Development of Evaluation Method for Nuclear Safety Culture of an Operating Team using Reliability Analysis Method

Sangmin Han [a], Poong Hyun Seong [a*]
[a] *Department of Nuclear and Quantum Engineering, KAIST 291 Daehak-ro, Yuseong-gu, Daejeon, South Korea, 305-338*
[*] ***Corresponding author: phseong@kaist.ac.kr***

1. Introduction

1.1. Nuclear Safety Culture

Safety culture has received attention in all safety-critical industries including nuclear power plants (NPPs) due to various prominent accidents, such as the concealment of a Station Black Out (SBO) at the Kori NPP unit 1 in 2012, the Sewol ferry accident in 2014 and the Chernobyl accident in 1986. In various reports, it has been pointed out that one of the major contributors to cause those accidents is a “lack of safety culture”. The Inter-national Atomic Energy Agency (IAEA), one of the most influential organizations in the nuclear industry, defined nuclear safety culture in the International Nuclear Safety Advisory Group (INSAG) report No. 4 published after the Chernobyl accident occurred.

“Safety culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted their significance.” [1]

Although the definitions of safety culture are different among nuclear-related organizations, the assessment of safety culture clearly targets the management and improvement of the characteristics and attitudes of individuals and organizations. Moreover, there is a wide consensus among academic researchers that safety culture should be evaluated and managed in a certain way.

To manage and improve the characteristics and attitudes of individuals and organizations, several methods have been developed from various nuclear-related organizations. There are three representative methods: the Independent Safety Culture Self-Assessment (ISCA) developed by the IAEA, the Independent NRC Safety Culture Assessment from the United States Nuclear Regulatory Commission (US-NRC), and a Nuclear Safety Culture Assessment (NSCA) survey process developed by the Nuclear Energy Institute (NEI). [2-4]

These methods are conducted based on surveys, interviews, and observations, and the assessment items of each method are different. Apparently, these assessment methods have limitations. The results are drawn qualitatively and are dependent on the judgment of experts. In addition, the results are also dependent on the reliability of the respondents, and analysis takes several weeks to provide results.

1.2. Research Objective and Scope

To solve the above-mentioned limitations, a new safety culture assessment method is proposed in this paper. For the first part of the study, assessment items were derived from reports related to nuclear safety culture. Here, assessment items were derived for use by an operating team, which is the smallest working unit in nuclear power plants (NPPs). Then, the modeling of team safety culture was performed using a method called level 1 probabilistic safety analysis (PSA), and the proposed method was validated.

PSA is one of the reliability analysis methods, which could assess engineering systems, where safety is critical, based on the occurrence frequency of a component failure The main advantages of PSA are as follows: 1) it is possible to estimate the states of components or systems in quantitative and qualitative manners, and 2) it enables to de-duce not only superficial problems but also latent problems in the system. Therefore, if PSA is applied to assess safety culture, results that are more objective and quantitative can be achieved with reduced man power and time to assess safety culture in a timely manner.

2. Development of Safety Culture Evaluation Method

2.1. Redefinition of the Assessment Items

In order to derive the assessment items of safety culture, a literature survey was per-formed. Reports published from five nuclear and nuclear-related institutes were re-viewed: INSAG-4 report and “safety culture assessment review team (SCART) guide-lines” published by the IAEA, safety culture reports “Principles for a Strong Nuclear Safety Culture” and “Traits of a Healthy Nuclear Safety Culture” published by the INPO, “safety culture policy statement” and “safety culture common language” published by the US.NRC, and NSCA survey process developed by the NEI [5-9]. Each report suggests their own attributes, characteristics, traits and principles of safety culture. However, their coverages and aspects are different among the reports; therefore, assessment items that have the same meanings were united. Next, items suitable for assessing a team, which is the basic work unit in a nuclear plant, were selected and refined. Then, items that have the similar meanings were unified and redefined, and categorized based on the reports. The categories and abbreviations are shown in Table I, and detailed assessment items are listed in Table II. A total of 35 items was selected.

