for disposal.

For reference: *in keeping with [3] provisions, the maximum dose rate at the surface of RW package of Class 3 (10 cm away from the surface, further explanation omitted) should not exceed 10 mGy/h, whereas in the first NSDF commissioned in Russia packages with a dose rate ranging from 2 to 10 mGy/h can be accepted only following a particular decision of the operating organization. Such decision is taken based on the evaluation of operational safety issues taking into account the special safety measures discussed in relevant operational NSDF documentation.*

During design development, taking into account the specified limit of 0.5 mGy/h at the package surface, the forecasted design dose effects (accounting for the safety factor of 2, see pp. 3.3.4 of OSPORB-99/2010 [5]) complying with the requirements of Russian regulatory legal acts were achieved for the NSDF without increasing the number of personnel and applying unpopular measures of its rotation.

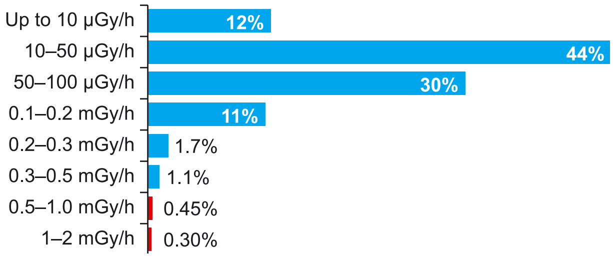


Fig. 2. Practically observable values of dose rates at the surface of Class 3 and 4 RW packages accepted for disposal

However, the lessons learned from the early days of NSDF operation have already demonstrated that the dose rate from the majority of waste containers (over 99 %) did not exceed the design limits, notably regardless the RW class (fig. 2).

Lack of this dependence could be explained by high-level biological protection ensured by thick-walled reinforced concrete containers used to package RW Class 3, as compared to the thin-walled metal ones for RW Class 4.

For reference: *wall thickness of a typical container for RW Class 4 (not higher than LLW) used today accounts for 4–6 mm of steel, whereas the one of a reinforced concrete NZK type container is over 100 mm of thick concrete. The gamma-radiation attenuation rates for the indicated containers and main gamma emitters (for reference) are presented below.*

Container material	Attenuation rate	
	^{137}Cs exposure	^{60}Co exposure
4 mm, steel (KRAD, KMZ containers)	1.07	1.07
100 mm, concrete (for example, NZK-MR)	3.30	2.60
150 mm, concrete (for example, NZK-150)	6.60	4.50

The dependence of surface dose rate from the specific activity of gamma emitters located inside was analyzed and it was demonstrated that despite different radiation energies of the radioisotopes contained in the radioactive waste and the geometric heterogeneity of the radiation source, the dependence can be determined by statistical methods (Fig. 3).

Evaluation of the results presented in Fig. 3 demonstrates the following:

1) confirmed was the previous thesis suggesting that the surface dose rate of over 0.5 mGy/h is typical for no more than 1% of currently available RW packages and those being transferred for disposal;
2) particular RW packages characterized with the specific activity values being within the limits established for a particular waste class cannot be handed over for disposal as the dose rate at their

