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# Improvement of the Reliability Data Management System(RDMS) for Domestic CANDU Plants

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## 1. Introduction

In the Final Safety Analysis Reports (FSARs) for domestic CANDU plants, the target values for unavailability of the shutdown systems (SDS#1, SDS#2), the emergency core cooling system (ECCS), and the reactor building system (R/B) are described. Therefore, a periodic reliability evaluation of these systems has been required, and a reliability data management system (RDMS) for CANDU safety systems was developed in 1999 to carry out reliability evaluation in consideration of the failure history of safety system components. However, as a long time has passed after the development, the RDMS is required to be compatible with the recent system environment (Windows 7 or later) from that at the time of development (Windows 98). In addition, safety and safety support system fault trees created then are required to be updated to reflect the latest design and operational conditions.

## 2. Methods and Results

In this study, the following improvements have been performed.

- Improvement of the Reliability Data Management System (RDMS) itself
- Improvement of the reliability analysis models to evaluate the unavailability of safety and safety support systems

### *2.1 Improvement of the Reliability Data Management System*

#### *2.1.1 Elicitation of the RDMS Improvement Items*

Since the current RDMS was implemented in a stand-alone manner in Windows 98 environment at the time of development, the system is incompatible with the recent operating environment (Windows 7 or later). Therefore it is necessary to improve the operating environment up-to-date.

In addition, it is impossible to collaborate through collecting and sharing reliability data managed by individual PCs then. Therefore, it is required to construct a system that can prevent data loss and share all users' data by managing it through a separate reliability data server that can be linked with the reliability analysis program.

#### *2.1.2 Database design and construction*

The information to be managed has been extracted from the current RDMS. Both logical design and physical design for the improved RDMS database have been performed by standardizing the extracted information. The RDMS database includes both system basic information and reliability data such as generic failure rate, specific failure rate, component failure history and system unavailability quantification results.

#### *2.1.3 User Interface Design and Implementation*

The design of the RDMS user interface has been performed in order to manage the following functions:

- Management of component failure data
  - ✓ Search for component failure code, input of failure data and management of plant outage history
- Calculation of specific component failure rate
  - ✓ Generic component failure rate management, specific component failure rate calculation/inquiry
- Quantification of safety and safety support system unavailability
  - ✓ System unavailability quantification/inquiry
- Quantification of safety and safety support system unavailability under user-defined conditions
  - ✓ Change of generic component failure rate, component failure data collection period or basic event failure probability
- Management of system basic information

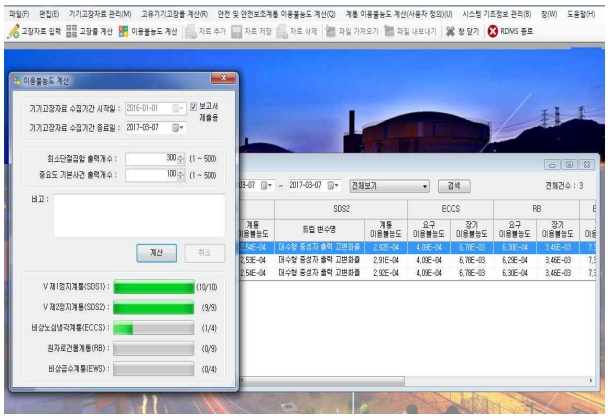

Fig. 1. Example of the Improved RDMS User Interface

*2.1.4 Structure of the RDMS*

The improved RDMS exchanges information with the system database through a Windows-based client program, evaluates the unavailability of each system in line with the reliability analysis program, and manages the evaluation results.

It consists of the reliability data management database, the RDMS GUI, and the reliability analysis program functionally as shown in Fig. 2.

- Reliability data management database
  - ✓ The database is operated by a separate database server located on the intranet of Wolsong Nuclear Power Generation, and manages all data of the system.
  - ✓ It provides the requested data from the RDMS GUI of a system user PC and stores component failure data as well as operation history from the client program, and system unavailability quantification results .
- The RDMS GUI
  - ✓ The RDMS GUI is a Windows-based client program that is installed and operated on a system user's PC. The user can interact with the improved RDMS through the user interface of the GUI.
  - ✓ System users can use the GUI to manage(inquire, input, modify, delete) the failure history of safety and safety support system components and to calculate the specific component failure rates.
  - ✓ System users can quantify safety and safety support system unavailability using the specific component failure rate data and inquire the results.
- Reliability analysis program(AIMS-PSA)
  - ✓ It is a software for Probabilistic Safety Assessment (PSA) developed by Korea Atomic Energy Research Institute (KAERI).
  - ✓ It is operated on a system user's PC to quantify the unavailability of each system in conjunction with the RDMS GUI.

