Systematic Application of the AtomCARE Real-time Plant Information to support Severe Accident Response Activities

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1. Introduction

AtomCARE (Atomic Computerized technical Advisory system for the Radiological Emergency, KINS)[1] system has been developed to provide technical support in case of nuclear emergency in Korea. To enhance further the existing capability, recently, we developed a framework[2] which systematically links AtomCARE real time variables with the PSA-based RiSARD (Risk-informed Severe Accident Risk information Diagnosis/prognosis)[3] program developed at KAERI. For the development, two activities have been made: one is development of an interface program to inter-connect the AtomCARE variables with the RiSARD program and the other is upgrade of the existing RiSARD program to effectively manage SAMG-related real-time variables and easily accommodate MELCOR severe accident analysis results. This paper summarizes the results of the aforementioned activities.

2. Methods and Results

The AtomCARE system collects about 200 plant safety parameters per unit with data transmission in every 10~20 seconds. As one of its modules, the newly developed monitoring program monitors the SAMG related variables among those received data and stores them (when required) into MS Access database file through which the safety parameters could be diagnosed and predicted in the RiSARD program. The monitoring program is also equipped with both exercise data simulation function and direct RiSARD accident sequence searching capability. The RiSARD program has been upgraded to accommodate MELCOR accident analysis data and utilize the AtomCARE real-time plant parameters in prognosis and diagnosis process.

2.1 Development of SAMG parameter monitor

The aforementioned parameter monitoring module traces several key variables related to the severe accident management guidelines (SAMG). In case of PWR, for instance, such parameters are core exit coolant temperature, reactor coolant system pressure, steam generator water levels and containment pressure, etc. Figure 1 shows the major functions of the monitoring program. When we need to investigate an accident, both the collected data saved as a database file and the monitoring program could be used in the RiSARD program to diagnose and prognose the accident. To facilitate this procedure, the monitoring program has been designed so that it can directly access and search the RiSARD database to find best compatible accident scenarios with the collected data. Since a simple searching algorithm is currently used comparing the received real-values with scenarios stored in the RiSARD database, further work should be made to enhance its searching performance. An additional role of the module is to employ data simulation function which can be applied for the emergency preparedness exercises.

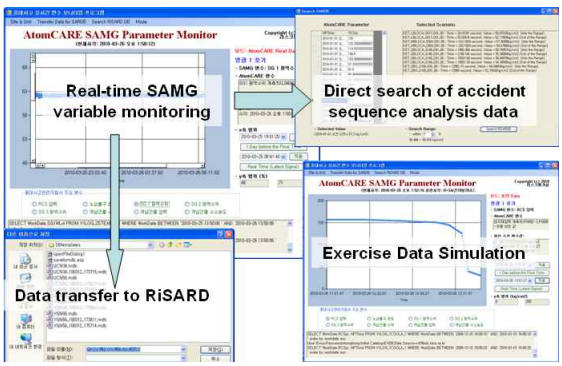

Figure 1. Functions of the SAMG Parameter monitoring program

2.2 Improvement of RiSARD program

RiSARD is a computational tool developed at KAERI to effectively support a severe accident management (SAM) for a nuclear power plant. In order to provide a diagnostic capability for plant states and a prognostic capability for an anticipated accident progression, the system examines (a) a symptom-based diagnosis of a plant damage state (PDS) sequence in a risk-informing way and (b) a PDS sequence-based prognosis of key plant parameter behavior, through a prepared database (DB) containing plant-specific severe accident risk (SAR)-related information such as Level 1 and 2 PSA, code analysis results and SAMG information, etc.

In recent times, a computer-based procedure and module have been added to the RiSARD system to support preparation of MELCOR-specific database and to utilize the AtomCARE real-time plant information to check the adequacy in implementing SAMG strategy as well as severe accident diagnosis/prognosis. For this

purpose, three main tasks have been done. The first task was to develop a stand-alone module for automatically transforming the prepared MELCOR analysis information into a standard data format which can be accommodated at the RiSARD system database. The second task was to improve the RiSARD system so that the prepared MELCOR database can be automatically connected in the RiSARD-based accident diagnosis/prognosis process. The third task was to develop an additional RiSARD module utilizing AtomCARE parameters transferred for accident diagnosis and prognosis as well as SAMG. Table 1 shows the mapping table of SAMG-related parameters for a typical KSNP plant. In order to automatically convert parameter/time units of code and AtomCARE into the user-specified units, a simple unit conversion function could be utilized as an additional input of the RiSARD program. Because these tables are entered as an input file of the RiSARD program, it can be easily changed depending on the specific plants users treat.

