Analysis for Human-related Events during the Overhaul

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1. Introduction

The event frequency due to human error is decreasing among 20 operating Nuclear Power Plants (NPPs) excluding the NPP (Shin-Kori unit-1) in the commissioning stage since 2008 [1]. However, the events due to human error during an overhaul (O/H) occur annually (see Table I).

Table I: Human-related events during O/H (2008~)

	No. of Events	No. of HE Events	No. of HE events during O/H
2008	14	4	1
2009	11	2	1
2010	8	1	1
2011*	6	1	1

* The events occurring in commissioning state (Shin-Kori unit-1) is excluded.

An analysis for human-related events during the O/H was performed. Similar problems were identified for each event from the analysis and also, organizational and safety cultural factors were also identified.

2. Analysis of events

The analysis for human-related events was performed using HuRAM^{+} that was developed to investigate the human-related events [2,3]. Human-related events during the O/H since 2008 are as follows.

1) Kori-3 (08.5.25) "Safety Injection due to inadvertent opening of the pressurizer PORV during hot standby operation"
   - Outline : During the Hot Standby operation following the completion of the O/H, a valid Safety Injection (SI) actuated due to the 'pressurizer low pressure' in Kori Unit-3. The 'pressurizer low pressure' was caused by inadvertent opening of the pressurizer Power Operated Relief Valve (PORV) due to human error. The PORV opening occurred when an I&C test engineer withdrew the Resistance–to-Current card during the 'RCS Resistance Temperature Detector cross calibration test' which, in conjunction with the selector switch for the train-B Cold Over Pressure Protection Signal (COPS) in 'ARM' position (which should be in 'BLOCK' position), resulted in opening of the PORV 'B'.
   - Causes : 1) Operators and the test engineer didn't confirm the position of the COPS selector before and after performing those tests, 2) The communication between the test engineer and MCR operators was not sufficient.

2) Wolsong-2 (09.9.3) "Loss of offsite power and SDG startup due to opening of switchyard breaker"
   - Outline : During the O/H, while performing a surveillance test for the Current Transformer (CT) of the main generator, the loss of voltage (LOV) at the safety bus occurred due to opening of the switchyard breaker in Wolsong Unit-2. The switchyard breaker was opened inadvertently due to spurious actuation of the 'reverse power relay.' In the response to the LOV, the Standby Diesel Generator (SDG) #2 started up automatically and the safety-related equipment loaded from the SDG was actuated automatically and successfully as designed.
   - Causes : 1) Operator's failure to confirm the plant initial condition for surveillance, 2) Improper process control for the O/H works

3) Yonggwang-5 (10.12.29) "Loss of voltage and Emergency Diesel Generator (EDG) startup due to human error during the O/H"
   - Outline : The safety bus protection relay in the train-A was actuated by human error while a test engineer was surveying on the protection relay in the train-B (class 1E) safety bus breaker during the O/H in Yonggwang Unit-5. As a result, the train-A safety bus opened instantly and the EDG started up. During the surveillance tests on protection relays for the train-B safety bus breakers, the test engineer examined the breaker protection relay in the train-A breaker room (supplied by the off-site power) instead of one in the train-B (power outage) breaker room. And the LOV on the safety bus of the train-A occurred.
   - Causes : 1) Accumulation of fatigue due to long-term activity in small and narrow work environment, 2) Not enough space in the Train-B breaker room, 3) Carelessness by performing due to lots of surveillance tests simultaneously, 4) Unfamiliar work environment, 5) Confusion due to the surveillance of protection relays in the Train-A and –B breaker rooms simultaneously

4) Kori-3 (11.4.19) "EDG startup and loss of voltage in safety bus of Kori-3,4 due to human error during O/H of Kori-3"
   - Outline : During the inner inspection for the Non Segregated Phase Bus (NSPB) of the 13.8kV non-

safety bus train-A (supplied by the off-site power) instead of 13.8kV non-safety bus train-B (power outage) in the turbine building, a grounding occurred due to human error which resulted in the loss of the offsite power in both the Kori Unit-3 (Safety train-A&B, Non-safety train-A) and Kori Unit-4 (Safety train-A&B). Resultingly, the powers of safety buses of Kori Unit-3 and Unit-4 were supplied by EDGs.

- Causes : 1) Wrong target selection by the supervisor, 2) Verbal instruction not following work procedure by the supervisor, 3) Insufficient confirmation by the supervisor and maintenance worker about the current NPP status, 4) Insufficient work control

3. Lessons Learned from Events

James Reason proposed an investigative system to understand about an organizational accident (Fig. 1) [4]. The investigative system shows how an accident occurs and the way how an investigator identifies the causes of the accident.

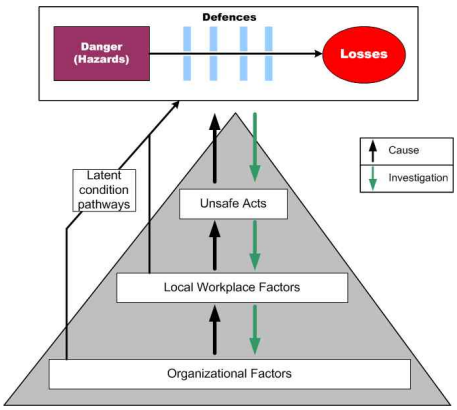

Fig. 1. Stages in the development and investigation of an organizational accident (James Reason)

From events analysis, several problems such as wrong work control, wrong work target selection, wrong supervision, etc. were revealed. And some of these were common problems among the O/H events. For these problems, real root causes including the organizational and safety culture are as follows.

1) The work burden is increased due to shortened O/H period.
2) The work control is difficult because several works are processed simultaneously.
3) Operators don't make sure the initial conditions continuously which are able to be changed due to long-term maintenance, test, inspection, and so on.
4) There are insufficient reviews of the effectiveness for other maintenance, test, inspection, and so on.
5) Insufficient supervision due to lack of human resources.
6) Inappropriate understanding about the current NPP status.

Lessons learned through the analysis of human-related events during the O/H are as follows.

1) Management or monitoring of the initial condition for the long-term maintenance, test, inspection, and so on
2) Reinforcement of cooperation and communication between teams or departments (or divisions)
3) Necessity to estimate the effectiveness and to verify the current NPP status through overall supervision, and to review for simultaneous maintenance, test, inspection, and so on
4) Enough review during the morning report, Pre-Job Briefing, and so on
5) Reinforcement of the administrative control
6) Reinforcement to estimate the plant status before maintenance, test, inspection, and so on
7) Reduction of night works to keep the tight O/H schedule

4. Conclusion

From the analysis for human-related events during the O/H, several root causes and lessons learned were identified. Also, organizational and safety cultural factors were also identified. However, the organization factors and safety culture related events are 1) hard to identify during the investigation, 2) hard to expect, 3) and revealed after an event occurs (such as latent failures).

To decrease these human-related events including organizational and safety culture during the O/H, we have to keep an eye on the followings.

1) Overall management for maintenance, test, inspections, and so on in detail
2) Maintenance, test, inspection, and so on that perform to keep up with the O/H process differently compared to the O/H schedule
3) A vast workload in limited time to keep up with the O/H schedule
4) Monitoring the initial condition that can be changed by temporary halt, other maintenance/test/inspection, and so on

REFERENCES

[1] KINS, Operational Plant Information System for Nuclear Power Plant (http://opis.kins.re.kr)
[2] KINS, Development of a root cause analysis method for human-related events, KINS/HR-806, 2007
[3] KINS, A study on the development of HuRAM, KINS/HR-872, 2008
[4] James Reason, Managing the Risks of Organizational Accidents, 1997