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MANAGEMENT OF SPENT NUCLEAR FUEL DRY STORAGE IN TAIWAN

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ABSTRACT

One of the high-priority issues for sustaining the operation of nuclear power stations (NPS) is how to manage and store the spent nuclear fuel safely. In the past few years, interim dry storage of spent nuclear fuel followed by reprocessing or geological disposal is the most favorable option and has become an acceptable alternative worldwide as well as in Taiwan for extending the storage capacity of spent nuclear fuel. Since July 2005, Taiwan Power Company (TPC) has been commissioning the Institute of Energy Research (INER) to establish the spent nuclear fuel dry storage facility at Chinshan NPS. The INER-HPS concrete cask storage system was developed by means of technology transfer from NAC International. Each cask can store 56 BWR spent nuclear fuel assemblies. In order to meet the site-specific requestsrequirements, some modifications were made.

The facility licensing will be issued in two phases: Construction Permit (based on the Preliminary Safety Analysis Report, PSAR) and Operating License (based on the Final Safety Analysis Report, FSAR). The application for Construction Permit was submitted in March 2007. To master the critical issues involved for licensing a site-specific ISFSI in Taiwan, the competent authority, Atomic Energy Council (AEC), not only organized a technical review team composed of experienced experts and scholars in various disciplines, but also completed two preliminary review studies for the original UMS system of NAC and the site-specific dry storage facility having similar geological features to Chinshan NPS. The verification and validation of computer codes used in various analyses of the facility design have to be reviewed first. Two confirmatory evaluations have been carried out regarding the safety concern of structural seismic analysis and radiation shielding design. Technical consultations from USA and Japan are remained to settle the unresolved safety issues. Licensing hearing is also required before issuing the Construction Permit.

This paper gives an overview of the regulatory requirements and a review program for applying spent nuclear fuel dry storage facility in Taiwan.

INTRODUCTION

In Taiwan, there are three NPSs in operation with a total installed capacity of 5,144 MWe. The fourth NPS is under construction and expected to operate in 2009. These NPSs are owned and operated by TPC. The current generating capacities account for approximately 14% of the total electricity production in Taiwan. After 40 years of operation, it is estimated that the first three NPSs will produce 4,950 metric tons of spent nuclear fuel while the fourth NPS will roughly produce 2,497 metric tons. The pool capacities and the spent nuclear fuel storage quantities for the first three NPSs are shown in Table 1. Nuclear professionals acknowledge that spent nuclear fuels are not entirely wastes. If the decision is to send them for reprocessing, they are regarded as valuable materials. If, however, they are decided to be disposed of, they then become high-level radioactive wastes. The Radwaste Management Policy (RWMP), proclaimed in 1997 by the Executive Yuan (the cabinet of Taiwan), sets out the principal guidelines for the nuclear industry in Taiwan to plan its own spent nuclear fuel management. Highlights are summarized as follows:

- ✧ To strengthen the implementation of spent nuclear fuel on-site dry storage for the mid-term target;
- ✧ To evaluate the feasibility of extraterritorial reprocessing option in accordance with international nuclear safeguards agreement; and
- ✧ To continue planning the final disposal program for spent nuclear fuel and to accelerate the development of a preliminary feasibility study program as well as an implementation program.

Table 1. Pool Capacities and Spent Nuclear Fuel Storage Quantities in NPSs

Reactor	Commercial	Pool capacity (Assembly)	Storage quantity		Nullified year After re-racking
			Assembly	Tones (MTU)	
Chinshan 1	12/6/1978	3,083	2,564	442	2010
Chinshan 2	7/16/1979	3,083	2,420	418	2011
Kuosheng 1	12/28/1981	5,026	3,316	557	2015
Kuosheng 2	3/15/1983	5,026	3,376	567	2016
Maanshan 1	7/27/1984	2,151	986	397	2125
Maanshan 2	5/18/1985	2,159	1,004	404	2126

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Spent nuclear fuels are temporarily stored in the spent fuel pools of each NPS. Although the re-racking project for extending the storage capacity of spent fuel pools has been undertaken, Chinshan NPS will still lose its full core offload reserve by the year 2010. To assure continuous operation of reactors, TPC has declared to build an Independent Spent Fuel Storage Installation (ISFSI) at Chinshan NPS and commissioned INER to implement this project in July 2005. Accordingly, INER has signed a contract with NAC International in August 2005 to commence the technology transfer of the Universal MPC System (UMS).

