Development of a Test for Determining Involvement of Violation in Human Error Events and Practical Countermeasure

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1. Introduction

In the event of a negative event in a nuclear system, the activities of the workers involved are generally considered "human error" once. However, if a serious loss or difficulty in recovering occurs as a result of an event, discussion of responsibility begins, and those directly related to negative outcomes can be punished for violations based on relevant legal standards. However, as Heinrich emphasized earlier, distinguishing between 'mistakes' and 'violations' based on the severity of the ending in an event is neither appropriate nor reasonable in terms of probability theory nor cognitive aspects. Nevertheless, it is controversial for some in society to view the person involved in the accident as a violation and strengthen direct regulations on violations. There are concerns about the consequences of breaking down the climate of prioritizing technological approaches to human errors that have been steadily built. This is a jump on safety-sensitive social climate due to the lack of systematic judgment standards and procedures that strictly distinguish human errors from violations. The purpose of this study is to develop an objective and systematic procedure for evaluating whether the activities of workers related to failures or accidents should be classified as violations rather than human errors. It was compared using various approaches and analysis methods for determining violations. No objective method was found to determine whether the violation was intentional or negligent. As an alternative, this study developed a criterion for determining and classifying violations based on the process and characteristics in which violations occur according to the cognitive stage. The perspective of human error 3.0 was applied to prioritize possible measures. The proposed model can also be applied to teams of multiple workers working together. The developed procedure was applied to the re-analysis of industrial accidents and nuclear power plant cases to compare and verify their practicality.

2. A Brief review on violation researches

2.1 Human Error and Violation

Since W. Heinrich mentioned that the direct causes of accidents are insecurity behavior and insecurity conditions, human insecurity behavior has been considered an important axis of preventing accidents [1]. Moreover, after Reason's study [2], it is common that unstable behavior is largely classified as 'human error' and 'violation'. As a result, when an accident occurs, it is not possible to confirm whether the person is intentionally harmed, and disclosing the act can cause controversy socially and organically, so most of the anxiety behavior, which is the cause of the accident, is considered and analyzed as a temporary 'human error'. However, the reality is that if the damage caused by the accident is too large to be ignored, or if it becomes a social issue and has to be held accountable, it is punished in the name of "violation" according to related laws or standards.

As is well known, there may be an active and voluntary approach to controlling workers' unsafe behavior, i.e., a passive approach by regulation and control, while there may be an active approach by inducing safety motivation. Discussing 'violations' in accident prevention is the latter approach. If an actor intentionally "violates" the safety norm, the violation includes the actor's intention, so it is desirable to improve the factors that affected the formation of the actor's intention to violate in order to prevent the corresponding "violation". However, while improving the physical environment may be technically possible, improving the psychological environment is not as easy. Therefore, many safety experts agree that it is not effective to control unstable behavior, including violations of workers through regulation, and that controlling it as punishment only increases side effects and is not desirable [3, 4].

For that reason, when introducing regulatory provisions to control violations of human error, close review of violations and objective standards should be premised, and proactive supervision should be strengthened, not post-regulation. Nevertheless, in recent years, some in society have moved to prevent accidents by strengthening punishment or regulations. However, the damage caused by accidents is accidental, as Heinrich said earlier, and is understood in modern science as a stochastic variable. It is not reasonable in terms of cognitive science to distinguish between 'human error' or 'violation' based on the severity of the damage. Nevertheless, discussions on whether the same behavior is "human error" or "violation" continue because there are no objective procedures or standards to distinguish between the two types of unsafe behavior. This study was conducted to develop systematic and objective procedures and standards that can objectively determine whether a person's behavior was 'human error' or 'violation' in the event of an accident while discovering factors affecting 'human error' and 'violation'.

