The Very Strict Waste Acceptance Criteria for Saligny L/ILW Repository in Romania Drastically Limits the Technology Selection for the Waste Treatment and Conditioning Facility - 9200

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ABSTRACT

This paper presents the design criteria and constraints for the development of the Waste Treatment and Conditioning Facility which will comply with L/ILW Final Repository requirements so to be built near Cernavoda NPP. The Repository will be designed to satisfy the main performance objectives in accordance to IAEA recommendation and on basis of a set of very strict Waste Acceptance Criteria resulted from the local conditions.

The Saligny Repository will be commissioned in 2014 and for accepting the radwastes from Cernavoda NPP it is necessary that the radwastes should be suitable treated/conditioned for long – term radionuclides isolation.

INTRODUCTION

Starting with October 1996, Romania became a country with an operating nuclear power plant. 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 till 2016.

The Strategy for radioactive waste management was elaborated by National Agency for Radioactive Waste (ANDRAD), the jurisdictional authority for final disposal and the coordination of nuclear spent fuel and radioactive waste management (Order 844/2004), with attributions established by Governmental Decision (GO) 31/2006. The Strategy specifies the commissioning of the Saligny L/IL Radwaste Repository near Cernavoda NPP, in 2014.

When was designed the L/IL Radwaste Repository, the following prerequisites have been taken into account:

1) Cernavoda NPP will be equipped with 4 CANDU 600 units;

2) National Legislation in radwaste management will be reviewed and/or completed to harmonize with UE standards;

3) The selected site is now in process of confirmation after a comprehensive set of interdisciplinary investigations. The initial concept of the Repository was based on a Treatment and Conditioning Facility sited near Repository, but due to responsibilities separation, the Treatment and Conditioning Facility is now Cernavoda NPP responsibility while, ANDRAD will be responsible for the Repository.

A lot of constraints, including limited available surface on site and bearing capacity limits the possibilities for selecting the technology. Incineration of wastes was not provided by actual methodology of waste segregation implemented to Cernavoda NPP, meaning the impossibility to use this major volume reduction opportunity between selected technologies.

In order to achieve all requirements, it is necessary to build a specific Treatment and Conditioning Facility capable to meet the very strict Waste Acceptance Criteria which occurred due to the local site conditions, taking into account ANDRAD requirements and CANDU reactor wastes specific characteristics. The conceptual design started from existing technologies in Europe and taking into account the specific characteristics of CANDU reactor radioactive waste, which contains variable but important quantities of tritium and radiocarbon.

In order to obtain a partial site license from CNCAN (Regulatory Body), that means to obtain the permission for further studies and on-site investigation, SITON in collaboration with SCN-Pitesti[1], has elaborated the "Radiological Safety Assessment documentation for Saligny I/LLW Repository".
The basis of this documentation is a developed design concept that considered the best practices in the field, and was assessed by IAEA into a frame of "Waste Assessment Technical Review Program - International Review Team (WATRP), Romania January 2007" [1].
WATRP recommendations were implemented into a new version of the Safety Report sent to the Regulatory Body. On basis of this Report, the partial license has been obtained in order to finalize the geological characterization of Saligny Site.
Presently, a potential site exists, but the wastes are not conditioned yet for disposal. At Cernavoda NPP, the radioactive wastes are collected in 220 l drums and stored in an Interim Storage Facility.

MAIN INPUT DATA FOR SALIGNY REPOSITORY DESIGN

Bearing in mind the purpose of Saligny Repository, the main input data refer to:
- Surface repository for low and intermediate short lived radwaste;
The repository dedicated only to radioactive waste generated by the four NPP Unit operation and decommissioning;
- Four CANDU 600 Units in operation for 30 years or possibly 40 years;
- ANDRAD strategy on radioactive wastes.
- Predictable Regulatory Body requirements for the new repository taking into account the new status of Romania as UE Member State.
Based on the input data the main constraints for the new repository design were identified:
1- Cernavoda NPP specific waste characterization is not finalized and therefore some uncertainties in the repository design may exist;
2- The wastes are not properly conditioned for the final disposal;
3- Environmental constraints due to characteristics of the site selected near Cernavoda NPP;
4- Regulatory constraints;
5- Public acceptance constraints.
For every constraint mentioned above, suitable measures were taken to reduce the uncertainties.
These requirements impose some constraints for Waste Treatment and Conditioning Facility.

