Regulatory Requirements for Desalination Plant Coupled with Nuclear Reactor Plant

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1. Introduction

A small-to-medium sized reactor has been developed for multi-purposes such as seawater desalination, ship propulsion, and district heating since early 1990s in Korea. Now, the construction of its scaled-down research reactor, equipped with a seawater desalination plant, is planned to demonstrate the safety and performance of the design of the multi-purpose reactor. And the licensing application of the research reactor is expected in the near future. Therefore, a development of regulatory requirements/guides for a desalination plant coupled with a nuclear reactor plant is necessary for the preparation of the forthcoming licensing review of the research reactor.

In this paper, the following contents are presented: the design of the desalination plant, domestic and foreign regulatory requirements relevant to desalination plants, and a draft of regulatory requirements/guides for a desalination plant coupled with a nuclear reactor plant.

2. Desalination Plant Design

The desalination plant coupled with the multi-purpose nuclear reactor plant adopts MED-TVC (Multi-Effect Distillation - Thermo Vapor Compression) process as the desalination process, which is one of the evaporation method and a combined process of the MED and TVC process. [1]

For the MED process, the evaporation-condensation system consists of several evaporators, called as 'effect', that are connected serially as shown in Fig. 1. The pressure of each evaporator is maintained to be lower than the atmospheric pressure. In the evaporator, heat transfer tubes are installed horizontally, and the driving steam flows into the tubes. From the top of the inside of the evaporator, seawater is sprayed on the horizontal tubes and some parts of seawater are evaporated by the heat transferred from the driving steam flowing inside of the tubes, so that steam is produced from the seawater. The driving steam is cooled by the sprayed seawater and loses its latent heat, so that it is condensed. The steam produced in each evaporator flows into the tubes of the next evaporator and is utilized as a heat source to evaporate the seawater.

For the TVC process, low pressure steam extracted from the final condenser is utilized as the driving steam again after a pressurization process through a thermo-compressor using high pressure steam supplied from the turbine generator of the nuclear reactor plant, in order to increase the efficiency of the desalination plant (refer to Fig. 1).

3. Regulatory Requirements/Guides for Desalination Plant

3.1 Status of Regulatory Requirements/Guides

Since a desalination plant coupled with a nuclear reactor plant has not yet been constructed in Korea, regulatory requirements/guides for such desalination plant have not been established. The TECDOC-1235 [2], published by the IAEA, is the only reference that is available in the development of the regulatory requirements/guides for the assurance of nuclear safety for a desalination plant coupled with a nuclear reactor plant.

When the water produced from a desalination plant coupled with a nuclear reactor plant is utilized as drinking water, it is necessary to establish a guideline for radioactivity content in the desalinated water, in order to protect the public who drinks the desalinated water against radiation exposures due to the potential radioactive materials in the desalinated water. The guideline for the natural drinking water may be applied to the desalinated water. In Korea, the guideline for the natural drinking water has not yet been established. However, the WHO [3] and such nations as Canada [4], the European Union [5], and Australia [6] have established the guideline.

3.2 A Draft of Regulatory Requirements/Guides

A draft of regulatory requirements/guides for a desalination plant coupled with a nuclear reactor plant has been developed. The draft includes general requirements, specific requirements, and regulatory guides, which specifies only the matters for the nuclear safety related with a desalination plant.

The draft general requirements will be legalized as an article in the Ordinance of the Ministry of Science and Technology (MOST) No. 31, "Regulations on Technical Standards for Nuclear Reactor Facilities, etc." The contents of the draft general requirements include: (1) prevention of a transfer of radioactive materials from a nuclear reactor plant to a desalination plant, (2) minimization of the effects resulting from the operation and accidents of a desalination plant on the safety of a nuclear reactor plant, and (3) protection of the public and environment against the radiation hazards due to the operation of a desalination plant and to the ingestion of desalination water.

