Summary of NRC Comments on Addendum B to ASME/ANS RA-S-2008

Below is a summary of U.S. Nuclear Regulatory Commission (NRC) comments. They are summarized by topic with examples to provide illustration. This summary and examples are not to be interpreted as including all the places in the standard where clarification and consistency needs improvement.

1. Stability of the Standard. The standard needs to be stable, as best as practical, such that changes to the standard primarily occur as a result of new information. A key factor in achieving stability is that the standard is written strictly to explain "what to do" in a clear, consistent, and cohesive manner. Another key factor is minimizing the frequency and degree to which the standard changes. Continuing to defer comments and not addressing clarity and consistency (to the extent practical) do not promote an efficient use of the standard. Many of the comments were provided by the NRC representative during the Committee on Nuclear Risk Management (CNRM) ballot on Addendum B and are included because the bases provided by the various ballot project managers (PMs) were not adequate.

   At this time, the CNRM should make a concerted effort to ensure that Addendum B produces a clear, consistent and cohesive standard in keeping with the "style guides" for an acceptable standard developed by ASME, American Nuclear Society (ANS) and American National Standards Institute (ANSI).

2. Clarity and Understandability of the Requirements. In some places in the addendum, the stated requirement is not clear or is ambiguous. The requirements should be written in a manner that would not drive a user, peer reviewer, or NRC reviewer to an inappropriate conclusion or interpretation. Further, as the current generation of CNRM members retires and the next generation (who may have experience with neither the probabilistic risk analysis (PRA) nor the history of the standard) takes ownership, the intent of the requirements needs to be clear. Use of the standard should not require assistance from the authors (e.g., the writing team) or an experienced PRA analyst in the specific technical area to understand what the requirement is stating, although accomplishment of the requirement may well require an experienced PRA analyst in that area (i.e., to understand and implement the associated method). Clarity and understandability are essential factors for the stability of the standard. The following examples illustrate places in the addendum where clarity is needed:

   a. SHA-B3, Capability Category (CC) I states, *"As part of the data used, INCLUDE a catalog of historically reported earthquakes*…." CC II/III states, *"As part of the data collection, COMPILE a catalog of historically reported earthquakes*…." The differences between the CCs in terms of what is required are vague, and the note does not provide clarity. CC I tells the analyst what to include in the data used. Since the content of the catalog in CC I and CC II/III is the same, the difference

between *"INCLUDE a catalog"* (which has to be compiled) in CC I and *"COMPILE a catalog"* in CC II/III is not clear, unless the sources are different; however, the requirement does not make that distinction.

b. Part 5 has a new requirement—SPR-B7. As part of this requirement, the text states that *"it is acceptable to use conservative recovery values."* In the CNRM ballot, the comment was asked, *"What is meant here by* 'conservative' *recovery values*?" The PM responded, *"The term 'conservative' here as elsewhere in the Standard is well known to PRA analysts and should not cause any confusion."* However, what is considered an acceptable recovery value is not well known; there is no consensus on what is meant by conservative, or what constitutes a conservative recovery value. Other supporting requirements (SRs) also use the term "conservative" without definition. "Conservative" is a term that is interpreted differently as to what is acceptable when making statements such as "a conservative analysis," "evaluate in a conservative manner," "conservative treatment," and "conservative recovery analysis." The addendum needs to define "conservative."

c. Section 1-1.2 now includes a new subsection (Section 1-1.2.2) on hazards and initiating events. This section provides a short explanation of the relationship between the terms "hazard," "hazard event," "hazard group," and "initiating event." In the CNRM ballot, it was commented that this discussion is confusing and inconsistent. Further, it was suggested that the section include a table to illustrate the relationship and an example table was provided to clarify the discussion. The PM responded in part that *"Other reviewers have not expressed this view."* The discussion in Section 1-1.2.2 remains confusing and requires multiple readings to understand and follow.

