NRR-PMDAPEm Resource

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Cc: TSCHILTZ, Michael
Subject: [External_Sender] Appendix H to NEI 12-06
Attachments: Appendix H to NEI 12-06 October 16 Path 1-3.docx

Mohamed/Nick,

Attached is an excerpt of Appendix H (through Path 3) in preparation for our public meeting next Wednesday. Our desired outcome would be to confirm that we have sufficiently resolved the NRC comments (#1-23) of 9/30, to enable more concentrated focus on the remaining portions of the Appendix in the coming weeks/months.

Thanks,
Andrew

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NEI 12-06 APPENDIX H

H.1 INTRODUCTION

The purpose of this appendix is to provide guidance for a mitigation strategies assessment (MSA) of the impact of the seismic hazard information developed in response to the U.S. Nuclear Regulatory Commission's "*Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident"* [1]. As a result of the information request, all licensees reevaluated the seismic hazard at their sites using updated seismic hazard information and present-day regulatory guidance and methodologies.

The mitigation strategies developed in response to EA-12-049 [2] assumed an extended loss of alternating current (AC) power (ELAP) with a loss of normal access to the ultimate heat sink (LUHS) from an unspecified event. EA-12-049 [2] was issued to help address beyond-design--basis external events prior to the time the information concerning the re-evaluated hazards was available. Specifically, since the information concerning the re-evaluated seismic hazards was not available to determine the impact on the facility, an unspecified event was used which presumed the event resulted in a loss of all AC power (a significant contributor for externally initiated events) combined with a loss of normal access to the ultimate heat sink, as described in EA-12-049 [2]. Now that the seismic hazards have been re-evaluated for all sites, more detailed evaluations of a plant's ability to withstand the re-evaluated seismic hazard can be performed and additional strategies for plant responses that preferably rely upon permanent installed plant equipment, which in some instances have been bolstered to withstand beyond-design-basis seismic events, can be developed. The use of permanently installed plant equipment for these strategies can reduce the need to rely on operator manual actions outside of the control room and instead rely on operator actions within the control room, which are more reliable.

The MSA determines whether the mitigation strategies as developed to meet EA-12-049 [2] can be implemented for the updated seismic hazard information resulting from the 50.54(f) request [1] mitigation strategy seismic hazard information (MSSHI). If it is determined that mitigation strategies developed to meet EA-12-049 [2] have not been evaluated or cannot be implemented for the MSSHI , the MSA considers other options such as performing additional evaluations, modifying existing mitigation strategies and/or diverse and flexible coping strategies (FLEX) equipment, or development of an alternate mitigation strategy (AMS) that addresses the MSSHI. If a mitigation strategy is developed that does not rely on FLEX, a basis for choosing the selected strategy should be provided. In those instances where an AMS is provided, FLEX equipment should provide for additional defense-in-depth through the provision of the FLEX equipment stored on site as described in section 5.3.1 and/or FLEX equipment transported to the site from the National Response Centers. The MSA will either demonstrate that the mitigation strategies can be implemented as currently developed or modified, or that an AMS can be developed for the MSSHI which provides for indefinite coping following a beyond-design-basis seismic event.

Licensees will use the guidance for performing an MSA in this Appendix to do the following:

- Confirm mitigating strategies, as currently implemented, are not rendered ineffective by the MSSHI;

- Develop and implement modifications necessary to ensure mitigating strategies are able to address the MSSHI; or
- Develop and implement alternate mitigating strategies.

A brief description of the MSA approach (and associated sections in this appendix) is as follows:

- Section H.2 establishes the characterization of the MSSHI.
- Section H.3 provides an approach for comparison of the seismic design basis used for mitigation strategy development to the MSSHI to determine if the MSSHI is bounded.
- Section H.4 provides guidance for the evaluation of mitigation strategies with respect to the MSSHI.
- Section H.5 provides performance criteria used to establish adequate seismic ruggedness requirements for structures, systems, and components (SSCs) that support mitigation strategies.
- Section H.6 provides requirements for documentation of the results.

