

SAFE TRANSPORTATION OF SALASPILS RESEARCH REACTOR DECOMMISSIONING WASTE: PROBLEM SITUATION AND SOLUTION

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ABSTRACT

Efficiency of radioactive waste (RW) transportation is regarded as an important feature of waste management optimization. In the present paper we analyze: I) actuality of transportation, II) strategic organization of particular transportation procedure, III) ensuring of environmental safety.

Actuality of transportation of large amounts of RW currently arises from implementation of the Decommissioning concept of Salaspils research reactor (SRR) and from the national Concept of RW management, having foreseen transportation large amount of RW and spent sealed sources for disposal. Taking into account socio-economic, radiation safety and other factors - as the optimal version of disposal of SRR decommissioning waste disposal transportation to the Baldone RW disposal site located ~ 25 km from the Salaspils RR has been chosen, because: 1) the Salaspils and Baldone sites are branches of the same joint national waste management institution – the State Agency "RAPA", 2) all RW is disposed at a **central** facility, thus reducing the nation's liability for RW by ensuring complete disposal at a central facility enabling also environmental restoration of the Salaspils site, 3) the Baldone site has space to accommodate a new vault, 4) RW transportation to Baldone and restoration of the Salaspils site is beneficial due to gaining possibility to carry out the already implemented environmental control and mitigation measures of the relevant areas.

Latvia has implemented international directives and recommendations on safe transport of radioactive materials foreseeing necessity of compliance assurance for transportation package. Taking into account currently existing absence of packages having EU certificates, as well as other safety and economic factors, the national Regulatory body and "RAPA" have chosen an exceptional authorization procedure for RW transport as a currently optimal solution for RW transportation, have elaborated it in detail and already implemented in practice: according to Cabinet Regulations *on Safe Transportation of Radioactive Materials*, the Radiation Safety Centre (RDC) issues relevant compliance assurance - the Special Arrangement Approval Certificate - according to the application submitted by the transportation operator.

Radiation safety of the transportation operations is promoted by implementation of the following unification measures: 1) the sole transportation operator and prevailing consignor – "RAPA", 2) the use of only one type of concrete containers (A-172), 3) establishment of a system of compulsory training in radiation safety for all relevant operators and drivers of vehicles of dangerous load transportation, 4) transportation by lorries, according to ADR Class 7, only in the day-time.

Basic technical measures undertaken for enhancing radiation and environmental safety: 1) RW transportation in a solid and predominantly in an immobilized state, ensuring minimization of possible dispersion of radioactivity, 2) elaboration and implementation in "RAPA" of emergency response plans and of a special response unit, with regular training in national/international courses, 3) implementation of regular on-site and off-site environmental monitoring. The State control programme of radiation objects of national significance ensures regular α -, β - and γ -monitoring of Salaspils and Baldone sites.

In order to ensure regular off-site monitoring, since 2002 RDC has been performing quarterly environmental gamma-surveys of the RW transportation route (Salaspils-Baldone) using the car-borne mobile laboratory, in the result confirming – according to γ -mapping data - proper environmental safety. These transportation safety features, being properly generalized, could be regarded as relatively generic principles of optimization of decommissioning waste transportation, providing environmental safety.

INTRODUCTION

It is generally accepted that one of the keystones of the dismantling and decommissioning (D&D) strategy is efficient organization and optimization of management of arising waste [1], as the D&D processes usually generate much greater RW volumes than routine practices with nuclear materials. Furthermore, as one of essential steps in optimization of D&D waste management can be considered RW transportation optimization [2], including organizational aspects (packing, transportation time, schedule, route) and environmental safety control. Importance of transportation features for the whole strategy arises, in particular, from the IAEA position stating that in the process of selection and efficient planning of the whole D&D strategy, disposal capabilities of arising waste have to be specified together with an evaluation of the different materials which will be produced by the D&D operations [1].