The discussion in Section 1-1.2.2 becomes more confusing because the language in various parts of the standard is not consistent with this discussion of these terms. That is, in some places in the standard, the terms "hazard," "hazard event," "hazard group," and "internal event" do not match the discussion in Section 1-1.2.2. For example, the definition in Section 1-1.2.2 for "internal events" states the following:

> [A]n *event resulting from or involving mechanical, electrical, structural, or human failures from causes originating within a nuclear power plant that directly or indirectly cause an initiating event and may cause safety system failure or operator errors that may lead to core damage or large early release. By historical convention, loss of offsite power is considered to be an internal event, and internal fires is considered to be an external event except when the loss is caused by an external hazard that is treated separately (e.g., seismic-induced LOOP). Internal floods have sometimes been included with internal events and*

> *sometimes considered as external events. For this Standard, internal floods are considered to be internal hazards separate from internal events. By historical convention, turbine-generated missiles and internal fires, even though they originate within the power plant, are internal hazards treated separate from internal events*.

This long definition and discussion is very confusing and contradictory. The discussion on the history is both unnecessary and adds to the confusion. From an historical perspective, the term "hazard" was not used in the past to differentiate the types of initiators; instead, the term "event" was used. Looking back (in the 1970s to 1980s), internal events were the random (spurious) failures of structures, systems, and components (SSCs) from causes internal to the SSC (e.g., disc failure in a valve) that could lead to an initiator. Consequently, failures from causes external to the SSC (e.g., flood, fire, earthquakes) were considered external events. The exception was the loss of offsite power, which has always been considered an internal event. Over time, the distinction between floods and fires occurring from causes internal and external to the plant was recognized, and floods and fires were further differentiated into internal and external floods, and internal and external fires. With this distinction, the community did not appropriately clarify the relationship of internal flood and internal fire with SSC failures from causes internal to the SSC. Consequently, the term "internal event" has been used in different ways as related to internal floods and internal fires. The standard has addressed this confusion by appropriately using the term "hazard" to differentiate internal events, internal floods, internal fires, earthquakes, external fires, external floods, and other internal and external hazards. The lengthy discussion in the definition does not provide any value; moreover, it adds to the confusion particularly for analysts who do not know the history of the term's use. The standard should simply define the terms (e.g., "hazard," "internal event," "internal flood," "internal fire") and then use them consistently. The following definition for "internal events" is suggested:

> *An event resulting from or involving spurious mechanical, electrical, structural, or human failures from causes originating within the SSC (e.g., disc failure in a valve, spurious operation inadvertently causing pump to stop) that directly or indirectly cause an initiating event. Loss of offsite power is an exception, and by historical convention is considered an internal event. Internal flood and internal fire are internal hazards, not internal events.*

The following provides some examples of the standard's use of terms inconsistently:

i. Section 2-1.1 states, "… *of internal events (excluding floods and fires within the plant) while at power. Consistent with the definitions in 1-1.2, internal floods and internal fires are considered separately*…." These statements are not needed since internal events do not include internal floods or fires. Moreover, the discussion in Section 2-1.2 is confusing and can be misinterpreted. The requirements in Part 2 are the necessary requirements for a Level 1/large early release frequency (LERF) PRA for internal events for at-power conditions. The other hazards groups build upon the internal events at-power PRA model. Statements such as *"Hence, even though Part 2 is given a title associated with the internal events hazard group it is understood that the requirements in this Parts are applicable to all the hazard groups within the scope of the PRA"* can be misinterpreted. Part 2 includes requirements that are not applicable and are not included for a different hazard group. In numerous places in the other parts, the SR will state *"use the applicable requirements*," which implies that not all the requirements in Part 2 are applicable.

ii. Similar sections in the remaining parts are not consistent, as shown in the following examples:

- Sections 3-1.1 and 3-1.2 use the appropriate language, "…*analysis of the internal flood hazard group while at-power*" and *"An internal events at-power PRA develop in accordance with Part 2 is the starting point for the development of*…."

