The Management of the Radioactive Waste Generated by Cernavoda NPP, Romania, an Example of International Cooperation – 13449

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ABSTRACT

The design criteria and constraints for the development of the management strategy for radioactive waste generated from operating and decommissioning of CANDU Nuclear Units from Cernavoda NPP in Romania, present many specific aspects. The main characteristics of CANDU type waste are its high concentrations of tritium and radiocarbon. Also, the existing management strategy for radioactive waste at Cernavoda NPP provides no treatment or conditioning for radioactive waste disposal. These characteristics embodied a challenging effort, in order to select a proper strategy for radioactive waste management at present, when Romania is an EU member and a signatory country of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. The helping of advanced countries in radioactive waste management, directly or into the frame of the international organizations, like IAEA, become solve the aforementioned challenges at adequate level.

INTRODUCTION

Starting in October 1996, Romania became a country with an operating nuclear power plant (NPP). Reactor 2 reached criticality on May 6th 2007 and it started its commercial operation in October 2007. The Ministry of Economy and Finance, decided to proceed with the commissioning of Units 3 and 4 of Cernavoda NPP, soon.

The main objective of Romania's National Policy for radioactive waste management is reasonable minimum impact of the waste management activities on population and environment, according to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, ratified earlier by Romania. The National Nuclear and Radioactive Waste Agency's (AN&DR's) strategy on low (LLW) and intermediate level waste (ILW) disposal has as objective the putting in operation of the Final Repository for LLW and ILW (LILW), the (DFDSMA) Saligny in 2019. This facility is in the responsibility of the AN&DR. However, wastes arising from the Cernavoda NPP must be treated, in order to achieve the Waste Acceptance Criteria (WAC) of DFDSMA Saligny. The related Radioactive Waste Treatment Facility (RWTF) is the responsibility of Cernavoda NPP. The main requirement for the RWTF is the necessity to achieve the treatment and conditioning of radioactive wastes that arise both from NPP operations and from future decommissioning activities, required for compliance with the WAC of the DFDSMA Saligny.

The DFDSMA Saligny will be designed to satisfy the main performance objectives on the basis of a set of WAC resulting from the best international practices, taking into account the local conditions, the requirements of AN&DR and applicable IAEA recommendations. In order to comply with the Saligny Repository WAC, it is necessary to adopt designed waste processing strategy.

DESCRIPTION OF PRESENT STATUS OF WASTE MANAGEMENT

Waste Inventory

In order to evaluate the different possibilities for safe management of short lived LLW and ILW (LILW-SL), the following waste streams and quantities (in m^3/year/reactor) from the Cernavoda NPP Romania, were used [1]:

- *Ion-exchange Resins* in two types: those which have been in contact with the fuel (FC) (~65%) and those which have not (NFC) (~35%). Total yearly volume is 6 m^3 and total activity is 18.5 Terra Becquerel (Tbq). These resins are stored in three concrete tanks adjacent to the power plant;
- *Compactable Wastes* consists mainly of materials resulting from decontamination and maintenance operations; typically clothing, plastics, rubber gloves, etc. This waste is packed into standard 220 litre (L) stainless steel drums and lightly compacted giving a volume reduction of approximately two (50%). The drums are then stored on the site, in a conventional industrial-quality building. Total yearly volume is ~25 m^3, and total yearly activity is 2.7 E^{-2}Tbq, with reference average density of 150 kg/m^3. After low compaction in drums, the density increases to about 440 kg/m^3;
- *Non-Compactable Wastes* arise mainly from maintenance operations and is typically metallic components, contaminated materials and equipment. The storage containers are the same as for the *Compactable Waste* (though it is not compacted) and the two waste streams share the same storage building. Total yearly volume is ~15 m^3 and total yearly activity is 7.4 E^{-3}Tbq, with reference average density of 227 kg/m^3;
- *Filters* come in five sizes, ranging from 120 mm in diameter and 1,150 mm long, to 455 mm in diameter and 1,400 mm long. Total yearly volume is 2.5 m^3 and total yearly activity is 7.4 E^{-2}Tbq.

There is a fifth waste stream comprising a range of organic liquids that the NPP operators already processed using the Synthetic Absorbent System (NOCHAR polymer) process and packed into 220 L drums. The contact dose rates from this material are generally low, in the order of a few micro Sievert per hour (μSv/h). The waste volumes are low, typically 2 m^3/year. Consequently, waste handling within the RWTF requires no special procedures or processes. It should be noted that there is also a strong possibility that waste immobilized by NOCHAR is to be sent to STUDSVIK, Sweden, for incineration, in which case it would be returned to Cernavoda as ash or immobilized ash in concrete.

In order to establish the waste management strategy, it was necessary to take into account both operational and decommissioning waste. Operational waste was evaluated on the basis of already more than 15 years of operation with enough accuracy, but for decommissioning waste, there were effectuated some suppositions, because no CANDU reactor has been decommissioned and few data about dismantling radioactive waste were available.

Taking into account the fact that a decommissioning plan is based on the inventory of existing equipment's and that the data come from a study already performed, it is possible to consider that the volumes foreseen for dismantling are enough robust data [2]. First of all considered, were the following probable key data for Cernavoda NPP, presented in Table I.

