Seismic Evaluation Guidance

Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic

This document does **NOT** meet the requirements of 10CFR50 Appendix B, 10CFR Part 21, ANSI N45.2-1977 and/or the intent of ISO-9001 (1994).

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Product Description

Following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the Nuclear Regulatory Commission (NRC) established a Near Term Task Force (NTTF) to conduct a systematic review of NRC processes and regulations. The NTTF was also tasked with determining if the agency should make additional improvements to its regulatory system.

Background

The NTTF developed a set of recommendations intended to clarify and strengthen the regulatory framework for protection against natural phenomena. Subsequently, the NRC issued a 50.54(f) letter that requested information to assure all U.S. nuclear power plants address these recommendations.

EPRI 1025287 provides guidance for conducting seismic evaluations as requested in Enclosure 1 of the 50.54(f) letter [1], which requests that licensees and holders of construction permits under 10 CFR Part 50 reevaluate the seismic hazards at their sites against present-day NRC requirements and guidance.

This report provides supplemental guidance for performing near-term expedited seismic evaluations and applicable plant modifications, along with a schedule for performing the applicable risk evaluations described in EPRI 1025287.

Objectives

To provide guidance on the performance of expedited plant seismic evaluations in support of the requirements of NTTF Recommendation 2.1: Seismic.

Approach

The project team formulated guidance for the seismic evaluations through a series of expert meetings, supplemented by a number of utility trials of the proposed guidance. An expedited seismic evaluation process is described along with references to the screening process and complete risk evaluation criteria from EPRI 1025287 as applicable. A number of public meetings were also held with the NRC during development of the guidance to discuss evaluation criteria and to achieve acceptance of the guidance and implementation schedules.

Results and Findings

This report outlines a process and schedule for responding to the seismic evaluations requested in the NRC's 50.54(f) letter [1] under Recommendation 2.1: Seismic. The process includes a near-term expedited seismic evaluation process followed by plant risk evaluations in accordance with EPRI 1025287. The guidance includes a screening process for performing the near-term evaluations, as well as equipment selection, seismic evaluation, and modification criteria for performing the near-term evaluations. The report also outlines how the near-term expedited seismic evaluation process and the long-term plant risk evaluations provide for a complete response to the NRC's 50.54(f) letter [1] under Recommendation 2.1: Seismic.

Comment [NRC1]: Formatting issue.

Applications, Value, and Use

The guidance in this report is intended primarily for use by all U.S. nuclear power plants to meet the requirements of NTTF Recommendation 2.1: Seismic. The primary value in this guidance is that it has been reviewed with the NRC and can be applied by all plants to provide a uniform and acceptable industry response to the NRC.

Keywords
Augmented Approach
ESEP
Earthquakes
Fukushima
Seismic hazard

List of Acronyms

AC	alternating current
ACI	American Concrete Institute
ADV	atmospheric dump valve
AFW	auxiliary feedwater
AISC	American Institute of Steel Construction
ANS	American Nuclear Society
ASME	American Society of Mechanical Engineers
BWR	boiling water reactor
CDFM	conservative deterministic failure margin
CEUS	Central and Eastern United States
CST	condensate storage tank
DC	direct current
ECCS	emergency core cooling system
EFW	emergency feedwater
ESEL	expedited seismic equipment list
ESEP	expedited seismic evaluation process
GERS	generic equipment ruggedness spectra
GMRS	ground motion response spectrum
HCLPF	high confidence of a low probability of failure
HPCI	high pressure coolant injection
HVAC	heating, ventilation, and air conditioning
IC	
ISRS	in-structure response spectra
MCC	motor control center
NEI	Nuclear Energy Institute
NPP	nuclear power plant
NRC	Nuclear Regulatory Commission
NSSS	nuclear steam supply system
NTTF	Near Term Task Force

PGA	peak ground acceleration
PORV	power operated relief valve
PRA	
PWR	pressurized water reactor
RCIC	reactor core isolation cooling
RCP	reactor coolant pump
RCS	reactor coolant system
RLGM	review level ground motion
RPV	reactor pressure vessel
SAMG	
SBO	
SFP	spent fuel pool
SG	steam generator
SMA	seismic margin assessment
SPRA	seismic probabilistic risk assessment
SRT	seismic review team
SRV	
SSC	structures, systems, and component
SSE	safe shutdown earthquake
SSI	soil-structure interaction
TDAFW	turbine driven auxiliary feedwater
TRS	test response spectrum
UHRS	uniform hazard response spectrum
WUS	Western United States

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Section 1: Purpose and Approach

Following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011 Great Tohoku Earthquake and subsequent tsunami, the United States Nuclear Regulatory Commission (NRC) established the Near Term Task Force (NTTF) in response to Commission direction. The NTTF issued a report that made a series of recommendations, some of which were to be acted upon "without unnecessary delay." Subsequently, the NRC issued a 50.54(f) letter that requests information to ensure that these recommendations are addressed by all U.S. nuclear power plants (NPPs). The principal purpose of this report is to provide additional guidance to augment licensee response to the request for information in the 50.54(f) Letter, Enclosure 1, Recommendation 2.1: Seismic [1]. Specifically, this report addresses interim evaluations of critical plant equipment to be implemented prior to performing complete plant seismic risk evaluations.

Section 1 of this report provides a summary of the purpose and scope of the Augmented Approach being recommended by the nuclear power industry to fulfill Enclosure 1: Seismic of the 50.54(f) request for information.

1.1 Augmented Approach to Responding to Information Request for NTTF Recommendation 2.1

The approach described in this report has been developed by EPRI, working with experts from within the nuclear industry, with the intent of identifying reasonable measures that can be employed to accomplish an effective seismic evaluation in an expedient manner. More specifically, the approach was designed to constitute a specific path to focus the initial industry efforts on short term evaluations that would lead to prompt modifications to some of the most important components that could improve plant seismic safety. This short term aspect of the Augmented Approach is referred to as the Expedited Seismic Evaluation Process (ESEP) and is described in the subsequent sections of this report. The ESEP addresses the requested information part of the 50.54(f) Letter [1] that requests "interim evaluations and actions taken or planned to address the higher seismic hazard relative to the design basis, as appropriate, prior to completion of the risk evaluation." The seismic risk evaluation portion of the Augmented Approach is documented in EPRI Report 1025287 [2].