- Section 4-1.1 states, "…*analysis of fires occurring within the plant while at-power."* However, a footnote states, *"Note that the term 'fire occurring within the plant' in this context is defined as any fire originating within the global analysis boundary as defined per the Plant Partitioning technical element."* Section 4-1.2 states, *"This Part assumes as an entry point for the Fire PRA that an Internal Events PRA for initiators other than fire has been completed*…." This statement implies that internal fire is an internal event.

d. In Sections 1-6.6.1(h) and 1-6.6.1(i), the requirements originally stated, "…*have a significant impact on the PRA*" and "…*determined to be significant*…," respectively. The use of the word "significant" is not consistent with the definitions in Section 1-2. As part of the recirculation ballot, "significant" was changed to "important"; that is, "…*have determined to be important to the PRA."* This change does not address the problem and is not an acceptable solution. The meaning of the word "important" is very subjective, and what is important to one analyst is not necessarily important to another.

e. Throughout, the standard states, *"perform using the applicable requirements in Section x of Part 2."* Such statements are vague. Because the analyst, as opposed to the standard, determines the applicable requirements, those requirements could therefore vary among the different analysts. The standard needs to either specify the applicable requirements or provide criteria for determining the applicable requirements. This comment was included in the CNRM ballot. The PM responded *"There is nothing specific enough in this comment to warrant a change in the text."* However, the comment is specific as to the problem.

f. The note in SFR-F3 states, *"Essential relays are defined in Reference [5-14]."* The comment was made during the CNRM ballot that the definition should be in the requirement because the notes and commentaries with the SRs are non-mandatory. The PM responded that no change would be made because the definition of the term is *"a long and complicated issue that is best left in the reference."* However, if this definition is the definition that must be used, then the reference needs to be in the requirement and not in the note.

g. Certain action verbs were identified that were not acceptable because they were not being used consistently with their definitions. These same verbs appear in the standard, but not as action verbs; however, they still need to be corrected. For example, "capture" was removed as an action verb, however, DA-C12 continues to misuse the term as a verb (e.g., "…*and to capture dependency on support system correctly*").

h. A "seismic-caused correlation" refers to identifying SSCs that may be equally affected by the earthquake; for example, if two pumps of the same design, manufacture, and size are co-located, 100-percent correlation may be assumed such that the analyst assumes that both pumps are equally affected (i.e., both pumps fail from the earthquake). The standard does not define the term "seismic correlation," and this becomes confusing because the standard also uses the term "dependencies." Based on the PM's discussion for SPR-B3, it appears that "correlations" and "dependencies" are different, also because the term "dependencies" has been deleted. However, the note in the new commentary states, *"the overall state of knowledge about the amount of dependency/correlation among earthquake-induced SSC failures is limited."* In other SRs (e.g., SPR-E4 and SPR-E6), the difference between correlations and dependencies is not clear.

Ordinarily, dependencies should have already been modeled in the fault trees, regardless of the causes. Perhaps "seismic-caused dependencies" refers to those dependencies that would not be modeled in an internal events PRA but that would appear in a seismic PRA. For example, if the supply for a cooling system came from a particular tank, the tank would not usually be modeled in the

internal events PRA, so the dependency of the cooling system on the tank would not appear. In the seismic PRA, the cooling system dependency should be modeled. In any case, a definition is needed.

i. SPR-B7 is a new SR. For CC II, it states, "…*ADJUST the recovery models accordingly. It is acceptable to use conservative recovery values."* For CC III, it states, "…*EVALUATE the likelihood that system recoveries modeled in the internal-events PRA may be more complex or even not possible after a large earthquake, and ADJUST the recovery models accordingly. USE plant-specific recovery values where available."* The SR implies that some kind of data base is available with either "conservative recovery values" or "plant-specific recovery values." The recovery model is performing a human reliability analysis (HRA) using plant-specific information. For CC II, a plant-specific HRA should be required; however, in performing the plant-specific HRA, it would be acceptable to use conservative assumptions (e.g., assuming 1 hour as opposed to 10 hours, difficulty in performing the action as opposed to easily performing the action) in performing the plant-specific HRA. However, the definition of a "conservative assumption" should still be given and examples provided, as is done in other parts of the standard, to help clarify such ambiguous terms.