TABLE I. The Probable Key Data for the Cernavoda NPP Life.

Commissioning		End of operation	End of conservation	End of decommissioning
Unit 1	1996	2036	2064	2080
Unit 2	2007	2047	2064	2080
Unit 3	2019	2056	2066	2080
Unit 4	2020	2056	2066	2080

On the basis of the ANDRAD (former name of the National Agency for Radioactive Waste) report, the major volumes of radioactive waste categories, presented in Table II, were considered.

TABLE II. Overall Waste Amount Estimated at the Cernavoda NPP.

Waste type	Operating	Refurbishing	Dismantling	TOTAL
Compactable waste	15,500 drums ($3410\ m^3$)	-	12,936 drums ($2736\ m^3$)	27,936 drums ($6146\ m^3$)
Non-Compactable waste	8,950 drums ($1969\ m^3$)	$3200\ m^3$	$13,680\ m^3$	8,950 drums + $16,880\ m^3$
Spent ion exchange resins ("fuel contact" i.e. mainly PHTS and BCU)	$930\ m^3$	-	$80\ m^3$	$1010\ m^3$
Spent filters	$310\ m^3$	-	$32\ m^3$	$342\ m^3$
"Organic liquids": spent oil, flammable solids, etc.	$310\ m^3$	-	$304\ m^3$	$614\ m^3$

Estimation of the radionuclide inventory of the decommissioning waste, accumulated during the operational period, is based on Canadian experience on CANDU 600 Reactors and it is presented in Table III.

Radioactive Waste Management Evolution to Cernavoda NPP

In the period of 1992-1998, under former National Authority for Electric Power-Nuclear Electric Group (RENEL-GEN) coordination, the concept of a repository with its treatment plant included, was developed by Subsidiary of Technology and Engineering for Nuclear Projects (SITON). The site selection program has included 37 potential surface sites in all of the country.

TABLE III. Overall Activity Inventory Estimation at the Date of Closure - 2080.

Nuclide	Operation (Bq)	Dismantling (Bq)	Total + 50% margin (Bq)
C-14	3.49E+13	2.96E+13	9.67E+13
Cl-36	1.65E+07	3.18E+09	4.80E+09
Cm-244	9.76E+09	2.05E+10	4.54E+10
Co-60	1.12E+11	1.07E+15	1.61E+15
Cs-134	4.61E+07	4.88E+07	1.42E+08
Cs-137	1.57E+13	5.10E+10	2.36E+13
Eu-152	1.21E+11	1.68E+09	1.84E+11
Eu-154	6.11E+09	6.79E+09	1.93E+10
Eu-155	1.72E+07	2.23E+09	3.36E+09
Fe-55	2.46E+09	5.45E+14	8.18E+14
H-3	1.06E+14	5.08E+12	1.66E+14
I-129	4.94E+08	5.41E+04	7.40E+08
Nb-93m	5.94E+06	3.72E+11	5.58E+11
Ni-59	2.27E+06	8.14E+07	1.26E+08
Ni-63	2.68E+10	1.59E+13	2.39E+13
Pu-241	1.45E+12	1.38E+15	2.07E+15
Ru-106	2.65E+11	5.89E+11	1.28E+12
Sb-125	6.92E+02	8.00E+03	1.30E+04
Sr-90	7.46E+12	4.09E+10	1.12E+13
Alpha LL	3.72E+12	4.50E+11	6.25E+12
Beta LL	1.12E+11	1.41E+12	2.28E+12

In 1994, after a complex of site selection program, the following three potential sites were selected: Mireasa, Cernavoda and Saligny. In 1995, after the completion of the local preliminary site investigations, only two candidate sites near Cernavoda NPP were selected: the Cernavoda and Saligny sites, respectively. The SITON has subsequently proposed and performed a prefeasibility study on the one of candidate site near Cernavoda NPP, named Cernavoda III, located at 3.5 km from the NPP site, with an available surface of 120 hectares, which was considered the best site [3]. The related RWTF includes a semiautomatic 1,500 t compactor, a grouting station for super compacted drums (pellets, or discs, or pucks) and drums immobilization in disposal containers and spent resin cement solidification station for immobilizing resins in disposal containers. Organic liquids are treated by others. Disposal containers were not yet imposed. However, the Beneficiary has preferred in 1996, the other site named Saligny, in the exclusion zone of NPP, located at 0.5 km from NPP site, with the there about 30 hectares available area due to local problems. The Cernavoda III site was considered in stand-by.

Accordingly, SITON has modified the prefeasibility study on the new site that implied more care in the design, due to limited area and low stabilization of setting field. The general feature of shallow land repository was provided with multi barrier system shaving disposal cells, like L'Aube in France and El Cabril in Spain. After some studies, an alternative with cells of 14 m long, 7 m wide and 4.5 m deep, for disposal of 380 cylindrical fiber reinforced containers (CBF-C type) with diameter of 0.85 m and height (H) of 1.25 m, was selected. The related RWTF located in the same enclosure, includes the same processes as in the previous study. The aforementioned prefeasibility study benefited from IAEA guidance, in the frame of the IAEA project ROM/9/14 "Review of Radioactive Waste Management at Cernavoda NPP".

