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The Human Factors Approaches to Reduce Human Errors in Nuclear Power Plants

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1. Introduction

After the Three Mile Island accident, people have been showing a growing interest in human errors in the nuclear field. Human errors in nuclear power plants have been an important factor in the human factors researches. As a part of human factors practices, nuclear power plants are conducting safety assessments such as Periodic Safety Review (PSR) and Probabilistic Safety Assessment (PSA) in order to reduce any possibility which might cause major accidents or damage. Especially, to reduce the human errors recently not only some efforts to eliminate human related causes have been attempted, but also a means to widely manage the human errors such as Human Factors Management Program (HFMP) has been developed. Therefore, this chapter concerns the properties of complex systems and addresses the various practices of human factors.

Traditionally, approaches to reduce human errors were to classify error types and to protect operators from Performance Shaping Factor (PSF). Classification of human errors were conducted in previous studies and applied to find cause factors in various ways. These analyses of human errors were gradually systematized as a safety reporting system. Especially, short-term and long-term countermeasures were attempted to minimize possible human errors in a complex system such as aircraft, nuclear power plant. The purpose of these countermeasures is to reduce human errors and to improve performance of operators and systems at the same time. These countermeasures previously focused on satisfaction assessment of Man-Machine Interface (MMI), but these focused on broad considerations which are operator related such as safety culture, communication, aptitude test, etc. in recent. With regulation, the will of employer and the safety consciousness of operators are necessary to manage them efficiently. This chapter concerns various trials of reducing human errors and discusses requirements to perform an identification of them.

2. Complex systems

In general industry, insuring tranquility of individuals and systems is acknowledging a prerequisite because that is the first requirement to avoid accidents. Especially, accidents in complex system do not simply lead to worker's individual disaster or pecuniary damage, but create unexpected damage or develop managerial risks or social issues. Therefore, when safety requirements are not satisfied in complex systems, the issues can bring serious problems in not only individuals and managements but also a longer society (Lee, 2006).

Process industry contributes to society by mass production based on cost-effectiveness through large system of high-reliability. However, if an accident occurs in this industry, it can be face with rejection rather than contribution because of a great deal of damage.

Recently, various safety-related efforts are being focused on large systems from workplace management for preventing individual's injuries to risk management for maintenance of systems, customer protection like Product Liability (PL) law, and preparing an expansion of social damage.

Among these efforts, safety related hardware is improving rapidly with the high-level reliability, but safety insurances for preparing human errors are not satisfied relatively. Especially, because relative importance of human errors related to accidents increases in large systems of high-reliability, it is difficult to determine correctly a direction of effective prevention. So, if efforts of accident prevention are effective, we should be more careful of which precautions are premised on relatively important considerations related to human error. That is, even if process industry is a high-tech industry of high-reliability, if it has not enough reliability, it can face unexpected new dimension of social antipathy, in spite of the achievement of industrial effect and role.

Therefore, we have to investigate items which consider improving the efforts for accident prevention in complex systems such as nuclear power plants. According to Lee's study (2006), he examined ten empirical reviews related to human error in nuclear fields and suggested basic considerations that need to prevent accidents. These reviews are misunderstandings about human error and suggestions which be found by trial and error;

1. Human error in an accident occurs by accident
2. Human error can be captured by the statistics
3. Human error is to blame to human
4. Human error can be reduced by enforcements
5. Human error can be reduced by voluntary efforts
6. Human error never recurs to the same human
7. Human error can be prevented by eliminating causes
8. Performance also means safety
9. The same cause, the same accident
10. Keep the basic principles against human errors

Also, according to the previous studies, accidents related to the complex system's reliability have three major the properties as follows (Lee, 2003; Park et al., 2008);

1. Dependency and inherence of an accident
2. Representativeness and latency of an accident
3. Chaining and structural properties of accidents

Not only nuclear power plants but other various major industrial accidents have these properties. Thus, the properties as stated above have to be considered to improve safety in a procedure for an accident analysis.

3. Human factors practices in NPPs (Nuclear Power Plants)

In the following, we introduce human factors practices which include human factors assessment and management in NPPs.

3.1 PSR

PSRs were adopted in order to guarantee the continued safe operation of nuclear power plants. PSRs are focused on considering various aging effects and are generally conducted approximately every ten years, and for this, analysis procedures are required such as an inspection, structure analysis, failure assessment and a combination of them (IAEA, 2010; Ko et al., 2006).

Through PSRs in Korean NPPs, the status of various human factors in operating NPPs has been reviewed by human factors experts and independent operation experts. Many points that are not suitable in a human factors sense have been revealed and remedies for these have also been discussed between the reviewers and plant personnel (Lee et al., 2004a, 2004b, 2004c; Lee et al., 2006a, 2006b).

In the process of PSRs, two different types of responses from plant personnel have been identified. One is to encourage our reviews and admit the findings as valuable information for upgrading human factors in their plant. Another is to refuse to assist in the reviews and to insist that they do not have any human factors problems.

We will describe here in detail about a PSR of human factors since we think that our PSR activities contribute considerably to an enhancement of the human factors in NPPs.

