Experience Review on Dismantling Procedure for American Decommissioned NPPs

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1. Introduction

Since Fukushima accident in 2011, the need for decommissioning of nuclear power plant (NPP) has been growing steadily all around the world.

According to IAEA, the number of shutdown NPPs is totally 150 globally. In Korea, there are 23 operating NPPs and 5 NPPs under construction. But Korea has no shutdown NPP and has no experience on decommissioning commercial reactor so far except for decommissioning research reactor, TRIGA MARK-3. Based on the NPP lifetime as a 45 years, it is expected that 440 NPPs in the world and 16 NPPs in Korea will come to an end of their lifetime until 2060[10].

In this study, decontamination and decommissioning (D&D) procedure of shutdown NPPs in US concentrated on dismantling of reactor vessel and its internals is investigated.

2. D&D Activities

Now there are 33 shutdown NPPs in America. Among them, 16 NPPs have already been decommissioned. USA is one of the most advanced and active countries in the field of D&D. Connecticut Yankee (CY), Maine Yankee (MY), Yankee Rowe (YR), Rancho Seco (RS), Trojan (TR) NPPs are chosen for this study. Their experiences in D&D could be a good reference for D&D preparing country like Korea.

Table I: Reactor information regarding 5 Shutdown NPPs similar to Kori-1. (as of 2010)

Name	CY	MY	YR	RS	TR
Type	PWR	PWR	PWR	PWR	PWR
Capacity (MWe)	560	860	167	873	1095
Operating Duration	28 yrs	25 yrs	30 yrs	14 yrs	16 yrs
D&D Start	1998	1997	2003	1997	1993
D&D End	2007	2004	2005	2009	2005
Cost (million $)	871	858	636	518	409

The first Korean commercial NPP, Kori-1, is a 576 megawatt pressurized water reactor (PWR). The lifetime of Kori-1 is going to be end in 2017. For that reason, 5 shutdown power plants above similar to Kori-1 are investigated as a case study to prepare for the future decommissioning works in Korea. These power plants are chosen based on the reactor type, capacity, etc.

2.1 Timeline of D&D Activities

As you can see in Table II below, there are D&D activities schedule of the 5 reference plants. Among primary systems such as reactor pressure vessel (RPV), steam generator (S/G) and pressurizer, S/G and pressurizer are removed earlier than RPV in the immediate dismantling work due to huge size and high radioactivity of RPV.

Table II: Major D&D activities schedule (End time).

Key Event	CY	MY	YR	RS	TR
Shutdown	Dec. 1996	Aug. 1997	Feb. 1991	June 1989	Nov. 1992
RCP removed	2000	June 1999	1994	2002	1996
S/G removed	Fall 1999	April 2000	1993	Mar. 2004	Nov. 1995
Pressurizer removed	Fall 1999	April 2000	1993	Mar. 2004	Nov. 1995
RPV removed	2003	Aug. 2002	Nov. 1996	July 2005	Dec. 1998
License Termination Plan submitted	July 2000	Oct. 2002	May 1997	April 2006	Aug. 1999
SF removed	May 2005	Feb. 2004	Feb. 2000	April 2001	April 1999
[End of D&D] License Termination	Nov. 2007	Spring 2005	2005	Oct. 2009	2005

Among the previously mentioned NPPs, Connecticut Yankee NPP, which is regarded as the most similar reactor with Kori-1 based on its type, reactor power, etc., is deeply investigated regarding its D&D procedure.

Fig. 1 below shows that after reactor went permanently offline, CY licenser, CYAPC, submitted PSDAR (Post Shutdown Decommissioning Activity Report). While LTP (License Termination Plan) was being supervised by NRC, primary systems like S/G, pressurizer, RPV and its internals and RCP in containment building were decontaminated and dismantled. By using chemical decontamination system, radiation exposure of 19.7 person Sv was down to 9.35 person Sv[4]. After the radioactive wastes were disposed, site remediation activity was implemented.