Also, in the order to procure the best suitable waste management technology, SITON transmitted to some radioactive waste agencies in Europe, a request for a preliminary offer. SITON received in 1997 the free preliminary offers from ANDRA, France, ENRESA, Spain, DBE, Germany and AEA, the United Kingdom. The analysis of these offers performed by SITON was also assisted by IAEA but, in the frame of the project ROM/9/31 "Repository for Low and Intermediate Radioactive Waste for Cernavoda NPP".

After a comprehensive and complex analysis, SITON selected to base the designs and management of the new cells on the L'Aube and El Cabril repository experiences, taking into account the limited available area of the Saligny Site (maximum 30 ha available area, of instead of the 120 ha at the Cernavoda III site). The new cells had the following dimensions: length 23 m, width 18.5 m and depth 10 m, for accommodating 320 rectangular concrete containers, measuring 2.25 m by 2.25 m by 2.2 m, based on designs and experiences gained at El Cabril site [4]. Likewise, the technology at the El Cabril site for high automated processing of radioactive waste was selected and implemented into the RWTF sited into same enclosure.

The WAC for the DFDSMA Saligny were assessed in the same time, in the frame of the Project extended and for Romania, named "Poland and Hungary: Assistance for restructuring their Economics" (PHARE) no. 4.10/94 "Technical Basis and Methodological Approach for WAC in Romania", in collaboration with AEA Technology, Belgatom and NIREX, in the period of 1997-1999. In period 1998-2005, the project slowed down, due to mostly non-technical reasons.

In 2005, ANDRAD (presently included in AN&DR) started to coordinate the sitting process by collecting and endorsing of the technical support studies elaborated by SITON and the Nuclear Research Subsidiary (SCN), for site confirmation. The work has been concentrated on the repository, without related RWTF.

In 2006, as a result of some studies and of the Conceptual Project [5], [6], [7], an initial safety documentation was prepared by SITON and SCN, on the AN&DR's request, having El Cabril technology as the basis. This documentation was assessed into the frame of IAEA Waste Management Assessment and Technical Review Program (WATRP), in 2007. In the new Safety Assessment of Saligny Repository, the IAEA recommendations have been implemented immediately by SITON resulting in a safer repository [8]. This revised documentation was submitted to Regulatory Body - Committee for Nuclear Activity Control (CNCAN), for site licensing. The configuration of this repository is presented in Figure 1 [9].

Also, AN&DR tries to improve the repository design, this activity being supported in international frame on the basis of open tendering into the PHARE project, entitled: "Support to ANDRAD to get the sitting license for Saligny LILW near surface repository", project PHARE RO 2006/018-147.05.01. This project has elaborated upon by the ONET Technology, France, which has reconsidered the prefeasibility study on the basis of more local site investigations and has proposed more suitable technical solutions, based on a feasible waste container type CBF-K.

The waste processing has been considered as reference only, being the responsibility of NPP operator.

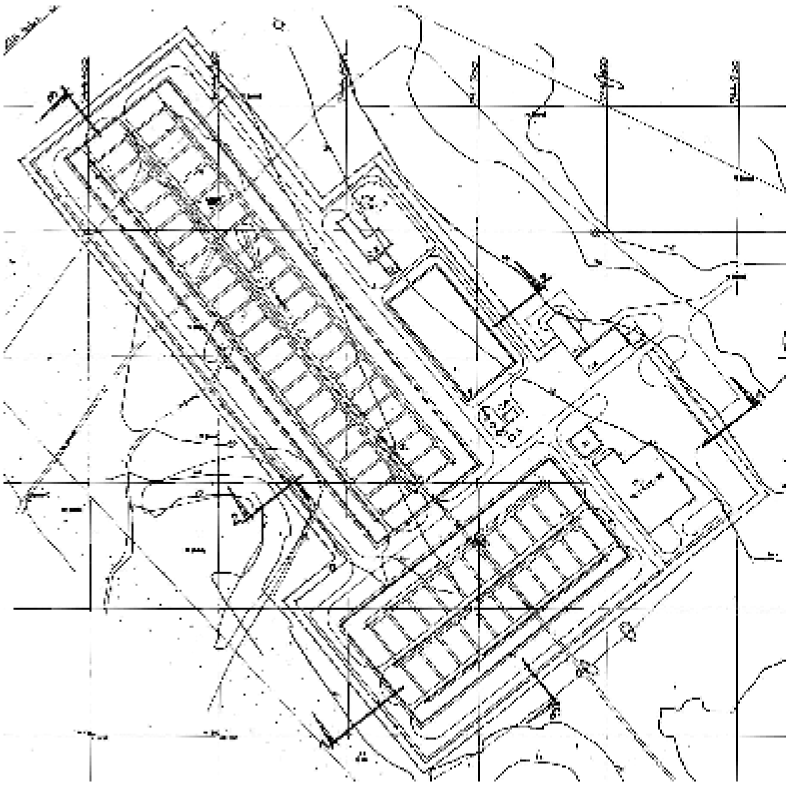

Fig.1. Saligny Repository Configuration to Conceptual Project Phase.

In 2008, AN&DR has received the partial sitting license, in order to finalize the Saligny site characterization and prepare the urban planning documentation.

