Regulatory Review of the Safety Case for Siting Licensing of Saligny Low and Intermediate Waste Repository - 8167

Daniela Maria DOGARU
National Commission for Nuclear Activities Control
14 Libertatii, 5 Bucharest ROMANIA

ABSTRACT

The paper contains the regulatory review comments produced following submission of siting license application of Saligny repository. The regulatory review was conducted in order to verify the compliance with Romanian regulatory criteria and requirements. After assessment of completeness of safety case and availability of supporting documents the review the main technical areas started. The review process was focused on the site characteristics, waste characteristics, safety considerations as scenarios development, mathematical models, identification and treatment of uncertainties, availability of parameters.

INTRODUCTION

According to the Romanian regulatory framework each step in the development of a near surface repository has to be licensed by regulatory authority. The regulatory authority in nuclear field is National Commission for Nuclear Activities Control (CNCAN) according to the Law 111/1996 on the safe deployment of nuclear activities. The steps in the development of a near surface repository which need a license are: siting, construction, operation, closure, active institutional control. In order to get a license the licensee has to submit to regulatory authority a safety case developed according to the application. Regulatory review of technical documentation is spread on six months and at the end of this period the regulatory authority has to issue a license or a letter of refuse of license which have to be justified.

According to the national strategy for radioactive waste management a new near surface repository for radioactive waste generated from operating and decommissioning of Cernavoda Nuclear Power Plant is planed to be in operation in 2014. To implement this action the National Agency for Radioactive Waste which is the owner of the repository submitted to CNCAN application for siting of the repository. The site investigation started with 37 sites, 3 candidate sites were characterized and the final selection of the site was made by based on safety and economical considerations. The selected site is located in Saligny in the exclusion area of Cernavoda Nuclear Power Plant.

For the demonstration of safety the licensee submitted to regulatory authority the safety case which includes a safety assessment report.

The regulatory authority independently reviewed the safety case and submits to licensee comments for implementation in order to improve the safety demonstration.

DESCRIPTION OF REPOSITORY

Site characteristics

Saligny site is located in the Constanta County, in the South-Eastern part of Romania, in the South Dobrogea region. It is situated at around 2 km South – East far from Cernavoda town and 1.5 km North – West from Saligny village [1].

Geologically, the Saligny site belongs to the Dobrogean part of the Moessic platform, placed at south of Ovidiu – Capidava fault in the South-Dobrogea platform. The main characteristic of this zone is the deep crystalline foundation covered by thick sedimentary layers. Saligny site structure consists of the sequence of the following geological units: silty loess, clayey loess, Quaternary red clay, Pre-Quaternary clay, Barremian limestone, Vallanginian clay, Jurassic limestone, Paleozoic sediments and the crystalline foundation of the green slates.

The physical characteristics of the site like grain size distribution, dry density, total porosity and effective porosity and other parameters have been measured according to the Romanian standards.

The mineralogical composition shows the predominance of the primary minerals as quartz, feldspars, mica, followed by the clayey minerals. The carbonate minerals are presented in all site horizons. The clayey minerals have a complex mineralogical composition, composed from smectite, illite, caolinite and chlorite minerals. The caolinite is also present but in small quantities.

The mineralogical composition emphasized two positive aspects for the retardation and reduction of the contaminant release in the surrounding environment: the presence of smectite as predominant clayey mineral in the unsaturated zone and the existence of important quantities of carbonates.

The regional hydrographic network of Dobrogea region contains:

- Danube River;
- The internal rivers of Dobrogea plateau;
- The Danube – Black Sea Canal;
- Lakes and ground waters;
- The Black Sea.

The permanent surface waters, from Saligny site vicinity are the Danube River – the Old Danube Branch, the Danube-Black Sea Canal, the lake and the river Tibrin. The Saligny site is delimited to the West and South by the Danube River and the Danube River – Black Sea Channel. The Old Danube is found at about 4 km from Saligny site, the flowing direction of the river in this area being from South to North. The Danube River – Black Sea Canal is starting from the vicinity of Cernavoda town and follows the old valley of Carasu River. In front of Cernavoda NPP, the canal is divided in two branches. One of the branches is linked with the deviation canal used for water cooling at NPP and on the other one there is a canal lock. The two branches merge again but, upstream from the joint point, there is a dam, which is maintaining an almost constant water level of the Canal The Danube River has the most important function in the hydrogeology of the Saligny site, owing to its direct connection with the main aquifer of the Cernavoda area, the barremian aquifer, with a dynamic that is depending by the variations of the river level. The water level of the Danube River is determinate by the precipitation regime from Europe. The level is high in the seasons that are rich in precipitations when it may reach +12 or even +14mdMN, and it is low in the periods that are poor in precipitations when the water level may reach values smaller than +4mdMN.

The hydro-geological characteristics, studied for defining the water and contaminant flow through the Saligny site, were the moisture content, the hydraulic conductivity at the saturation state and the retention/assignation capacity of water.

