Protocol for Enhanced Evaluations of Beyond Design Basis Events
Supporting Implementation of Operating Experience Report 2013-01

1. PURPOSE

This protocol includes the guidance provided in Operating Experience Level 1 (OE-1: 2013-01), *Improving Department of Energy Capabilities for Mitigating Beyond Design Basis Events*[1], to support implementation of Action 2 of OE-1: 2013-01 as well as amplifying/supporting information that was developed during the Beyond Design Basis Evaluation (BDBE) Pilot activities that were completed in 2013.

> The purpose of this guide [attachment 2 of the OE document] is to provide expectations for performing an enhanced evaluation of beyond design basis events (BDBEs) as a part of the annual DSA updates. It is generally expected that existing DSAs subject to the criteria of Action 2 already include an evaluation of BDBEs as required by DOE-STD-3009. The enhanced evaluation incorporates an analytical approach that was developed during the BDBE pilots, but documents the results of the analysis in the same manner as described in DOE-STD-3009. The enhanced evaluation process should incorporate lessons learned as described in, *A Report to the Secretary of Energy: Beyond Design Basis Event Pilot Evaluations, Results and Recommendations for Improvements to Enhance Nuclear Safety at Department of Energy Nuclear Facilities*, January 2013.

This protocol was developed by the Office of Nuclear Safety. Any questions can be directed to Mike Hillman at (301) 903-3568.

2. INTRODUCTION

> *Action 2 of the April 2013 Operating Experience Level 1 Report states:*
>
> *Program Offices shall direct contractors responsible for hazard category 1 and 2 nuclear facilities that have the potential to exceed DOE's 25 rem public dose evaluation guideline based on an unmitigated accident analysis, to conduct an evaluation using the guidance in Attachment 2 in conjunction with the 2015 annual update of their Documented Safety Analyses (DSAs). This action is not applicable to Transportation DSAs. Program offices shall provide a consolidated report on the all actions taken to their respective Under Secretary no later than December 31, 2015.*

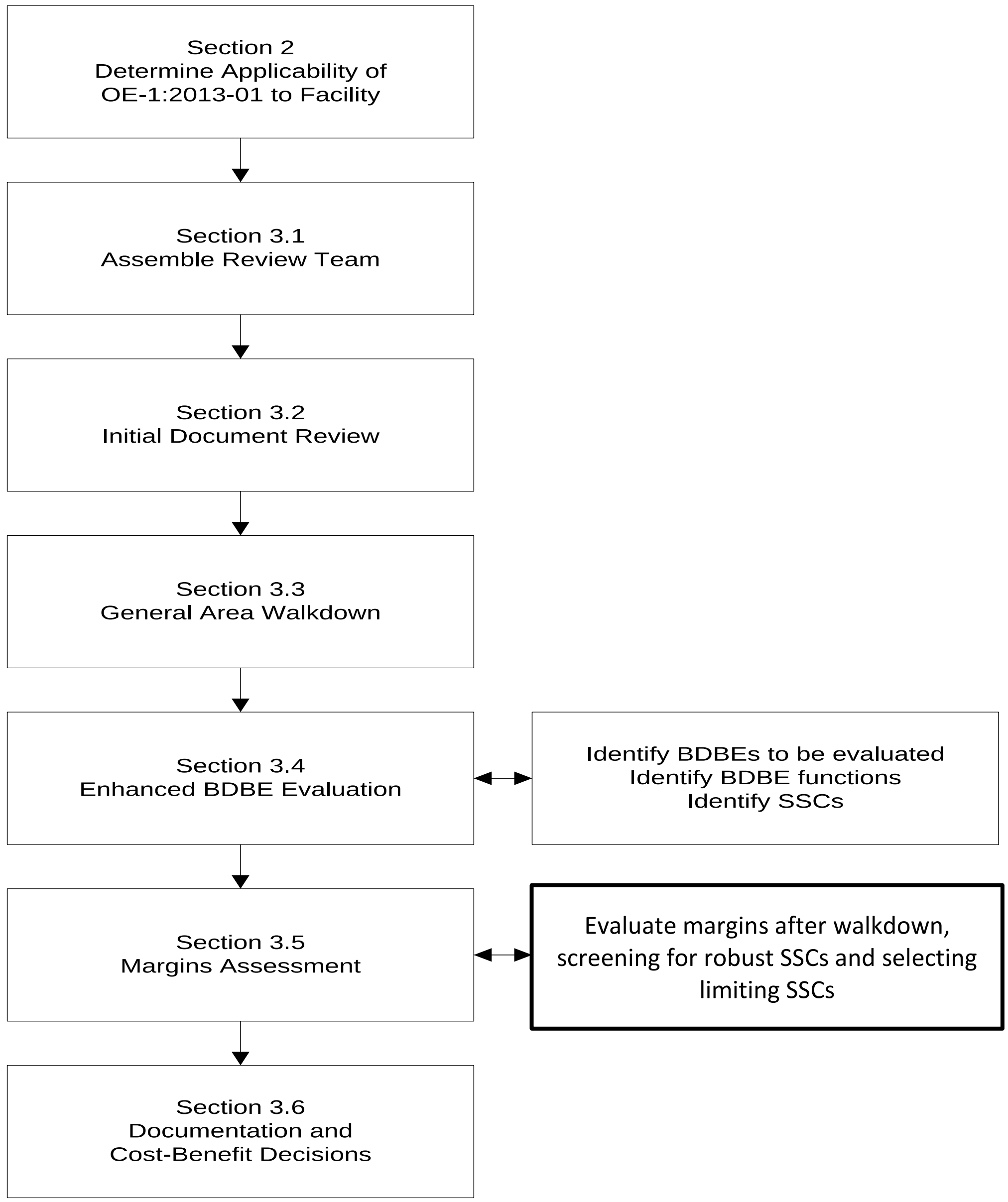
This protocol provides additional support to contractors and Program Offices to implement the requirements outlined in OE-1:2013-01. The protocol follows the same flow as described in Attachment 2 of OE-1:2013-1. Specifically, the review process is as follows:

- Evaluation Team Makeup
- Initial Document Review
- General Area Walkdown
- Enhanced BDBE evaluation
- Margin Assessment/Structured Walkdown
- Documentation of Results

[1] Text inside of text boxes throughout this protocol is directly quoted from OE-1: 2013-01.