Table I: Abbreviations of Categories

Category	**Abbreviation**
Operation Information Acquisition	IA
Personal Accountability	PA
Respectful Cooperation	RC
Recognition of Nuclear as Unique Technology	NU
Conservative Decision Making	CD
Questioning Attitude	QA
Regular Inspection	RI
Continuous Learning	CL

Table II: Detailed assessment items and their grouping for team safety culture

Assessment Items	**Category**
Active use of trusted resources in the workplace	IA
Understanding not only the work of individuals but also the status of the whole plant	
Confirmation of safety-related deviations in the workplace	
Confirmation of sub-contractors' awareness of changes in resources to improve safety in the workplace	
Accountability to arbitrate, manage, and correct safety issues	PA
Recognition of accountability and authority to improve and maintain safety	
Recognition of individuals' accountability to safety which should not be imputed or damaged in any way	
Recognition and comprehension of safety culture principles	
Leadership taking the lead for safety actions	
Cooperation with users to decide on safety-related improvements	RC
Action without dogmatic decision-making	
Alerting peers of their unsatisfactory accountability	
Trust and respect within peers	
Compliance with designed safety margins	NU
Special attention to work that can affect reactivity	
Special attention to work that can affect radiation confinement	
Prior consideration of safety issues	
Consideration of the professionalism, competences, and experiences of the workers as valuable assets	
Compliance with procedures	CD
Reconsideration of decision-making with external and internal assessment	
Attitude on asking experts for opinions in unexpected situations	
Suspension and reexamination of work having uncertain results	
Understanding the importance of maintaining the safety criteria	
Immediate reporting of a violent event or doubts about safety	QA
Reexamination of a violent event or doubts about safety	
Recognition of the possibility of an unexpected situation occurring	
Leadership not penalizing individuals for suggesting a different opinion	
Continuous self-assessment and independent supervision of tasks	RI
Continuous self-assessment of safety culture	
Maintaining and administrating systems and components so as not to interrupt decision-making	
Sharing and evaluating one's experience or working customs among peers	
Periodic monitoring of the workplace	
Periodic learning and training	CL
Open-minded attitude towards learning	
Leadership training	

2.2. Modeling of Team Safety Culture

The purpose of safety culture assessment is to manage and improve the characteristics and attitudes of individuals and organizations to achieve three goals: reduced occurrence frequency of incidents and accidents by building a safety conscious working environment (SCWE), proper management and mitigation of occurred incidents and accidents, and reexamination and prevention of recurrence of incidents or accidents. If one of these three goals are not achieved, it will be difficult to say that the safety culture is in a desirable state. Figure 1 shows the context of a desirable safety culture. In this context, each assessment item has its corresponding purpose. [10]

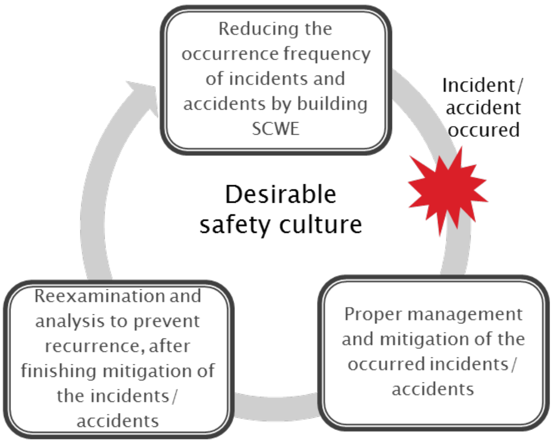

Figure 1. Context of safety culture assessment

Continuous learning and personal accountability are the fundamental attitudes that an operating team should always have. A team should always be ready for the possibility of an incident or accident to occur, and be well trained to maintain a certain level of skill and knowledge to handle and prevent events. Therefore, it is possible to say that continuous learning and personal accountability affect the whole process. Additionally, there is a well-founded basis to support this fundamental attitude from the reports published by the US.NRC. Such as 'Individuals, including supplemental workers, are adequately trained to ensure technical competency and an understanding of standards and work requirements. Individuals master fundamentals to establish a solid foundation for sound decisions and behaviors.'[11], 'Everyone must take personal ownership for his or her actions and decisions for accountability to become a fundamental part of an organization's safety culture.'[12], and 'Personal accountability means that every member of the organization takes ownership for their job and appreciates the role they play in supporting the organization's overall safety mission.'[13]