Related with scale of Dobrogea the local seismicity is the lowest one.
The Cernavoda region belongs to Cernavoda structural block whose main characteristic is represented by the presence of evaporitic formation under the barremian loamy calcareous complex, unlike Medgidia structural block, in this last case being completely missed. The second element making a difference between the two blocks is the presence of crystalline rigid bed at a depth higher than 1100m in Cernavoda block, while Medgidia block is ~ 400 m upper. The delimitation of the two blocks is made by a deep fault of North-South approximate direction, known as Gherghina fault.
Dobrogea has a continental climate characterized by lower rainfalls compared with the rest of the country, being considered as grade 1 aridity area (about 500 mm / year), high thermal variation (about 68 °C) and a high sun shining time (about 2200 hours / year).

Design repository description

The Saligny site is located within the exclusion area of Cernavoda NPP (with 1000 m radius), about 350 m from the limit of the Cernavoda NPP enclosure and about 750 m North-East from the loop of Bucharest - Constanta railway.
The repository was designed with the following structures and systems, which have long-term barrier function:

- Immobilization matrix of waste (waste form);
- Disposal module, which contains the immobilized wastes;
- Disposal cell, which contains the disposal modules and the fill material between them;
- Improved foundation soil;
- Long-term closing system of cells;
- Draining system of infiltrated and meteoric waters from the site.

The safety functions for repository engineered barriers considered into conceptual design are the following:

- Physical, chemical, hydraulic and biological isolation of wastes and long term minimization of radio nuclides releases into geosphere.
- Guarantee of a chemical barrier, physical confinement, retention and retardation of radio nuclides, as well as control of gases generation and release.
- Completion of natural barriers functions, regarding assurance of wastes confinement.
- Long-term stability of disposal facility [1].

For the CANDU pressurized heavy water design (PHWR), the origins of the waste contamination can be classified into the following groups:

- Fuel fission products: Cs-134, Cs-137, I-131, Sr-90, Ce-141, Ba-140;
- System material activation products: Zn-95, Co-60, Fe-59, Cr-51, Zr-95, Nb-95, Mn-54, H-3, C-14.

The radioactive wastes streams for repository consist of:
- Compactable wastes - compacted as pellets fixed into concrete matrix.
- Drums with non-compactable wastes fixed into concrete.
- Drums with material resulted from crumbling of spent filter cartridges, fixed into concrete.
- Drums with spent resins conditioned into concrete matrix.
- Drums with spent organic liquids or other wastes conditioned into concrete matrix [1].

The disposal modules have parallelepiped structure, made of reinforced concrete.

The material used for disposal module has a very low corrosion rate in order to confer both a good long term operation and intrinsic safety of the containers system.
The disposal modules have to be designed so that to resist fall during the filling period of repository

The disposal ensemble consists of four disposal cells set on a general foundation slab. Each of them consists of:

- Disposal cells and modules
- Visiting/collecting galleries for infiltrated water into cells together with the drainage system, mobile hangars
- Final coverage layers.

Number of 60 cells was considered as an emplacement optimum maximum capacity on the site. The estimated volume of conditioned wastes from operation as well as from decommissioning of NPP Cernavoda based on 40 years of operation of 4 units is about 56,800 m^3. If it is considered raw wastes resulted from operation for 30 years of the four nuclear units, as well from their decommissioning, the total volume of conditioned wastes disposed at repository will be 46,500 m^3.
Cell internal empty spaces (between modules) will be filled with backfilling material after the disposal modules have been introduced in cell. The concrete filling is carried out from the last level of containers to upper level of cell walls. During the disposal the cell is protected by a mobile hangar.
The final covering layers, consisting of sand waterproofing and drainage alternating layers, geo-membrane, broken rock, and clay or compacted loess are carried out after the filling and covering with concrete plate of all the cells which compose a cells ensemble.

All buildings of disposal ensemble will be carried out on improved ground. The taluses protection around the disposal ensemble will be monitored during building, operation and institutional control period in post-closure phase of the repository.
The layers of the proposed system for the long-term covering of the disposal cells, enumerated beginning from the cells, are the following:
- An excavated loess layer to form the adequate inclination.
- A sand layer with draining and supporting function for next layer.
- A synthetic waterproof membrane.
- A sand second layer with draining function.
- A compacted clay layer with waterproof function.
- A sand layer with draining function.
- A protection layer consisted of broken rock and soil planted with perennial vegetation with horizontal roots.

After the cells are filled and covered with the reinforced concrete cap, and the protection is performed with bituminous waterproofing layer, the excavated loess layer will be performed, with slopes that will provide the rapid evacuation of meteoric water.
The engineered barriers, made of waterproof materials and membranes, will prevent the surface water infiltration into the repository structures.
The protection layer formed of crushed rock has also the role to prevent the intrusion of animals and of plant roots towards the cells with radioactive waste.

The soil superior layer is performed in order to rebuild the natural environment, after the repository is closed.

SAFETY ASSESSMENT

The safety case submitted to regulatory authority contains among other documents requested by regulations, a safety assessment report. The content of safety assessment report details both for operation and post closure period. This paper is focused on the safety assessment of post closure.

