Prerequisites of ideal safety-critical organizations

TAKEUCHI Michiru[1], HIKONO Masaru[2], MATSUI Yuko[3], GOTO Manabu[4], and SAKUDA Hiroshi[5]

1. Institute of Nuclear Safety System, Inc., 64 Sata Mihama-cho Fukui Pref., 919-1205 Japan (currently Institute of Elderly Housing Sciences, 5-5-15 Nishinakajima Yodogawa-ku Osaka, 532-0011 Japan (mtakeuchi@keiyuu-kai.or.jp))
2. Institute of Nuclear Safety System, Inc., 64 Sata Mihama-cho Fukui Pref., 919-1205 Japan (hikono.masaru@inss.co.jp)
3. Institute of Nuclear Safety System, Inc., 64 Sata Mihama-cho Fukui Pref., 919-1205 Japan (matsui@inss.co.jp)
4. Institute of Nuclear Safety System, Inc., 64 Sata Mihama-cho Fukui Pref., 919-1205 Japan (m-gotou@inss.co.jp)
5. Institute of Nuclear Safety System, Inc., 64 Sata Mihama-cho Fukui Pref., 919-1205 Japan (sakuda@inss.co.jp)

Abstract: This study explores the prerequisites of ideal safety-critical organizations, marshalling arguments of 4 areas of organizational research on safety, each of which has overlap: a safety culture, high reliability organizations (HROs), organizational resilience, and leadership especially in safety-critical organizations. The approach taken in this study was to retrieve questionnaire items or items on checklists of the 4 research areas and use them as materials of abduction (as referred to in the KJ method). The results showed that the prerequisites of ideal safety-oriented organizations consist of 9 factors as follows: (1) The organization provides resources and infrastructure to ensure safety. (2) The organization has a sharable vision. (3) Management attaches importance to safety. (4) Employees openly communicate issues and share wide-ranging information with each other. (5) Adjustments and improvements are made as the organization's situation changes. (6) Learning activities from mistakes and failures are performed. (7) Management creates a positive work environment and promotes good relations in the workplace. (8) Workers have good relations in the workplace. (9) Employees have all the necessary requirements to undertake their own functions, and act conservatively.

Keyword: safety-critical organizations; safety culture; high reliability organization; organizational resilience

1 Introduction

In recent years, it has been pointed out that for the prevention of industrial accidents safety management across the whole organization, including corporate management and psychological aspects of the organization is important, in addition to traditional safety measures onsite (*e.g.* improvements of facilities and reinforcement of training). Suganuma *et al.*[1,2] called this a transition from a "job safety approach" to an "organizational safety approach", and as a representative research area of the latter approach they highlighted the study of safety culture. The concept of safety culture originated when the International Nuclear Safety Advisory Group (INSAG) [3] pointed out that the Chernobyl nuclear power plant accident in the former Soviet Union in April 1986 was caused by a lack of safety culture. The term has now become widely known. Also in Japan, the former Nuclear and Industrial Safety Agency (NISA) instituted a guideline for NISA to estimate nuclear operators' activities that would favor the prevention of the deterioration of

their safety culture and safety climate. Every nuclear operator is requested to look to detect any symptom of deterioration of safety culture and safety climate in the course of its daily safety activities, and to aggressively seek to upgrade its safety culture. On the other hand, it is true that there still remain many problems because safety culture is ambiguous in its concept and is hardly scalable. (For example, refer to Wilpert[4] and DeJoy[5])

Although it is popular in Japan to focus on safety culture or safety climate as noted before, there are other research areas that also focus on safety management across the whole organization. Researchers of High Reliability Organizations (HRO) studied concretely what kind of organization can prevent an accident from occurring and evade catastrophic situations (See in the part of Appendix, *1). HRO studies have been promoted by researchers from the University of California, Berkeley since the late 1980s. These studies began from a simple question, *i.e.* "Among two organizations which are apparently similar, one repeats accidents, trouble and misconduct, but the other maintains high safety and

reliability over long periods. Where on earth does this difference occur from?" (Nakanishi[6]).

Nishimoto[7] quotes Roberts[8] who is one of the theoretical founders of the HRO concept, and defines an HRO as "the organization that has a systematical structure that works in situations that have the potential for large-scale risk, but that detects early signs and prevents it from a disaster".

Although the opinion of researchers may vary regarding the characteristics of an HRO, Weick and Sutcliffe[9] cited 5 features of an HRO. These are: (1) Preoccupation with failure, (2) Reluctance to simplify interpretations, (3) Sensitivity to operations, (4) Commitment to resilience, (5) Deference to expertise. Although these are the features which an HRO has in order that neither an accident nor an unexpected event may arise, Nakanishi[6] also pointed out that once such a contingency arises, an HRO will concentrate its power towards restoring the system on the basis of the premise that "there cannot be a perfect system.", that is an HRO makes efforts not to fall further into a serious situation even if it commits a small fault.

