

## Comparison of HuRAM<sup>+</sup> and HERA for Development of Data Worksheet for Simulator-based HRA Databank

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### 1. Introduction

The Korea Atomic Energy Research Institute (KAERI) launched a project in 2012 to develop a simulator-based human reliability analysis (HRA) data handbook that can support the generic process of HRA by using the full-scope simulator of Korean nuclear power plants in 2012. The scope of the project covers post initiating HFEs included in internal events HRA. We defined the minimum requirements of information for the HRA process from restructuring the contents of existing documents such as the requirements, standards, and guidelines [1]. We also compared the existing HRA methods and HRA database to select essential data fields [2]. We performed a preliminary study to see the possibility to induce the operator's emergency operating procedure (EOP) noncompliance behaviors under a simulated emergency [3].

The purpose of this paper is to compare the HuRAM<sup>+</sup> and HERA to obtain an insight into the construction of a data worksheet for a qualitative HRA. In this paper, we performed a case study for applying simulator training data to HuRAM<sup>+</sup> and HERA. With this insight, as well as the results of the researches mentioned above, we have a plan to develop a systematic and qualitative HRA and a data worksheet for the work.

### 2. Methods and Results

#### 2.1 HuRAM<sup>+</sup> and HERA

HuRAM<sup>+</sup> was developed by KINS to support an examiner during an event investigation to identify inappropriate human actions and their relevant root causes [4]. HERA was developed for the NRC as a repository of retrospective qualitative analysis of actual or simulated incidents. The objective of HERA is to make available empirical and experimental human performance data, from commercial nuclear power plants (NPPs) and other related technologies, in a content and format suitable to HRA practitioners [5].

Figure 1 shows a structure of the HRA process of HuRAM<sup>+</sup> and HERA and relations among data fields. HuRAM<sup>+</sup> consists of seven analysis steps. A (event description) and B (event sequence / HSE) are for a brief summary for a human related event while C (HSE information), D (HSE task/context information), E

(error mode analysis), and F (PSF analysis) are for each human subevent (HSE) involved in the event. Similarly, Worksheet A is for an event that consists of more than a subevent and Worksheet B is for the subevents with HERA. HERA defines nine kinds of subevents, which are categorized by an event-type group (i.e., human, plant, and external) and related information (i.e., positive outcome, negative outcome, and contextual information).

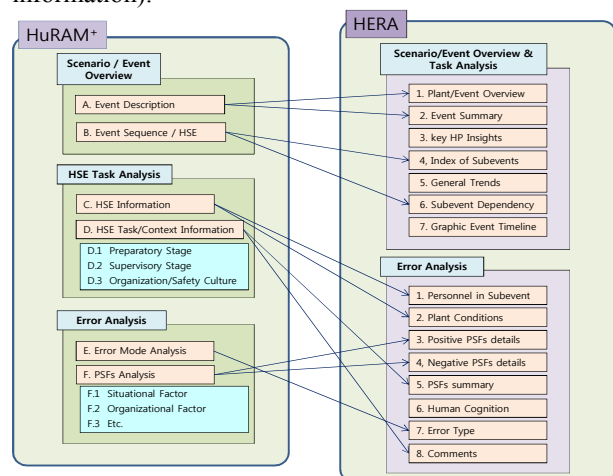


Figure 1. Structure of HuRAM<sup>+</sup> and HERA

#### 2.2 Case Study

We analyzed simulator training data for a main steam line break (MSLB) and a nearly coincident steam generator tube rupture (SGTR) with HuRAM<sup>+</sup> and HERA. We collected data on nine simulated emergency operation training cases for the scenario at a Westinghouse 3-loop PWR. Figure 2 and 3 show examples of a case study with HuRAM<sup>+</sup> and HERA respectively.

For HuRAM<sup>+</sup>, since the structure of the worksheet is simpler than HERA's, it is somewhat convenient to input data into the HuRAM<sup>+</sup> worksheet, especially the error mode part. Organization and safety culture factors are strengthened, however it is not easy to input data for the data fields.

Since HERA was developed to provide an HEP for probabilistic safety assessment (PSA), it includes data fields for an HEP estimation such as recovery action and dependency those HuRAM<sup>+</sup> does not consider. However, it impose burden on time and cost to input

data into HERA data worksheet. HuRAM<sup>+</sup> and HERA commonly have too many performance shaping factors (PSFs) to analyze them.

### 3. Conclusions

In this paper, we compared HuRAM<sup>+</sup> and HERA to obtain an insight into the construction of a data worksheet for a qualitative HRA and performed a case study. HERA requires a burden to analyze and input an event data due to too many data fields even though it is well designed to estimate HEPs. It is somewhat more convenient to input data into the HuRAM<sup>+</sup>; however, it is difficult to analyze the organization and safety culture factors.

