AGAPE- ET

AGAPE-ET for Human Error Analysis of Emergency Tasks and Its Application

,

150

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AGAPE-ET (A Guidance And Procedure for human

Error analysis for Emergency Tasks) , 31

. AGAPE-ET ,

(error-likely situation) ,

. AGAPE-ET

,

AGAPE-ET PSA

.

ABSTRACT

The paper presents a proceduralised human reliability analysis (HRA) methodology, AGAPE-ET (A Guidance And Procedure for Human Error Analysis for Emergency Tasks), covering both qualitative error analysis and quantification of human error probability (HEP) of emergency tasks in nuclear power plants. The AGAPE-ET method is based on the simplified cognitive model. By each cognitive function, error causes or error-likely situations have been identified considering the characteristics of the performance of each cognitive function and influencing mechanism of the performance influencing factors (PIFs) on the cognitive function. Then, error analysis items have been determined from the identified error causes or error-likely situations and a human error analysis procedure based on the error analysis items is organised to help the analysts cue or guide overall human error analysis. The basic scheme for the quantification of HEP consists in the multiplication of the BHEP assigned by the error analysis item and the weight from the influencing factors decision tree (IFDT) constituted by cognitive function. The method can be characterised by the structured identification of the weak points of the task required to perform and the efficient analysis process that the analysts have only to carry out with the necessary cognitive functions. The paper also presents the application of AGAPE-ET to 31 nuclear emergency tasks and its results.

1.

(PSA: Probabilistic Safety Assessment)

(HRA: Human Reliability Analysis)

. 1 THERP, ASEP, SLIM, HCR, HCR/ORE,

STAHR (HFE: Human Failure

Event)

. 1

,

, , (EOC: Error of Commission)

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1 HRA ,

CREAM, MERMOS, ATHEANA

2 HRA . CREAM CPCs (Common Performance

Conditions)

,

(generic) ,

(guidance)

. MERMOS (safety requirement) (human factor

mission) , SAD(S:Strategy, A:Action, D:Diagnosis)

. , MERMOS

, .

ATHEANA EFC (Base Case Scenario) (Deviation

Scenario) EOC ,

/ ,

(risk-

informed regulation) .

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AGAPE-ET (<u>A</u> <u>G</u>uidance <u>A</u>nd <u>P</u>rocedure for Human

<u>E</u>rror Analysis of <u>E</u>mergency <u>T</u>asks) , 30 .

AGAPE-ET

. ,

PSA

EOC (Error of Commission) .

2

AGAPE-ET

,   (error mode)   ,

. AGAPE-ET   ,

(Error-Likely Situations)   ·   ,

·   ,

(steps)   ,

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.   2   AGAPE-ET   ,

3   31   .   ,   4

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2.   : AGAPE- ET

AGAPE-ET   . AGAPE-ET

[, 2001;   ; 2002;

Kim, 2002]   .

2.1. AGAPE- ET

AGAPE-ET

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.   , AGAPE-ET

. AGAPE-ET

[, 2001; Kim, 2002]   ,

'   ', '   ', '   ', '

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,   .   , AGAPE-ET

(Activation & Detection),   (Information Gathering),   (Situation

Assessment),   (Planning & Decision-making),   (Task Execution)

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3

AGAPE-ET   .

- ,

    (Error Likely Situations)   .

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        ,   1   .

                            .

                        [, 2001;   , 2002]

    .

            (Activation & Detection)

                        , AGAPE-ET   '

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                ', '   ,   ,

5   .

- -01 :   ,   ,

- -02 :   ,

        ,

- -03 :   ,   ,

- -04 :   ,

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- -05 :   ,

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                    (,   ,

).   , '   -03'   '   -05'

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                                    , '   -04'   ,

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          '   ,   .

                    ,   '   /   ', '   ', '

    ,   .   .

- -01:   ,   ,   ,   ,

                        ((manual)   )   ,

- -02:

                                        (:   ,

                , Loop   )   ,

- -03:   ,

- -04:   .

                                                (integration)

                                        '   ',

    '   /   ', '   ',   .

          .

- -01:   (Judgement),   (Evaluation)

                                '   (Knowledge-based)'

                  ,

- -02:   ,   ,   /

                  ,

- -03:   ,

- -04:   ,

              , '   ', '   (Errors of Commission)'

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- • -01: ,
- • -02:

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- • -02: .