Our PSR of human factors complies with the IAEA (International Atomic Energy Agency) safety guide (IAEA, 2003). The following items are defined in the IAEA guide;

a. Staffing levels for the operation of a nuclear power plant with due recognition of absences, shift working and overtime restrictions
b. Availability of qualified staff on duty at all times
c. Policy to maintain the know-how of the plant staff
d. Systematic and validated staff selection methods (e.g. testing for aptitude, knowledge and skills)
e. Programs for initial training, refresher training and upgrading training, including the use of simulators
f. Training in safety culture, particularly for management staff
g. Programs for the feedback of operating experience for failures and/or errors in human performances that have contributed to safety significant events and of their causes and corrective actions and/or safety improvements
h. Fitness for duty guidelines relating to hours of work, good health and substance abuse
i. Competence requirements for operating, maintenance, technical and managerial staff
j. Human-machine interface: design of the control room and other work stations; analysis of human information requirements and task workload; linkage to PSA and deterministic analyses
k. Style and clarity of procedures.

These broad areas were grouped into five categories; (1) procedures, (2) Human Machine Interface (HMI), (3) human resources, (4) human information requirements and workload, and (5) use of experience. The relationship between the five areas and the IAEA assessment items is shown in Table 1.

Our assessment areas	Items defined in IAEA safety guide
(1) Procedures	(k)
(2) HMI	(j)
(3) Human resources (4) human information requirements and workload	(a), (b), (c), (d), (e), (f), (h), (i)
(5) Use of experience : incorporated into (1), (2), and (3)	(g)

Table 1. Relations between our assessment area and the PSR items defined in IAEA safety guide (IAEA, 2003)

For the five assessment areas, the details of these assessments are described as following.

1. Procedures

Class	Detail
a. Check Points	• The availability of the procedures; to evaluate if the plant provides procedures that explicitly identify the tasks related to plant safety • The appropriateness of the style and structure; to assure that procedures do not result in an excessive load to operators and cause them to become confused during their task performance • The suitability of the detailed elements; to evaluate if the structure and properties of the procedures satisfy the requirements in NUREG-0899, NUREG-1358, NUREG/CR-1999, other relevant NRC documents, IAEA TECDOC-1058, and various plant procedure management and guideline documents
b. Methods	• Procedural document reviews • Interviews with plant personnel • On-site reviews • Expert panel reviews
c. Scope	• Operation procedures: EOPs (emergency operation procedures), GOPs (general operation procedures), SOPs (system operation procedures), AOPs (abnormal operation procedures), and alarm procedures • Many departmental procedures

Table 2. Procedures assessment

2. HMI

Class	Detail
a. Check Points	• The availability of HMI; to evaluate if all HMI elements are provided as required for a performance of the tasks. Comparison between a list of HMI elements made from the analyses of the operation procedures and operator interviews and the list of HMI elements on the control boards • The suitability of HMI; to verify if the HMI properties are suitable for human factors guidelines NUREG-0700 or NUREG-0700 Rev. 2 and KINS-G-001 chapter 18.
b. Methods	• The effectiveness of HMI; to assure that HMI supports task performance so that operators can achieve the intended task objectives through the HMI. Experiments in a plant simulator were performed to evaluate the effectiveness of HMI • The suitability of the work environmental conditions; to check by measurement if illumination, noise, vibration, etc. on selected spots are within required limits
c. Scope	• MCRs (main control rooms), RSPs (remote shutdown panels), local control panels, SPDS (safety parameter display systems), and main computer systems

Table 3. HMI assessment

3. Human Resource

Class	Detail
a. Check Points	*Work Management* • working hour management (e.g. adequate work hour, overtime) • shift management (e.g. rules of shift work, shift rotation schedule) • job substitute management (e.g. job substitute considering qualification, authority, and human factors) • work management during an O/H (overhaul) period *Health Management* • medical examination (e.g. epidemiology) • mental health and alcohol, substance abuse • health promotion activity (e.g. musculoskeletal disorders) • job satisfaction and devotion • health promotion activity • staff morale *Recruit and Qualification* • recruit (e.g. criteria for recruiting) • qualification and requirements for NPP personnel • maintaining a specialty of plant personnel *Training Program* • execution of SAT (Systematic Approach to Training) • assessment of instructors (academic career, job career) *Safety Culture* To check if the plants make an effort to enhance the awareness of plant safety through education; • plan and contents of safety culture education Operator Training using Simulators; To check if the plants provide adequate simulator training to operators for them to operate the plant safely and manage emergency state well; • training program for operators using simulators • suitability of simulators (e.g. facility status, maintenance and management status)
b. Methods	• document reviews • structured interviews with plant personnel • on-site reviews • expert panel reviews

Table 4. Human resource assessment

4. Human Information Requirements and Workloads

Class	Detail
a. Check Points	To determine if explicit task information requirements are satisfied and if a job operation by a department, a plant person, and an individual task is appropriate
b. Methods	• selection and reviews of a total of 80 departmental procedures • structured interviews with plant personnel • on-site reviews • expert panel reviews
c. Scope	• mental workload related information requirements • other factors related information requirements - personal requirements; expertness, experience, job characteristics, levels of knowledge - organizational requirements (among individuals or departments) ; work orders, training and education factors • environmental factors related information requirements (e.g. illumination, noise, vibration) • Workload (e.g. objective and subjective workload, physiological workload)

Table 5. Human information requirements and workloads assessment

5. Use of Experience

Class	Detail
a. Check Points	To review various operational experiences and to incorporate the findings of the above elements into human factors
b. Scope	• the issues and recommendations raised by the regulatory body • operation and maintenance experience • trip and event reports • human error reports • minor deficiency reports, • the implementation of the TMI action plan • FSAR changes

Table 6. Assessment for use of experience

Conclusively, reviews of human factors in NPPs by external experts have revealed many human factor problems which have remained hidden. Through PSRs, practical methods to assess the factors other than HMIs and the procedures have been established.

