MAIN CONCERNS OF NUCLEAR SAFETY SUPERVISION DURING OPERATION OF SPENT FUEL STORAGE FACILITIES IN CHINA

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Abstract

With the continuous development of China's nuclear power projects in recent years, spent fuel has gradually entered a long-term storage stage, in which wet storage is the main way. The supervision of spent fuel storage facilities is becoming increasingly important. As China's nuclear safety regulatory system in this area is not complete, and there are few examples to refer to, it is urgent to explore and clarify the important concerns. Based on China's nuclear safety regulatory requirements and related regulatory experience of such facilities, this paper puts forward some suggestions for reference.

1. INTRODUCTION

In recent years, the spent fuel storage in spent fuel pools of some operating nuclear power plants in China has approached or reached the storage limit. These nuclear power plants are preparing to add temporary spent fuel storage projects. As China's nuclear safety regulatory system in this regard is not yet complete, and there are few reference examples, it is urgent to explore and clarify the relevant ways and methods of nuclear safety supervision. The most urgent thing is to put forward the most important concerns in the supervision work according to the basic requirements of the current nuclear safety supervision.

2. MAJOR CHALLENGES

With the sustained and steady development of China's economy and the steady growth of electricity demand, the situation of atmospheric environmental pollution reduction is grim. As green energy, nuclear power has gradually changed from moderate development in the past to rapid development of national energy and nuclear power medium-term and long-term planning and national "13th Five-Year Plan". It has a certain scale. By mid-2018, the total installed capacity of nuclear power generating units has reached 36.9 million kilowatts and 38 units; 19 units under construction have installed capacity of about 21 million kilowatts. According to the planning and the current progress of nuclear power construction projects, it is estimated that by 2020, the total installed capacity of power generation will reach 52 million kilowatts.

According to the general development policy and current situation of nuclear power in China, some studies have predicted the overall scale of nuclear power in the future according to the rapid development and slow development respectively, and estimated the storage demand of anti-spent fuel in Table 1 [1].

TABLE 1 Spent Fuel Production and Accumulation in the Future under the Rapid and Slow Development of Nuclear Power in China (t U）

	Year	2020	2025	2030	2050
Rapid development	Spent fuel production	1 000	2 000	3 200	7 700
	Spent fuel accumulation	7 000	15 000	28 900	141 000
Slow development	Spent fuel production	1 000	1 200	1 600	2 500
	Spent fuel accumulation	7 000	13 800	20 800	62 700

It can be seen that the annual production and total accumulation of spent fuel are very considerable, bringing severe challenges to the back end of nuclear fuel, whether in the rapid or slow development situation or in the mid-speed development value that can be obtained from the two.

3. BASIC REQUIREMENTS FOR STORAGE TECHNOLOGY

At present, two methods are widely used in the world to store spent fuel, namely wet storage and dry storage. Wet storage is the main method of spent fuel storage. Most of the spent fuel discharged from the reactor is stored in the pool. Wet storage can also be divided into stack storage, off-heap storage and pool storage before reprocessing.

Whether wet storage technology or dry storage technology, the following requirements must be met [2][3]:

(a) The integrity of spent fuel cladding should be maintained during handling and exposure to corrosive environment.
(b) During storage, in order to prevent the aging of spent fuel, the spent fuel should be cooled for enough time so that the temperature does not exceed the limit.
(c) Keep spent fuel in sub-critical state under normal and accident conditions.
(d) Radiation shielding for spent fuel must be able to protect operators, the public and the environment from radiation doses that do not exceed the management limit.
(e) Ensuring environmental safety by minimizing the release of isotopes.
(f) Always ensure the recoverability of spent fuel.

Wet and dry storage technologies are considered to be the most reasonable storage technologies for increasing spent fuel storage. At present, wet storage technology is the main technology in China.

Wet storage of spent fuel is a mature technology and a safe and reliable storage method. Because water has good heat conductivity, the pool water is continuously circulating and cooling, and the decay heat generated by spent fuel is derived. The radioactive activity of spent fuel is reduced by decaying radioactive nuclides through storage. Wet spent fuel storage facilities include spent fuel unloading pool, storage pool, pool water purification and cooling system, pool water leakage monitoring system, container lifting and spent fuel assembly lifting device, and spent fuel storage rack or spent fuel storage basket with critical safety. At the same time, water is also a kind of shielding material with high transparency, which can ensure that under the condition of direct visual supervision, operators can use some related equipment to complete the discharge and transshipment of spent fuel.

4. BASIC NUCLEAR SAFETY REQUIREMENTS FOR WET STORAGE

4.1. Ensure that the water in the storage tank does not leak and that spent fuel can be continuously submerged.

4.2. Ensure that there is enough space in the storage tank and the neutron adsorption capacity is strong enough to avoid accidental chain reaction.

4.3. In case of accident, ensure the supply of cooling water and prevent spent fuel from melting.

5. MAIN CONCERNS OF NUCLEAR SAFETY REGULATION

5.1. Container Receiving System

(g) The fuel assemblies received at each time shall be approved by the higher authorities.
(h) Operating permits for the acceptance and storage of spent fuel.
(i) Received container integrity.
(j) Contamination on the surface of the receiving container should be below the limit.

5.2. Container unloading system

(a) The maximum total weight of the treated container is less than the batch limit.
(b) Only one vessel is unloaded vertically underwater in the unloading pool at the same time.
(c) The discharge pond water reaches the required water level.
(d) Continuously purify the pool water so as to minimize the radioactive concentration in the air above the discharge pool.
(e) The lifting height of spent fuel assembly shall not exceed the minimum safe shielding water layer on it.

5.3. Spent fuel storage system

(a) The water depth of storage pool ensures that the shielding water depth on the top of spent fuel assembly is not less than the design height when it is transported in normal condition. In credible accident condition, the shielding water depth on the top of storage rack is not less than the design height.
(b) The liquid level of spent fuel storage pool is monitored and controlled by pool level measuring instrument and pool level signal instrument. When the water level of the pond falls to the limit set at the edge of the pond, a warning signal is issued.
(c) The spacing between adjacent storage boxes of storage racks shall be limited to ensure the storage of spent fuel assemblies.
(d) The pool water in the storage tank is continuously pumped out for filtration-ion exchange purification treatment at a periodic rate within a specified time, so that the radioactive concentration of the pool water is maintained below the design limit, and the dose rate at the height required by the design of the pool water surface is less than the design limit.
(e) The storage pool hall is equipped with comprehensive mechanical ventilation.
(f) Maintaining the average horizontal temperature of the storage tank < the design process conditions, and the maximum operating temperature is the design process conditions.
(g) The water quality of storage pond meets the limit requirements.

5.4. Pool water cooling system

(a) The outlet temperature of the pool water cooler is less than or equal to the design limit.

(b) The inlet temperature of the cooling water of the pool water cooler is less than or equal to the design limit.
(c) The outlet temperature of the cooling water of the pond water cooler is less than or equal to the design limit.
(d) The water flow through the pool water cooler is less than or equal to the operation requirement.

6. CONCLUSION

Through the supervision practice of spent fuel storage facilities currently in operation in China, the main concerns of spent fuel acceptance and unloading, storage and transshipment systems are optimized and determined, which improves the operation level of spent fuel storage facilities, accumulates experience and provides basis and operation experience for the supervision of spent fuel storage facilities in the future.

REFERENCES

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