This protocol is intended to be a high-level resource and the Office of Nuclear Safety is prepared to provide additional assistance and training on the OE to support completion activities required in the OE. An overview of the process described in this protocol is presented below in Figure 1.

Figure 1. Overview of Steps in the BDBE Enhanced Evaluation Protocol



3. REVIEW PROCESS

This section recites the OE-1: 2013-01 guidance related to the enhanced BDBE evaluation process and provides amplifying/supporting implementation guidance.

3.1 Evaluation Team Makeup

As with any DSA preparation and update activity, the BDBE evaluation should be conducted by a qualified team leader and a multidisciplinary team consisting of experts in the areas of facility operations, facility safety analysis, structural/mechanical engineering, NPH, and emergency management, the last of which is particularly relevant to the objective of this evaluation. The intent is to perform an expert-based and qualitative evaluation.

3.2 Initial Document Review

The facility's DSA should serve as a starting point for the evaluation of BDBEs. The DSA is expected to include a discussion of the BDBEs considered, and may include a discussion of analyses or enhancements made to the facility to meet DOE Order 420.1 C, *Facility Safety*, i.e., requirement to evaluate the impact of changes in NPH data and/or analysis methodologies every ten years. The new analyses and enhancements should identify how the design has "evolved" to provide assurance of safety under events that are beyond the original design basis.

Amplifying/Supporting Information

Facility documentation that is relevant to the BDBE evaluation should be collected and reviewed. This should include the DSA; relevant calculations; design and technical reports related to the BDBEs to be evaluated, as listed in Section 3.4; and design documents for safety Systems, structures, and components (SSCs) that may be impacted by BDBEs.

Documentation reviews should be focused on understanding the original design basis events for the facility; the safety classification and performance category of SSCs; updates to the original design basis events; the additions, upgrades and retrofits of SSCs implemented over the years and their design basis; Natural Phenomenon Hazards (NPH) analysis and any related open items and assumptions; records of past walkdowns and reviews; etc.

The team should also review the DSA's accident analysis as related to BDBEs, with the intent of understanding the range of events considered, key analytical assumptions, and estimated consequences. The outcome of the documentation review should be to develop a good understanding of the facility layout and operation, key safety controls and functions, and targeted focus areas in the facility to be considered during the BDBE evaluation.

3.3 General Area Walkdown

As described in the HSS report to the Secretary referenced above [*A Report to the Secretary of Energy: Beyond Design Basis Event Pilot Evaluations, Results and Recommendations for Improvements to Enhance Nuclear Safety at Department of Energy Nuclear Facilities, January 2013*], it is prudent for the team to perform a walkdown of the facility to support a qualitative evaluation of how a BDBE may impact the facility (the qualitative evaluation is discussed in the next section of this attachment) and to look for potentially unknown vulnerabilities to BDBEs (e.g., unsealed penetrations or low-lying electrical equipment in the case of flooding accidents). This walkdown also ensures the reviewers are familiar with facility's size, key features and distances to other structures and potential temporary service connections (like fire hydrants or well water sources).

Amplifying/Supporting Information

A general area walkdown provides useful information on:

- the plant layout,
- physical conditions of SSCs,
- substantiate key analytical assumptions, and
- configuration details.

This information is key to evaluating potential vulnerabilities to BDBE hazards and their impacts on SSCs. Insights from this walkdown, together with document reviews and qualitative evaluations may allow the team to rule out certain accident scenarios such as severe flooding, based on the facility's elevation or location.

The general area walkdown may be followed by additional focused walkdowns of plant areas or equipment, as described in Section 3.5.

3.4 Enhanced BDBE Evaluation

This enhanced BDBE evaluation is intended to identify BDBEs that may cause a release of radioactive material beyond that analyzed in the unmitigated accident analysis in the DSA. In addition BDBEs that can disable important controls relied on to mitigate the release of radioactive material shall be evaluated. The types of BDBEs that should be evaluated include:

- Seismic events
- Floods (external and internal sources)
- Fires (external and internal sources)
- Lightning
- Wind and tornadoes
- Snow and ice
- Ash fall
- Station blackout, as an initiating event or as a consequence from any of the above event
- Cascading effects of design basis events analyzed in the DSA that were previously ruled out because of the low likelihood of associated multiple failures.

If BDBE's from the above list are excluded, the rationale for exclusion should be documented. The general categories of failures to be considered for each BDBE listed above include:

- Collapse of building structure and interior walls
- Breach of water storage pools or collapse of storage racks
- Loss of electrical power and emergency power equipment (e.g. , transformers, switchgear, or motor control centers)
- Loss of electrical distribution systems (e.g., conduit or cable trays)
- Operational failure of active mechanical equipment (e.g. , pumps, compressors, or fans)
- Loss of pressure boundary of static equipment (e .g., tanks, vessels, or gloveboxes)
- Failure of distribution systems (e.g., piping, tubing, or ducts)
- Failure of alarms
- Loss of an emergency response center.
- Adverse spatial seismic interaction (e.g., failure of adjacent buildings or failure of adjacent stacks)
- Adverse flood-inducing interaction (e.g., failure of an adjacent water tank)

The enhanced BDBE evaluation should provide a gross estimate of the bounding impacts associated with BDBEs. It is qualitative in that it relies on a simple "what if" type of hazard evaluation technique where a multidiscipline team participates in a brainstorming session to methodically evaluate the potential failures in facility systems, structures, and components (SSCs) that could be caused by each type of BDBE. The evaluation should estimate the consequences associated with failures of SSCs that provide safety functions such as confinement, energy removal (e.g., decay heat removal or fire suppression), or prevention of energetic reaction (e.g., explosion). The evaluation may draw upon existing unmitigated accident analysis performed in the DSA.