3.2 HFMP (Human Factors Management Program)

From the results of our PSRs, it has been found that human factors in NPPs need to be managed continuously by an organization inside the plant. For this reason, we are developing a prototype of the HFMP. We introduce the HFMP here as a proposition for a human error management in NPPs.

It will have a top level general human factors management procedure document, and detail documents for practice procedures, checklists, and technical criteria. The top level procedural document contains a general procedure and other information such as purpose, scope of application, references, definition, responsibility, and basic articles including the organization, committee, training and education for the operation of the HFMP. Plant personnel who are exclusively in charge of human factors are newly assigned and a committee for the HFMP operation is formed in the plant. General HFMP procedure has the form of a Plan-Do-Check or Study-Act which is a basic process in a BPM (business process management). It describes procedures for planning, execution and operation, assessments, reviews by the HFMP committee and decision making. Attachments of detailed procedures are provided for the management of individual human factors such as plant procedures, work management, qualification, training and education, workload management, HMI, and human error management. These items are considered in the HFMP based on the requirements for a PSR of human factors in NPPs. HFMP will have a complete form this year and many discussions with plant personnel and many cases of a real application will be attempted to establish the system. Figure 1 shows a structure of documents which include procedures and guides for HFMP.

4. Human error analysis

4.1 Human error taxonomy

When designing installations for safety-related complex systems it is important to be able to analyse the effect of human errors on essential tasks. For this reason the sensitivity and reliability of these systems to errors must be judged from some kind of EMEA (Error Mode and Effect Analysis) based on a classification of types of human error. To be useful also for adopting new technology in the HMI, taxonomy through psychological mechanisms is necessary rather than taxonomy derived from behaviouristic classification (Rasmussen, 1988). However, there is no generally approved and used taxonomy for human errors. Taxonomy for human errors is just made for specific purpose.