2.2 Types of Violations

Studies and approaches to violations were first developed by the Human Factors in Reliability Group (HFRG) in the United Kingdom, and the results were published in collaboration with the Health and Safety Executive [5]. This attempt was to find organizational factors that promote violations, and to find management policies to eliminate and reduce those factors. As an individual study, Mason's Study [6], he argued that violation of rules and procedures is an important contributor to many accidents, accounting for about 70% of all accidents, depending on the industry. As is well known, violations are concepts corresponding to 'human errors' such as slip, lap, and mistake, and are classified as violations such as routine violations and exceptional violations [2]. This concept is also reflected in HFACS developed by Wiegmann and Shappell [7]. Later, the U.S. State Department classified human errors and violations based on human cognition, judgment, decision-making, and action

processes, and in particular, violations were classified as situational violations, daily violations, and intentional violations based on risk assessment [8]. In addition, English and Branaghan classified the types of violations as 1) malicious violations, 2) improved violations, and 3) optimizing violations [9].

2.3 Process and criteria for determination of violations

Meanwhile, Klein analyzed the decision-making process from the perception to behavior of the crisis situation, and summarized the process [10]. When encountering an abnormal situation, humans first recall whether they have experienced similar experiences in the past through situational recognition, seek the most effective behavior based on their behavioral memory, and at this time, select or reject the behavior through mental simulation. J. Reason's early study [11] is often mentioned when reviewing violations, and it was argued that it was possible to determine whether the worker intentionally violated based on nine questions. Later, J. Reason, along with his colleagues, presented criteria for classifying rule-related behavior into 10 categories for effective behavior guidance, and the criteria 4 questions [12].

- Is the procedure to be followed appropriate for the situation?
- Have the procedures been followed?
- Did the action provide psychological rewards?
- Were the results of improvisation successful if there were no procedures to follow? In addition, Johnson attempted to explain the process of expressing violations and groupthink based on the cognitive process[13].

In summary, in order to determine whether an act was a 'violation', it is necessary to determine whether the intention of the actor was reflected in the process of forming the act. However, few studies have been found on violations in the country. Although studies in the field of traffic safety psychology are sometimes found, due to the nature of driving, all data other than the driver's own dictation are recorded videos, and if errors during driving do not lead to accidents, it is not sufficient as evidence for violations.

There are studies reported in the nuclear power field such as Kang et.al. [14], but there is a limitation in that it is difficult to use it to derive violation prevention measures only to list influencing factors based on case studies. In addition, Oh's [15] study, which attempted to present countermeasures based on accident statistics of railway engineers, includes cases reported as violations, but it is not appropriate to judge the development of violations or violations of safety regulations based on interviews with manufacturers.

3. Development of procedures and countermeasures for determining violations

Since Reason's studies 2, 12) were approached from a psychological perspective, the violation judgment procedure began with the existence of the violation intention. However, since this approach is not appropriate for general managers in industrial sites with insufficient psychological knowledge and experience, this study sought an approach that could be judged from the perspective of general safety managers.

3.1 Procedures for determining a violation intended

In order to determine the violation, the actor's intention to act must be confirmed, but in reality, it is difficult to confirm whether it is intended afterwards, so it is inevitable to infer the reverse from the illegality of the outcome of the act. In order to check whether an individual violates, it is inevitable to analyze the cognitive process of each actor, so Fig. 1 is used for this. According to this, in order to determine whether a violation is violated, it is desirable to simplify the information processing process into 'detection-cognitive-situation-decision-action plan-action', and in particular, it is necessary to analyze each according to possibility of violation intention intervention at action plan stage.

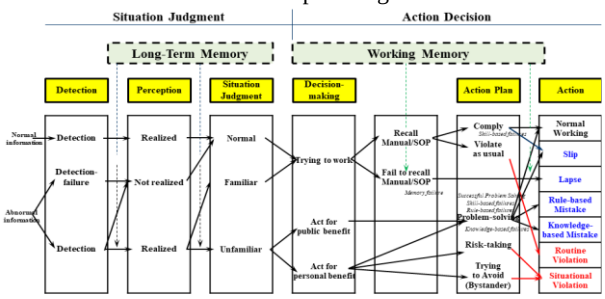

Fig.1. Manifestation information processing of unsafe act.

3.2 Determination of violations and measures to prevent

It is common to judge whether a violation occurs at an industrial site after experiencing an accident. Therefore, since it starts from judging whether there is an objective abnormal situation, it is based on the above cognitive model, but the following procedure was judged to be more realistic in terms of safety management.

1) Condition 1: Normal situation

Assuming that there is a standard operating procedure (SOP) that should be performed normally in that situation, the following questions should be reviewed in turn, on the premise of the existence and training of the procedure.

