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THE STATUS OF NUCLEAR WASTE FROM NPP IN ROMANIA

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ABSTRACT

AREN founded in 1990 is a Romanian NGO focused to sustain its employees or corporate members to develop all kinds of nuclear activities in connection with environmental protection as a scientific organization, having as the first objective activities with respect to Cernavoda NPP. As the only CANDU type reactor equipped Nuclear Power Plant (NPP) in Europe, we pay very much attention to all aspects regarding implementation of this concept in our country and the consequences of this implementation.

From July 1996 the first unit in operation supplied into the grid around 40 TWh electric power and around 400 Tcal of thermal power for district heating until September 2004. The second unit is still under construction managed also by the Canadian project team, having a finalization target year of 2007. The temporary LILW, and spent fuel dry storage facilities are also on Cernavoda NPP site inside the safety exclusion area boundary of the first unit. The capacity of temporary LILW warehouse concrete building, practically located into the security plant fence, is around 2,400 m^3. The occupied capacity is estimated as 140 m^3 until the end of 2004. The spent fuel dry storage MACSTOR type (a Canadian solution for spent fuel storage) with about 12,000 spent fuel bundles capacity is in operation on Cernavoda NPP site, since May 2003.

Nuclearelectrica as the owner implemented all the projects based on the licenses and permits granted by the National Commission for Nuclear Activities Control (CNCAN) for each step: the sitting, construction, commissioning and operation. According to the specific Romanian regulations, every project on the site, like the interim dry storage facility, was also subject to the licensing process by the Environmental and Public Health authorities. The public acceptance has been an important step of the licensing procedure. Cernavoda NPP used different legal procedures for public debate including announcements in local and national newspapers and public hearing. No objections against the nuclear facilities on Cernavoda site have been raised.

This paper develops the status, policy and trends regarding management of NPP Cernavoda nuclear waste and provides a short description of site environmental monitoring from a pro-nuclear NGO member point of view like a member of AREN.

INTRODUCTION

Located at 180 km east of Bucharest, in Constantza County at about 2 km SE from Cernavoda town, on the north side of the Danube-Black Sea Channel, is the site of Cernavoda NPP having a CANDU 6 reactor type designed for 5 units of 706.5 MW maximum power per unit at 15^0 C cooling water temperature. First of this has been in commercial operation since the middle of 1996 and covers more than 10% of the national power demand. In the cold season the first unit also covers all heating needs for the town.

Three years ago the Romanian Government announced its commitment for completion of the second reactor, which was already more than 40% installed since Romania must look for continuing the nuclear power as the most practicable economic solution for the future.

The operational performance of Unit 1 from Cernavoda NPP has largely complied with "Current Western European Nuclear Safety Objectives and Practices". In spite of some temporary financial restraints the plant was operated with full compliance of licenses and regulations.

Nuclearelectrica as the owner of NPP Cernavoda implemented the plant management for Unit 1 operation and radioactive waste management, including spent fuel management, consisting of:

1. The LILW warehouse concrete building, practically located inside the security plant fence, having around 2,400 m^3 capacity, with the occupied capacity estimated as 140 m^3 until the end of 2004;
2. The spent fuel dry storage, MACSTOR type (Canadian solution for spent fuel storage) having about 12,000 spent fuel bundles capacity in operation since May 2003.

In accordance with the new Romanian Law (Law 320/2003) the National Agency for Radioactive Waste (ANDRAD) was assigned from the middle of 2003 responsibility for the coordination at a national level of the process of managing in a safe manner the spent nuclear fuel and radioactive waste, including disposal and to ensure the establishment of the national repositories for spent fuel and radioactive waste disposal; the national repositories will be in the ownership of and will be operated by ANDRAD. Until this year a "wait and see" strategy regarding disposal was considered the best option for LILW and spent fuel in Romania.