In particular, in the choice of the optimal decommissioning version of the Salaspils research reactor (SRR) it was proposed that the conditioned waste immediately after dismantling of SRR should be transported for disposal at the existing Baldone repository – there is no net benefit from short term decay storage at the site. However, the waste would only be sent for final disposal to the Baldone facility if it cannot be decontaminated and reused, recycled or disposed of conventionally. The D&D waste of medium and low activity, solid and liquid are proposed to be disposed of.

These above mentioned features substantiate the actuality and importance to organize, manage and perform efficient timely transport of D&D waste of SRR in a prescribed limited period of time.

GENERAL CHARACTERISTICS OF SALASPILS REACTOR AND ARISING WASTE

The Salaspils research reactor of IRT-type site was put into operation in 1961 near the capital of Latvia – Riga. SRR was originally built as a pool type light water reactor (LWR) with nominal thermal power 2 MW. From 1966 till 1990 the Critical Assembly RKS (or Zero Power Reactor) was in operation. The Critical Assembly was a pool type LWR with water, graphite and/or beryllium reflectors. In 1975, after the SRR reconstruction, its nominal power reached 5 MW. In June 1998 the reactor was shut down, and finally, on the basis of the results of the Decommissioning Concept of SRR [3], the Cabinet of Ministers in October, 1999 (the Order No. 57) took the decision on decommissioning of SRR to the “green field” status - a complete decommissioning of the reactor, including complete dismantling of all auxiliary systems of reactor, biological shielding, as well as RW processing and its transportation and disposition in the storage site.

Basic consideration on predisposal and disposal actions would be as follows:

- activated and highly contaminated materials - with the mass of ~ 440 t - will be – taking into account the cost factor - conditioned for directly final disposal,
- low contaminated material ~ 880 t - will preferably be decontaminated, but such materials with unfavourable geometry will be conditioned as RW,
- mixed materials - ~ 880 t - will be separated before contamination if economically feasible. Otherwise they will be conditioned as RW foreseen for final disposal.

Based on existing Radioactive Materials Transport Regulations (IAEA Standards [4] and national Cabinet Regulations) as well as the prescribed waste acceptance criteria (WAC) defined in the RW management Regulations, the total volume of RW to be disposed in the repository has been estimated to be ~ 1200 m³.

On the whole, the following significant amounts of materials have been evaluated to be present in decommissioning waste: 37 t of stainless steel, 352 t of steel, 13 t of Al, 1650 t of concrete, 18 t of lead, 50 t of paraffin, 14 t of cast iron, 66 t of material mixture, graphite, 500 kg of Be.

Considering the expected inventory of the D&D waste in the contaminated and activated components of SRR, these wastes can be categorized as low and intermediate level activity waste (LILW). In addition, all D&D waste from contaminated materials and majority of activated components is categorized as short-lived waste, furthermore, due to relatively low contribution of certain long-lived nuclides (in the activated components) in the total inventory, one can approximately assume that for the disposal purposes all the D&D waste of SRR can be considered as the LILW-SL waste.

STRATEGIC ORGANIZATION OF WASTE TRANSPORTATION

There have been performed comprehensive studies with the purpose to develop the best possible strategy of waste disposal site and transportation to the RW repository. Namely, taking into account socio-economic, radiation safety, geographical and other factors, for the optimal version of the D&D waste disposal it has been decided to transport and dispose it in the Baldone site located only ~35 km from SRR. In the frame of the “Long Term Safety Analysis of Baldone RW Repository” performed by CASSIOPEE the Environmental Impact Assessment regarding the disposal of decommissioning waste from SRR has been made, with the following basic outcomes [5]:

- a) Disposal of the D&D waste at the Baldone site reduces the nation’s liability for RW: this ensures that all RW is disposed of at a central facility and enables the Salaspils site to be restored and used for other purposes. From the organizational viewpoint it is very favourable that SRR and the Baldone repository are branches of the same common institution – the State Agency “RAPA”.
- b) As the Baldone repository is a long existing facility, it already has the infrastructure required to support a RW disposal programme. It also has the space on site to accommodate a new vault. The local infrastructure would not be significantly affected by the new works and programme of RW disposal.
- c) Although all the data relating to the non-nuclear environmental effects of the proposed new vault are not yet fully available, no significant environmental disturbance is anticipated. The decommissioning of SRR, the removal of the waste from the Salaspils site to the Baldone repository and the restoration of the Salaspils site for an alternate use would bring environmental benefits: it should be possible to control most of the environmental effects related to taking the waste to the Baldone repository through management and mitigation measures.
- d) The decommissioning of SRR reduces the risks to the public by clearing radioactive and hazardous materials from the site, by isolating the wastes in steel or concrete containers and by placing them in the vault.

On the whole, it is estimated that in a total approximately 210 journeys would be required to transport the D&D waste from Salaspils to Baldone, and proposed that the waste should not be transported during the night. The 210 journeys averaged out over the cumulative period of waste emplacement – 5 years – give in an average the annual amount of movements – 42 journeys by lorries.

IMPLEMENTATION OF PARTICULAR TRANSPORTATION PROCEDURE

As already since 1999 early decommissioning and dismantling measures of the unused reactor's systems as well as collection and conditioning of operational and historical waste have been started, there appeared an actual necessity to provide a possibility of timely transportation and disposal of the RW arising from D&D of Salaspils RR, in order to prevent potential harm to environment and to public health (in compliance with International Convention on Nuclear Safety, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of RW Management and the "precautionary principle (having been conceptualized in the 1992 UN Conference on Environment and Development), as well as relevant national documents – the Concept of RW management, the Law on Radiation Safety and Nuclear Safety and the corresponding Cabinet Regulations.

Taking into account that up to now, according to National Regulations, namely, "Regulations on Safe Transportation of Radioactive Materials" (Nr. 266, from 1998) and their updated version – in a full compliance with the IAEA Standards [4], the EU Directive 94/55/CE (from 1994) and other international recommendations - "Regulations on Protection against the Ionizing Radiation in the Transportation of Radioactive Materials"(No.307, from 2001), the Latvian Regulatory body cannot legally issue compliance certificates for domestic package designs due to the absence of accredited domestic testing laboratories (as required by the Regulations), only the package designs having been approved in the EU countries and countries under the Agreement of Acknowledgment of Compliance Assessment System. Taking into account available radiation safety and economical considerations, a decision has been taken on transportation of the D&D waste in concrete containers (of A-172 type) produced in Estonia (corresponding the Swedish technology), which cannot be legally approved according to Latvian Regulations.

Therefore, for satisfying the necessity of timely transportation of the D&D waste, the National Regulatory Body – the Radiation Safety Centre (till July 2001 – Radiation and Nuclear Safety Inspectorate) and "RAPA" have - as a currently optimal solution for RW transportation - chosen, elaborated in detail and already implemented in practice an exceptional authorization procedure for transportation of radioactive materials, (in particular, those RW arising from D&D of the Salaspils RR as well as of other origin) under special arrangement, whereby, according to Regulations No.307, the Regulatory Body (currently - Radiation Safety Centre) issues a relevant compliance assurance – namely, the Special Arrangement Approval Certificate - according to the Application (which has been specified in these Regulations) submitted by the transportation operator to the Regulatory Body.

The contents of the Application is specified by the Cabinet Regulations and completely comply with all requirements of the IAEA Standards [4] and it is submitted to the Regulatory Body. The Application is considered by the Regulatory body who takes the decision on issuance of the Special Arrangement Approval Certificate being afterwards coordinated with the State police regarding the transportation route of the particular load.

In accordance with national Regulations No. 307 and in compliance with international documents [4], the information to be specified in this Approval Certificate contains, in particular, such basic points:

- a) The name, the registration number and the address of the producer of the radioactive material (including RW), of the package and of the load consignor,
- b) The transportation mode,
- c) Any restrictions to the transportation route and notions related the choice of the route,

- d) Reference to the compliance certificate issued by other authorized institutions, or to additional technical data,
- e) Description of the packaging with reference to the drawing or the technical project specification,
- f) Necessary pictures showing the structure of the package, together with a short description of the packaging, of the used material, of the gross mass, the basic external dimensions and the outward appearance,
- g) Specification on the allowed radioactive content, on the physical state and chemical composition of the radioactive material (including RW), on the maximal allowed activity and the dispersivity level of the radioactive material (including RW).