In 2010, AN&DR has received an extension of partial sitting license. Simultaneous, AN&DR request the elaboration of reconsidered Project and Preliminary Safety Analysis, for construction licensing. This activity, has been supported into the frame of the project PHARE RO 2006/018-411.03.03 "Design and Safety Assessment for Construction of Saligny L/ILW National Repository".

In 2012, AN&DR submitted to CNCAN for review, the last version of Technical Project and the Preliminary Safety Report of the Saligny Repository. Also, AN&DR requested the elaboration of the Conceptual Project for a Radioactive Waste Treatment Facility, suitable for the Saligny Repository WAC, in order to be sure that, the Saligny Repository's requirements will be properly meet. This project was elaborated upon by NUVIA, UK, in collaboration with SITON, in the frame of the project PHARE FT 2007/19343.06.05, entitled "Support to AN&DR in Developing the Technique and Technological Solutions for a New Radioactive Waste Treatment Plant". Current status of the near surface repository for LILW-SL from Saligny, near Cernavoda NPP, was presented by AN&DR, into the frame of IAEA Workshop on Auditing and Verification of Radioactive Waste [11].

Radioactive Waste Treatment Strategy Evolution

The radioactive waste treatment strategy selected by SITON was dependent on the existing possibility to storage and disposal of radioactive waste.

The existing storage capacity to Cernavoda NPP consists in an Interim Storage Facility with a nominal capacity of 20 years per one reactor, amounting to 1,408 m^3, which is estimated to be enough until 2019 - 2022, depending upon new units operation.

Also, the project for the new Radioactive Waste Repository (DFDSMA) at Saligny, located in the exclusion zone of Cernavoda NPP, is in its final stage. In order to establish the optimum strategy for radwaste processes, it was started to the proposed technologies for management of radwaste generated to Cernavoda NPP, into the frame of received preliminary offers. They were identified in the preliminary studies, 5 alternatives for radioactive waste treatment to comply with repository WAC. In addition, 4 supplementary strategies were evaluated, all being presented in the Table IV. The last alternative, no. 9, was preferred by AN&DR, as being more suitable for Cernavoda NPP specific requirements. The origins of these nine technologies are the following:

- Alternatives 1A, 1B, 1C - ANDRA and SGN, France
- Alternative 2 - ENRESA, INITEC and E.N., Spain
- Alternative 3 - DBE, Germany
- Alternative 4 - AEA TECHNOLOGY, UK
- Alternative 5 - SCN PITESTI, Romania
- Alternative 6 - NUVIA, UK
- Alternative 7 - SITON, Romania
- Alternative 8 - SITON, Romania
- Alternative 9 - ONET, France, NUVIA, UK and SITON, Romania

Table IV shows the main characteristics of these alternatives which have already been developed, to the different stadia of prefeasibility and feasibility studies. Alternative no. 9 is now in review stadium, for approval. The main difference consists of spent filter cartridges handling, which is transferred to Cernavoda NPP's responsibility, in the last alternative. Also, it is provided that, the spent resins will be transferred to the RWTF in a special shielded over-pack, with a defined specification, but not yet designed. Presently, it is in development the Saligny Repository (DFDSMA), in the alternative with CBF-K containers, as reference Disposal Container.

Also, the alternative 9 contains some innovative treatment technologies, which improve the waste volume reduction. These technologies are detailed later, in the dedicated chapter.

Description of Present Technical Solutions for the Saligny Repository

Presently, the proposed disposal concept has resulted from the approved Technical Project, which consists also of a near-surface disposal facility, with multiple barriers.

TABLE IV. The Main Alternatives of Radioactive Waste Treatment Technologies Evaluated for Radioactive Waste Disposal to Cernavoda NPP.

Alternative No.	Cells Dimensions	Container Dimensions	Containers /Cells No.	Main Processes Differences
1A	Exterior diam. 14x7x4.5 m	Cylindrical CBF-C Ø =0.85 m, H=1.25 m	400	- super-compaction 2000 t; - organic liquids treated by others
1B	Exterior diam. 14x7x4.5 m	Cylindrical CBF-C Ø=0.85 m, H=1.25 m	400	- no super-compaction; - organic liquids treated by others
1C	Exterior diam. 14x7x4.5 m	Rectangular CBF-K 1.7x1.7x1.7 m	64	- same technology like 1A; - other container dimensions
2	Exterior diam. 23x18.5x10 m	Rectangular 2.25x2.25x2.2m	320	- spent resin immobilized in mobile installation; - super-compaction 3000 t; - cementation of organic liquids in waste mortar
3	Exterior diam. 25.5x18.5x8.7 m	Rectangular 3x1.7x1.4 m	400	- super-compaction 2000 t; - spent resins drying
4	Big cell with separation wall as necessary	Rectangular metallic or concrete container	Not specified	- only mobile installations
5	Not established	Metallic drum 400 L	Not specified	- cementation of drums in cell
6	Exterior diam. 29.1x15.6x7.5 m	Rectangular module	216	- same technology like 2
7	Exterior diam. 29.1x15.6x5.5 m	Rectangular module 2.25x2.25x2.25 m	144	- same technology like 2
8	Exterior diam. 29.1x15.6x5.5 m	Rectangular module 2.25x2.25x2.2 m	144	- super-compaction 1500 t; - organic liquids burned; -spent resins immobilized in fixed installation
9	Internal diam. 27.9x15.2x5.7 m (ONET)	Rectangular CBF-K 1.7x1.7x1.7 m (ONET)	384	- innovative technologies (NUVIA); - organic ashes are cemented