- *Have you been trained on past procedures*? If there is no prior education, it is an accident caused by management factors, and it cannot be regarded as a personal violation.
- *Has the procedure been recalled or recognized?* Recall is a psychological term that refers to recalling the content with one's own will, and recognition refers to recalling the content among the examples presented [18]. If you cannot remember the pre-trained content, it is a human error and corresponds to a lapse. If remembered but not observed, review the intent of the breach in the following questions.
- *Are the procedures intended to be followed*? It is a violation if there is no intention to comply. Even if it is reported that there was no violation of the actor, the intention to comply can be determined through a subsequent review of the probability of violation [17].

If there was no intention of violating the procedure, it would be a simple human error, but the cause would be situational appraisal or collective norms [19]. If it is due to personal emotion, it is reasonable to judge it as situational violation and personal violation. However, if it is an act conscious of group norm, not according to emotion, it is reasonable to view it as an organizational violation as a routine violation. If it is not an emotion or an act conscious of collective norms, it is classified as an individual's intentional act as a daily violation.

The reason for this distinction is that most of the existing measures to prevent recurrence after an event or accident were education or training. In the case of slip and knowledge-based mistake, some of the system functions or structures can be changed or responded by training or education. In the case of lapse, it is possible to respond only by means that can help memory regeneration.

However, in the case of violations, even if it is a routine violation that seems to be the same in appearance, the countermeasures must be changed depending on whether or not it was an act conscious of collective norms. In other words, if it was due to the emotional response of the situation, training on situational awareness or exchange of situational information should be preceded. However, if it was an act conscious of the collective norms of the organization, it should be recognized as a problem of safety culture, not a problem of personal violations, but a problem of the entire organization. On the other hand, regardless of organizational norms, if it was a personal violation, it should be regarded as a daily violation, and safety motivation should be considered first as a countermeasure. However, personal sanctions or regulations may be considered only in the case of malicious personal violations.

2) Condition 2: Detection Failure

Even when there are abnormal signs but the operator and the official do not detect them, questions such as situation 1 are sequentially applied. Even in this case, if it is not intended to comply with the relevant procedure, it is a violation of human error, and it is necessary to review situational appraisal or collective norms as a cause.

3) Condition 3: Perception Failure

Even if abnormal signs are detected, but workers and officials are not aware of them, questions such as situation 1 are applied one after another. Even in this case, if it is not intended to comply with the relevant procedure, it is a violation of human error, and it is necessary to review situational appraisal or collective norms as a cause.

4) Condition 4: When abnormal detected and recognized

In this case, it depends on whether the current situation is the situation specified in the procedure or not. In the case of the situation specified in the procedure, it is generally not different from the progress in the normal situation.

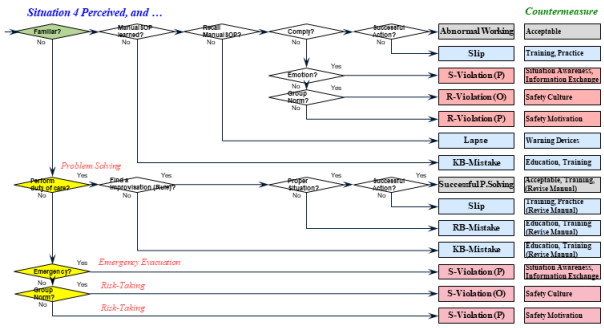

Fig.2. Categorization of unsafe act into human error/violation

However, in the case of abnormal situations not specified in the procedure, the following questions are usually added as to whether an effort has been made to avoid the crisis [20].

- *Is duty of care fulfilled*? The duty of care serves as a criterion for determining whether a hedging action was performed in a crisis. If you have fulfilled your duty of care, it cannot be regarded as a violation, and it is reasonable to judge it as a human error that occurred during an attempt to solve a problem. However, if you have not fulfilled your duty of care, it means that he/she did not take evasive action even after recognizing the situation, and intentionally attempted to perform risk-taking, so he/she is subject to judgment on whether he/she violated.
- Was it an emergency situation not specified in the procedure? If it was an emergency, it should be recognized as a situational violation.
- Are you conscious of collective norms? If collective norms have affected, it is a situational violation, but it should be judged as an organizational violation, not a personal violation. Only if not, it can be judged as a violation of personal punishment.