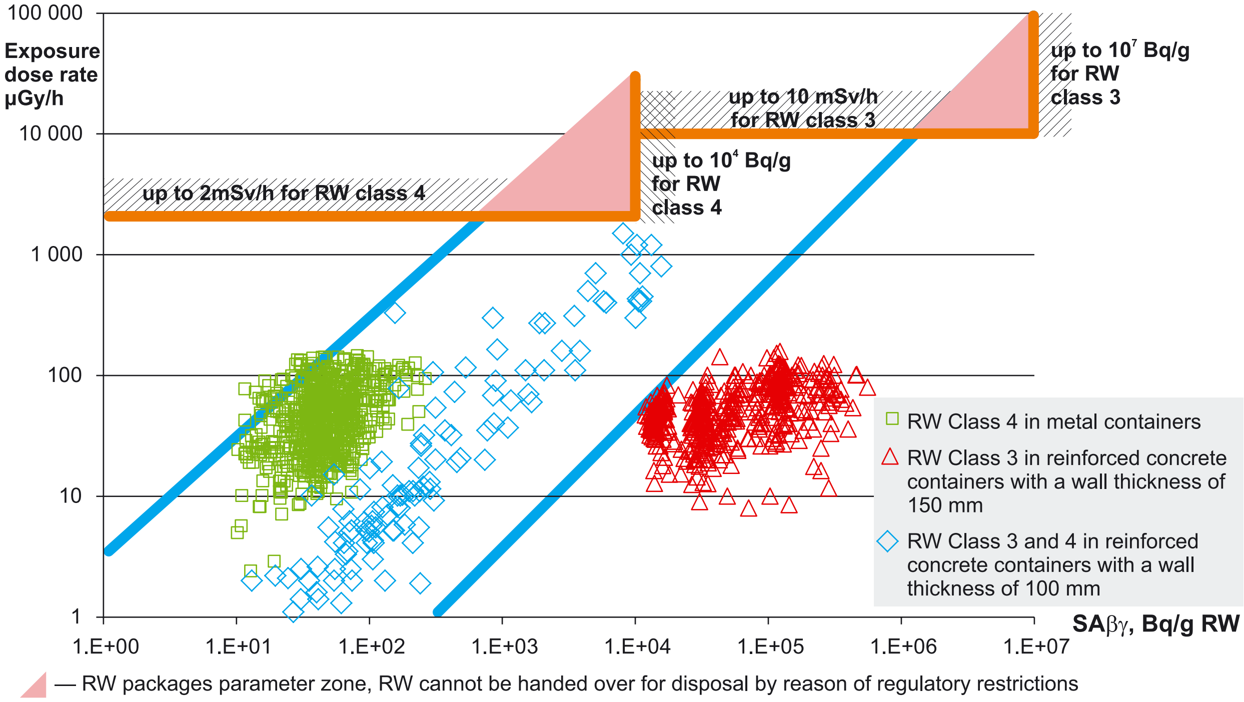


Fig. 3. Dependence of actually observed dose rate values on the surface of RW packages accepted for disposal (μGy / h) on the specific activity of gamma-emitting radionuclides present in RW and existing regulatory restrictions

surface may exceed the one established for relevant RW class according to NP-093-14 provisions (this value accounts for 10 mGy/h for RW class 3 and 2 mGy/h for RW class 4). In Fig. 3 these parameter zones are shown as rectangular triangles with a red fill.

The above means that the development of radionuclides concentration technologies applied to radioactive waste during its pre-disposal treatment (RW is transferred by waste generating enterprises to reduce the RW amount) will result in a situation when the acceptance of certain RW types becomes impossible due to the counter-restrictions of the two currently existing regulatory legal acts — PPRF 1069 and NP-093-14.

As it comes to RW class 4 this challenge can be easily addressed by applying containers with thicker biological shielding (for example, NZK-MR or similar types of containers may be used instead of KMZ, fig. 3). However, for RW class 3 with a specific activity ranging from 10^6 to 10^7 Bq/g and the radioactive composition featuring high-energy isotopes (for example, ^{60}Co), a specific solution is required. No containers certified for disposal and enabling to dispose of such RW so that the surface dose rate does not exceed 10 mGy/h are currently available in Russia. Therefore, such containers should be developed in a short run. To ensure their acceptance by disposal facilities, their design development shall involve parameters of transport and process DFRW flows corresponding to the already implemented ones and those being currently developed by the National operator [6—8].

It should be noted that container replacement by a more thick-walled one always results in higher RW disposal costs. There are two reasons behind this being independent from each other:

- the cost of thick-walled containers is higher than the one of a thin-walled;
- RW disposal tariffs are set based on the RW package volume. Therefore, the supplier will have to hand over a thick-walled biological shielding at a cost of RW class 3.