CCs II and III require the analyst to adjust the system recoveries modeled in the internal events PRA given a large earthquake. CC I states, *"Do not INCLUDE recoveries."* This requirement is confusing since the recoveries are already included in the internal events PRA. Confusion would be alleviated if the requirement were stated *"ASSUME any system recoveries modeled in the internal events PRA are not possible after a large earthquake and recovery values are to be set to 1.0."*

This SR is further confusing when considering SPR-B2 and SPR-B4b. SPR-B2 does not require the analyst to assume no recovery in CC I, and SPR-B4b allows recovery if the analyst provides a "documented basis." Moreover, SPR-B7 appears to be redundant to SPR-B2 and SPR-B4b.

j. SPR-B2 uses the term "scaling factor." This is not an HRA term and it is not clear what is requested.

k. Section 1-1.3.3 now states the following:

> *It is intended that, by meeting all the SRs under a given HLR, a PRA will meet that HLR. The Technical Requirements Section of each respective Part of this Standard also specifies the required documentation to facilitate PRA applications, upgrades, and peer review. The SRs specify what to do rather than how to do it, and, in that sense, specific methods for satisfying the requirements are not prescribed. Nevertheless, certain established methods were*

contemplated during the development of these requirements. Alternative methods and approaches to the requirements of this Standard may be used if they provide results that are equivalent or superior to the methods usually used and they meet the HLRs and SRs presented in this Standard.

This statement is not helpful, since if a particular method was "contemplated during the development" of the requirement, the analyst may not have any knowledge of it and must guess.

The text also states that "*The use of any particular method for meeting an SR shall be documented and shall be subject to review by the peer review process described in Section 1-6."* It is not necessary to call for documentation, since, for each technical element, one of the documentation SRs always states, "…*including the inputs, methods, and results."* Moreover, it is not appropriate to have this requirement in this location of the standard because it could easily be overlooked since Part 1 of the standard does not provide any general documentation requirements and because each technical element already addresses documentation. The requirement in the statement "…*and shall be subject to the review by the peer review process described in Section 1-6*" needs to be located in Section 1-6.

A comment noting that the established methods are not specified in the standard was included in the ballot; the PM responded that the *"comment addresses issues beyond the scope of the current proposal*…." The comment relates to a proposed change in Addendum B.

l. High-level requirements (HLRs) are typically general requirements and the associated SRs specify what is needed to accomplish the HLR. Section 1-1.3.3 states, *"The HLRs are defined in general terms and present the top level logic for the derivation of more detailed SRs."* Consequently, the HLR must have a direct correlation to the associated SRs. However, this structure has not occurred in places such as the following:

   i. Some HLRs (e.g., HLR-SHA-H and HLR-SHA-I) have no SRs, which is confusing to the analyst. Section 1-1.3.3 states, "By *meeting all the SRs under a given HLR, a PRA will meet that HLR."*

   ii. Because of this relationship between HLRs and their associated SRs (as explained in Section 1-1.3.3), the SR cannot require the analyst to do something less than the HLR because the PRA would not meet the HLR. This violation has occurred in places. For example, HLR-SFR-A states, *"The seismic fragility evaluation shall be performed to estimate plant-specific, realistic seismic fragilities of SSCs*…." SFR-A2 for CC I allows the use of generic data, which does not meet the HLR for plant-specific,

realistic seismic fragilities. SLR-SFR-C and SFR-C1 are another example, in that it appears that only CC III requires that the evaluation be realistic.

iii. Some SRs are clear by themselves but not clear in terms of their relationship to meeting the HLR, as in the following example for HLR-SHA-F:

- The SRs associated with HLR-SHA-F do not appear to be related and do not accomplish what is required by the HLR. HLR-SHA-F states, *"Uncertainties in each step of the hazard analysis shall be propagated and displayed in the final quantification. The results shall include fractile hazard curves, median and mean hazard curves, and uniform hazard response spectra."*

  For SHA-F1, for CC I, the SR states, *"In the final quantification of the seismic hazard, INCLUDE mean estimates."* For CC II/III, the SR states, *"In the final quantification of the seismic hazard, INCLUDE and document uncertainties."* This SR has several problems. For CC I, the analyst is to include mean estimates of what? Why are mean estimates required for CC I and not for CC II/III? Moreover, for CC II/III, the SR is not informative; it is a vague and general statement. The correlation and distinction between CC I and CC II/III are not clear. Why is documentation part of the SR for CC II/III?

