PSA

Standardization of Domestic Human Reliability Analysis and Experience of Human Reliability Analysis in Probabilistic Safety Assessment for NPPs under Design

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Abstract

This paper introduces the background and development activities of domestic standardization of procedure and method for human reliability analysis (HRA) to avoid the intervention of subjectivity by HRA analyst in probabilistic safety assessment (PSA) as possible, and the review of the HRA results for domestic nuclear power plants under design studied by Korea Atomic Energy Research Institute. We identify the HRA methods used for PSA for domestic NPPs and discuss the subjectivity of HRA analyst shown in performing a HRA. Also, we introduce the PSA guidelines published in USA and review the HRA results based on them. We propose the system of a standard procedure and method for HRA to be developed.

1.

(risk-informed)

(Probabilistic

Safety Assessment: PSA) ASME PRA Standard(ASME

PRA) [1] NEI PRA Peer Review Guideline(NEI PRA)[2]

. PSA

, .

PSA (generic)

,

(plant specific) PSA .

PSA

PSA .

PSA

. (Human Reliability Analysis: HRA)

/

PSA .

HRA ,

, .

PSA 5

HRA HRA

HRA HRA

PSA .

PSA HRA HRA

2002 8 HRA

[3]. HRA PSA HRA

PSA

. HRA

[3]:

● HRA

● (ASME NEI PRA) HRA

●

HRA

HRA

PSA   HRA   . 2   PSA

HRA   ,   HRA   ASEP(accident sequence evaluation

program)[4]   THERP(technique for human error rate prediction)[5]

                              . 3   ASME   NEI   PRA   ,

            HRA   . 4   HRA

     ASME   NEI PRA   .

HRA   .

2.   HRA   ASEP/THERP

                    PSA   HRA   HRA

                ASEP [4]   THERP[5]

          .

                              SHARP(systematic human action reliability procedure)[6]

        ,   ,   ,   .   PSA

                HCR [7], THERP [5], ASEP [4], SLIM [8], cause based decision

tree [9]   .   CREAM [10], ATHENA [11]

                      PSA   ..

1.   HRA

No	PSA	PSA			
1	3,4 1,2	PSA	KOPEC	1992	HCR/THERP
2	3,4	PSA	KAERI	1993	ASEP/THERP
3	2,3,4	PSA	KAERI	1997	ASEP/THERP
4	3,4	PSA	KAERI	1997	ASEP/THERP
5	KNGR	PSA	KOPEC	1999	THERP
6	5,6	PSA	KAERI	2001	ASEP/THERP
7	5,6 (/)	PSA	KAERI	2001	THERP
8	5,6	PSA	KEPRI	2002	ASEP/THERP
9	1	PSA	ACT		ASEP/THERP
10	2	PSA	KOPEC		ASEPTHERP
11	1	PSA	KOPEC		ASEP/THERP
12	3,4 1,2 (update)	PSA	KOPEC		HCR/THERP (,)

KOPEC: , KAERI: , ACT: –

1 HRA [3].

HRA 1992 3,4 1,2 PSA

. PSA HRA 3,4 1,2

ASEP THERP .

PSA

2 ((pre-accident) (post-accident)) 3

[6]:

- A ( ): . .
- B : , ,
- C ( ):

,

ASEP THERP

A . ,

C . B

. 1

PSA ASEP

THERP .

(decomposition) ,

. :

- A : ((omission error) + (commission error))
- C : (diagnosis error) + (execution error)

A

.

(omission)

(commission error) . A

. PSA (quantitative risk

assessment: QRA), A THERP ASEP

. PSA A THERP ASEP

. A 1 PSA

, A

. , A

C ASEP THEERP

.

1 PSA C

. C

HRA , , . C

.

, , , [4, 5].

.

.

3,4 1,2 PSA C ASEP

THERP HRA .

C .

ASEP THERP C :

- = ( ) X (factors)

- = Σ [X]

.

, , / , .

.

,

(feedback) . HRA

(performance shaping factors: PSF)

. "X"

A HRA " (reluctance)" B HRA

. A "X" (dynamic action) B

(step-by-step action) . HRA

. ASEP THERP

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  -
  - (, ,
)
-
  -
  -
-

■

■

■

■

3. ASME   NEI PRA   HRA

ASME   NEI   PRA   HRA   .

ASME PRA   6   :

- : PRA   ,   ,
- :   ,
- : PRA   , Capability I, II, III
- :   ,   (HLR: high level requirements)
  (SR: supporting requirements), 9   (,   ,   ,
      ,   ,   ,   ,   ,   )
- PRA   : PRA
- : PRA   ,   NEI PRA

PRA   Capability II

.

2. ASME PRA

	Capability Category I	Capability Category II	Capability Category III
		, , (SSC)	
	/		

NEI   4   3   :

- :   ,   ,
- PRA   :   ,   ,   ,
- :   ,   , 11   PRA
  (,   ,   ,   ,   ,   ,   ,
          ,   ,   ,   /   ) ,
-

●   ,   ,

NEI   PRA   3   4   .   3

            Grade 3   .