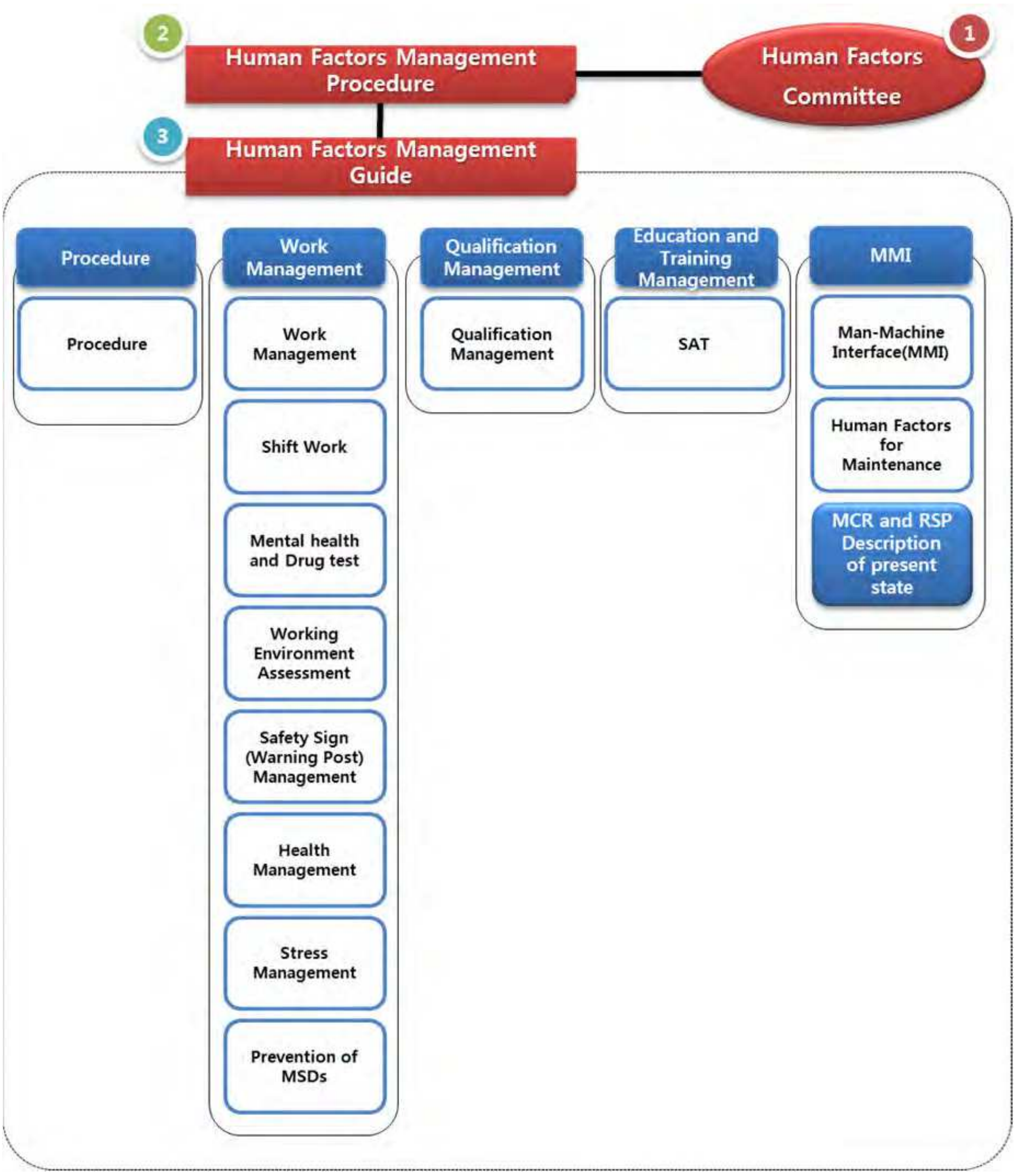


Fig. 1. Construction of HFMP

Swain (1982) suggested task-based taxonomies which state what happened. These taxonomies of human errors are classified as either error of commission or error of omission. Error of omission is defined as slip or lapse in performing a task, while error of commission is defined as erroneous action while executing a task. Many studies of human error taxonomy focused on symbolic processing models. These approaches are more cognitive in their direction, and consider the human as having reference mental models and how things work, and how to perform. Rasmussen (1982) suggested SRK model. Reason (1990) suggested 4 types of error modes slips, lapses, mistakes and violations. Hollnagel (1993; 1996) suggested Cognitive Reliability and Error Analysis Method (CREAM) which based on a set of principles for cognitive modelling, Simple Model of Cognition (SMoC), Contextual Control Model (COCOM).

4.2 IAD (Industrial Accident Dynamics)

The dependency and the potentiality of the hazards in a NPP are defined by estimating the relative factors of the events using the IAD diagram as shown in Figure 2.

IAD matrix has usually been applied to the industrial safety domain. This technique is arranged as seven accident occurrence stages (background factors, background and initiating factors, initiating factors, intermediate factors, immediate factors, near accident, and accident) and two management stages (measurable results and countermeasures) for the column of a matrix. A row consists of four general classes: (1) machine, material and object of work, (2) human, (3) environment, and (4) others (management, supervision, education, etc.). In nuclear field study, these factors were modified to make the best use of the Frank Bird's accident theory (lack of control, fundamental factors, immediate factors, accident and injury) for ensuring an easiness of analyses. And finally, the IAD matrix consisted of the managerial and influencing factors, the fundamental causes and factors, unsafe conditions, unsafe actions, accident inducing factors, and the result and loss, as well as the 4M (Lee et al., 2007; Hwang et al., 2007; Hwang et al., 2008).

4.3 HPES

Human Performance Enhancement System (HPES) developed originally by INPO has been used in many countries, including Korea. In the case of our country, the Korean utility company modified the original HPES to become K-HPES similar to the J-HPES in Japan, which is a Japanese version of HPES and was developed by the Central Research Institute of Electric Power Industry (CRIEPI). The development and application of K-HPES was led by the top management of the Korean utility company in the early 1990s. The top management compelled plant personnel to generate K-HPES reports to the pre-assigned number of cases during the early years of its application. This enforcement hindered the advantages of voluntary reporting and brought about adverse effects in the use of the system. Workers felt stress by this reporting assignment, additional to their normal work, and sometimes reported artificial data, and hesitated to use the reports in their work practice.

Another feature of the initial version of K-HPES that caused its failure was the difficulty of plant personnel to produce a report by using K-HPES. It used many cognitive terms that are not understandable to plant personnel and required a high level of skill in the analysis of human error cases.

Many revisions have been performed. The system has become more simple and a web-based version has been developed (Jung et al., 2006). Also the compulsive attitude of management in the operation of K-HPES was mitigated. An analysis and report generation can be done with the web-based K-HPES. New K-HPES without the disadvantages that the initial version had may help plant personnel to reduce the number of human errors.