Appendix A illustrates a way to document results of team deliberations during the BDBE evaluation process.

<u>Amplifying/Supporting Information</u>

The BDBE evaluation should be approached by first identifying the critical safety functions (CSFs) that must be protected in the facility. CSFs are those functions (e.g., criticality control, reactivity or explosive material control, heat removal, and confinement) important for preventing or mitigating potentially significant releases of radioactive material. SSCs that protect CSFs are identified as safety class or safety significant features in the DSA hazard/accident analysis. Another source of information on BDBE sensitive SSCs is the site's or facility's emergency management procedures. The evaluation should be focused on the SSCs that could play a role in mitigating the effects of a BDBE, and in doing so, would protect the facility if they remain operable post-event.

The qualitative evaluation process provides an estimation of the impacts associated with BDBEs. It is qualitative in that it that relies on a "What-if" type of hazard evaluation technique. During "What-if" brainstorming sessions, the team, assisted by facility and subject matter experts, should postulate, evaluate, and document the effects of each type of BDBE on the CSFs and associated SSCs affected.

The evaluation should focus on SSCs, regardless of their safety classification, that are desired to remain viable to prevent or mitigate the release of radioactive material following a BDBE. For example, in the case of a spent fuel pool, the team should focus on SSCs that serve to provide containment, ventilation and cooling functions.

This qualitative evaluation process is applied to each type of BDBE so that different failure modes and associated effects can be understood for each SSC. Although a seismic event will typically present the worst-case consequences, it is important to step through all applicable BDBEs using the same structured "What-if" technique used earlier in the qualitative evaluation.

At the conclusion of the qualitative evaluation, the BDBE evaluation team should document their logic and results and decide whether any SSCs warrant additional evaluation using a semi-quantitative margins assessment, or structured walkdowns. This approach should be considered for specific SSCs whose failure could have significant off-site impacts (i.e., greater than 25 rem). This evaluation process is exemplified in the Appendix A sample review spreadsheet.

It is important to note that not all candidates for margin assessment need a semi-quantitative review, as described in Section 3.5 and Appendix B.

3.5 Margins Assessment/Structured Walkdowns

SSCs identified as mitigating BDBE consequences should be subjected to a margins assessment (MA) to provide insights into their margin-to-failure. Civil/structural engineers should perform the MA by reviewing existing design basis analyses and supporting calculations for SSCs. This information should then be used as a baseline to compare against a SSC's expected response to higher level stresses. A MA can be difficult to accomplish if facility design information is not available, i.e., for older DOE facilities. In this case, the MA may have to rely on bounding, simplified assumptions and judgments by subject matter experts, supported by the results of structured walkdowns. Margins assessment should be accomplished by analyzing the facility for higher stress levels than the systems' design (for example, the next higher seismic performance or design category) based on qualitative expert judgment.

Amplifying/Supporting Information

The intent of the first step in the margins assessment is to identify those candidates for margin assessment (identified above) that, based on the available design information, the expert judgment of the reviewers, and additional insights gained from the walk down process, stand out as those SSCs whose margin is most limiting in the facility's response to a BDBE. The idea is to perform the margins assessment on a select number of SSCs as part of an overall, cost effective approach to enhanced safety posture for beyond design basis accidents.

Structured walkdowns should be conducted by subject matter experts to verify configurations associated with the candidates for margins assessment, as well as opportunities for enhancements that will improve the ability of SSCs to perform its post-BDBE function. Walkdowns should also be focused on the vulnerabilities of SSCs to failures in accidents, up to and including the bounding BDBE. Appendix B provides additional guidance for conducting structured walkdowns.

The margin assessment may take the following approach:

Step 1 – Identify the candidate SSCs for margins assessment based on the qualitative "What-if" evaluation;

Step 2 – Grouping: Once the SSCs to be evaluated and their BDBE function is identified, the SSCs can be grouped by SSC class. The grouping classes of SSCs listed in DOE-EH-0545 may be followed.

Step 3 – Subgrouping: Within each Class the SSCs may be grouped by similarity, for example if there are multiple pumps in scope, they may be grouped according to similar pump characteristics.

Step 4 – Screening out rugged SSCs: Using screening criteria, certain groups of SSCs may screened as being rugged for the BDBE (e.g., concrete structures), and would require no analysis beyond verification of the screening attributes. Ruggedness attributes can be based on DOE-EH-0545

Step 5 – Selecting limiting components: From the remaining non-rugged items, subject matter experts should use their judgment in recommending to facility management those SSCs which, on a cost-benefit basis, warrant further analysis to best provide facility management a perspective of the residual risk. As the DSA is updated annually, items not previously analyzed may be analyzed based on cost-benefit, operating performance and lessons learned considerations.

Step 6 – Analysis: SSCs that are selected as limiting components are evaluated for margin, based on existing calculations, test reports, or new evaluations. The results of this analysis should also be used to confirm the decision making applied in selecting the limiting components.

Step 7 – Documentation of the process, focusing on the screening of rugged SSCs, limiting component selections and the margins assessment results.