Since 2000 the National Regulatory Body has issued 15 Special Arrangement Approval Certificates for transportation of waste arising from dismantling and decommissioning of SRR, 15 certificates - for transportation of the waste arising from decommissioning of one joint stock company that had a large stock of disused sealed sources as well as contaminated scrap. The same scheme and procedure is used at the present time for transportation of disused sources to repository. The total amount of movement of all waste (including reusable and non-radioactive) arising from dismantling of SRR is given in Table 1.

Table 1 Material flux from dismantling and decommissioning of SRR

Year	1999	2000	2001	2002	Total
Metallic scrap for reuse, tons	11	31	48	23	113
Concrete for disposal, tons	9	64	230	51	364
Other materials, tons	3	38	9	11	61
Conditioned RW, tons	2	7	16	16	41
Conditioned disused sealed sources, TBq	6.2	4.6	1.8	5.2	17.8

Besides establishment and implementation of the indicated procedure of the issue of the Special Arrangement Approval Certificate, in Latvia there have also been developed and implemented other essential measures having a specific unified nature, thereby succeeding to establishing of common organizational and supervision measures and, thus, promoting ensuring of transportation safety. As the result, the following advanced solutions have been reached:

- 1) Arrangement of a situation, where the sole RW transportation operator and a highly prevailing RW consignor, nowadays in Latvia there is the State Agency "RAPA" - owing to establishment in 2000 (on the basis of SRR and of the Baldone RW repository) of a common RW management institution – the State company "RAPA" (and in January 2004 re-arranged into a State Agency), ensuring a unified administration and maintenance of the shutdown SRR as well as the whole cycle of RW management.
- 2) Besides, "RAPA", being the sole organization in Latvia dealing with RW management and, besides, actively participating in dismantling of SRR including full responsibility for all stages of decommissioning waste management and performing, according to the State subprogram "*RW Management*" (from 12 May, 2000), in particular, the following activities: a) transportation of RW and radioactive materials; b) collection, sorting, packing, processing and storage of RW; and others.

- 3) The procedure of reviewing the applications for the Special Arrangement Approval Certificate is advanced by the use for transportation of SRR D&D waste of only one type of concrete containers (A-172), of the size 1,2*1,2*1,2 m, produced in Estonia with the “Quality Certificate of prefabricated elements No. A-172/1998.08.31”, according to the Swedish technology certificate. Furthermore, this standard concrete container type (A-172) has been tested according to an upgraded IAEA requirement as Industrial package Type III or Type A.
- 4) According to the Cabinet Regulations on Road Transportation of Dangerous Loads there has been established a system of compulsory licensing/training system in radiation safety for all relevant operators /drivers of vehicles of dangerous load transportation, namely, these Regulations state that: a) by transporting the materials ADR Class 7 (“Radioactive materials”), the transportation operator shall observe the ADR agreement, the national Law on Radiation Safety and Nuclear Safety, as well as shall receive a licence for practices with sources of ionizing radiation issued by the Radiation Safety Centre, b) the drivers of vehicles shall receive the driving licence for dangerous load transportation, which is issued after completion of a special training course in the Directorate of the Road Traffic Safety and having successfully passed relevant examination. For improving of the training quality and unification of practical requirements as an essential measure can be underlined the attraction the Radiation Safety Centre staff to the special education of these drivers.
- 5) Transportation of the D&D waste is carried out only by one type of lorries (model - ZIL-OT-20), container is in a fixed position in the transportation compartment of the lorry belonging to the sole national RW management agency “RAPA” and subject to “RAPA”s Quality Management System; the route does not cross any railways and populated areas and this transportation is accomplished only in the day-time.