The preferred site is in the Cernavoda area, inside the exclusion zone of the Cernavoda NPP site (Saligny) and the land owners are: Saligny Local Council and private owners. The Repository is dedicated to LILW-SL, with certain quantities of LLW generated by operation, refurbishment and decommissioning of 4 Units at the Cernavoda NPP site. The maximum capacity of the approved configuration is about 122,000 m^3. The improved site surface is 40 ha, arranged by a part of superficial silty loess stratum removal. The effective repository surface is 22 ha, which can accommodate 64 cells, with following dimensions: 27.9 m long, 15.2 m wide and 5.7 m height, accommodating up to 24,576 disposal modules of CBF-K type, measuring 1.7 m, by 1.7 m, by 1.7 m. Each cell capacity is designed for 384 disposal modules in rectangular array (of 8 by 16 modules, in three levels). The concept of the Repository is based on interdisciplinary studies that took into account, the experience of the developed countries obtained in the aforementioned IAEA and PHARE programs. The disposal structure will be constructed in accordance with specifications of accepted procedures and with the provisions of a rigorous Quality Management System program. The environmental protection requirements constitute integral design requirement for the Saligny Repository. The prevailing loessoid soils are sensitive to rain humidity in operation period and will require correlated geotechnical and construction measures to address. The main characteristics of the Saligny Repository, with its multiple-engineering barriers system, can be summarized as follows:

1) Reinforced concrete structure in the walls and the botoms of all disposal cells are lined with a water proof coating (typically epoxy resins) and then covered by a slab, after cells filling with diposal modules;
2) Caping system with alternanate impemeable and non-impermeable strata, which provide long-term protection to the cells against meteoric water infiltration; and
3) Drainage system to detect and collect any infiltration water.

The configuration of this last version of the Saligny Repository layout is shown in Figure 2.

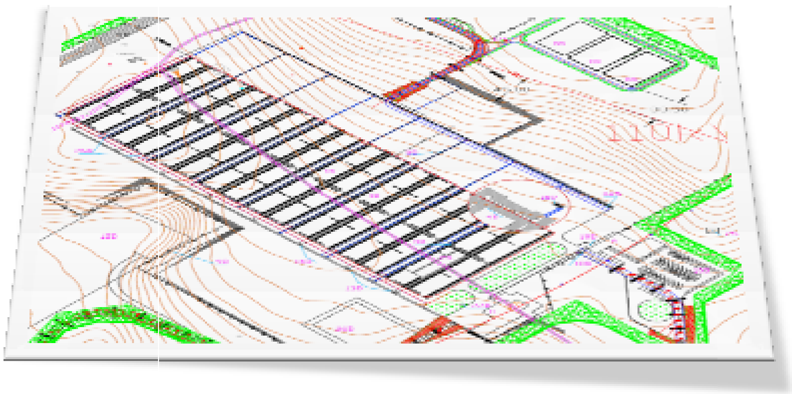

Fig.2. Saligny Repository Present Configuration.

Description of RWTF Evolution

The processes for radioactive waste management, in compliance with the WAC of Saligny Repository, were proposed to the Technical Project according the waste handling processes, illustrated in Figure 3 [10]. These processes include assumptions that, can be summarized as follows:

- The disposal module consists of a 5 m^3, cubic concrete container;
- The external volume of the container is 5 m^3;
- The thickness of the container is 10 cm ;
- The mass of the empty container is 4,275 kg;
- "Homogeneous" waste means powdery or dispersable waste;
- Homogeneous waste is to be solidified into a solid matrix before conditioning into the disposal module;

- Filters are first crumbled, and therefore are then considered, as homogeneous waste;
- The size of the drum of solidified homogeneous waste is to be selected according to the activity of the waste: irradiating waste needs shielding, therefore shall be conditioned in small drums;
- The optimal scenario considers that filters (irradiating) are solidified into 200 L drums and resins (less irradiating than filters) and liquids (low, to very low activity levels), are solidified into 400 L drums.

