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A Preliminary Study on the Culpability of Violation Errors in Nuclear Events and their Investigations

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1. BACKGROUND

Previous recent several studies on human errors in nuclear reveal a demanding research topic on violation type errors [2018/2019/2020 Lee]. Violation errors should be considered additionally during various human factors safety assessments such as HRA(human reliability analysis) and V&V(verification and validations) of design and severe accident management strategies as well as within human error event investigations, PSR (periodic safety review), Stress Test, and their back-fittings.

This high-reliability era is demanding a different level of safety. The expected technical advances resulted into the super-connected-ness and rather more vulnerability (2018 Lee). Nuclear itself has revealed very unique and hard-to-overcome characteristics for system safety. (2015, 2016 Lee)

- large and complex system into a social disaster
- non-injury system loss with low self-motives
- latent hazards by multiple barriers and DID
- rare data for learning from errors
- tightly-coupled but delayed risk
- out-of-loop by the partial automation/integration

People is expecting the safety as a feeling of rather wholistic security without uncertainty rather than simple completed functional performances. However the human errors including violations still remain the basic uncertainty to nuclear safety. Violation especially might be a typical types of erroneous performance to be happened in "*unprepared*" *scenarios,* "*unknown-unknown*" *risk,* and *fundamental surprise* in *unexpected situations* described in Fukushima report (2015 IAEA).

This paper describes a preliminary study on the violation type human errors and their treatments during human error event investigations in nuclear. The first and most basic issue of violation is about how to cope with the culpability, and an approach is proposed with multi-layered framework and human error 3.0 concept(2015/2019 Lee) for enhancing the human error investigations in nuclear.

2. VIOLATIONS UNDER A SAFETY CULTURE ISSUE IN HUMAN ERROR INVESTIGATIONS

The human error event investigation systems such as ACRS, HPES, HPIP, HFACS, etc. may have a traditional typical approach to human errors. The traditional human error investigations have adopted a classification on human failures to be included in event structures. Many classifications and taxonomy on human behaviors have been developed. Various criteria such as consequences, human behavior and/or system function, and causal and/or influencing factors can be adopted to discriminate the different characteristics of human error events.

The types of violations such as routine/permitted violation, mannerism, negligence, avoidance, optimized and convenience violation, temporal and exceptional violation, test violation, after-event violation, asked/induced violations could be examples found in recent revisit to human errors. Influencing and causal factors can characterize violations. Recent proposal to the house model of violation is described with 10 keys and 152 factors (2016 Kang et al).

1	Work Manual	3	Organization/Safety management	5	Workplace	6	Communication	7	Worker
1	Work manual existence	1	Human resource management	1	Noise	1	Communication existence	1	Physical fatigue
2	Work manual accessibility	2	Employee support program	2	Temperature	2	Communication frequency	2	Physical illness
3	Work manual design	3	Supervisor for team control	3	Illuminance	3	Communication contents - clarity	3	Physical suitability
4	Work manual unity	4	Safety leadership of supervisor	4	Humidity	4	Communication contents - appropriateness	4	Visual and auditory sense
5	Work manual contents - accuracy	5	Organization culture	5	Air quality	5	Communication contents - distortion	5	Capacity for locomotion
6	Work manual contents - concreteness	6	Organizational justice	6	Chroma	6	Communication timing	6	Safety consciousness
7	Work manual contents - quantity	7	Schedule planning of organization	7	Vibration	7	Communication participant	7	Activeness
8	Work manual contents - revision	8	Cooperation management	8	Radiation	8	Communication method - equipment	8	Motive of volunteering
		9	Value of organization safety	9	Space openness	9	Communication method - cross check	9	Self-esteem
2	Job/Task	10	Safety program	10	Tidiness	10	Communication language - intonation	10	(social) self-efficiency
1	Job/Task type	11	Organization structure of decision making	11	Work path	11	Communication language - technical term	11	Optimism
2	Job/task importance related to safety	12	Safety learning organization	12	Workplace scale			12	Mental stress
3	Authority for task	13	Crisis response	13	Other workers in workplace	8	Team	13	Responsibility
4	Job autonomy	14	Maintenance of equipment in nuclear power plant	14	Occurrence of a extreme situation	1	Management of job/task	14	Impulsivity
5	Job identity	4	Education/Training	15	Visual/Auditory device	2	Leadership	15	Attitude to education/training
6	Shift operation	1	Education/training program existence	16	Facility design - electrical	3	Pride of leader	16	Emotion/tension state
7	Working hours	2	Education/training time	17	Facility design - mechanical	4	Intelligence of leader	17	Organizational commitment
8	Workload - task difficulty	3	Education/training contents	18	Facility design - software	5	Team membership	18	Job satisfaction
9	Workload - task complexity/diversity	4	Education/training methods	19	Interface	6	Team custom regulation	19	Reliance on systems
10	Workload - task quantity	5	Education/training instructor	20	Deterioration of nuclear power plant	7	Teamwork/cohesiveness	20	Conflict between work and family
11	Workload - working time	6	Education/training program	21	Equipment H/W & S/W - Existence	8	Team decision making	21	Mental illness
12	Workload - frequency			22	Equipment H/W & S/W - Arrangement	9	Team mental model	22	Attention
13	Workload - multiple task			23	Equipment H/W & S/W - flaws	10	Team education/training	23	Locus of control
14	Workload - [illegible]			24	Equipment H/W & S/W - design	11	Personal relationship (co-worker, boss)	24	Drug abuse
15	Number of workers			9	Supervisor	12	Team structure	25	Confusion/forgetting/mistake
16	Breaking time			1	Supervisor authority	13	Team collectivism	26	Assumption/prediction/preconception
17	Working speed			2	Supervisor qualification and ability	14	Cooperation	27	Job ability
				3	Supervisor behavior/attitude	15	Taking over in team	28	Previous experience of accident
				4	Accident investigation and analysis	16	Crisis response	29	Ethics
				5	Accident management			30	Memory
				6	Improvement and precaution measures			31	Work experience
								32	Safety knowledge
								33	Work planning ability
								34	Crisis response ability

