Transactions of the Korean Nuclear Society Autumn Meeting
Gyengju, Korea, October 27-28, 2016

Review of Fire-Induced Multiple Spurious Operation Scenarios for a Pilot Plant

Kwang Hong Kim*, Jai Ho Lee , Do Hwan Lee
KHNP-CRI, 70 Yuseongdaero 1312beon-gil, Yuseong-gu, Daejeon 34101, Korea
**Corresponding author: broader.kim@khnp.co.kr*

1. Introduction

With the enhancement of fire safety regulation requirements in nuclear power industry, multiple spurious operation (MSO) identification and treatments should be included in post fire safe shutdown analysis (PFSSA). In this study, the MSO scenario reviews are performed for Shin Kori Unit 3(SKN3) which is the first nuclear power plant of the Advanced Power Reactor 1400 constructed in Korea. The reviews include whether fire-induced MSOs are a concern in SKN3, and what specific scenarios could affect the safe shutdown condition of the plant following a fire. The applicability of MSO scenarios to SKN3 is preliminarily evaluated by reviewing PWR Generic MSO List of Table G-2 in NEI 00-01. Through the review of the generic MSO list, the MSO equipment list and logics of SKN3 are developed.

2. Regulations and Guidance

2.1 Application of the regulations and Guidance

US NRC Regulatory Guide 1.189 (Rev.2) provides the current regulatory position for deterministic fire protection of nuclear power plants. Section C.5.3.1.1 of RG 1.189 endorses the use of Chapter 4 of NEI 00-01(Rev.2) as an acceptable approach to addressing MSOs.

2.2 Implementation of the Guidance of NEI 00-01

Section 4 of NEI00-01 (Rev.2) provides a methodology for MSO identification and treatments, and addressing fire-induced MSOs. This methodology was developed for operating plants and, therefore, some of the methodology is not applicable for SKN3. In spite that NRC RG. 1.189 endorses the deterministic MSO analysis methodology of NEI00-01(Rev.2), the methodology of NEI00-01(Rev.3) is almost the same as that of Rev.2. Comparing to Rev.2, NEI00-01(Rev.3) provides three more scenarios in the MSO generic list of Rev.3. In this study, therefore the PWR generic MSO list found in Table G-2 of NEI 00-01(Rev.3) is used to evaluate the applicability of MSO scenarios to SKN3, and to develop the equipment logics for each scenario.

3. Methodology

3.1 Analysis Process

Each of these scenarios is reviewed to determine if they are applicable to SKN3. Piping and Instrumentation Diagram (P&ID) drawing for the plant are used for this evaluation. During the analysis of the generic scenario, the safe shutdown equipment list (SSEL) and safe shutdown equipment logics are developed. The overview of the MSO identification and treatment process are illustrated in Figure 1.

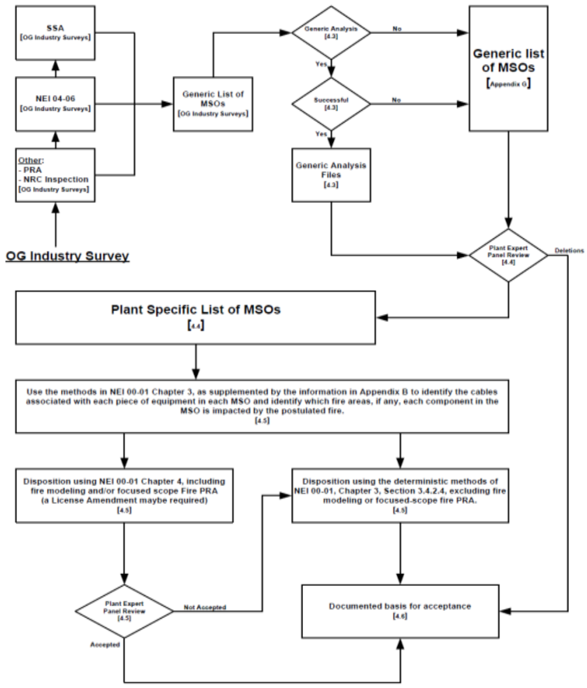

Figure 1. Methodology for MSOs Scenario Analysis (Courtesy of NEI00-01(Rev.3))

3.2 Scenario Logics

For each applicable MSO scenario to SKN3, the set of equipment whose failure would cause the MSO to occur, or whose success would prevent the MSO, are identified. If the scenario required multiple pieces of equipment, this equipment is expressed in a logical relationship. Figure 2 shows a typical example of the logical relationship between safe shutdown equipment for an MSO scenario.

