Statistic Analysis of Incidents and Failures in the Commissioning Stage of KSNP

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1. Introduction

Currently 9 KSNPs (Korea Standard Nuclear Power Plant) have been operating since first operation of Yonggwang unit 3 in 1994. After Ulchin unit 6 in 2005, KHNP didn't have commissioning experience for almost 6 years and Shin-kori unit 1 reflected the latest design changes against existed KSNP has experiences that are components failures, human errors and so on. Thus, KINS analyzes 40 operating experience in order to effectively regulate for new nuclear power plants which will be constructed in near future.

This paper classified 3 failure modes, which are components failure and human error at shutdown or low power state, inadvertent actuation in rapidly transient such as load rejection test with 50, 80, 100% and abnormal function of reactor protection or regulation system.

2. Trend Analysis

Until now, 40 events in KSNP included Shin-kori unit 1 were reported to regulatory body according to MEST notice 2009-37. Especially, Yonggwang unit 3 that is the first KSNP in korea had 11 events caused by components malfunction, operator human error but followed NPPs(Yongwang unit 4, Ulchin unit 4 and 6) could minimize reportable events due to feedback of operating experience from earlier other units. Fig. 1 shows the event status in commissioning stage of KSNP.

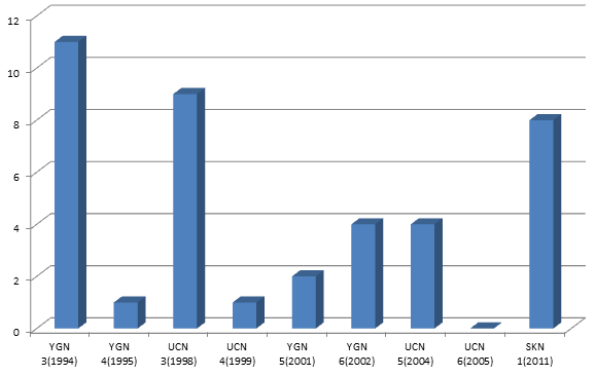

Fig. 1. Event status in commissioning stage of KSNP.

2.1 Events at power rate

There are so many tests, maintenance and installing equipment in commissioning stage. In case of tests which are detecting of core parameters, functional test of reactor regulation system, they are generally performed according to power rate. As a results of analysis the most frequently events occurred at low power rate. The reason why is that vulnerable components inadvertently actuated by priority at zero power rate. At 50 and 80% power rate there are relatively much more events than the others because there are rapid transient such as load rejection test at that power rate. Fig. 2 is event status at power rate

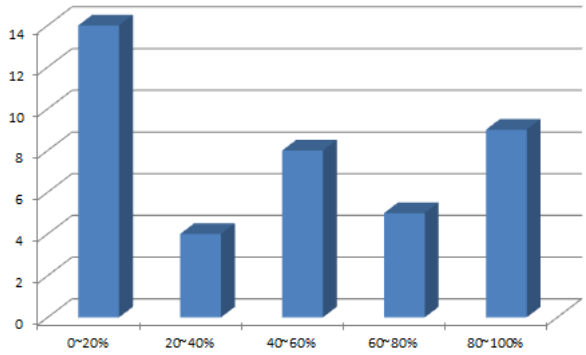

Fig. 2. Event status at power rate

2.2 Causes of events

We also mainly analyze 5 type causes that are mechanical failure, I&C, electrical failure, human error and external factor contributed events in order to learn the lessons. The most main cause is inadvertent signal on I&C system and the second cause is human error. In case of human error, the types of that are mainly wrong equipment handling by operator and inadvertent control during emergency. The root causes regarding human error are that KHNP didn't compose of organization with insufficient time and lacks of operator training. Fig. 3 shows the causes of events

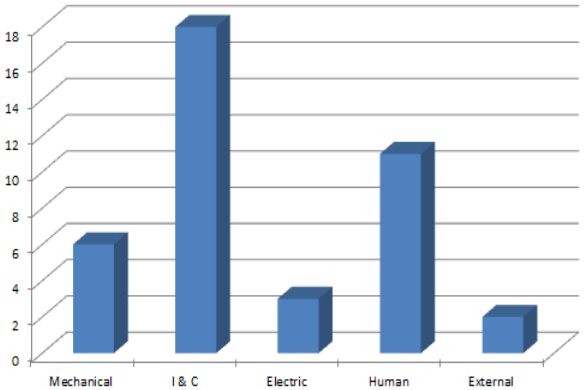

Fig. 3. The causes of events

2.3 Events in primary and secondary system

Through the classification between primary and secondary system, event during commissioning stage occurred in secondary system at the rate of 80% (31/40). We evaluated the main reason that quality assurance management of secondary system is more vulnerable than primary system and another reason is that unstable signal factor in BOP system provided cause during emergency transient. Table I is status of event between 1 and 2 system