  For SHA-F2, the SR states *"In the probabilistic seismic hazard analysis, INCLUDE appropriate sensitivity studies and intermediate results to identify factors that are important to the site hazard and that make the analysis traceable."* This SR does not appear to have a relationship to its HLR, which requires uncertainties to be propagated.

  For SHA-F3, the SR states, *"CALCULATE the following results as a part of the hazard quantification process, compatible with needs for the level of analysis determined in (HLR-SHA-A): (a) mean hazard curves*…." The relationship of this SR, regardless of CC, to the HLR is not clear, because the HLR requires uncertainties to be propagated.

  The SRs for this HLR do not clarify what is needed such that the analyst can ultimately be assured that uncertainties have been propagated and, therefore, the PRA has met the HLR.

HLR-SHA-F becomes further confusing when considering HLR-SHA-E and specifically SHA-E2. For CC II/III, the SR states, *"INCLUDE both the aleatory and epistemic uncertainties in the local site response analysis."* Note 2 to this SR states, "…*it is essential that the uncertainties are properly characterized and propagated in this step*…." The note appears to specify a requirement, but one that is associated more with HLR-SHA-F. Moreover, it would appear that SHA-E2 is related to HLR-SHA-F and not HLR-SHA-E.

m. For FQ-A2, the SR was revised to state, "…*IDENTIFY the ~~specific~~ appropriate initiating event or events*…," which introduces confusion as to what is meant by "appropriate." A note that was added does not provide clarity and reads as part of the requirement. The note sometimes uses the phrase "specific initiating event" and sometimes "appropriate initiating event." It is not clear if these terms are meant to be different and, if so, what is the difference. Neither the SR nor the note makes the requirement clear. The requirement appears to be that the analyst, when quantifying, needs to include as initiators those events that were not internal event initiators, but that are now initiators because of the internal fire. If this interpretation is accurate, then the purpose of this SR is unclear, since these initiators would have already been identified, and consequently, it becomes confusing as to what is being required here.

n. Section 1-6.1.3 now states, "*If the methods have not been separately peer reviewed, then the task of peer reviewing the technical adequacy and appropriateness of the method (rather than just its application) will fall to the PRA peer review team. In that case, an extensive peer review is very important."* The last sentence is confusing—is it requiring an extensive peer review, and what constitutes an "extensive peer review"? The paragraph goes on to state, "*In addition, the composition of the peer review team may need to be augmented with experts in PRA methods development so that the team includes such expertise in addition to expertise in PRA methods application."* It is not clear whether this sentence is intended as a requirement or as a recommendation. This ambiguity would disappear if the sentence were reworded as, for example, "…*In addition, the composition of the peer review team shall be augmented with the experts in PRA methods development for the unreviewed methods if this expertise does not exist in the team."* Moreover, this entire paragraph should be moved to Section 1-6.2.4. Section 1-6.1.3 contains the requirements for the peer review methodology, while Section 1-6.2 relates to peer review team composition and personnel qualifications and Section 1-6-2.4 contains the requirements for the specific qualifications of the review team.

o. Section 1-6.2.4(c) provides requirements for the size of the peer review team and the length of the onsite review. These requirements were originally written for the peer review of an internal events and internal flood PRA. The team size and

length would not be the same if the scope of the peer review included other hazards (e.g., internal fire, seismic). This distinction needs to be made.