4. Regulatory Manageability to violations

4.1 Determination of regulatory targets

When reviewing the above process, the following questions are sequentially required to define the situation.

- Were there any abnormal signs?
- Have abnormal signs been detected?
- Are the detected anomalies recognized?
- Were the perceived anomalies specified in the procedure?

In addition, the following questions must be raised one after another to determine whether a situation is defined and whether it is a violation.

- Have you been trained on past procedures?
- Is the procedure described above (recall or re-recognition)?
- Are the procedures intended to be followed?

Regarding the above questions, it is reasonable to judge and respond to the violation only when 1) there is an educated fact, and 2) the relevant procedure is recalled, but 3) the intention to violate the procedure is confirmed. However, even in that case, it is necessary to review the consciousness of situational emotions or collective norms. As a result, it is not reasonable to conclude that the violation type human error is entirely a personal type violation, and it is judged that organizational violations and personal type violations can be distinguished only when judgments are based on clear classification criteria. Moreover, when selecting the subject of disciplinary action or regulation, it should be limited to the case where risk-taking behavior is performed, even though it is clearly recognized that its behavior is not appropriate in a given situation. In other words, it means that the gravity of the damage caused by the violation should not be the background for determining whether it is a violation.

4.2 Measures and regulations to prevent recurrence

Just Culture refers to a systematic mindset that assumes that accidents are caused by system elements rather than by individual deviations, and attempts to find and improve problems in the system. This concept by Reason has been inherited in several studies. For example, according to ICAO (2018), the importance of substitution tests is emphasized to review the question, "*Would you have done the same thing even if other workers worked in that situation?*" [21].

If a positive answer is obtained to this question, the situation should be recognized as an accident by an organization, not a personal deviation. For the same reason, Hudson et al. suggested that, as shown in Fig. 9, incentives are needed to turn a violation into a safe behavior, but since voluntary participation is the most effective, personal coaching or counseling should be preceded, and disciplinary or regulatory should be followed after oral warnings and written warnings[22] The procedures used in Korea are also based on this model, but it is regrettable that they are showing interest in disciplinary action or regulation, which is the last step, while neglecting prior measures.

Regulations can be largely divided into two categories: input standard or specification standard and performance standard [23]. Here, the input standard refers to a standard that does not require a separate interpretation of the regulated person by clearly presenting what measures are needed, and the calculation standard refers to improvement performance through business performance. At this time, it is common to leave the specific method of achieving the criteria to the choice of the regulated person. However, it is virtually impossible to develop input standards that can be applied to all situations, and it is difficult to expand input standards in that the more input standards are mass-produced, the more regulatory they rely on, while voluntary efforts and personal responsibility are neglected. Therefore, it is necessary to induce voluntary efforts. It is common for the concept of so-called Duty of Care to be introduced. In other words, it is to induce voluntary responsibility recognition and participation because regulations for all situations cannot be made perfectly. Ordinary sanctions may include various means ranging from administrative sanctions to judicial sanctions, including criminal punishment. However, it should aim to achieve the organization's goals, namely safe and efficient production. Therefore, various incentives to secure participation of target institutions after regulation, such as provision of necessary information and social reputation, even when enforcing regulations for workplaces

It is common to include a wide range of tools, such as informal controls, taxation, risk assessment, risk management systems, industry standards, independent inspection and verification agencies, and a mix of policies. Likewise, in the case of personal violations, as the characteristics, uncertainties, and complexity of various tasks increase, it is difficult to secure regulatory compliance with traditional sanctions, so it is necessary to analyze the case so that various sanctions can be reviewed.

Even at this time, the management plan for all disciplinary measures is not appropriate. Accident recurrence measures or improvement plans should be developed differentially according to the type and characteristics of individual anxiety behavior. As suggested in several previous studies, disciplinary action or regulation is not an effective behavior change method, and the most effective method is safety motivation, which is commonly and consistently concluded [5,24,25]. Therefore, disciplinary action or regulation should be reviewed as a last resort, and there should be no way to discourage workers from working by means of disciplinary action or punishment. This is because the factors that have the greatest influence on the unsafe behavior are workers' climate [1] and eventually the organization's safety culture [12].

