Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 17-19, 2017

Application of HuRECA analysis method to APR-1400 HRA

Saehan Kim[a*], Kyemin Oh[a],
[a]*KHNP Central Research Institute, Nuclear System Safety Lab., 70, 1312-gil Yuseong-daero, Daejeon, 34101*
[*]*Corresponding author: shanny1234@khnp.co.kr*

1. Introduction

According to the tendency of introducing computer - based subject room, it is necessary to analyze human reliability analysis in computer – based subject room environment [1].

In this situation, HuRECA (Human Reliability Evaluator for Computer-based Control Room Action) has been developed to reflect the design characteristic of computer-based subject room [1].

The purpose of this paper is to derive the final Human Error Probability (HEP) through the HuRECA human reliability analysis method for reference plant A which is a computer-based subject room environment. And compare it with the final HEP derived from the THERP, K-HRA method. Finally, it will be concluded by comparing the CDF derived by quantification after applying it. For this purpose, the top 14 cases of human errors in the reference plant A were extracted and analyzed.

2. HRA methodologies

The first HRA methodology was started by A.D Swain(1983) of US SNL, suggesting THERP methodology. Since then, the HRA Handbook (NUREG/CR-1278) has been presented as the basic data, which is widely used as the HRA methodology [2].

Especially, in 1979, due to the occurrence of the TMI (Three Mile Island) accident, the HRA methodology began to develop and focus on the possibility of accident due to human errors [2].

2.1 THERP

THERP, developed by Swain and Guttmann (1983), is the HRA methodology that has been in use since its first use in WASH-1400 (U.S.NRC.1997). THERP assumes operator behavior as a component of system components and evaluates human error [4]. In this method, diagnosis failure and execution failure are analyzed. In case of diagnosis failure, the diagnosis error probability is calculated by inputting the diagnosis time, and then the final diagnosis error probability is calculated by multiplying the correction value considering various error factors. The execution failure is divided into several unit tasks, and the error probability of each unit task is evaluated to calculate the total execution failure error [2].

2.2 K-HRA

The K-HRA method is developed by the experts of human reliability analysis in Korea under the supervision of the Korea Atomic Energy Research Institute (KAERI) in order to enhance the consistency of the analysis procedure, evaluation rules and standards.

The K-HRA method is divided into human error analysis before the accident and human error analysis after the accident, and the error influence factors and analysis rules have been presented [3].

Basically, human error case is divided into diagnosis error and execution error, and execution error is evaluated by analyzing and adding error possibility of each unit operation [3].

2.3 HuRECA

The HuRECA method is a human reliability analysis method that observes and analyzes operator behavior under a computer-based subject room environment. It has been developed to reflect the main characteristics of the computerized procedure system (CPS) and soft controller, which are important design elements of the computer-based subject room. The HuRECA method basically maintains the basic quantification framework of the K-HRA method. The basic analysis procedure for performing HuRECA is the same with the K-HRA analysis procedure [1].

3. Application

3.1 Diagnosis error

To obtain the diagnosis error probability, a basic diagnostic error and a diagnostic error correction value are required. First, diagnostic margin time is required to obtain basic diagnostic errors, which is based on the THERP detailed analysis statement (reference plant A). Using the THERP 12-4 graph based on the diagnostic margin time, the basic diagnostic error probability was determined.

Next, the diagnostic error correction value refers to the diagnostic error correction value of K-HRA detailed analysis statement of reference plant B, which has the same human error event. The level of CPS, a new item added to HuRECA, was also referred to the procedure level of K-HRA of reference plant B.

3.2 Execution error

To calculate the probability of execution error, one task is divided into several unit tasks. The unit tasks are based on the HRA detailed statement of reference B that has the same human error case. The supervision / confirmation at the time of execution, an additional item in HuRECA, are determined by judging the procedure of each case. However, if the execution of unit work is performed at local, it cannot be applied to HuRECA, which can be applied only to MCR. Therefore it is analyzed by K-HRA.

4. Result

The human error events that showed the greatest change (Table.2) in conversion from THERP to HuRECA were RCOPH-S-SDSE with 1,052% increase and EFOPV-S-CSAS with 90% decrease. Conversion (Table.2) from K-HRA to HuRECA showed the biggest change with 247% increase in DCOPH-S-SHEDLOAD and 83% decrease in HR-PCL. Table.1 shows the diagnostic error probability, performance error probability, and HEP(mean) value derived from the K-HRA, THERP, and HuRECA human reliability analysis methods. Table.3 shows each CDF change based on THERP application, reflecting the HEP(mean) values in Table.1.