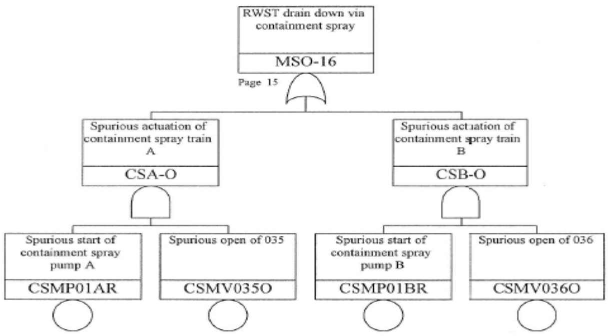

Figure 2. A Typical Scenario Logic

4. Scenario Analysis

4.1 IRWST Drain down

The SKN3 design includes an IRWST, Volume Tank, and a Reactor Cavity. The path between BAST and IRWST is isolated by normally closed manual valves. The IRWST can be drained through the Holdup Volume tank to the Reactor Cavity if a combination of valves spuriously opened. It is noted that "power to these valves is disconnected (key locked power off) during plant normal power operation." A key lock switch does not prevent spurious operation due to a fire in all cases, therefore the scenario is evaluated. To prevent drain down of the IRWST to the Reactor Cavity, one of the following sets of valves must remain closed:

- 3-447-V-0001, 3-447-V-0002; or
- 3-447-V-0003, 3-447-V-0004

The logic relationship is used in the analysis is:

(3-447-V-0001 and 3-447-V-0002) OR
(3-447-V-0003 and 3-447-V-0004).

4.2 Primary Sample System

This scenario causes loss of reactor coolant through the primary sample system, challenging the RCS inventory control function. The scenario for primary sample system evaluates the spurious opening of valves leading to loss of RCS inventory. The sample lines off the primary are 3/8 inches in diameter. Even though all sample lines opened simultaneously, the equivalent flow would be well within the makeup capability of the charging pumps. The scenario is not considered a concern for SKN3.

4.3 Loss of HVAC to credited loads

The scenario evaluates spurious isolation of the HVAC system to credited loads. Credited loads may include pump rooms. In the SKN3 design, individual room or area coolers are used primarily and these coolers are supplied by chilled water and the essential water system. Each essential service water pump could supply 100% capacity to the HVAC loads. Therefore, only one pump is required to be free of fire damage in the system. The scenario logic contains the following pumps:

- ESW Pump PP01A
- ESW Pump PP01B
- ESW Pump PP02A
- ESW Pump PP02B

The logical relationship used in the analysis is:

((3-633-M-PP01A OR 3-633-M-PP02A) OR
(3-633-M-PP01B OR 3-633-M-PP02B))

The final review will be determined for the next step.

4.4 Steam Generator Blowdown

The Scenario causes drain down of steam generator inventory through the blowdown system, challenging decay heat removal function. This scenario evaluates the spurious opening of steam generator blow down valves. This blow down will result in the loss of steam generator inventory. Valves in the steam generator blowdown are modeled in the scenario. Only one steam generator is required to survive. Both paths are "AND" gated together in the logic for analysis purposes. The scenario logic includes:

- 3-455-V-005, 006, 007, 008; and
- 3-455-V-081, 082, 083, 084, 085, 086

The logic relationship used in the analysis is:

((V005 OR V007) OR (V081 AND V083 AND V085))
AND
((V006 OR V008) OR (V082 AND V084 AND V086))

The valves are not on the required SSD flow path.

5. Conclusion

It was preliminarily reviewed that 41 scenarios of 63 scenarios of NEI's generic list could be applicable to design of SKN3. And 22 scenario of NEI's generic list were evaluated not applicable to SKN3. During the review of the scenario contained in NEI 00-01, no additional MSO scenarios specific to SKN3 were identified. For the further study, the final review will be determined and then detailed circuit analysis will be performed by fire zone and area based on the exact location contained the cable and raceway.

Reference

[1] NRC RG 1.189, Rev.2, "Fire Protection for Nuclear Power Plants", October 2009.
[2] NEI 00-01, Rev. 3, "Guidance for Post Fire Safe Shutdown Circuit Analysis", October 2011
[3] EPRI TR-100370, "Fire-induced Vulnerability Evaluation", April 1992.
[4] EPRI TR-105928, "Fire PSA Implementation Guide", December 1995
[5] NRC RG 1.785, Rev.2, "Physical Independence of Electric Systems", September 1978.