After performing a detailed study on technical, safety, social, economical, and environmental impacts in 1990, TPC has decided to implement an ISFSI project. It will be installed inside Chinshan NPS, which is located at the northern tip of Taiwan nearing the coast, and will serve for the dry storage of 1366 spent nuclear fuel assemblies. The design capacity will accommodate 25 storage casks and each cask is allowed to store 56 BWR spent nuclear fuel assemblies. The technology transfer between INER and NAC International was emphasized on a type of vertical concrete cask design, the NAC-UMS storage system (Certificate no. 1015), which is a qualified system certified by the U.S. Nuclear regulatory Commission (USNRC).

ISFSI is a passive system. Therefore, the materials used will play crucial roles in affecting the safety of casks. The competent authority of spent nuclear fuel management in Taiwan, Atomic Energy Council (AEC), will carry out full technical review and confirmatory evaluations to assure that safety function is available. A third-party inspection has been demanded to enhance the quality assurance of cask fabricating activities and the foreign technical consultation will be arranged. Although the physical protection level of such facility is similar to that of NPS, a comprehensive analysis against commercial airplane attack on cask should be made and addressed. Licensing hearing is also required before issuing the Construction Permit. This paper gives an overall picture of the regulatory requirements and the review program for the licensing of an ISFSI in Taiwan.

CHINSHAN ISFSI PROJECT

Choosing an approved storage cask system from a qualified vendor is certainly a favorable option to speed up the design and fabrication process in Taiwan. However, in order to meet the domestic regulatory requirements, site-specific environmental and operational conditions, some modifications shall be done on the original design of UMS. For example, to meet the loading capacity limit of the spent fuel pool crane, the thickness of the lead shell and the low alloy steel bottom door of the transfer cask were both reduced. To meet the site boundary dose limit of 0.05mSv/yr requested by TPC, each vertical concrete cask (VCC) is enveloped with an add-on shielding (AOS) at the storage site[1]. The AOS looks like the cylindrical cover of a “DVD spindle” and was decomposed into several donut-shape cylindrical segments and a lid. Once VCC is installed, components of AOS will be assembled one by one. The relative position of VCC and AOS is fixed via four separated blocks attached to the inner side of each donut-shape cylindrical segment. With the incorporation of AOS, the off-site dose limit could be reduced by almost 80%.

Based on TPC’s up-to-date construction plan, ISFSI is expected to begin operation by the end of 2009. The capacity of this facility is set to hold 1366 BWR spent nuclear fuel assemblies. The combined capacity of this facility with the spent fuel pools will be sufficient to store all the spent nuclear fuels generated during the 40-year operation of Chinshan NPS. To meet the project schedule, the major milestones for this project should include the following:

- ✧ Submission of PSAR to AEC for review in 2007;
- ✧ Completion of ISFSI pad and all auxiliary equipment for at least two sets of casks and canister in July 2008;

✧Completion of loading and storage for the first two casks of spent nuclear fuel assemblies at Unit 1 in 2009;

✧Completion of loading and storage for the first two casks of spent nuclear fuel assemblies at Unit 2 in 2010; and

✧Completion of loading and storage for all the spent nuclear fuel assemblies in 2011.

The major components of INER-HPS storage system and the simulated layout of ISFSI are shown in Figure 1 and Figure 2, respectively.

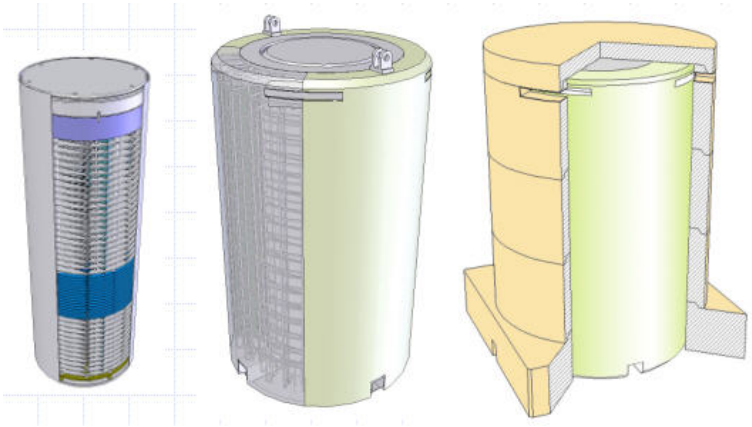

Figure 1. The major components of INER-HPS system

Figure 2. The layout of ISFSI at Chinshan NPS

REGULATIONS of SPENT FUEL SAFETY

Although the concept of spent nuclear fuel dry storage has been adopted in 18 countries, it is completely new to Taiwan. In order to develop the regulatory requirements as well as the inspection technology for the design, construction, and operation of ISFSI, AEC has conducted many studies on spent nuclear fuel dry storage management since 1991.