Human Error case	K-HRA			THERP	HuRECA		
	Diagnostic Error	Execusion Error	HEP (mean)	HEP (mean)	Diagnostic Error	Execusion Error	HEP (mean)
HR-PCL	2.82E-05	1.25E-03	1.28E-03	5.77E-04	2.16E-05	2.00E-04	2.22E-04
DAOPH-S-AACDG	2.66E-04	1.50E-02	1.53E-02	1.47E-03	2.01E-04	8.00E-03	8.20E-03
MSOPH-S-SGADV-HW	8.78E-03	6.00E-02	6.88E-02	5.33E-02	6.66E-03	6.00E-02	6.67E-02
CVOPH-S-IRWST	1.29E-03	1.00E-03	2.29E-03	1.89E-03	8.63E-05	1.00E-03	1.09E-03
CVOPH-S-RCPSEAL	4.39E-03	4.00E-03	8.39E-03	1.72E-02	1.66E-03	4.00E-03	5.66E-03
AFOPH-S-RESTART	8.48E-05	5.00E-04	5.85E-04	8.24E-04	6.36E-05	1.00E-04	1.64E-04
MSOPH-S-ASC-SLOCA	4.00E-03	8.00E-03	1.20E-02	3.40E-02	9.99E-04	8.00E-03	9.00E-03
RCOPH-S-SDSE	5.31E-04	2.00E-02	2.05E-02	1.12E-03	4.03E-04	1.25E-02	1.29E-02
AFOPH-S-ALT-LT	9.09E-05	1.50E-03	1.59E-03	7.03E-04	6.89E-05	1.00E-03	1.07E-03
DCOPH-S-SHEDLOAD	9.78E-05	5.00E-04	5.98E-04	1.66E-03	7.41E-05	2.00E-03	2.07E-03
EFOPV-S-SIAS	1.40E-04	1.00E-03	1.14E-03	3.96E-03	1.06E-04	1.00E-03	1.11E-03
RPOPV-S-RTRIP	4.39E-04	1.00E-03	1.44E-03	2.66E-03	3.33E-04	1.00E-03	1.33E-03
SIOPH-S-HLI	9.78E-05	5.00E-04	5.98E-04	2.76E-04	7.41E-05	1.00E-04	1.74E-04
EFOPV-S-CSAS	1.40E-04	1.00E-03	1.14E-03	3.96E-03	1.06E-04	3.00E-04	4.06E-04
			1.36E-01	1.24E-01			1.10E-01

Table.1 Diagnostic and execution error possibility of K-HRA, THERP, HuRECA

Sheet NO.	Human Error Cases	HEP Change	
		THERP->HuRECA	K-HRA->HuRECA
1	HR-PCL	▼62%	▼83%
2	DAOPH-S-AACDG	▲458%	▼46%
3	MSOPH-S-SGADV-HW	▲25%	▼3%
4	CVOPH-S-IRWST	▼43%	▼53%
5	CVOPH-S-RCPSEAL	▼67%	▼33%
6	AFOPH-S-RESTART	▼80%	▼72%
7	MSOPH-S-ASC-SLOCA	▼74%	▼25%
8	RCOPH-S-SDSE	▲1,052%	▼37%
9	AFOPH-S-ALT-LT	▲52%	▼33%
10	DCOPH-S-SHEDLOAD	▲25%	▲247%
11	EFOPV-S-SIAS	▼72%	▼3%
12	RPOPV-S-RTRIP	▼50%	▼7%
13	SIOPH-S-HLI	▼37%	▼71%
14	EFOPV-S-CSAS	▼90%	▼64%
	SUM	▼11%	▼19%

Table.2 HEP change by application of different HRA methodology

	HuRECA	K-HRA
CDF Change	▼0.58%	▲18.33%

Table.3 CDF change based on THERP application

5. Conclusion

The reason for the huge gap in HEP value is as follows. First, the job type and design factors for applying the HuRECA methodology are not explicitly considered. The reason for this is that it was difficult to identify the type of job and the design elements with the THERP detailed statement and the associated emergency procedure only.

In addition, there was no clear criterion to apply THERP human error correction value to HuRECA due to the difference between THERP and HuRECA methodology.

In order to solve this problem, it is necessary to closely examine the emergency procedures related to human error cases and clearly identify the type of job and design elements to be considered when applying the HuRECA methodology, if necessary, interviews with operators should be conducted to clarify the considerations.

REFERENCES

[1] Korea Atomic Energy Research Institute (KAERI), J.H KIM, Development of Human Reliability Analysis method HuRECA based on computer-based main control room.

[2] A.D. Swain, H.E. Guttmann, Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Application Final Report, NuREG/CR-1278.

[3] Korea Atomic Energy Research Institute (KAERI), Development of K-HRA methodology.

[4] Department of Nuclear Engineering, Hanyang University, M.S JAE, Application of THERP to human error evaluation.