After an incident or accident has occurred, an operating team should mitigate the event so not to damage the core through human actions. To manage events properly, in-formation processing should be carried out. Information acquisition means to gather all the information on the NPP to monitor the situation. Then, the team should plan actions to mitigate the event by considering the uniqueness of the NPP, such as the reactivity of the NPP or radiation confinement. After planning, the team implements the planned action through a conservative decision-making process. In the context of the safety culture, prevention of the recurrence of an event is also important as the proper mitigation of the event. Regular inspection should be implemented to prevent event recurrence.

A questioning attitude and respectful cooperation are treated as a recovery of other attitudes. By having a questioning attitude, the team can report and reexamine the doubts about safety issues or a violent event at a NPP. A questioning attitude triggers the recovery process. Additionally, respectful cooperation can help when other attitudes are unsatisfied by cooperating each other. INPO has stated in the published reports that the role of a questioning attitude and respectful cooperation is as follows. 'Individuals continuously challenge existing conditions and activities in order to identify discrepancies that might result in error or inappropriate action.'[6], and 'Individuals are encouraged to investigate anomalies and consider possible adverse consequences of actions.'[14] Therefore, a questioning attitude and respectful cooperation are adequate as a recovery. The relationships between a desirable safety culture and each category of assessment items are shown in Figure 2.

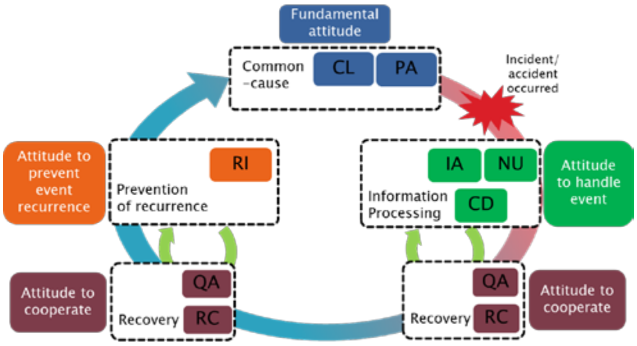

Figure 2 Categories of assessment items in safety culture context

From a PSA point of view, fundamental attitudes such as continuous learning and personal accountability can act as a common-cause failure in team safety culture. Attitude to handle an event and attitude to prevent event recurrence are the mitigation systems of team safety culture, and attitude to cooperate is the recovery probability when attitude to handle an event or attitude to prevent event recurrence failed.

The relationships between assessment items were expressed in success trees instead of fault trees, because safety culture is oriented from success. As mentioned above, the mitigation systems of team safety culture include 'attitude to handle an event' and 'attitude to prevent event recurrence'. In this regards, as top events, 'attitude to handle an event' and 'attitude to prevent event recurrence' are used, and they include common-cause failure and recovery of assessment items.

To increase the creditability of the suggested model, a literature survey and expert opinion were used. Papers that described the relationships between factors of safety culture were reviewed to confirm the suggested relationships. B. Muniz found a correlation between factors in his paper, 'Safety culture: Analysis of the causal relationships between its key dimensions' in safety-critical system. The assessment items, which have the same meaning as his safety culture factors, were identified and compared. [15] It showed meaningful correlation values between the assessment items.

Likewise, a total of 30 out of 70 relationships were identified to have a meaningful relationship. [16-19] For the assessment items that were not reported in the literature, expert opinion was used to verify their relationships. A safety culture assessor, respondent, and researcher who study safety culture were selected as the experts. The opinions of suggested relationships were gathered from the experts and factor-analyzed. Relationships that did not agree with the opinions of the experts were removed while those that did were added. Revisions were done three times, and the current model shown in Figures 3 and 4 are believed to provide a reasonable result for safety culture assessment.

