

Development of the COMPRE-A Program for Evaluating Proliferation Resistance (PR) and Physical Protection (PP) of the Nuclear Facility

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1. Introduction

Globally, the joint researches are in progress aiming at development of the more innovative and safe nuclear energy system in aspects of physical protection ("PP") and proliferation resistance ("PR"). For the nuclear facility, the risk analysis on PR&PP is an essential part of establishing the plan for preventing and/or mitigating the potential threat (e.g. terrorism, sabotage and etc).

Typically, for evaluating the risk of PR&PP in the nuclear facility, the methodology such as GIF (i.e. Generation-IV International Forum) [1] and INPRO (i.e. International Project on Innovative Nuclear Reactors and Fuel Cycles) [2] are developed and applied in the process of the international collaboration research. Even though these are appropriate for evaluating risks at nuclear facilities, there are some limitations to be considered carefully.

In order to make up for the limitation inherent in these methodologies, a new methodology called "Comprehensive Methodology for PR&PP Evaluation (COMPRE)" is being developed by the Korea Institute of Nuclear Non-proliferation and Control (KINAC). Currently, a project for improving a computational program implementing the COMPRE methodology is ongoing in KINAC, and the "COMPRE-A (i.e. COMPRE-Advanced model)" program was developed as part of this project.

This paper describes details of the COMPRE-A program developed for establishing the platform corresponding to features of the evaluation factor derived for COMPRE, and for enhancing easiness of the result analysis through embodying the visualization and comparison tools for the evaluation result.

2. Components and Functions of the COMPRE-A Program

The "COMPRE" incorporates all requirements to be generally considered for evaluating risks in perspective of PR&PP at nuclear facilities. A series of measures is drawn from the analysis of factors that determine risks, and evaluation attributes are derived for each measure. Provided that specific values are given to each attribute, it is possible to calculate the risk quantitatively and also to compare risks between facilities using this methodology. [3]

The COMPRE-A is an advanced version of the computational program for evaluating the PR and PP of the nuclear facility in accordance with the "COMPRE". This is a GUI(Graphical User Interface) program based on the windows form, and as illustrated in Figure 1, is composed of the unified GUI, database and three (3) modules distinguished by function. Main functions of each module are summarized in Table I.

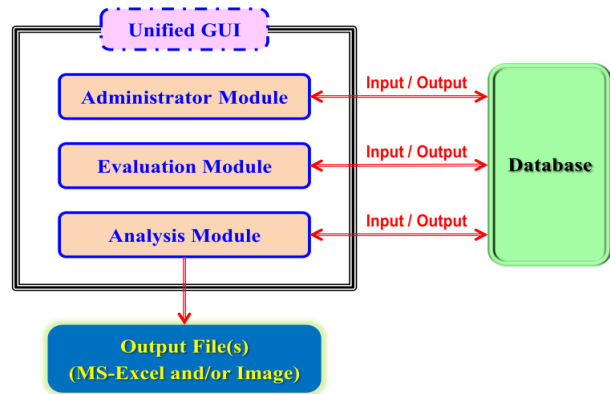


Fig. 1. Schematic diagram for the structural concept of the COMPRE-A program

Table I: Main functions by each module consisting of the COMPRE-A program

Module	Main Functions
Administrator	<ul style="list-style-type: none"> • Generation of template for evaluating PR&PP • Management (e.g. copy, modification, and delete) of template
Evaluation	<ul style="list-style-type: none"> • Performing the evaluation for PR&PP • Management (e.g. copy and delete) of the evaluation result
Analysis	<ul style="list-style-type: none"> • Analysis for an evaluation result • Comparison of two (2) or three (3) evaluation results • Visualization and output for the result

Figure 2 shows the main screen of the COMPRE-A program, and three (3) different modes are executable by clicking each button in this screen. Details of each execution mode and database are described in the following subsections.

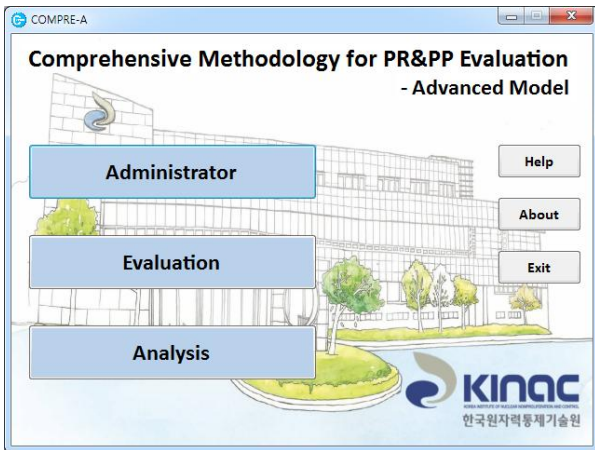


Fig. 2. Main screen of the COMPRE-A program

2.1 Administrator Mode

By clicking an "Administrator" button in Figure 2, the administrator module is called and a window of the project list is displayed. In this mode, it is possible to generate template for evaluating PR&PP and/or to manage (i.e. copy, edit, and delete) the template generated.