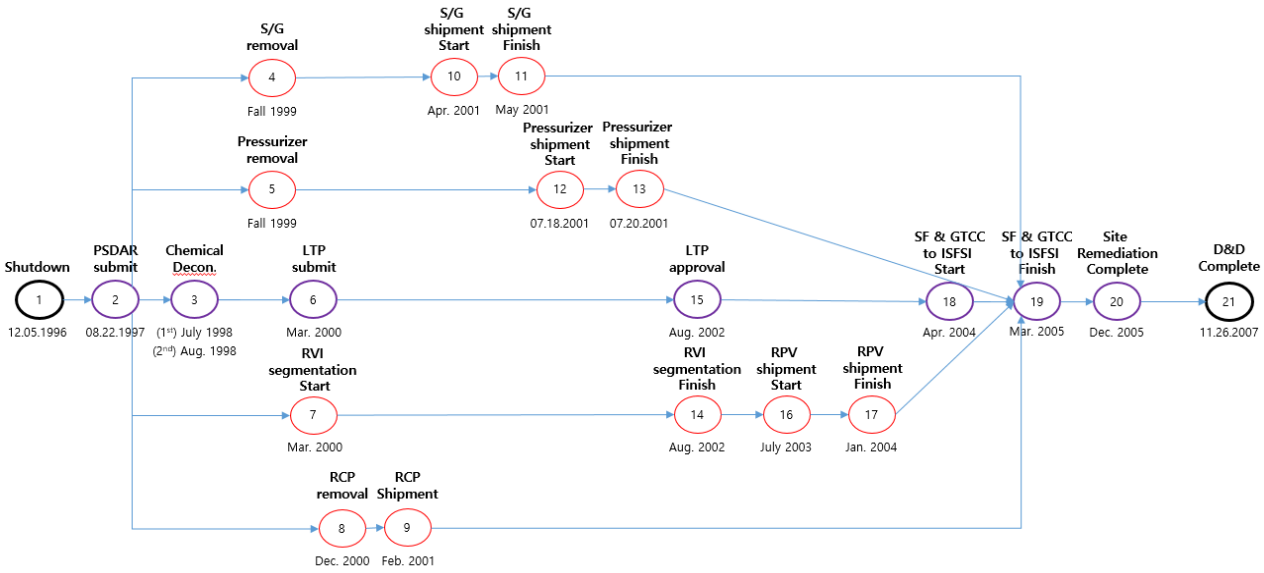

Fig. 1. Decommissioning Project Management CPM (Critical Path Method) for Connecticut Yankee NPP.

CYAPC disposed of radioactive wastes to 3 different facilities. RPV and S/G were shipped to Barnwell disposal site by barge while RCP and pressurizer were transported to Clive disposal facility by train. And SF (Spent nuclear Fuel) and GTCC (Greater-Than-Class-C) wastes were sent to CY ISFSI.

2.2 Segmentation

Fig. 2. Vessel package from Trojan NPP transported to disposal site by barge[8].

Dismantling works on RPV and its internals are very challenging due to their high dose rate and gamma heat around them. The procedure to remove a RPV can be divided into 2 methods. The first option is that RPV and its internals are segmented before removing. This option has been chosen for decommissioning of Connecticut Yankee, Maine Yankee, Yankee Rowe, Rancho Seco NPP. The second option is RPV including internals is removed together without segmentation and separation. In Trojan NPP, the procedure which removes RPV and RVI together was used and those intact radioactive wastes were transported to disposal site as a package.

The primary cutting technology utilized in Connecticut Yankee and Maine Yankee NPP was an abrasive water jet. Mechanical cutting tools were also used in segmentation activities. But thermal techniques such as plasma arc cutting, laser beam cutting and oxy-fuel cutting were not used[4, 5].

In Yankee Rowe NPP, segmentation was accomplished by using remote plasma arc cutting machine. Mechanical and thermal cutting methods were also employed for piping and other metal components[6].

Mechanical cutting and hydraulic press separation was mainly utilized to cut into RPV and RVI in addition to core barrel and its thermal shield at Rancho Secho NPP. There were 20 rem of radiation exposure and 0.08 MCi (2.7 + 15 Bq) radioactivity emission which needs to be eliminated while dismantling of reactor vessel[7].

3. Conclusions

Lessons learned from the 5 US decommissioned nuclear reactors have proved that abrasive water jet and mechanical cutting techniques have proven to be the most frequently used tools for segmentation. Moreover detailed activation analysis on primary system should be followed for safe D&D activities.

However many US decommissioning projects encountered that collection and removal of irradiated small and scattered debris from segmentation were challenging issues. That's why cutting enclosure was implemented to restrict the spread of debris to other area of refueling cavity. Furthermore lifting of total weight (apx. 1,000,000 kg) on primary system including RPV, RVI and interior low-density concrete was extremely heavy. And the gamma heat emitted from RVI was approximately 175 ℃. So it surely needs pre-cooling to prevent boiling LDCC (Low-Density Cellular Concrete).

One thing we should keep in mind is that there is no mighty dismantling method for decommissioning activity. Before Kori-1 NPP goes permanently off-line, we need to find the way which is the most appropriate D&D procedure for Kori-1. It should be chosen for safe, cost-effective and reliable decommissioning through foreign case study.

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