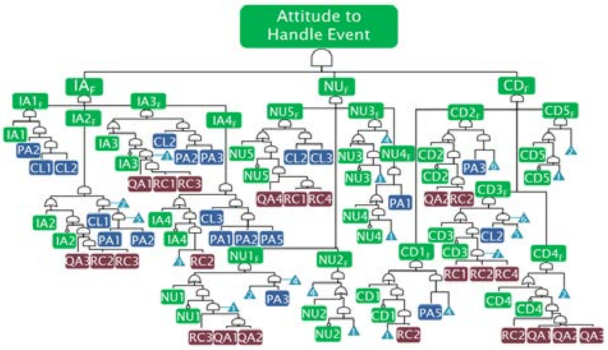

Figure 3. Success tree of ‘attitude to handle event’

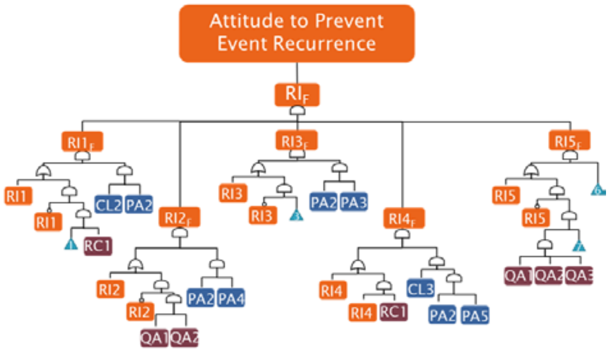

Figure 4. Success tree of ‘attitude to prevent event recurrence’

Then, the state of team safety culture was determined by whether these two mitigation systems failed. The event tree in Figure 5 shows the state of team safety culture, and there are four states: safe success (SS), unsafe success (US), safe failure (SF), and unsafe failure (UF). Safe success in team safety culture indicates that a team succeeded in handling an event and prevented event recurrence. An unsafe success state indicates that a team succeeded in handling an event but failed to implement the proper prevention through follow-up actions. Even if the team fails to handle an event, the team should provide follow-up actions to prevent event recurrence. An unsafe failure state indicates that the team failed to handle an event and failed to put forth effort to prevent event recurrence. Here, the most desirable state of team safety culture is the safe success state.

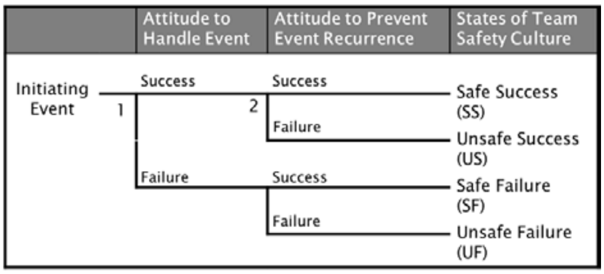

Figure 5. Event tree of team safety culture and its possible states

2.3. Quantification of Team Safety Culture

In section 2.2, a model for team safety culture was introduced. For quantitative assessment of safety culture, the probability of each basic event should be calculated. Then, based on the probability and the relationship among the assessment items, the success probability of the top event will be calculated. The success probability of the top event determines the probability of the team safety culture states, and the proportion of state probabilities are the unique characteristics of a team.

‘Operational definition’ is adopted to give a nominal probability of each assessment item. Operational definition is a generally used method to identify theoretical definitions, in this case assessment items, by specifically observable events or conditions which present the theoretical definition. Operational definition can describe exactly what the variables are and how they are shown within the context. Therefore, we can evaluate team safety culture by observing the operation of a NPP.

By observing the team, assessors can easily determine whether the team is in a normal state or failed state for a certain assessment item as time progresses. Then, the nominal success probability of an assessment items can be calculated as in Equation 1.

$$\text{Nominal Success Prob. of an Assessment Item} = \frac{\text{Total \# of success cases}}{\text{Total \# of all cases}} \tag{1}$$

Additionally, the common-cause failure and the recovery probability of each assessment item should be considered to calculate the final success probability of the assessment items. The probabilities of the top events of the success trees, attitude to handle an event and attitude to prevent event recurrence, can be calculated as follows:

$$\begin{aligned} & p\{\text{Attitudes to Handle Event}\} \\ & = \prod_{i=1}^{3}\prod_{j=1}^{k}[\, p\{\text{Assessment items in CL inducing CCF of } \mathrm{i_j}\ \} \\ & \times p\{\text{Assessment items in PA inducing CCF of } \mathrm{i_j}\} \\ & \times [\, p\{i_j\} + p\{\overline{i_j}\} \cdot p\{\text{Assessment items in QA to recover failure of } \mathrm{i_j}\} \\ & \times p\{\text{Assessment items in QA to recover failure of } \mathrm{i_j}\}]] \end{aligned} \tag{2}$$

