A Comparative study of MR functions identified in a two-unit CANDU plant

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1. Introduction

As a part of the project developing the Maintenance Effectiveness Monitoring Program, which is known as Maintenance Rule (MR), for CANDU type reactors in KHNP, a comparison has been performed investigating the differences in functional point of view in a two-unit CANDU plant.

Several obvious differences in design features have been identified through the investigation. A comprehensive view has been obtained by comparing the MR functions of the plant.

The first CANDU unit of the plant was originally designed in 1959 and built in 1983. It has been in the process of license renewal and expected to get a permission of continuous operation. The latter unit was built in 1997 from the design of the year 1986. There is a 14-year difference in operation time between the units.

The comparison of the MR function for each unit has been performed and their result is presented in this paper. The influences on the MR program, which has been developed as a separate program for each unit, are discussed considering the different design dates, the shared function, and the design changes for the life extension.

2. Methods and Results

In this section some of the differences in the functions of a two-unit CANDU plant, which consist of the leading unit and the latter unit, are described. Comparing the MR functions identified in the two units provides a clear understanding of the differences in design features and the changes after the early design.

2.1 Shared MR functions in a two-unit CANDU plant

The development process of the MR program consists of three stages: Scoping, Importance Determination and setting Performance Criteria [1]. For Scoping, CANDU functions are classified as safety-related, non-safety-related, or out-of-scope.

Though the first unit was built far earlier, most of the shared systems in the unit had a two-unit capacity. The shared systems are the Emergency Water Supply (EWS), the Emergency Power Supply (EPS) diesel generator, the D_2O supply and D_2O upgrading facility, the de-mineralized water plant, some Compressed Air systems, the off-gas management system, etc. Shared functions located in the first unit are also used in the second unit and connected from the first unit. However, those functions are only defined in the first unit program and are not included in MR functions of the second unit.

Table 1 compares the functions between the units in the two-unit CANDU plant. Many functions are defined as same functions in both units. Most of the specific functions in the first unit are shared functions. Due to the assignment of the functions, the total number and the in-scoped number of functions in the first unit are much more than in the second unit.

Table1. Comparison of the number of functions in a two-unit CANDU plant

	Unit 1	Unit 2
Total number of functions	668	650
Number of shared functions	44	-
Number of unit specific functions	47	30
Number of in-scoped function in the MR program	302	276

2.2 Unit specific functions for each unit

In the first unit, only three functions have a specific design feature apart from shared functions. On the other hand, more functions defined in the second unit are including specific design features.

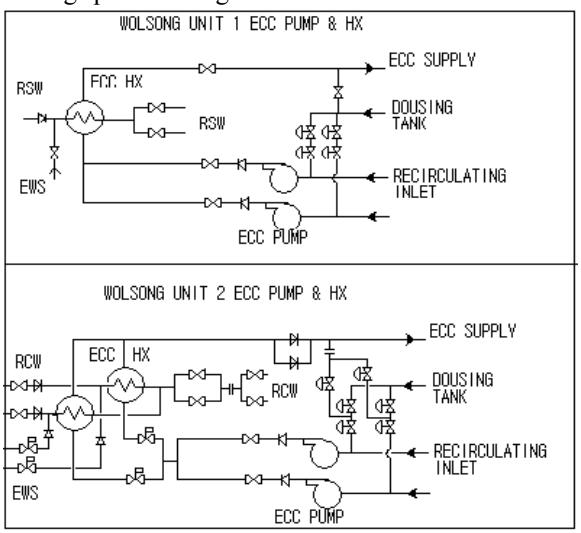

Figure1. CANDU plant ECC Pumps and Heat Exchangers

One of major differences in the safety system design features is shown in Figure 1. The cooling source for

one Heat Exchanger (HX) of the Emergency Core Cooling (ECC) system is the Raw Service Water (RSW) in the first unit, but the Re-circulating Cooling Water (RCW) system is utilized as the cooling source of the two ECC HXs in the second unit.

The drained water from Turbine Re-heater system is used as a part of the Feed-water system which supplies water to the Steam Generator using the Re-heater Drain pumps in the first unit. In the second unit, the drained water is supplied to the high pressure Feed-water Heaters as heating source. The function of the Main-steam Dump to Condenser in the two units is the same function, but defined as the different system codes (unit 1: 43330, unit 2: 36510).

In the second unit, 30 functions are identified as specific functions. Most of the functions are including the added design features or advanced technology introduced after the first unit was built. The examples of specific functions of the second unit are the Containment Gate isolation valve in the Spent Fuel Canal, cooling water supply from the Reserve Feed-water Tank (RFT) for the Feed-water pumps, support system connections to the Tritium Removal Facility (TRF), the Turbine auxiliary control system utilizing Programmable Logic Controller (PLC), etc.

2.3 Functions including additional design requirements in the second unit

Some functions in the second unit are related with the additional requirements. The Post LOCA Instrument Air (PLIA) system, the Post Accident air sampling and monitoring system, the Gross Containment Leakage Monitoring (GCLM) system, and the Hydrogen control system are the examples. Those systems are designed in accordance with the Atomic Energy Control Board (AECB) R-7 "Requirement for Containment Systems for CANDU Nuclear Power Plants" published in 1991 [2]. The Post Accident monitoring system is designed under the Canadian Standard Association (CSA) N290.6 "Requirements for Monitoring and Display of CANDU Nuclear Power Plant Station in the Event of an Accident" published in 1991 [3].

Those functions related to additional requirements which had been applied since TMI-2 accident in 1979 are defined in the second unit. The Main Steam Isolation Valves (MSIVs) in the second unit are added design feature introduced from Pressurized Water Reactor (PWR). However, it is not in the Canadian regulatory requirements. [4] Above functions for the second unit are not designed in the first unit.

2.4 Functions changed for the continuous operation of the first unit

During a recent outage for the life extension and continuous operation of the WOLSONG Unit 1, many systems and components have been upgraded or replaced. Replacing the aged components, which are pressure tubes and electric devices, was of a major scope. Some safety systems, such as ECC, the Shutdown Systems (SDSs), are also upgraded referring to design features of the second unit. The actuation conditions for the safety systems of the first unit were slightly different than the second unit's before. It has been found that the actuation conditions for the systems of both units became very similar after the design change.

3. Conclusions

In the process of developing the MR program, the functions of a two-unit CANDU plant were defined from the design documents of each unit. Several obvious differences in design features have been identified by comparing their corresponding functions on the perspective of MR functions.

Shared functions between the two units are defined in the first unit's MR program. The functions including unit specific design features are also identified in both units. Small numbers of functions are unit specific in the first unit. Several functions of the latter unit are related with the additional requirements applied in the second unit since the first unit was built. During a recent outage, some components in the first unit have been replaced and some have been upgraded to make their functions similar to the second unit.

As a result of comparative study on the MR functions of a two-unit CANDU plant in which the first unit was built far earlier than the latter unit, a comprehensive vision of the differences and similarities between the units was presented.

REFERENCES

[1] Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, NUMARC 93-01 *Revision 3*, NEI, July 2000.
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[4] Design Manual, Steam Generator Steam and Feedwater system, 86-36100/63620/63614-DM-000, R-2, AECL, 1996.