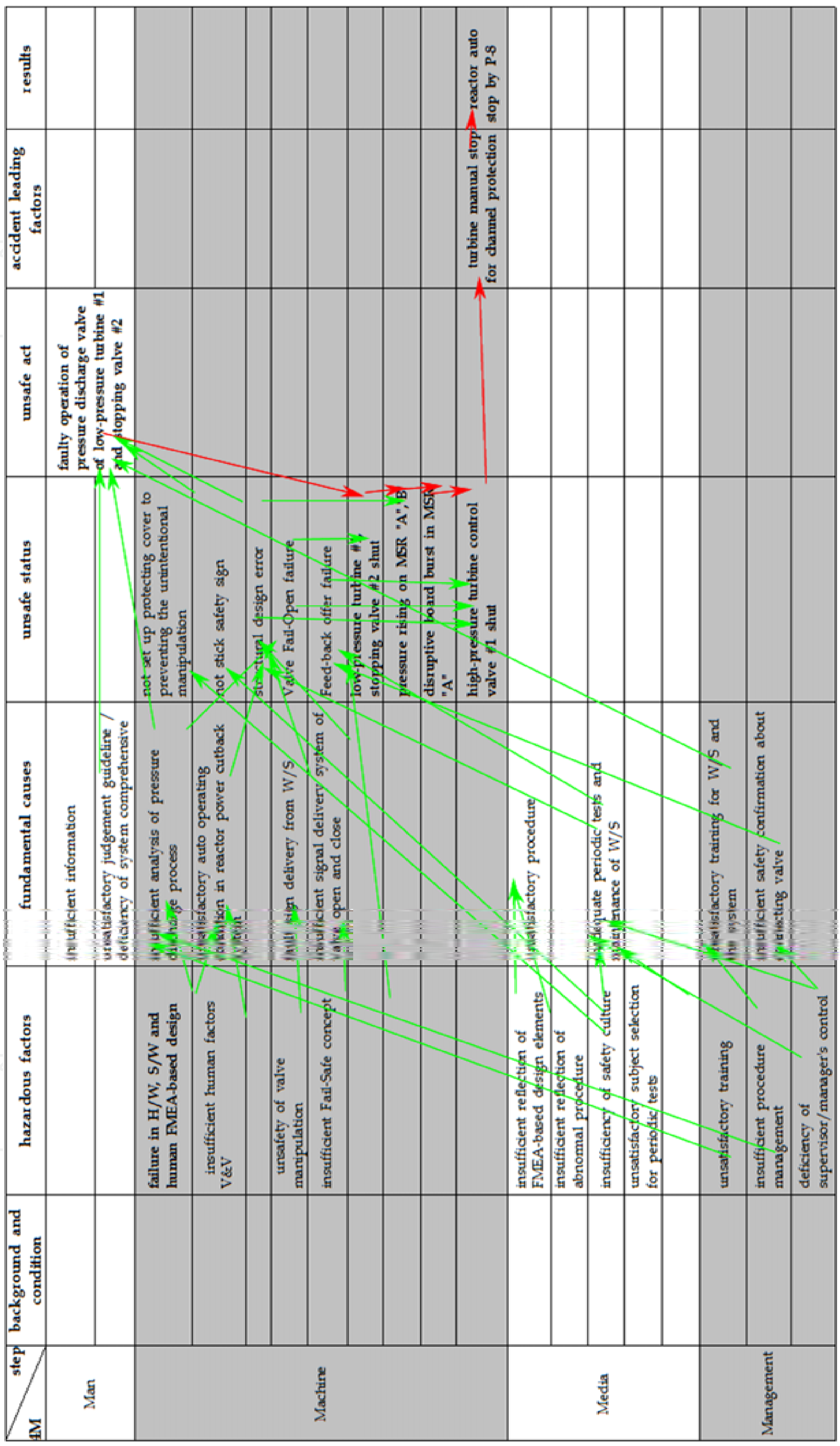


Fig. 2. Hazard factors using the IAD diagram – case study

5. Countermeasures of reducing human error in Korea

During the period 2004 to 2005, the Nuclear Safety Commission has suggest the importance of short and long term countermeasure as trip events of NPPs by human error has grown in Korea (KINS, 2006). Thereby, as part of countermeasure of reducing human error, human factors and nuclear power experts established a basic plan for reducing human error. These long-term countermeasures, the three directions and ten practical tasks have been selected and promoted. Also, experts suggested implementation plan for reducing human errors based on these practical tasks (Table 7).

Plan	Main execution items
Development of system and program for individual job analysis	- Management of individual job list of departments - Personality/aptitude tests and psychology tests - Establishment of job fitness
Task analysis of procedures related in safety	- A state-of-the-art review of task analysis methods - Development of task analysis methods
Improvement of method for EOP (Emergency Operating Procedure) presentation	
Grasp and improve communication types	- Analysis communication types among operators - Analysis communication types between operator and local - Analysis communication types between operator and support group - Improvement of communication channel and offer of communication tool
Development of teamwork enhancement technique	- Development of teamwork enhancement technique and reflection to training - Development of teamwork enhancement index
Simulator construction and application using web virtual technology	
Korea human error program development based on behaviour	- FMS (Fundamental Monitoring System), examination, human error tracking - Compensation for behaviour
Human factors assessment support	- MCR environment assessment - Human factors review support of automatic facility
Job support system development using mobile	

Table 7. Implementation plan suggested by experts group

Recently, the Korea Atomic Energy Research Institute (KAERI) is developing several technologies for human error reduction and suggests plans as countermeasure. The following sections are main activities or assessment for human factors management (Lee et al., 2011).

5.1 A suitability evaluation for human resources

A suitability assessment of department assignment intends to prevent human errors through job assignment considering employees' ability. Also, a purpose of this assessment is establishing an effective suitability assessment and developing an application plan in Korea NPPs. KAERI utilize the Organizational Personality Type Indicator (OPTI) which is developed to identify relationship with validity, immersion and satisfaction, based on relationship and propensity correlation between personality types of individual and organization in organization diagnosis, development, personnel administration and psychology (O'Reilly et al., 1991; Yoo, 1999). Especially, the assessment guaranteed applicative possibility in business for a suitability assessment of department assignment through analyzing factors needed preliminary application after investigating relationship among propensities of organization, team administrator and individual.

