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PROPOSAL OF A DRY STORAGE INSTALLATION IN ANGRA NPP FOR SPENT NUCLEAR FUEL

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ABSTRACT

When nuclear fuel is removed from a power reactor core after the depletion of efficiency in generating energy is called Spent Nuclear Fuel (SNF). After its withdrawal from the reactor core, SNF is temporarily stored in pools usually at the same site of the reactor. During this time, short-living radioactive elements and generated heat undergo decay until levels that allow removing the SNF from the pool and sending it for reprocessing or a temporary storage whether any of its final destinations has not yet been defined. It can be loaded in casks and disposed during years in a dry storage installations until be sent to a reprocessing plant or deep repositories. Before any decision, reprocessing or disposal, the SNF needs to be safely and efficiently isolated in one of many types of storages that exist around the world. Worldwide, the amount of SNF increases annually and in the next years this amount will be higher as a consequence of new Nuclear Power Plants (NPP) construction. In Brazil, that is about to construct the Angra 3 nuclear power reactor, a project about the final destination of the SNF is not yet ready. This paper presents a proposal for a dry storage installation in the Angra NPP site since it can be an initial solution for the Brazilian's SNF, until a final decision is taken.

1. INTRODUCTION

When nuclear fuel is removed from the reactor core because it is not anymore efficient maintaining a chain nuclear reaction, it is called "irradiated fuel" or "nuclear spent fuel" (SNF) [1]. Among 1/4 to 1/3 of the total reactor fuel is substituted by fresh fuel, every 12-18 months [2]. The spent fuel is stored, generally, in pools at the same site of the reactor, next to the core or in attached installations. This kind of storage is called "wet storage". After the SNF withdrawal from the reactor core, the generated heat and the short-medium living radioactive elements decay with time until levels that allow removing from pools. Depending of the established route in each country nuclear program – reprocessing or definitive deposition as radioactive waste is considered.

Brazilian plans do not involve SNF reprocessing as a fuel back-end of the nuclear cycle. Therefore, it is necessary to safely store SNF in order to have easy access to the fuel and, if necessary, to move it inside the installation at the origin or out of it, through a simple and less expensive manner.

CNEN's specific report [3] informed that Brazil still waits a definitive decision about the SNF destination: reprocessing or disposal. This decision will demand time, but there is already a hypothesis that a construction of a wet or dry storage installation will be necessary when the amount of SNF stored at the reactor place will be near to its maximum capacity. In 2008, CNEN [4] was still waiting a world-wide consensus about the attitude to be taken regarding to SNF, stated that the Eletronuclear Company foresees the construction of an additional wet storage installation for Angra-1, -2 and -3 nuclear power plants.

After a specific time the SNF can be transferred from pools to cylindrical containers, called casks, that and after draining are filled with an inert gas and sealed up, and can be transferred to a specific installation and placed in silos or directly over a concrete floor, remaining safely stored [5]. Casks for SNF storing cylinders can be made of metal and/or concrete, with internal steel covering. These casks can remain in shelters or be send to outdoor installations far from the reactor that are designed for this purpose [6]. Figure 1 shows the sequence of SNF withdrawal from the reactor pool, posterior storage in casks and transport to outdoor installations and disposal.

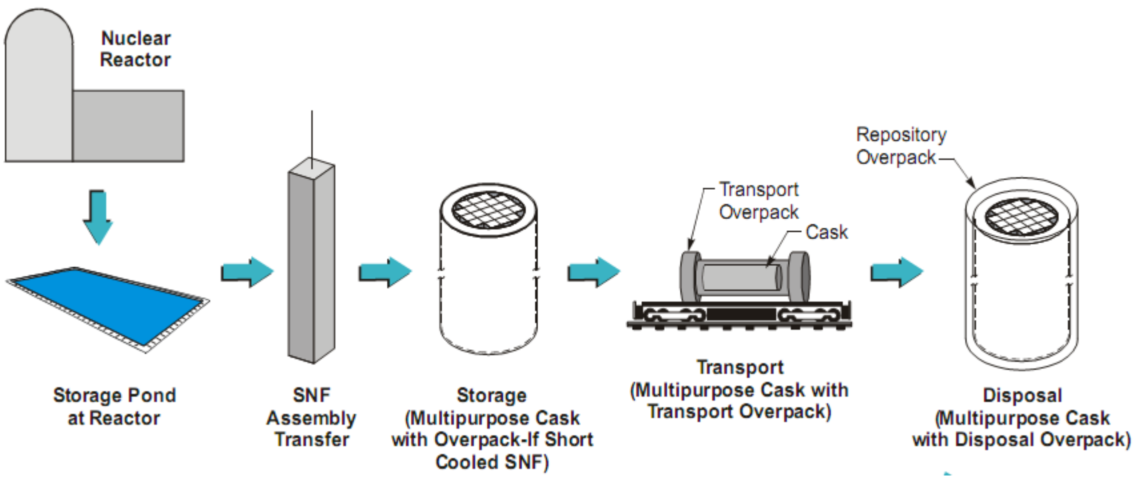


Figure 1. Sequence of SNF withdrawal, storage and transport in cask [8]

In some countries that have SNF storage installations a common practice is to adopt dry storage in many nuclear power plants whose pools storage capacity is compromised. The United States Nuclear Regulatory Commission (USNRC) determined that dry fuel storage installations must be safely, at least, for 20 years [7]. USNRC also considers that this type of storage is safer than the storage in pools because it avoids corrosion by water.