H.2 CHARACTERIZATION OF THE MITIGATION STRATEGY SEISMIC HAZARD INFORMATION (MSSHI)

The MSSHI is the licensee's reevaluated seismic hazard information at the plant's site, developed using probabilistic seismic hazard analysis (PSHA). It includes a performance-based ground motion response spectrum (GMRS), uniform hazard response spectra (UHRS) at various annual probabilities of exceedance, and a family of seismic hazard curves at various frequencies and fractiles developed at the plant's control point elevation. Licensees typically submitted the reevaluated MSSHI including the UHRS, GMRS and the hazard curves at their plants to the NRC in March 2014, in response to the NRC 50.54(f) letter dated March 12, 2012. Figure 1 below describes the use of GMRS, UHRS and/or seismic hazard curves for the various mitigation strategy paths described in Section H.4.

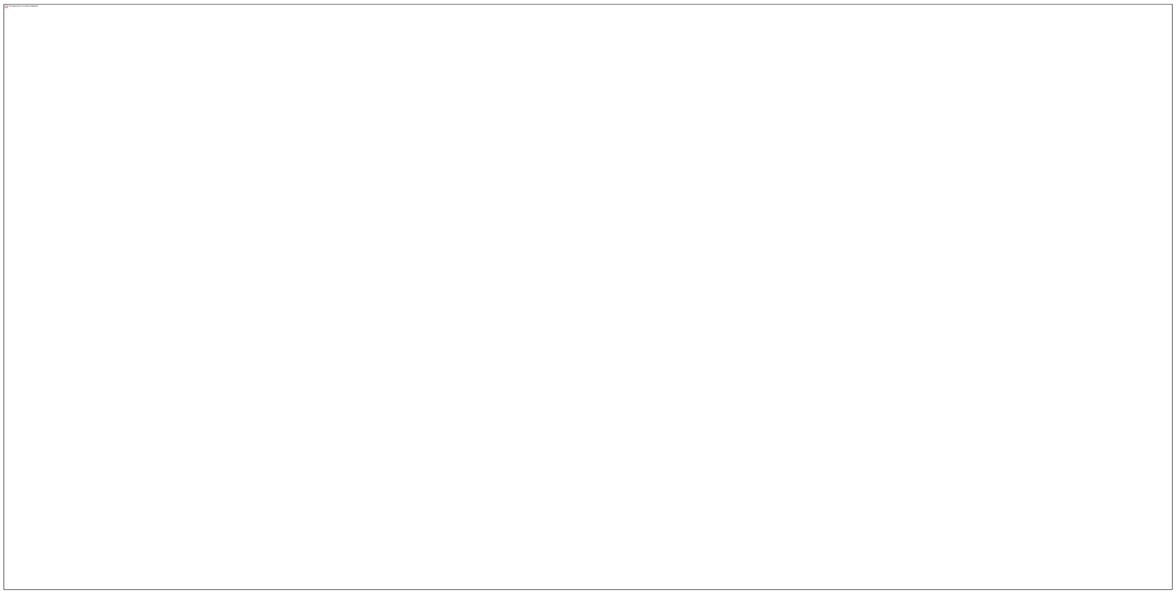

Figure 1: MSSHI Use for Appendix H Paths

As shown in Figure 1, the GMRS curve is used in paths 1 through 4. The hazard curves are used, in addition to UHRS and GMRS, in path 5 when the MSA is based on a probabilistic evaluation such as a seismic probabilistic risk assessment (SPRA). Detailed descriptions of the use of MSSHI for each of the five paths are discussed in the sections below.

H.3 APPROACH FOR COMPARISON OF EXISTING SEISMIC DESIGN BASIS / PLANT CAPACITY TO MSSHI

This section provides the approach for comparing the GMRS (consistent with the screening criteria in Electric Power Research Institute (EPRI) 1025287 [6]) to the seismic design basis spectrum used for developing the FLEX mitigation strategies. In most cases, FLEX was designed or evaluated using the safe shutdown earthquake (SSE)[1]. In some cases, FLEX equipment storage structures were designed using American Society of Civil Engineers (ASCE) 7-10 [5] or storage was outside a structure and evaluated for seismic interactions. The term SSE is defined in the safety analysis reports (SAR) of plants, but is broadly used in this appendix to encompass the previous mitigation strategy seismic design bases, including FLEX storage structures designed using ASCE 7-10, which was deemed an acceptable alternative design criteria in Section 5.3.1. For path 3, the GMRS is compared to a plant capacity spectrum derived from the individual plant examination of external events (IPEEE) program using plant's high-confidence-of-low-probability-of-failure (HCLPF) capacity. The development of the IPEEE HCLPF spectrum or IHS is described in EPRI 1025287 [6].