A sentence was added to the end of the paragraph, stating *"Regardless of any such exceptions, the collective qualification of the review team shall be appropriate to the full scope of SRs within the scope of the hazard group PRA being peer reviewed."* It was noted (ballot comment t11) that this sentence was meant to clarify that *"all SRs are to be reviewed even if exceptions to the team makeup are implemented into the peer review."* Although the added sentence is appropriate, it has no relationship to the purpose stated in the comment. Furthermore, the comment is more appropriately addressed in Section 1-6.3.

p. Ballot comment t11 should be addressed in Section 1-6.3, on the review of PRA elements to confirm the methodology. Moreover, because this is a standard, it should provide minimum requirements rather than suggestions, in keeping with the intent of a standard and the stated objective from Section 1-1.2, *"This Standard sets forth the requirements*…." Therefore, the added sentence beginning *"Hazard group-specific suggestions*…" needs to be revised, as does the last sentence of the paragraph. Each related section of each part (e.g., Section 2-3.3) needs to state the minimum within each technical element that the peer reviewer shall review. However, the peer reviewer still has flexibility on the scope and level of detail for each item. For example, for systems analysis, both front-line and supports systems need to be reviewed; however, the peer reviewer decides which ones and to what depth.

q. If action verbs are used to differentiate the CCs, then the action verbs need to clearly state what is being required. In places, this clarity is not achieved. For example, consider the use of the terms "estimate" and "calculate." The term "estimate" may be used for one CC, while "calculate" is used for the other CCs; however, the difference between the CCs in the action to be taken by the analyst is not clear, particularly when a calculation is to be performed for each CC. It appears that "estimate" is used to imply a less rigorous or refined calculation. This assumption is incorrect, in that a calculation does not necessarily result in a more rigorous or refined result. This attempted distinction is further confusing because it is the remainder of the SR that makes the distinction, not the action verb itself.

r. In Parts 2 through 10 of the standard, Section x-1.2 is *"Coordination with Other Parts of This Standard."* However, Section 5-1.2 also discusses other standards that are intended to be used with Part 5. Some of these standards are in draft, and, moreover, this section could be misinterpreted to mean that the use of the referenced standards is required.

s. In the SR for CC III in FSS-G4 and CC II/III for FSS-G5, the wording was changed from *"QUANTIFY the effectiveness, reliability, and availability of*…*fire*

barrier…" to *"CALCULATE the reliability and availability of…fire barrier…that accounts for the effectiveness."* The effectiveness is not a part of reliability or availability. It is a separate determination of the ability of the fire barrier to protect the cables inside, and it may be qualitative rather than computational. Therefore, FSS-G4 should be changed to *"CALCULATE the reliability and availability of any passive fire barrier feature included. ASSESS the effectiveness of the fire barrier feature."* FSS-G5 should be changed to *"CALCULATE the reliability and availability of the active fire barrier element. ASSESS the effectiveness of the fire barrier element."*

t. DA-C13 states, *"Special attention should be paid to the case of a multi-plant site*…." The use of "should" makes this a suggestion, not a requirement. The sentence needs to be revised to state, *"PAY special attention to the case of*…."

u. If an SR is differentiated by CCs, it is because the requirement can be performed to different levels of detail, plant performance, and realism. Nonetheless, the SR still specifies the same requirement. This is not the case in places. For example, for SFR-C2, it is not clear that CC I/II requires the same as CC III but just to different levels of degree; that is, it appears that the distinction for the CC is not per the criteria in Table 1-1.3-2. There is further confusion because for SFR-C3 through C6 for CC III, it is stated that it is addressed in SFR-A2.

3. Inconsistency in the Standard. Inconsistencies can be found in each part of the standard and across parts of the standard. The more significant inconsistencies include the following:

a. Treatment of uncertainties. There are several inconsistencies associated with the treatment of uncertainties, such as the following:

i. One issue is related to actual requirements for the identification and characterization of uncertainties. This issue was controversial and discussed at length within the CNRM. Consensus was achieved; it was decided that the sources of model uncertainty need to be identified and their impact understood. It was agreed that this did not include understanding the degree to which the result may change, but only what parts of the PRA model may be affected. This decision was made because the degree to which the result may change depends on the application; that is, identifying the sensitivity studies that need to be done depends on the application under consideration and how it affects the decision being made. Consequently, a requirement that includes performing a sensitivity study is not consistent with the decision made by the CNRM. Part 5, in particular, is inconsistent in this regard with the rest of the standard.