, where, i=1 means IA; i=2 means NU; i=3 means CD, and k is the number of assessment items in the category,

$$\begin{aligned} & p\{\text{Attitude to Prevent Event Recurrence}\} \\ & = \prod_{l=1}^{5} [\, p\{\text{Assessment items in CL inducing failure of } i_l\} \\ & \times p\{\text{Assessment items in PA inducing failure of } i_l\} \\ & \times [\, p\{RI_l\} + p\{\overline{RI_l}\} \cdot p\{\text{Assessment items in QA to recover failure of } i_l\} \\ & \times p\{\text{Assessment items in RC to recover failure of } i_l\}]] \end{aligned} \quad (3)$$

Finally, the probability of each state in team safety culture can be calculated as follows.

$$p\{SS\} = [\, p\{IA_F\} \cdot p\{NU_F\} \cdot p\{CD_F\}] \cdot [\, p\{RI_F\}] \quad (4)$$

$$p\{US\} = [\, p\{IA_F\} \cdot p\{NU_F\} \cdot p\{CD_F\}] \cdot [\, p\{\overline{RI}_F\}] \quad (5)$$

$$p\{SF\} = [\, p\{\overline{IA_F \cdot NU_F \cdot CD_F}\}] \cdot [\, p\{RI_F\}] \quad (6)$$

$$p\{UF\} = [\, p\{\overline{IA_F \cdot NU_F \cdot CD_F}\}] \cdot [\, p\{\overline{RI_F}\}] \quad (7)$$

3. Case Studies

To demonstrate the applicability of the suggested method, case studies were con-ducted. Case studies were conducted to confirm three hypotheses as follows:

Hypothesis 1: There is a certain relationship between ‘success’ safety culture states and human performance.

Hypothesis 2: Each team shows a unique ratio of safety success probability to that of unsafe probability, regardless of the scenario.

Hypothesis 3: Cutset analysis of the proposed method will provide not only the root cause but also the latent cause of failure.

3.1. Relationship between team performance and team safety culture

A NPP is operated by teams consisting of several operators. An important aspect of a team is sharing a common goal and performing a task to achieve that goal. In this regards, performance of an operating team could affect the systems of a NPP. Team performance has three main elements: 1) whether a team has the capability to achieve a common goal; 2) whether team members are satisfied with their achievements, and 3) whether team members are willing to improve their abilities by themselves.

Because team performance is directly connected to ability, characteristics, and co-work of a team, the performance of a team is different among the various teams at a NPP. Additionally, indirect or direct external stimulation can easily improve their performance.

Representative team performance evaluation methods are the behavioral observation scale, behaviorally anchored rating scale (BARS), and operation performance assessment sys-tem (OPAS). All the mentioned methods analyze the tasks that an operator should perform, and identify the factors that can affect team performance. The factors that affect team performance can be categorized as environmental, knowledge, skills, strategy, resolving time, and procedure compliancy. Most of the factors for team performance are similar to factors that have a strong influence on team safety culture. For these reasons, many studies have suggested that team performance is significantly related to team safety culture [20- 22].

However, in the strictest sense, team performance is only related to one part of team safety culture, the attitude to handle accidents or incidents. The reason why researchers can-not claim that team safety culture has a positive relationship with team performance is be-cause they only investigated factors for single failures in the safety culture of teams, while in fact, the factors for team safety culture are not single failures. However, while the suggested measure can evaluate the ‘attitude to handle accidents or incidents’ separately, team performance can be used as a case study. Therefore, the proposed method compared the team performance score and the probability of having the ‘attitude to handle accidents or incidents’.