Eventually, the increased total cost of conditioning, packaging and disposal may exceed the benefits that the supplier intended to get by means of concentrating the radionuclides in RW composition during their treatment.

Significantly lower dose rate associated with actually disposed waste as compared to the design one has produced a significant impact on the RWDF personnel radiation exposure. Thus, annual doses obtained by all RWDF personnel did not exceed 1/4 of the established allowable dose limit specified for relevant groups of personnel (A, B).

The data presented in the article may be used by FSUE NO RAO during the design development of new near-surface disposal facilities to be sited in restricted administrative and territorial entities Ozersk and Seversk. However, this data cannot be used to mitigate RW acceptance criteria established for the first section of the near-surface disposal

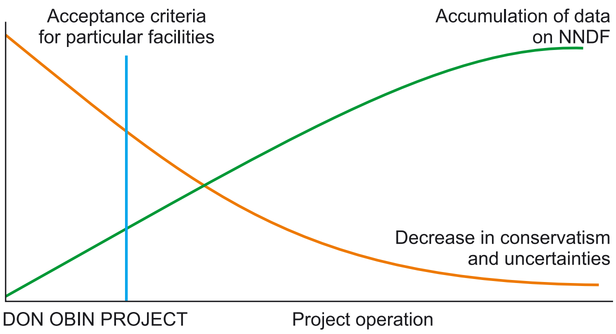


Fig. 4. Dynamics of data accumulation on NSDFs and relevant decrease in conservatism and uncertainties in the safety assessments [9]

facility located in the restricted administrative and territorial entity Novouralsk due to the reasons discussed below.

As it was already mentioned above in keeping with current regulatory requirements, the feasibility of RW acceptance criteria developed for a specific disposal facility should be demonstrated in its design documentation [2, 3]. However, it is well-known that the acquisition of information on such facilities should continue even after the design development stage is finished. Significant amounts of data (including those capable of affecting the safety of the facility and safety demonstration) are accumulated during NSDF operation. This situation is outlined in Fig. 4.

During operation, the level of conservatism and the uncertainties present in NSDF safety case decreases. However, current regulations do not provide for a mechanism enabling to review RW acceptance criteria without amending the design documentation. At the same time design documentation for already completed facility can be currently amended only if the facility is being reconstructed and/or upgraded.

Thus, the problem of excessively strict acceptance criteria introduced at the design stage evolves. It results in higher facility costs and unjustified expenses of enterprises handing over the waste for disposal. A possible solution addressing this problem would be introducing the possibility of justifying waste acceptance criteria both in design and operational documentation (for example, in process operator's guide) with due account of the knowledge gained during NSDF operation.

During the first years of operation, verification of disposal facility's operating efficiency in terms of its useful storage capacity filling is done. In keeping with the designs, useful storage capacity of a disposal facility should account for 70 % of the actual (construction) one [6]. Such a low value is due to the fact that disposal facility can receive packages with various weight, size and strength characteristics.

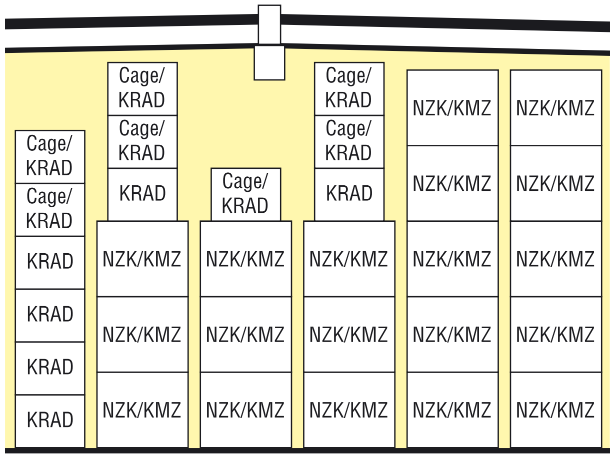


Fig. 5 Extract from the layout representing RW package emplacement in a near-surface disposal facility (unused storage capacity is shown in yellow)