The draft specific requirements will be published as a new Notice of the MOST, "Technical Standards for a Desalination Plant Coupled with a Nuclear Reactor Plant." The contents of the draft specific requirements provide:

- installation of a closed heat transfer loop between a nuclear reactor plant and a desalination plant to prevent a transfer of radioactive materials,
- structural design bases, design to allow performing in-service inspection, and establishment of in-service inspection plan for the structures, systems, and components (SSCs) that perform the function to prevent a transfer of radioactive materials,
- continuous monitoring of leakages of radioactive materials due to the failure of pressure boundary of the closed loop between a nuclear reactor plant and a desalination plant,
- consideration of transients and accident conditions of a desalination plant in the design and the safety analysis of a nuclear reactor plant,
- safety evaluation of the balance of the energy demands between the electricity generation plant and the desalination production plant, and installation of an alternative heat source preparing for the coincident loss of both loads,
- limitation on the increase of the risk of a nuclear reactor plant due to the installation of a desalination plant,
- protection of a nuclear reactor plant when the SSCs important to the safety are shared between a nuclear reactor plant and a desalination plant,
- guideline, monitoring, record, and report of radioactivity content in the desalinated water produced from the desalination plant,
- criteria for the environmental release of the desalinated water, cooling water, and brine that are contaminated by radioactive materials, and
- protection against the radiation hazards due to the discharge of brine and cooling water to the environment.

Also, draft regulatory guides have been developed for the licensing review of a desalination plant, and they will be published as the section 10.5, "Desalination Systems," of KINS/GE-N001, "Safety Review Guides for Nuclear Power Plants of PWR Type." The contents of the draft regulatory guides include review areas, acceptance criteria, and review procedures. Especially, the acceptance criteria specify the guideline for the radioactivity content in the desalinated water that is produced from a desalination plant and used as drinking water: a guideline dose of 1 mSv per year. This guideline value is derived, based on an assumption that individuals drink 2 liters of desalinated water everyday. The guideline value is recommended for natural drinking water by the WHO, Canada, the European Union, and Australia [3-6].

4. Conclusion

A draft of regulatory requirements/guides for a desalination plant coupled with a nuclear reactor plant has been developed for the preparation of the licensing of a multi-purpose nuclear reactor. The draft regulatory requirements/guides will be finalized through reflecting expert comments from various fields. And the draft will be legalized and applied directly to the licensing safety review of a desalination plant coupled with a nuclear reactor plant, which will be contribute to assuring the safety of a nuclear reactor plant equipped with a desalination plant.

REFERENCES

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[3] World Health Organization, "Guidelines for Drinking-water Quality," Vol.1, Third Edition, Geneva, 2004.

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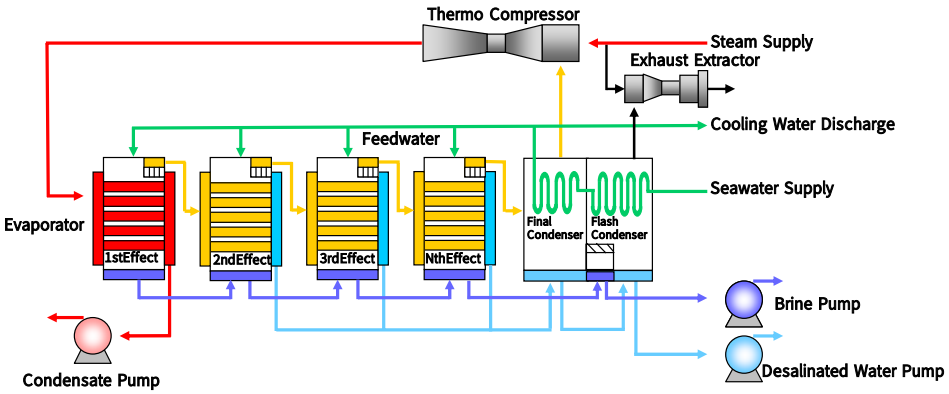

Fig. 1. MED-TVC Process