As illustrated in Figure 3, a template consists of information on the evaluation project, measure, section, attribute, and group. The measure (top level), section (intermediate level), and attribute (bottom level) written out in a template are based on the hierarchical structure. Type of each attribute is assigned as one of the following; i) selective, ii) input, iii) pass/fail.

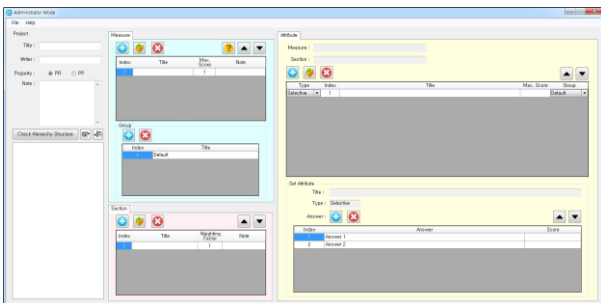


Fig. 3. Screen for generating a template in the "Administrator" mode of the COMPRE-A program

2.2 Evaluation Mode

By clicking an "Evaluation" button in Figure 2, the evaluation module is called and a window showing a list of the template and evaluation result is displayed, which consists of two (2) tabs titled "New Evaluation" and "Edit Evaluation". In this mode, it is possible to perform the evaluation (Figure 4) for PR&PP using a template generated or a result already obtained, and/or to manage (i.e. copy and delete) the evaluation result.

As mentioned previously, the quantitative risk of PR&PP at a certain nuclear facility can be evaluated on

the condition that specific values are correctly assigned to each attribute in consideration of type (i.e. selective, input, or pass/fail).

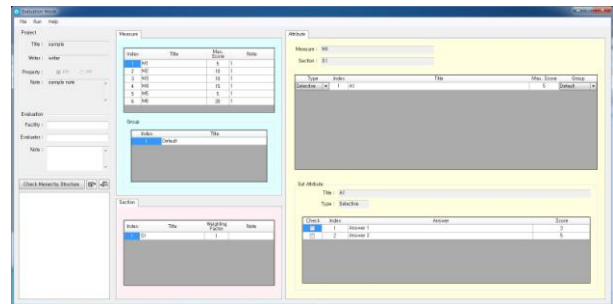


Fig. 4. Screen for evaluating the PR&PP in the "Evaluation" mode of the COMPRE-A program (using a template previously generated in the "Administrator" mode)

2.3 Analysis Mode

By clicking an "Analysis" button in Figure 2, the analysis module is called and a window showing a list of the evaluation result is displayed, which consists of two (2) tabs titled "Single Analysis" and "Multiple Analysis". In this mode, it is possible to analyze the evaluation result and/or to visualize and output the evaluation result obtained.

Single analysis is performed for an evaluation result, and a window for each analysis result displays the summary and details by measure/attribute/group in the individual tab. (Figure 5) In addition, multiple analysis is carried out for comparing two (2) or three (3) evaluation results, and a result window shows the summary of all results to be compared and difference between the results in the individual tab. (Figure 6)

The evaluation result (e.g. unadjusted and adjusted scores) by each measure can be visualized in the form of bar and spider diagrams. And, the single and multiple analysis result can be saved as the MS-Excel and/or image (PNG format) file.

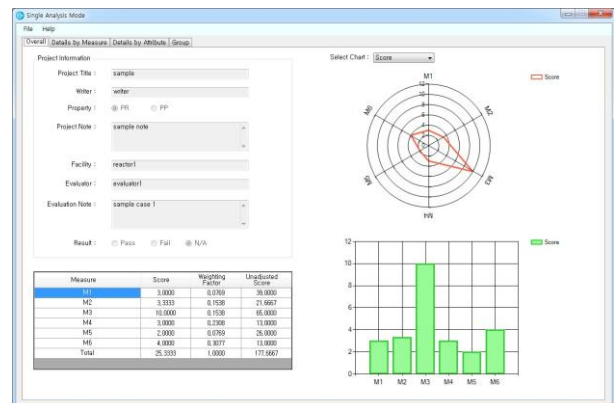


Fig. 5. Screen displaying the single analysis result in the "Analysis" mode of the COMPRE-A program

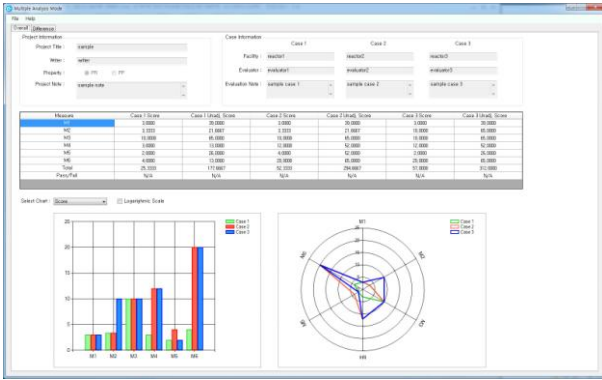


Fig. 6. Screen displaying the multiple analysis result in the "Analysis" mode of the COMPRE-A program

2.4 Database (DB)

Input and output of the COMPRE-A program are recorded and managed in the format of MDB, which is one of the file extensions of MS-Access software. Database is composed of a total of ten (10) tables, five (5) for information on the project template generated in the administrator mode and five (5) for the evaluation result obtained through the evaluation mode. Table II presents information on DB tables which comprises database of the COMPRE-A program.