Table I: status of event between 1 and 2 system

System	The number of event
Primary	9 (22%)
Secondary	31 (78%)

3. Analysis of Failure Character during the Test

3.1 Event at low power (below 20%)

There are several human errors due to insufficient skill of operator in the initial low power test. The main contents of event are reactor trip by failure of components, inappropriate SG control and non-compliance with procedure due to lacks of experience

Table II. List of reactor trip while load rejection test

	Unit	Date of event	Rx Power	System	Cause	Trip
1	Y3	’94.10.26	4	1	I&C	Auto
2	Y3	’94.10.29	12	2	H	Auto
3	Y3	’94.11.29	20	2	I&C	Auto
4	Y3	’95.02.18	10	2	H	Auto
5	Y4	’95.07.20	20	2	I&C	Auto
6	U3	’98.01.04	12	2	E	Auto
7	U3	’98.04.06	12	2	E	Auto
8	U3	’98.07.10	12	2	M	Man.
9	U3	’98.08.03	8	2	H	Auto
10	Y6	’02.10.02	20	2	H	Auto
11	U5	’04.01.04	19	2	I&C	Auto
12	SK1	’10.07.06	0	1	E	-
13	SK1	’10.09.17	0	1	H	-
14	SK1	’11.01.25	0	1	H	Auto

3.2 Reactor trip while load rejection test

As soon as switchyard line is blocked, load rejection test will begin to start and assessment items of this test will be turbine runback/setback, houseload operation, power load unbalance, function of reactor power cutback system and finally function of steam bypass control system. The main reason of reactor trip during load rejection test, we can divided by abnormal actuation of SBCS, errors of reactor control system and inadvertent control due to card failure in plant control system

Table III. List of reactor trip while load rejection test

	Unit	Date of event	Rx Power	System	Cause	Trip
1	Y3	‘95.03.17	100	1	I&C	Auto
2	Y3	’95.03.18	98	1	I&C	Auto
3	U3	’98.02.07	54	2	I&C	Auto
4	U3	’98.02.09	54	2	I&C	Auto
5	Y5	’02.01.21	50	2	H	Auto
6	Y6	’02.11.22	100	2	I&C	Auto
7	U5	’04.02.20	80	2	I&C	Auto
8	SK1	’10.10.31	50	1	I&C	Auto
9	SK1	’10.11.17	80	2	I&C	Auto

3.3 Event at reactor protection system

Several events regarding RPS failure occurred during commissioning stage of KSNP and also there was events regarding RPS failure during commercial stage. The most problem is related to RPS card, Power supply system, RSPT and control assembly coil.

Table IV. List of event at reactor protection system

	Unit	Date of event	Rx Power	System	Cause	Trip
1	Y3	’94.10.26	4	1	I&C	Auto
2	Y3	’95.03.17	100	1	I&C	Auto
3	Y3	’95.03.18	98	1	I&C	Auto
4	U4	’98.06.01	100	1	I&C	Auto
5	Y5	’01.12.31	50	2	Ex	Auto
6	SK1	’10.10.31	50	1	I&C	Auto

4. Conclusions

This paper performs to statistically analyze 40 event experienced in order to effectively regulate new nuclear power plants. As a result of analysis of failure character during commissioning test, the most events occurred at low power rate and load rejection test. The most system failed is reactor protection system. Especially, this paper didn’t describe in detail containment spray event at SK1 but for the prevention of reoccurrence and safe operation of plants, most lessons-learned is focused on operation technique and safety culture.

Operating experience feedback is one of the most important aspects of construction of new nuclear power plants. So we hope that this statistic study during commissioning stage provides utility and regulator with valuable insight

REFERENCES

[1] Durk H. Lee et al, OE Report on KSNP Commissioning, KINS/ER-183, Vol.1 and 2, 2011
[2] Event Investigation Report, http://opis.kins.re.kr