Development of EU-APR Initial Decommissioning Plan for EUR Design Certification

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1. Introduction

The Korea Hydro & Nuclear Power (KHNP) has currently developed the design of EU-APR, which is an improved design of APR1400 with the necessary changes to enhance safety and to comply with European utility requirements (EUR). According to the recent EUR, Rev. D, Chapter 2.16.2 (Decommissioning Plan), the decommissioning plan (DP) is divided into two (2) types: initial decommissioning plan (IDP) and final decommissioning plan (FDP), and, at the design phase of nuclear facility, it is required to prepare an IDP. The IDP should demonstrate that the NPP can be safely decommissioned and provide assurance that decommissioning can be accomplished within the acceptable limits of personnel exposure to radiation [1]. Through this study, therefore, the IDP was intended to be developed to justify the feasibility of the EU-APR decommissioning as required by the EUR, and the table of content and the corresponding information to be included in the IDP were summarized.

2. Development of Decommissioning Plan

According to EUR, Rev. D, Chapter 2.16.2.2.B, the chapters of the first IDP which needs to be provided during the design phase are as follows:

- Introduction
- Description of facility
- Physical and radiological inventory of the facility
- Decommissioning strategy
- Maintaining safe conditions
- Decontamination and dismantling techniques
- R&D programs
- Management of material and waste
- Decommissioning implementation schedule
- Project organization
- Cost and financing of the decommissioning activities
- QA program

Of these chapters above, the chapters of R&D programs, project organization, and QA programs is not required by the EUR, because they are not critical at this stage of the IDP to demonstrate the feasibility of the decommissioning and in accordance with Chapter 2.16 of EUR where it is only required to allow to make an initial evaluation of the decommissioning costs.

The contents for each chapter included in this IDP are presented below.

2.1 Description of facility

The facility and its associated structures and buildings and safety-related equipment to be decommissioned are described sufficiently to provide a good understanding of the facility including:

- Design principles,
- External appearance and schematic facility layout,
- General description of the buildings,
- General description of radioactive waste store (if this information is available),
- General description of facility systems.

Also, the following design features of the plant to facilitate the decommissioning are addressed:

- ALARA considerations,
- Radioactive waste minimization,
- Measures to limit the spread of contamination,
- Key design features that facilitate decommissioning.

2.2 Physical and radiological inventory of facility

The physical inventory of the components/equipment and structures and radiological inventory to be potentially generated during decommissioning are addressed including:

- Key assumptions for radiological and physical inventories estimation,
- A complete listing of all system components and structures of the plant subject to a potentially radiological contamination: both the contaminated material and neutron-activated materials,
- A detailed description of the locations, amounts and characteristics (e.g., radionuclide of concern, inventory and distribution of radionuclides, etc.) of existing and expected radioactive and other hazardous materials (e.g., asbestos, mercury, lead, and PCB, etc.) at the facility,

- Amount and type of wastes to be disposed of during the Decommissioning of the plant, including waste which can be released and/or recycled.

2.3 Decommissioning strategy

Decommissioning options, which is country-/site-specific, can range from immediate dismantling and removal of all radioactive materials from the site, allowing unrestricted release, to an option of in-situ disposal involving encapsulation of the reactor and subsequent restriction of access, and are as follows:

- Immediate dismantling,
- Deferred dismantling,
- Entombment option.

Three (3) decommissioning approaches above are considered for decommissioning, which describe the strategies application and their main differences. Of these, the preferred strategy, including decommissioning scenarios, initial status of the plant, decommissioning sequence, and final status of the plant, and its rationale are also provided.

2.4 Maintaining safe conditions

The evidence that the workers, the public and the environment will be properly protected from radiological hazards resulting from the plant decommissioning activities during all process phases is addressed.

A list of major decommissioning activities that may produce any environmental impact during normal performance of the decommissioning operations is given in Table 1. Also, the initiating event scenarios of incidents/accidents relevant for decommissioning activities can be established using the following the hazard identification process:

Table 1 Major decommissioning activities from normal operation

Normal decommissioning activities
Decontamination of primary circuit
Dismantle reactor coolant system (RCS)
Dismantle reactor vessel (RV) and internals
Dismantle non-primary circuit reactor building components
Deplant other nuclear island buildings
Decontaminate nuclear island buildings
Remove spent fuel from site
Demolish nuclear island buildings
Decommission radwaste management facilities
Decommission spent fuel buffer storage facilities

- Hazard Identification,
- Hazard Screening,
- Hazard Grouping,
- Representative Hazard.

A result of safety assessment should be compared with the relevant safety criteria, and preventive and mitigating measures should indicate the administrative measures and safety management program needed to ensure the safe conditions, of which the impact should be described.