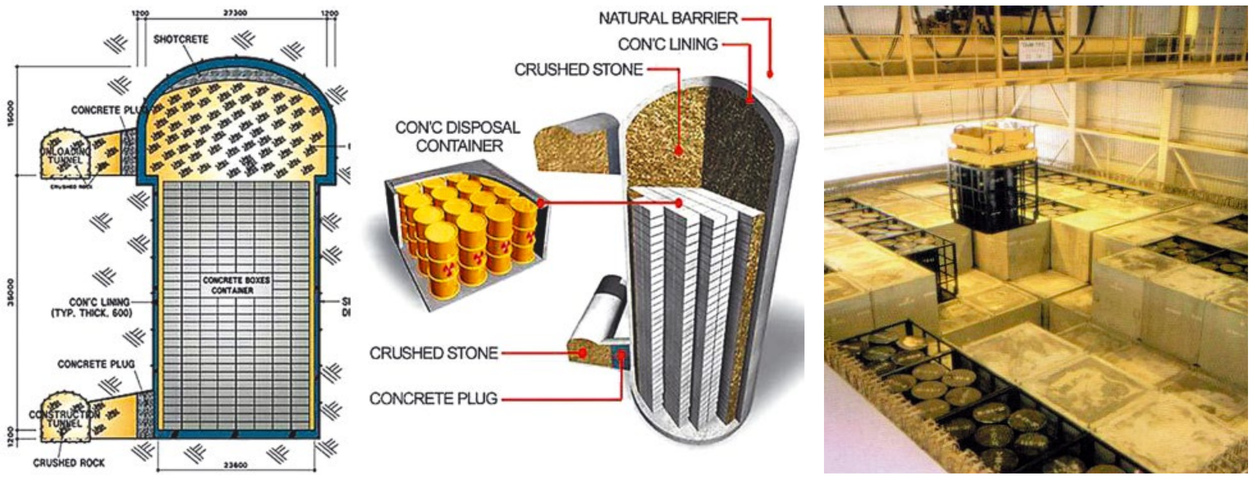
According to safety requirements, these can be arranged only in a few strictly defined ways [6] (Fig. 5).

For reference: *at present time, designs developed for the first section of the near-surface disposal facility provide for the acceptance of 5 different most common types of packages arranged according to their weight, size and strength characteristics (NZK-150/1, NZK-RADON (MR), KMZ, KRAD-1.36, cage with four 200-liter drums). Whereas, the temporary list of the State Corporation Rosatom includes over 20 package types.*

In practice, it is difficult to achieve even this relatively low useful capacity indicator, since annual RW acceptance program is being developed based on the applications submitted to the National operator on RW acceptance for disposal. However, these applications do not comply with production needs for efficient emplacement of radioactive waste in the repository.

At the same time, in keeping with effective provisions of norms and rules in the field of atomic energy use [10] and the disposal facility's designs, unused useful capacity should be filled with a special buffer material.

The list of containers for RW package manufacturing that the National operator is obliged to accept for disposal is being constantly expanded. However, in practice, introduction of new containers results in more complicated transport and process flow charts since RW of the same classes and morphology can be handed over in packages with different weight and size characteristics. As mentioned above, such a variety of containers makes it necessary to abandon the use of multi-purpose automatic load-handling devices, as well as to engage personnel in RW packages slinging.



a) *b)*

Fig. 6. Use of standardized containers in RW disposal a) Korea [11]; b) Spain [12]

These processes result in higher specific cost of disposal due to the underuse of the useful disposal capacity and the need to fill this volume with clay materials having special properties (swelling, sorption properties, etc.).

