Development of Database for Incidents related to Safety Culture using Harmonized Safety Culture Model

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1. Introduction

Safety culture refers to how an organizational culture prioritizes and values safety. Since the safety culture factors consist of a multi-layered organic structure such as employers, managers, and executives, vulnerable factors related to safety culture may differ depending on the organization. Weaknesses in safety culture have proven to contribute significantly to incidents and accidents across different industries, including the nuclear industry [1,2]. This is why it is important for people associated with organizations to understand and adhere to the characteristics of an effective safety culture. To this end, nuclear and nuclear-related organizations have in place the sets of safety culture guidelines. For example, there is a safety culture model developed by Korea Institute of Nuclear Safety (KINS) to inspect the safety culture in Korea [3]. However, the guidelines from various institutions were similar in intent but different in structure. This can create unnecessary complexity and uncertainty in understanding expectations and implementing programs to enhance safety culture.

To address these challenges, International Atomic Energy Agency (IAEA) published the Harmonized safety culture model (HSCM) by discussing existing safety culture frameworks to harmonize different sets of guidelines from institutions including the World Association of Nuclear Operators (WANO), and the Institute of Nuclear Power Operations (INPO) as well as regulatory agencies. This model provides a description of the traits and attributes that are present in organizations with an effective culture for safety [4]. These factors, as representing the values and basic assumptions in organizations, can be used to measure the level of safety culture.

Therefore, this study aims to develop a database that derived safety culture factors using HSCM for incidents occurred during seventeen years (1994 – 2020) due to lack of safety culture according to the Operational Performance Information System for nuclear power plant (OPIS) of the KINS. Thereafter, it is expected that the database developed in this study can be used to evaluate the different' vulnerable factors according to the organizations.

2. Methods and Results

2.1 Development of Database for Human Error-Induced Incidents

The database is derived based on safety culture factors in human-error-induced incidents actors related to safety culture issues using HSCM for 24 incidents that occurred during seventeen years (1994 - 2020) reported in the OPIS of KINS as shown in Table 1. All incidents are events in which the International Nuclear Event Scale (INES) level has been raised due to lack of safety culture, and these are classified by the types of NPPs and the site of NPPs for identification of the different characteristics of design for each type and the organizational environments of executives, managers, and employees for each site for NPPs respectively.

2.2 Harmonized Safety Culture Model of IAEA

The IAEA's newly published HSCM describes the traits and attributes that are observed when a strong culture for safety is present. It is composed of 10 traits and 43 attributes specified to indicate the appearance of an organization with a healthy safety culture, as shown in Table 2. It lists exemplary behaviors such as individual responsibility for safety, questioning attitude, responsibilities for decision-making, and highlights effective communication and a high level of trust as some of the major indicators of a healthy culture for safety. The resulting model closely resembles the existing WANO trait framework [5] and includes the existing IAEA characteristics [6].

Through comparison with the WANO trait framework and IAEA characteristics of a strong safety culture, it is revealed that IR.1 and CL.1 of HSCM are a combination of PA.1 and WP.4, respectively, and a combination of LA.7 and CL.2 of WANO trait framework, and also revealed that CO2, LR3, DM4, WE5 and CL4 of HSCM are attributes that are not present in the WANO trait framework. Among these attributes, CO.2, DM.4, and WE.5 are attributes derived from attributes of IAEA characteristics, and LR3 and CL4 are newly introduced attributes. The other attributes are the same as WANO framework. Table 2 shows the result of the comparison with WANO framework and part of IAEA characteristics.

In order to derive the safety culture factors that were insufficient from the incidents, the causes related to safety culture were first identified. The causes in Table 1 show those identified in the report of the incidents that occurred in May 2019, and causes from other incidents were also identified in the incident report of OPIS. And they were linked to the corresponding ones by comparing the definition or examples of the attributes that compose the HSCM as shown in Table. 1.

Table 1. Database for human-error-induced incidents related safety culture issues

