Development of Mitigation Strategy for Beyond Design Basis External Events for NRC Design Certification

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1. Introduction

Following the events at the Fukushima nuclear power plants (NPPs), U.S. Nuclear Regulatory Committee (U.S.NRC) issued the recommendations which are prioritized into three tiers (Tier 1, Tier 2, and Tier 3).[1,2] For Recommendation 4.2 among the Tier 1 Recommendations which should be initiated without delay, U.S.NRC issues the order (EA-12-049) regarding requirements for mitigation strategies for beyond-design-basis external events (BDBEEs) which address multiunit events and reasonable protection of equipment identified under such strategies.[3] To endorse the methodologies of development of mitigation strategy, U.S.NRC issued the interim staff guidance (JLD-ISG-2012-01)[4] and endorsed Nuclear Energy Institute (NEI) 12-06.[5] NEI 12-06 outlines the process to define and deploy the diverse and flexible mitigation strategies(FLEX strategy) that will increase defense-in-depth for beyond-design-basis scenarios to address the extended loss of alternating current (ac) power (ELAP) and loss of normal access to the ultimate heat sink (LUHS) occurring simultaneously at all units on a site as shown in Fig. 1.

The order (EA-12-049) is issued to all reactor licensees, including holders of active, Construction Permit (CP) holders, and Combined License (COL) holders. U.S.NRC wants design certification applicants to address the Commission-approved Fukushima actions to the fullest extent practicable, especially Tier 1 Recommendations.[6] Applicants for the new reactor design certification should prepare and submit FLEX strategy for NRC staff's review. Site-specific data related with the new reactor can't be determined during the new reactor design certification applications so that the unit-specific FLEX strategy should be developed. In this study, how to develop FLEX strategy for beyond-design-basis external events for U.S.NRC design certification is examined.

2. FLEX strategy

FLEX strategy is an indefinite coping capability to prevent damage to the fuel in the reactor and spent fuel pools and to maintain the containment function by using installed equipments, on-site portable equipments, and pre-staged off-site resources for ELAP and LUHS occurring simultaneously at all units on a site . A three-phase approach for mitigating beyond-design-basis external events should be used. The initial phase uses installed equipments and resources. The transition phase requires providing sufficient, portable, onsite equipment and consumables until they can be accomplished with resources brought from off site. The final phase obtains sufficient off-site resources to sustain those functions indefinitely.

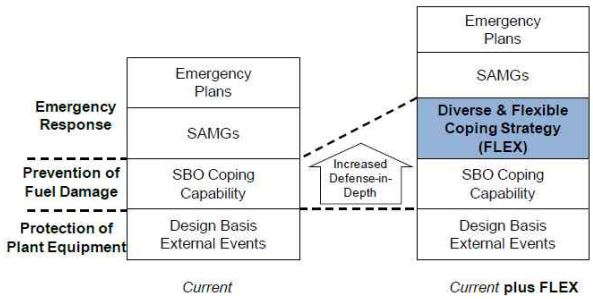

Fig. 1. FLEX enhancement of defense-in-depth

2.1 Site Assessment Process

Fig. 2 shows a schematic diagram of site assessment process to develop FLEX strategy. The first step is to establish the baseline coping capability to address a simultaneous ELAP and LUHS event.