2. DRY STORAGE INSTALLATION

Before the construction and the licensing phase of any nuclear installation, some environmental impacts or those caused by man must be foreseen in Environmental Impacts Studies and Safety Analysis Reports. Environmental impacts are related to atmospheric events as winds, rain, snow, landslides, earthquakes, air salinity, floods, hurricanes, etc. and the other are related with possible incidents as fire, chemical explosions, leaks, or accidents as airplanes falls or even different kind of terrorist attacks.

2.1. Radioactive Waste Storage Installation in Angra NPP

The dimensions of the casks in a SNF dry storage installation are relevant. For this reason, a simulation for the Angra reactors site was performed.

2.1.1. Storage of the casks

The dry storage system is used since 1970 and differs from wet storage, because in the former air is used to cool SNF heat generation by radioactive decay.

The cooling system is passive and made by air convection. Different of wet storages in pools, dry storage does not demand water systems or electric devices. In this type of storage casks regular maintenance and monitoring of the SNF are more spaced and the reliability is higher [9].

Inside the cask, SNF is involved by an inert gas (frequently helium, argon or lightly reactive gas as nitrogen, which also prevents oxidation).

In the physical containment, metal or concrete are structures that can shield the radiation emitted by SNF mainly gammas and neutrons. To shield gammas thick walls of casting iron, steel or combinations of steel, lead and/or depleted uranium can be used [10, 11]. Neutrons can be shielded with materials like boron and highly hydrogenated materials like polyethylene.

In this paper, we considered a metallic cask for 21 PWR-SNF elements. The main cask dimensions are shown in Figure 2.

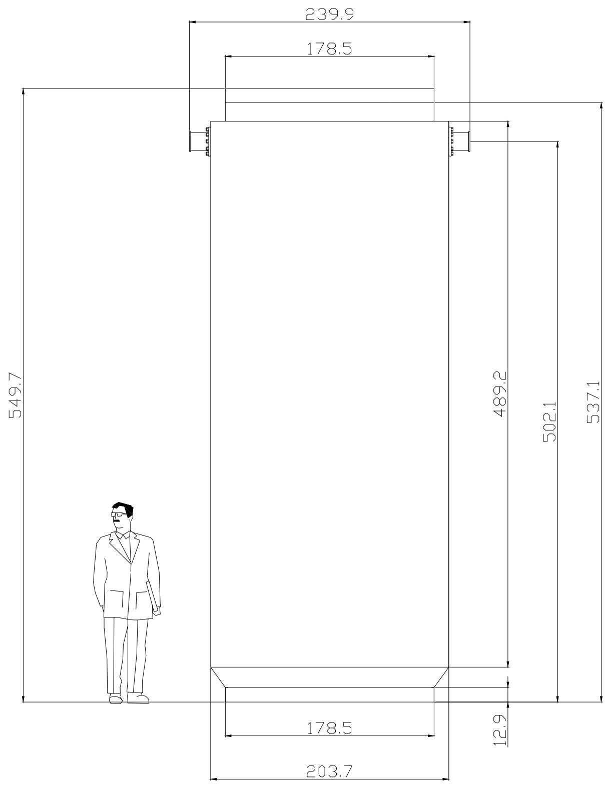


Figure 2. Twenty-one SNF elements cask proposal and its main dimensions.

2.1.2. Angra-1 and -2 NPP spent fuel elements

To generate energy, Angra-1 nuclear reactor core is composed by one hundred and twenty-one fuel elements and Angra-2 one hundred and ninety-three fuel elements. Each year nearly 1/3 of the total reactor fuel is changed so the amount of accumulated SNF elements per year is: forty-one elements for Angra-1 and sixty-four elements for Angra-2. Therefore, SNF elements generated in Angra-1 could be stored in two casks, and those from Angra-2 in three casks. In both cases, 21 SNF elements can be placed in each cask.

If the life time of Angra's reactor is considered of 30 years, Angra-1 will accumulate 1230 SNF elements that can be distributed among 59 casks and Angra-2 1930 SNF elements distributed among 91 casks. To this total, some units should be added for probable damaged elements and in case of reactors useful life increase.

If the reactors life time will be increased up to 10 years, additional 20 casks should be considered for Angra-1 and 30 casks for Angra-2. The SNF dry storage installation should be dimensioned for 79 SNF casks for Angra-1 and 121 SNF casks for Angra-2. Thus, the dry storage installation must have an initial capacity for 200 SNF casks.

