Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 25-26, 2012

Kori 1 SBO and Maintenance Rule in Korea

Kilyoo Kim, DaeIl Kang
Integrated Safety Assessment Division, Korea Atomic Energy Research Institute, P.O. Box 105, Yuseong, Daejeon 305-600, South Korea, kykim@kaeri.re.kr

1. Introduction

On February 9, 2012, during the 29-th refueling outage of Kori 1 nuclear power plant, a station blackout (SBO) occurred and the event was not reported for a long time. By reviewing the Kori 1 SBO event [1], we are trying to find a necessary system or process to prevent the similar event in this paper.

One of reason of the SBO event is the lack of a configuration control including a safer outage work scheduling. It is discussed here why the configuration control is not working even though it is known that the maintenance rule (MRule) [2] is adopted in KHNP.

After the SBO event, two main actions were taken by KHNP and NSSC(Nuclear Safety and Security Commission); 1) extended overhaul period and 2) evaluation of outage work schedule by regulatory body. It is also discussed in this paper how these two actions can be performed.

2. Methods and Results

In this section, Kori 1 SBO event is analyzed, and since the results are connected to MRule and on-line maintenance (OLM), MRule and OLM are described.

2.1 Kori 1 SBO Event

The electric power supply system of Kori 1 is shown in Fig. 1. Fig. 1 shows that the only possible electric source remained was emergency diesel generator (EDG) B when a wrong protective relay test caused a trip of unit auxiliary transformers A and B (UAT A/UAT B). In Fig. 1, if no maintenance, the available electricity can be five, and let's say them EDG A, EDG B, SAT A, SAT B, UAT. For example, SAT A means 154kV offsite electricity which comes through station auxiliary transformer (SAT) 'A'.

Usually, train A (EDG A and SAT A) and train B (EDG B and SAT B) are completely managed by train-wise. Thus, if train A is out of service, then train B should be alive, and vice versa. This concept is well shown in the outage work schedule of electric power supply system during Kori 1 28th refueling outage (see Fig 2.). In Fig. 2, even though a wrong protective relay test occurs, at least two electric sources are always alive (e.g., EDG A and SAT A).

However, the outage work schedule of electric power supply system during Kori 1 29th refueling outage (see Fig 3.) which was badly scheduled and eventually caused SBO, did not secure two electric sources on Feb. 9. Unfortunately, a protective relay test on Feb. 9 was approved when risk is too high to be accepted.

2.2 Maintenance Rule

MRule was adapted 1996 in USA to enhance the safety. One of main object of MRule is to monitor the systems or components performance. Another object of MRule is to control the configuration, i.e., to evaluate and manage the increased risk induced by test & maintenance activity as mentioned in a)4) of MRule.

MRule became one of KHNP self-managing programs in Korea. However, configuration control a)4) term is not included in KHNP MRule, and is separately managed in RIMS program. In RIMS program, a risk monitor called RIMS (Risk Informed Management System) can evaluate the Core Damage Frequency (CDF) when a configuration is changed. Unfortunately, in Kori 1, when the SBO event occurred, RIMS program was not prepared even though KHNP MRule without a)4) was operated. If RIMS program was available, the SBO could be avoided.

2.3 On-line Maintenance

On-line maintenance (OLM) is the maintenance performed during power operation instead of during refueling outage to reduce the risk and the outage period. OLM increases the risk during power operation, and reduces the risk during outage. It is known that OLM in many cases has net benefit in the risk point of view. For example, since low power/shutdown CDF decreases by 50.3%, and full power CDF increases 7.1 % , total CDF decreases by 26.0% if EDG OLM is implemented in APR 1400[3].

Although there is net benefit in the risk point of view, since the risk during power operation increases, OLM has been carefully adapted by a stepwise approach by Korean regulator. Since OLM of EDG is active and beneficial in U.S.A, and net beneficial in the risk point of view in Korea, OLM of a very simple system was implemented at first, and EDG was a target system of the next OLM. However, after Fukushima accident, it becomes difficult to continue OLM of EDGs due to anti-nuclear atmosphere.

2.4 Actions in Response to Kori 1 SBO

NSSC announced 20 actions in response to Kori 1 SBO [4]. One of them is that KHNP should set up a test

& maintenance schedule in which the increased risk is acceptable, and that the regulatory body evaluate it independently. However, this action item can be easily implemented if MRule a)4) is included in a regulatory scheme. Also, it is announced that the size of resident inspectors of regulatory body will be increased 5 times larger than in the past.