Reason[10] has a similar perspective on HRO's in regard to coping with any unexpected situation.
Reason focuses on the human contribution where a system can be well maintained even if it is incomplete in an uncertain and changing society because humans have the ability to adapt, self-adjust and compensate in a timely manner, and he states that a resilient organization is one that has systems with intrinsic resistance to its operational hazards.

On the basis of past activities of Institute of Nuclear Safety System, Inc., (INSS), *i.e.* development and implementation of leadership training methods, development of research methods for identifying organizational safety climate and experience in investigations of organizations, this study started from 2010 examining other related research areas. At that time, nuclear power plants in Japan maintained safe and stable operations. The objective of this study was to search to identify the requisites of ideal safety-critical organizations to improve safety further.
In the course of this study, on March 11, 2011, the Fukushima nuclear power plant accident occurred due to the Great East Japan Earthquake and the ensuing tsunami. The purpose of this study has thereafter increased further in importance and urgency.

By way of background, this study is intended to explore the prerequisites of ideal safety-critical organizations, marshalling arguments of 4 areas of organizational research on safety, each of which has overlap: a safety culture, high reliability organizations (HROs), organizational resilience, and leadership especially in safety-critical organizations. In this study, the concrete questionnaire items and items on checklists used in each area are grouped by reference to the KJ method[11,12]. The study seeks to examine the prerequisites for the ideal model of an organization where high safety is required. The contents of the items in questionnaires and checklists used in each area may be regarded as the ideal model of organizations in each respective area.

The prerequisites for the ideal model of an organization are arranged here. It is reasonable for an actual organization to utilize these prerequisites as a framework to grasp its own status through comparing it to the prerequisites for the ideal model. This framework is also considered to be applicable to analyze an organizational accident and to identify or consider countermeasures.

2 Methods

The KJ method is a technique to deal with qualitative data that was developed by ethnologist and geographer, Jiro Kawakita. Since he published 'Hassoh (Abduction)' in 1967, the KJ method has had a far-reaching impact. The method is briefly described here. Firstly, data is transcribed to a label, with data referring to two or more matters divided into multiple labels. The next step is group formation to combine the labels. To understand the meaning behind the collected labels, a concept formation called 'making name plates' is performed. A name plate that represents the meaning behind the combined labels is made and it is put on the labels. Labels that cannot be combined are kept alone at this stage, and sometimes remain alone at the end of the process. By repeating this procedure, groups are constructed from data. In the KJ method, illustration and narration (literal explanations or oral presentations) follow. The authors of the current work undertook group formation to

combine the labels by reference to the KJ method from January, 2011 to February, in order to gain a greater understanding of the prerequisites of ideal safety-critical organizations, marshalling arguments from the 4 areas of organizational research on safety mentioned. In this study, the total number of original labels is 424. The items used as data for the KJ method are described in the following sections.

2.1 Safety culture

50 questionnaire items about safety climate were used as data for the KJ method and transcribed to labels. They had previously been used by Fukui, Yoshida, and Yoshiyama[13], and thereafter by Fukui and Takagi[14] for the purpose of measuring the safety climate at nuclear power plants .

Miyachi, Murakoshi, Akatsuka, and Suzuki[15] surveyed research related to safety climate, and stated that the concept of the safety culture is diverse and its measurement methods are not established, and it does not differ greatly from the study of safety climate. Therefore questionnaire items for measurement of the safety climate were used here (See in the part of Appendix, *2).

Questionnaire items for the safety climate collected by Fukui, Yoshida and Yoshiyama[13] , as well as by Fukui and Takagi[14] were categorized into 6 factors, that are: "organizational attitude for safety", "workplace safety education", "confidence in knowledge/skills ", "safety conscious behaviors", "attitude of immediate superior", and "morals". In addition to these, from morale investigation items developed by the Japan Institute for Group Dynamics[16] , 4 factors are used: "teamwork", "meeting quality", "communication adequacy" and "mental health".

2.2 High Reliability Organizations (HRO)

The following questionnaire items / diagnosis tables were used as HRO items and were transcribed to labels.

2.2.1 Seventy-six items on the evaluation list to assess your capabilities for assured performance (Weick & Sutcliffe[9])

The utilized items in this study are stated in the 8 worksheets, in particular "a starting point for mindfulness", "vulnerability to mindlessness",

"tendency toward doubt, inquiry, and updating", "preoccupation with failure", "reluctance to simplify", "sensitivity to operations", "commitment to resilience", and "deference to expertise".