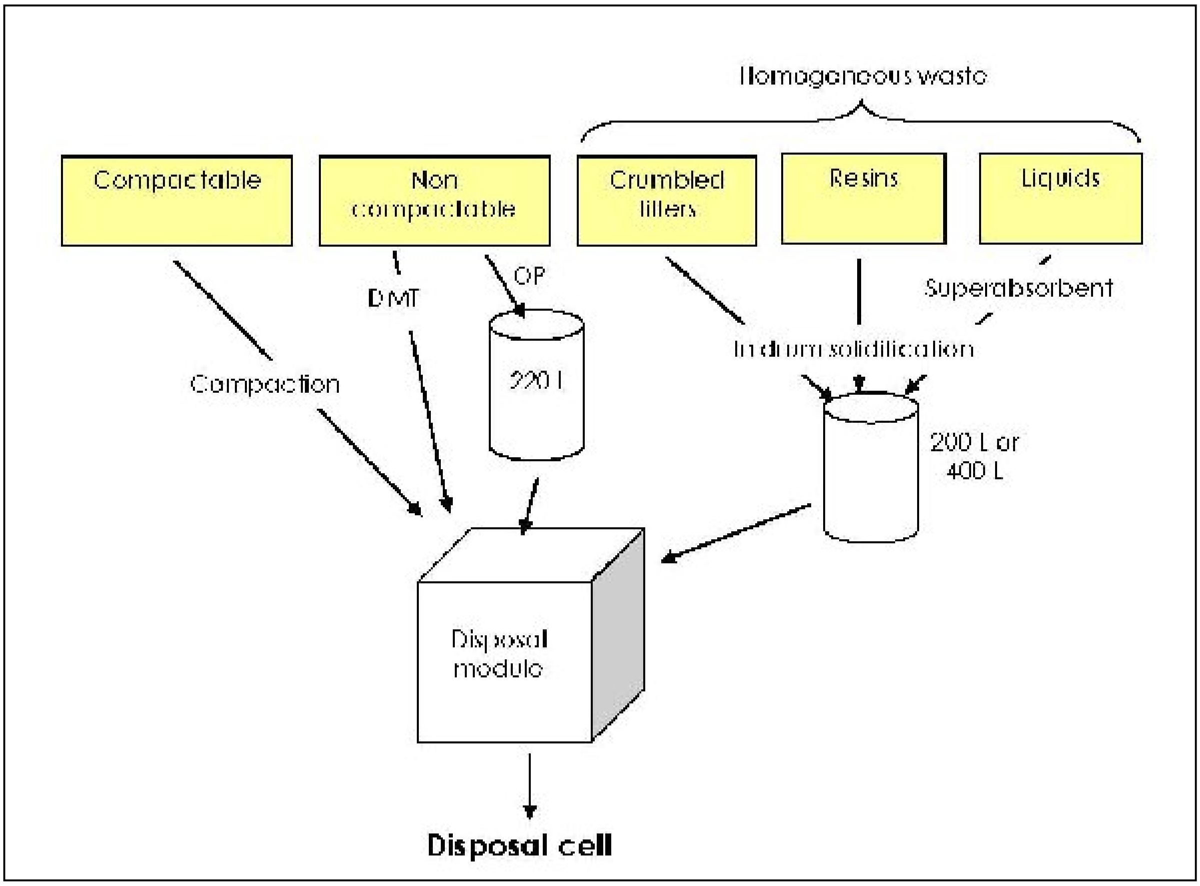

Fig.3. Radioactive Waste Management to Technical Project Phase.

In the frame of the PHARE Project FT 2007/19343.06.05, entitled "Support to AN&DR in Developing the Technique and Technological Solutions for a New Radioactive Waste Treatment Plant"(2009), these processes were improved according to the fluxes presented in Figure 4 [12].

The design has been developed from detailed work, carried out by NUVIA with SITON support and which included a review of available technology and an option study, together with a continuous dialogue with AN&DR staff. This allowed the basic RWTF processes to be developed, as summarized in Table V.

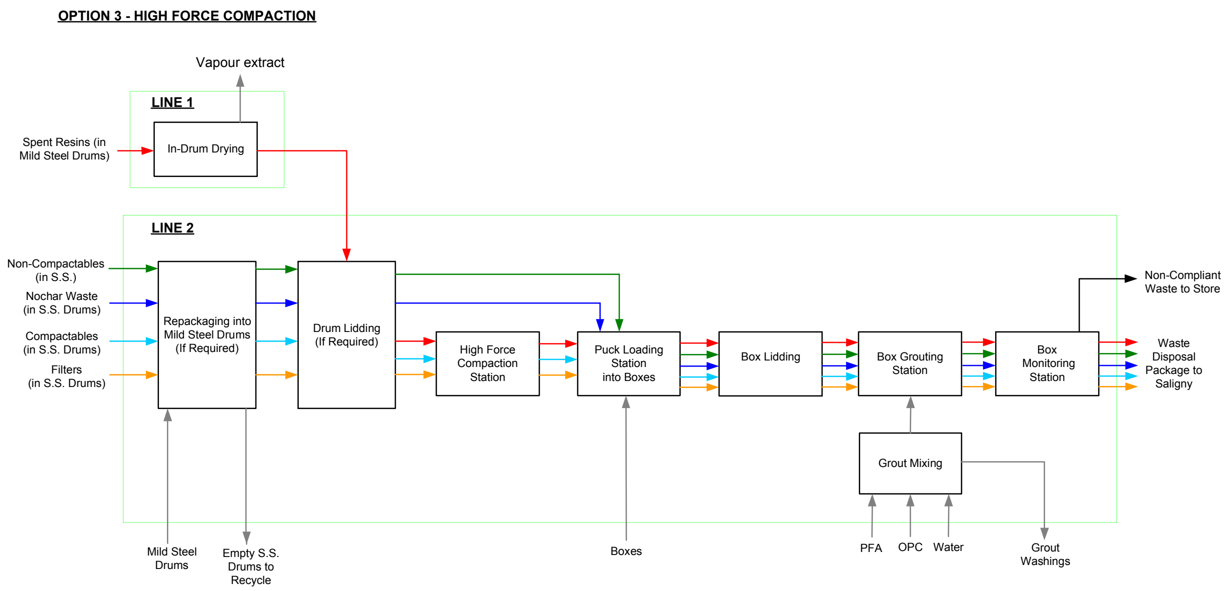

Fig.4. Improved Waste Treatment Technology Process Proposed by NUVIA.