We are now trying to develop the framework of a data worksheet for a qualitative HRA based on simulator training data. The purpose of our data worksheet is to provide key information for HEP estimation and to enhance the understanding of an operators' behavior under an off-normal plant status. We aim less encumbered means of obtaining the needed data for HRA by changing the existing data worksheet framework of HuRAM<sup>+</sup> and HERA and by reducing data fields that require reading the between the lines.

### ACKNOWLEDGEMENT

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### REFERENCES

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사건보고서번호	PTE8-20100825-T1	사건일시	2010. 8. 25	A. 사건개요
사건제목	MSLB+SGTR			
발생호기	영상 1 발 시뮬레이터 실습	발전소타입	Westinghouse	
운영모드	원자로 트립	원자로출력	0	
비고				
HSE ID	HSE-3	HSE 발생일자	08:46	
HSE 설명	보드운영원이 SRO의 지시사항을 수행하지 않고 착각하였음. SRO가 E-2 수행 중 Floutout page 에 의해 방사선 백색비상발령을 지시하였는데 이를 수행하지 않았음			
HSE 발생 상황 정보	C. HSE 기본 정보			
분석근거자료	운영상 자료 분석 (PTE #8)	분석자/분석일	최선영/2011. 5. 31	
작업자/경력	<input type="checkbox"/> 운전원, <input type="checkbox"/> 기술/장비/시험원, <input type="checkbox"/> 외부업체 작업자, <input type="checkbox"/> 관리자, 해당 보직경력 ( )년 <input type="checkbox"/> MCR, <input type="checkbox"/> 보조원, <input type="checkbox"/> 타빈원, <input type="checkbox"/> 격납건물, <input type="checkbox"/> 기타( )			
취무유형	<input type="checkbox"/> 설계/제작/설치, 시험/경험, <input type="checkbox"/> 정기시험, <input type="checkbox"/> 주기시험, <input type="checkbox"/> 보정, <input type="checkbox"/> 정비, <input type="checkbox"/> 교정/정비, <input type="checkbox"/> 예방정비, 운전, <input type="checkbox"/> 이상, <input type="checkbox"/> 비정상, <input type="checkbox"/> 비상			
취무분야	<input type="checkbox"/> 운전, <input type="checkbox"/> 기계, <input type="checkbox"/> 전기, <input type="checkbox"/> 계측, <input type="checkbox"/> 기타			
원차시/지시서	E-2	해동/기타	<input type="checkbox"/> 1차계동, <input type="checkbox"/> 2차계동	
오류유형(I)	<input type="checkbox"/> EOC(누락오류), <input type="checkbox"/> EOC(부적절한 수행오류)			
오류유형(II)	<input type="checkbox"/> Mistake(진단/의사결정오류), <input type="checkbox"/> Slip/Lapse(수행오류), <input type="checkbox"/> Violation(규정위반)			
오류유형(III)	<input type="checkbox"/> Latent Error(잠재오류), <input type="checkbox"/> Active Error(즉발오류)			
오류발생시점	<input type="checkbox"/> 전출력 운전, <input type="checkbox"/> 출력/감발 운전, <input type="checkbox"/> 계획예방정비			
	E. 오류유형분석			

일시 (mm/ss)	사건경위	HSE	비고
00:31	MSLB 발생 (SG B, inside containment)		
00:52	SGTR (SG B)		B. 사건경위 및 HSE
01:53	원자로 트립		
02:01	EOP E-0 수행 시작		
02:01 - 04:01	E-0, 1.0 ~ 13.0 수행		
04:01 - 04:16	E-0, 14.0 생략 (확인지시생략)		13.1에서 CV 압력이 1.5를 초과하는 것을 알아서 (이미 살수가 작동중이었다란 것을 알고 있음)
04:16 - 04:53	E-0, 15.0 ~ 18.0 수행		
05:07 - 05:28	E-0, 19.0인 RCS 온도 정검 항목에서 TO가 온도와 압력을 같이 보고하면서 RCS 압력이 단계 21.2의 RCP 정지조건이 만족된다고 보고하여 SRO는 19.0 수행단계에서 21.2 (RCP 정지)를 지시하고 이에따라 RCP 정지 작동을 수행하였음. 그 후 20.0으로 다시 돌아오지 않고 전체 생략하면서 기기작동 (20.4, PZR PORV 차단발 생)을 누락하였음. (작동지시 생략, 기기작동 생략)	HSE-1 +	최소한 한 개는 멀어야 하는데 이를 따르지 않았음 (SRO가 지시를 하지 않았음)

Figure 2. Case Study with HuRAM<sup>+</sup>

#### Worksheet, Part A

Coder 최선영	2nd Checker	Ops Review	HF Review
Date 10/4/2011	Date	Date	Date

#### Section 1: Plant and Event Overview

Document identifying plant and event information.