Figure 1. A Classification of Influencing Factors of Violations in Nuclear (Kang, et. al. 2015)

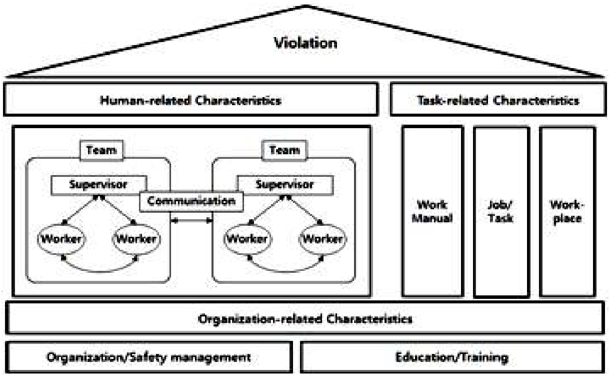

Figure 2. A House Model of Violations in Nuclear (Kang, et. al. 2015)

More complicated understandings on violations are psychological modes, status, and cognitive level of human error nature. Reason's taxonomy shows a typical classification of human errors in a perspective of psychology. It utilizes an interpretation of internal process of memory, attention control and others. Intention especially discriminate the violations and sabotage from more typical slip, lapse, and mistakes.

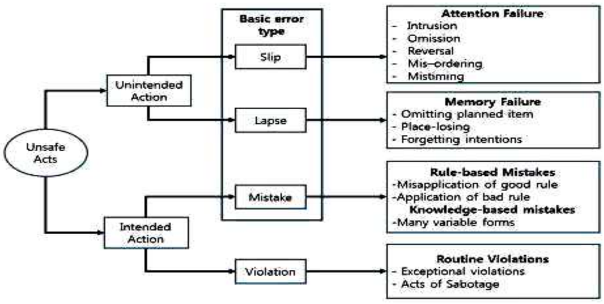

Figure 3. Types of Human Errors (by Reason)

Although human error researchers such as Embey, Kirwan, Reason, etc. have excluded some part of human errors by introducing the psychological criteria of intention, however, human error events including violations seem to remain vague to get an effective countermeasures. Violation is a unique type of human erroneous performance in the sense of both the huge impact to the system safety in practice and the profound interest from the psychological and judical perspective.

Safety culture instead of violations becomes prevailing as a common and descriptive term of the most of recent safety reports that included violations expecially(2019 NSSC, 2020 Jung). It sometimes raises more sophisticated issue of safety culture, that might be one of the most prevailing words within event investigations nowadays around nuclear and a conclusive measure to get nuclear safety after Fukushima and Chernobyl accidents. Mainly after IAEA's self-assessment model there have been various efforts to resolve the safety culture issue by adopting system dynamics simulation, organization/attribution model, business process modeling, competence enhancement, managerial regulatory model, and others (2020 Lee). In the other side of efforts on safety culture, more scrutinized taxonomy and schemes to capture the details of safety culture have been articulated rather than studying the violation itself.

Safety culture may not separated from human errors including violations and even up to sabotages. New categorizations are proposed in terms of EOC(error of commission) (2019 Kim) and EOO(error of omission) such as mannerism(2014 Lee), and to cover the security issues together (2018 Suh & Im). The safety culture looks a main issue in human error events in spite of three plausible regressions (2016, 2018 Lee). Human error taxonomy could be extended to include this new comer of violations rather than safety culture. The causal factors within human error event investigation should be exhaustive for including all HOFs(human and organizational factors). A study example is the lessons learned from trip events extended to the organizational factors as the main results of human error investigations (2009 KAERI, 2014 Kim et. al.)

3. CULPABILITY ISSUES ON VIOLATIONS

Human error investigations meet the concerns of responsibility, since the errors can be described as a pass over the rules and criteria, and understood with a repent. It frequently reveals issues of blame to people just involved in the event. A substitution test logic to discriminate the 'honest error' is an example of the culpability study on violations in aviation.