                      PRA   ASME   Capability II   NEI   grade 3
                              .

                                        ,   Capability II

   Grade 3   .

표 3. NEI PRA   Grade

	Grade 1	Grade 2	Grade 3	Grade 4

	-NRC Generic Letter 88-20
	
	               -
	        PRA
	grade 1 -
	          ,
		- Grade 2 ,
		
		                    (risk ranking)
		
		                    -
		Grade 2 Grade 1
			- Grade 3 PRA
			
			              - Grade 3 Grade 2
				- , ,
				
				            - Grade 4 Grade 1, 2, 3

	IPE for GL 88-20 requirement Assessing severe accident vulnerabilities	MOV ranking, Maintenance rule support	Graded QA/IST/ISI/ on-line maintenance, single TS changes	-Replace technical specification. with an on-line risk monitor

GL: generic letter, MOV: motor operated valve, QA: quality assurance,
IST: in-service testing, ISI: in-service inspection, TS: technical specification

표 4. ASME   NEI PRA

ASME 9 HLR 34 (SR)		NEI – 30

4 HLR – 15	– 3
	– 2
	                    PSA
	– 3
	        / – 7
		– 3
		              – 4 (,
		   ,)
		                    – 18
		(, ,
		   )
		            – 2
		   – 3

4 HLR – 18	– 4
	              PSA
	– 2
	        / - 9
	– 3	

1 HLR – 1		

          4   ASME PRA   9

(HLR)   HLR   34   (supporting requirements: SR)

                  .   HLR   HLR   ,   ,

PSA 　　　　　　, 　　　　　　　　　　　　　　. 　　　NEI PRA

　　　　　　　　　30 　　　　　　　　　　　　　　, ASME PRA

　　　　　　　　　　　　, 　　　　　　　　　　　　　　,

　, 　　　　　　　　　　　　. 2

　　:

● 　　　　　, PSA

●

●

● ASME, NEI PRA 　　　　　　PSA 　　HRA

● 　　　　2

● 　　　　　　　　　　PSA 　　HRA 　　,

　　　　HRA

4. 　　　　HRA 　　　　　　HRA

　　　　　　HRA 　　　ASME PRA

　　　. 　　　　　　　　HRA

.

5 　　　　　　　HRA 　　　　　　　[12]. ASME

PRA 　　　　　　,

Capability I 　　　　　　　, 　NEI

Grade II 　　　　　　PSA 　　　　　.

ASME capability

II 　NEI grade 3 　　　　　.

5. 　　　　　HRA

No	PSA		
1	3,4	1993	ASEP IPE 　HRA
2	2,3,4	1997	ASEP IPE 　HRA
3	3,4	1997	ASEP IPE 　HRA
4	5,6	2001	ASEP IPE 　HRA
5	5,6 (/)	2001	THERP IPE 　HRA

*IPE: individual plant examination

1	. . /	& , .
2	( )	.
3	RPS/ESFAS	HRA
4		1
5		
6		, , HRA
7	, (AOP)	
8	,	
9	, (time window), ,	(cues) (time window) , (:)
10	(PSFs)(:)	HRA
11		HRA
12		HRA
13	(credit)	HRA
14		HRA
15	, PSA	HRA

PSA   HRA   6   .

3&4   HRA   ,

PSA   HRA   .   :

-

- ,   (AOP)

- (time analysis)   (cues)

- /

- (,   ,

)

●

　　　　　HRA　　　　　ASME　 NEI PRA
HRA　　　　　　　　.
　　　　　　　　　　　　　　　　.　　　　　HRA　　　　　　　　　　　　:
● 　　　　　　　　:　　　　　　　　　　　　　　　　　　　　　　　, 　　,
　　　,
● 　　　　　　　　　:　　　　　　　　　　　　　.　　　　A
　　　　　(CCF)　　　　　　　　,　　　　　　　　, 　C

● 　　:　　　　　　　　　　　　　　.
　　　ASEP　 (ASME PRA　　　　)
● 　:　　　　　　　　　　　　　　.
　　　THERP　 (ASME PRA　　　　)
　■ 　　　　　　　　　　　 – 　,

　■ 　　　　　　　　　　　　 –

● 　PSA　 (　,　　, 　/　)
● 　　　　　　,　　　　　: NEI PRA

5.
　　　　HRA　　　　　　　　　　　　HRA
　　, HRA　　　　　　　　　　.　　　ASME
NEI　　　HRA　　,　　　　HRA
　.
　　　　HRA　　1992　　3,4　　1,2　PSA
　ASEP THERP　.　　　　　　HRA
　.　　　　　　,
　(　　,　　,　),
　.　　　　HRA
　ASME PRA　　Capability I NEI PRA
Grade 2　　　.

HRA   , HRA

.   HRA   ,

,   ,   ,   PSA   ,

,   . .

HRA

HRA   .

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