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(, ,)

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2.2. AGAPE-ET

AGAPE-ET

(BHEP: Basic Human Error Probability)   (weight)

.   (BHEP)   HRA   THERP(Swain, 1983), HEART(Williams,

1988), INTENT(Gertman et al., 1992), CREAM(Hollnagel, 1998), CBDT(Parry, 1992)

,

. (weight)

,

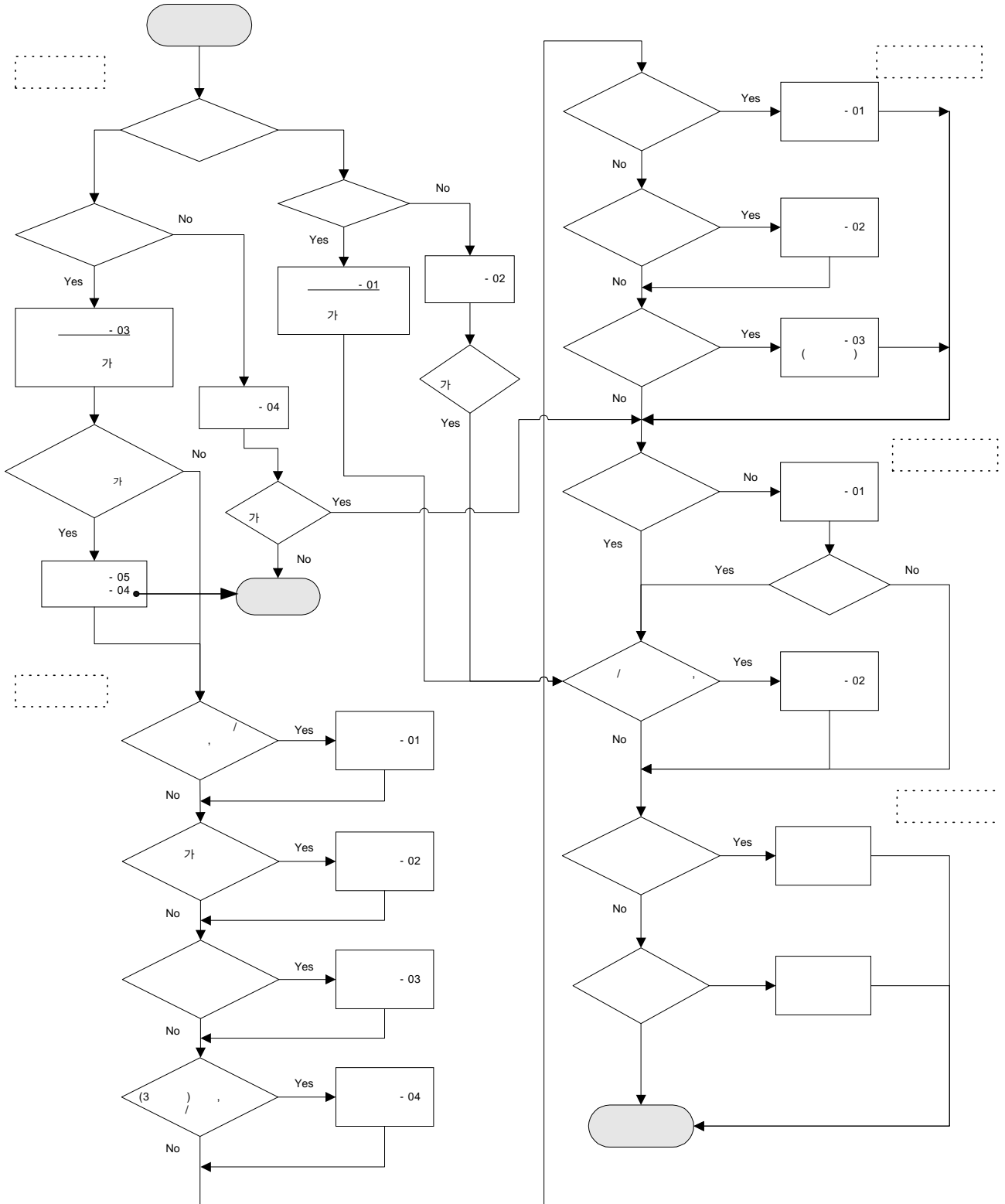, (IFDT: Influencing Factors Decision Tree) .

BHEP   IFDT   [, 2002]   .