Date	Site	Type	Cause related to safety culture issues
2020-07-19	Hanul U-6	KSNP-1000	No conservative decision-making is made during the test to respond to abnormal situations
2019-05-10	Hanbit U-1	WH-900	Poor operation of meetings before critical operations
2019-01-21	Wolseong U-3	CANDU-6	Control rod manipulation by non-lincese holders
2018-06-11	Wolseong U-3	CANDU-6	Insufficient activities to reflect experience in improvement requirements
2017-03-28	Kori U-4	WH-900	Insufficient follow-up activities for improvement requirements
2016-12-20	Hanul U-5	KSNP-1000	Do not identify the cause of problems at the plant and reflect lessons learned
2016-02-27	Hanbit U-1	WH-900	No measures are taken to prevent recurrence, such as not issuing notice of improvement in operation
2015-09-03	Kori U-4	WH-900	Unsecured shift supervisor among operators and training center faculty members
2014-10-17	Hanbit U-3	CE-1000	Poor operation of safety culture-related conference organizations
2014-10-01	Hanbit U-2	WH-900	Plant evaluation indicators include loss of generations due to unplanned OH extension, which acts as a pressure to comply with OH processes
2014-06-17	Wolseong U-4	CANDU-6	Insufficient preparation for workers' work management for changes in external factors, such as revision of the labor standards law
2014-02-28	Hanbit U-2	WH-900	
2013-04-14	Kori U-4	WH-900	
2013-04-14	Kori U-4	WH-900	
2012-11-26	Hanul U-6	KSNP-1000	
2012-02-09	Kori U-1	WH-600	
2011-06-21	Kori U-2	WH-600	
2010-09-17	Shin Kori U-1	OPR-1000	
2009-09-03	Wolseong U-2	CANDU-6	
2006-05-07	Hanul U-1	Framatom-9	
2005-11-06	Wolseong U-1	CANDU-6	
2003-12-22	Hanbit U-5	KSNP-1000	
1997-01-17	Hanul U-2	Framatom-9	
1994-10-20	Wolseong U-1	CANDU-6	

Harmonized Safety Culture Model		
Attributes		Examples
IR1	Adherence	Individuals understand and accept the importance of standards, processes, procedures, expectations and work instructions
IR2	Ownership	Individuals demonstrate personal commitment to safety in their behaviours and work practices
IR3	Collaboration	Individuals and work groups help each other achieve goals by communicating and coordinating their activities within and across organizational boundaries
QA1	Recognize unique risks	Individuals understand the unique risks associated with nuclear and radiation technology
QA2	Avoid complacency	Individuals recognize and plan for the possibility of mistakes, unforeseen problems and unlikely events, even when past outcomes were successful
QA3	Question uncertainty	Individuals stop when uncertain and seek advice
QA4	Recognize and question assumptions	Individuals question assumptions and are prepared to offer different perspectives when they believe something is not correct.
CO1	Free flow of information	Individuals communicate openly and candidly, both up, down, and across the organization. The flow of information up the organization is considered to be as important as the flow of information down the organization.
CO2	Transparency	Communication with oversight, audit, regulatory organizations and the public is appropriate, professional and accurate.
CO3	Reasons for decisions	Leaders ensure that the reasons for technical and administrative decisions are communicated to the appropriate individuals in a timely manner.
CO4	Expectations	Leaders frequently communicate and reinforce the expectation that safety is emphasized over competing goals.
CO5	Workplace communication	Communication about safety is included in all work activities so that everyone has the information necessary to work safely and effectively
⋮	⋮	⋮
PI1	Identification	A method for collecting issues is implemented. The issues collected are not only major issues but also minor issues as they may become major issues.
PI2	Evaluation	Issues are thoroughly evaluated to determine underlying causes and whether the issue exists in other areas.
PI3	Resolution	Identified issues are corrected as appropriate. The effectiveness of the actions is assessed to ensure issues are adequately addressed.
PI4	Trending	Issues are analysed to identify possible patterns and trends. A broad range of information is evaluated to obtain a holistic view of causes and results.
RC1	Supportive policies are implemented	The organization clearly states and effectively implements a policy that supports an individual's rights and responsibilities to raise safety concerns.
RC2	Confidentiality is possible	The organization implements at least one method for raising and resolving concerns that is confidential and independent of line management influence.
WP1	Work management	There is a systematic approach of selecting, scheduling, coordinating, and completing work activities such that safety is emphasized.
WP2	Safety margins	Work is planned and conducted such that safety margins are preserved.
WP3	Documentation and procedures	Documentation, including procedures, is complete, accurate, accessible, user-friendly, understandable, and up-to-date.