Audio-visual recording data for a loss of coolant accident (LOCA) from a full scope main control room (MCR) simulator of a NPP in Korea were collected and analyzed. OPAS and the suggested safety culture evaluation were conducted independently and compared. The safety culture evaluation process was done as outlined in chapter 2. Because we cannot observe the ‘regular inspection’ and ‘continuous learning’ part of the suggested method, it is assumed as a probability of 1. The relationship between the OPAS score and the probability of a success state in team safety culture is shown in Figure 6.

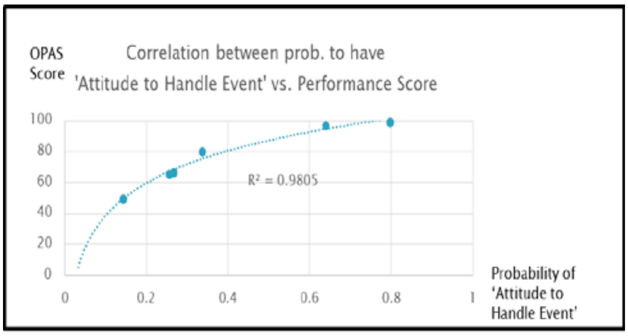

Figure 6. Relationship between probability to have ‘Attitude to handle event’ vs. OPAS score

From case study 1, it can be said that the higher the probability was for a ‘success’ state of the safety culture, the greater the performance score was. Thus, it can be said that there is a quantitative relationship between the ‘success’ state of the safety culture and human performance.

3.2. Team characteristics of team safety culture

To prove hypothesis 2, which is, each team shows a unique ratio of safety success probability to that of unsafe probability, regardless of the scenario, analysis of team safety culture was conducted. Audio-visual recording data of a loss of coolant accident (LOCA), steam generator tube rupture (SGTR), and station blackout (SBO) from a full scope main control room (MCR) simulator of a NPP in Korea were collected and analyzed. Teams 4, 5, and 6 were the targets for the analysis.

There are the probability of a safe success state, the probability of an unsafe success state, the probability of a success state, and the ratio of the probability of a safe success to the probability of an unsafe success state or 4 operating teams. 4 teams had different probabilities of success state, which is relevant to the team performance; however, the ratio was similar between the probability of safe success and the probability of an unsafe success state. The ratio was fixed regardless of the scenario and the team performance within the team; however, it was different from team to team. Figure 7 shows this result graphically.

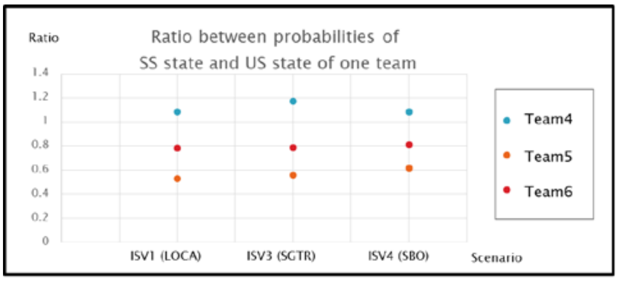

Figure 7. Ratio between probabilities of SS and US state of teams

The fact that it was assumed that the probabilities of the assessment items for regular inspection was 1, this implies that the team had similar probabilities for fundamental attitude and cooperative attitude regardless of the scenarios. Therefore, it is possible to say that fundamental attitude and cooperative attitude can be treated as team characteristics, which do not change by a given situation or performance as an output.

3.3. Cutset analysis of the proposed method

Hypothesis 3 was that cutset analysis of the suggested method will provide not only superficial causes but also latent causes of failure. To prove hypothesis 3, cutset analysis was conducted using audio-visual recording data from a team for a LOCA accident from a full scope MCR simulator. Because the performance of team 4 was in the middle range of, team 4 was selected to be analyzed. A report on team 4 stated that the cause of the performance score was from 'unskilled use of the computerized procedure system (CPS), due to a lack of training with it.' Based on the analysis report, the cutset analysis result was compared. Cutset analysis was done with the AIMS-PSA tool. Because the program provides only fault trees, success trees were converted into fault trees as shown in Figure 8.