The goal of the margins assessment is not to show that an SSC will meet any challenge, but to identify those SSCs which are most vulnerable to higher-level stresses associated with BDBEs. Consequently, the process is intended to provide insight into the capability of active or passive SSCs that play a role in minimizing the release of radioactive material to survive BDBEs by evaluating their design and robustness.

The selection of limiting components can use available design information, coupled with increased levels of performance challenges, to inform the facility operator of those SSCs that may be more prone to failure (those with lesser design margins) post-BDBE. If existing design information does not yield adequate insight into SSC margins, the challenge of identifying an upper limit for the BDBE can be addressed by bounding the event at the next higher performance category (PC).

For example, a PC-3 structure with uncertain design margins could be evaluated for a BDBE level-up to a PC-4 demand level (seismic acceleration, wind speed, etc.). If the PC-4 site-specific hazard has not been developed, then an upper bound event (such as 1.67 times the design basis earthquake for the seismic BDBE) may be selected as the BDBE. This qualitative evaluation process provides an upper bound to the BDBE analysis that is applied to each type of BDBE so different failure modes and associated effects can be understood on all applicable SSCs.

In the case of the seismic margins assessment, one analysis method to estimate margin is to calculate the High Confidence of Low Probability of Failure (HCLPF) capacity of the SSC. The HCLPF is a measure of seismic ruggedness. It is defined as the earthquake motion level at which there is a high (95 percent) confidence of a low (at most 5 percent) probability of failure (e.g., EPRI NP-6041-SL, *A Methodology for Assessment of Nuclear Power Plant Seismic Margin*; and EPRI 1002988, *Seismic Fragility Application Guide*, Final Report, December 2002.) This type of evaluation may be difficult if reliable design-basis calculations are not retrievable. In this case, additional calculations or investigations may be necessary to support the development of the margin. Similar techniques can be used for other NPH events.

If the SSC margin assessment (e.g., HCLPF) is below the review level BDBE, then the detailed failure mode and its consequence may be investigated and possible preventive or mitigative measures can be developed for the final results and recommendations report. This report may also rely on cost-benefit analysis that would be handled separate from the DSA.

3.6 Documentation of Results

Descriptions of performance capabilities of the existing SSCs should also be added to or referenced in the DSA, as new and relevant information is learned from above BDBE evaluation. SSCs that provide protection against BDBEs are typically safety class controls, or a subset of these controls, credited in the DSA for design basis events. If the BDBE evaluation identifies non-credited SSCs, it is not expected that these SSCs would be classified as safety class or safety significant based solely on BDBE consequences, and, therefore, additional technical safety requirements for these SSCs would not be created. These may include facility features such as temporary utility connections (power or water) and critical parameter instrumentation readings that permit monitoring after a BDBE occurs. The OSA should identify these SSCs as important for providing additional mitigation of BDBEs, and these SSCs should be maintained within the facility configuration management and maintenance programs in the same manner that other non-safety class and safety significant DSA controls are treated to preserve their safety function. PSOs should establish for their facilities whether the Unreviewed Safety Question program should be used to determine the approval authority for changes to BDBE controls, or whether more general provisions of maintenance and configuration control should be relied upon.

Based on the results of the enhanced BDBE evaluation, existing DSA descriptions of BDBE accident scenarios should be updated as necessary to clarify important assumptions needed to develop abnormal or emergency operating procedures. This may include details such as potential accident conditions associated with the range of BDBEs, cascading effects of certain scenarios, time-frames associated with scenario development, and time-critical mitigative actions. Additionally, emergency management plans for responding to BDBEs (updated using the guidance in Attachment I) could also identify potential facility design changes for consideration. An example would be the addition of standardized connections, outside the facility, that could be used to supply cooling water, deliver fire suppression water, or provide electrical power using resources obtained through emergency management mutual aid agreements. These improvements should also be conveyed as part of the DSA annual update.

Amplifying/Supporting Information

The documentation of the BDBE evaluation should include the following information:

a. Pre-evaluation preparatory activities
b. BDBE review team personnel and responsibilities
c. Technical references used in the evaluation
d. Scope of Review
e. BDBEs evaluated and BDBEs eliminated, with justification
f. Review level BDBE and its basis
g. BDBE Evaluation
h. Results of qualitative evaluation for each BDBE
i. Recommended actions resulting qualitative evaluation
j. SSC Ruggedness Determination
k. Limiting Component Selection
l. Results of Margins Assessments that where performed
m. Recommended actions resulting from Margins Assessments
n. Recommendations for improvements of the DSA
o. Recommendations for improvements of emergency planning and response capabilities

A structured and systematic approach should support the team's BDBE evaluation and document the results of team deliberations. An example data format that can be used to support the review is provided in Appendix A.

The BDBE evaluation results should be examined and compared to information contained in the facility's DSA to determine whether DSA information could be enhanced. The DSA should document: the scope, method and criteria used for the evaluation of the BDBEs; the results of impact of failure of hazard controls; and the results of analysis of additional opportunities to mitigate BDBEs. These analyses can serve as bases for cost-benefit considerations for improvements, either to the facility's existing SSCs, or by adding dedicated systems and components (such as alternate portable emergency power or water sources) for BDBE response, as well as improvements associated with enhanced emergency management capabilities.

SSCs that provide protection against BDBEs are typically the safety class controls, or a subset of these controls, credited in the DSA for design basis events. The DSA may benefit from added descriptions of performance capabilities for these elements, as learned from the BDBE evaluation. For example, insights gained with respect to design margins would enhance SSC system evaluations contained in the DSA.

In the case when the BDBE evaluation identifies non-credited SSCs that provide mitigation, it is not expected that these SSCs would be classified as safety-class or safety-significant based solely on BDBE consequences, and, therefore, additional technical safety requirements for these SSCs would not be created. Rather, the DSA should address these SSCs as important to provide BDBE protection.