The GMRS at frequencies 1 Hz and higher is compared to the SSE (or IHS) to determine whether the SSE (or IHS) bounds the GMRS, or identify any areas of exceedance of the SSE (or

[1] Some plants have used the term "Design Basis Earthquake" or DBE, which is synonymous to SSE.

IHS). The results of the comparison are used as input to the evaluation of mitigation strategies in Section H.4. The assessment process is illustrated in Figure 2 and described in detail below.

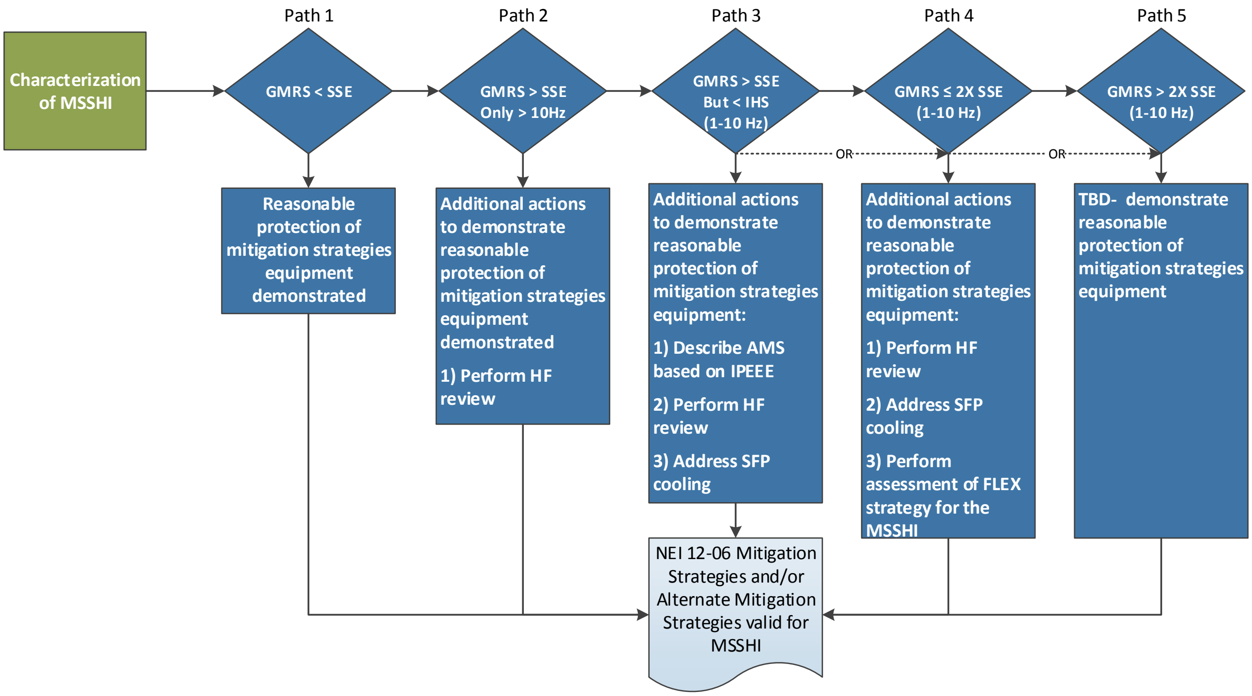

Figure 2: Mitigation Strategy Assessment Process for the MSSHI

H.4 EVALUATION OF MITIGATION STRATEGIES

The mitigation strategies are evaluated with respect to the MSSHI, using the process illustrated in Figure 2.