This approach reflects careful consideration of the NRC's description of an acceptable approach for the seismic elements of Recommendation 2.1 (documented in Attachment 1 to Seismic Enclosure 1 of the March 12, 2012 Request for Information [1]). In general, the approach described in this report is intended to conform to the structure and philosophy of the nine steps suggested by the NRC and outlined in that attachment. Key elements of the approach have been added to provide an expedited schedule for implementing key seismic modifications associated with selected equipment as described in Section 3 of this report. As such, this is an "augmented approach" being recommended by the industry that provides additional seismic safety considerations (i.e., reviews and potential seismic upgrades for a select set of equipment) in a more expedited fashion than was requested in the 50.54(f) [1] request for information.

Figure 1-1 illustrates the timeline for employing the Augmented Approach, with a breakdown shown between the Expedited Seismic Evaluation Process (ESEP) and the seismic risk evaluations. The Augmented Approach response to the seismic portion of the 50.54(f) letter is based on a progressive screening approach and is broken down into six major task areas:

1. Seismic Hazard and Site Response Characterization
2. Ground Motion Response Spectrum (GMRS) Comparisons and Plant Screening
3. ESEP Seismic Evaluations
4. ESEP Seismic Modifications
5. Prioritization of plants for Risk Assessments
6. Seismic Risk Evaluations

Task areas 1 and 6 are described in detail within EPRI 1025287 [2] and the methodology will not be repeated in this report. Task 2 is partially described in EPRI 1025287 [2] and is also discussed in Section 2 of this report as it applies to the ESEP. Tasks 3 and 4 apply to the ESEP and are the subject of the remaining sections of this report. Task 5 is described in EPRI 1025287 Section 5.

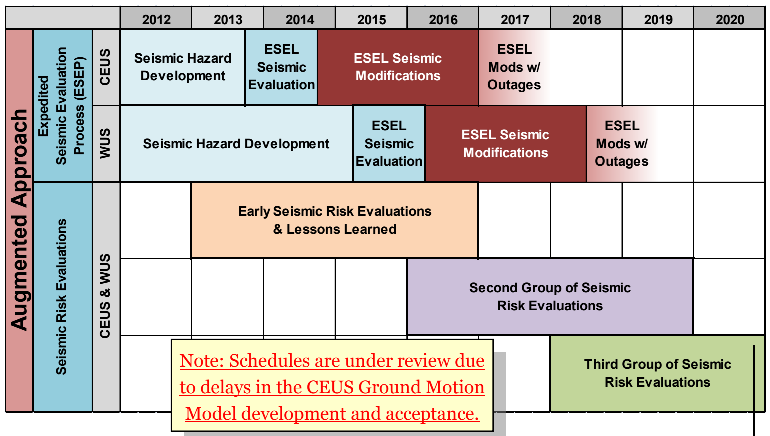

Figure 1-1
Recommended Augmented Approach to Respond to Information Request 2.1 for Seismic

1.2 Expedited Seismic Evaluation Process (ESEP)

The ESEP was developed to focus initial resources on the review of a subset of the plant equipment that can be relied upon to protect the reactor core following beyond design basis seismic events. Figure 1-2 depicts the basic elements of the ESEP. This figure also describes where each of the key elements is discussed within this report (see the grid on the left of the figure).

In selecting the items to be included in an expedited seismic evaluation, the ongoing FLEX process [3, 4, 5] offers an appropriate starting point for consideration. As described in Section 3, the FLEX process adds an additional layer of defense-in-depth protection for beyond design basis events. The installed equipment and connection points associated with FLEX are therefore considered an appropriate list of items to consider for the expedited seismic evaluation. Section 3 in this report describes the selection criteria for the Expedited Seismic Equipment List (ESEL). The use of the FLEX process to obtain an equipment list for the ESEP does not affect or change any requirements for the FLEX implementation. FLEX is used only as an input to obtain an appropriate set of equipment for ESEP.

Operating nuclear plants in the U. S. are expected to conduct this ESEP as described in Figures 1-1 and 1-2 on the schedule shown in Table 1-1. The ESEP was developed to be able to promptly assess and address potential seismic safety enhancements.

Figure 1-3 contains a more detailed flow chart of the ESEP actions. A more complete set of actions included within the ESEP is listed. These actions will be referenced in later sections of this report.

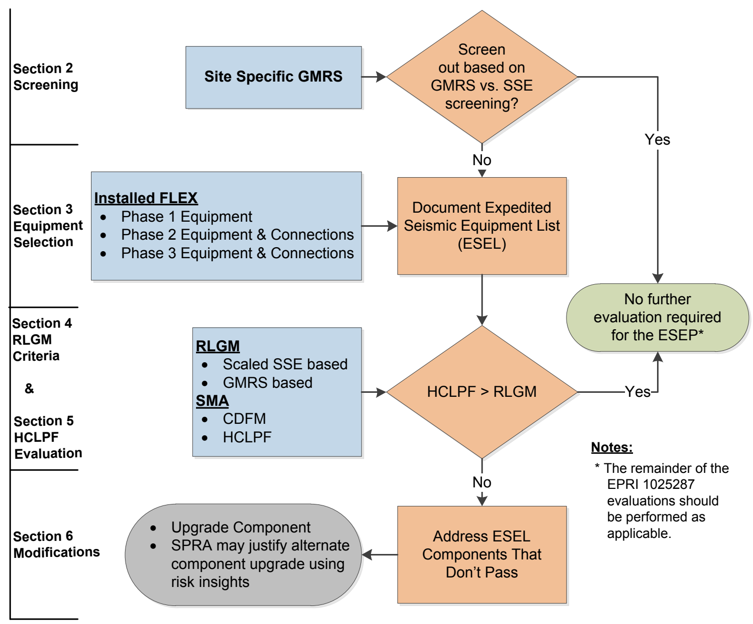

Figure 1-2
Expedited Seismic Evaluation Process for the Augmented Approach

Sections 2 through 7 of this report describe the elements of the ESEP. Section 2 contains the description of the screening criteria associated with comparisons of the ground motion response spectra (GMRS) to the safe shutdown earthquake (SSE). Section 3 characterizes the equipment selection criteria for the ESEP. Section 4 describes the elements of the recommended methods to develop the review level ground motion (RLGM). Section 5 describes the seismic capacity criteria based on characterization of the high confidence of a low probability of failure (HCLPF) capacity associated with the equipment reviewed as part of the ESEP. Section 6 contains the description of the modification criteria. Finally, Section 7 documents the submittal criteria for the ESEP.

Table 1-1
Expedited Seismic Evaluation Process Implementation Schedule

Comment [AK2]: This, like the other figure covering schedule, needs to be updated.