THE DERIVATED MAIN INPUT DATA FOR THE TREATMENT AND CONDITIONING FACILITY DESIGN

Starting from the above mention constraints for Saligny Repository, the following constraints for Waste Treatment and Conditioning Facility were identified [2]:
1. The main input data for treatment and conditioning facility consist in radwaste characteristics.
In order to evaluate the different possibilities for radioactive waste (short lived, L/I level) treatment and conditioning for disposal, the specification for radwaste quantities (in m^3/ year) from Cernavoda NPP Romania, includes:
- Compactable waste: 100
- Non-compactable waste: 60
- Spent ionic resins: 25
- Spent filter cartridges: 10
- Organic liquids: 10
The technical specification of radioactive wastes from each Nuclear Power Unit at Cernavoda NPP, yearly generated, includes the following information:
Compactable waste : ~25 m^3, 2.7 E-2 Tbq, average density: 150 kg/m^3

[1] Subsidiary of Nuclear Research-Pitesti of National Authority for Nuclear Activity

Non-compactable waste : 15 m3, 7.4 E-3 Tbq, average density: 227 kg/m^3
Spent ion resins: 6 m^3, 18.5 Tbq
Spent filter cartridges: 2.5 m^3, 7.4 E-2 Tbq
Organic liquids: 2.5 m^3, 3.4 E-2 Tbq
4 Units CANDU 600 reactors will be operational.
These data present an uncertainty degree because there have been established by the designer, on basis of design specifications from other CANDU 600 reactors.
At this phase, Cernavoda NPP has accepted these approximations for design purposes.
2. The general wastes are collected in 200 l drums and stored at the existing Interim Storage Facility. The compactable wastes are in drums of 200 l, low-compacted. Organic liquids are collected in SS 200 l drums and stored at NPP.
Spent ion resins are collected in 2 x 300 m^3 concrete lined tanks in Service Building and spent filter cartridges are stored in concrete shielded pipes at Interim Storage Facility. It is predicted that spent resins and spent filter cartridges will also be immobilized into the 200 l drums. That means the necessity to optimize a Disposal Container to accommodate standard 200 l drums.
3. The responsible organization for waste treatment and conditioning is Cernavoda NPP, which has not the suitable facilities for wastes treatment and for the near future Cernavoda NPP will have not enough storage capacity. That means the necessity to put in operation the Waste Treatment and Conditioning Facility before 2014. This aspect expedites the selection of necessary technologies.
4. The next important design constraint consists in waste acceptance criteria for Saligny Repository which include the accepted Disposal Container. Presently, the waste acceptance criteria for Saligny Repository have not been established yet, but in this design phase, IAEA acceptance criteria for a surface Repository are considered. This approval shows some degree of uncertainty.
5. At the same time, the responsible authority for wastes disposal, ANDRAD, requires a Disposal Container guaranteed for 300 years, for disposal in Saligny Repository, namely a concrete rectangular container.
6. Incertitude about spent ion resins due to C-14 concentration. Only fuel contact spent resins are considered for disposal to Saligny Repository. Moderator contact spent resins will be sent to Geological Disposal Facility but it is necessary to condition and assure their intermediate storage. Only the Regulatory Body can approve the disposal of fuel contact spent resins to Saligny Repository in Romania and in Europe acceptance criteria for C-14 have not been stated. Bearing in mind that spent resins contains 90% of L/I L Radwastes total radioactivity and only fuel contact spent resins represents about 70% of total activity that can be sent to Saligny Repository. This represents a high degree of incertitude for Safety Report and for general Repository concept.
7. The bearing capacity of Saligny Site loessoid soil limits the weight of the Disposal Container and implicitly the drum weight.
8. Romanian Legislation is now in process of being harmonized with UE Legislation having impact on WTCF.

THE WTCF HISTORY

In the period of 1992-1998, under RENEL-GEN[2] coordination, the concept of a Repository with its treatment conditioning facility included was developed. After many studies, an alternative with cells of 14 m x 7 m x 4.5 m for disposal of 380 containers with diam. = 0.85 m and H= 1.25 m fiber reinforced containers was selected.
2 National Authority for Electric Energy-Nuclear Energy Group

The related WTCF includes a semiautomatic 1500 t compactor, a grouting station for pellets and drums immobilization in Disposal Containers and spent resin cement solidification station for immobilizing resins in Disposal Containers. Organic liquids are treated by others.