2.2.2 Sixty-four actions associated with practice, and 97 questions for checking (B&W Pantex)

B&W Pantex[17] proposed the following 4 practices to develop an HRO, and provided actions associated with the practices and questions for checking. The 4 practices are "manage the system, not the parts", "reduce system variability", "foster a culture of reliability", and "learn and adapt as an organization".

2.2.3 Seventeen items of HRO self assessment for operations superintendents

BP[18] describes items regarding leadership and HRO. Leadership items are described later. As for HRO, BP presents a framework as "HRO self assessment for operations superintendents" which is composed of categories *i.e.* "preoccupation with failure", "deference to expertise", "commitment to resilience", "reluctance to simplify" and "sensitivity to operations" which are similar to those of Weick & Sutcliffe. BP presents evaluation items for each category respectively.

2.3 Resilient organizations

According to the points on resilient organizations shown by Reason[10] , 43 items were utilized as data for this study and transcribed to labels. Reason showed that each of the 3Cs (commitment, cognizance and competence), which are the cultural drivers for resilience, manifested itself in each of the 4Ps (principle, policy, procedures and practice) (See in the part of Appendix, *3) and mapped the 3Cs onto the 4Ps in a 4 x 3 table. He stated, "The indicators in the matrix provide a snapshot of what a resilient organization might look like." Some examples are given below. As for principle and commitment, "Safety is recognized as being everyone's responsibility, not just that of the risk management team." As for policy and commitment, "Safety-related information has direct access to the top." As for procedure and commitment, "The training of junior staff goes beyond the conventional apprenticeship system and procedures are in place to ensure that trainees reach pre-established competency criteria and

receive adequate mentoring and supervision." As for practice and commitment, "Safety-related issues are discussed by all staff whenever the need arises." Some of the items have a health-care flavor, but these are readily generalized to other hazardous domains.

2.4 Leadership in safety-critical organizations

For many years, research on the relationship between organizational culture, organizational climate and leadership has been undertaken. (Lewin, Lippitt, & White[19] , Likert[20] and McGregor[21]) Recent research as well as older research, places leadership as a prerequisite of organizational climate. (Dragoni[22] , Ostroff *et al.* [23]) This study focuses not on general leadership but on the leadership in organizations that require high-level safety.

The following questionnaire items were used as leadership in safety-critical organizations items, and transcribed to the labels.

2.4.1 The fifth level leadership item (43 items)

As mentioned before in relation to HRO, BP wrote about fifth level leadership competences (See in the part of Appendix, *4). Concretely, it defines 6 competences, *i.e.* "operates from intrinsic motivation and inner will", "thinks strategically", "catalyzes change", "thinks and acts systemically", "creates space and empowers others", and "embodies self-management and humility".

2.4.2 A leadership activity scale at nuclear power plants

Misumi *et al.* [24,25] composed a leadership activity scale at nuclear power plants. Concretely, it has 10 items to measure the P function (a function for an achievement of group's target, and solving an issue) and ten items to measure the M function (a function for an intention of maintenance of a group). The 20 items are the objectives of the analysis (See in the part of Appendix, *5).

3 Results and discussion

In this section, firstly the results of the KJ method are stated in detail. Next, out of the results, we describe the characteristics of the 4 research areas: a safety culture, high reliability organizations (HROs), organizational resilience, and leadership in safety-critical organizations.

3.1 Results of the KJ method

Prerequisites of the ideal model were finally converged into 9 categories through 5 stage steps. Here, 30 categories at the fourth stage and 9 categories at the fifth stage (final) are shown in the first and second column of Table 1 respectively, and representative labels are shown in the third column. Hereafter, the fifth category is written in parenthesis [ ], the fourth category is in parenthesis { }, and the original label is in < >.

Firstly, the general predisposition of the fifth stage 9 categories is described. Out of the 9 categories at the fifth stage, category 1 to 3 in Table 1 ([The organization provides resources and infrastructure to ensure safety], [The organization has a sharable vision], [Management attaches importance to safety]) are the requirements on the system of a whole organization or on the common vision, and they are also the requirements specified for the tendency of safety at the managers level. The categories 4 to 6 in Table 1 ([Employees openly communicate issues and share wide-ranging information with each other], [Adjustments and improvements are made as the organization's situation changes], [Learning activities from mistakes and failures are performed]) are more concrete requirements for action. Finally, category 7 to 9 ([Management creates a positive work environment and promotes good relations in the workplace], [Workers have good relations in the workplace], [Employees have all the necessary requirements to undertake their own functions, and act conservatively]) are further general items. It is understandable that the last three items are quite general except for {Employees make conservative, safety-oriented decision and act.} in the [Employees have necessary matters of their own operations].