Region	Activity	Schedule[1]
Central and Eastern United States (CEUS) Plants	Submit updated seismic hazards and GMRS and screening	September 2013
	Complete ESEL HCLPF Calculations (if necessary) and submit ESEP report to NRC	September 2014
	Complete ESEL modifications not requiring plant outages	December 2016
	Complete ESEL modifications requiring plant outages	Within 2 outages of December 2014
Western United States (WUS) Plants	Submit updated seismic hazards and GMRS and screening	March 2015
	Complete ESEL HCLPF Calculations (if necessary) and submit ESEP report to NRC	January 2016
	Complete ESEL modifications not requiring plant outages	June 2018
	Complete ESEL modifications requiring plant outages	Within 2 outages of January 2016

[1] Note: Schedules are under review due to delays in the CEUS Ground Motion Model development and acceptance.

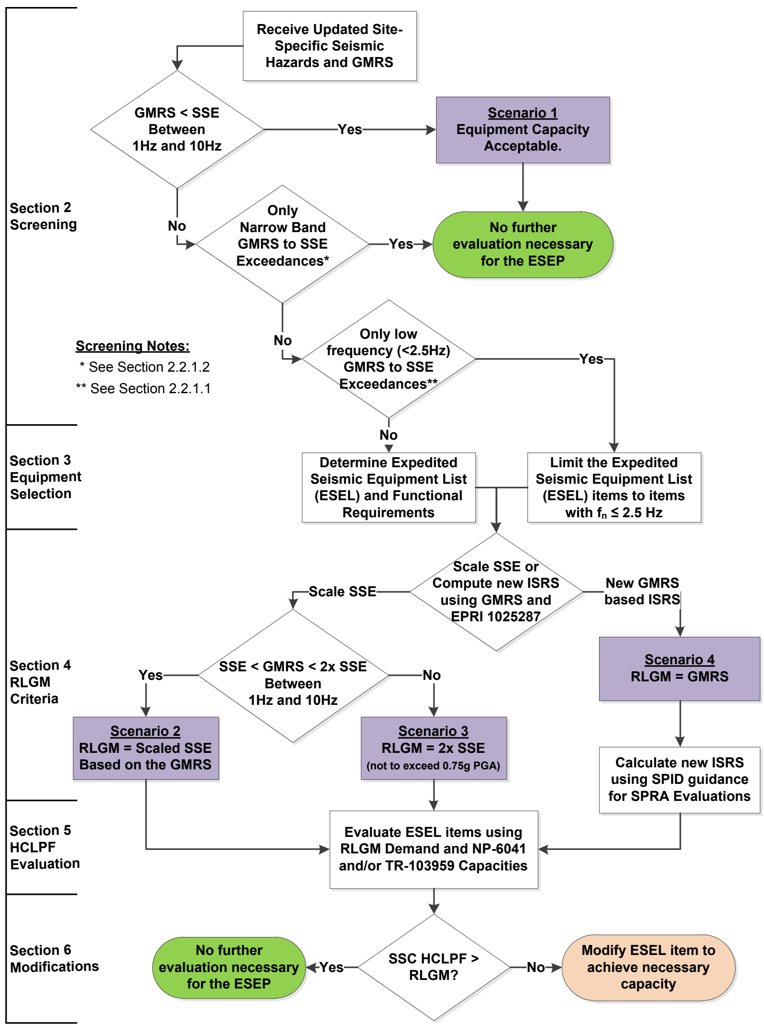

Figure 1-3
Detailed Flow Chart of the ESEP for the Augmented Approach

Comment [lmr3]: Remove scenario 3 box parenthetical note – not to exceed 0.75g PGA

Section 2: Screening for the ESEP (SSE-to-GMRS)

2.1 Background on Screening

Screening for application of the ESEP is based on a comparison of the SSE with the GMRS and uses criteria from EPRI 1025287 Section 3 [2]. The horizontal GMRS should be compared to the horizontal 5% damped SSE as outlined in Figure 2-1. This screening process, along with examples, is described in more detail below.

2.2 SSE Screening Task (SSE-to-GMRS Comparison)

The SSE is the plant licensing basis earthquake as identified in EPRI 1025287 Section 2 [2]. Similar to Reference 2, the first step in the SSE screening process is to compare the SSE to the GMRS in the 1 to 10 Hz region of the response spectrum. If the SSE envelopes the GMRS between 1 and 10 Hz, then the plant screens out of the ESEP[2].

Comment [lmr4]: Revise footnote to delete second sentence. The max RLGM is described in Section 4.

If the initial comparison of the SSE to GMRS does not demonstrate that the SSE envelops the GMRS in the 1 to 10 Hz region, then the licensees may consider two special screening considerations described below.

2.2.1 Special Screening Considerations

Consistent with EPRI 1025287 Section 3.2.1 [2], there are two special screening considerations:

- GMRS Comparisons and Screening of Plants at Low Seismic Hazard Sites, and
- Narrow Band Exceedances in the 1 to 10 Hz Range.

[2] For Diablo Canyon, the Double Ddesign Earthquake/licensing (DDE) should be used as the SSE for screening. The more recent 0.75g basis earthquake (i.e. Hosgri 0.75 g) should be appropriate for this evaluation earthquake and its associated ISRS are appropriate for the upper bound for this evaluation.

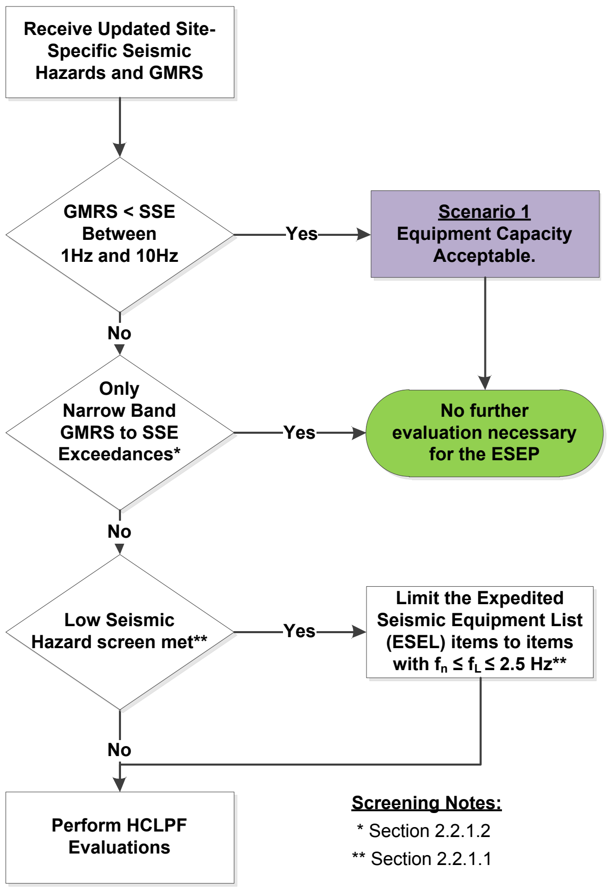

Figure 2-1
Comparison of GMRS to SSE (5% Damping) for the ESEP

2.2.1.1 GMRS Comparisons and Screening of Plants at Low Seismic Hazard Sites

The screening process described in EPRI 1025287 Section 3.2.1.1 [2] can be used to determine if the plant can be screened out as a low seismic hazard plant.