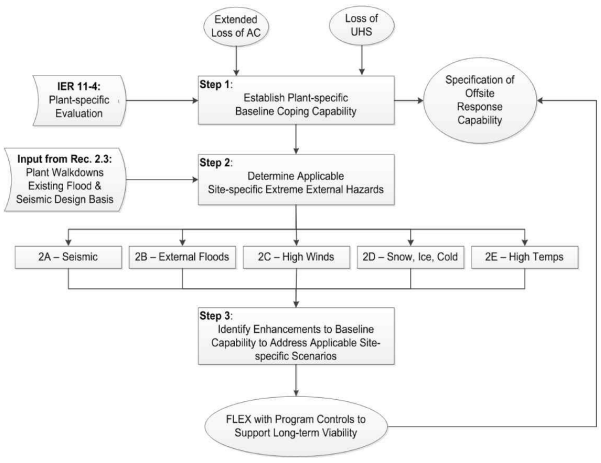

Fig. 2. Schematic diagram of site assessment process

At the second step of site assessment process, applicable BDBEEs for each site are determined. BDBEEs are grouped into seismic events, external flooding, storms, extreme snow, ice, and cold, and extreme heat. Whether external hazards apply to the site and the nature of that in terms of timing, severity and persistence are determined. Protection and deployment

of FLEX equipment which are used for implementation of FLEX strategy, procedural interfaces, and utilization of off-site resources are considered associated with each external hazard.

Definition of site-specific FLEX capabilities considers the aggregate set of on-site and off-site resources. The programmatic controls for implementation of FLEX include quality attributes, equipment design, equipment storage, procedure guidance, maintenance and testing of FLEX equipment, training, staffing, and configuration control.

Finally, the minimum capabilities of off-site responses are specified and a means to ensure the necessary resources should be established. The timely provision of effective off-site resources will need to be coordinated by the site and will depend on the plant-specific analysis and strategies for coping with the effects of the BDBEE.

2.2 FLEX Strategy for NRC Design Certification

For the new reactor design certification application, site-specified data can't be used so that only unit-specific baseline coping capability can be determined. In this section, the method to develop FLEX strategy for NRC design certification is addressed.

The applicants should establish the minimum coping capabilities consistent with unit-specific evaluation of the potential impacts and responses to an ELAP and LUHS. FLEX strategy should ensure that satisfactory performance of necessary fuel cooling by keeping the fuel in the reactor and the spent fuel covered and containment functions are maintained. Baseline assumptions such as reactor transient, reactor coolant inventory loss, spent fuel pool conditions, event response actions, effect of loss of ventilation, personnel accessibility, instrumentation and controls, containment isolation valves, and qualification of installed equipment should be defined.

There are fifteen guidelines to support the development of FLEX strategy related with power, equipment, reactor inventory loss, makeup flow, loss of ventilation, and etc. To assure reliability and availability of the FLEX equipment, the applicants should have sufficient equipment to address all functions at all units on-site, plus one additional spare. For multiple strategies each strategy does not require N+1. Permanent, installed connection points for portable fluid and electrical equipment should be provided. A primary and an alternate connection or delivery point for fluid and a primary and alternate method to repower key equipment and instruments utilized in FLEX strategies should be identified.

The effects of loss of HVAC in an extended loss of ac power event should be addressed. Areas requiring personnel access should be evaluated to ensure that conditions will support the actions required by the plant-specific strategy for responding to the event. The parameters selected must be able to demonstrate the success of the strategies at maintaining the key safety functions as well as indicate imminent or actual core damage to facilitate a decision to manage the response to the event within the emergency operating procedures (EOPs) and FLEX support guidelines or within the severe accident management guidelines (SAMGs).

The applicants should obtain the required on-site equipment and ensure appropriate arrangements are in place to obtain the necessary off-site equipment including its deployment at the site in the time required. Staging area for receipt of the equipment and a means to transport the off-site equipment to the deployment location should be identified. Standard connectors for electrical and mechanical equipment compatible with the site connections should be provided.

3. Conclusions

The development method of FLEX strategy for US NRC design certification is examined. The applicants should make unit-specific FLEX strategy and establish the minimum coping capabilities consistent with unit-specific evaluation of the potential impacts and responses to BDBEEs.

REFERENCES

[1] SECY-11-0093, "Recommendations for Enhancing Reactor Safety in the 21st Century, the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," 2011.

[2] SECY-11-0137, "Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned," 2011.

[3] Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," 2012.

[4] JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," 2012.

[5] NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Revision 0, 2012.

[6] SECY-12-0025, "Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Subsequent Tsunami," 2012.