The BDBE evaluation may identify additional preventive or mitigative controls or potential improvements to existing SSCs that may be needed in response to BDBEs. SSCs important for providing additional mitigation of BDBEs should be maintained within the facility configuration management and maintenance programs in the same manner that other non-safety class and safety significant DSA controls are treated to preserve their safety function. PSOs should consider some type of control to determine the approval authority for changes to BDBE controls, or whether more general provisions of maintenance and configuration control should be relied upon.

Updates to the DSA may also benefit from added discussion related to analytical details of BDBE scenarios. Differing failure modes, consequences, and facility conditions associated with the spectrum of BDBEs, along with important assumptions, time-frames associated with scenario development, and time-critical mitigative actions may be important to document in the DSA, as these details delineate the limits of expected facility operator actions (functions and timeframes), which in turn allows improved integration of emergency response plans and procedures across the site.

The coordination with emergency management planning for responses appropriate for BDBEs could also lead to plans for design changes with appropriate considerations of costs and benefits. An example of this possibility is the provision of standardized connections external to the facility for pumped water supply for cooling or fire suppression and/or electrical supply by emergency diesels brought in through emergency response capabilities.

Implications of severe accidents, including BDBEs, on emergency management programs or procedures are addressed in the Office of Emergency Operations Guide, *DOE/NNSA Emergency Management Approach for Severe Event Response Based on Lessons Learned from the Fukushima Nuclear Accident*. Insights and results gained from emergency management personnel’s participation in the BDBE evaluation process should be considered and actions taken consistent with this approach.

Appendix A: Beyond Design Basis Event Enhanced Evaluation

Example Output for Liquid Rad Waste Operations[1]

Critical Safety Function (CSF)	Essential SSCs Related to CSF	Beyond Design Basis Event	BDBE Impacts	Candidate for Margin Assessment?	Comments[2]
Maintain Hydrogen Concentration in Tank Headspace Below Lower Flammability Limit	Fan (ID # XYZ)	Seismic	Loss of Operability	Shaft damage - Yes; Load Path-Yes; Anchorage-Yes; Interactions-Yes	Evaluate potential impacts from structural failure, equipment characteristics, and robustness of anchorage
		Wind/Tornado	Loss of Operability	Interactions-Yes	Evaluate potential impacts from structural failure, missile impacts. Offsite power assumed lost
		Flood (External)	None-Backup Power available	No	Estimated maximum flood level below building basemat elevation, offsite power assumed lost but no effects on backup power
		Ash Fall	Loss of Operability	Interactions-Yes; Fan Components-No	Evaluate potential impacts from structural failure and resulting binding in mechanical or rotating equipment. Offsite and backup power assumed lost.

Appendix A: Beyond Design Basis Event Enhanced Evaluation

Example Output for Liquid Rad Waste Operations[1]

Critical Safety Function (CSF)	Essential SSCs Related to CSF	Beyond Design Basis Event	BDBE Impacts	Candidate for Margin Assessment?	Comments[2]
		Snow/Ice	Loss of Operability	Interactions-Yes; Fan Components-No	Evaluate potential impacts of structural failure (i.e., roof fall).
		Station Blackout	Loss of Operability	No	Evaluate impacts from loss of offsite and backup power.
		Wildland Fire	Loss of Operability	No	Evaluate impacts from engulfing facility fire.
		Lightning	Loss of Operability	No	Evaluate impacts from loss of power.
	Ducting in areas A, B & C	Seismic	Loss of Confinement	Anchorage-Yes; Interactions-Yes; Connections-Yes	Evaluate potential impacts from structural failure, robustness of anchorages, ducting connections.
		Wind/Tornado	Loss of Confinement	Interactions-Yes	Evaluate potential impacts from structural failure, missile impacts.
		Flood	None	No	Estimated maximum flood level below building basemat elevation.

Appendix A: Beyond Design Basis Event Enhanced Evaluation

Example Output for Liquid Rad Waste Operations[1]

Critical Safety Function (CSF)	Essential SSCs Related to CSF	Beyond Design Basis Event	BDBE Impacts	Candidate for Margin Assessment?	Comments[2]
		Ash Fall	Loss of Confinement	Interactions-Yes;	Evaluate potential impacts from structural failure.
		Snow/Ice	Loss of Confinement	Interactions-Yes;	Evaluate potential impacts from structural failure.
		Station Blackout	None	No	Loss of power has no effect on passive confinement.
		Wildland Fire	Loss of Confinement	No	Evaluate impacts from engulfing facility fire.
		Lightning	None	No	Loss of power has no effect on passive confinement.
	Electrical power	*Repeat as Above*	…	…	…
	Diesel Generator	*Repeat as Above*	…	…	…

Appendix A: Beyond Design Basis Event Enhanced Evaluation

Example Output for Liquid Rad Waste Operations[1]

Critical Safety Function (CSF)	Essential SSCs Related to CSF	Beyond Design Basis Event	BDBE Impacts	Candidate for Margin Assessment?	Comments[2]
Active Confinement Ventilation	HEPA Filtration (Filters and housing ID #X)	Seismic	Loss of Confinement	Anchorage-Yes; Interactions-Yes; Filter/Housing-Yes	Evaluate potential impacts from structural failure, robustness of anchorages, ductility/robustness in filter media/housing.
		Wind/Tornado	Loss of Confinement	Interactions-Yes;	Evaluate potential impacts from structural failure, missile impacts, atmospheric pressure changes.
		Flood (External)	None	No	Estimated maximum flood level below building basemat elevation.
		Ash Fall	Loss of Confinement	Interactions-Yes;	Evaluate potential impacts from structural failure.
		Snow/Ice	Loss of Confinement	Interactions-Yes;	Evaluate potential impacts from structural failure.
		Station Blackout	None	No	Loss of power has no effect on passive filtration function.