,

(BHEP)   (IFDT)   (AHEP:

Adjusted Human Error Probability)   .   ,

(HEP)   .

$$HEP = \sum_i AHEP_i = \sum_i BHEP_i * \omega_i(PIF_i), \qquad\qquad (\quad 1)$$

$\omega_i(PIF_i)$: i IFDT   ,

$BHEP_i$: i (BHEP),

$AHEP_i$: i (AHEP).

1.   AGAPE-ET

3.   :

AGAPE-ET   PSA   31

.   AGAPE-ET

HRA

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[, 2002]   .

.   AGAPE-ET

,   3&4   PSA

5   (HFE)   .

1   31   .

      1. PSA   (HFE)

No.	Event Name	Human Failure Event (HFE)	Related Operator Task
1	SDOPHEARLY	Operator fails to perform feed and bleed (F&B) operation within 20 min (Early)	Feed and bleed operation
2	MSOPHSR-L	Operator fails to do RCS cooldown and depressurization (in SLOCA scenarios)	RCS cooldown and depressurization
3	MSOPHSR-T	Operator fails to do RCS cooldown and depressurization (in Transient scenarios)	RCS cooldown and depressurization
4	AFOPHALTWT	Operator fails to arrange alternate water source	Arrangement of alternate water source
5	MXOPHDPLI	Operator fails to initiate RCS aggressive cooldown and depressurization for LPSI within 30 min	RCS aggressive cooldown and depressurization
6	MXOPHEBOR	Operator fails to initiate emergency boration using Charging Pump within 1 hour	Emergency boration using charging pump
7	MFOPHSUFWP	Operator fails to line up and start MFW startup feed pump 079	Line up and start MFW startup feed pump 079
8	SDOPHLATE	Operator fails to perform F&B operation within 2.5 hr (Late)	Feed and bleed operation
9	HSOPHHLCLR	Operator fails to initiate hot and cold leg recirculation	Hot and cold leg recirculation
10	MXOPHDPLR	Operator fails to RCS cooldown and depressurization for LPSR within 2 hrs	RCS cooldown and depressurization
11	MSOPHEVADV-2	Operator fails to manually open ADVs in local (with local hand pump)	Open ADVs in local
12	SCOPHSDCOP	Operator fails to perform shutdown cooling operation	Shutdown cooling operation
13	SCOPHCSSOP	Operator fails to perform shutdown cooling operation using CSS pump when SDC pumps fails	Shutdown cooling operation using CSS pump
14	SCOPHSDCOPLT	Operator fails to switch shutdown cooling operation after F&B success and CSR failure (Long-term phase)	Shutdown cooling operation
15	AFOPHPPSTART	Operator fails to restart AFW pump after running failure of shutdown cooling operation	AFW pump restart
16	RCOPHPCON	Operator fails to control RCS pressure	RCS pressure control
17	MXOPHULK	Operator fails to prevent the faulted SG from overfilling using SGBDS	Venting of faulted SG using SGBDS
18	MXOPHFNB	Operator fails to perform F&B operation within 10 min (ATWS)	Feed and bleed operation
19	MSOPHEVISOLADV	Operator fails to isolate ADVs of faulted SG	Isolation of ADVs of faulted SG
20	MFOPHSUFWPL	Operator fails to restart MFW startup pump 079 to maintain secondary heat removal	Restart of MFW startup pump 079
21	AFOPHSG1ISOL	Operator fails to isolate AFW supply to faulted SG on LSSB	Isolation of AFW supply to faulted SG

22	FSOPVSIAS	Operator fails to generate SIAS manually (SLOCA and Transient)	Manual generation of SIAS
23	FSOPVSIAS-M	Operator fails to generate SIAS manually in the Medium LOCA	Manual generation of SIAS
24	FSOPVRAS	Operator fails to generate RAS manually (SLOCA and Transient)	Manual generation of RAS
25	FSOPVRAS-LM	Operator fails to generate RAS manually in the Large or Medium LOCA	Manual generation of RAS
26	FSOPVAFAS	Operator fails to generate AFAS manually	Generation of AFAS
27	FSOPVCSAS	Operator fails to generate CSAS manually	Generation of CSAS
28	FSOPVMSIS	Operator fails to generate MSIS manually	Generation of MSIS
29	CVOPHCHGP4	Operator fails to manually start CVCS charging pump 4	Manual start of CVCS charging pump 4
30	EGOPHDG01E	Operator fails to start AAC DG-01E and connect to 4.16kV bus	Start of AAC DG-01E and connection to 4.16kV bus
31	MXOPHRWT	Operator fails to refill RWT	RWT refill

3.1. AGAPE-ET

31   AGAPE-ET   AGAPE-ET
              .   .

        1   2   .
-04   4, 11, 13, 14, 29
                       , 8, 15, 20, 31

                                                    .   -05   7
      ,   ,
                                                             .

