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Preliminary Assessment of Coping Capacity of HANUL Unit 3 under ELAP and LUHS

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1. Introduction

After the Fukushima nuclear power plant accident, there has been increasing concern about the beyond design basis accident caused by natural disaster such as beyond design flooding and earthquake. In response to the concern, Korea government and nuclear industry decided to implement the assessments (stress test) on nuclear power plants in Korea. The stress test for KORI unit 1 and WOLSONG unit 1 were completed in 2013[1,2,3] and evaluations for other domestic nuclear power plants are in progress.

The aim of stress test is to reassess safety margins of plant under the extreme conditions. Specifically, the tests measured the capability of equipment to cope with damage from disasters such as earthquake, flooding, etc. The identifying weak point from stress test could be used to enhance the plant safety.

The Multi-Barrier Accident Coping Strategy (MACST) has been developed to respond to the Extended Loss of Alternating current Power (ELAP) and the Loss of Ultimate Heat Sink (LUHS) caused by Beyond Design Basis External Events (BDBEE).

Recently, the stress test for HANUL unit 3 has been performed. This paper presents result of preliminary assessment of coping capacity of HANUL unit 3 under ELAP and LUHS with beyond design natural disaster.

2. Method and Results

2.1. MACST Strategy

The objective of Multi Barrier Accident Coping Strategy (MACST) is to establish a coping capability to avert damage to the fuel in the core and spent fuel pools and to retain the containment function by using on-site equipment and MACST equipment. The MACST strategies are focused on maintaining or restoring essential plant safety functions. It should be noted that the MACST has been developed as three-phase coping strategies [4].

The MACST strategies consist of on-site equipment which include mobile equipment stored at or near the plant site and off-site equipment for the provision of additional resources for longer term response.

The main strategies to deal with these beyond design basis conditions involve a three-phase approach [4]:

- Phase 1 : initial coping by plant installed equipment
- Phase 2 : Transition from plant equipment to on-site MACST equipment to maintain key safety function
- Phase 3 : Providing additional capability from off-site MACST equipment until electrical power, water, and coolant injection systems are restored to get to safe shut down

2.2. Assessment Scenarios

The assessment has been performed (1) to examine the coping capacity of core cooling without damage of core fuel in the event of loss of safety function, (2) to retain the pressure boundary of the reactor coolant system during the transient condition, (3) to keep the containment building temperature and pressure for integrity of the containment structure. Including loss of AC power and/or heat sink scenarios, the set of following scenarios were considered to evaluate the plant response capability in accordance with the stress test guideline of Nuclear Safety and Security Commission (NSSC) [5]. In addition, supplement scenarios were considered with natural disasters such as beyond design earthquake and flooding.

1) Loss Of Offsite Power (LOOP)
2) Station Black-Out (SBO)
3) SBO combined with loss of AAC DG (Extended Loss of AC Power (ELAP)
4) Loss of Ultimate Heat Sink (LUHS)
5) LUHS + Loss of Alternative Heat Sink
6) ELAP + LUHS
7) Earthquake induced tsunami accompanying ELAP + LUHS
8) Storm surge/tsunami and precipitation accompanying ELAP + LUHS
9) Beyond design earthquake (0.3g) accompanying ELAP + LUHS

2.3. Coping strategies of scenario 6 (ELAP + LUHS)

The most impactful scenario to reactor safety is loss of alternating current power and the ultimate heat sink result from BDBEE. Fig. 1 shows the summarized situation of plant and relevant coping strategy.

In simultaneous ELAP and LUHS scenario, the reactor safely shut down by reactor trip signal. The essential equipment for maintaining safety function under the ELAP and LUHS conditions is provided the electrical power from class 1E batteries. When the Direct Current (DC) load shedding is completed on time, the available time of the class 1E battery are extended to 10.5 hours.