5.2 A development of job suitability criteria

A Fitness for Duty (FFD), decision criteria of job suitability in human factors aspects, is developed to prevent human errors related in job of employee and improve job efficiency. The FFD derived factors which are necessary to manage human resources of employees in Korea NPPs using analysis for 10CFR26 (U.S. standard), ILO standard, employee characteristic and present state of suitability management. The reduced management factors are health diagnosis, mental health, drug management, job stress management, behavior observation, fatigue management, employee support and so on.

5.3 A human error analysis method for digital devices

In order to introduce advanced digital devices, KAERI analyzed types of human errors which occur on processes when user of digital devices use and developed plans which evaluate occasion possibility. Even if the digital devices are the same controller, the properties of devices can differ with the results through control methods. So, considering this point of view, they defined the Interaction Segment (IS) and the Error Segment (ES) which combined external physical units and control methods, and derived the types of human errors which are possible to rise up superposition of ES. If developed assessment applies job analysis, we can derive possible types of human errors and risk factors every types.

5.4 A communication analysis

Communication can help to harmonize job performance of employees in NPPs, but the communication can become causes of creating human errors as well as means of preventing human errors. Therefore, various studies which related in communication protocol and types between employees and interaction types with interface facilities are necessary in order to analyze communication types and improve communication tools. Especially, these studies can help to prevent hazard of human errors caused by communication.

5.5 Human error reduction campaign posters

The Korea Hydro and Nuclear Power (KHNP) bench marked the excellent foreign nuclear power plants and introduced human error prevention tools. The KHNP produced 40 posters for human performance improvement as shown in figure 3. The preceding posters which KHNP developed in 2006 give a message about specific information related to human errors events. However it is not enough to arouse interest in the effectiveness of posters because most people are favorably disposed toward a simple poster which has much of illustration. Therefore, KAERI developed new types of 30 posters for human error tools as shown in figure 4 (Lee, 2009). The developed posters illustrated the HE precursors to express effectively the primary intention and to make up for discrepancies in the current posters. The error precursors listed in table 8 were compiled from a study of the INPO’s event

database as well as reputable sources on human performance, ergonomics, and human factors (INPO, 2002). These posters put the accent on worker's receptiveness than notification of information and lay also emphasis on visual characteristics.
Except for these technologies, the others propel various methods for reducing human errors. These contain a teamwork evaluation of Main Control Room (MCR) crews, a behavior based safety program, an enhancement of the procedures and a human error hazard analysis.

Category	HE precursors
Task Demands	Time pressure, High workload, Simultaneous tasks, Repetitive actions, Irrecoverable acts, Interpretation requirements, Unclear goals & responsibilities, Unclear standards
Work Environment	Distractions/Interruptions, Changes/Departure from routine, Confusing displays, Work-arounds instrumentation, Hidden system response, Unexpected equipment condition, Lack of alternative indication, Personality conflict
Individual Capabilities	Unfamiliarity with task, Lack of knowledge, New technique not used before, Imprecise communication habits, Lack of proficiency, Indistinct problem-solving skills, "Unsafe" attitude for critical tasks
Human Nature	Stress, Habit patterns, Assumptions, Complacency, Mind-set, Inaccurate risk perception, Mental shortcuts (biases)

Table 8. HE precursors

Fig. 3. An example of the preceding posters (Title : Reconfirmation of communication by habit)