Appendix A: Beyond Design Basis Event Enhanced Evaluation

Example Output for Liquid Rad Waste Operations[1]

Critical Safety Function (CSF)	Essential SSCs Related to CSF	Beyond Design Basis Event	BDBE Impacts	Candidate for Margin Assessment?	Comments[2]
		Wildland Fire	Loss of Confinement	No	Evaluate impacts from engulfing facility fire.
		Lightning	None	No	Loss of power has no effect on passive filtration function.
	Ducting	Same as CSF Related to Maintaining H_2 below LFL	…	…	…
	Fans	Same as CSF Related to Maintaining H2 below LFL	…	…	…
	Electrical power	Same as CSF Related to Maintaining H2 below LFL	…	…	…
	Diesel Generator	Same as CSF Related to Maintaining H2 below LFL	…	…	…

Appendix A: Beyond Design Basis Event Enhanced Evaluation

Example Output for Liquid Rad Waste Operations[1]

Critical Safety Function (CSF)	Essential SSCs Related to CSF	Beyond Design Basis Event	BDBE Impacts	Candidate for Margin Assessment?	Comments[2]

1. BDBE Evaluation is focused on accident in a DSA involving hydrogen deflagration/detonation in a tank located within a facility process cell (exceeds the 25 rem offsite evaluation guideline). The DSA controls for the Design Basis Accident include purge ventilation (preventive) and HEPA filtration (mitigate consequences following the accident).
2. Comments should capture important assumptions during team deliberations, as well as the logic used in selecting items, if any, for further margins assessment.

APPENDIX B - STRUCTURED WALKDOWNS

Structured walkdowns provide an opportunity for the team and facility personnel to identify potential vulnerable to specific BDBEs as well as opportunities for systems enhancements that may bolster the ability of systems to perform their BDBE function. Structured walkdowns should be conducted by subject matter experts and are focused on identifying the vulnerability of SSCs to failure in accidents, up to and including the bounding BDBE. Structured system-specific walkdowns also support the margin-to-failure analysis for each selected SSCs.

This Appendix provides guidance for seismic, flood, and high wind walkdowns. The information and methods in this Appendix should also be used for all evaluated BDBEs (e.g., fire, snow/ice, etc.)

Walkdowns are a visual examination of a SSC, to collect data for a qualitative, or deterministic, or probabilistic analysis, and/or to identify potentially adverse conditions associated with the BDBE being evaluated.

1. SEISMIC WALKDOWN

1.1 Qualifications of Seismic Walkdown Engineers

The Seismic Walkdown Engineers (SWEs) should have a degree in mechanical or civil/structural engineering, or equivalent; and experience in seismic engineering at DOE facilities or nuclear power plants. They should be assisted, as necessary, by a system engineer (particularly for electrical and I&C walkdowns), a maintenance technician, and operations personnel.

1.2 Objective of Seismic Walkdown

The objective of the seismic walkdown is to collect field information on the as-installed SSCs to be used as input to the seismic evaluation. The seismic walkdown protocol and checklist of DOE-EH-0545, Seismic Evaluation Procedure for US Department of Energy Facilities, U.S. Department of Energy, or equivalent, can be used in this case.

If there is a current BDBE evaluation, the objective of the seismic walkdown may be to verify that the field condition matches the existing BDBE evaluation. In this case, an example of checklist can be seen in EPRI Technical Report 1025286 *Seismic Walkdown Guidance for Resolution of Fukushima Near-Term Task Force Recommendation 2.3: Seismic*.

1.3 Preparatory Activities to Support Seismic Walkdown

An initial walkdown of the facility is recommended to familiarize the walkdown personnel with the facility, and to identify accessibility needs such as area access approval or escort, work requests for radiation monitoring support, scaffolding, and opening of electrical cabinets. Also, to prepare for the seismic walkdown, the SMEs will document the objective of the walkdown. Typical objectives could include: (1) A qualitative walkdown to determine failure modes (how the SSC will fail, and interactions), or (2) A semi-quantitative to calculate margins (HCLPF), or (3) A confirmatory walkdown to verify that the field condition matches the analyzed condition modeled in an existing BDBE assessment.

Prior to conducting the walkdown, the following information or equipment may be needed to support the walkdown:

1. A seismic walkdown equipment list, which identifies the SSCs to be walked-down, their location, and their seismic function. Preferably including orthographic/plant drawings, P&ID, or electrical diagrams showing the scope.
2. The ground motion for the review level earthquake (i.e. the upper-bound BDBE earthquake), and corresponding in-structure spectra.
3. The normal operating or consequent loads concurrent with the BDBE.
4. The SSC design and risk analysis input information, including drawings, calculations and seismic margins, specifications, maintenance history.
5. Personnel protective gear where needed, and flash light, tape measure, caliper (if needed to measure bolt diameter), and camera.

1.4 Scope of Seismic Walkdown

A seismic walkdown must address three critical areas: (1) The adequacy of the SSC, (2) the adequacy of the SSC anchorage and bracing, and (3) the potential for adverse seismic interactions. These three areas are discussed below.

1.5 SSC Adequacy Walkdown

The seismic evaluation of SSCs for BDBE combines walkdown-based information and design-based information to perform a qualitative (failure mode), or deterministic (demand vs. capacity), or a probabilistic (HCLPF) estimates of likelihood of failure and failure modes. For a deterministic or probabilistic evaluation, system-specific and equipment-specific walkdowns must be performed, following the guidance of DOE-EH-0545 and EPRI NP-6041, to develop high confidence of low probability of failure (HCLPF) estimates.

Seismic evaluation walkdown sheets (SEWS) should be developed, similar to those in DOE-EH-0545, with supporting photographic record.