Low-frequency GMRS exceedances (below 2.5 Hz) at low seismic hazard sites do not require a plant to perform a full ESEP. Instead, it is sufficient to first identify the Expedited Seismic Equipment List (ESEL, see Section 3) items that are potentially susceptible to damage from spectral accelerations at frequencies below which the highest frequency f_L (f_L < 2.5

Hz) acceleration exceeds the SSE spectral acceleration. Examples of ESEL items and failure modes potentially susceptible to damage from spectral accelerations at low frequencies are:

1) Liquid sloshing in atmospheric pressure storage tanks

2) Sliding and rocking of unanchored components

After identifying the ESEL items that are potentially susceptible to lower frequency accelerations, the ESEL can be limited to items whose natural frequency is below the highest frequency f_L (f_L < 2.5 Hz) where the GMRS spectral acceleration exceeds the SSE spectral acceleration. Other than this limitation, the ESEP should be completed as shown in Figures 1-3 and 2-1.

2.2.1.2 Narrow Band Exceedances in the 1 to 10 Hz Range

The screening process described in EPRI 1025287 Section 3.2.1.2 [2] can be used to determine if the plant can be screened out as having only narrow banded GMRS exceedances between 1 and 10 Hz. If the plant passes this criterion, then the plant screens out of the ESEP.

Section 3: Equipment Selection

3.1 Introduction and Background

In response to Order EA 12-049 [4], all U.S. plants are required to create mitigating strategies for beyond design basis events. Industry has prepared a guidance document [3] that governs the requirements for this diverse and flexible coping capability, referred to by the industry as FLEX. Figure 3.1, below, illustrates how FLEX supplements the existing capabilities to add an additional layer of defense in depth against severe natural events. The ESEP will focus on a subset of key installed equipment using FLEX as a vehicle to develop this equipment list.

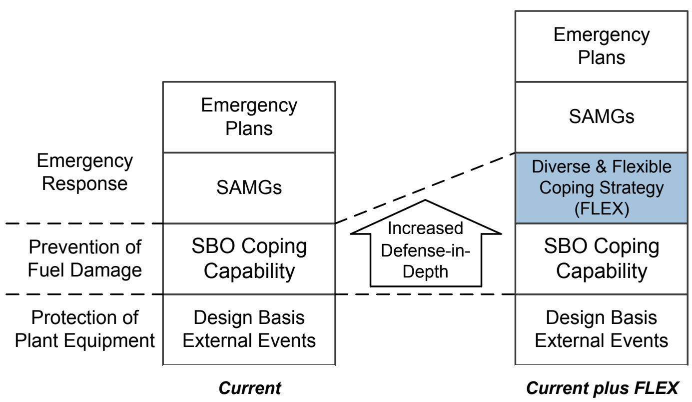

Figure 3-1
FLEX Enhances Defense in Depth (Ref [3])

3.2 Selection of Expedited Seismic Equipment List (ESEL)

The selection of the Expedited Seismic Equipment List (ESEL) will be derived from equipment identified in the plant-specific FLEX implementation strategy. In responding to EA 12-049, each plant will have defined an essentially indefinite coping capability for scenarios involving an extended loss of alternating current (AC) power condition. Loss of ~~alternating current (~~AC~~)~~ power has been found to be an important contributor to seismic risk in many seismic probabilistic risk assessments (SPRAs). Thus, by considering the selected FLEX equipment as the source for the ESEL, plant capabilities to mitigate an important contributor to seismic risk are being enhanced.

The underlying strategies for coping with these conditions involve a three-phase approach:

1. Initially cope by relying on installed plant equipment.
2. Transition from installed plant equipment to on-site FLEX equipment.
3. Obtain additional capability and redundancy from off-site equipment until power, water, and coolant injection systems are restored or commissioned.

Plant-specific evaluations for FLEX will determine the specific equipment and strategies to be employed in these three phases. The scope of the ESEL is limited to installed plant equipment and FLEX equipment connections. As described above, Phase 1 relies upon equipment that is installed in the plant. Phases 2 and 3 rely on portable on-site or off-site equipment to supplement installed equipment, but these capabilities tie into and utilize installed plant equipment. Per NEI 12-06 [3], installed plant equipment relied upon to respond to an earthquake as part of FLEX must be seismically robust. NEI 12-06 defines "robust" as "the design of an SSC either meets the current plant design basis" or "has been shown by analysis or test to meet or exceed the current design basis". The purpose of the ESEP is to demonstrate or provide additional seismic margin for ESEL items. It does not redefine any of the terms or criteria in NEI 12-06.

Each plant should review their FLEX implementation approach to identify the installed plant equipment and portions of systems required to accomplish the reactor and containment safety functions identified in NEI 12-06 Tables C-1 and C-2 for Boiling Water Reactors (BWRs) and Tables D-1 and D-2 for Pressurized Water Reactors (PWRs). Tables 3-1 and 3-2 identify these safety functions and provide a summary of the typical equipment and portions of systems that would be included in the ESEL. In addition to the ~~stress~~physically-based failures (load path and anchorage) of specific pieces of installed equipment, functional failure modes of electrical- and mechanical portions of the installed Phase 1 equipment should be considered (e.g. RCIC/AFW trips). Additional guidance on the specific scope of failure modes is provided in Section 5. The selection process for the ESEL should assume the FLEX strategies (modifications, equipment, procedures, etc.) have been implemented.