This concept was selected and approved by RENEL - GEN and acceptable for the candidate site selected at Cernavoda, at about 3 km from Cernavoda NPP.
After this phase, RENEL – GEN changed the preferred site from Cernavoda to Saligny, also a candidate site, due to local problems.
At the same time, the former CITON with IAEA assistance, received information about the development of a new Repository and radwaste management upon technical co-operation programs.
Simultaneously with the Repository concept the related WTCF concept was developed.
First, the dimensions of the cells were changed according to models at L'Aube and El Cabril repository experiences, taking into account the limited available area of Saligny Site (maximum 30 ha available area of instead 120 ha at Cernavoda site).
The new cells had the following dimensions: 23 m x 18.5 m x 10 m for accommodating 320 rectangular concrete containers of 2.25 m x 2.25 m x 2.2 m.
According to new cells, the similar technology to El Cabril Repository for treatment and conditioning of radwastes was selected.
This later alternative was developed in the period 1998-2004.
After 2004, under ANDRAD coordination, some studies reanalyzed the Repository concept including WTCF.
Upon National Agency for Nuclear Activities - R&D Program, CITON proposed different cells with the following dimensions:
- 28 m x 15 m x 10 m for 2880 CBF;
- 29.1 m x 15.6 m x 7.5 m for 216 modules, respectively 3 rows x 72 modules;
- 29.1 m x 15.6 m x 5.55 m for 144 modules, respectively 2 rows x 72 modules.

So, the WTCF has been developed according to the preliminary studies.
The responsibility for WTCF was transferred to Cernavoda NPP and this represents the major uncertainty of the WTCF concept.
In the new prefeasibility study, the WTCF has been neglected since it was considered to be a different investment. However, is being preserved the initial area dedicated to WTCF in the perimeter of Saligny Repository.

POSSIBLE WASTE TREATMENT CONDITIONING SCENARIOS

The following variants were analyzed [3]:

ALTERNATIVE 1A

Process functions:
- Super compaction of compactable radwaste by a 2000 t super compactor
- Batch cement solidification of spent ion exchange resins
- Grouting in containers pellets and drums
- Cutting the spent filter cartridges and placement in 200 l drum.

Auxiliary functions:
- Waste package monitoring
- Waste package handling system
- Laboratories
- Water collection systems
- Protection from inadvertent intrusion
- Utilities (fluids, electricity, telephone, etc.)
- Airlocks for personnel access to the WTCR
- Offices

Main characteristics of the technology:
- Super compaction of compactable waste and of even non-compactable waste;
- Spent resins are directly cemented in CBF using all container capacity;

- Low level wastes are containerized in 200 l drums and disposed in 400 l drums. These drums are cemented in cells;
- The CBFs with intermediate wastes, respectively spent resins and spent filter cartridges, are stabilized in cells with gravel;
- Organic liquids are sent to the other location for treatment.

The capacity of a 14 m x 7 m x 4.5 m cell can accommodate 800 drums or 400 CBFs.
This technology implies the impossibility to retrieve drums from cells.
This alternative was proposed by CITON in the initial prefeasibility study approved by RENEL- GEN in1995, for Cernavoda Site.

ALTERNATIVE 1B

Main characteristics:
- No super compaction;
- The same process like in alternative 1A;
- All wastes are fixed in CBFs;
- Threefold volume increased;
- Not recommended technology.

ALTERNATIVE 2

Process functions:
- Super compaction of compactable radwaste by a 3000 t super compactor
- Batch cement solidification of spent ion exchange resins in 200 l drums
- Grouting in disposal containers pellets and drums
- Spent filter cartridges are managed with their boxes
- Organic liquids will be directed to liquid system of the WTCF building

Auxiliary functions:
- Developed automatic handling system
- Separative drainage systems, raining water system and cells drainage system, respectively
- Protection from inadvertent intrusion
- Utilities (fluids, electricity, telephone, diesel, etc.)
- Airlocks for personnel access in the WTCR
- Offices

Main characteristics of the technology:
- Super compaction of compactable waste and of even non-compactable waste with higher force than other technologies;
- Spent resins are directly cemented in a 200 l drum by a mobile facility;
- Spent filter cartridges are cemented in their boxes into the middle of a dedicated cell;
- Organic liquids are introduced in the liquid systems for concrete preparation;
- Disposal containers, respectively modules of 2.25 m x 2.25 m x 2.2 m which can accommodate 18 drums or about 50 pellets.

The cell capacity is 320 modules of 23 m x 18.5 m x 10 m with inner dimension.
This alternative was proposed by CITON in the feasibility study in 1996 for Saligny Site.
The Safety Report submitted to Regulatory Body was not approved and their remarks were not implemented due to the modifications in RENEL-GEN organization responsibilities. Romanian Authority for Nuclear Activities assumed responsibility for the Repository. Now, the SCN – Pitesti try to demonstrate the acceptability of the Saligny Site while CITON and UTCB are investigating the optimum solution for soil consolidation.