1. Primary Source Document: PTE8-Transcript
2. Other Source Docu
3. Plant Name: 영광 1
4. Plant Type:  BW
5. Plant Operating Mode: NL
- 5a. Plant Power Level:
6. Event Type:
  - Initiating Event:  Yes  No
  - Common Cause:  Y
- 6a. Event Date / Time: 8/25/2010 오후
- 6b. Event Description: MSLB+SGTR
7. Affected Function(s):
8. Affected System(s):
9. Affected Component(s): SG B
10. Source:
  - LER
  - ASP Analysis
  - AIT
  - Other

#### Section 4: General Trends Across Subevents / Lessons Learned

Part A: General Trends  Not Applicable  
Part B: Lessons Learned  Not Applicable  
Explain any key lessons learned from this event and / or any key corrective actions taken as a result of this event.

#### Section 5: Human Subevent Dependency Table

Subevent	Start Time	End Time	Parent Subevent	Dependencies
00:31	00:31	00:31		
00:52	00:52	00:52	00:31	
01:53	01:53	01:53	00:52	
02:01	02:01	02:01	01:53	
02:01-04:01	02:01	04:01	02:01	
04:01-04:16	04:01	04:16	02:01-04:01	
04:16-04:53	04:16	04:53	04:01-04:16	
05:07-05:28	05:07	05:28	04:16-04:53	

#### Section 2: Event Summary / Abstract

영광 1 발전소 시뮬레이터 실습용 Containment 안에서 SG B 쪽 main steam 배관에 leak (MSLB) 발생 직후 다시 SG B에 SGTR 발생하였을 관련 EOP는 E-0, E-2, E-3, E-0A-3-1의 순으로 운전이 요구되나 이와 관련된 운전을 수행하면서 일부 절차서의 내용과 위배되는 운전을 수행하였음 1. SRO가 단계 전체 지시를 생략하면서 기기작동과 관련된 내용 지시를 건너뛰었음 2. SRO는 기기작동 관련 지시를 올바르게 지시하였는데도 4. 다른 기기의 작동을 수행하였음 3. SRO가 방사선 백색비상 발령 지시를 내렸는데도 아무도 관련 발령을 내리지 않았음 4. SRO가 절차서의 주의 사항을 읽고 생략하며 절차서의 내용을 머무르는 기기작동을 지시하였음 5. SRO가 CSP stop 명령을 지시한 후 관련 밸브 close 지시는 생략하였음

#### Section 3: Index of Subevents

Subevent	Coll.	Start Time	End Time	Parent	Dependencies	Description	Time	Unit	Operator	Subevent	Comments
00:31	00:31	00:31	00:31			1차원 MSLB 발생, EOP가 요구된 절차서 수행 이후 19.0으로 RCS 온도가 상승함	13	00:31			
00:52	00:52	00:52	00:52	00:31		19.0인 RCS 온도 정검 항목에서 TO가 온도와 압력을 같이 보고하면서 RCS 압력이 단계 21.2의 RCP 정지조건이 만족된다고 보고하여 SRO는 19.0 수행단계에서 21.2 (RCP 정지)를 지시하고 이에따라 RCP 정지 작동을 수행하였음. 그 후 20.0으로 다시 돌아오지 않고 전체 생략하면서 기기작동 (20.4, PZR PORV 차단발생)을 누락하였음. (작동지시 생략, 기기작동 생략)	12	00:52			
01:53	01:53	01:53	01:53	00:52		EOP E-0 수행 시작	13	01:53			
02:01	02:01	02:01	02:01	01:53		E-0, 1.0 ~ 13.0 수행	12	02:01			
04:01	04:01	04:16	04:16	02:01		E-0, 14.0 생략 (확인지시생략)	13	04:01			
04:16	04:16	04:53	04:53	04:01		E-0, 15.0 ~ 18.0 수행	12	04:16			
05:07	05:07	05:28	05:28	04:16		E-0, 19.0인 RCS 온도 정검 항목에서 TO가 온도와 압력을 같이 보고하면서 RCS 압력이 단계 21.2의 RCP 정지조건이 만족된다고 보고하여 SRO는 19.0 수행단계에서 21.2 (RCP 정지)를 지시하고 이에따라 RCP 정지 작동을 수행하였음. 그 후 20.0으로 다시 돌아오지 않고 전체 생략하면서 기기작동 (20.4, PZR PORV 차단발생)을 누락하였음. (작동지시 생략, 기기작동 생략)	12	05:07			

Figure 3. Case Study with HERA