4.3 Analysis of Violation-type Industrial Accident Cases

Based on the above logic, this study attempted an accident analysis on cases of violations that occurred when a number of workers, such as nuclear power plants and chemical plants, worked as a team. The analysis targets were two accidents in the industrial field related to chemical accidents, two accidents in the nuclear field, and a total of four accidents. The Haddon matrix was used to analyze the accident, while Lee and others referred to estimating the potential of performance shaping factors (PSF's) in the system. As a result of the analysis, several officials were involved in each accident, and it was generally the unstable behavior of the worker that directly affected the accident, but the trigger was a violation of the procedure in the work plan. In addition, the cause of the unstable behavior was the lack of awareness of the importance of the procedure, and management and organizational factors such as lack of safety awareness or lack of management and supervision were pointed out as prior factors. In addition, in the case of tasks that must be followed by procedures, the problem of the absence of warning devices or warning signs, which are the last means of providing dangerous information to workers, was pointed out.

However, regardless of direct factors, it was also identified as a leading factor that the job designer failed to consider the worker's violation-type human error in the system design stage. In other words, functions that have a significant impact on system operation should have taken a systematic approach, such as adopting a Fool-Proof design when designing the system, but it could not be denied that it created an accident-causing environment.

In conclusion, considering the above points, it is inevitable to create an environment or system in which workers' violations are inevitable and to blame individuals for human error in such circumstances. In order to properly understand the violation behavior of workers, efforts to find and improve structural and organizational causes with a possible violation environment, as well as behavioral and scientific efforts to find the cause of the violation intention and expression of each worker. In addition, manuals such as laws, safety rules, standard work procedures, technical control limits, and standard work procedures that are subject to violation cannot be complete, so there should be a review in terms of behavioral science.

5. Conclusions and Discussions

The purpose of discussing whether a worker violates is to prevent unsafe behavior or situation from recurring. Many safety experts agree that controlling workers' violations through regulation is not effective, and controlling them as enforcement and punishment only raise side effects undesirable and uncertain [22,23]. Violation has the intention of the offender. Therefore, in order to fundamentally prevent violation instability behavior that reflects personal intentions, factors that have influenced the formation of the actor's intention to violate should be improved first. At this time, it should be fully understood in advance by stakeholders that it is technically possible to improve the physical environment, but it is not easy to improve the psychological environment.

This study describes a test to establish an objective standard for judging the unsafe behavior of workers causing accidents as intentional violations [27]. Questions were sequentially required to define the worker's current situation. Additional questions should be raised in order to determine whether the situation was violated after being defined.

This paper compared to previous studies is to distinguish the types of human errors, and the countermeasures vary accordingly. Many previous studies have commonly pointed out that disciplinary action or enforcing regulation should be placed at the bottom even when taking measures in response to these series of questions. New paradigm such as *Human Error 3.0* and resilience will be beneficial to find more effective and practical countermeasures to human errors and violations [28]. In conclusion when introducing regulatory provisions to control worker violations, it was judged that close review and objective standards for violations should be premised, and system function improvement or proactive supervision should be prioritized, not post-regulation such as disciplinary or punishment.