Table 1　Prerequisites of ideal safety-critical organizations and representative labels

Fifth stage category	Fourth stage category	Examples of original 424 labels
(1) The organization provides resources and infrastructure to ensure safety	The organization provides management resources and infrastructure to ensure the safety When an unexpected event occurs, workers can contact the person of expert and authorization to decide, and access management resources. Management and the organization offer suitable training, tools, and supports in order to teach knowledge required for work. The organization appoints talented people suitable for a duty and entrusts necessary authority. Moreover, it is made clear to everybody. The organization develops, arrange and apply a safety system.	• Provide resources and infrastructure to ensure system remains effective • Maintain focus on preventing system accidents at all costs and at all times (no reduction in focus or resources) • Should problems occur, someone with the authority to act is always accessible and available, especially to people on the front lines. • We have access to necessary resources if unexpected problems occur. • Resources are devoted to training and retraining people on technical systems and equipment. • Clinical supervisors train their charges in the mental as well as technical skills necessary to achieve safe and effective performance. • Do you have an adequate number of managers with the appropriate technical education and/or experience to understand the technical underpinnings of the business? • We consistently involve people with the greatest expertise when evaluating risks or investigating failures.. • Develop and deploy safety system. • Is there a stop work program that is enforced when operational safety is uncertain?
(2) The organization has a sharable vision	The organization copes together with employees when productivity and safety conflict. The organization deliberates about what kind of impact their activity has on outside stakeholders. The organization creates sharable objective and pursue it. The organization watches things from the larger context, a global image, and a long-term viewpoint.	• Are managers willing to openly dialogue with employees about conflicts between production and safety? • Stress importance of staying within established safety system regardless of impact to production. • We spend time identifying how our activities could potentially harm our organization, employees, our customers, other interested parties, and the environment at large. • Patient partnering and openness should be encouraged. • Works with others toward creating and pursuing shared goals. • Sets clear standards for building an enduring great BU and company. • Influences strategic creation and choices. • Does not compromise long-term viability through short-term choices.
(3) Management attaches importance to safety	Managers think much of safety. The organization or administrators pay attention to eliminating any safety problem.	• Supervisors in a power plant usually discuss safety problems. • The organization prioritizes clinical goals over non-clinical demands on health-care staff whenever that is possible. • Supervisors in a power plant usually look around the field site and pay attention to eliminating any safety problem. • How committed is management to ensuring the safety system provides safety? To what extent are safety analysis reports for each hazardous operation: Readable?

Table 1   (continued)

Fifth stage category	Fourth stage category	Examples of original 424 labels
(4) Employees openly communicate issues and share wide-ranging information with each other	Employees and leaders give feedback daily. Employees usually gather together and discuss in order to solve a problem or to see how matters stand. Workers have questions and come forward on safety matters. Information is commonly shared daily and also at an unexpected occasion. Vertical and lateral communication in the organization is good.	• Gives straight constructive feedback in a timely fashion. • People are always looking for feedback about things that aren't going right. • People are encouraged to express different views of the world. • During an average day, people come into enough contact with each other to build a clear picture of the current situation. • Reporting system policies – separation of data collection from disciplinary procedures • Be vigilant for common operational pitfalls. • When something unexpected happens, the information is not widely shared. (adverse item) • Does your organization communicate human error prevention techniques through pre-work briefs, peer checking, and proper documentation of work? • Your immediate superior has good communication with his/her own immediate master. • Your immediate superior has good communication with other sections.
(5) Adjustments and improvements are made as the organization's situation changes	The organization effectively makes an operational program and controls it. The organization corresponds to a change flexibly and adaptively. Whenever a change occurs to greater or lesser degrees, the organization acknowledges and reflects it to procedures, equipments, and training programs. Continuous and effective adjustments and improvements on processes, systems and culture are made.	• Our operating and control of work procedures are of high quality and appropriate granularity. • Protocols backed by training in the recognition and recovery of errors. • Forecasting and predicting the future is not that important here. • Does your organization implement and institutionalize operating experience as evidenced by changes to procedures, equipment, and training programs. • Ensures that new ideas are integrated with existing formal and informal policies and processes. • Are assessments of sufficient depth? That is, are they comprehensive, objective, and self-critical? • What percentages of processes are modified based on leaning from feedback (vs. the total number of processes implemented in a specified time period)?
(6) Learning activities from mistakes and failures are performed	The organization learns from mistakes and faults. When a problem occurs, the organization tries to grasp the situation and causes of the problem thoroughly.	• We regard close calls and near misses as a kind of failure that reveals potential danger rather than as evidence of our success and ability to avoid disaster. • We focus more on our failures than our successes. • When things don't go as expected, people rarely try to uncover what they assumed in the first place. (adverse item) • People around here are quick to deny problems when they show up. (adverse item)

Table 1   (continued)