LOW AND INTERMEDIATE RADIOACTIVE WASTE MANAGEMENT

There are no strong rules for classifying radioactive waste. The Romanian National Report [18] stipulates categories based on operational purposes of solid wastes generated from the NPP and the radioactive waste can be classified as following:

a. Spent filters cartridges;
b. Low activity solid wastes, Type 1 (contact gamma dose rate < 2 mSv/h);
c. Medium activity solid wastes, Type 2 (contact gamma dose rate between 2 mSv/h and 125 mSv/h) and Type 3 (contact gamma dose rate higher than 125 mSv/h);
d. Aqueous radioactive wastes;
e. Organic liquid radioactive wastes;
f. Gaseous radioactive wastes.

In this category all waste having higher than 10^{-2} mSv/hour is considered to be included and required special protection and shielding measures have been provided for their transportation, handling and storage.

So the characteristics of the spent resins handled within the plant systems are ranging within large limits. Both the activity and composition of the radionuclides retained in the ionic exchange resins depend mainly on the function, which the purification system performs within the plant. The resin activity used in the purification system of the heat transport system, or the activity of the water in the spent fuel bay is due mainly to Cesium 134 and 137, which originate in the spent fuel. Resin activity used in the purification system of the moderator is due mainly to Cobalt 60 and Chromium 51. Spent Resins Handling System includes storage tanks for spent resins from the plant's purification circuits in three vaults made of reinforced concrete lined with epoxy, located in the basement of the Service Building, in the proximity of the Reactor Building. The capacity of each vault is of 200 m^3 for 10 years, before being discharged and carried to the disposal facility.

Fig. 1. General View of the LILW Facility

The spent filters cartridges result from heat transport purification system, moderator purification system, spent fuel bay water purification system, heat transport pump sealing system, D2Osupply system for the fuelling machine, and the active drainage system. The spent filter cartrid ges usually have, when they are discharged from the plant process systems, a radiation dose up to 5 mSv/hour and in a severe situation, upto 50 mSv/hour. Highest dose rate reached till now was 12 mSv/h for large filter cartridges from the Spent Fuel Bay - Cooling and Purification System. The spent filter cartridges are handled by means of a large flask, having a weight of 8.6 - 8.8 tons (including the cartridge), or a small flask, which has a weight of 2.7 tons (including the cartridge). Protection wall thickness of the flasks have been calculated in order to provide a radiation dose reduction from 50 Sv/hour to 0.25 mSv/hour in case of a large flask and from 50 Sv/hour to 0.15 mSv/hour in case of a small flask. The spent filter cartridges are unloaded from the process systems, are dried (H-3 < 5 μSv/h) and then carried to the Interim Solid Radioactive Waste Storage Facility. Transfer of spent filter cartridges is performed by means of suitably shielded containers.

Other kind of solid low active wastes are produced from various operations consisting mainly of materials from decontamination and maintenance operations, protective clothing and metallic parts, as well as contaminated materials and equipment. Waste is collected in bags, which are checked for tritium before compacting. If tritium is detectable the bags are dried. The solid wastes are collected into 220L stainless steel standard drums.

Fig. 2 The warehouse inside view

Solid radioactive wastes are collecting separately, as either compactable or non-compactable wastes. Compactable waste includes paper, textiles, plastics, rubber and other compactable materials. Non-compactable waste includes: general waste (tools, metallic parts, wood pieces, construction waste) and special waste (glass, iodine, particulate and tritium filters cartridges, molecular sleeve).