RADIATION AND ENVIRONMENTAL SAFETY OF RW TRANSPORTATION

For enhancing radiation and environmental safety there have been undertaken and implemented a series of basic technical measures, also taking into account IAEA recommendations on applications alternative safety measures for RW transportations under special arrangement [6].

Transportation of D&D waste from SRR to the Baldone site will be done in accordance to the European Agreement of Transportation of Dangerous Materials (ADR). Requirements of ADR for Class 7 follow the guidance of IAEA Regulations for the Safe Transport of Radioactive Material [4].

The D&D waste to be transported is in a solid state and immobilized by the injection of the binding agent (mainly – cement) inside the concrete containers as recommended in the national waste acceptance criteria (Cabinet Regulations No. 129 „Requirements for the practices with RW and related waste”). This immobilized waste can be considered as Low Specific Radioactive Material III (LSA-III) or, if conditioned in containers without immobilization before transport, as Surface Contaminated Objects II (SCO-II). In both cases waste packages should meet the IAEA requirements [4] for Industrial Packages Type II. As already mentioned above, the applied standard concrete container proposed (A-172) has been tested to an upgraded IAEA requirement as Industrial package Type III or Type A. The maximal allowed activity of the package ensuring its safe transportation is specified in the Cabinet Regulations No.129.

Risk Management and Communication

There have been evaluated basic potential hazards [7] related to transportation of D&D waste from Salaspils to Baldone. Regarding to offsite safety for D&D waste transportation, it can be assumed: approximately $2 \cdot 10^6$ km distance is generally supposed as the threshold limit for assuming a significant

road accident [5,8] which corresponds to approximately 80,000 journeys from SRR to Baldone repository. Even in the case of an accident, the packaging of the waste – in accordance with the aforementioned International and national regulations – ensures the minimization of dispersion of radioactivity. For such a general situation, a simple contingencies plan, focused on communications for a quick response from the responsible organization and of the authorities, may be assessed as sufficient.

Besides, the transportation of SRR waste to the Baldone repository even during the maximal activity of SRR dismantling activities will be of relatively small size: the average transportation frequency will be approximately one transportation in several weeks, with a maximum of two-three transportation operations in a day.

In compliance with generally accepted requirements [4,8] ordering for the transportation operators to establish proper emergency response plans and emergency response units as well as to develop and implement appropriate Quality Assurance programme [9], “RAPA” as the sole national operator of RW transportation has implemented a series measures for management of the occurrence of non-compliance and/or incidents/accidents, in particular, to prevent radiological accidents and to mitigate their consequences, namely:

- a) Two local plans, in agreement with relevant local municipalities:
 - 1) “preparation for and action in the case of accident in srr of “rapa””, specifying
 - 2) Detail obligations and responsibilities for the rw , and
 - 3) “preparation for and action in the case of accident in the baldone rw disposal site;
- b) Has established an operative emergency response team.
- c) With the aim to enhance the general confidence level for rw management and, in particular, for rw transportation, has implemented the quality management system based on iso 10013 and currently being updated in compliance with ISO 9000 standards.

For enhancing the risk communication capabilities, a special local phone communication network for the whole agency “RAPA” has been established.

The requirement to establish the main national plan for emergency response is fulfilled by accepting in April 2003 the Cabinet Regulations “Requirements to preparedness for radiation accident and to actions in case of such accident”

For general upgrading of emergency preparedness and ensuring the maximal possible environmental safety level, “RAPA’s” emergency response unit and RW transportation personnel is regularly subject to advanced training in the frame of IAEA Regional and National Projects as well as in the Baltic-Sweden Project on Cooperation in radiation safety issues.

Proper level of operational and environmental radiation protection is also ensured by the State control programme of radiation objects of National significance, providing, in particular regular α -, β - and γ -monitoring of Salaspils and Baldone sites, including:

- Gamma background – in the control and supervision zones;
- Radioactive contamination control:
- In the workplaces in the control and supervision zone (alpha and beta surface contamination),
- Soil contamination (beta, gamma),

- Air contamination (beta, gamma),
- Contamination of plants (beta, gamma).

