Selection of the Important Performance Influencing Factors for the Assessment of Human Error under Accident Management Situations in Nuclear Power Plants

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CREAM, SLIM, INTENT 10 .

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Abstract

This paper introduces the process and final results of selection of the important Performance Influencing Factors (PIFs) under emergency operation and accident management situations in nuclear power plants for use in the assessment of human errors. We collected two types of PIF taxonomies, one is the full set PIF list mainly developed for human error analysis, and the other is the PIFs for human reliability analysis (HRA) in probabilistic safety assessment (PSA). 5 PIF taxonomies among the full set PIF list and 10 PIF taxonomies among HRA methodologies (CREAM, SLIM, INTENT, ..) were collected in this research. By reviewing and analyzing PIFs selected for HRA methodologies, the criterion could be established for the selection of appropriate PIFs under emergency operation and accident management situations. Based on this selection criteria, a new PIF taxonomy was proposed for the assessment of human error under emergency operation and accident management situations in nuclear power plants.

I.

(PSA: Probabilistic Safety Assessment) . (HRA)

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,   [1]   .

,   THERP[2],

HEART[3], CREAM[4]   (Basic HEP)

, SLIM[5], IDA[6]   .

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.   Swain's

THERP[2], Williams' HEART[3], Whalley's PHECA[7], Gerdes' Influencing Factors[8], Bellamy's PSF

Taxonomy[9]   5   ,

SLIM[5,10], INTENT[11], IDA[6], HRMS[12], Julius' Errors of Commission[13],

Macwan's Errors of Commission[14], INCORECT[15], CREAM[4], Taylor-Adams' PSF Taxonomy for CORE-

DATA[16], Rogers' PSF Taxonomy for CORE-DATA[17]   10   .

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II.

1.   (PIF)

(context)   (condition)   ,

[18].

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.   , PSF (Performance

Shaping Factors), PIF (Performance Influencing Factors), IF (Influencing Factors), PAF (Performance Affecting

Factors), EPC (Error Producing Conditions), Context Factors, CPCs (Common Performance Conditions)

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1)

- Swain's THERP (1983)

  Swain   "   "

  , 67   PSFs   external PSFs, stressors PSFs, internal PSFs

  ,   external PSFs   Situational

  Characteristics, Job & Task Instructions, Task & Equipment Characteristics   ,

  Stressors PSFs   Psychological Stressors   Physiological Stressors   , Internal PSFs

  Organismic Factors   .

- Williams' HEART (1986, 1988)

  HEART(Human Error Assessment and Reduction Technique)   38

  EPC(Error-Producing Conditions)   , EPC   "nominal

  probability"   .

- Whalley's PHECA (1987)

  PHECA   1987   S. Whalley   (Chemical Process Plants)

                          PSF   .

                                      . Whalley   PSF   5   PSF List (Swain &

  Guttmann, Embrey, Singh, AMAS, Ergonomic literature)   PSF   PSF

                        ,   (Company Accident

  Reports, Medical Department Records, Incident Reports, Plant Log Books, Supervisor Records, Computer

  Printout)   5   ,   PSF

            . Process, Personnel, Ergonomic   .

- Gerdes' Influencing Factors (1997)

  Gerdes   PSF   IF (Influence Factor)   , 32   PSF

                    ,   108   IFs   . 4   ,

  HUMAN, TASK, MACHINE, ENVIRONMENT   . 4

          .

- Bellamy's PSF Taxonomy

  Bellamy   (conditions),

          (performance shaping factors)   8   : Individual

  Factors, Man-Machine Interface Characteristics (Displays and Controls), Task Demands, Task

  Characteristics, Instructions and Procedures, Stresses, Environment, Socio-Technical Factors. THERP

Stresses   .

2)

                              1   .   .
-    Embrey's SLIM (1984) & PLG-SLIM (1994)
     Embrey   SLIM
                                              ,   1   [5]
                         . PLG SLIM   /
                                        . Embrey SLIM   PLG SLIM
             SLI (Success Likelihood Index)   .
-    INEL INTENT (1992)
     INTENT   (errors of intention)   ,

              .

-    Phillips' IDA (or STAHR) (1985)
     IDA (STAHR)

                                                                                  .

-    Kirwan's HRMS (1997)
     HRMS

          .

