

SAFETY ASPECTS OF SPENT NUCLEAR FUEL INTERIM STORAGE INSTALLATIONS

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ABSTRACT

Nowadays safety and security of spent nuclear fuel (SNF) interim storage installations are very important, due to a great concentration of fission products, actinides and activation products. In this kind of storage it's necessary to consider the physical security. Nuclear installations have become more vulnerable. New types of accidents must be considered in the design of these installations, which in the early days were not considered like: fissile material stolen, terrorists' acts and war conflicts, and traditional accidents concerning the transport of the spent fuel from the reactor to the storage location, earthquakes occurrence, airplanes crash, etc. Studies related to airplane falling had showed that a collision of big commercial airplanes at velocity of 800km/h against SNF storage and specially designed concrete casks, do not result in serious structural injury to the casks, and not even radionuclides liberation to the environment. However, it was demonstrated that attacks with modern military ammunitions, against metallic casks, are calamitous. The casks could not support a direct impact of this ammo and the released radioactive materials can expose the workers and public as well the local environment to harmful radiation. This paper deals about the main basic aspects of a dry SNF storage installation, that must be physically well protected, getting barriers that difficult the access of unauthorized persons or vehicles, as well as, must structurally resist to incidents or accidents caused by unauthorized intrusion.

1. INTRODUCTION

Nowadays safety and security of spent nuclear fuel (SNF) interim storage installations are very important. These locations have a great concentration of fission products, actinides and activation products. In the wet storage case, the water level has to be constantly monitored due to avoid possible fuel element exposition to atmosphere and the possible cladding melting and the liberation of fission material. If that fuel were exposed to air and steam, the zirconium cladding would react exothermically, catching fire at about 1,000 degrees Celsius. NRC (Nuclear Regulatory Commission) concedes that such a fire cannot be extinguished; it could rage for days. By the way, spent fuel pools hold five to 10 times more long-lived radioactivity than a reactor core. Particularly there are large amounts of Cesium-137 in fuel pools. With a half-life of 30 years, Cesium-137 gives off highly penetrating radiation and is absorbed in the food chain as if it were potassium. According to the NRC, as much as 100 percent of a pool's Cesium-137 would be released into the atmosphere in a fire resulting in massive off-site radiation exposures. A single SNF pool holds more Cesium-137 than was

deposited by all atmospheric nuclear weapons tests in the Northern Hemisphere combined [1].

We must consider other factors on analyzing the safety of an installation, like:

(a) Seismic: the occurrence of a Richter magnitude 8 earthquake could cause cracks in the SNF storage pool walls leaking the water and consequently exposing the stored SNF to atmosphere;

(b) Electrical energy fallout (turning off the SNF pool cooling system);

(c) Heavy object falling in the pool that could damage the pool's wall and bottom;

(d) Unauthorized invasion with aggressive intent; or

(e) Airplane crash.

A safety plan is important and concern, either for an interim wet storage installation or the dry installation. For the first case, the most important care concerns primarily to the pool and for the second case, importance must be given to the storage casks, by the way, physical and radiological criterions of safety must be warned.

Safety and security of SNF is commented nowadays by environmentalists that reported nuclear power as a technology of mitigation on Greenhouse emission [2].

2. PHYSICAL SECURITY

Physical security includes the moment in which SNF is withdrawn from the nuclear reactor and follows, through a transporting system, up to the place of the interim storage installation. During this meantime, traffic accidents, SNF or auxiliary equipments stolen or sabotages, as well terrorist acts, crash of airplanes and belligerent acts in the storage installation can occur.

2.1. Traffic Accidents

According to GAO [3], studies performed by the Sandia National Laboratory (USA) in 2000, show that, an accidental liberation of radionuclides from casks with SNF provoked by traffic accidents is very unlikely. The results obtained from simulation of such type of situation allow affirming that in 99.9 % of the accidents, the transport casks would not suffer any significant damage. The probability of radioactive material liberation in road accidents, by transporting SNF, is very small, i.e. of the order of 2.8 accidents per 10 millions. Railway transport, instead of road that is more sensitive to accidents, is always preferred for larger volumes.

2.2. Theft during Transportation

The security against theft during transportation of casks with SNF is also a security item that should be analyzed. Because of the high mass of the casks, about 40,000kg (lighter casks), stealing for extraction of fissile material is very difficult since withdrawing of the SNF requires special devices and protection of the wrapped people.