Fifth stage category	Fourth stage category	Examples of original 424 labels
(7) Management creates a positive work environment and promotes good relations in the workplace	Superiors support and coach their subordinates. Superiors trust and respect their subordinates. Managers create a good environment by conducting themselves in a consistent, reliable, optimistic, self-confident manner. Managers communicate openly.	• Mobilizes collective action. • Acts as catalyst, coach and champion to move from good to great. • A superior entrusts his/her subordinates' own business to them. • A superior respects the instruction by his/her low rank administrator. • Exhibits passion for achievement for its own sake. • Managers walk the talk and transparently demonstrate espoused cultural values. • Communication: listens openly and speaks purposefully. • Disciplinary system policies – peers involved in disciplinary proceedings.
(8) Workers have good relations in the workplace	Workers have good relations in the workplace.	• The colleagues at your workplace have good teamwork. • It is difficult to ask others for help. (adverse item)
(9) Employees have the necessary requirements to undertake their own functions, and act conservatively.	Mental health of employees is stable. Employees have necessary knowledge, skills, experience, self-confidence, and sense of responsibility. Employees decide and act conservatively.	• Generally speaking, an employee sometimes feels unreasonable pressure from his/her superior. (adverse item) • You think about your future life, and feel somehow anxious. (adverse item) • People have more than enough training and experience for the kind of work they have to do. • People at all levels of our organization value quality. • Do employees use simulated work scenarios (or hands-on training) to evaluate their ability to make conservative decisions? • Colleagues in the work place make sure that the safety is secured before entering into the work.

3.2 Characteristics of the 4 research areas: high reliability organizations, leadership, resilient organizations, and safety culture

Group organization of the specific question items and check list items which are used in each area was carried out by reference to the KJ method to this point, and the prerequisites for the ideal model of an organization where high-level safety is required have been examined. In this section, a reverse analysis is undertaken, to examine how explicitly each area highlights the prerequisites for the shown ideal model. Specifically, with respect to 30 categories at the fourth step and 9 categories at the fifth step, if a label is involved in an area, a check mark "○" is put in this area, and if no label is involved in this area, a mark "×" is put in. The result is summarized in Table 2. In the table, "HRO" stands for high reliability organizations, "LS" stands for leadership required in a safety critical organization, "Res" stands for a resilient organizations and "SC" stands for safety culture. For example, the labels which compose the first line category {The organization provides management resources and infrastructure to ensure safety} in Table 2, are those of HRO and Res, and no label of LS nor of SC corresponds to this category.

Table 2 Prerequisites of ideal safety-critical organizations and the characteristics of the 4 research areas

Fifth stage category	Fourth stage category (summary)	HRO	LS	Res	SC
(1) The organization provides resources and infrastructure to ensure safety	The organization provides management resources and infrastructure to ensure the safety.	○	×	○	×
	When an unexpected event occurs, workers can contact a person of expertise and authority to decide, and access management resources.	○	×	×	×
	Management and the organization offer suitable training, tools, and support in order to teach knowledge required for work.	○	○	○	×
	The organization appoints talented people suitable for a duty and entrusts necessary authority. Moreover, it is made clear to everybody.	○	×	○	○
	The organization develops, arrange and apply a safety system.	○	×	×	×
(2) The organization has a sharable vision	The organization copes together with employees when productivity and safety conflict.	○	×	×	×
	The organization deliberates about what kind of impact their activity has on outside stakeholders.	○	×	○	○
	The organization creates sharable objective and pursue it.	×	○	×	×
	The organization watches things from the larger context, a global image, and a long-term viewpoint.	○	○	○	○
(3) Management attaches importance to safety	Managers think much of safety.	○	×	○	○
	The organization or administrators pay attention to eliminating any safety problem.	○	○	○	○
(4) Employees openly communicate issues and share wide-ranging information with each other	Employees and leaders give feedback daily.	○	○	○	×
	Employees usually gather together and discuss in order to solve a problem or to see how matters stand.	○	○	×	○
	Workers have questions and come forward on safety matters.	○	○	○	○
	Information is commonly shared daily and also at an unexpected occasion.	○	×	○	○
	Vertical and lateral communication in the organization is good.	○	×	○	○
(5) Adjustments and improvements are made as the organization's situation changes	The organization effectively makes an operation program and controls it.	○	×	○	×
	The organization corresponds to a change flexibly and adaptively.	○	○	×	×
	Whenever a change occurs to greater or lesser degrees, the organization acknowledges and reflects it to procedures, equipments, and training programs.	○	○	×	○
	Continuous and effective adjustments and improvements on processes, systems and culture are made.	○	○	○	×
(6) Learning activities from mistakes and failures are performed	The organization learns from mistakes and faults.	○	○	○	×
	When a problem occurs, the organization tries to grasp the situation and causes of the problem thoroughly.	○	○	○	×
(7) Management creates a positive work environment and promotes good relations in the workplace	Superiors support and coach their subordinates.	×	○	×	×
	Superiors trust and respect their subordinates.	×	○	○	○
	Managers create a good environment by conducting themselves in a consistent, reliable, optimistic, self-confident manner.	○	○	×	○
	Managers communicate openly.	×	○	○	×