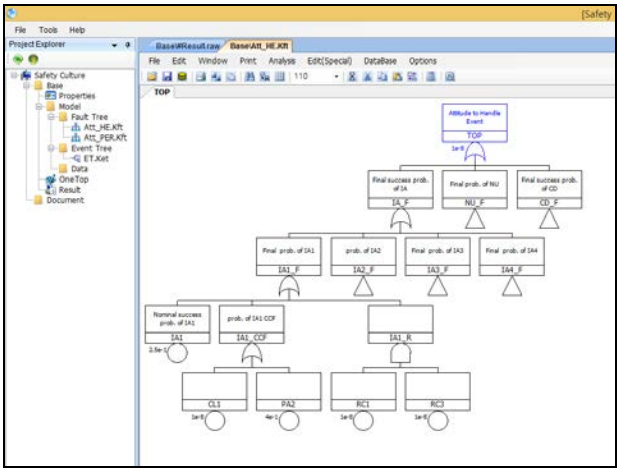
Figure 8. Modeling of team safety culture using AIMS-PSA

From the AIMS-PSA results, the main causes of failure in team safety culture were as follows: 1) A lack of recognition of accountability and authority to improve and maintain safety (PA2); 2) Not suspending and reexamining work which had an uncertain result (CD5); 3) Inactive use of resources in the workplace (IA1), and 4) Non-compliance with procedures (CD2). IA1 and CD2 correspond to the 'Unskilled use of CPS, due to a lack of training with it', however the other two causes from the cutset analysis were not the ones pointed out in the report. PA2 and CD5 were latent causes that the team had but not observable or considered as an important issue. However, cutset analysis of the suggested safety culture evaluation method could determine the latent problems of the team. Therefore, it was possible to say that the cutset analysis of the proposed method will provide not only superficial causes, but also latent causes of failure.

4. Discussion

In Chapter 3, three hypotheses were proven to confirm the applicability and validity of the proposed method. Through the proposed method to evaluate team safety culture, the relationship between team safety culture and team performance was quantitatively determined, which the existing method could not do. Team performance had relevance only with 'attitude to handle an event' in team safety culture. This result was as expected based on previous research which was not as clear.

The team 4, 5 and 6 showed a steady ratio between the probability of 'safe successes' and 'unsafe success' states. That is, the ratio of the probabilities of team safety culture states is a team characteristics, and it is permanent value within a team.

Additionally, the cutset analysis of the proposed method could analyze team safety culture more effectively than that of the performance score or any other safety culture evaluation methods. Especially, the proposed method has strengths in the multiple and concurrent aspects of the analysis; on the other hand, human factor engineering is mainly focused on whether a team follows a procedure because performance scoring system is based on task analysis. By using cut set analysis for the proposed method, latent causes can be determined to help improve team safety culture.

Through the case studies, we not only verified the validity of the proposed method but also showed the strength of the proposed method by proving the three stated hypotheses.

5. Conclusion

In this research, to solve the limitations of existing safety culture assessment methods, the concept of level 1 PSA was applied to propose a new safety culture evaluation meth-od. To compensate for existing shortcomings and to adopt PSA, safety culture assessment items from several organizations were unified and redefined. Then, fault trees and event trees were established from the relationships among the assessment items by making assessment items basic events in PSA. Assessment items were sorted into 4 groups for the purpose of safety culture assessment and based on the characteristics of a team: 1) reducing the frequency of accidents or incidents that occur by building a safety conscious working environment; 2) proper mitigation when accidents or incidents occur; 3) prevention of event recurrence after mitigation, and 4) cooperation with peers, even if a team member fails to have the proper attitude. Group 1 was considered as a common-cause failure, and group 4 came under recovery. Groups 2 and 3 corresponded to the mitigation system of the entire team safety culture. Then, team safety culture states were determined by the state of the mitigation systems. There were four states defined as ‘safe success’, ‘unsafe success’, ‘safe failure’, and ‘unsafe failure. A safe success state means that the team properly managed the occurred event and tried to prevent event recurrence by inspections. An unsafe success state is a state where the team did a proper mitigation, but the team did not make an effort to analyze and find improvements to prevent recurrence. A safe failure state means, even though the team did not properly mitigate events, the team made changes so not to make the same mistakes. An unsafe failure is the most undesirable state in a team safety culture, where the team did not properly mitigate an event and also did not perform follow-up actions to prevent event recurrence. To calculate the probabilities of these states, a guideline giving the probabilities of basic events was provided by the operational definitions.