     2. AGAPE-ET   (HFE)

			1 (HFE)
-01		,	2, 3, 16
-02		,	-
-03		, ( )	1, 4, 5, 6, 7, 9, 10, 12, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27, 28, 30
-04		, ( )	4, 8, 11, 13, 14, 15, 20, 29, 31
-05			7

●   :   1   9   '
              ,   'RCS   ,'
          (CET   ,   )
     .

●   :

3 .

- : ,

  1 5 ' ' , (HPSI)

  'HPSI ' 'SI ' , ' , ' , .

- : AND

  , 1 '

  ' AND OR ('AND

  ^ OR ^ NOT'). , 19 'SGTR SG ADV '

  , ADV . RCS

  ADV ,

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- :

  4, 5, 7, 8, 10, 11, 13, 14, 15, 20, 29, 31 ,

  , TSC

  , , 5 29 ,

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- : /

  ' ' 1, 8, 18 ,

  -04

  . 29

  , 20

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- ( ) : 1, 8

  ' ' , 2, 3, 5 'RCS

  ' 1, 2

  . 16 'RCS '

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3.2. PSA

　　　　　　　　　　　3&4　　　PSA　　　　　　　　　　　(ET: Event Tree)　　　　　　　　　(FT: Fault Tree)　　　　　　　　　　　　　　　　　　　　6

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① 'SDOPHEARLY' : Operator fails to perform F&B operation (early)

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　RCS

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　　　　　　　　　20　　　，　　　　　4　　　　　　　　　　16

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② 'MXOPHDPLI' : Operator fails to perform aggressive cooldown for LPSI injection within 15 min.

　　　　　　　SLOCA　　SGTR　　　　　　　(SIAS)　　　　，HPSI

　，　　　　　　　　　LPSI

　　．

　　　．　　　SI　　　　'SI　　　'　'HPSI　　　　'

　　　，　　　　　　　MMI　　　　　　'SI

'　　　　(HPSI　　　　　　　　)，　　　　　　　．

　　　　　　　　　　　　　　　　（　）

．　　　　　　　　，

．　　　　'SDOPHEARLY'　　　　　　．

③ 'AFOPHALTWT' : Operator fails to arrange alternative water source

11

(SDC)

(
), SDC   ,
                              .

                    (CST)   (DWST)   (raw water)
                    .

            .   LOCA   , CST   -02(LOCA),   26, 58
                        ,   47
        CST   .   ,
                    (2 hr   )   ,
                                          .   1E-03   .

④   'SDOPHLATE-HD1' : Operator fails to perform late F&B operation with high dependency to
    AFOPHALTWT

                                                                                          ,
                                          .   'AFOPHALTWT'
            '   ,   . ①
    'SDOPHEARLY'   ,   ,
                                              .

                              1E-02   , 'AFOPHALTWT'   1E-01
        .

⑤   'HSOPHHLCLR' : Operator fails to initiate hot and cold leg recirculation

                MLOCA/LLOCA   HPSI   HPSR   ,
                                                                                  .
    HPSI   HPSR   ,
                                      ,   ,
                                          .   1E-03
        .

⑥   'MFOPHSUFWP' : Operator fails to line up MF startup FWP 07P

                SGTR (LOCV, GTRN, LOCCW, LO416kV/FW)   MFW
    , AFW   ,
        .

                          .   SGTR (   )
        ,   SGTR   LOAF   .

12

SGTR   , 'SBCS   RCS   '
          .   SG   , RCS
    (   )
    .   .   ,

                        ,   '   -01'
                             .   5.0E-3   .

4.

                    HRA   1   HRA   2   HRA

        HRA   AGAPE-ET (<u>A</u> <u>G</u>uidance <u>A</u>nd <u>P</u>rocedure for human <u>E</u>rror analysis of <u>E</u>mergency
<u>T</u>asks)   ,   PSA   31
                AGAPE-ET
          .

    AGAPE-ET   11   ,
                                                                        HRA
      .   ,

          (Error-Likely   Situations)   ,

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    AGAPE-ET   31
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