ALTERNATIVE 3

Process functions:
- Super compaction of compactable radwaste by a 2000 t super compactor
- Spent exchange resins transfer to treatment system
- Heat drying of spent ion exchange resins
- Super compaction of dried spent ion exchange resins

- Chopping the spent filter cartridges and placing in 200 l drum
- Grouting in containers pellets and drums

Auxiliary functions:
- Waste package monitoring
- Waste package handling system
- Laboratories
- Water collection systems
- Protection from inadvertent intrusion
- Utilities (fluids, electricity, telephone, etc.)
- Airlocks for personnel access in the WTCR
- Offices

Main characteristics of the technology:
- Super compaction of compactable waste and even of non-compactable waste;
- Heat drying of spent ion exchange resins;
- Super compaction of dried spent ion exchange resins that means high volume reduction factor;
- Limited capacity of container for spent ion exchange resins pellets due to their high radioactivity;
- Spent filter cartridges are chopped and placed in 200 l drums;
- Organic liquids are sent to another location for treatment.

Disposal containers, i.e. 3 m x 1.7 m x 1.4 m modules can accommodate 8 drums or about 24 pellets. Disposal cells 25.5 m x 18.5 m x 8.7 m outer dimensions have the capacity of 400 modules.

ALTERNATIVE 4

Process functions:
- Super compaction of the compactable radwaste by a mobile super compactor
- Batch cement solidification of spent ion exchange resins in 200 l drums by a mobile installation
- Spent filter cartridges are fixed into cells with their boxes
- Mobile cementation facility
- Radwaste liquids treatment with a small system

Auxiliary functions:
- Similarly with other technologies

Main characteristics of the technology:
- Mobile super compaction facility can be considered only for a short period of time;
- Batch cement solidification of spent ion exchange resins in 200 l drums by a mobile installation is similar to the other alternatives;
- Spent filter cartridges are stabilized into cells in their boxes that present a major advantage. No treatment systems are needed;
- Mobile cementation facility for grouting the pellets and drums in Disposal Containers;
- Radwaste liquids treatment employing a small system can provide suitable conditions;
- No Treatment - Conditioning Building is necessary.

The alternative assumes the presence of a big cell, like with Drigg Repository, possibly with some separation walls.

The alternative implies the presence of some available area and utilities at Cernavoda NPP Site.

ALTERNATIVE 5

Process functions:
- Low compaction of the compactable radwastes in 200 l drums.
- Cementation of non-compactable radwastes in 200 l drums.
- Cementation of 200 l drums in 400 l drums considered as Disposal Container.
- Immobilization of spent ion exchange resins in 100 l drums with bitumen and placing them in the shielded 400 l drums.
- Chopping and compaction of spent filter cartridges in 200 l drums, immobilization by cementation in 400 l drums.
- Organic liquids are treated and conditioned in 200 l drums which are further cemented in 400 l drums.

Auxiliary functions:
- Similarly with other technologies.

Main characteristics of the technology:
- Lack of the super compaction means the lack of a volume reduction opportunity;
- Cementation of non-compactable radwastes in 200 l drums is similar with other technologies;
- Cementation of 200 l drums in 400 l metallic drums considered as Disposal Container. The Disposal Containers do not meet ANDRAD requirements.
- Immobilization of spent ion exchange resins in 100 l drums with bitumen and placing them in the shielded 400 l drums. In some countries, bitumen is forbidden and it is possible that this prescription should be adopted in Romania, in the future.
- Chopping and compaction of spent filter cartridges in 200 l drums, immobilization by cementation in 400 l drums. This solution was proposed with other alternatives, except metallic Disposal Container.
- Organic liquids are treated and conditioned in 200 l drums which are further cemented in 400 l drums. This technical solution was not considered with other alternatives. This technology implies increasing of radwaste volumes.

With this alternative there is no requirement on Disposal Vault/Cell. Resulted volumes can exceed the Saligny Repository limited capacity.

APROACHESS FOR SOLVING THE CONSTRAINTS AND UNCERTAINTIES

Uncertainty about radwaste characteristics

To solve this uncertainty was elaborated a document: -"Radioactive wastes to be disposed off the Saligny Repository. Volumes şi inventory", was elaborated by ANDRAD, March, 2007; This document gathered together all available information collected by ANDRAD from many collaborators envolved in waste management.