Case studies were conducted to confirm whether the suggested measures represent reality and the suggested measures are applicable to the real world. Audio-visual recording data from a MCR simulator was analyzed to prove the three stated hypotheses with the following results: 1) there is a certain relationship between the ‘success’ states of safety culture and human performance; 2) each team shows a unique ratio of safety success probability to that of unsafe probability, regardless of the scenario, and 3) cutset analysis of the proposed method provides not only root causes but also latent causes of failure.

The case studies show that the proposed method represents well the structure of team safety culture and also confirms that the proposed measure will be useful, by offering more objective, quantitative results with less calculation time.

REFERENCES

[1] International Atomic Energy Agency (1991). International Nuclear Safety Advisory Group. “Safety Culture”. Safety Series No.75

[2] International Atomic Energy Agency (2014). “Independent Safety Culture Assessment Review Service leaflet”. Nuclear Safety and Security Programme

[3] United States Nuclear Regulatory Commission (2014). “Guidance for Conducting and Independent NRC Safety Culture Assessment”. Inspection Procedure 95003.02

[4] Nuclear Energy Institute (2009). “Overview of the NSCA survey process”, Nuclear Safe-ty Culture Assessment (NSCA). Tab A1. Rev.0

[5] International Atomic Energy Agency (2008). “Safety Culture Assessment Review Team Guidelines”, Service Series No.16

[6] Institute of nuclear power operations (2004). “Principles for a Strong Nuclear Safety Cul-ture”, Building on the Principles for Enhancing Professionalism,

[7] United States Nuclear Regulatory Commission (2011). “Safety Culture Policy Statement” 76 FR 34773

[8] United States Nuclear Regulatory Commission (2014). “Safety Culture Common Lan-guage”. NUREG-2165

[9] Nuclear Energy Institute (2009). “Conduct of the Assessment Including Data Analysis”. Nuclear Safety Culture Assessment (NSCA). Tab B3. Rev.0

[10] M.D. Cooper (2000). “Towards a Model of Safety Culture”. Safety Science. Vol. 36. Pp.111-136.

[11] United States Nuclear Regulatory Commission (2015). Safety culture Trait talk, Issue 8 : Continuous Learning.

[12] United States Nuclear Regulatory Commission (2015). Safety culture Trait talk, Issue 9 : Personal Accountability.

[13] Stephanie Morrow (2014). United States Nuclear Regulatory Commission, Personal Accountability Supports an Organization’s Safety Culture, Stephanie Morrow

[14] Institute of nuclear power operations (2012). “Traits of a Healthy Nuclear Safety Culture”, INPO 12-012

[15] Beatriz Fernandez-Muniz. Et.al (2007). “Safety Culture: Analysis of the causal relationship between its key dimensions. Journal of Safety Research. 38. pp.627-641

[16] Thanwadee Chinda et.al (2007). “Structural equation model of construction safety culture”. Engineering, Construction and Architectural Management”, Vo.18 Iss.2 pp.114-131

[17] Phil Wadick (2010). “Safety culture among subcontractors in the domestic housing construction industry", Structural Survey, Vol. 28 Iss 2 pp. 108-120

[18] Sherif Mohamed, Thanwadee Chinda, (2011). "System dynamics modelling of construction safety culture". Engineering, Construction and Architectural Management. Vol. 18 Iss 3 pp. 266-281
[19] Yildirim Uryan (1998), “Organizational Safety Culture and Individual Safety Behaior: A case study of the turkish national police aviation department”. Ph.D. Thesis. University of Central Florida, Orlando, Florida, 211 pages.
[20] Sharon Clarke (2006). “The Relationship Between Safety Climate and Safety Performance: A Meta-Analytic Review”. Journal of Occupational Health Psychology. 2006, Vol.11 No.4 pp.315-327
[21] Guldenmund, Frank W. (2000). "The nature of safety culture: a review of theory and research." Safety science 34.1. pp. 215-257.
[22] Cox, Sue, and Rhona Flin. (1998). "Safety culture: philosopher's stone or man of straw?." Work & Stress 12.3. pp. 189-201.