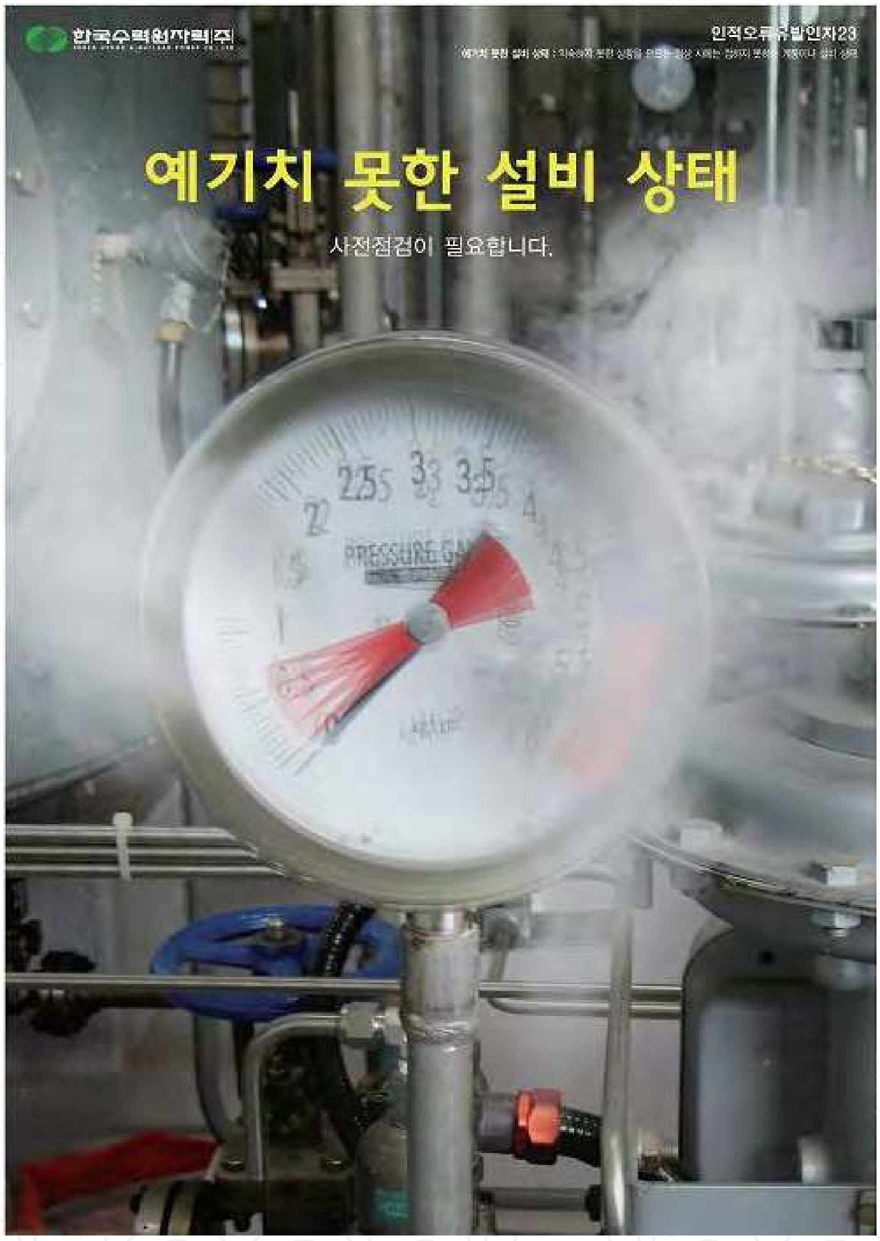


Fig. 4. An example of the developed posters (Title : Unexpected equipment condition)

6. Discussion

In this chapter, we introduce various human factors activities for reducing human errors in NPPs. Previous human factors activities were focused on regulation according to nuclear power laws. But these activities are going to expand an enterprise management as mentioned section 4-5 in recent years. The HFMP is an example of representative human factors activity in fragments. These management programs are necessary for complex systems, because many jobs interfered. That is, NPPs need integrated management systems with the parts working in coordination.

Several technologies and assessments, as mentioned section 5, are developed, and the others are going to improve still methods for preventing and reducing human errors. New methods for reducing human errors have to identify and verify application effectiveness in on-site. These can help to offer methods to be considered for reducing human error in NPPs as well as other fields of industry.

7. References

Hollnagel, E. (1993). *Human Reliability Analysis: Context and Control*, Academic Press, ISBN 978-0123526588, London.

Hollnagel, E. (1996). Reliability Analysis and Operator Modeling, *Reliability Engineering and System Safety*, Vol. 52, No. 3, pp. 327-337, ISSN 0951-8320.

Hwang, S. H., Kim, D. H., Oh, I. S., & Lee, Y. H. (2007). A case study for a human error analysis in nuclear power plants, *Proceedings of the Conference on Ergonomics Society of Korea*, Busan, Korea, November, 2007 (in Korean).

Hwang, S. H., Park, J., Jang, T. I., Lee, Y. H., & Lee, J. W. (2008). A research for the instrumented-related countermeasures from the precedents due to human errors in nuclear power plants, *Proceedings of the Ergonomics Society of Korea*, Gumi, Korea, May, 2008 (in Korean).

IAEA (International Atomic Energy Agency) (2010). *Periodic Safety Review of Nuclear Power Plants: Experience of Member States, IAEA TECDOC Series No. 1643*, IAEA, ISBN 978-92-0-100710-0, Vienna, Austria.

IAEA (International Atomic Energy Agency) (2003). *Periodic Safety Review of Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.10,* IAEA, ISBN 92-0-108503-6, Vienna, Austria.

INPO (Institute of Nuclear Power Operations) (2002). *Human Performance Fundamentals Course Reference*, National Academy for Nuclear Training, Revision 6, INPO, Atlanta.

Jung, Y. S., Lee, J. S., & Chi, M. G. (2006). Development and Application of Web Based K-HPES for Human Error Analysis, *Fall Conference of Korea Nuclear Society*, Kyungju, Korea, November, 2006.

KINS (Korea Institute of Nuclear Safety) (2006). *2007 Directions of Nuclear Safety Policy (proposal)*, 32th Nuclear Safety Commission.

Ko, H. O., Chang, Y. S., Choi, J. B., Kim, Y. J., & Choi, Y. H. (2006), Development of Web-based Aging Assessment System for Major Components of CANDU Type Nuclear Power Plants, *Proceedings of Spring Conference of the Korean Society of Mechanical Engineers*, pp. 1186-1191, Jeju, Korea, July, 2006 (in Korean).

Lee, Y. H. (2003). An Effective Counter Plan of Human Errors to Promote Preventing Activity Major Industrial Accidents, *Safety and health*, the October issue, 2003 (in Korean).

Lee Y. H., Lee, H. C., & Son. H. S. (2004a). *Development of a Methodology for Analysing Information Requirement & Workload for Periodic Safety Review*, KAERI/TR-2699/2004, KAERI, Daejon, Korea (in Korean).

Lee Y. H., Lee, J. W., Park. J. C., Hwang, I. K., & Lee, H. C. (2004b). *Evaluation of Procedures for Periodic Safety Review of Nuclear Power Plants*, KAERI/TR-2880/2004, KAERI, Daejon, Korea (in Korean).