Medium activity solid radioactive wastes (type 2 and 3 as above mentioned) are produced in small quantities and only under special circumstances. They are remotely handled with suitable shields or additional containers. The medium activity solid wastes type 2 are classified as compactable (paper, textiles, plastics, rubber and others) and non-compactable waste (tools, metallic parts, wood pieces, construction materials and also spent filters cartridges from plant purification circuits). The medium active solid waste type 3 is only non-compactable waste. They consist of spent filters cartridges, activated reactor components or other highly-contaminated materials. This kind of waste is produced in small quantities and only under special circumstances. They are handled by means of special shielded containers. The Solid Radioactive Waste Intermediate Facility is located on the concrete platform inside the inner security fence of Unit 1, at the East direction from the reactor building. After pretreatment (segregation and compaction) the solid wastes are confined and sent to this deposit facility. It consists of three above ground structures with a designed life of 50 years:

- a warehouse concrete building for 2,400 m^3 of 220 liter stainless steel drums capacity storage containing compactable and non-compactable low and intermediate level solid radioactive waste;
- Two concrete structures: one with cylindrical cells for around 58 m^3 spent filter cartridges capacity and other with 8 independent concrete cubes for around 41 m^3 overall capacity for large and highly contaminated waste.

The quantitative estimation shows that 6% of drums and 12% of cartridge make up the occupied capacity until the end of 2004.

The aqueous liquid wastes collected by the Liquid Radioactive Waste system, released to the environment, are categorized as follows:

• Level 1 low activity wastes, resulting from laundry, showers, some laboratories and drainages of Service Building, and having the activity between 3.7 ×10 -1 Bq/l – 3.7 ×10 2 Bq/l;

• Level 2 medium activity wastes, resulting from the system for upgrading heavy water, decontamination of equipments and washing of plastic objects, other laboratories and drainages of Service Building, and having activity between 3.7 ×10 1 Bq/l – 3.7 ×10 4 Bq/l;

• Level 3 medium activity wastes, resulting from the drainage system of the Reactor Building, and from the drainages of spent fuel pools and of spent fuel storage tanks, and having activity between 3.7 ×10 4 Bq/l – 3.7 ×10 6 Bq/l.

Generally, the Level 3 medium activity wastes are treated for decontamination before release. Liquid Radioactive Waste (aqueous) is collected in five 50 m^3 capacity liquid effluent delaying tanks located in the basement of Service Building. The content of any tank shall be discharged to the Danube River or to the Danube - Black Sea Channel (via Condenser Cooling Water Duct), after a strict control. A decontamination unit is provided to minimize the radioactive particles in any effluent if necessary. It includes filtering and ionic exchange by means of a pre-coat type filter using as filtering material ionic micro resins and a special fiber material adequate for the colloidal filtration since the main contaminants consist of a combination of colloidal particles and ionic materials within a de-ionized water medium.

Organic liquid radioactive wastes consist of spent oils, spent solvents, liquid scintillate cocktails, flammable solids, sludge, which cannot be processed through Liquid Radioactive Waste System because of their unacceptable environmental impact. These wastes are stored in 220L stainless steel drums in the basement of the Service Building.

The sources of liquid organic wastes are:

• *oil*s: lubricating oils from pumps and motors used in Zones 1 and 2 contaminated mainly with tritium (at Cernavoda NPP there are three controlled zones; the level of risks and potential of contamination decreases as follows: Zone 1, Zone 2 and Zone 3);

• *solvent*s: from the decontamination area and from the laboratories and maintenance activities (white spirit, ethylene glycol, alcohol ethyl, toluene, chloroform and acetone);

• *liquid scintillate* contaminated mainly with tritium and segregated by tritium content. Liquid scintillate from sampling of Moderator System, PHT Systems and their auxiliaries is segregated from liquid scintillate from sampling of Liquid Effluents Systems;
• *radioactive sludg*e, from maintenance activities on the active drainage contaminated with gamma nuclides;
• *flammable solids* (solid – liquid mixture) from maintenance activities contaminated with gamma nuclides.

When sufficient volumes of such waste have been accumulated they will be treated according to the quantity and type of radioactivity they contain.