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REFERENCES

[1] H. W. Heinrich, D. P. Etersen and N. Roos, "Industrial Accident Prevention", 5th ed., McGraw-Hill Book Company, New York, 1980.
[2] J. Reason, "Human Error", Cambridge University Press, 1990.
[3] T. Krause, J. H. Hidley and S. J. Hodson, "The Behavior-Based Safety Process", Van Nostrand Reinhold, New York, 1990.
[4] D. K. Denton, "Safety Management: Improving Performance", McGraw-Hill Book Company, New York, 1982.
[5] Human Factors in Reliability Group (HFRG), Improving Compliance with Safety Procedures reducing Industrial Violations, HSE, 1995.
[6] S. Mason, Procedural Violations-Causes, Costs, and Cures, in "Human Factors in Safety Critical Systems" edited by F. Redmill and K. J. Rajan, pp. 287-318, Oxford, England, Butterworth-Heinemann, 1997.
[7] D. A. Wiegmann and S. A. Shappell, "Human Error Analysis of Commercial Aviation Accidents Using the Human Factors Analysis and Classification System (HFACS)", United States, Office of Aviation Medicine, 2001.
[8] Department of Defense, "Human Factors Analysis and Classification System - A Mishap Investigation and Data Analysis Tool", No. 16, Dept. of Defense, US, 2005.
[9] D. English and R. J. Branaghan, An Empirically Derived Taxonomy of Pilot Violation Behavior, Safety Science, Vol. 50, No. 2, pp. 199-209, 2012.
[10] G. Klein and V. M. Chase, "Sources of Power: How People Make Decisions", Cambridge, Massachusetts: MIT Press, 1999.
[11] J. Reason, "Managing the Risks of Organizational Accidents", Ashgate, 1997.
[12] J. Reason, D. Parker and R. Lawton, Organizational Controls and Safety: The Varieties of Rule-related Behaviour, Journal of Occupational and Organizational Psychology, Vol. 71, No. 4, pp. 289- 304, 1998.
[13] C. Johnson, "A Handbook of Incident and Accident Reporting", Glasgow Univ. Press, 2003.
[14] B. R. Kang, S. H. Han, D. Y. Jeong and Y. H. Lee, Conceptual Models of Violation Error in a Nuclear Power Plant, J. Korean Soc. Saf., Vol. 31, No. 1, pp. 126-131, 2016.
[15] J. K. Oh, J. T. Kim, Y. W. Kim and S. G. Kim, Analysis of The Causes of Human Error Occurrence of The KTX Pilot and Deduction of Improvement Directions, Conference of the Korean Society for Railway, Vol. 10, pp. 1586-1592, 2015.
[16] I. G. Hong and J. B. Baek, A Qualitative Study on Safety Rule Violation Motives at Manufacturing Plants, J. Korean Soc. Saf., Vol. 31, No. 2, pp. 133-142, 2016.
[17] H. K. Lim, "Reanalysis of Fatal Industrial Accident Cases from the Viewpoint of Violation Type Human Errors" (Report Number: NSTAR-20NS41-135), Korea Atomic Energy Research Institute, 2020.
[18] K. Pawlik and M. R. Rosenzweig, "International Handbook of Psychology", Sage Publications, London,2000.
[19] S. H. Han, "Development of Supportive Functions for Preventing Violation Errors" (KAERI/CM-2330/2016), Korea Atomic Energy Research Institute, 2017.
[20] B. O. Alli, "Fundamental Principles of Occupational Health and Safety", 2nd ed., ILO, Geneva, 2008.
[21] APRAST/12-WP/11, "Fostering Just Culture in Operators and Service Providers", ICAO, 2018.
[22] P. Hudson, M. Vuijk, R. Bryden, D. Biela and C. Cowley, Meeting Expectations: A New Model for a Just and Fair
Culture, SPE Inter/ Conf. on Health, Safe and Env. in Oil and Gas Exploration and Production, Society of Petroleum Engineers, Nice, France, 2008.
[23] N. Gunningham and R. Johnstone, "Regulating Workplace Safety: Systems and Sanctions", Oxford University Press, 1999.
[24] N. Maier, "Psychology in Industry", Houghton Mifflin, Boston, 1965.
[25] D. Petersen, "Safety Management: A Human Approach", 3rd ed., ASSE, 2001.
[26] K. S. Lee, H. K. Lim, S. R. Chang, K. W. Rhie and Y. C. Kim, Development of a Comprehensive Model for Human Error Prevention in Industrial Fields, J. of Ergonomics Society of Korea, Vol. 27, No. 1, pp. 37-43, 2008.
[27] H. K. Lim, et al, Development of an Objective Judgement Procedure for Determining Involvement of Violation-Type Unsafe Acts caused Industrial Accidents, J. of Korean Soc. Safety, Vol. 37, No. 2, pp. 35-42, April 2022
[28] Y.H. Lee, How to Analyze the Human Error Events in Nuclear for Coping with Violations More Effectively by Human Error 3.0 Concept, Proc. Joint Int. Sym. of STSS/ISOFIC/ISSNP, 2021