The document was used tothe elaboration of Saligny Repository concept and the new Prefeseability Study and was considered in this paper.

Uncertainty related to Disposal Container optimization

This uncertainty is solved by adopting the 2.25 m x 2.25 m x 2.2 m concrete container as per ALTERNATIVE 2 presented above. It was demonstrated that for 200 l standard drums this container is optimum from point of view of Report Total volume/Useful volume which is a very important criterion for Saligny Repository site having a limited available aria.

Uncertainty about selection of technologies

The responsible organization Cernavoda NPP required for a "Study for the Establishment of the Treatment and Conditioning of Radioactive Wastes Produced by Cernavoda NPP in View of Final Disposal". The future study which is to be elaborated in 2009 will solve all uncertainties related to selection of technologies

Waste Acceptance Criteria constraint

Besides IAEA criteria a document " Technical Basis and Methodological Approach for Waste Acceptance Criteria" PHARE Project 4.10/94 in October 1999 was elaborated and can constitute a guide until the responsible Organization will approve the Saligny Repository specific Waste Acceptance Criteria. The document guided all studies elaborated by SITON till now.

Disposal Container constraint

The ANDRAD requirements related to fabrication material and to the form of the Disposal Container are according to the optimization of Disposal Container presented at above point 2.

Uncertainty about disposal of fuel contact spent resins

C-14 concentration in fuel contact spent resins is below of specification from CFR 10 Part 61 "Licensing Requirements for Land Disposal of Radioactive Waste" which in Table 1 specifies the maximum allowable concentration of 8 Ci/m^3 for C-14.

This limit should be accepted by Regulatory Body.

Constraint related the bearing capacity of Saligny site

Upon Contract “Experimental Polygon for demonstration of foundation solution on columns of compacted loess for Saligny Repository, inclusive in-situ and laboratory tests” contract 78/872, 2008, it is possible to solve the problems related to low bearing capacity of Saligny Repository site loessoid soil including solutions for WTCF Building.

Uncertainty about impact of legislation modification on WTCF

The proposed technical solutions take into account the UE general requirements about radioactive waste management because SITON propose some best practices already applied in some countries from Europe. That means that the future modification in the National Legislation for the harmonization with European Legislation will have no impact on the selected technologies for WTCF.

THE RESULTED PROPOSAL FOR WTCF

Starting from all considerations, the proposed WTCF will contain the following characteristics:
Saligny Repository is planned to operate from 2014. The compactable solid waste (about 25 m^3/unit/year) is low force in-drum compacted in 200 liter drums for storage. The drums will be transferred to the WTCF where they are super-compacted with the pucks being placed into concrete disposal containers (2.25 m x 2.25 m x 2.20 m). The non- compactable wastes (about 15 m^3/unit/year) will be size reduced and stored in 200 liter drums. They will be packed into concrete disposal containers at the repository and the inter drum voids filled with cement. The spent ion exchange resin (about 6 m^3/unit/year) will be encapsulated into 200 liter drums by cementing at Cernavoda using a mobile facility. The drums will be packed into concrete disposal packages and the inter drum voids filled with cement. The spent filter cartridges (about 2.5 m^3/unit/year) will be opened and the wastes treated as non-compactable wastes. The organic liquids (about 2.5 m^3/unit/year) may be solidified in a cement matrix, possibly with the addition of an emulsifier.

For the above waste management strategies the following functions/facilities will be required [4]:

- Super-compactor
- Box packaging installation
- Box waste grouting installation
- Mobile or fixed ion exchange resin grout installation
- Spent filter opening and drum loading installation
- Organic liquid solidification installation
- Buffer stores
- Transport.

First of all the wastes streams generated by operating and decommissioning of Cernavoda NPP Units were identified and the flow sheets for treatment and conditioning of all streams were elaborated.

In order to assure the conditions for treatment and conditioning it is necessary to design a Building taking into account the following considerations:

- The processes of conditioning the different types of wastes produced, received or handled in the building shall be carried out in such a way as to guarantee the segregation of wastes having different physical-chemical and radiological characteristics, such that the production of secondary wastes be minimized and the final products obtained meet the Acceptance Criteria;
- All potentially radioactive aqueous liquid effluents shall be incorporated in the water used for the container immobilization grout, in compliance with all the requirements applied to blocked wastes, thus avoiding the release of these wastes off site;
- The design, physical layout and installation of the systems and associated components shall take into account all aspects affecting the optimization of radiological protection;
- The operating methodology shall be straightforward and specific for each category of wastes and shall ensure relative flexibility as regards streams and operating times.