Gaseous Radioactive Waste System has as its objective potentially contaminated air circulated through four ventilation systems:
. Central Contaminated Exhaust System filters the air through a High Efficiency Particulate Air (HEPA) filter.
. Reactor Building Exhaust System and Spent Fuel Bay Exhaust System pass the air through a pre-filter, a HEPA filter, an activated charcoal filter (to retain radioiodine) and a final HEPA filter.
. Upgrader Tower Exhaust System releases the unfiltered air since it contains small quantities of tritium only. In areas of the nuclear island where heavy water systems are located, a Closed Cycle Vapor Recovery System recovers the majority of released tritium vapors. All potentially contaminated exhausted air is routed to the exhaust stack, which discharges it in atmosphere.

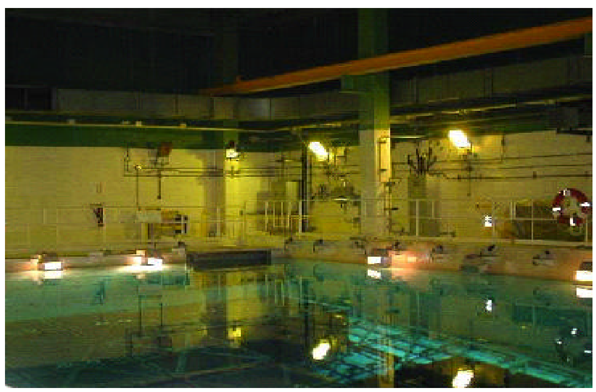

Fig. 3. Spent fuel bay

THE SPENT FUEL MANAGEMENT

CANDU fuel bundles consist of tubular zirconium alloy sheaths containing ceramic uranium oxide pellets. A bundle weighs about 24 kilograms, which includes about 19 kilograms of uranium. About 5,000 spent fuel bundles are produced each year by the Unit 1 NPP.
The typical operations for management of spent fuel Cernavoda NPP are:
> Defueling of fuel from a channel (normal, or, in case of leakage, early);
> Sending of the failed fuel for storage in the Failed Fuel Bay;
> Sending of the normal fuel for storage in the Spent Fuel Bay having a capacity of 50,000 fuel bundles;
> Wet storage of spent fuel for at least 6-7 years for cooling into the Spent Fuel Bay;
> Transfer of the fuel to the Spent Fuel Dry Storage (50 years design period of dry storage).
> Sending of the failed fuel for storage in the Failed Fuel Bay;
> Sending of the normal fuel for storage in the Spent Fuel Bay having a capacity of 50,000 fuel bundles;
> Wet storage of spent fuel for at least 6-7 years for cooling in the Spent Fuel Bay;

>. Fuel preparation in Transfer Area built as extension to the Spent Fuel Bay Building;
> Transfer of the fuel to the Spent Fuel Interim Dry Storage.

The fuel is prepared for dry storage in the Spent Fuel Bay and in the Shielded Work Station (SWS), which is a new construction in extension to the Service Building, adjacent to the spent fuel storage bay area. The fuel preparation area is located in the main Spent Fuel Storage Pool where the spent fuel bundles are transferred from trays into a fuel basket that can hold 60 bundles in vertical position. The fuel transfer area is located at the main spent fuel storage pool and in the service building extension. In the fuel transfer area, the fuel basket is lifted out of the water into a shielded workstation where the basket is dried and welded. The transfer flask, pre-positioned over the SWS is used to move the basket out of the SWS. The service building extension crane then moves the transfer flask from the SWS onto the transporter, ready to be towed to the Spent Fuel Interim Storage area.

The Spent Fuel Interim Dry Storage Facility in operation at the middle of 2003 is located at around at 700 m SW-W from the first reactor, close to the envelope of the initially planned fifth reactor on-site. The layout is as in Fig.4.