Post closure safety assessment

The safety assessment refers to the time period starting after the repository closure. In this period it is assumed that all the cells are filled with waste packages, covered by the concrete caps and over all, it is executed the cover system for long term. It is assumed that the other buildings of the repository existing on the site in the operational period will not exist longer in the site at the post-closure time period.

This safety assessment is done by the dose assessment of the possible individuals exposed, which could live, work or use the zone surrounding the repository and thus could be exposed to a dose due to active sources associated to the radioactive waste in the repository.

The methodology for assessment of post-closure considered a reference scenario representing the normal evolution of the repository system for long time. The development of this scenario is based on the site description, disposal system description, repository filling and its long term closure description and radioactive waste description. A number of alternate scenarios taking into account the accidents and unplanned events which could be possible on the long term and which have been not accounted in the reference scenario were developed.

The analysis of these results was based on the effective dose signification as safety indicator for the post closure. The comparison between the effective dose and the constraint limits not any more valid for the time period 10,000 – 100,000 years after repository closure, most appropriate in this case being the comparison with the natural radiation level (a qualitative element). The conclusion of the result analysis is that between 10,000 and 100,000 years after repository closure the maximum annual effective dose for the Reference Post Closure Scenario is 1.90×10^{-7} Sv/year. It is 4 magnitude orders lower than the mean dose due to the natural radiation level for Dobrogea region equals to 2.43×10^{-3} Sv/year.

The Alternative Post-Closure Scenarios for repository have been selected as result of the expert's judgment based on the occurrence probability of these events and on their potential consequences. These scenarios are:

- Residence building on the disposal site
- Examination of samples collected from the site
- Archeological investigation of the site.

The values of the annual individual dose as result of the human intrusion in the site after the end of the institutional control period (300 years) as well as the contribution of the main exposure pathways corresponding to the radionuclides considered for this assessment.

The major contribution to the dose is given by the C-14 mainly through the contamination by ingestion. Even if Cs-137 has a short half-life period, its inventory is still significant even after 300 years and consequently the contamination through ingestion and external irradiation could also be important. The annual individual doses and the total dose summed for all radionuclides is about 2.467×10^{-3} Sv/year for residence building scenario which is the most restrictive.

REGULATORY REVIEW OF SAFETY CASE

The regulatory review of the technical documentation was conducted in order to review the compliance with the safety criteria and regulatory requirements. After the checking of completeness of the safety case the technical review started.

A summary of the main technical aspects resulted from regulatory review is presented below:

- The safety report does not describe the safety concept. The safety concept shall be clearly defined in order to emphases the basic principles for achieving the safety. The safety concept shall contain integrated information on containment functions provided by site and facility, the waste acceptance criteria, the role and duration of institutional control, administrative actions in order to improve the safety, the path ways, including human intrusion, by which future people might be exposed to radioactive materials placed in the facility and how these exposures are kept well below regulatory limits. The safety concept shall be used for defining the safety functions linked with engineering barriers which are the basis for design of the disposal system.
- The current safety report does not provide a sufficient basis for waste acceptance criteria including which waste streams are acceptable for disposal
- The site needs more investigations in order to complete the determination of site specific parameters.
- The amount and the nuclide inventory of the radioactive waste are based on the first 10 years operation experience. This seem to be irrelevant, estimation shall be expended on the experience of other CANDU reactors. It is not demonstrate how the inventory was screened to the current set of radionuclides. The current inventory does not contain a number of short-lived radionuclides of potential importance for the operational safety assessment. The screening process needs to be described.
- The values for Kd used in the modeling are insufficiently justified, or otherwise not traceable.
- The basis for the drainage system model is not adequately justified or complete.
- There is no reference for external dose factors used in the analysis. A spot check of several values showed them to be inconsistent with currently accepted values from ICRP for environmental assessments.
- The parameter uncertainty analysis presented in the Safety Report is inadequate. A proper parameter uncertainty analysis should grow from knowledge about the site, with ranges of parameters developed from knowledge (or lack of knowledge) of site parameters.
- The set of scenarios included in the analysis is weak with regard to reasonable alternative futures.
- The uncertainty analysis should include consideration of alternative conceptual models, to the extent they are credible.
- The limited number of scenarios and conceptual models included in the safety report suggest that the consideration of FEPs was not done in a challenging way intended to elicit real uncertainties about the disposal concept.
- The current analysis of gas generation, migration, and dose is inadequate. Each of these elements of the analysis need to be evaluated in greater detail, using Saligny-specific information.

- The justification of the fraction of inventory available for release and the time period over which the release will occur in not documented; it is necessary to evaluate degradation of the waste based on real data.
- The current analysis of doses from gaseous radionuclides is rudimentary, unjustified, and does not include the most significant potential sources of dose.
- Conceptual model is not detailed enough: 1) a separate near field model should be developed, 2) unsatured zone, 3) separate aquifer model, 4) separate biosphere model.

REFERENCES:

1. Safety Report for Siting a Near surface Repository at Saligny Site, rev. May 2007