If the SSE spectrum bounds the GMRS at frequencies 1 Hz and greater, licensees should follow the process described in Section H.4.1 (Path 1 in Figure 2) and document completion of the MSA, demonstrating that the mitigating strategies are reasonably protected to the MSSHI. In the event that the GMRS is not bounded by the SSE, an assessment of the impacts on mitigation strategies is required. The purpose of the assessment is to determine the adequacy of strategies in consideration of the MSSHI. Sections H.4.2 through H.4.5 of this appendix provide guidance for development of an MSA to demonstrate that the FLEX strategies or AMS are reasonably protected for the MSSHI.

The MSA evaluates the plant equipment, operator actions and procedures required to successfully implement the mitigation strategies so that a site may cope indefinitely due to the beyond design-basis seismic event. Sections H.4.2 and H.4.4 provide approaches to evaluate implementation of the mitigation strategies with respect to the MSSHI. Section H.4.3 provides an approach for evaluation of an AMS that is capable of demonstrating plant safety with respect to the MSSHI. An AMS primarily relies upon permanent installed plant equipment and in some instances may include certain aspects of FLEX mitigation strategies that that have been evaluated to the MSSHI.

For each of the paths identified in H.4.1 through H.4.5, the MSA should be appropriately documented per Section H.6 of this appendix.

H.4.1 PATH 1: GMRS < SSE

If the GMRS described in Section H.2 is bounded by the SSE spectrum at frequencies 1 Hz and greater, then additional evaluation is unnecessary, consistent with Path 1 of Figure 2. Section 3.2.1 of EPRI 1025287 describes two "Special Screening Considerations" for plants with low seismic ground motions or narrow banded exceedances in the frequency range between 1-10 Hz that can be applied in this Path 1 evaluation. In addition, minor GMRS exceedances accepted by the NRC as not significant in the site specific NRC NTTF 2.1 final determination letter (October 2015 reference TBD), can be considered to meet the path 1 screening assessment. For plants meeting these criteria, the FLEX strategies are reasonably protected to the MSSHI based on the underlying process used to develop the FLEX strategies.

H.4.2 PATH 2: GMRS < SSE WITH HIGH FREQUENCY EXCEEDANCES

If the GMRS described in Section H.2 is less than the SSE in the 1 to 10 Hz range consistent with Section 3.2 of EPRI 1025287 [6], but is not bounded at frequencies >10 Hz, an MSA should be performed as illustrated in Path 2 of Figure 2. Section 3.2.1 of EPRI 1025287 describes two "Special Screening Considerations" for plants with low seismic ground motions or narrow banded exceedances that can be applied in this Path 2 evaluation. In addition, minor GMRS exceedances accepted by the NRC as not significant in the site specific NRC NTTF 2.1 final determination letter (October 2015 reference TBD), can be considered to meet the path 1 screening assessment in H.4.1.

Introduction:

For plants where the GMRS spectrum above 10 Hz exceeds the SSE spectrum, licensees can demonstrate adequacy of the mitigation strategy with respect to the MSSHI by performing an MSA that consists of an evaluation of HF sensitive in-plant SSCs required for mitigation strategy implementation.

Basis:

FLEX equipment has been evaluated to demonstrate adequacy following the guidance in Section 5. The SSE exceedances (i.e., >10 Hz) can be evaluated by performing an MSA to show that mitigation strategies can be implemented as planned using the guidance in Sections 3 and 4 of EPRI 3002004396 [7] and the acceptance criteria in Section H.5 to address the effect of the HF exceedances on sensitive components.

Background and Discussion:

FLEX equipment has been evaluated to demonstrate adequacy following the guidance in Section 5. This evaluation can be supplemented to consider HF GMRS exceedances above the SSE using the process as follows. Section 4 of EPRI 3002004396 [7] describes a HF evaluation process focusing on contact control devices subject to intermittent states (e.g. relay chatter) in seal-in and lockout circuits. For the MSA HF evaluation, the acceptance criteria from Section H.5 can be used and the scope of circuits to be reviewed include installed FLEX SSCs credited for the Phase 1 response as well as permanently installed Phase 2 or 3 SSCs that have the capability to begin operation without operator manual actions.

Therefore, the MSA HF evaluation scope is focused on seal-in and lock out circuits in the following systems and equipment.