If the BDBE exceeds the reference spectrum of DOE-EH-0545, then the SEWS-based evaluation is insufficient to establish the seismic adequacy of active mechanical equipment (pumps, compressors, fans, motor operators) and electrical equipment and components, must be based on test date, or generic values of HCLPF for similar equipment, documented and justified on a case-by-case basis.

1.6 Anchorage and Bracing Walkdown

An important part of the seismic walkdown is the anchorage and bracing inspection. It has two objectives:

1. Identify inadequate anchorage conditions, including (1) damaged or missing anchorage or braces; (2) undersized bolts, braces or welds, (3) poorly installed bolts or braces, (4) corrosion beyond surface rust, (e) cracks in concrete through or near bolts.
2. Collect and document the anchorage pattern and parameters, and load path and bracing characteristics to calculate seismic capacity of the support system. Refer to DOE-EH-0545 for anchorage attributes to be collected to calculate anchorage capacity.

1.7 Seismic Interactions Walkdown

The seismic interaction walkdown should identify credible interactions (i.e. interactions that can physically take place) and significant interactions (i.e. interactions that, should they take place, could damage the target).

The interaction source should be evaluated using the seismic input of the interaction target. For example, if the interaction source is performance category 2 (PC-2) but the target is PC-3, then the demand on the source should be based on PC-3 input.

The following types of interactions should be addressed:

1. Spatial interactions: Such as falling, swing impact, rattle impact of adjacent electrical cabinets, collapse of masonry block walls, rolling gas bottles, excessive differential motion causing tearing, etc. The guidance of DOE-EH-0545 can be used for the assessment of spatial interactions. The zone of influence (ZOI) of spatial interactions may be calculated based on the floor response spectra acceleration at the attachment points of the interaction source. Potential interactions from unanchored equipment may be evaluated using the method in ASCE 43. Spatial interaction walkdowns may also identify housekeeping-related issues that should be corrected.

2. Spray interactions: Sprays from leaks from overhead piping systems, vessels or tanks onto water-sensitive systems and components (such as electrical, I&C). Any piping system, vessel or tank that is not qualified for BDBE should be assumed to spring a leak by failure and, in the case of wet fire systems, by spurious actuation during the BDBE. (Ref. Information Notice 83-

41, June 22, 1983, Actuation of Fire Suppression System Causing Inoperability of Safety Related Equipment).

3. Flood interactions: Flooding as a result of leak or rupture of pipes, vessels or tanks, causing submergence of essential systems and components, or overload of floors and walls.

4. System interactions: Systems interactions from non-BDBE qualified systems and components causing erroneous or spurious signals to be transmitted, causing the unintended operation of shutdown of systems and components and excessive, contradictory alarms in the control room. Systems interactions must be evaluated on a case by case basis.

5. Seismic-induced fire: Seismic induced fires can be caused by spill of flammable material from inadequately anchored containers, leaks from natural gas or hydrogen lines, overturning of bottles of compressed flammable gases not secured by a minimum of two chains. Also, fires can be caused by seismically-induced contact between high voltage switchgear or hot shorts (Ref. EPRI-NP-6898, September 1990, Survey of Earthquake-Induced Fires in Electrical Power and Industrial Facilities", Ref. EPRI TR-100370, Fire Induced Vulnerability Evaluation FIVE, 1993).

1.8 Walkdown Deliverables

The following documents should be filed and retrievable at the end of the walkdown:

1. The pre-walkdown input listed in prerequisite to seismic walkdown, above.
2. The qualifications of the SWEs.
3. The walkdown checklists and results, identifying whether there are open items or items that require resolution, signed by the SWEs.
4. The walkdown notes, records, photographs (field notes as well as typed versions of the checklists should preferably be kept).

2 FLOOD WALKDOWN

2.1 Qualifications of Flood Walkdown Engineers

Personnel performing visual inspections for flood protection should be knowledgeable in the design of the flood protection feature. In the case of earthen or structural features one member of the walkdown team should be a geotechnical, civil, or structural engineer.

2.2 Objectives of Flood Walkdown

The objectives of the flood protection (i.e. prevention or mitigation) walkdown are to:

1. Verify the adequacy of permanent structures, systems, components (SSCs) relied upon to prevent or mitigate flood damage from the BDBE.

2. Verify the adequacy of portable flood mitigation equipment, their readiness, operability and accessibility in case of the BDBE. Verify that procedures for the use of portable flood mitigation equipment are up-to-date and periodically drilled and tested.

2.3 Flood Protection Features

Flood protection features include flood prevention and flood mitigation features. They may be passive or active:

1. Passive features include berms, dykes, walls, retention ponds, drains, slopes, etc.

2. Active flood protection features include sump pumps, isolation and check valves, flood level alarms, and flood doors.

2.4 Preparatory Activities to Support Flood Walkdown

An initial walkdown of the facility is recommended to familiarize the walkdown personnel with the facility, and to identify accessibility needs such as area access approval or escort, work requests for radiation monitoring support, scaffolding, and opening of electrical cabinets. Also, to prepare for the flood walkdown, the SMEs will document the objective of the walkdown. Typical objectives could include: (1) A qualitative walkdown to determine failure modes (how the SSC will fail, and interactions), or (2) A confirmatory walkdown to verify that the field condition matches the analyzed condition modeled in an existing BDBE assessment.

Prior to conducting the walkdown, the following information or equipment may be needed to support the walkdown:

1. Current DBE flood safety analyses, including flood history, topographical maps, and design-basis analyses with supporting drawings.

2. Current DBE flood warnings, procedures, plant-specific actions, such as deployment of portable equipment, and site-wide emergency response.