-    Macwan's Errors of Commission (1994)
     Macwan   ,   PIFs(Performance Influencing Factors)
                              (misdiagnosis)
              ,   [2, 19, 20]   . PIF

                              .   PIF   ,
                          .
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-    Julius' Errors of Commission (1995)
     Julius   PIF   Macwan (1995)   PIF
         ,   context-independent PIFs
                              context-dependent PIFs   ,
                                                    . Julius   PIFs   1
                   .

-    Hollnagel's CREAM (1997)

                                        4

Hollnagel   (context factors)   1   9   CPCs (Common

Performance Conditions)   ,   PSF

, CPCs

.

- Kontogiannis' INCORECT (1997)

   Kontogiannis   Hollnagel   ,   CREAM

,

, dynamic event tree [21]   Risk

            . INCORECT   1   10   Performance Conditions

   . Kontogiannis   'stress', 'workload', 'task complexity'

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- Taylor-Adams' CORE-DATA (1995)

   CORE-DATA (Computerized Operator Reliability and Error Database)

         Birmingham   University   Taylor-Adams   .

   CORE-DATA   5   ,   external error mode,

   psychological error mechanism, performance shaping factors, task-equipment taxonomy, human action

   taxonomy   .   performance shaping factors   PHECA, THERP, HEART

                16   .

- Rogers' PSF Taxonomy for CORE-DATA (1996)

   CORE-DATA   PSF   PSF

                                    ,   1   PSF   .

   Rogers   17   PSF   .

   1.

Original SLIM	PLG-SLIM	HRMS	INTENT
1. Quality of design 2. Meaningfulness of procedures 3. Role of operations 4. Teams 5. Stress 6. Morale /Motivator 7. Competence	1. Plant interface and indications of conditions 2. Significant preceding and concurrent actions 3. Task complexity 4. Procedural guidance 5. Training and experience 6. Adequacy of time to accomplish action 7. Stress 8. Other	1. Time 2. Quality of information/ interface 3. Training/ Expertise/ Experience/ Competence 4. Procedures 5. Task organization 6. Task complexity	1. HMI 2. Stress 3. SRK 4. Experience 5. Safety culture 6. Training 7. Motivation 8. Workload 9. Supervision 10. Communication 11. Procedures
IDA	CREAM	Kontogiannis' Performance Conditions	Taylor-Adams' PSFs for CORE-DATA

1. Quality of information
  - Design
  - Meaningfulness of procedures
2. Organization
  - Role of operations
  - Teams
3. Personal
  - Stress
  - Morale/ Motivation
  - Competence
	1. Adequacy of organization
	2. Working conditions
	3. Adequacy of MMI and operational support
	4. Availability of procedures/plans
	5. Number of simultaneous goals
	6. Available time
	7. Time of day
	8. Adequacy of training and preparation
		1. Time availability
		2. Plan availability and accessibility
		3. Information availability and accessibility
		4. Simultaneous tasks
		5. Decision-making criteria
		6. Response dynamics and system coupling
		7. Supervision
		8. Capability degrading factors (CDFs)
		9. Teamwork and social factors
		10. Organizational factors
			1. Alarms
			2. Communication
			3. Ergonomic design
			4. HMI ambiguous
			5. HMI feedback
			6. Labels
			7. Lack of supervision/checks
			8. Procedures
			9. Refresher training
			10. Stress
			11. Task complexity
			12. Task criticality
			13. Task novelty
			14. Time pressure
			15. Training
			16. Workload

Rogers' Revised PSFs for CORE-DATA	**Macwan's commission error**	**Julius' commission error**	
1. Adequacy of HMI 2. Training 3. Procedures 4. Adequacy of Supervision/Monitoring 5. Communication 6. Team organization 7. Stress 8. Task complexity 9. Task novelty/unfamiliarity 10. Workload 11. Distractions 12. Adverse conditions 13. Fatigue 14. Motivation 15. Safety culture 16. Adequacy of design 17. Robustness of design	● Scenario-independent PIFs 1. Crew training and experience 2. Crew confidence 3. Relative experience of RO and SRO 4. Recent experience with one or more faulty signals ● Scenario-dependent PIFs - Plant related 5. Values of critical parameters 6. Rate of change of critical parameters 7. Instrument failure - EOP related 8. Phase of EOP 9. Type of logic structure 10. Number of logical conditions - Operator related 11. Operator diagnosis 12. Memory of recent actions 13. Perceived importance 14. Perceived consequences 15. Operator expectations	● Context-independent PIFs - Training related 1. Degree of familiarity with and frequency of training on, EOPs; 2. General philosophy towards using the EOPs; 3. Generic rules for handling procedural ambiguities; 4. Method of resolving conflicting information from different instrumentations. - Crew team characteristic 5. Team structure; 6. Established protocol for communication; 7. Adequacy of resources; - Plant related 8. Human factors design of the plant ● Context-dependent PIFs - Plant related 9. Value of critical parameter; 10. Trend of critical parameters; 11. Availability of equipment; 12. Availability of instrumentation - EOP related 13. EOP response phase (verification, diagnosis) - Operator related 14. Confidence in diagnosis 15. Expectation 16. Memory of previous actions and accident history	