Figure 1 presents the flow sheet of the proposed treatment and conditioning of waste streams generated by Cernavoda NPP operation.

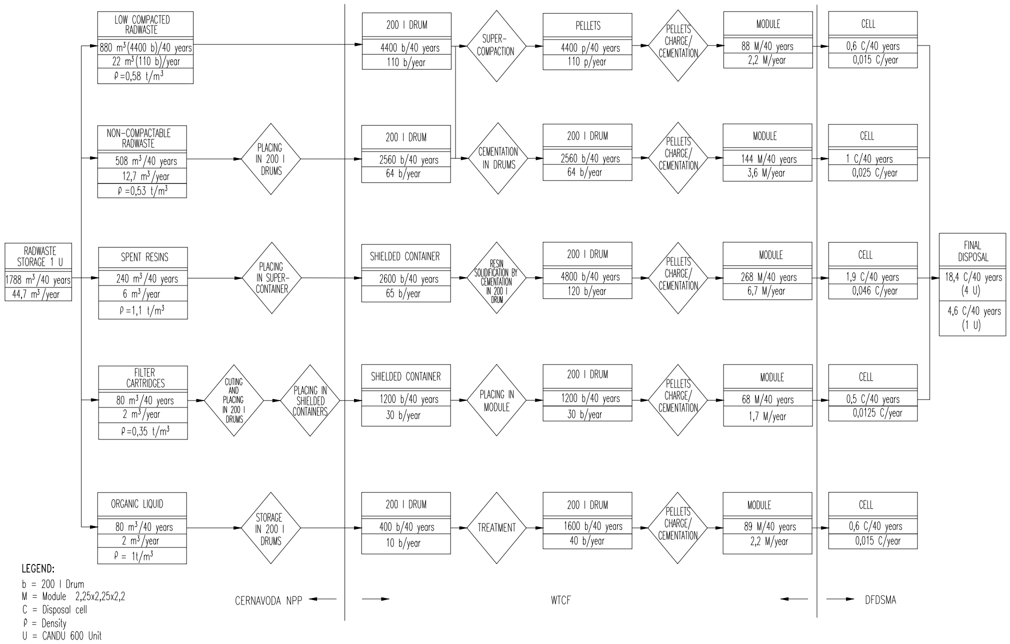


Fig. 1. Diagram of Treatment /Conditioning of radwastes streams generated by Cernavoda NPP Operating

Figure 2 presents the general flow sheet of the WTCF and correlation with Cernavoda NPP and Saligny Repository.