- Devices whose chatter could cause malfunction of a reactor SCRAM[2]
- Devices in seal-in or lockout circuits whose chatter could cause a reactor coolant system (RCS) leakage pathway that was not considered in the mitigation strategy. Examples include the automatic depressurization system (ADS) actuation relays in boiling-water reactors (BWRs) and relays that could actuate pressurizer power-operated relief valves (PORVs).
- Relays and contactors that may lead to circuit seal-ins or lockouts that could impede the FLEX capabilities for mitigation of seismic events, including credited installed Phase 1 direct current (DC) systems and alternating current (AC) systems supported through the inverters and any permanently installed Phase 2 or 3 SSCs that have the capability to begin operation without operator manual actions.

H.4.3 PATH 3: GMRS < IHS

If the high-confidence-of-low-probability-of-failure (HCLPF) plant capacity spectrum (IHS) developed from the evaluations for Individual Plant Examination of External Event (IPEEE) envelops the SSE between 1 and 10 Hz with the exception of small narrow band exceedances that meet the criteria of EPRI 1025287 [6], an AMS may be used based upon the IPEEE, consistent with Path 3 of Figure 2. IPEEE safe-shutdown paths would be used to demonstrate reasonable protection of SSCs relied upon for this AMS. Alternatively, licensees may elect to perform an MSA of the impacts of MSSHI on mitigation strategies consistent with Path 4 of Figure 2 or perform an SPRA-informed MSA consistent with Path 5 of Figure 2.

The following prerequisites apply in order to use the IPEEE evaluations for H.4.3:

1. Licensees using this approach should have previous seismic evaluations that were conducted under the IPEEE effort and accepted by NRC per Enclosure 2 of their May 9, 2014 letter [8] or in a subsequent determination, provided the IHS completely envelops the GMRS between 1 and 10 Hz, with the exception of small narrow band exceedances that meet EPRI 1025287 [6] criteria.

[2] A SCRAM is a manually-triggered or automatically-triggered rapid insertion of all control rods into the reactor, causing emergency shutdown.

2. Licensees using this approach should have conducted a full scope IPEEE or, if a plant was in the focused scope bin, the licensee can bring the focused scope IPEEE assessment in line with a full scope assessment as defined in GL 88-20 Supplements 4 [10] and 5 [11] and NUREG-1407 [9] in accordance with the guidance in EPRI 1025287[6]. Plants that conducted a reduced scope IPEEE assessment cannot use Path 3 for their AMS.
3. For IPEEEs, the EPRI SMA approach was based on EPRI NP-6041-SL Rev. 1 [15]. This approach defined the SEL for evaluation of safe shutdown success paths to be comprised of those SSCs required to bring the plant to a stable condition (either hot or cold shutdown) and maintain that condition for at least 72 hours. Therefore, for plants with an IPEEE based on the SMA described in EPRI 1025287 [6] approach, the IPEEE results must be evaluated for limitations that are based on the 72 hour coping duration. Plants that performed a seismic PRA or the NRC margin method for IPEEE may have limitations based on coping durations of less than 72 hours that also must be evaluated. Generally, the conclusions of the SMAs and SPRAs are not sensitive to coping duration. However, certain consumable items, such as water and fuel oil inventories, may have been evaluated based on a limited onsite supply. The ability to continue coping would require re-supply of consumables. Site access is restored to a near-normal status and/or augmented transportation resources are available within 24 hours consistent with NEI 12-01 [16] to allow for additional supplies to be brought in and allow for continuation of coping strategies and maintain the plant in a stable condition. FLEX Phase 3 deployment could replenish consumables beyond the 72 hours coping duration and a plant-specific evaluation should be performed to conclude that SSCs that limit the EPRI SMA-based IPEEE coping duration to 72 hours are available for an indefinite period following the beyond design-basis seismic event to support continued maintenance of the safe shutdown condition.