Thus, the first years of NSDF operation have shown that big variety of certified waste disposal containers available in Russia can be considered as a significant factor affecting the performance and waste emplacement efficiency. At the same time, as shown in this article, the currently available range of containers does not allow to dispose of all existing RW types.

In this context, it's reasonable to rely on the knowledge gained by other nuclear developed countries. For example, in Korea only one container type is used for RW disposal (fig. 6a), in Spain — two types: for intermediate-level (reinforced concrete containers) and low-level (cages with drums) having the same size (fig. 6b). In many other countries, standard types of RW packages are used as well.

Thanks to the unification approach applied with regard to waste disposal containers the above-mentioned countries have attained over 90% filling of the useful storage capacity. As the result, 25—30% higher economic efficiency of the projects was attained, thus, significantly affecting the overall cost of national RW disposal programs. Moreover, the following benefits are associated with the use of standard-sized specialized waste disposal containers:

- RW packages can be stacked using automatic load-handling devices producing positive effect on the operational safety of the near-surface disposal facility as personnel involvement is being avoided;
- stacking in a greater number of tiers resulting in lower disposal costs.

In addition, it was revealed that the increased conservatism of safety assessments performed prior to repository construction (design development stage) cannot be reduced at subsequent stages (no mechanism is available). This prevents the National operator from reviewing specific acceptance criteria based on the operating experience.

References

1. Order of the Government of the Russian Federation of December 19, 2012 No 1069 "About criteria of reference of solid, liquid and gaseous waste to radioactive waste, criteria of reference of radioactive waste to special radioactive waste and to the retrievable radioactive waste and criteria of classification of the retrievable radioactive waste". (In Russian).

2. Federal Law of July 11, 2011 No 190-FZ "On Management of Radioactive Waste and Amendment of some acts of Law of the Russian Federation". (In Russian).

3. Federal Standards and Rules in the Field of Atomic Energy Use "Criteria for Accepting Radioactive Waste for Disposal". NP-093-14. (In Russian).

4. The publication URA.RU: https://www.youtube.com/watch?v=xQXZXYtrx2Q. (In Russian).

5. Basic sanitary rules of radiation safety (OSPORB-99/2010). (In Russian).

6. Ecological safety report justifying the license for the operation of the first stage of near surface disposal facility, the Novouralskye department of the Seversky branch of FSUE NO RAO. Available at: www.norao.ru. (In Russian).

7. Ecological safety report justifying the license for construction (reconstruction) of near surface disposal facility, the Novouralskye department of the Seversky branch of FSUE NO RAO. Available at: www.norao.ru. (In Russian).

8. Ecological safety report justifying the license for siting and construction of near surface disposal facility, the Cheliabinskaya obl., Ozersk. Available at: www.norao.ru. (In Russian).
9. Pron I. A. Basic approaches to the waste acceptance criteria establishment and experience in the field of radioactive waste disposal. *The 12th school-seminar "Organizational and legal support of two systems: SSU RV and RW and EGS RW"*.3—8 September 2018, Sochi.
10. https://www.korad.or.kr/korad/eng/.
11. http://www.enresa.es/eng/index/activities-and-projects/el-cabril.

Information about authors

Pron Igor Aleksandrovich, Deputy General Director for Operations, The Federal State Unitary Enterprise «National Operator for Radioactive Waste Management» (49A bld.2, Pyatnitskaya st., Moscow, 119017, Russian Federation), e-mail: iapron@norao.ru.

Konovalov Vladimir Yurevich, Head of Nuclear and Radiation Safety and Operation Department, The Federal State Unitary Enterprise «National Operator for Radioactive Waste Management» (49A bld.2, Pyatnitskaya st., Moscow, 119017, Russian Federation), e-mail: vykonovalov@norao.ru.

Bibliographic description

Pron I. A., Konovalov V. Y. The The Near-Surface Disposal Facilities of Radioactive Waste: Operational Experience. *Radioactive Waste,* 2018, no. 4 (5), pp. 8—14. (In Russian).