2.5 Decontamination and dismantling techniques

The main decontamination and dismantling (D&D) techniques, which is somehow site-dependent due to a large extent based on the availability of waste disposal facilities and decommissioning strategies, to be considered during decommissioning are described and most common technologies used at the current European D&D are follows:

<u>*Decontamination techniques*</u>

- Chemical decontamination
  - Chemical Oxidizing Reduction Decontamination (CORD): use of alkaline permanganate (AP),
  - Low Oxidation State Metal Ion (LOMI): use of AP,
  - Decontamination for Decommissioning (DfD): use of fluoroborique acid,
  - NITROX or CITROX : use of nitric or citric acid,
  - CAN-DECON: use of citric acid and EDTA.
- Mechanical decontamination
  - High pressure water processes,
  - Dry/wet blasting,
  - Carbon dioxide/wet ice blasting,
  - Sponge blasting.
- Ultrasonic decontamination
- Electrochemical decontamination
- Concrete decontamination
  - Scarifying techniques,
  - Needle scaling (e.g., scabbling, shaving, etc.),
  - Hammering.

<u>*Dismantling techniques*</u>

- Mechanical cutting
  - Mechanical shears,
  - Sawing (e.g., band saw, circular saw, etc.),
  - Clam shell pipe cutter,
  - Abrasive water jet cutting (AWJC).
- Thermal cutting
  - Oxy-fuel cutting/lance,
  - Plasma cutting,
  - Oxy-acetylene/plasma cutter torch track,
  - Electric arc water jet cutting,
  - Contact arc metal cutting (CAMS),

  - Laser beam cutting.
- Concrete structure dismantling
  - Selective cutting (e.g., diamond wire sawing, Flame, thermic lance, rock splitter, etc.),
  - Concrete blasting (e.g., impact/crushing, hydraulic bursting, explosive, etc.).

Also, it is should be justified that the plant can be decommissioned in a safe manner using the proven best technologies available at the time of study.

2.6 Management of material and waste

The decommissioning waste management strategy, which is strongly dependent upon regulatory requirements and national plans for radwaste disposal, is established considering the current knowledge in European decommissioning and radwaste management experience and practices, which includes:

- Waste classification: clearance waste (CW), very low level waste (VLLW), low level waste (LLW), intermediate level waste (ILW), and high level waste (HLW) based on IAEA guidance [2],
- Identification of waste streams: spent fuel, metal-small, metal-large reactor pressure vessel (RPV), metal-large NSSS (Other than RPV), metal-spent fuel racks, concrete-scabbled, concrete-debris, cable, soil, resin-RCS, resin/filter-others, dry active waste (DAW), insulation, hazard materials,
- Solid and liquid radioactive waste management : pre–treatment(collecting/ characterization/segregation), treatment, conditioning, package/transport, and disposal,
- Waste minimization program (recycle and clearance).

2.7 Decommissioning implementation schedule

The time schedule for decommissioning of the plant is presented, which accounts for all relevant activities arising from decommissioning sequence, dependent on the selected decommissioning strategy, of the plant. General decommissioning time schedule is as follows:

- Pre-shutdown activities: 2 years,
- Decommissioning Preparations: 2 years,
- Decommissioning operation & site restoration: 7.5 years,
- Total duration of decommissioning: 11.5 years.

This period covers 5.5 years of spent fuel cooling in the spent fuel pool and transfer to an interim storage. For SAFSTOR, a 50 years dormancy period is assumed to be additionally considered.

2.8 Cost and financing of the decommissioning activities

The cost of engineering and project management, of radioactive waste, and of the actual dismantling is presented in order to establish a mechanism to provide and ensure the adequate financial resources for safe and timely decommissioning. To this end, it is necessary to take into account the following country- and site-specific information; legal requirements, the decommissioning strategy to be considered, the end state of the site, other relevant issues including the waste management options, the availability and cost of radioactive waste disposal, and the local labor rates.

At this stage of IDP that the specific data are not available, therefore, the sufficient information needed to determine a first estimate of the decommissioning cost in compliance with guidance specified in the EUR Rev. D Chapter 2.16.2.1, should be provided.

3. Conclusions

In this study, the IDP was developed to comply with the requirements specified in the Chapter 2.16 of EUR. However, it should be noted that the information provided in the stage of the IDP is considered as preliminary, and the IDP should be updated further during later stages. It is expected that the IDP is able to be utilized for application of the EUR design certification as well as preparation of the licensing issue for new envisaged nuclear power plant (NPP) or operating NPP in Korea.

REFERENCES

[1] European Utility Requirements for LWR Nuclear Power Plants, Vol.2 Ch. 16, “Decommissioning”, Rev.D Octover 2012.

[2] IAEA No. GSG-1,”Classification of Radioactive Waste, Vienna November 2009.