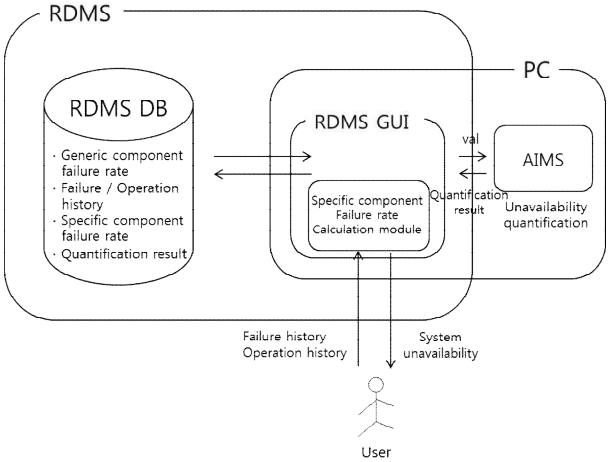


Fig. 2. Functional structure of the improved RDMS

*2.2 Improvement of Reliability Analysis Models (Fault Trees)*

The reliability analysis models of Wolsong unit 1 and Wolsong units 2,3,4 are based on the licensing report for reliability analysis [1], which was prepared for system reliability analysis by AECL, CANDU plant designer. The fault trees of Wolsong unit 1 and Wolsong units 2,3, 4 have been prepared by reflecting the latest design changes and operational conditions [2,3].

*2.2.1 Reflection of the Latest Design Conditions*

The reliability analysis models reflect the recent design changes as follows:

- In Wolsong unit 1, the major design changes of the Emergency Water System (EWS) are its power duplication and the automatic actuation as alternative cooling water source in case of loss of raw service water supplied to the ECC heat exchanger.
- The major design change in Wolsong units 2,3,4 is the installation of a Passive Auto-catalytic Recombiner (PAR), a hydrogen control facility in a reactor building. This is reflected in the reliability analysis model of the reactor hydrogen concentration control system.

*2.2.2 Reflection of the Latest Operational Conditions*

- Regarding stand-by components whose availability is verified by periodic surveillance testing, correct test intervals are applied as shown in Table I:

Table I: Examples of Test Interval Changes

| No | Test procedure | Test interval |
|---|---|---|
| 1 | Emergency core cooling system medium pressure injection isolation valve(MV31) logic circuit test(W1) | 4 weeks → 14 days |
| 2 | Emergency core cooling system medium pressure injection isolation valve(MV50) logic circuit test(W1) | 4 weeks → 14 days |
| 3 | Emergency core cooling system high pressure injection isolation valve(MV79) test(W1) | 4 weeks → 14 days |
| 4 | Emergency core cooling system high pressure injection isolation valve(MV80) test(W1) | 4 weeks → 14 days |
| … | … | … |

## 3. Conclusions

The improved RDMS manages the history of component failures as well as the failure rates of specific components of safety and safety support systems for Wolsong unit 1 and Wolsong units 2,3,4 and evaluates the unavailability of the systems using the reliability analysis models.

The RDMS has been substantially improved in the co mpatibility of the operating environment (Windows 98 → Windows 7 or later) as well as database operation me thod (stand-alone → client / server), enabling the sharin g and collaboration of reliability analysis results and the integrated management of reliability data.

Through the improvement of the reliability analysis m odels, the latest design changes and operational conditions of Wolsong unit 1 and Wolsong units 2,3,4 h ave been reflected.

The dormant unavailability for the safety systems from the improved RDMS have met the system unavailability target of 1.00E-03 presented in the Final Safety Analysis Report, and the long-term unavailability for the safety systems from it have met the system unavailability target of 1.00E-02.

With the improved RDMS program, system users can easily and quickly evaluate the reliability of safety and safety support systems, and ultimately it is expected to h elp secure the safe operation of CANDU plants. In addition, it will be helpful to actively cope with the regulatory body's requests regarding safety system unavailability.

## REFERENCES

[1] AECL, Wolsong NPP 2/3/4 Probabilistic Safety Assessment(PSA) Organization of Volumes, 86-03660-PSA-001, 1995. 06.
[2] KHNP, At-Power Probabilistic Safety Assessment Report of Wolsong Unit 1, 2015. 12.
[3] KHNP, At-Power Probabilistic Safety Assessment Report of Wolsong Units 2/3/4, 2015. 12.