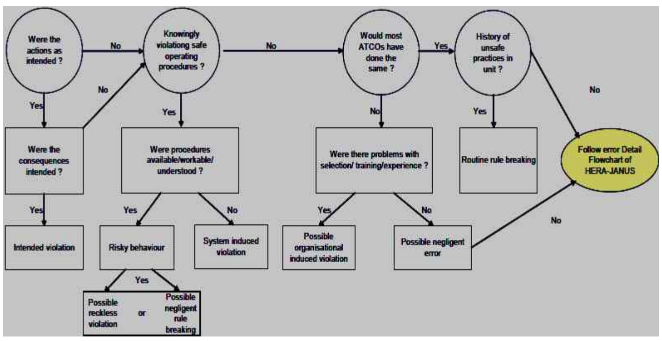

Figure 4. Substitution Test on Violations in Aviation (Adopted from Reason and Govaarts in HERA-JANUS, part)

It seems an articulated guide for discriminating acceptable behaviors for 'Just' culture in aviation. Violations can be characterized by intentions at first, however, there must be two different kinds of intentional failures. One is a failure to make an appropriate intention and the other is the problem of intention itself. The first should be separated from the faulty and bad intentions. They are focused to promote the questioning attitude and reporting more actively, however just a simple version of early considerations to provide a culpability basis to errors.

Beside the intention of consequences, other details to scrutinized violations for judical system need be investigated such as prior perception of rules and rule-breaking, etc. A more exhaustive set of keys and factors can help violation studies in more detail. (2020 Lee)

Table 1. Keys and Factors to Violations (2020 Lee)

keys		sub-factors
intention	consequence (negatives)	loss/damage punishment
	value gain (positives)	gain interest, fun etc. personal value convenience, others
	mis-captured	(selected in domain tasks)
perception	rule	rule itself/details rule purpose intended rule-breaking meaning of rule-breaking
	availability	physical informational
management	intervention	self peer supervisory
	E&T	education-class, case, mt'l training – OJT and etc. PJB etc.
	experiences	job-related personal others
	organization	(selected in domain org.)
	others	(selected on purpose)

4. AN EXTENDED FRAMEWORK PROPOSED FOR VIOLATION INVESTIGATIONS

The categorization of violations may give a more details on their causes. The objectivity may be vague and quarrelsome, strongly dependent on the perspective of investigations rather than any technical one. So a further categorization of violations by incorporating the suggested factor can be beneficial but still biased to its perspective.

A new perspective of *Human Error 3.0* changes the main focus of human error investigations from the factual causes to the practical countermeasures (2016, 2018, 2019 Lee). A few postulations on violations are suggested as followings

- cause is not necessarily to be a countermeasure
- influenced externally rather than internally
- external factors is to be managed
- blame is not always effective/true to violations

A study on the three eras of human error studies according to the consequences and their measures into *Human Error 1.0~3.0* describes suggestions enough to include violations as a new type of human errors during human error event investigations. It might be inevitable to add three additive layers of analysis on human error events.

Table 2. Different Layers to Violations Analysis

functional level	event sequence
behavioral level	human assignments : R&R
culpability level	• consequences • countermeasures

The culpability level includes two respective analyses on human errors. The one is level of responsibilities assigned prior events. It can be conducted according to the objectiveness and validity. However another different analysis is focused to the necessity to ask responsibility within the countermeasures after the human error analysis.

A new concept of *Human Error 3.0* can be incorporated to assess the violations during human error investigations especially for countermeasures of more practical purpose. It has more focused to the countermeasures rather than causes of human error events, since the effective countermeasures can be different from the causal factors in practice. Violations may have culpabilities to blame the person of human error behaviors, however, be beneficial for a more practical approach to include violations within the eventual consequences of human error events.

5. DISCUSSIONS AND CONCLUSIONS

This is a preliminary study on the culpability of violations during the human error investigations. Further study in on-going in nuclear especially for regulation side. Violations also can be described as a just non-compliance of rules and criteria at first, but eventually concluded into a rule-breaking, an abuse, a criminal activity, and other culpability terms. Violation itself not means a necessity of blame to human but an effective countermeasure. A multi-layered investigation to human errors may be beneficial to cope with the following demanding issues rather than safety culture in nuclear.

- organized irresponsibility
- human credibility in security and insider threats
- organizational responsibility to stress test
- optimal R&R within and between organizations
- judical and technical study on human errors

Human errors are expected to be seldom solely deliberate and malicious in a system. Moreover they are induced by the situation-and⁻atmosphere of overall system. The responsibility blaming and related safety culture issues to violations might be inventable and sensitive to public especially for the safety in nuclear events. The technical understanding for lessons learned should go before the blaming process. Experiences of human errors in nuclear are very rare and expensive, however, they are also *invaluable* to reveal the uncovered limitations of system internals and to fix them with countermeasures. Violations are informative with other human errors, too. So the proposed culpability approach to violations requires further study with more emphasis to countermeasures available and recommendable in a system.

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