Lee Y. H., Lee, J. W., Park. J. C., Hwang, I. K., & Lee, H. C. (2004c). *Evaluation of Man-Machine Interface for Periodic Safety Review of Nuclear Power Plants*, KAERI/TR-2881/2004, KAERI, Daejon, Korea (in Korean).

Lee, Y. H. (2006). A More Effective Approach to the Analysis and the Prevention of the Human Errors, *Proceedings of Spring Conference of Ergonomics Society of Korea*, Seoul, May, 2006 (in Korean).

Lee Y. H., Park, J. C., Lee, J. W., Lee, H. C., Han, J. B., & Hwang. I. K. (2006a). *Human Factors Evaluation of Procedures for Periodic Safety Review of Yonggwang Unit # 1, 2*, KAERI/TR-3123/2006, KAERI, Daejon, Korea (in Korean).

Lee Y. H., Park, J. C., Lee, J. W., Han, J. B., Lee, H. C., & Hwang. I. K. (2006b). *Human Factors Evaluation of Man-Machine Interface for Periodic Safety Review of Yonggwang Unit # 1,2,* KAERI/TR-3124/2006, KAERI, Daejon, Korea (in Korean).

Lee Y. H., Lee, J. W., Park, J, C., Hwang, I. G., Lee, H. C., Moon, B. S., Jang, T. I., Kim, D. H., Hwang, S. H., Park, J., Lee, J. G., Lee, S. K., Koo, J. Y., & Hong, J. M. (2007). *Human Error Cases in Nuclear Power Plants: 2002~2007*, KAERI, ISBN 978-89-88114-26-1, Daejeon, Korea (in Korean).

Lee, Y. H., Lee, Y., Kwon, S. I., Jung, Y. S., & Kang, J. C. (2009). A Development of Posters for Human Performance Improvement in Nuclear Power Plants, *Proceeding of Asia Pacific Symposium on Safety 2009*, pp. 296-299, Osaka, Japan, October, 2009.

Lee, Y. H., Jang, T. I., Lee, Y., Oh, Y. J., Kang, S. H., & Yun, J. H. (2011). Research Activities and Technique for the Prevention of Human Errors during the Operation of Nuclear Power Plants, *Journal of the Ergonomics Society of Korea*, Vol. 30, No. 1, pp. 75-86, ISSN 1229-1684 (in Korean).

O'Reilly, C. A., Chatman, J., & Caldwell, D. F. (1991). People and Organizational Culture: A Profile Comparison Approach to Assessing Person Organization Fit, Academy of Management Journal, Vol. 34, No. 3, pp. 487-516, ISSN 0001-4273.

Park, J., Lee, Y. H., Jang, T. I., Kim, D., & Hwang, S. H. (2008). Applicability of an ecological interface design approach for an information requirement and workload assessment in nuclear power plants, *2nd International Conference on Applied Human Factors and Ergonomics*, ISBN 978-1-60643-712-4, USA Publishing, Las Vegas, USA, July, 2008.

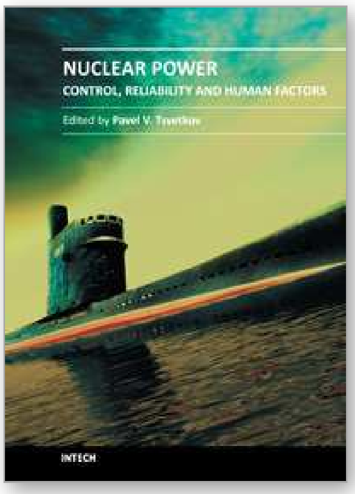
Rasmussen, J. (1982). Human Errors: A Taxonomy for Describing Human Malfunction in Industrial Installations, *Journal of Occupational Accidents*, Vol. 4, No 2-4, pp. 311-333, ISSN 0376-6349.

Rasmussen, J. (1988). Human Error Mechanisms in Complex Work Environments, *Reliability Engineering and System Safety*, Vol. 22, pp. 155-167, ISSN 0951-8320.

Reason, J. (1990). *Human Error*, Cambridge, England, Cambridge University Press, ISBN 978-0521314190.

Swain, A. D. (1982). Modeling of Response to Nuclear Power Plant Transients for Probabilistic Risk Assessment, *Proceedings of the 8th Congress of the International Ergonomics Association*, Tokyo, Japan, August, 1982.

Yoo, T. Y. (1999), Scale Development for Organizational Personal Type Indicator (OPTI), *Journal of Korean Psychological Association*, Vol. 12, No. 1, pp. 113-139. ISSN 1229-0696 (in Korean).



Nuclear Power - Control, Reliability and Human Factors
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Advances in reactor designs, materials and human-machine interfaces guarantee safety and reliability of emerging reactor technologies, eliminating possibilities for high-consequence human errors as those which have occurred in the past. New instrumentation and control technologies based in digital systems, novel sensors and measurement approaches facilitate safety, reliability and economic competitiveness of nuclear power options. Autonomous operation scenarios are becoming increasingly popular to consider for small modular systems. This book belongs to a series of books on nuclear power published by InTech. It consists of four major sections and contains twenty-one chapters on topics from key subject areas pertinent to instrumentation and control, operation reliability, system aging and human-machine interfaces. The book targets a broad potential readership group - students, researchers and specialists in the field - who are interested in learning about nuclear power.