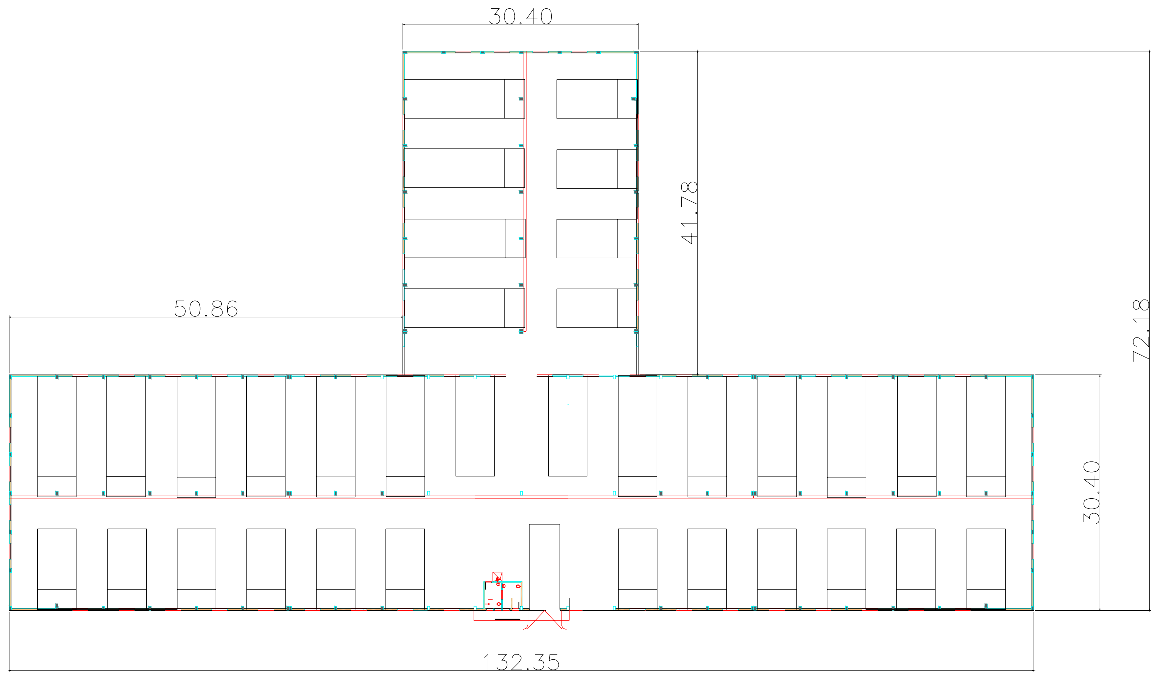
2.1.3. Angra 3 NPP spent fuel elements

Angra-3 reactor will be similar to Angra-2 and will generate about 1930 SNF elements along its 30 years life time that can be stored in 91 casks. So, an installation that includes Angra-1, -2 and -3 must have a capacity to store 321 SNF casks.

2.2. Angra NPP Storage Installation Dimensions

The main dimensions of a covered dry storage installation for SNF from PWR power plants are shown in Figure 3. As it can be seen in the drawing, the frontal length is 132.35m and the total depth 72.18m. The external height of the building 11.17m and the internal height 9.57m. The floor will be made of reinforced concrete with a thickness of 1m and must be able to support the casks weight.

It is considered that the casks would be installed in closed enclosure, only to prevent damages caused by weather (Angra NPP site is over the shore) and the walls and roof do not have additional shielding. The installation should have an overhead traveling crane (with 100ton capacity) for unloading the SNF casks that arrive from the reactors. The handling of the casks inside of the installation will be carried through lift trucks, Figure 4, especially designed for this purpose since this kind of handling offer greater mobility than the overhead traveling cranes.



Dimensions in meters

Figure 3. SNF storage installation proposal and its main dimensions

Figure 4. Handling of SNF casks by a lift truck [12]

Figures 5 and 6 show the locations of the SNF-PWR dry storage installation at the site of the Angra-1 and -2 nuclear power plants, considering the inclusion of the Angra-3 reactor.

Figure 5. Aerial view of a possible location of SNF dry storage installation at Angra's reactors site.

Figure 6. Possible location of the SNF dry storage installation at the Angra's reactors site.

3. CONCLUSIONS

The corrosion of spent nuclear fuel elements stored in dry storage is much smaller than that stored in pools.

When SNF elements are inserted inside the casks, they are protected from damages and the casks can be freely moved at the storage installation.

Cooling of the SNF inside the cask is carried through a passive way without the need to control water purity or use of water cooling systems as necessary in water pools.

In the proposed covered installation the stored casks, placed on a reinforced pad (floor), can be freely moved by transporting vehicles.

As it was projected, the storage installation shall be capable to store all SNF-PWR generated at the Angra's site for a minimum period of 20 years.

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