Table 2   (continued)

Fifth stage category	Fourth stage category	HRO	LS	Res	SC
(8) Workers have good relations in the workplace	Workers have good relations in the workplace.	○	○	×	○
(9) Employees have the necessary requirements to undertake their own functions, and act conservatively.	Mental health of employees is stable.	○	○	×	○
	Employees have necessary knowledge, skills, experiences, self-confidence, and sense of responsibility.	○	○	○	○
	Employees decide and act conservatively.	○	○	○	○

HRO with largest number (267 labels) covers 26 categories out of 30 categories at fourth stage. The four categories that HRO does not cover are: {The organization creates sharable objectives and pursue them}, {Superiors support and coach their subordinates}, {Superiors trust and respect their subordinates}, {Managers communicate openly}. It is supposed that HRO contains few categories specifically for managerial functions except the category, {The organization creates sharable objectives and pursue them}. On the other hand, there are three categories that only HRO covers: {When an unexpected event occurs, workers can contact the person of expertise and authority to decide, and access management resources}, {The organization develops, arranges and applies a safety system}, {The organization copes together with employees when productivity and safety conflict}. The item {The organization develops, arranges and applies a safety system} is fairly abstract, and has a relation to the structural base, therefore it may be treated as an exception, but the other 2 categories represent respectively an emphasis on a response to an unexpected event, and a posture to challenge the issue of productivity and safety with employees, and they are thought to be characteristic for HRO.

LS covers 20 out of the 30 categories. It covers general content of (7), (8) and (9), and only one category out of five categories in (1) [The organization provides resources and infrastructure to ensure the safety]. Categories that LS exclusively covers are {The organization creates sharable objectives and pursues them} and {Superiors support

and coach their subordinates}. It is thought to be characteristic that targets are definitely taken up.

Res covers 19 categories out of 30 categories. The feature is that it does not cover (8){Workers have good relations in the workplace}. There is no category that the Res only covers.

Lastly, SC covers 16 categories out of 30 categories. It does not take up (6){Learning activities from mistakes and failures are performed}, and only one category out of 5 categories of (1){The organization provides resources and infrastructure to ensure the safety} is covered. There is no category that the SC only covers (See in the part of Appendix, *6).

As stated above, each area has its specific emphasis, but on the other hand, some categories are common to every area. Out of the fourth stage categories, the following five categories are common to all of HRO, Res, LS and SC: {The organization watches things from the larger context, a global image, and a long-term viewpoint}, {The organization or administrators pay attention to eliminating any safety problem}, {Workers have questions and come forward on safety matters}, {Employees have necessary knowledge, skills, experience, self-confidence, and sense of responsibility}, and {Employees decide and act conservatively}.

4 Concluding remarks

In this paper, by reference to the KJ Method, it is shown that prerequisites for the ideal model of an organization that requires high-level safety were arranged as follows:

(1) The organization provides resources and infrastructure to ensure safety.

(2) The organization has a sharable vision.

(3) Management attaches importance to safety.

(4) Employees openly communicate issues and share wide-ranging information with each other.

(5) Adjustments and improvements are made as the organization's situation changes.

(6) Learning activities from mistakes and failures are performed.

(7) Management creates a positive work environment and promotes good relations in the workplace.

(8) Workers have good relations in the workplace.

(9) Employees have all the necessary requirements to undertake their own functions, and act conservatively

As shown in the previous section, main emphases (characteristics) and common points of each area come into view from the questionnaire items and check lists they apply. All thirty categories have not been embraced into a more comprehensive area, and though each area has common points with each other, the difference of emphasis has become clear.

As a conclusion, concerning the ideal model, the next 3 points for the tasks ahead should be noted. For the first point, 9 prerequisites for the ideal model of an organization that requires high-level safety were arranged. Moreover, the study of mutual relationship between these 9 prerequisites still needs to be developed. If a relation diagram can be drawn about the relationship or independency between 9 prerequisites, it is thought that an understanding of an ideal model will deepen.

For the second point, although the ideal model of the organization that requires high-level safety was developed from 4 areas of organizational research on safety each of which has overlap: a safety culture, high reliability organizations (HROs), organizational resilience, and leadership in safety-critical organizations, it is necessary to check whether the 9 prerequisites for the ideal model are sufficient or not from the viewpoints of other areas or concepts. For example, this study could not cover the arguments of "resilience engineering" by Hollnagel *et al.*[26,27].

From that point, it is needed to reconsider the ideal model of the organization.