With the purpose to control and ensure radiation and environmental safety of the territory being crossed by the transportation route, the Radiation Safety Centre carries out - using carborne mobile laboratory - regular off-site monitoring - gamma survey, in particular, of the Riga city region, which includes the area around the State agency "RAPA" too. According to the State control programme of the ionizing radiation objects of national significance, the Radiation Safety Centre carries out - 4 times per year - gamma surveys monitoring of the RW transportation route (the road Salaspils – Baldone).

Carbone mobile laboratory, granted to Latvia and implemented in the monitoring programme by the Danish Emergency Management Agency, has been equipped with the NaI(Tl)-detector, the Exploranium GR320 spectrometer, the Exploranium GR660 software as well as with Differential Geopositioning System (DGPS). The detector is mounted on the roof at the height of 220 cm - towards the rearward side of the roof and being located on its right side..

The optimum driving speed is 30 – 40 km/h, detection radius - 20 m. During the search the data are analyzed with the Exploranium GR660 software. While measuring it is possible to see colour plots (rainbow) of the spectra (see Figure 1.).

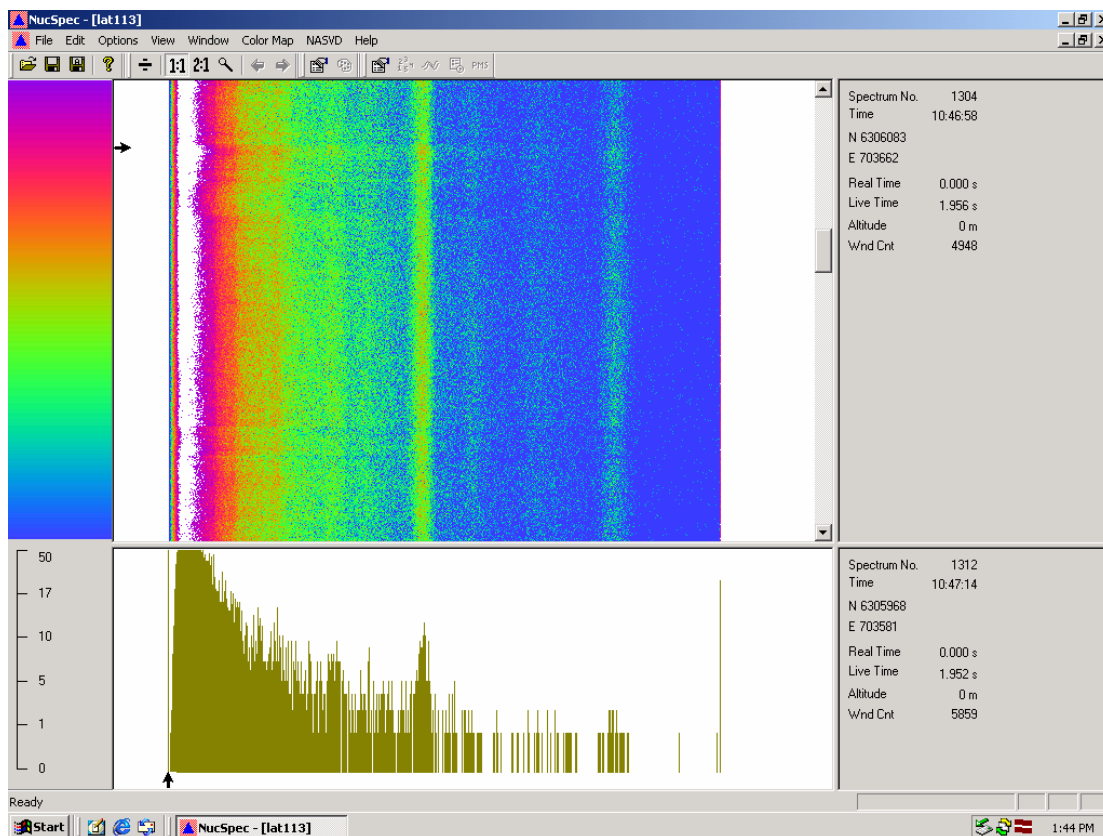


Fig. 1. Layout of the NUCSpec software with an open data file

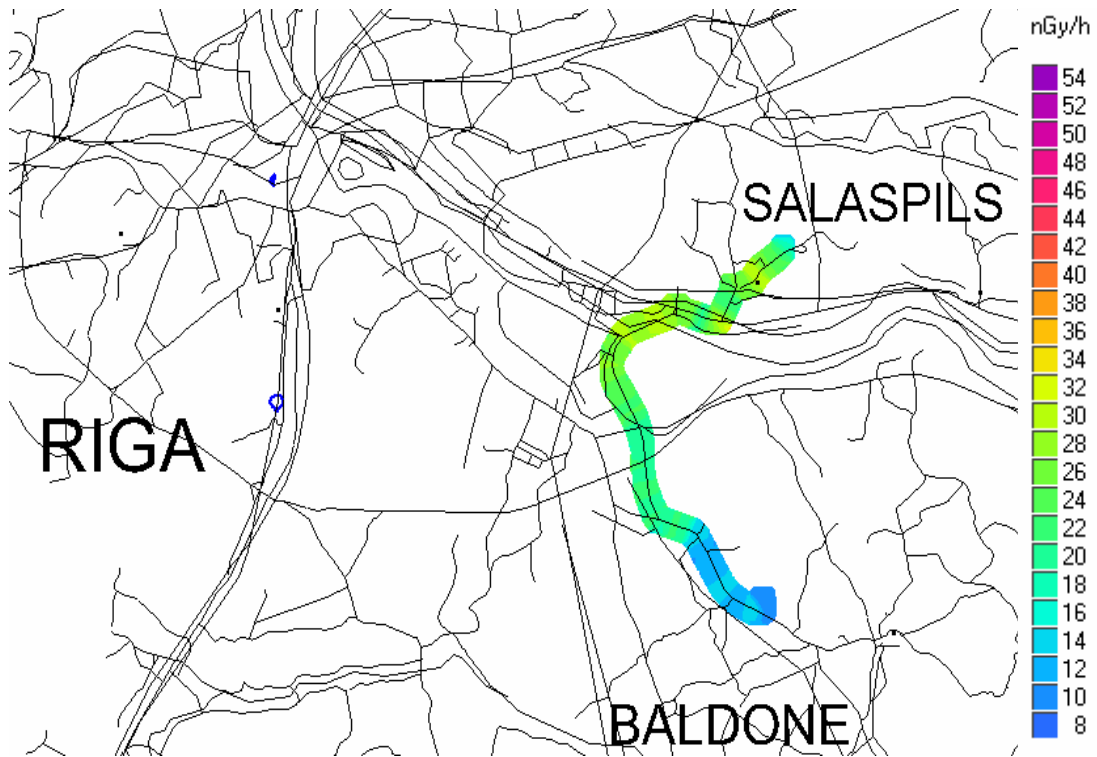


Fig. 2 Map of dose rates measured along RW transportation route Salaspils – Baldone, spring 2003.