Table 2. Comparison of the HSCM with WANO framework and part of IAEA characteristics

HSCM			WANO framework and part of IAEA characteristics		
Traits	Attributes		Traits	Attributes	
IR Individual Responsibility	IR.1	Adherence	**PA.** Personal Accountability	PA.1	Standards
	IR.2	Ownership		PA.2	Job ownership
	IR.3	Collaboration		PA.3	Teamwork
QA. Questioning Attitude	QA.1	Recognize unique risks	**QA.** Questioning Attitude	QA.1	Nuclear is recognized as special and unique
	QA.2	Avoid complacency		QA.4	Avoid complacency
	QA.3	Question uncertainty		QA.2	Challenge the unknown
	QA.4	Recognize and question assumptions		QA.3	Challenge assumptions
CO. Communication	CO.1	Free flow of information	**CO.** Safety communication	CO.3	Free flow of information
	CO.2	Transparency		B.8. Managements shows a continual effort to strive for openness and good communication throughout the organization	
	CO.3	Reasons for decisions		CO.2	Bases for decisions
	CO.4	Expectations		CO.4	Expectations
	CO.5	Workplace communication		CO.1	Work process communications
LR. Leader Responsibility	LR.1	Strategic alignment	**LA.** Leadership Accountability	LA.4	Strategic commitment to safety
	LR.2	Leader behaviour		LA.8	Leader behaviors
	LR.3	Employee engagement		N/A	
	LR.4	Resources		LA.1	Resources
	LR.5	Field presence		LA.2	Field presence
	LR.6	Rewards and sanctions		LA.3	Incentives, sanctions, and rewards
	LR.7	Change management		LA5	Change management
	LR.8	Authorities, roles, and responsibilities		LA.6	Roles, responsibilities, and authorities
	-	-		LA.7	Constant examination
DM. Decision-Making	DM.1	Systematic approach	**DM.** Decision-Making	DM.1	Consistent process
	DM.2	Conservative approach		DM.2	Conservative Bias
	DM.3	Clear responsibility		DM.3	Accountability

	DM.4	Resilience		N/A	
WE. Work Environment	WE.1	Respect is evident	**WE.** Respectful Work Environment	WE.1	Respect is evident
	WE.2	Opinions are valued		WE.2	Opinions are valued
	WE.3	Trust is cultivated		WE.3	High level of trust
	WE.4	Conflicts are resolved		WE.4	Conflict resolution
	WE.5	Facilities reflect respect		D.9. Housekeeping and material conditions reflect commitment to excellence	
CL. Continuous Learning	CL.1	Constant examination	**CL.** Continuous Learning	CL.2	Self-assessment
	CL.2	Learning from experience		CL.1	Operating experience
	CL.3	Training		CL.4	Training
	CL.4	Leadership development		B.4. Leadership skills are systematically developed	
	CL.5	Benchmarking		CL.3	Benchmarking
PI. Problem Identification and Resolution	PI.1	Identification	**PI.** Problem Identification and Resolution	PI.1	Identification
	PI.2	Evaluation		PI.2	Evaluation
	PI.3	Resolution		PI.3	Resolution
	PI.4	Trending		PI.4	Trending
RC. Raising Concerns	RC.1	Supportive policies are implemented	**RC.** Environment for Raising Concerns	RC.1	SCWE policy
	RC.2	Confidentiality is possible		RC.2	Alternate process for raising concerns
WP. Work Planning	WP.1	Work management	**WP.** Work Processes	WP.1	Work management
	WP.2	Safety margins		WP.2	Design Margins
	WP.3	Documentation and procedures		WP.3	Documentation
	-	-		WP.4	Procedure adherence

2.3 Results

Fig. 1 shows the results of the analysis of 24 incidents that occurred due to lack of safety culture using the HSCM traits and attributes. Based on the attributes, IR.1, IR.2. LR.4, CL.2, and WP.3 are relatively frequently found as factors for lack of safety culture, while QA.1, QA.4, CO.1, LR.3, LR.8, DM.4, WE.1, WE.2, WE.3, WE.4, RC.1, RC.2, and WP.2 are not found. Since QA.1, WE, RC are attributes such as trust, belief inherent to the organization, it is difficult to derive from the incident reports. The other attributes were found to be relatively few.

Fig. 2 shows the results of analysis by type of Korea NPP. The types of Korea NPP include CANDU, Framatome, Westinghouse (WH) -600, WH-900, Combustion Engineering (CE) -1000, OPR-1000, APR-1400. The APR-1400 type was excluded because there were no incidents yet caused by the lack of safety culture. There are differences in results depending on the types of NPP. The CANDU type is mainly caused by lack of LR.4, and the WH-900 type is mainly caused by lack of LR.4 and IR.2. While the WH-600 type is mainly caused by lack of LR.7 and CL.2.