Introduction:

An IPEEE-based AMS relies on the comprehensive seismic evaluation of plant equipment to demonstrate reasonable protection for the re-evaluated MSSHI. Licensees that choose this path can rely on the previous seismic evaluations that were conducted under the IPEEE effort and accepted by NRC per Enclosure 2 of their May 9, 2014 letter [8] or in a subsequent determination, provided that the IPEEE HCLPF spectrum (IHS) envelops the GMRS between 1 and 10 Hz, with the exception of small narrow band exceedances that meet the criteria in EPRI 1025287 [6]. The development of the IHS is described in EPRI 1025287 [6].

IPEEEs relied on the results of an SPRA, an EPRI seismic margins assessment (SMA) methodology, or an NRC SMA methodology to demonstrate the capability to bring the plant to a safe shutdown condition following a review level earthquake (RLE) as described in NUREG-1407 [9]. These seismic evaluation approaches evaluated multiple redundant safe shutdown success paths. The safe shutdown success paths provide independent means of achieving a safe shutdown condition following a severe seismic event (e.g., core cooling by heat removal from the steam generators and core cooling by RCS ‘feed and bleed’).

To provide a complete MSA seismic evaluation, the IPEEE evaluation is supplemented by reviews of spent fuel pool cooling functions and high frequency exceedances (as applicable).

Basis:

Seismic evaluations performed under IPEEE included SSCs in multiple redundant safe-shutdown success paths. Therefore, based on the results of the IPEEE, safe-shutdown of the plant following a seismic event can be accomplished, and consequences can be mitigated, for a seismic event up to the plant capacity level (i.e., the IHS) for which SSCs in the IPEEE were evaluated.

In addition, seismic evaluations for spent fuel pool cooling should be performed using the MSSHI to demonstrate that spent fuel would remain cooled following a seismic event, and a review of HF sensitive components should be performed, as needed.

Background and Discussion:

IPEEE Evaluations

The IPEEEs were completed by plants in the 1990s under NRC Generic Letter (GL) 88-20 Supplements 4 [10] and 5 [11] in accordance with the guidance of NUREG-1407 [9]. Acceptable approaches to perform IPEEE included the NRC seismic margin assessment (SMA) method, the EPRI SMA method, or an SPRA. For each approach, a seismic equipment list (SEL) was developed that included multiple redundant safe shutdown success paths and/or accident sequences. The evaluation of SSCs in these redundant safe shutdown success paths demonstrates reasonable protection of the capability to maintain or restore core cooling and containment capabilities for a beyond design-basis seismic event up to the level of the IHS, which envelopes the GMRS in the 1 to 10 Hz range (see Section H.2).

NUREG-1407 [9] categorized plants performing IPEEE in three bins – reduced scope, focused scope and full scope.

The IPEEEs were generally performed using input motions based on the following:

a. Median-centered response spectrum using the NUREG/CR-0098 [12] shape, anchored to 0.3g peak ground acceleration (PGA).
b. For SPRAs, plants generally used the mean Uniform Hazard Response Spectra (UHRS) and hazard curves developed by Lawrence Livermore National Laboratory (LLNL) in NUREG-1488 [13] and/or EPRI in EPRI NP-6395-D [14].
c. In some cases, past SPRAs were submitted for IPEEE closure that used input motions and hazard curves that preceded the LLNL and EPRI hazard curves of NUREG-1488 [13] and EPRI NP-6395-D [14] respectively.

Consistent with the input spectrum shape used in an IPEEE, an IHS can be developed, as described in EPRI 1025287 [6].

Spent Fuel Pool Cooling Evaluation

Equipment needed to accomplish the spent fuel pool (SFP) cooling function (SFP cooling system components, SFP makeup capability, and SFP level instrumentation etc.) should be evaluated for seismic adequacy to the MSSHI. For developing in-structure response spectrum (ISRS) corresponding to the GMRS, it is acceptable to scale the SSE-based ISRS by the highest ratio of GMRS/SSE in the 1 to 10 Hz range for these evaluations. A high frequency evaluation of the SFP cooling key safety functions is not warranted since operators would have a significant amount of time to restore SFP cooling.

High Frequency Evaluation:

Licensees following this path that also have high frequency exceedances (GMRS > IHS above 10 Hz) should perform a high frequency evaluation of relays in the IPEEE scope consistent with the criteria in Sections 3 and 4 of EPRI 3002004396 [7], using the acceptance criteria in H.5 .