FLEX strategies necessarily rely upon operator actions for implementation. The operator actions that are included in plant's base implementation should be considered in determining the scope of equipment to be included in the ESEL. The primary means of accomplishing implementation of the FLEX strategies should be used. If an alternate means is used, the basis for its selection should be documented. All installed equipment necessary for successful implementation should be included, (e.g., required control cabinets, governors for turbine-driven pumps).

Some equipment relied upon for implementation of FLEX capabilities need not be included in the ESEL:

- Only a single success path is required for the safety functions identified in Tables 3-1 and 3-2. Equipment required to support an alternative means to accomplish a function is not required to be included in the ESEL.
    1. NEI 12-06 requires primary and alternate connection points for portable equipment. Only one connection point needs to be included, provided the required function can still be accomplished. Justification should be provided for any cases where the primary connection point is not selected.
    2. Limiting instrumentation to one indication per key parameter is acceptable, provided the required function can still be accomplished.
    3. Plants may have identified additional resources that may be beneficial, but are not required (e.g. multiple water sources available for CST makeup). Only the minimum set of sources to perform the required function needs to be considered.
- Some specific SSCs normally considered in SPRAs are excluded. These will be addressed by plants as part of the longer-term seismic risk evaluations, if required.
    1. The following types of SSCs are excluded from the ESEP.
        - Structures (, e.g., containment, reactor building, control building auxiliary building, etc.)
        - Piping, cabling, conduit, HVAC, and their supports
        - Manual valves, check valves, and rupture disks
        - Power operated valves not required to change state as part of the FLEX mitigation strategies
        - NSSS components (e.g. RPV and internals, RCPs and seals, etc.)
- Portions of SSCs that are not directly relied upon in the FLEX strategy may be excluded, such as:
    1. Portions of systems that are not used as transport mechanisms for delivering required flows are excluded (e.g. components beyond boundary valves).
    2. Electrical equipment components not specifically relied upon to perform the FLEX functions are excluded (e.g. power sources and distribution not directly supporting FLEX active components).

- Controls for which plant procedures provide instructions for manual operation (in the event of control system, component, permissive, or interlock failures) that ensure performance of the required FLEX function are excluded.
- Phase 3 portions of installed equipment (and FLEX connections) that are not relied upon in the FLEX strategy to sustain the critical functions of core cooling and containment integrity may be excluded. Recovery strategies in Phase 3 are excluded.

Table 3-1
Summary of NEI 12-06 Performance Attributes for BWR Core Cooling & Containment Function

Safety Function		Method	Baseline Capability	Typical Installed ESEL Equipment	Typical Installed ESEL Support Equipment

Core Cooling	Reactor Core Cooling	• RCIC/HPCI/IC	• Use of installed equipment for initial coping	• RCIC pump, gland condenser, & lube oil cooler
				• RCIC valves
					• DC Power
					  • Plant batteries
					  • DC distribution panels, MCCs & switchgear, as required

		• Depressurize RPV for Injection with Portable Injection Source	• Diverse connection points for portable pump	• ECCS injection valves	• Selected electrical components, if required
			• Multiple means to depressurize RPV	• SRVs	• Portions of DC power
		• Sustained Source of Water	• Use of alternate water supply up to support core and SFP heat removal	• Onsite water storage tanks, if required	• Level instrumentation

	Key Reactor Parameters	• RPV Level
		• RPV Pressure
			• (Re-)Powered instruments	• Selected Instruments	• DC Power and/or
					• Vital AC Power,
					  • Selected Vital AC distribution panels
					  • Inverters
					• Instrument racks
					• Instrument panels

Containment	Containment Function	• Containment Venting or Alternative	• For Mk I and II a venting capability and, if desired, an alternative capability • For others, a reliable, hardened vent or other capability.	• Containment vent system, if applicable • Selected suppression pool cooling equipment	• DC power • Pneumatic supplies
	Containment Integrity (BWR Mark III Only)	• Hydrogen igniters	• Re-powering of hydrogen igniters with a portable power supply.	• Igniter glow plugs	• Distribution panels required to supply power, if any
	Key Containment Parameters	• Containment Pressure • Suppression Pool	• (Re-)Powered instruments	• Selected Instruments	• DC Power and/or • Vital AC Power, • Selected Vital AC

Safety Function	Method	Baseline Capability	Typical Installed ESEL Equipment	Typical Installed ESEL Support Equipment
	Temperature • Suppression Pool Level			distribution panels • Inverters • Instrument racks • Instrument panels

Table 3-2

Summary of NEI 12-06 Performance Attributes for PWR Core Cooling & Containment Function

	Safety Function	Method	Baseline Capability	Typical Equipment	Typical Support Equipment

Core Cooling	Reactor Core Cooling & Heat Removal (steam generators available)	• AFW/EFW	• Use of installed equipment for initial coping	• AFW/EFW pump
				• AFW/EFW valves
					• DC Power
					  • Plant batteries
					  • DC distribution panels, MCCs & switchgear, as required

		• Depressurize SG for Makeup with Portable Injection Source	• Connection for portable pump	• SG ADVs/PORVs	• None, typically
		• Sustained Source of Water	• Use of alternate water supply up to support core and SFP heat removal	• Onsite water storage tanks, e.g., Condensate Storage Tank or equivalent, if required	• None
	RCS Inventory Control/Long-Term Subcriticality	• Low Leak RCP Seals and/or borated high pressure RCS makeup required	• Site analysis required to determine RCS makeup requirements • Boration and/or letdown path may be required	• Injection path valves • Letdown path valves	• None
	Core Cooling and Heat Removal (Modes 5 and 6 with SGs not available)	• All Plants Provide Means to Provide Borated RCS Makeup	• Diverse makeup connections to RCS for long-term RCS makeup and residual heat removal to vented RCS	• Injection path valves (May be same as above)	• None
			• Source of borated water required	• Onsite tank, if required.	• None

	Key Reactor Parameters	• SG Level
		• SG Pressure
		• RCS Pressure
		• RCS Temperature
			• (Re-)Powered instruments	• Selected Instruments	• DC Power and/or
					• Vital AC Power,
					  • Selected Vital AC distribution panels
					  • Inverters
					• Instrument racks
					• Instrument panels

...mme nt	Containment Function	• Containment Spray	• Connection to containment spray header or alternate	• Containment spray valves	• None

Comment [AK5]: The first column has something in the box under core cooling in the printout handed out at the meeting, but is missing from the clean copy

Safety Function		Method	Baseline Capability	Typical Equipment	Typical Support Equipment
			capability or Analysis		
	Containment Integrity (Ice Condenser Containments Only)	• Hydrogen igniters	• Re-powering of hydrogen igniters with a portable power supply.	• Igniter glow plugs	• Distribution panels required to supply power, if any