The regulatory requirements for ISFSI in Taiwan are based on the provisions of the “Nuclear

Materials and Radioactive Waste Management Act[2]", "Enforcement Rules for the Nuclear Materials and Radioactive Waste Management Act[3]", "Fees on Regulatory Services under the Nuclear Materials and Radioactive Waste Management Act", "Regulations for the Review and Approval of Applications for Construction Permit of Radioactive Wastes Treatment, Storage and Final Disposal Facilities[4]", and "Hearing Proceeding Guidelines for the Construction of Radioactive Material Facilities[5]" . In particular, the "Guidelines on the Safety Analysis Report (SAR) for the Application of Spent Nuclear Fuel Dry Storage Facility[6]" guides the applicant in preparing the licensing documents. The SAR shall contain:(1) Introduction; (2) Description of site characteristics; (3) Principal design criteria; (4) Organizational structure, administrative management and training program; (5) Facility operations; (6) Safety assessment including off-normal operations and accidents; (7) Radiation protection and environmental radiation monitoring program; (8) Fire protection program; (9) Physical protection plan, material and accounting record management plan; (10) Quality assurance plan; and (11) Preliminary decommissioning plan. Meanwhile, the regulatory requirements of storage cask licensable from its country of origin are also applied in Taiwan.

REVIEW PROGRAM and LICENSING ISSUES

It is emphasized that the facility licensing will be performed in two steps: Construction Permit (based on the Preliminary Safety Analysis Report, PSAR) and Operating License (based on the Final Safety Analysis Report, FSAR).

To master the critical issues involved for licensing a site-specific ISFSI in Taiwan, AEC, in 2005 and 2006, has organized a technical review team composed of around 30 reviewers in various disciplines and completed two preliminary review studies for the original UMS system and the site-specific dry storage facility having similar geological features to Chinshan NPS. Several safety issues have already been identified including seismic behavior, heat removal function, radiation shielding and radioactive materials confinement.

As for the review program, the applicant must submit to AEC a permit application containing SAR and the financial guarantee statement. Once the application is received by AEC through an acceptance review, a notice of receipt will be published either on its web site at http://www.aec.gov.tw or in the press release. Almost all documents submitted to AEC are available for public inspection, except proprietary information. Subsequently, the safety review work and the licensing hearing will be performed. After completing its safety review and resolving public comments, AEC will issue a safety evaluation report (SER) and make a decision on issuing the Construction Permit. Figure 3 shows the Construction Permit review process including SAR review process and hearing procedure.

The applicant (TPC) submitted an application for Construction Permit in March 2007. An acceptance review has been performed to identify the omissions and deficiencies, and then determine if sufficient information was provided to begin a detailed technical review. To discuss the licensing issues, a technical review team consisting of experienced experts and scholars in various disciplines was

called upon to make a safety review. The verification and validation of computer codes used in various analyses of the facility design must be reviewed first. Eight critical safety issues including (1) structural safety; (2) confinement integrity; (3) heat removal; (4) criticality safety; (5) shielding design; (6) radiation protection; (7) spent nuclear fuel handling; and (8) quality assurance of cask fabrication and facility construction were fully examined. Considering the site-specific limits and design modifications, AEC staff has performed two confirmatory evaluations on structural seismic analysis and radiation shielding for the INER-HPS system. Furthermore, foreign technical consultations from Sandia National Laboratories (SNL) and Japan Nuclear Energy Safety Organization (JNES) via technical cooperation have been arranged, particularly, to settle the unresolved safety issues, such as structural seismic behavior and heat removal function of the INER-HPS concrete cask. The safety evaluation report will be issued in January 2008 based on the review schedule.

Even after the completion of facility construction, the facility shall not be formally operated until AEC has inspected the construction engineering and qualified the pre-operation thereof, and has issued an Operating License therefore. The Operating License is valid for 20 years from the date of issuance. When there is a need to continue the operation after the license is expired, an application for renewal should be filed at least 2 years prior to the expiration.