For the third point, although the ideal model of the organization that requires high-level safety was shown in this paper, it will become important hereafter to apply it to an actual organization and to determine the gap between the ideal and reality. In particular, an examination about which of the prerequisites is not taken up in an actual organization, that is, where the gap between the reality and the ideal is large, as well as why this occurs, is thought to be necessary.

In addition, as described in the introduction, this study was intended to provide an overview of the organizational research area, *i.e.*, safety culture, high reliability organizations, high resilience systems, and leadership in safety-critical organizations, which has been the authors' research theme since before the Fukushima nuclear accident. It is anticipated that the results will be utilized as a framework in making a detailed, broad analysis of the organizational factors at play in the Fukushima accident. It is thought that by using the prerequisites of the ideal model, activities to extract organizational variables in the Fukushima accident will be necessary going forward.

Appendix: Footnote of the term in the text

*1: Ueno[28] has taken up the HRO concept as what showed very specifically and definitely the state of the safety culture of an organization.

*2: However, a difference may be pointed out. For example, according to Mearns & Flin[29], the safety culture shows a fundamental sense of values, a norm, a premise, and assumption, and belongs to the culture of the society to some extent. The safety climate is visible figures of the safety culture, and in other words, it is regarded as a certain condition in a specific moment (Cox & Flin[30]). Akatsuka[31] has indicated that, when we evaluate the state of an organization towards safety, the necessity to distinguish the difference among both is minor. However, he also stated that it should be examined separately as to whether both should be made almost the same in cases such as intervention for organizational improvements including education.

*3: The 4 Ps is a framework provided by Degani & Wiener[32], experts in a U.S. human factor research area. It classifies various sides of organization management activities.

*4: For the fifth level leadership, BP[18] mentioned Collins[33], Goleman, Boyatzis, and McKee[34], in its bibliography. Collins summarized the fifth level leadership and explained it as the person with fifth level leadership can maintain the greatness of a company by the combination of contradictory characters *i.e.* the will as a businessperson and the humility as an individual. Goleman *et al.* defined the competency of EQ leadership as these four of self awareness, self-management, social awareness, relationship management)".

*5: Misumi *et al.* developed the scale of leadership action for maintenance assistant manager, operation shift manager, on-site leader of cooperating contractor, and maintenance on-site leader respectively. This time, the scale of maintenance manager was used.

*6: Among the items of the safety culture, there is an item [In your workplace, experiences of avoidance of an accident by a hair's breadth are talked about with each other]. This time, it is included in the category (4) [Employees openly communicate issues and share wide-ranging information with each other]. In the category (6) [Learning activities from mistakes and failures are performed], the very positive item beyond only information sharing is contained. This draws out lessons from a failure seeing it as one end of a bigger system problem.

References

[1] SUGANUMA, T.: Evaluating safety culture and proposing safety countermeasures through a two-step survey, 2007, The Journal of Sagami Women's University, 2007, 71: 95-114. (in Japanese).

[2] SUGANUMA, T., HOSODA, S., INOUE, S., SHI, G., OKUMURA, T., YOMURA, T.: A trial of case analysis based on the organizational accident model, The journal of science of labour, 2006, 82: 76-94. (in Japanese).

[3] International Nuclear Safety Advisory Group (INSAG). Safety culture, a report by the international nuclear safety advisory group. Technical Report 75-INSAG-4, IAEA, 1991.

[4] WILPERT, B.: The relevance of safety culture for nuclear power operations. In B. Wilpert, N. Itoigawa(Eds.), Safety culture in nuclear power operations. New York: Taylor & Francis, 2001: 5-18.

[5] DEJOY, D.M.: Behavior change versus culture change: Divergent approaches to managing workplace safety, Safety Science, 2005, 43(2): 105-129.

[6] NAKANISHI, A.: High reliability organization, Tokyo: Productivity Publication, Japan Productivity Center, 2007. (in Japanese).

[7] NISHIMOTO, N.: Issues on High Reliability Organization (HRO) Studies, 2006, Japan Computer Emergency Response Team Coordination Center, <http://www.jpcert.or.jp/research/> (June 6, 2011) (in Japanese).

[8] ROBERTS, K.H.: Some characteristics of one type of high reliability organization, Organization Science, 1990, 1: 160-176.

[9] WEICK, K.E., SUTCLIFFE, K.M.: Managing the unexpected: Assuring high performance in an age of complexity, San Francisco: Jossey-Bass, 2001.

[10] REASON, J.: The human contribution: Unsafe acts, accidents and heroic recoveries, Farnham, England; Burlington, Vt.: Ashgate, 2008.

[11] KAWAKITA, J.: Abduction, Tokyo: Chuokoron-sha Inc, 1967. (in Japanese).