	Key Containment Parameters	• Containment Pressure	• (Re-)Powered instruments	• Selected Instruments	• DC Power and/or
					• Vital AC Power,
					  • Selected Vital AC distribution panels
					  • Inverters
					• Instrument racks
					• Instrument panels

A summary of the anticipated types of equipment expected to be on an ESEL are provided in the tables below:

Table 3-3
Representative BWR Equipment within the Scope of ESEL

Mechanical Equipment	Electrical Equipment
▪ RCIC pump and valves ▪ RCIC lube oil and gland condenser ▪ Safety relief valves (SRVs) ▪ SRV accumulators ▪ RPV injection valves ▪ Reliable hardened vent valves	▪ Batteries ▪ DC distribution panels ▪ DC MCCs ▪ DC switchgear ▪ Vital AC distribution panels ▪ Battery charger(s) ▪ Inverter(s) ▪ Instrument racks ▪ Transmitters

Table 3-4
Representative PWR Equipment within the Scope of ESEL

Mechanical Equipment	Electrical Equipment
▪ Turbine driven AFW pump and valves ▪ SG Power Operated Relief Valves (PORVs) ▪ Condensate Storage Tank ▪ SG injection valves ▪ RCS injection valves	▪ Batteries ▪ DC distribution panels ▪ DC MCCs ▪ DC switchgear ▪ Vital AC distribution panels ▪ Battery charger(s) ▪ Inverter(s) ▪ Instrument racks ▪ Transmitters

Finally, similar to seismic equipment lists for SPRAs, it is acceptable for the ESEL to be iterative. That is, if during the ESEP process, it is determined that an SSC has a seismic capacity below the RLGM, it may be appropriate to supplement the FLEX implementation to provide an alternative capability. For example, if an installed air accumulator relied upon to supply air for an air-operated valve is determined to have seismic capacity below the RLGM, it is acceptable to provide an alternative supply of air (e.g., air bottles) with a higher seismic capacity provided that capability fits within the overall performance requirements of NEI 12-06.

3.3 Format and Content of Expedited Seismic Equipment List (ESEL)

In order to support the appropriate evaluation of the seismic capacity, the ESEL must include additional information beyond the list of equipment. The needed information includes:

- The unique equipment ID
- A description of the equipment

- The normal and desired operating state of the equipment as evaluated in the site specific FLEX strategies, and
- Other information that may be useful to the evaluation of seismic capacity.

An example of a recommended format for the ESEL is provided in Table 3-5. Additional information may be included useful to the evaluation such as building, elevation, location, etc.

Table 3-5
Example Format of ESEL Summary Table

ESEL Item #	Equipment ID	Description	Equipment Normal State	Equipment Desired State	Notes
1	XT15-C001	TDAFW Turbine	Standby	Operating	AB10000

Notes for Table 3-5:

The column headings are explained below:

- ESEL Item #: This is a record number for each ESEL item on the list. This is typically a unique sequential number that allows ease of reference to a particular SSC.
- Equipment ID: This is a unique equipment identification number for the SSC. This would generally be taken from the plant master equipment list or other common data system used at the plant.
- Description: This is a text description of the SSC. This would generally be taken from the plant master equipment list or other common data system used at the plant.
- Equipment Normal State: This column identifies the normal state of the SSC (e.g., normally energized/de-energized, normally closed/open, normally standby/running, etc.) based on the initial plant conditions defined in the baseline coping capability of NEI 12-06.
- Equipment Desired State: This column identifies the desired state of the equipment evaluated in the site specific FLEX mitigation strategy. For some equipment this will be different than the normal state. For example, a valve that is normally closed during plant operations may need to be opened to support a required function.
- Notes: This is a column field to provide notes and/or comments (reference drawings, specific room location, etc.). Codes may also be defined and used to provide a variety of information (e.g., failure mode of interest).

Section 4: Review Level Ground Motion (RLGM) Spectrum Criteria

This section of the Expedited Seismic Evaluation Process (ESEP) for the Augmented Approach consists of addressing those plants which cannot be screened out based on the comparisons of the GMRS to the SSE (as described in Section 2 of this report). Plants whose GMRS exceeds the SSE in the 1 to 10 Hz range require further seismic evaluation beyond the design basis. The further seismic evaluation is conducted to a Review Level Ground Motion (RLGM) level, which consists of a response spectrum above the SSE level. Figure 1-3 contains a flowchart that shows how the development of the RLGM fits into the ESEP.

If a plant does not screen out from the ESEP as described in Section 2, then a RLGM would be computed using one of the following criteria:

1. The RLGM will be derived by linearly scaling the SSE by the maximum ratio of the GMRS/SSE between the 1 and 10 Hz range (not to exceed 2 x SSE ~~and 0.75g PGA~~). In-structure RLGM seismic motions would be derived using existing SSE-based in-structure response spectra (ISRS) scaled with the same factor.

Comment [lmr6]: A RLGM cap of 0.75g, PGA is not needed. Just use 2 x SSE.

Comment [lmr7]: For DC and SONGS, the RLGM should bound the GMRS or justification should be provide for a lower RLGM. Using a cap of 0.75g, PGA for SONGS is only the SSE x 1.12.

2. Alternatively, licensees who have developed appropriate structural/soil-structure interaction (SSI) models capable of calculating ISRS based on site GMRS/uniform hazard response spectrum (UHRS) input may opt to use these ISRS in lieu of scaled SSE ISRS. In this case, the GMRS would represent the RLGM. EPRI 1025287 [2] and the ASME/ANS PRA Standard [10] give guidance on acceptable methods to compute both the GMRS and the associated ISRS.

Approach number 1 above, where the RLGM is developed based on the SSE, is a much more expedient approach (both in terms of schedule and resources) for developing the floor spectra in the structures housing ESEL items since it involves a simple linear scaling of existing SSE-based floor spectra. Two example cases of implementing approach 1 are depicted in Figures 4-1 and 4-2.

- **Figure 4-1** depicts the case where the GMRS exceeds the SSE but is less than twice the SSE in the 1 to 10 Hz range. The RLGM for this case is developed by linearly scaling up the SSE by the maximum ratio of the GMRS/SSE between the 1 to 10 Hz range. For this example, that maximum ratio occurs at 10 Hz.