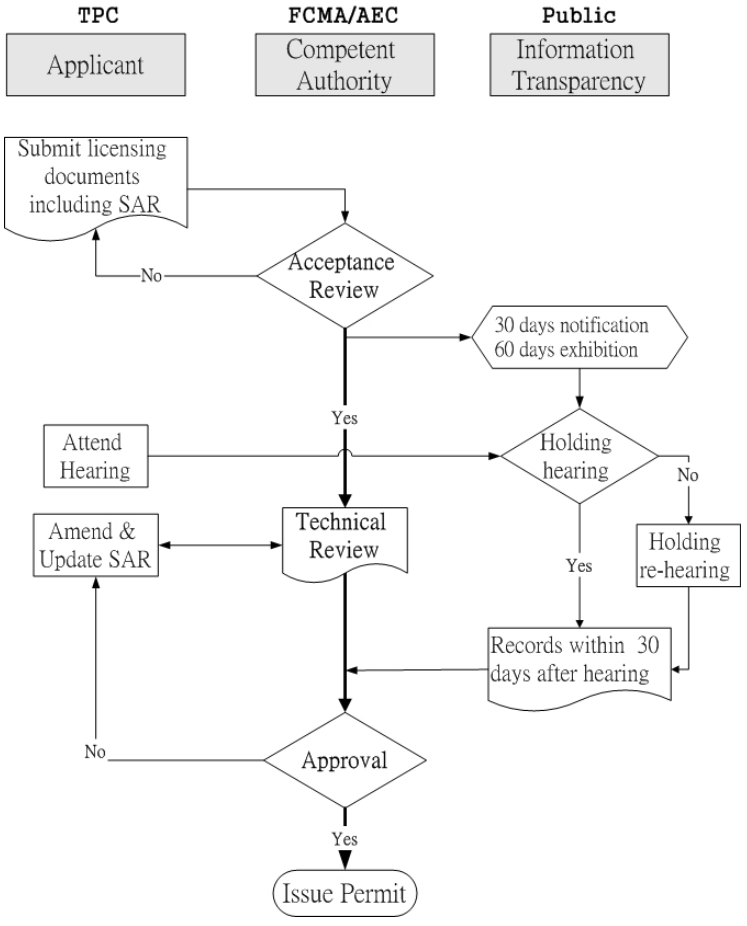

Figure 3. Flow Chart for Construction Permit Review Process

PUBLIC COMMUNICATION

Public participation plays a significant role in enhancing public confidence in AEC and its ability to carry out its mission — to protect public health and safety in radioactive waste treatment, storage and final disposal. AEC has long recognized the importance and value of public communication and involvement as key cornerstones of strong, fair regulation in the nuclear industry.

As far as public health is concerned, the radiation effect from spent nuclear fuel dry storage facility should be reasonably reduced, and the radiation protection design shall ensure the annual effective dose equivalent to an individual of the general public outside ISFSI not exceeding 0.25 mSv, which is 25% of the dose limit for an individual of the general public (1mSv in one year). Particularly, TPC promised that the acceptance criteria for an individual of the general public will not be greater than 0.05 mSv/year.

As to public communication, upon receipt of TPC's application for the Construction License of the Facility, AEC immediately posted the application documents on its website in accordance with paragraph 2 of Article 17 of "Nuclear Materials and Radioactive Waste Management Act," and requested the local township office (Shihmen), adjacent township offices, township public health centers, libraries, Taipei County Government, and Taipei County Council to give a 60-days proclamation in order to solicit opinions from the public. An announcement of hearing was posted on July 6. During the period from July 10 to 20, people from the local and other communities could enroll themselves for attending the hearing. Subsequently, AEC held a pre-hearing on July 31 in the vicinity of a proposed facility to hear opinions from the public about the hearing agenda. Later on, the hearing was held on August 10. A total of 78 participants took part in the hearing, including case applicant, 20 experts in related agencies, and 28 people from various domains such as the congress, the local communities and the environmental groups.

The objective of the hearing is to provide the opportunity for the public to express their opinions about related issues. By compiling the opinions collected during the case's proclamation period, hearing records, and the review result of Safety Analysis Report from experts, AEC will bring up a review conclusion for the application. However, before making any conclusion to the review, TPC shall submit to AEC the certificate of environmental impact documents ratified by the environmental protection competent authorities as the prerequisite for approving or rejecting the application[7].

CONCLUDING REMARKS

The construction of on-site ISFSI has been chosen as a preferred mid-term solution in Taiwan. Other than conducting preliminary review studies, choosing an approved storage cask system from a qualified vendor is a favorable option to speed up the design, fabrication process, and licensing procedure. However, modifications of cask system design must be undertaken to meet the domestic regulatory requirements and site-specific environmental conditions. Factors endangering the safety

of spent nuclear fuel and causing risk to the public health shall be re-assessed; especially the structural seismic analysis and the heat removal function in Chinshan NPS. Additionally, public acceptance plays a critical role in making construction licensing successful. In substance, guaranteeing stringent safety standards, document transparency, and public participation in the licensing phase are our most important concerns.

As the operation of Taiwan's NPSs is advancing into the forth decade, spent nuclear fuel management is gaining more and more attentions. The technologies involved in spent nuclear fuel dry storage encompass several disciplines. Even though some subjects are newly encountered in Taiwan, we will continue to work closely with the experts and relevant organizations either locally or worldwide to assure that state-of-the-art technologies are available and well received by the implementer as well as the research institutes.

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