Table II: DB tables consisting of the COMPRE-A program

Table		Data to be dealt with
Subject	Name	
Project	Project	Basic information on the project inputted in the administrator mode
	Measure	Information on measure inputted in the administrator mode
	Section	Information on section inputted in the administrator mode
	Attribute	Information on attribute inputted in the administrator mode
	Group	Information on group inputted in the administrator mode
Evaluation Result	EProject	Basic information on the project and evaluation to be performed
	EMeasure	Information on measure inputted in the administrator mode and the evaluation result for each measure
	ESection	Information on section inputted in the administrator mode and the evaluation result for each section
	EAttribute	Information on attribute inputted in the administrator mode and the evaluation result for each attribute
	EGroup	Information on group inputted in the administrator mode and the evaluation result for each group

3. V&V of the COMPRE-A Program

The verification and validation (i.e. V&V) for the COMPRE-A program was performed by comparing with the result calculated by using MS-Excel software according to an identical methodology.

A sample case for V&V is composed of three (3) types of measures, and the detailed input applied to the evaluation is tabulated in Table III. Specific values were inputted through the administrator mode, and entries of pass/fail type were not considered in the score evaluation.

Table III: List of input values for a V&V case of the COMPRE-A program

Measures	Max. Score	Section	Relative Weight	Attribute	Max. Score	Input Value	
Material Characteristics	100	MC	1	Material quality	15	4.2	
				Material quantity	5	3.1	
				Nuclear technology	10	9.1	
Safeguardability	200	DI	1	Necessary information is included	P/F	P	
				Initial and final DI are submitted on time	P/F	P	
				Design changes are reflected appropriately	P/F	F	
				State of the art technology for designing facility is used	2	1	
				State of the art technology for the verification of design changes can be applied	2	0	
				Uncertainty of the equipment for MC&A	P/F	P	
		MC&A	1	Uniformity of the materials (sampling error) for MC&A	P/F	P	
				Annual throughput	5	2.4	
				Amount of MUF	P/F	F	
		Verification	1	Near real time accountability system	3	1.1	
				All the necessary measuring equipments are installed	P/F	F	
				The results can be obtained at the site	P/F	P	
		C&S	2	-	Possibility to use shared equipment	10	5.1
					Frequency of C&S	24	11
					Operation of C&S according to FA	P/F	P
Automation of C&S equipment	17				15		
Possibility of applying RM	3				1		
Illumination system is reliable	P/F				P		
Legal & Institutional Framework	50	CS1	-	International Agreements	15	0	
				Legal Framework	11	10	
				Competent Authority	5	3	
				Import/Export Control	21	1.4	
				Regional Cooperation	14	0.6	

Table IV summarizes the comparison result of the score evaluation for a V&V case (with input values presented in Table III) using COMPRE-A and MS-Excel. From this table, it was found that results obtained by two (2) kinds of software were equal to four (4) decimal places.

Accordingly, it was judged that the quantitative risk of PR&PP at nuclear facilities could be evaluated within the acceptable range in accordance with the methodology implemented in the COMPRE-A program.

Table IV: Comparison of the evaluation results for a V&V case using COMPRE-A and MS-Excel

Measures	Score by COMPRE-A		Score by MS-Excel	
	Adjusted	Unadjusted	Adjusted	Unadjusted
Material Characteristics	54.6667	191.3333	54.6667	191.3333
Safeguardability	96.9909	169.7341	96.9909	169.7341
Legal & Institutional Framework	11.3636	79.5455	11.3636	79.5455
Total	163.0212	440.6129	163.0212	440.6129

4. Conclusions

As part of the project for improving a computational program implementing the COMPRE methodology, the COMPRE-A program was developed. This program provides not only the platform corresponding to features of the evaluation factor derived for COMPRE but also the visualization and comparison tools for enhancing easiness of the result analysis.

The V&V for the developed program was performed through comparison with the result obtained by using MS-Excel for a sample case consisting of three (3) measures, six (6) sections and twenty-six (26) attributes. From the comparison result, it was confirmed that the risk in aspects of PR&PP at nuclear facilities could be quantitatively evaluated within the acceptable range using the COMPRE-A program.

Furthermore, this program can be extensively applied to the quantitative evaluation for the hierarchical structure which consists of three (3) tiers (i.e. top, intermediate, and bottom levels) and type of items to be evaluated in the bottom level (i.e. attribute) can be categorized as one of the following; i) selective, ii) input, iii) pass/fail.

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