2.3. Airplanes Crash

The effect of crash of airplanes has been minutely studied. Theoretical studies, regarding the crash of airplanes, were carried out and showed that the collision of an aircraft Boeing 747-400 at 800km/h against a concrete cask would not cause serious structural damages to the surface of the container, not even liberation of radionuclides [4]. For Pennington and

McGough (2002) calculations, a multi-purpose concrete model NAC, 5.7m height, 3.5m in diameter and mass of 137,000kg has been used. The impact was compared to a collision between plastic bags with bird feathers hurled against a column of concrete. Nevertheless, there might be harmful consequences because of the fire provoked by the explosion of the fuel tanks of the collided aircraft. A Boeing 747-8 aircraft can carry 243m³ of fuel and an Airbus A380, 310m³. The burning temperature of the fuel is approximately 815°C. This temperature, for an appreciable period (30 minutes, at least), before the extinction of the fire, might cause cracks in the concrete casks. If so it would be necessary to transfer SNF to new storage containers.

Other studies [5], including mechanical and thermal impacts against the storage building that contain metallic casks, point to building structure damages that can lead to its destruction, however, not damaging the casks structure. The operation license for the interim on-site facility at Lingen, Germany, emphasized an airplane crash accident with no admissible radiological consequence to be feared [6] and the licensed transportation of casks that guarantee the safe enclosure of the radioactive substances.

The impact of an aircraft against a building that contains a storage pool is different since a probable collapse of the building allied to the explosion of the aircraft and consequent fire, would damage the stored SNF. The water of the pool would be spread, mixed to the aircraft fuel and evaporate because of the combustion heat. The damages to the cladding would provoke the emission of fission products to the atmosphere and if achieve catastrophic radioactive levels in the atmosphere can result in dangerous damages.

2.4. Sabotages, Terrorism and Belligerent Acts

A great problem appeared after the event of September 11, 2001. Two commercial airliners hijacked by terrorists crashed intentionally into the two towers of World Trade Center in New York City, USA, resulting in the collapse of both building. The hypothesis of a terrorist act against a SNF interim storage installation that might damage the structure of buildings, pools, casks or the whole storage installation is now considered on the installation security. This act might provoke the liberation of high rates of radiation and even contamination of the adjacent areas.

The sabotage is usually made by individuals of bad intentions who enter the installation and provoke damages of great magnitude. The sabotage can affect, for example, the water of the cooling system of the storage up to structural damages because of explosives detonation. In this case, it should be added to the cost of the SNF storage security expenditures of vigilance as well as the entry and exit control of people and vehicles.

Explosives can be used by terrorists and the consequences can be devastating, if the existent installations do not have protection actions against this type of situation. In studies carried out by Hirsch and Neumann (2001) [7], regarding attacks with military modern perforating ammunitions against metallic casks, the authors show that a straight impact could not be supported. The projectile possibly will penetrate the cask, damaging the SNF and contaminating the surrounding area (e.g., villages or cultivated terrains).

However, according to the General Accounting Office (GAO) (2003) studies made by the NRC and DOE (Department of Energy), indicate that the probability of men's contamination with radioactive material leaked from the casks in a terrorist attack, in a severe transport

accident or in the dry SNF storage, is minimal. As reported, the containment safety probability, during transportation of the SNF, is 0.007% for road accidents and 0.004% for railway accidents.

Analyzing all the literature about this question it should be emphasized that the degree of radioactivity release after some kind of impact of SNF casks outdoors is small as well in a SNF storage installation. Terrorist attacks are previewed and storage areas as well transportations trucks are well protected with barriers against unauthorized people or vehicles access into the storage area or to intercept transportations vehicles. But during the SNF transportation all kind of eventual impacts should be analyzed.

3. CONCLUSIONS

The best physical protection against land attacks or sabotages are barriers. Barriers can obstruct unauthorized people or vehicles. The use of barbed wire fences, living wire (shrub), brick or concrete walls, steel grids and trenches around the installation difficult invasions. Another security items can be a couple entrance with straight identification during the access, inner and outer surveillance cameras, trained animals, armed security, access way with obstacles, use of alarms, etc.

Protection of the casks and of the storage sites against heavy ammunitions or airplane crashes can be made by preventions, proposed with a more adequate construction like a subterranean installation with a difficult access area for non-workers.

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