Fig. 3 shows the results of analysis by the site of Korea NPP. The NPP sites currently operating in Korea include Kori, Saewool, Wolseong, Hanbit, and Hanul NPPs. The Saewool NPP was excluded because there have been no incidents yet caused by the lack of safety culture. There are also differences in results depending on the sites of NPP. Wolseong and Hanbit NPPs had similar results due to the lack of LR.4 and CL.2, and Hanul NPP had mainly been caused by the lack of LR.4 and WP.3. While it was confirmed that Kori NPPs are primarily caused by the lack of IR.2 and CL.2

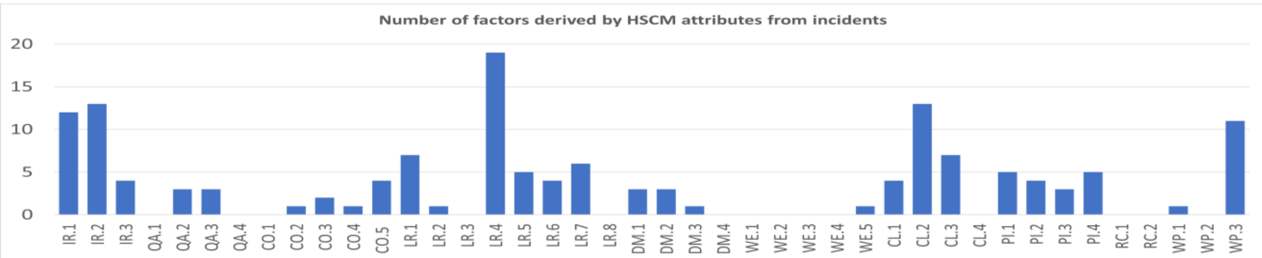

Fig. 1. The number of attributes derived based on HSCM from incidents

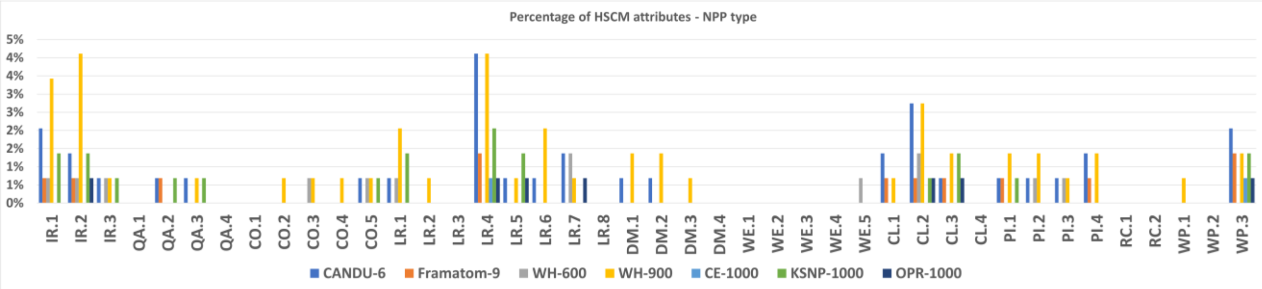

Fig. 2. Percentage of HSCM attributes that affected the incidents for each type of NPP

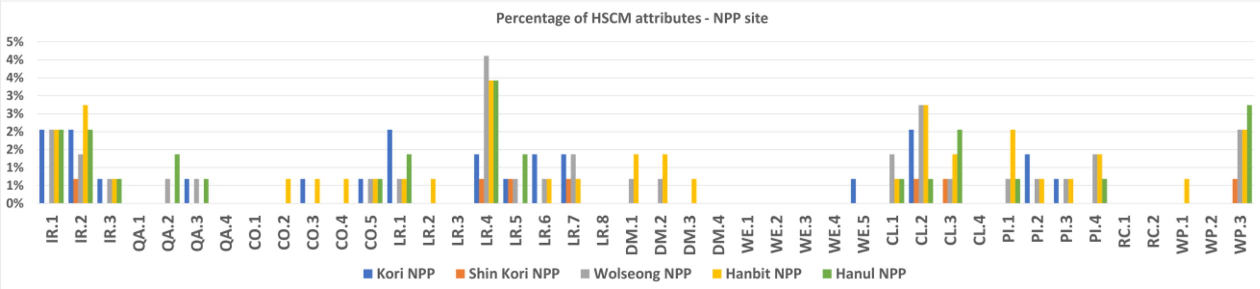

Fig. 3. Percentage of HSCM attributes that affected the incidents for each site of NPP

3. Conclusions

This study constructed a database by analyzing the incidents related to the safety culture issues based on the attributes of HSCM. The results of deriving the HSCM attributes from the incidents indicated that the IR.1, IR.2, LR.4, CL.2 and WP.3 are derived relatively more than other attributes. Moreover, there were differences in the results according to the sites and types of the NPPs. These differences are due to the different characteristics of design for each type of NPPs and an organizational climate of executives/managers/employees for each site of NPPs.

In further study, the database developed in this study will be used to evaluate the root-cause and interconnection between attributes and identify vulnerabilities in safety culture-related incidents.

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