TABLE V. Summary of the Processes Carried Out in the RWTF.

Waste stream	Imported into the RWTF	Process 1	Process 2	Final form
Ion exchange Resin	In a special steel drum within a shielded Over-pack	Drying	Super-compaction	Super-compacted discs are grouted into the CBF-K module
Compactable	In the drums used for interim storage	Super-compaction		Super-compacted discs are grouted into the CBF-K
Non-compactable	In the drums used for interim storage	Contents are emptied into a CBF-K		Waste is grouted into the CBF-K
Filters	In a shielded Over-pack	Transferred into a CBF-K		Waste is grouted into the CBF-K

Radioactive Waste Processes

- ***Resins* -** There are three Resin drying stations allowing a throughput from the drying station of three drums per day. The drums containing dried Resin are reduced in height from 850 mm, down to ~445 mm discs, by Super-compaction. Therefore it is possible to load the CBF-K module with 12 discs (arranged in three layers of four) and this will take four days.
- ***Compactable Waste* -** The Compactable Waste drums are reduced in height, from 850 mm, to ~310 mm, by Super-compaction. Therefore, it is possible to load the CBF-K module with 16 discs, arranged in four layers.

- ***Non-Compactable Waste*** **-** It is estimated that the contents of 18 drums of Non-Compactable Waste drums fills one CBF-K module. The Non-Compactable Waste Cell should be able to unload at least, one drum per hour. This would enable a CBF-K box to be filled, in about two days.
- ***Filters*** **-** The current assumption is that, eight Filters are loaded into each CBF-K module. The expected time to take an over-packed Filter into the cell, remove the Over-pack, load it into the CBF-K module and remove the empty Over-pack, is two hours. This would enable a CBF-K module to be filled, in about two days.
- ***Grouting*** **-** The waste will be processed on a campaign basis and the grout plant will accept CBF-K modules, as they become filled with waste. On arrival at the grouting station, the lid is sealed in place. The grout delivery arm is placed into the top of the box and grout is delivered at ~1 L/second (s). The modules containing Filters require the largest volume of grout, estimated to be 2080 L. On completion of grouting, the mix plant is washed down. The CBF-K is moved from the grout delivery station within the first 2 hours of grouting completion, to the grout curing station, where it remains for a further 20 hours.

The volumes of waste processed by the RWTF are estimated in conformity with SITON works. As noted above, the throughput has been calculated on the assumption that, four units are operational and thus presents the bounding case. On this basis, it is forecast that the RWTF is produce ~38 CBF-K modules each year. The average plant throughput is therefore ~1 CBF-K module per week. Provision is made for CBF-K buffering in the adjacent store.

DISCUSSIONS

Having the beneficial support from IAEA coordination, it has been possible to obtain the suitable technologies for Repository configuration and the properly processes for radioactive waste treatment, storage and disposal.

The improved site proposed by ONET has a permit to reconfigure the cells into an improved configuration, taking into account an existing high voltage electricity line, in the direction of Cernavoda NPP location. A key problem is related to the balance between more safety further above the ground water table, like in the SITON cells configuration, or having more site stability by removing some part of silty clay superficial strata with high compressibility, like in ONET configuration. The site stability is more important in this case, the difference in safety being to be substituted by improved engineering barriers.

Also, after a big effort initiated by SITON, in the frame of the program of research-development for Cernavoda NPP radioactive waste management, with proper international support of IAEA and European Developed Countries, the present strategy for waste processing was selected and accepted by AN&DR. The main differences between the technical solutions provided into Technical Project proposed by ONET and those proposed by NUVIA into the PHARE Project FT-2007/19343.06.05, agreed by AN&DR, are summarized in Table VI:

TABLE VI. From Raw Waste to Conditioned Waste.

Stream	Raw Waste		Conditioning Parameters		No. of Modules	
	ONET	**NUVIA**	**ONET**	**NUVIA**	**ONET**	**NUVIA**
Compactable	15,360 discs	14,784 discs	20 discs per module	16 discs per module	768	924
Non-compactable (from operation)	8,950 drums	10160 drums	4 drums per module	18 drums per module	2237	565
Non-compactable (from dismantling and refurbishment)	16880 m^3	16,880 m^3	Initial density = 600 kg/m^3; final = 800 kg/m^3	Initial density = 600 kg/m^3; final = 800 kg/m^3	4869	4869
Resins	1010 m^3	778.8 m^3	1 to 5; 1.6 m^3 per module	12 discs per module	2525	312
Filters	342 m^3	115.2 m^3	1 to 4; 800 L per module	8 filters per module	1710	115
Liquids	614 m^3	384 m^3	1 to 5; 1.6 m^3 per module	0.4 m^3 ash per module[a]	1919	384
TOTAL					**14028**	**7169**

[a] The ash from organic liquid incineration is immobilized by concreting in CBF-K modules

The main improvements of NUVIA project, consist of discharge of 18 drums with non-compactable waste into a CBF-K module, performed into a special enclosure, instead of filling the CBF-K module with only 4 drums with non-compactable waste, like in ONET project, in spent resin drying in drums, followed by super-compaction of these drums, and the filling of CBF-K modules with 8 filters, extracted from over-packs. Also, it is provided for the incineration of organic liquids, followed by cementation of resulting ashes, instead organic liquid cementation. The waste generated from the NPP dismantling and refurbishments considered to be processed, like in the ONET proposal.

