Development of Starting Principles and a Culpability Logic Suggested for more Effective Analysis on Violations in Nuclear Events

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1. INTRODUCTION

Human error has been the biggest uncertainty in safety of nuclear system. It has been dramatically compromised by technological improvements to human factors, especially human interfaces. However, the recent changes of new technologies and social developments have led to greater and more sensitive concerns to the safety. As a result, there is a controversial issue in which a personal responsibility is prioritized by the person related, often considering human errors that occur at a very low frequency as violations. Therefore, violations have been highlighted in many incidents in advance. As safety requirements are strengthened and rules are scrutinized, it becomes natural that controversy over responsibility of peoples in safety issues is inevitable, and sensitivity to violations is increasing day by day. This paper is part of a basic study to supplement the regulatory direction for human error by securing technical understanding and more effective countermeasures against violations.

2. PREVIOUS STUDIES ON VIOLATIONS

The technical approach to violation errors is not simple in situations where the scope of human error officials and types of violations are rapidly expanded and interests are sharply divided. Unlike human error centered on mistakes, violations are excluded from technical discussions at all because they are beyond the freedom of responsibility and value neutrality. However, the possibility of more technical access to violations would be a task that cannot be ignored in a realistic situation where the level of impact and scope of violations has become serious.

In cognitive psychology, violations were viewed as intentional errors, so in order to prevent violations, human internal intentions (or motivational initiatives) must be addressed, which were traditionally considered out of technical domain (Reason 1992). Prior studies of violation errors either address most legislation or administrative aspects, or emerge as a comprehensive safety culture discussion (Hudson 1989, Lee 2015, 2018 etc.).

Recent research on violations (Kang 2015, Han et al. 2016, Lee et al.2016) shows that violations have different types of personality, as well as external factors that may affect or technically intervene and control violations.

First, fact-finding is also important in approaching human error, but the ergonomic end goal is problem solving, and effectiveness throughout the entire process comes first. Second, the view that applies to violations is important. It is not difficult to find room for intervention in violation errors if the burden of responsibility can be resolved in the follow-up analysis of human error cases. However, it is not easy to corroborate how (or is it appropriate/reasonable to see) violations because they were specifically included and acted upon before the liability issue, and often become controversial, mixed with the liability issue. Finally, there is a need for principles and detailed processing logic that can fundamentally check the discussion of liability for violations.

Previous studies propose trial and error and solutions (or countermeasures) in the follow-up investigation and proactive analysis of events containing violation errors by applying the concept of human error 1.0~3.0 through experience in human error events/incidents. Violation error seems to be largely due to their unique characteristics, which have not been adequately addressed in general human error studies and are not practically effective information. In that human error research is ultimately aimed at effective counter-measures, including prevention of errors, it is a countermeasure-focused technical approach that focuses on the possibility of capturing and managing external elements that can be controlled before or after each type rather than capturing the internal mechanism of violations. We intend to contribute to establishing the direction of technical resolution efforts for violation errors in the future by presenting relative characteristic items of violation errors and challenges to address them more realistically and effectively.

New kinds of efforts for the different level of safety are also required in the nuclear power sector due to these technological developments and changes. Traditional efforts for safety can be divided into pre- and post-measures, and retrospective analysis of events that have already occurred during traditional follow-up measures has been emphasized as a key to the safety in practice [4]. The results of follow-up countermeasures, such as retrospective analysis, must be closely linked to prior/proactive actions in the pre-measure [8, 9]. A retrospective analysis is to derive useful information for proactive action from safety-related events.

The most uncertain part of retrospective analysis is frequently, however, related to human errors. This is because human error is neither determined nor visible to the extent and the causality of many influencing factors. Therefore, very few designs have been proven to be sufficiently prepared for the possibility of human error.

A traditional way to prepare for human errors is to reduce the problems of causal factors by continuous feedback of the analysis results of the correct cause of the error in post-analysis. Thus, in retrospective analysis of events, the approach to human errors is key to determining the usefulness and effectiveness of the event investigations and their results.

3. STARTING PRINCIPLES FOR VIOLATION INVESTIGATION

There is a possibility that many human errors can be judged to be violations in advance. However, when it is mentioned as a violation error, it is likely to be treated as if it is not approaching the possibility of technical supplementation. A carefully adjusted approach would be required for human error investigation analysis considering violation-type error. The notion of *Human Error 3.0* can provide a foundation to enhance the current approaches to go beyond the causal analysis to countermeasure-centered analysis. A key objective of a prudent approach is to ultimately obtain more effective countermeasures. This means that new efforts are needed to overcome the limitations of traditionally transitioning to discussions related to responsibility and punishment. A complementary step was proposed for violation (2020 Lee)

Various new types of violations are raised from the human error studies [3,5,6,14]. Sometimes test-purpose and asked/induced violations matter as *after-event* issue. Mannerism, negligence, avoidance, [11] and *Organized Irresponsibility* [10] are also reported as important violations. They may go beyond the routine/permitted, optimized/convenience, temporal/exceptional violations.

A study describes a new categorization of violations to give a more details on the types and causes of them. However it may be beneficial that the causal analysis go just behind the countermeasures selectable. A reciprocal approach to causes and countermeasures is proposed.