- **Figure 4-2** depicts the case where the RLGM would be set at the maximum of two times the SSE. In this case, the maximum ratio of the GMRS to the SSE over the 1 to 10 Hz range exceeds a value of 2.

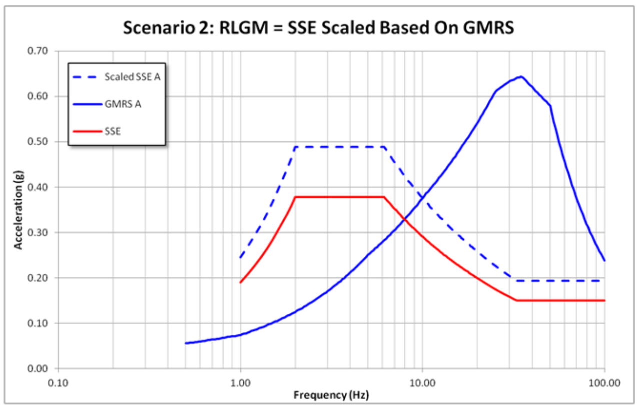

Figure 4-1
RLGM Generated by Scaling Up SSE Spectrum (Scenario 2 from Figure 1-3)

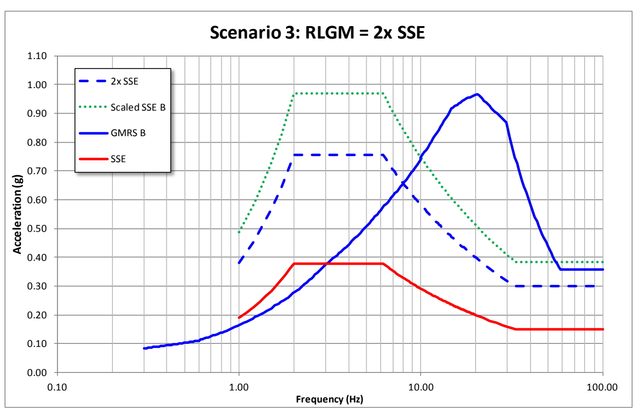

Figure 4-2
RLGM Defined as Twice the SSE (Scenario 3 from Figure 1-3)

Section 5: SSC Capacity Criteria for the ESEP

The ESEP consists of first the GMRS/SSE screening assessments (Section 2), followed by generating the scope of equipment (Section 3) and subsequently followed by the development of the RLGM (Section 4). Those plants required to perform the beyond design basis review as part of the ESEP are then required to demonstrate that ESEL items have sufficient seismic capacity to meet or exceed the demand characterized by the RLGM. The criteria for the seismic capacity of the components included within the ESEL consists of calculating a HCLPF seismic capacity and comparing that level to the seismic demand of the RLGM.

Demonstration that the HCLPF capacity exceeds the RLGM for the components within the ESEL will verify adequate seismic ruggedness for this program and would indicate that no further action would be required, as shown in Figures 1-2 and 1-3. Conversely, Section 6 of this report discusses the process for the resolution of those components which cannot demonstrate this margin over the RLGM. The detailed criteria for the development of the HCLPF capacity, along with many examples of the methods used to perform the calculation, are well documented in technical literature and will not be repeated in this document. Several references for HCLPF procedures are listed in Table 5-1.

Table 5-1
Partial List of Fragility and Margin References

SPRA Topic	Document Title	Reference
Seismic Fragility & Margin	Seismic Fragility Applications Guide Update	EPRI Report 1019200 (Dec 2009)[6]
	Seismic Fragility Application Guide	EPRI 1002988 (Dec 2002) [7]
	Methodology for Developing Seismic Fragilities	EPRI TR-103959 (June 1994) [8]
	A Methodology for Assessment of Nuclear Plant Seismic Margin	EPRI NP 6041 (Oct 1988) [9]

There are two basic approaches for developing the HCLPF values:

- Deterministic Approach

- Probabilistic Approach – generated based on a seismic fragility calculation

The deterministic approach is typically considered to be the easiest to apply, and there are more practitioners with experience with its implementation. As such, a brief summary of some of the salient features of the deterministic approach are provided herein. The deterministic approach to defining the HCLPF of essential components is commonly referred to as the Conservative Deterministic Failure Margin (CDFM) approach.

For the ESEP, the response is specified as described in Section 4 of this report, and the capacity is generated based on CDFM methods. EPRI NP-6041-SL [9] contains a detailed description of the CDFM process. The basic elements of the CDFM capacity development are summarized in Table 5-2 below.

Table 5-2
Summary of Conservative Deterministic Failure Margin Approach for Seismic Capacity (EPRI NP-6041-SL [9])

Load Combination:	**Normal + Seismic**
Material Strength:	Code-specified minimum strength or 95% exceedance actual strength if test data are available.
Static Capacity Equations:	Code ultimate strength (ACI), maximum strength (AISC), Service Level D (ASME), or functional limits. If test data are available to demonstrate excessive conservatism of code equations, then use 84% exceedance of test data for capacity equation.
Inelastic Energy Absorption:	For non-brittle failure modes and linear analysis, use 80% of computed seismic stress in capacity evaluation to account for ductility benefits, or perform nonlinear analysis and go to 95% exceedance ductility levels.

For those structural failure modes which can be evaluated by analysis, a seismic capacity estimate requires an estimate of:

1. material strength,
2. static capacity or failure equation, and
3. inelastic energy absorption capability.

Each of these parameters should be conservatively estimated to achieve the above-recommended level of capacity conservatism.

Material strengths used in the CDFM approach should be the approximately 95% exceedance probability strengths from material test data. Otherwise, code- or design-specified minimum strengths should be used. These values represent the approximately 95% exceedance probability strengths of all materials meeting the code specifications. As discussed in EPRI NP-6041-SL [9] a higher exceedance probability is needed for brittle failure modes.

Functional failure modes cannot typically be evaluated solely by analysis and have to be assessed using test data or generic equipment ruggedness spectra (GERS). The GERS are always set lower than the lowest test response spectrum (TRS) for which failures were observed, if any such failure test data exist. If either the component-specific test data or the applicable GERS are to be considered to demonstrate operability, then a margin factor is needed between the computed seismic response and the TRS in order to achieve a HCLPF capacity. Recommendations are provided in [9] for the calculation approaches for CDFM capacities for functional failure modes.

Seismic Capacity Screening Guidelines

The EPRI seismic margins report [9] contains a set of screening criteria tables frequently used in both SPRAs and SMAs, including Table 2-4 titled "Summary of Equipment and Subsystems Screening Criteria for Seismic Margin Evaluation."