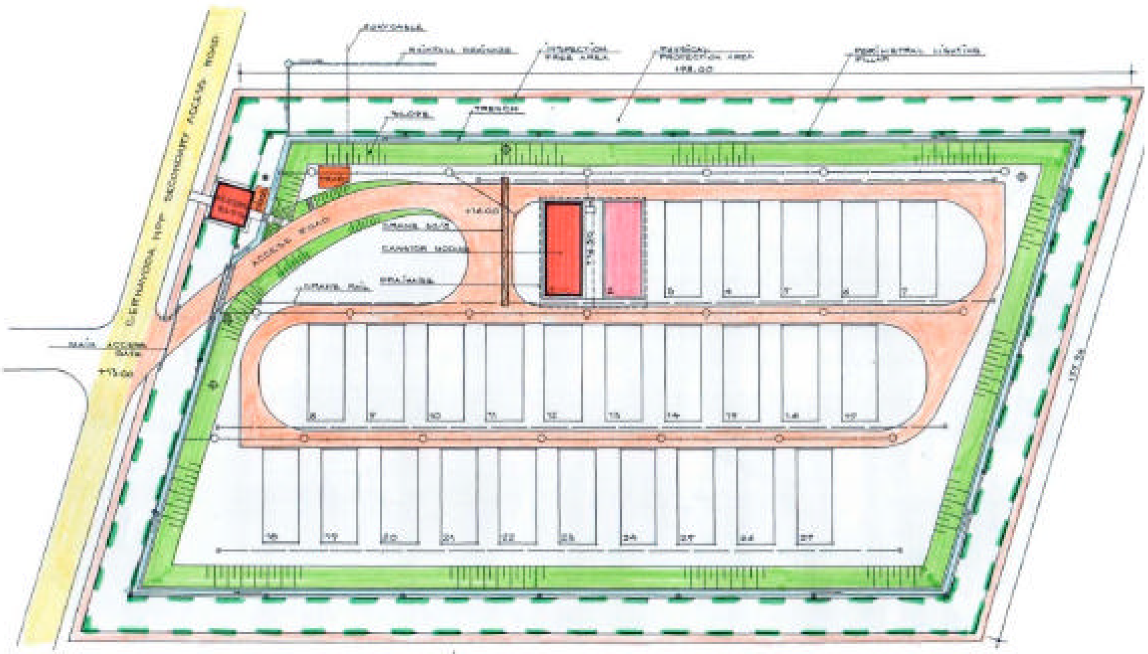

Fig 4. Layout of the Spent Fuel Interim Dry Storage Facility

The storage capacity will be expanded gradually from 12,000 to 324,000 spent fuel bundles in 27 modules. It can accommodate the spent fuel inventory of two reactors.

The dry storage technology is the Canadian MACSTOR System. It consists of storage modules located outdoors in the storage site, and equipment operated at the spent fuel storage bay for preparing the spent fuel for dry storage. The spent fuel is transferred from the preparation area to the storage site in a transfer flask. The transportation is on-site. The reinforced concrete storage modules have two sealed barriers for storing the spent fuel. Each module consists of 20 storage cylinders arranged in two rows. Each cylinder holds 10 baskets of 60 bundles and twenty storage cylinders are in one storage module for a total capacity of 12,000 bundles per module. The fuel storage area consists of a fenced site sized to accommodate a quantity of 300,000 spent fuel bundles.

Fig 5. Spent fuel dry storage module

Fig 5. Spent fuel dry storage module

The facility is designed to meet the stringent Safeguards requirements imposed by the International Atomic Energy Agency (IAEA) for the control of nuclear fissile materials.

The heat produced by the spent fuel bundles dissipates by conduction, convection and radiation to the basket external surface. The heat is then transferred to the storage cylinder mainly by convection and radiation, and some conduction at the bottom of the storage container. The heat of the storage cylinder is mainly evacuated by convection to air inside the module. A set of air inlets and outlets laid as a labyrinth provides a path so that the cooling air, driven by its natural buoyancy, enters at the bottom air inlets and exits at the top air outlets. The air circuit is designed for redundancy and diversity, as several openings on both sides of the module are available to maintain adequate cooling even when some air paths are assumed to be blocked (defense in depth against common cause failures). Each storage cylinder is provided with a vent and drain line.