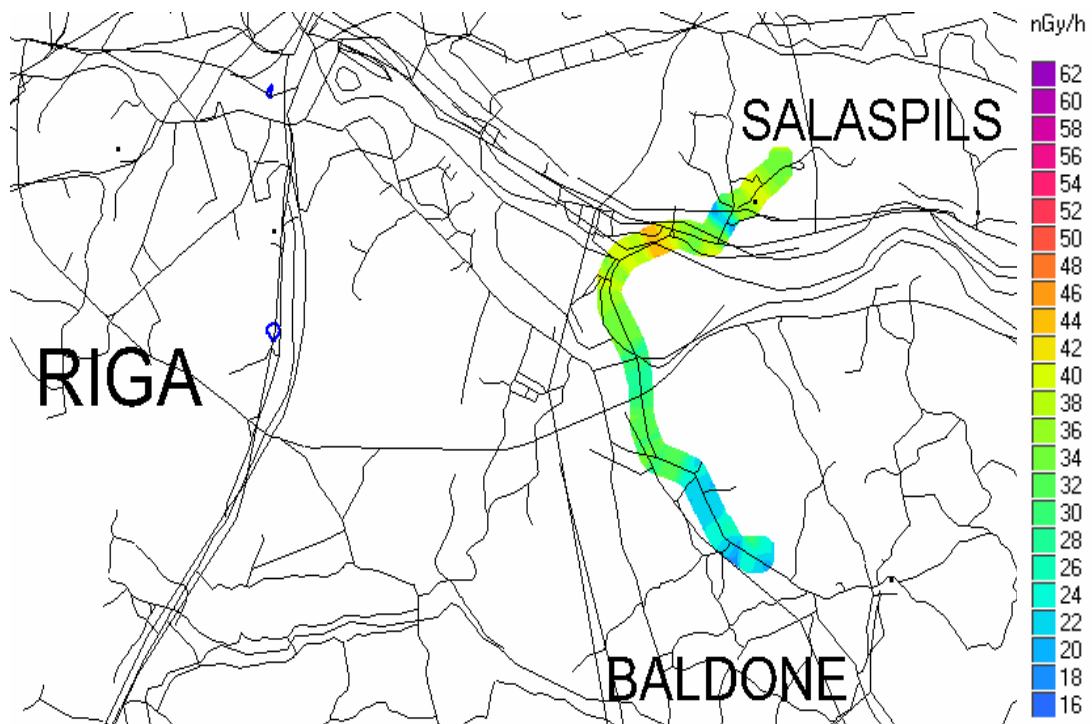


Fig. 3 Map of dose rates measured along RW transportation route Salaspils – Baldone, autumn 2003.

Each spectrum is shown as a horizontal coloured pixel line, the horizontal axis corresponds to the energy (channel number), colour – to the number of counts in channel. Afterwards the data are analyzed with the Nucspect software which includes facilities for the Noise Adjusting Singular Value Decomposition (NASVD) processing where it is possible to reconstruct single measurements with the noise removal – or one can just analyse the general shapes found in the series of measurements. The derived air kerma rates are plotted on a map. On the road Salaspils – Baldone air kerma rates were determined in the range 8 – 62 nGy/h (see Figure 2. and Figure 3.)

Therefore, the accumulated data of the carborne monitoring of the RW transportation route show that the gamma-background dose rates in the nearby region does not exceed the normal average gamma-background dose rate values, thus, the RW transportation process has no harmful impact on the radiological status of the relevant environment.

In compliance with the already accepted advanced international practice and recent recommendations [10, 11] on proper transparency and stakeholder involvement in all stages of RW management – including RW transportation – the Radiation Safety Centre provides the information of public on radiation safety issues and data, including on the carborne gamma monitoring data by publishing them in the Annual Reviews of the Radiation Safety Centre.

CONCLUSIONS.

The elaborated system of RW transportation arising from dismantling and decommissioning of Salaspils Research Reactor ensures compliance with the complete set of regulatory requirements for safe transportation of radioactive materials. Regarding the environmental radiation safety of RW transportation such conclusion is confirmed by the initial set of data obtained by the carborne mobile gamma survey.

The developed for the particular facility (SRR) solutions, will – after their forthcoming development - serve for further optimization of RW transportation and, finally, for a whole optimization of management of the RW arising from SRR dismantling and decommissioning. At the same time, the derived features could be considered as a relatively generic sample, and, being properly generalized, can be extrapolated to optimization of disposal and transportation of the D&D waste also in the case of other research reactors as well as transportation of RW being of similar origin, with the basic aim to succeed the observance of requirements and recommendations on radiation and environmental safety as well as reaching the best possible economical circumstances of the D&D waste transportation.

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