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- HUMAN:
- SYSTEM: H/W
- TASK:
- ENVIRONMENT:

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Level I	Level II	Level III & IV
ENVIRONMENT	**Team & Organization Factors**	**Management & Policy** (Gerdes) - work/rest schedule (Gerdes, Swain) - shift rotation (Swain) - supporting team - level of supervision - inadequate instruction - plant policy (here and Swain) - rewards and punishments (Gerdes, Swain) - …… **Team Communication Related Factors** - structure of instruction/information delivery - standardization in instruction/information delivery - standard communication network (Salas) - media of instruction/information delivery (:page phone, fax, paper, etc.) - ……

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THERP, ASEP, HCR

. SLIM, IDA

, INTENT

. CREAM, INCORECT

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‘ (simultaneous goals and tasks)’

. NRC ATHEANA[23]

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. , MMI

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,

(, training, experience, motivation, ..),

(, procedure, MMI, organization factors...).

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- : training, experience, procedure, MMI/information, time
- : stress, workload, motivation, task complexity, simultaneous
tasks/goals, working condition, supervision, team factors, communication
- : adequacy of resources, decision making criteria, response
dynamics & system coupling, availability of equipment, trend and value of critical parameters, time of
day, organization factors, task organization, safety culture

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. <stress, workload, task complexity,
safety culture, organization factor> .

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	PIFs	
HUMAN	1. Training & Experience	1. Adequacy of training (frequency, recent training, fidelity of simulation program) 2. Experiences/practices of real operating events 3. Learning of the past events/experiences 4. Career of operator
TASK	2. Availability & Quality of Procedures	1. Availability 2. Format or type 3. Clarity of instruction and terminology 4. Decision making criterion 5. Logic structure
	3. Simultaneous Goals/Tasks	1. Number of simultaneous goals/tasks 2. Priority bet. goals/tasks
	4. Control Type of Task	1. Dynamic/Step-by-step
SYSTEM	5. Availability & Quality of Information	1. Information availability (instrumentation fail/stuck) 2. Clearness of meaning (Direct indication/Interpretation required/ Ambiguous/Unreliable information) 3. Distinguishability of information 4. Control display relationships
	6. Status & Trend of Critical Parameters	1. Value of critical parameters 2. Trend of critical parameters (Rate of change of critical parameters 3. Number of dynamic changing variables 4. Degree of alarm avalanche
	7. Status of Safety System/Component	1. Success/Fail state of safety system/component 2. Level of trust on the system/component
	8. Time Pressure	1. Available time vs. Required time
ENVIRONMENT	9. Working Env. Features	1. Task location: (MCR/Local CR/Local area) 2. Accessibility
	10. Team Cooperation & Communication	1. Clearness in role/responsibility definition 2. Direction, type, method, protocol 3. Standardization in instruction/information delivery 4. Team cohesiveness/collaboration
	11. Plant Policy & Safety Culture	1. Plant specific prioritized (or preference for /objection to) goals/strategies 2. Safety/economy tradeoff 3. Routine violations

V.

                                                    Swain's THERP, Williams' HEART, Whalley's PHECA,
Gerdes' Influencing Factors, Bellamy's PSF Taxonomy   5
                                                            SLIM, INTENT, IDA, HRMS, Julius' Errors of
Commission, Macwan's Errors of Commission, INCORECT, CREAM, Taylor-Adams' PSF Taxonomy for
CORE-DATA, Rogers' PSF Taxonomy for CORE-DATA   10   .   ,
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Acknowledgement

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