POLICY AND TREND

Until this moment, all the radioactive wastes produced by the NPP Unit 1 are stored in a warehouse at its site, as mentioned above, designed for 50 years of waste equivalent of waste from one unit. For the wastes collected after Unit 2 is put in operation, it is expected to reach sufficient quantity after 10 years to need the construction of a new treatment plant and of a surface repository, which shall accommodate the short-lived radioactive waste from the NPP. The site, which is selected for the repository, is close to Cernavoda NPP, inside the exclusion aria, on the Saligni hill. The NPP wastes that will not be allowed to be disposed in the repository shall be stored, waiting for geological disposal, together with the spent fuel. Meantime, conditioning of such wastes shall be performed as well as technology development. Fig 6 shows the Romanian strategy main steps, the last phase depending on an economical solution.

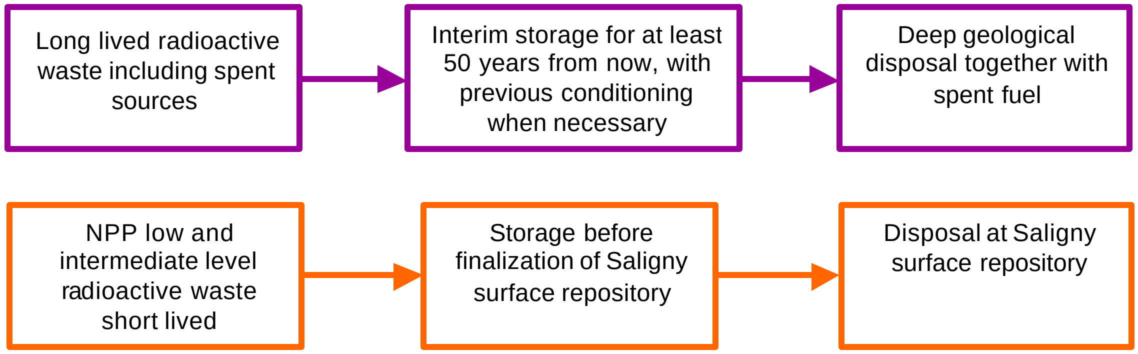

Fig.6 Current provisional strategy for long lived and short lived radioactive waste management

CONCLUSIONS

Unit 1 Cernavoda NPP having CANDU-6 type pressurized heavy water reactor, using natural uranium dioxide as fuel is only one of its kind in Europe. For this reason all governmental and nongovernmental organizations pay much attention to its operation and management, mainly regarding safety and environmental protection focused on the radiological protection to the people around the site.

The management of nuclear waste at Cernavoda NPP meets the IAEA general requirements, as:

- high safety and low environmental impact;
- integration in plant operation;
- technology transfer and local participation;
- Low cost;
- health physics and environmental protection:
- legal dose for workers: 20 mSv/year;
- administrative dose limit for workers:18 mSv/year;
- legal dose limit for a member of public:1 mSv/year;
- dose constraint for a member of public:0.1 mSv/year;

A special attention is given to public acceptance and methods used to consult the public. A good successful example of this is the approval process for the Spent Fuel Interim Dry Storage Facility. Not one Romanian NGO association or society was neglected. Very large preliminary information was provided to the news papers to explain the necessity, solution type, implication and environmental impact in order to have a real informed public reaction. The authorization process includes the CNCAN of the Authorization in all stages of the project and finalized by the Ministry of Environmental Protection Authority. AREN as a pro-nuclear NGO association participates in all phases of preparing and consulting mainly local public in order to clarify difficult-to-understand aspects and finally to obtain a majority in public acceptance.

Regarding the final repository for various types of radioactive waste we agree with the “wait and see” Romanian policy as well suited for our country.

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