Table 1. Mapping table between SAMG-related variables with AtomCARE, MAAP and MELCOR code

SAMG Variables	CARE Variable : MDB Table	MELCOR Variable	MAAP Variable
Steam Geneartor 1 Water Level (Wide)	SG1Lvl (%) : 2STEAMA_1	CVH-LIQLEV.634 (m)	ZWBS (m)
Steam Geneartor 2 Water Level (Wide)	SG2Lvl (%) : 2STEAMA_1	CVH-LIQLEV.644 (m)	ZWUS (m)
RCS Pressure	PZRpr (kg/cm2(a)) : 1SYSA_1	CVH-P.500 (Pa)	PPS (Pa)
Maximum Core Exit Temperature	CoreTmax (oC) : COREA_1 CET 1,2,3,4 (oC) : COREA_1	CVH-TLIQ.190 (K)	MAX_CET (K)
Cavity Water Level	CvWtrLvl (%) : CVBLDA_1	CVH-LIQLEV.810 (m)	ZWRB(1) (m)
Containment Pressure (Narrow)	CVPr (0~1,120cmH2O) : CVBLDA_1	CVH-P.840 (Pa)	PRB(4) (Pa)
Containment H2Concentration	CVH2 (%) : CVBLDA_1	CVH-MASS.6.840 (Kg)	NFH2RB(4) (%)

2.3 Application strategy

Figure 2 shows a summarized procedure for the practical application of the developed SAMG parameter monitor and RiSARD program including database building, data processing and their final utilization to support the accident response activity.

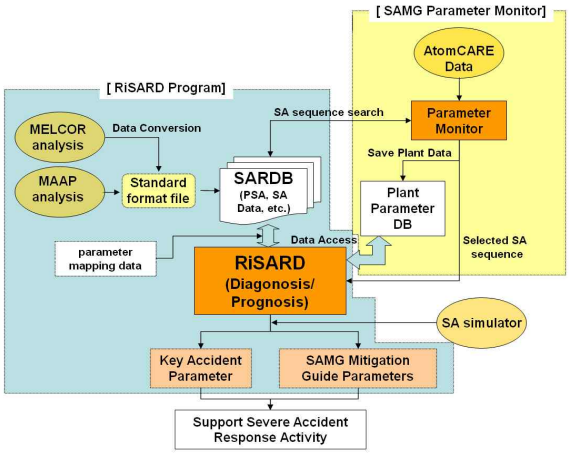

Figure 2. Application strategy of AtomCARE real-time parameter to support SA response activity

In Figure 2, the SAMG parameter monitoring program monitors the AtomCARE variables and converts the data in the format of RiSARD-specific input files when required. By the foregoing function, we can directly search RiSARD accident scenarios using real-time data received from the plant. The RiSARD program reads MELCOR severe accident analysis data with standard format and reads AtomCARE database file generated by the monitoring program. Through such an operation of RiSARD, we can obtain information about functional states of the plant and safety systems expected at the time of a severe accident as well as future trend of the key plant parameters that are essentially required for taking the relevant SAM actions, consequently leading to an answer about what is the best strategy for SAM.

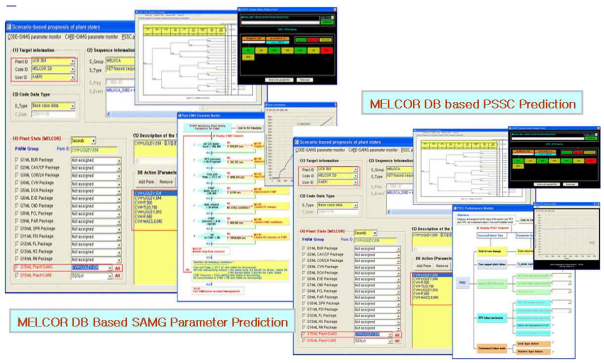

Figure 3. An example of RiSARD Application (KSNP)

3. Summary

In this paper, we introduced an AtomCARE real-time parameter monitor and the RiSARD program improved to further utilize the real-time variables and accommodate MELCOR severe accident analysis results. This framework could facilitate the applicability of AtomCARE data in diagnosing status of plant safety systems at the time of severe accidents and prognosing the further severe accident progression, based on the currently available severe accident risk information. Further works should be focused on (1) developing the plant-specific risk information databases and (2) integrating the RiSARD program with the AtomCARE parameter monitoring program systematically.

REFERENCES

[1] KINS, Development and Operation of the Network System for Nuclear Safety, Annual Report, 1999~2010
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[3] Ahn, K.I., Song, Y.M., 2008. Implementation of a concept for a risk-informed diagnosis and prognosis of plant states through the RISARD system, *ANS PSA 2008 Topical Meeting*, Knoxville, Tennessee, September 7–11.