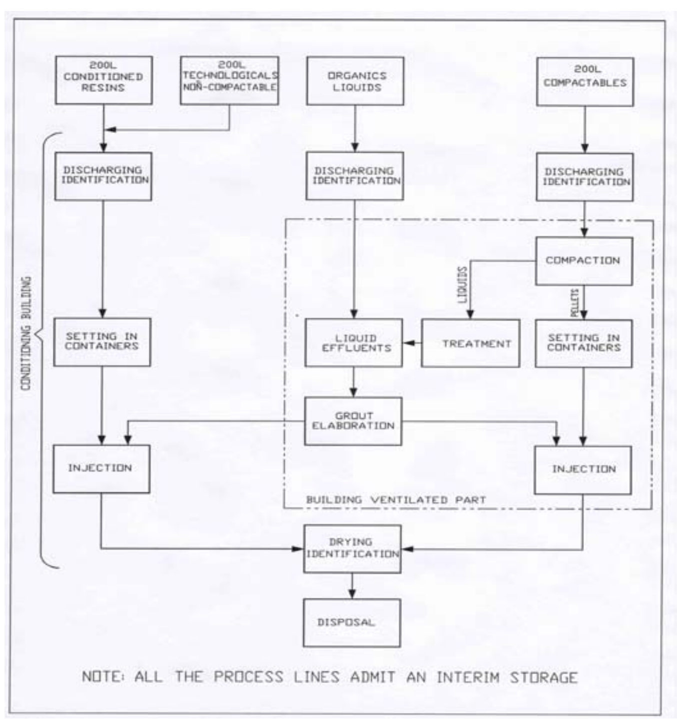
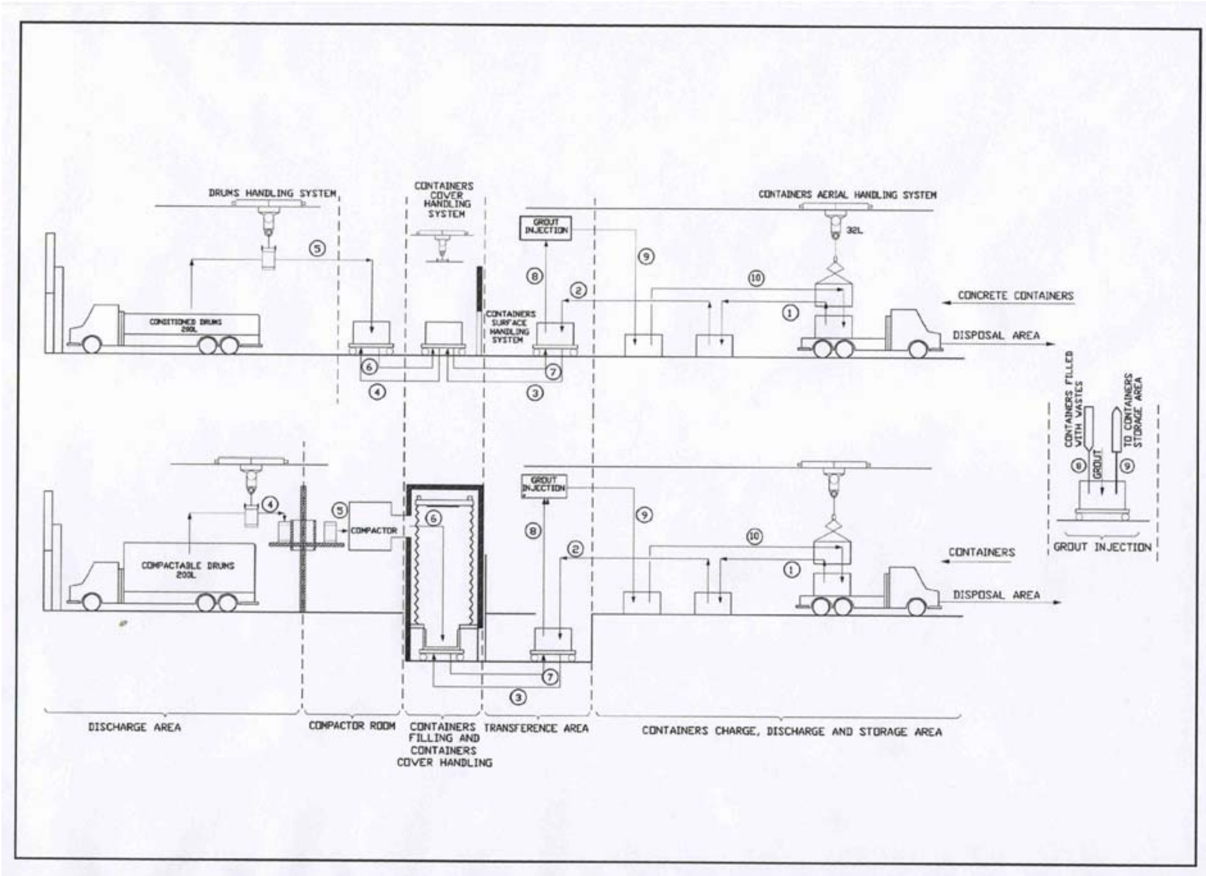


Fig. 2. General flow sheet of the WTCF

In Figure 3 the flow sheet of treatment and conditioning at WTCF is presented.

Fig. 3. Diagram of the WTCF with treatment/conditioning processes



The above considerations shall lead to the adoption of the following criteria:
- The building shall be equipped with a warehouse for the discharging of compactable non-compactable and conditioned wastes, and another from which the final product (container full of immobilized wastes) to be stored on the platforms shall be dispatched. The layout shall allow the routes to be followed by the waste packages to be minimized, such that operating times be reduced to the maximum extent possible;
- The compacting press shall be located between the Drums Discharging Warehouse and the Containers Warehouse, and an enclosure shall be set aside for the collection and treatment of the liquid effluents generated as a result of the process;
- The design of the building shall be such that all the potentially radioactive aqueous liquid effluents, including those generated during cleaning of the areas, may be channeled by gravity to the effluent collection system tanks;
- Enclosures containing tanks holding radioactive effluents shall be designed such that liquids may be retained in the event of accidental spillage;
- The building shall be equipped with a controlled ventilation system with the locks required to maintain, under negative pressure conditions enclosures containing treatment and conditioning systems and open to the possibility of contamination. The building shall contain all the equipment required by this system for filtering and surveillance of off-site releases;
- The concept, implementation and design of the different enclosures shall adhere to the applicable requirements (shielding, confinement, accesses, location of work stations, surveillance, etc.) for the optimization of radiological protection.