Also, KHNP is going to increase the overhaul period to avoid a human error during outage.

3. Conclusions

If MRule including a)4) is in a regulatory scheme, a much safer outage work can be scheduled or rescheduled, and thus there would be no Kori SBO event, and the NSSC requiring action for safer outage scheduling can be easily fulfilled.

Just extending outage period may be a solution to avoid a human error but not ultimate solution for the safe outage work in Korea. Rather OLM would be better with a sophisticated tool (risk monitor) in the good regulatory scheme (MRule including a)4)) although more research and experience may be required in the configuration management. However, we should remember if OLM of EDG was performed, there would be no Kori SBO event. Furthermore, to export nuclear power plants, risk informed applications such as OLM, risk monitoring, and MRule, etc., should be more actively implemented.

REFERENCES

[1] IAEA, Report of the EXPERT MISSION to review the Station Blackout Event that happened at Kori 1 NPP on 9 February 2012 Republic of Korea, 4 – 11 June 2012

[2] U.S. NRC, "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants", 10 CFR 50.65, July 1991

[3] Woosang Lim, et al, Effects on Probabilistic Shutdown Safety by Preventive Maintenance during Power Operation, Trans. of Korean Nuclear Society Autumn Meeting, 2001

[4] NSSC, The current situation and future action plan for Kori 1 SBO, March 21, 2012

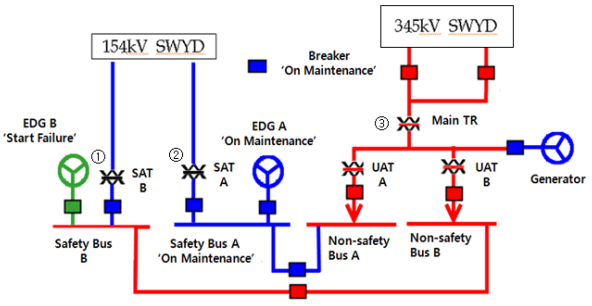

Fig. 1. Kori 1 Electric Power Supply System

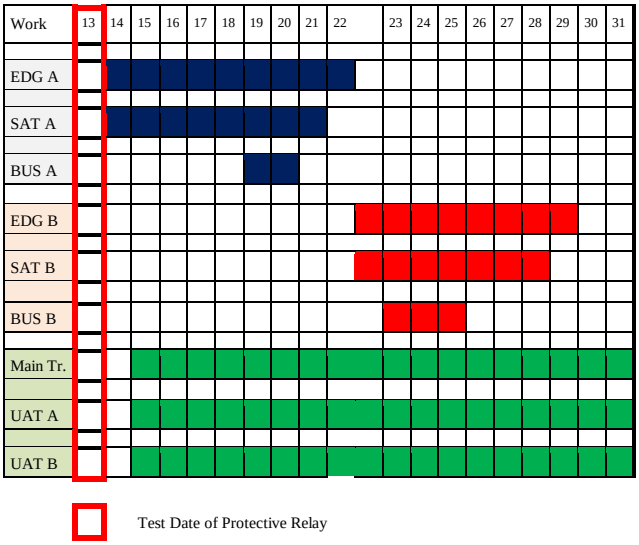

Fig. 2. Kori 1 outage work schedule of the 28th refueling outage

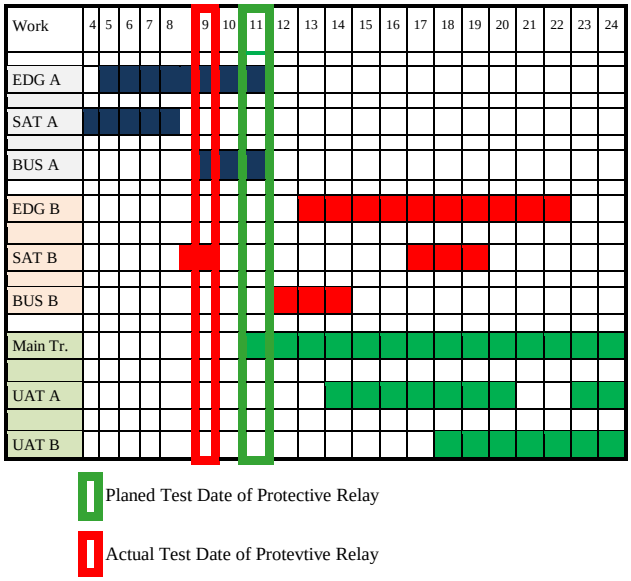

Fig. 3. Kori 1 outage work schedule of the 29th refueling outage