The criteria documented in this table were based primarily on information from SPRA/SMA studies and on available seismic experience data (both actual earthquake experience and testing experience). The NRC-sponsored "Expert Panel" on the Quantification of Seismic Margins developed a consensus seismic capacity screening criterion, which was the starting point for the table. The EPRI Seismic Margin Program reviewed additional data and refined and expanded the NRC Expert Panel recommendations, which resulted in Tables 2-4 [9]. The guidelines are intended to provide generic conservative estimates of the ground motion below which it is generally not necessary to perform a seismic margin review for particular elements. Thus, for a given ground motion level, the guidelines list the equipment which should, in general, be "screened out" from margin review because of their generically good performance in earthquakes or seismic simulation tests at or above this level. These guidelines are to be used only in conjunction with a walkdown of plant-specific elements by the seismic review team (SRT). The guidelines are intended to assist the SRT in "screening out" components during their walkdown, but the SRT must exercise its own collective experience and judgment in the use of these guidelines for any specific component.

Several important considerations associated with the use of this table include:

- Separate criteria are listed depending on the 5% damped peak spectral acceleration associated with the ground motion.
- Caveats and restrictions associated with each specific system, or component type are required to be met. These are documented as notes to the table.
- The table is applicable to equipment up to 40 ft above grade.

It is important to recognize that a major part of an SMA is investigation of equipment anchorage. The screening table values given in this report are for the capacity of the element per se, and do not include consideration of anchorage, which varies from plant to plant. Thus anchorage must be considered in addition to the guidance given in the screening tables. This anchorage evaluation should include any specific load path and support configurations that would not have been included within the experience data (earthquake, testing, and analysis) that went into the development of the EPRI NP-6041-SL screening tables. ~~Thus c~~Components that are anchored to sub-structural elements that may not have the same capacity as the main structural system (e.g., block walls, frames, stanchions, etc.) ~~that are not typical of those within the experience data~~ should also be reviewed as part of the ESEP process for calculating the HCLPF. A justification should be provided if the load paths for components anchored to sub-structural elements are not reviewed~~Equipment anchored to these sub-structural components are not typical of those within the experience database upon which the screening tables are based.~~

Nearby block walls should be identified during walkdowns and subsequently evaluated. In addition, piping attached to tanks should be reviewed to address the possibility of failures due to differential displacements. Other potential seismic interaction evaluations will be deferred to the full seismic risk evaluations performed in accordance with EPRI 1025287 [2].

Reference [6] is an update to the EPRI fragility methodology and contains a description of the criteria for application of these screening tables at elevations beyond 40 ft above grade and should be used as part of this evaluation.

Section 6: ESEL Modification Criteria

Demonstration that the HCLPF capacity for any ESEL item exceeds the RLGM verifies that the item has adequate seismic ruggedness for the ESEP and that no further action would be required, as shown in Figures 1-2 and 1-3. Conversely, if the ESEL item HCLPF does not exceed the RLGM, modifications should be performed as described below.

Any ESEL item whose HCLPF capacity is less than the RLGM should be modified such that the HCLPF meets or exceeds the RLGM. This criterion applies for ESEL items identified in Section 2.2.1.1, as well as items identified in Section 5. These modifications are intended to provide a near-term improvement of plant safety. They do not impose a long-term commitment to maintain the improved plant conditions beyond the point where the long-term plant risk evaluations are completed in accordance with NRC 50.54(f) letter [1] and EPRI 1025287 [2].

Modifications should be completed within 2 years of submitting the plant specific ESEP summary report to the NRC (Section 7). Additionally, if a plant outage is required to implement the ESEL item modification, the modifications should be completed within 2 outages of submitting the ESEP summary report to the NRC.

Consideration of the ESEL modifications may be revised based on insights from a completed SPRA. The results of a completed SPRA may show that alternate modifications would produce more effective safety enhancements. In that case, the more beneficial modifications identified by the SPRA could be implemented rather than the ESEL modifications. Those alternate modifications would have the same implementation schedule described above. The results of these alternate plant modifications would be expected to provide more beneficial, long-term plant safety improvements.

Section 7: ESEP Report

A report should be prepared summarizing the ESEP evaluations and results. The report should be submitted to the NRC for review following completion of the evaluations (see Table 1-1). The level of detail provided in the report should be sufficient to enable NRC to understand the inputs used, the evaluations performed, and the decisions made as a result of the interim evaluations. It is not necessary to submit HCLPF calculations. Relevant documentation should be cited in the submittal, and be available for NRC review on-site in easily retrievable form.

The report should include the following information.

- A brief summary of the FLEX seismic implementation strategies, including functions to be achieved and how the selected equipment achieves those functions
- A list of the selected equipment (ESEL) and a justification for any ESEL equipment that is not the primary means for FLEX implementation for seismic events
- A plot of the GMRS submitted by the licensee in accordance with the 50.54(f) letter and EPRI 1025287 [2] and comparison to the SSE
- A description of the RLGM selected and the process to estimate ISRS
- A summary of the methodologies used to perform the HCLPF calculations and the results including:
  - the HCLPF screening process used (e.g. NP 6041)
  - the HCLPF calculation process (s) used
  - tabulated ESEL HCLPF values including the key failure modes
- Identification of any ESEL items that were inaccessible for walkdown along with the planned walkdown and evaluation schedule, including specific dates for completion.
- Description of the ESEP results including:
  - identification of required modifications
  - modification implementation schedule

Section 8: References

1. NRC (E Leeds and M Johnson) Letter to All Power Reactor Licensees et al., "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," March 12, 2012.
2. EPRI 1025287, Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic EPRI, Palo Alto, CA: 2012.
3. NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide", Revision 0, August 2012 (ML12242A378).
4. Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," March 12, 2012 (ML12054A736)
5. Japan Lessons-Learned Project Directorate, 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," Interim Staff Guidance Revision 0, August 29, 2012,(ML12229A174)
6. EPRI 1019200, "Seismic Fragility Applications Guide Update," December 2009.
7. EPRI 1002988, "Seismic Fragility Application Guide," December 2002
8. EPRI TR-103959, "Methodology for Developing Seismic Fragilities," July 1994.
9. EPRI NP-6041-SL, "A Methodology for Assessment of Nuclear Plant Seismic Margin, Revision 1", Electric Power Research Institute, August 1991.
10. American Society of Mechanical Engineers/American Nuclear Society (ASME/ANS) RA-Sa-2009.