3. Obtain the probable maximum BDBE flood height, and identify if it exceeds the current capabilities of flood prevention or mitigation features. External BDBE flood heights can be due to the following sources, as applicable for the site: intense

precipitation (Ref. NRC Generic Letter 89-22), storm surge, stream/river/lake swell, seismically BDBE-induced or age-induced dam failure, hurricane surges, meteorologically-induced or seismically-induced seiches in large inland lakes and coastal harbors, seismically-induced tsunamis, landslides, and ice melts. (Ref. NRC Standard Review Plan NUREG 0800 Section 2.4).

4. Identify the type of flood damage to be evaluated, such as external hydrostatic pressure on structures, tanks, etc., buoyant uplift force on closed structures, dynamic wave forces, loss of electrical and I&C by submergence, criticality by loss of geometry or introduction of water, etc.

5. Determine the Flood walkdown list and (based on the list) the qualifications of flood walkdown personnel.

6. Determine accessible and inaccessible areas, i.e. areas that cannot be inspected due to (a) personnel safety hazard, (b) high radiation, (c) the need for major equipment disassembly to achieve access, (d) restricted for security reasons, or (e) buried or embedded commodities.

2.5 Passive Flood Protection Attributes to Check

1. Check that the location and elevation of BDBE-essential SSCs does not subject them to flood effects that may cause loss of function.

2. Verify the adequacy of earthen features: Their height, width, length and perimeter, their condition (erosion, failure, restrictions, etc.), signs of leakage, and overall site drainage capabilities.

3. Verify the adequacy of credited structures: Their height, length and perimeter, their material condition (corrosion, integrity, cracks in concrete, etc.), signs of leakage (stains, deposits, etc.), condition of seals at penetrations (water-tight doors, walls or floor penetrations, etc.), sources of in-leakage into buildings, including the elevation of non-sealed doorways and the opening of vent pipes.

4. Verify the adequacy credited storm drains, ditches, culverts, sumps: Conformance to drawings, general condition, cleanliness and risk of blockage, size if required in the BDBE list.

5. Evaluate the potential for roof ponding: Check the conditions of roof drains and slopes credited to limit the load from a BDBE precipitation to exceed the design roof live loads (1 inch-deep standing water exerts a distributed load of 2 lb/ft^2).

2.6 Active Flood Protection Attributes to Check

1. Verify the adequacy of portable flood mitigation equipment, their readiness and accessibility in case of the BDBE.

2. Verify that the equipment is stored in flood-protected areas.

3. Verify that procedures for the use of portable flood mitigation equipment are up-to-date and periodically drilled and tested.

2.8 Walkdown Deliverables

The following documents should be filed and retrievable at the end of the walkdown:

1. The input data listed in Pre-Requisite to Flood Walkdown, above.
2. The qualifications of the flood walkdown personnel.
3. The walkdown checklists and results, identifying whether there are open items or items that require resolution, signed by the flood walkdown personnel.
4. The walkdown notes, records, photographs (field notes as well as typed versions of the checklists should preferably be kept).

3. HIGH WIND WALKDOWN

3.1 Qualifications of Wind Walkdown Engineers

Personnel performing visual inspections should be knowledgeable in the design of the wind protection features. One member of the walkdown team should be a structural engineer, or equivalent.

3.2 Objectives of High Wind Walkdown

The objective of the wind walkdown is to verify the adequacy of structures, systems, and components (SSCs) relied upon to prevent or mitigate wind damage from the BDBE. Wind damage can take several forms: external pressures on structures, external-internal pressure differential in closed structures, and tornado missiles where defined to be part of the BDBE.

3.3 Preparatory Activities to Support High Wind Walkdown

An initial walkdown of the facility is recommended to familiarize the walkdown personnel with the facility, and to identify accessibility needs such as area access approval or escort, work requests for radiation monitoring support, scaffolding, and opening of electrical cabinets. Also, to prepare for the high wind walkdown, the SMEs will document the objective of the walkdown. Typical objectives could include: (1) A qualitative walkdown to determine failure modes (how the SSC will fail, and interactions), or (2) A confirmatory walkdown to verify that the field condition matches the analyzed condition modeled in an existing BDBE assessment.

Prior to conducting the walkdown, the following information or equipment may be needed to support the walkdown:

1. Current DBE wind safety analyses, and design-basis analyses with supporting drawings.
2. Current DBE high wind or tornado watch and warnings, procedures, plant-specific actions, such as deployment of portable equipment, and site-wide emergency response.
3. Determine the BDBE wind speed and calculate the corresponding wind pressures and forces.
4. Determine BDBE tornado missile type, shape, maximum velocity.
5. Obtain the list of SSCs credited and their function following the BDBE high wind, and tornado if applicable.

3.4 Walkdown Attributes

1. Perform an exterior visual walkdown of SSCs credited to resist high winds, for general conformance to the design drawings and the basis for BDBE high wind assessments.
2. Check the condition of blow-away siding and blow-out panels, where credited.
3. Evaluate the wind and tornado interactions from non-qualified SSCs collapsing or being ejected onto BDBE-essential SSCs.
4. Look for materials around the site that can become larger missiles than the BDBE tornado missiles, if tornado is applicable.
5. Check the condition of tornado or high wind barriers or credited features, against design drawings, if applicable.
6. Look for large openings that could permit the penetration of tornado missiles, if applicable.

3.5 Walkdown Deliverables

The following documents should be filed and retrievable at the end of the walkdown:

1. The input data listed in Pre-Requisite to Wind Walkdown, above.
2. The qualifications of the wind walkdown personnel.
3. The walkdown checklists and results, identifying whether there are open items or items that require resolution, signed by the wind walkdown personnel.
4. The walkdown notes, records, photographs (field notes as well as typed versions of the checklists should preferably be kept).