Availability of FLEX Equipment s:

The alternate mitigation strategies described in H.4.3 do not generally rely upon availability of FLEX equipment. In these cases where the alternate mitigation strategies do not rely upon the availability of FLEX equipment, availability of FLEX equipment should still be treated in the MSA as a means of additional defense in depth.

Portable FLEX Equipment

Portable FLEX equipment is stored onsite and available for deployment to support the maintenance of core cooling, containment, and spent fuel cooling functions.

Portable FLEX equipment is stored in accordance with Section 5.3.1 and is considered rugged with respect to an increased seismic hazard. The portable FLEX equipment are located in an area where ground motion amplification through a structure is not expected (i.e., structure located on grade, equipment stored on the ground elevation of the building) and the equipment is restrained. As previously established in Section 11, "Portable towable equipment that is designed for over the road transport typically used in construction/remote sites are deemed sufficiently rugged to function following a BDB seismic event."

Offsite Resources

Portable FLEX equipment is also available from offsite. The industry has established two (2) National SAFER Response Centers (NSRCs) to support utilities during beyond-design-basis events. Each plant has established contracts with the Pooled Equipment Inventory Company (PEICo) to participate in the process for support of the NSRCs as required. Each NSRC will hold five (5) sets of equipment, four (4) of which will be able to be fully deployed when requested, the fifth set will have equipment in a maintenance cycle. In the event of a beyond-design-basis seismic event, equipment can be moved from an NSRC to a local assembly area established by the Strategic Alliance for FLEX Emergency Response (SAFER) team. From there, equipment can be taken to the site and staged at the SAFER onsite Staging Area by helicopter if ground transportation is unavailable. Communications will be established between the site and the SAFER team via satellite phones and required equipment moved to the site as needed. First arriving equipment will be delivered to the site within 24 hours from the initial request. The order in which equipment is delivered is identified in the *SAFER Response Plan*.

Therefore, additional defense-in-depth to provide reasonable protection against the MSSHI is expected to be available from on-site and/or off-site portable equipment.

<u>Assessment of AMS where FLEX Equipment Relied Upon</u>

An AMS utilizes any configuration of FLEX equipment and/or plant equipment to maintain or restore core cooling, spent fuel pool cooling, and containment capabilities for the duration of the event. Therefore, some portion of the AMS developed under H.4.3 may utilize FLEX equipment.

Equipment stored on-site or off-site whose primary function is to support an AMS will be considered to be FLEX equipment in accordance with the definition in Appendix A. Such equipment should be designed and implemented to the same standards (e.g., programmatic controls) to which the FLEX strategies were designed and implemented.

To the extent that FLEX equipment is relied upon within the AMS, the MSA should address the following:

- The sequence of events should be established based on the MSSHI as the initiating event.
- The MSA should use the General Criteria and Baseline Assumptions in Section 3.2.1 with the exception that the only losses that need to be considered (e.g., ELAP, LOOP, LUHS) are those that would be caused by the MSSHI.
- The impacts of the MSSHI should be used in place of the SSE to perform the screening and evaluation per Section 6. Reasonable protection from the MSSHI should be provided for the FLEX equipment which is being used in the AMS.
- If deployment locations of FLEX equipment are changed as a result of the evaluation per Section 6, the design considerations for the strategy should be reevaluated per Section 11.2.1.
- The equipment storage guidance of Section 11.3 should be reassessed based on the impacts of the MSSHI.
- The impacts of the MSSHI should be used in place of the SSE in the consideration of robustness of plant equipment as defined in Appendix A. For determining robustness only the GMRS should be used as the applicable hazard.
- The impacts of the MSSHI should be used to evaluate the applicability of the Minimum Baseline Capabilities of Section 3.2.2 with the only losses (e.g., ELAP, LOOP, LUHS) needing to be considered being those that would be caused by the MSSHI. Additionally, the AMS may use plant equipment, FLEX equipment, or any combination of the two.
- The seismic protection features relied upon for the AMS should meet the performance criteria provided in Section H.5.
- New or modified actions to FLEX should be validated in accordance with Appendix E.