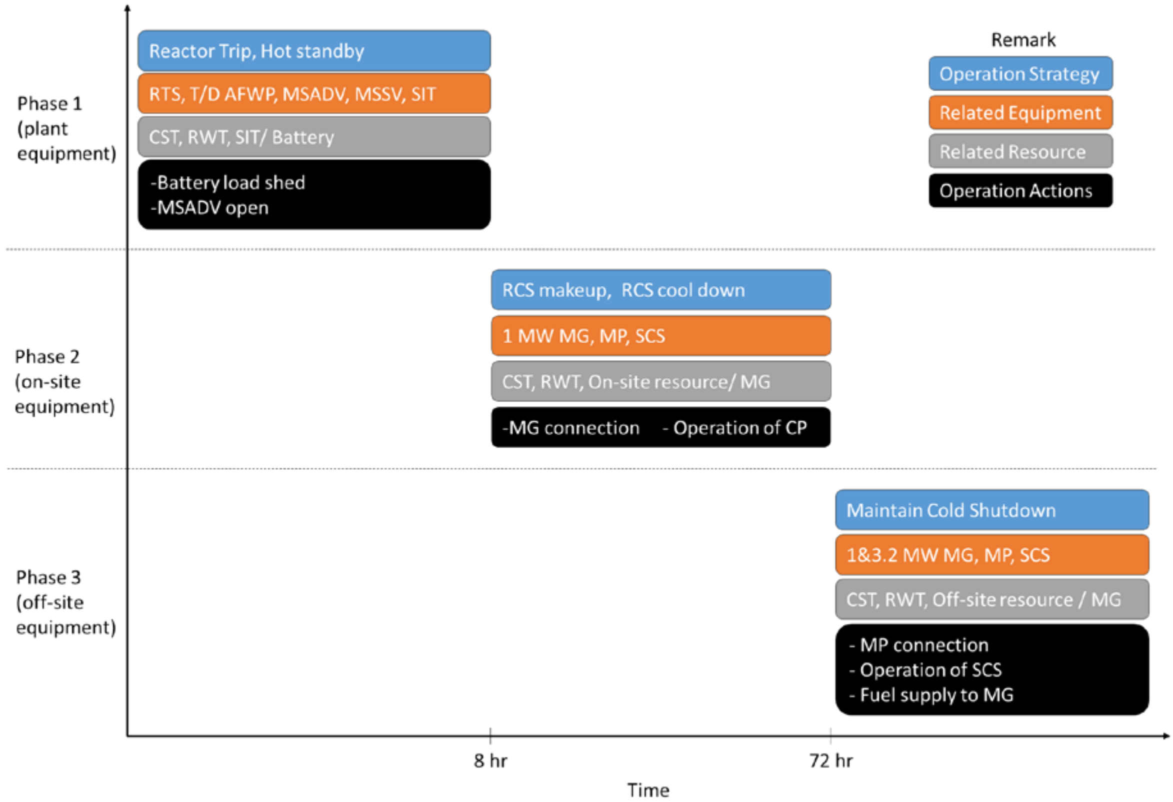

Fig.1 Plant Coping Strategy for ELAP and LOUHS

After the reactor and turbine trip, Reactor Coolant System (RCS) is cooled down by Main Steam Safety Valves (MSSVs) and Atmospheric Dump Valves (ADVs). When the level of Steam Generator (SG) is reached to the set-point of operation of auxiliary feed water pump, Turbine-Driven Auxiliary Feed Water Pump (TD-AFWP) supply feed water to SG through Condensate Storage Tank (CST). Decay heat is transferred to secondary side through SG tube and the core heat removal is performed by natural circulation due to the loss of Reactor Coolant Pump (RCP) power.

The Charging pumps are not available under ELAP and LUHS conditions, which can result in the RCP seal leakage. The seal leakage rate is assumed to be 25 gpm (1.58 ℓ/s) per one RCP [6]. Amount of RCP seal leakage is reduced by cool down and depressurization of the RCS.

For LUHS, AC power can be recovered after the connecting to 1MW Mobile Generator (MG). However, it is insufficient to operate Component Cooling Water System (CCWS). After connecting to 3.2 MW MG, the CCWS could be supplied the electrical power. The Mobile Pumps (MP) will be staged and operated. And it will provide sufficient water to plant cool down. The Shutdown Cooling System (SCS) can be initiated and can maintain the plant to the cold shutdown state. The electricity supply to essential equipment can be sustained since the continuous supply of fuels to MG is possible from off-site resource.

2.4. Coping strategies of scenario 9 (ELAP + LUHS+0.3g)

In the event of the simultaneous ELAP and LUHS with beyond design earthquake (0.3g), sequences of event of scenario 9 are similar to the scenario 6's.

The essential equipment related to source of cooling water are guaranteed to survive the earthquake conditions (0.3g) except Raw Water Tank. The Raw Water Tank was designed as non-seismic equipment. However, post Fukushima action items showed that it has sufficient structural integrity capacity for 0.3g seismic conditions despite non-seismic design.

Electricity for essential equipment for maintaining safety functions under the accident conditions is supplied by seismically rated batteries.

Considering the earthquake applicable to the site, the on-site MACST equipment should be stored in a location reasonably protected. Therefore, Mobile equipment for MACST strategy will be stored in seismically designed buildings.

3. Conclusions

The preliminary assessment of coping capability of HANUL unit 3 has been implemented under ELAP and LUHS conditions considering simultaneous natural disaster.

The essential equipment for maintaining safety function are available under the simultaneous ELAP and

LUHS with 0.3g earthquake conditions. The essential equipment related to plant cooling has coping capacity to cool down the RCS. The HANUL unit 3 has sufficient coping capacity under extreme conditions such as ELAP and LUHS initiated by beyond design natural disaster.

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