Even if there are some differences between quantities of estimated waste, it is clear that by using NUVIA improvements, the number of modules can be reduced drastically. However, the ONET proposal for repository configuration remains the best technical solution for DFDSMA Saligny.

Also, to the Regulatory Body - CNCAN request, the IAEA approved the technical assistance, in order to improve the capacity of CNCAN for Radioactive Waste Repository licensing and consequently, there were performed the following projects:

- IAEA TC Project: ROM-9/028 – Technical Assistance for Romanian Regulatory Authorities for Enhancement of Regulating Capacity; and
- Report of Mission of Experts, IAEA no. IAEA-TCR-03852 – Assistance and Assessment of the Application of Sitting Radioactive Waste Disposal Facility Proposed for Saligny Site.

Also, it is necessary to mention that, for existing National Repository for Radioactive Waste from Baita, Bihor, there were performed some safety verification international activities, in the frame of following projects:

- PHARE Project: RO-006/SCR-A6-1 “Preparatory Measures for Long-Term Safety Analyses of National Repository for Low and Intermediate Radioactive Waste Baita-Bihor”, Risk Audit, 2001; and
- PHARE Project: RO-2002/000.632.08.01 “Preliminary Safety Analyses for National Repository Baita, Bihor”.

CONCLUSIONS

The very strict requirements, including many uncertainties and constraints concerning loessoid soil foundation with low stability and higher concentrations of mobile radio nuclides (H-3 and C-14) in the waste, drastically limited the possibilities to select the configuration of the repository and the adequate processes for radioactive waste management at the Cernavoda NPP site.

After many studies and optimization analyses, the technical solutions that meet all strict requirements derived from the special conditions of the Saligny Repository, were identified with international help. Every step of the different design activity was supported by the IAEA, in the frame of co-operation projects and by PHARE programs, in the frame of support projects.

The proposed technical solutions were established on basis of an iterative process under IAEA guides and taking into account the present best practices in the world. The processing of the radioactive wastes will be performed according to best international practices, to ensure the long-term stability of the radionuclide containers and their isolation, in optimum conditions.

As a general conclusion, it is necessary to underline the international support under IAEA guidance, which can be considered like an example of international co-operation, in order to solve difficult radioactive waste management problems, at the Cernavoda NPP site.

REFERENCES

1. Radioactive Waste that will be disposed to the Saligny Repository. Volumes and Inventory, ANDRAD, March 2007.
2. Researches for Decontamination and Management of Radioactive Waste Generated by Nuclear Facilities Decommissioning, RAAN-SITON, PN-51/07-ST/TP-MT-03, February 2009.
3. Report ST-1809-02 Prefeasibility Study of the Repository for Low and Intermediate Radioactive Waste, RAAN-SITON, Nov. 1995.
4. Report ST-2030-01 Technical Solutions Optimization to L/ILW Repository, RAAN-SITON, July 1997.
5. Report RI-1516 Study Concerning L/ILW Repository Achievement, RAAN-SITON, July 2006.
6. Contract 27406-ST-01 “Technical and Economic Assessment of the Optimum Treatment and Conditioning of L/I Level Radwastes for Final Disposal at Saligny Repository”, RAAN-SITON, Nov.2006.
7. Report RI-1543 "Conceptual Project for L/IL Radioactive Waste Repository Saligny", RAAN-SITON, April 2007.
8. Report RI-1547 "The Implementation of WATRP recommendation on Safety Analysis for L/IL Radioactive Waste Repository Saligny", RAAN-SITON, April 2007.

9. Contract DD-DFDSMA-4R22-SP-TP-MT-00 “The Prefeasibility Study for Saligny Repository”, RAAN-SITON, Nov.2007.
10. PHARE Project: RO-2006/018-147.05.01 “Support to ANDRAD to get the sitting license for Saligny LILW near surface repository. Feasibility Study for DFDSMA”, Nov. 2009.
11. C. Liţescu, O. Niculae, S. Diaconu, Current status of near surface repository for LILW-SL from Cernavodă NPP, Proc. IAEA-TCP-ROM-9031 “Improving Radioactive Waste Management in Romania” Workshop on Auditing and Verification of Radioactive Waste, 1-5 Oct. 2012, Pitesti, Romania.
12. E. Forster, S. Latinwo, V. Nesbitt, “Task 1.1: Technologies Report for Treatment & Conditioning of Cernavoda Radioactive Wastes”, Nuvia Limited, Oct. 2010.

ACKNOWLEDGMENTS

This work was supported by a grant of the Romanian National Authority for Scientific Research, CNDI –UEFISCDI, project number 156/2012.

It also benefitted from important support from AN&DR, in particular from Mr. Antonius Sorescu, Radioactive Waste Department Director.