When a new human error 3.0 perspective is introduced, the following fundamental principles apply in the investigation of nuclear events: First of all, all events can be independently re-analyzed in terms of human error. This should be distinguished from a judicial and blaming perspective, which is independent of the technical perspective of a particular area and, in particular, views human error as a responsible cause. (Therefore, applying the multi-perspective and multi-layered scheme proposed by 2020 Lee)

The pre-requisite of human error analysis: The human error perspective on specific events is a separate and independent view to others. As with other technical perspectives, it is based on separate expertise such as human factors engineering ergonomics. In particular, the ergonomic view of human error does not regard functional failure of related personnel as the cause of the problem, unlike the judicial or administrative accountability perspective. Pre-conceptions on the possibility that human error may have served as the cause of the incident should be excluded.

Since human error 3.0 places the importance of countermeasures higher than the cause, the level of causal analysis where responsibility is automatically incurred is carefully limited to the minimum possible and allowable. In general, the concept highlighted in human error 2.0 is to investigate and analyze human engineering improvement elements with the aim of capturing them. Human error 3.0 believes that no particular independent component may exist that may have defects and can be improved further. Nevertheless, various negative consequences can occur, so countermeasures are to find a way to prevent the occurrence of a negative ending. In particular, the investigation of events with the possibility of human errors and violations in mind should include the following Starting fundamental principles in addition to the general perspective required during human error event investigation:

- *principle of no-intention and goodness*
- *principle of objective evidence by controllable element*
- *principle of independence of measures to causes*
- *principle of practicality over causality*
- *principle of responsibility limit and proportionality*

3.1 Principle of No-Intention and Good Faith:

The fundamental assumption is the goodness of the workers (or persons involved) to the detailed functions and roles of the relevant events in the investigative analysis of the events. The employee assumes that he/she has done his/her best at that point on the expected functions and assigned roles. It is assumed that there is no ill-intention at the starting point of the analysis. (This is the same concept as the principle of presumption of innocence) Therefore, sabotages initiated from malicious attack intentions are not subject to this analysis and are treated separately (security-related) through separate check logic for the intent of the parties in detailed analysis, if necessary.

3.2 Principle of Controllable Evidence:

In order to identify the factors that caused human error, the relevant influencing factors are checked, and a comprehensive list of the root (or background) causes is utilized. At this time, the possibility of control of the candidate and the final item of the causal element must be verified. If the actor's own controllability is clear or insufficient, evidence shall be adopted by other parties (or factors) with controllability.

3.3 Principle of Independence of Measure to Cause

The cause and countermeasure of the incident are independent. The elimination of causes may be one of the significant candidates for countermeasures, but is not the only or best countermeasure. Measures may be independent of the cause and may be developed in a variety of ways through creative proposals. In particular, information of regret that can be captured independently of the cause is an important starting point for countermeasures.

3.4 Principle of Practicality over Causality

Measures should be practical and chosen in two dimensions. It is a relative review of the resources and efforts required to implement the measures and the results of implementation of the measures. This means a process of frequent cost-effectiveness analysis in engineering decision making, but it is a decision for safety and should not be based on simple efficiency.

3.5 Principle of Responsibility Limit/Proportionality

In order to be judged as a violation of the relevant person, the person shall undergo an inspection logic on the violation requirements. However, even if it is found to be a violation, it cannot exceed the limit of ergonomic capabilities as well as the size of its effective authority. Even if the party agrees to its assigned responsibilities, as recently raised in the issue of *Organized Irresponsibility*, the legitimate liability associated with the breach shall not exceed the scope of capabilities and authority. Where the parties are jointly responsible, they shall be established in proportion to the size of the authority and capability in effect.

4. A LOGIC FOR CULPABILITY OF VIOLATIONS

Categorization itself may give benefits to figure out not only for capturing the causes of violations but also for devising the countermeasures to them. Violations in human error investigations gives rise the concerns of responsibility understood with a repent, and can be described as a pass over the rules given and criteria required. Frequent analyses have focused to the responsibility, and applied to blaming rather than coping with them. It frequently blames to sharp-end people just involved in the event. A substitution test logic ([15] revised from [1,5] Reason & Govaarts in HERA-JANUS) may help to discriminate the ‘honest error’ for the culpability of violations. A scrutinized test logic is proposed for determine the culpability of violations with double-fold aspects:

- *Liable Validity of culpability*
- *Practical Effectiveness of culpability*

The objectivity may be vague and strongly dependent on the judicial investigations rather than any causal and technical one. When detailed works on violations are required to their culpability, further categorization and substitution test of violations can be applied by incorporating the criteria of intention, perception, and management [15]. However, countermeasures should be prioritized to causes if we want to cope with human error rather than just blame the responsible people [16].

Countermeasure can be devised by virtue of available technical resources and selected through perspectives including traditional cost-benefit analysis and other decisions. Three-layered approach consisting functional, behavioral, and culpability layers is proposed to specify the rationality of countermeasures in addition to causes during investigations. Culpability is tested after function assignments and weighted separately to its worth to countermeasures. It can work for human credibility in security and insider threats that may slightly differ from the traditional approach to human errors.

5. CONCLUSIONS

In this paper, Investigation of nuclear incident including human error by applying the concept of Human Error 3.0 was suggested with some of the basic principles. Human error and a violation with the proposed principles are applicable to highly reliable system, such as the field of nuclear safety features of the proposed human error that is in line with the 3.0 based on the point of view. High confidence in the area of (accident and failure) Analysis of the case a proposal to implement more effectively. The proposed approach and principles are regulations relating to human error in the field of basic policy of nuclear power, reflecting the safety of nuclear power operators can be used as a basis for activities.

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