Figure 4 presents the general lay-out of the WTCF Building which assure the conditions for all activities related the treatment and conditioning of wastes streams. In fact the spent resins treatment can be made with a mobile installation.

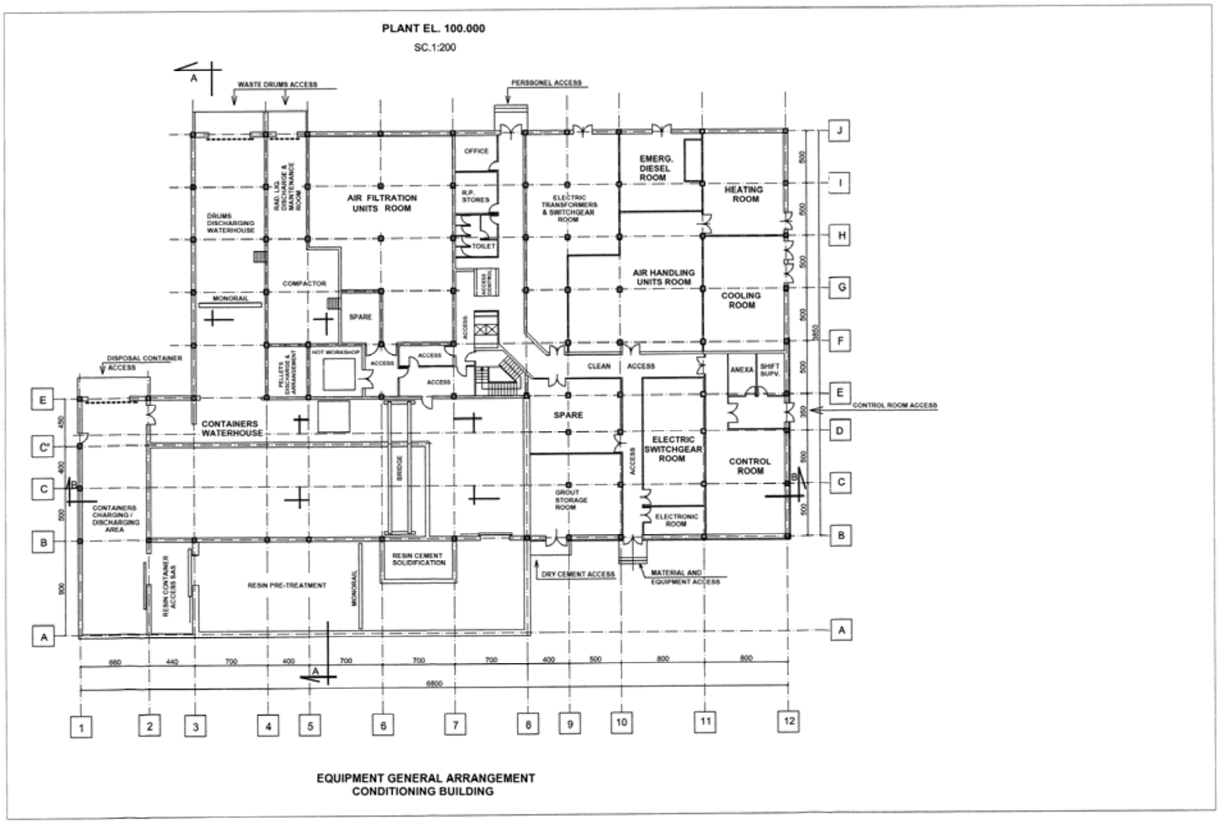


Fig. 4. General lay-out of the WTCF Building

CONCLUSIONS

The very strict requirements including many uncertainties and constraints drastically limites the possibilities to select the suitable treatment/conditioning technologies for the Waste Treatment/Conditioning Facility designed for the radwastes generated by Cernavoda NPP.
After many studies and optimization analyses the technical solutions that meet all strict requirements derived from special conditions of Saligny Repository were identified.
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 treatment/conditioning of the radwastes will be performed according to best practices to ensure the long-term stability of the containers and the radwaste isolation in optimum conditions.

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[4] Report DD-DFDSMA-4R22-SP-TP-MT-00 The Prefeasibility Study for Saligny Repository, RAAN-SITON, 2007.