[12] KAWAKITA, J.: The second series of abduction, Tokyo: Chuokoron-sha Inc, 1970. (in Japanese).

[13] FUKUI, H., YOSHIDA, M., YOSHIYAMA, N.: A Study on Safety Climate at Nuclear Power Plants, INSS JOURNAL, 2001, 8: 2-14. (in Japanese).

[14] FUKUI, H., TAKAGI, M.: Safety Climate at Nuclear Power Plants, Proceedings of 2006 Annual Meeting of the Atomic Energy Society of Japan, Sapporo, Japan, Sep.27-29, 2006, 657, Hokkaido University 2006. (in Japanese).

[15] MIYACHI, Y., MURAKOSHI, A., AKATSUKA, H., SUZUKI, A.: Development of evaluation method of safety climate in work site, RTRI report, 2009, 23(9): 23-28. (in Japanese).

[16] MISUMI, J. The behavioral science of leadership: An interdisciplinary Japanese research program. Ann Arbor, MI: University of Michigan Press, 1985

[17] B&W PANTEX: High reliability operations: A practical guide to avoid system accident, Amarillo: B&W Pantex, 2008.

[18] BP. Refining and Pipelines Leadership Fieldbook, 2006

[19] LEWIN, K., LIPPITT, R., WHITE, R.K.: Patterns of aggressive behavior in experimentally created social climates, Journal of Social Psychology, 1939, 10: 271-299.

[20] LIKERT, R.: The human organization, New York: McGraw-Hill, 1967.

[21] MCGREGOR, D.: The human side of enterprise, New York: McGraw-Hill, 1960.

[22] DRAGONI, L.: Understanding the emergence of state goal-orientation in organizational work groups: The role

of leadership and multilevel climate perceptions, Journal of Applied Psychology, 2005, 90: 1084-1095.

[23] OSTROFF, C., KINICHI, A.J., TAMKINS, M.: Organizational culture and climate. In W.C. Borman, D.R. Ilgen, R.J. Klimoski (Eds.), Handbook of psychology: Vol.12. Industrial and organizational psychology. New York: Wiley, 2003: 565-594.

[24] MISUMI, J., YAMADA, A., SHINOHARA, S., SATO, S., SEKI, F., SHINOHARA, H., HASHIGUCHI, K., YOSHIDA, M., YOSHIYAMA, N., SAKURAI, Y., HANAFUSA, H., MISUMI, E., KINJOU, A., KUBO, T., MORI, K., KIDO, N.: Construction of scales to measure leadership behavior at nuclear power plants(1), INSS JOURNAL, 1994a, 1: 8-31. (in Japanese).

[25] MISUMI, J., YAMADA, A., SHINOHARA, S., SATO, S., SEKI, F., SHINOHARA, H., HASHIGUCHI, K., YOSHIDA, M., YOSHIYAMA, N., SAKURAI, Y., HANAFUSA, H., MISUMI, E., KINJOU, A., KUBO, T., MORI, K., KIDO, N.: Construction of scales to measure leadership behavior at nuclear power plans(2), INSS JOURNAL, 1994b, 1: 32-52. (in Japanese).

[26] HOLLNAGEL, E., WOODS, D. D., LEVESON, N.: Resilience Engineering: Concepts and Precepts, Ashgate, 2006.

[27] HOLLNAGEL, E., PARIES, J., WOODS, D. D., WREATHALL, J.: Resilience Engineering in Practice: A Guidebook, Ashgate, 2010.

[28] UENO, A.: Measurement of safety culture of organizations and the concept of high reliability organization (HRO), Journal of Safety Studies and Education, 2009, 2: 53-59.

(in Japanese).

[29] MEARNS, K., FLIN, R.: Assessing the state of organizational safety: culture or climate, Current Psychology, 1999, 18(1): 5-17.

[30] COX, S., FLIN, R.: Safety culture: Philosopher's stone or man of straw, Work and Stress, 1998, 12(3): 189-201.

[31] AKATSUKA, H.: Safety culture and safety climate in an organizational safety approach: on the difference of both, Bulletin of Japan Society for the Study of Vocational and Technical Education, 2009, 39(2): 31-38. (in Japanese).

[32] DEGANI, A., WIENER, E.L.: Philosophy, policies, procedures, and practices: The four "P"s of flight deck operation. In N. Johnston., N. McDonald., R. Fuller(Eds.), Aviation Psychology in Practice. Aldershot: Avebury Technical, 1994:44-67.

[33] COLLINS, J.: Good to Great: Why some companies make the leap…and others don't, New York: Haper Business, 2001.

[34] GOLEMAN, D., BOYATZIS, R., MCKEE, A.: Primal Leadership: the hidden driver of great performance, Harvard Business Review, 2001, 79(11): 42-51.