This comment was included in the CNRM ballot with regard to SR SPR-E6. This SR states, *"PERFORM appropriate sensitivity studies to illuminate the sensitivity of the core damage frequency and large early release frequency results to various attributes of the analysis."* The PM responded that *"The incorporation of sensitivity studies has always been a full part of seismic PRA methodology, going back to the PRA procedures guide in 1982."* The PRA Procedures Guide, a guidance document, recommends, not requires, sensitivity studies for various analyses of the other hazards analyzed in the PRA, and not just for seismic hazards. In a standard that provides requirements, every requirement should be necessary to meet the objective and scope of the standard. The standard provides the requirements for a base PRA independent of an application. The CNRM recognized the value of sensitivity studies, but it also recognized that the information from the sensitivity studies indicates how the results of the PRA are used and not what is needed for a technically acceptable PRA. A sensitivity study is used to understand the results with regard to a decision; the nature of the decision and not the standard determines what sensitivity studies must be done.

ii. In certain places, particularly in Part 5, the standard only require medians or requires both medians and means; however, the other parts of the standard require the calculation and use of means for core damage frequency (CDF) and LERF.

iii. The actual placement of the requirements and the language presents issues in some cases. In Part 2, uncertainties is addressed as an HLR as part of the quantification technical element. In Part 4, uncertainty is a technical element, not an HLR, and in Part 5 it is something else (e.g., see WHA-A1 and WHA-A2). Further, the language of the requirement differs. For example, the phrase "source of uncertainty" in Part 2 only refers to model uncertainty, but in Part 4 it includes both parameter and model uncertainty. Part 5 includes general statements such as *"include both aleatory and epistemic uncertainties."* There are no technical reasons for these inconsistencies, and they cause confusion for the analyst.

b. Use of action verbs. Inconsistencies are associated with the use of action verbs, as in the following examples:

i. For some SRs, an action verb was changed, but in others the same change was not made. For example, the CNRM agreed that the action verbs had to be consistent with their definitions in an English dictionary. An example of this type of inconsistency was provided as part of the CNRM ballot, noting that the use of the term "credit" was not consistent,

the term was being misused, and it needed to be changed. Corrections were made in some places. For example, the action verb was corrected in SR-A22 from *"DO NOT TAKE CREDIT for system or component operability*…" to *"DO NOT INCLUDE system or component operability*…." However, others were not corrected. For example, LE-C9 still states, for CC I/II, *"DO NOT TAKE CREDIT for continued equipment operation or operator actions*…" and for CC III, *"JUSTIFY any credit given*…." The PM responded that *"All SRs noted used DO NOT TAKE CREDIT—change not made. This comment will be referred to the Subcommittee on Standards Maintenance."* This does not explain why the action verbs were corrected for some SRs and not for others. This standard uses action verbs to direct the analyst; using inconsistent action verbs leads to confusion.

ii. The standard uses the terms "estimate" and "calculate." The use of different action verbs in requirements implies that something different is required. Consequently, the standard implies that the analyst is required to perform a different action when "estimate" is used than when "calculate" is used. This distinction is not clear in the standard. The word "calculate" means *"to determine by mathematical methods."* The word "estimate" means *"to form an approximate judgment regarding the worth, amount, size, weight, etc."* In the standard, the frequencies and probabilities are generally obtained by calculation, that is, by using a mathematical method as opposed to making a judgment as to the probability or frequency. Using the term "estimate" instead introduces ambiguities; it allows the analyst to make a judgment rather than perform the calculation, although making a judgment is not the intent in many cases.

For example, IE-C5 states, *"ESTIMATE initiating event frequencies*…" and IE-C9 states, "…*ESTIMATE the initiating event frequency*…." However, IE-C15 states, *"CALCULATE*…*for the*…*initiating event frequencies*." "Calculate" is the appropriate action verb. IE-C5 and IE-C9 should also use "calculate." HR-G4 is an example of an acceptable usage of "estimate"; time measurements are not a calculation.

iii. Action verbs were incorrectly changed. For example, in the following examples:

- In AS-A7, the SR stated, *"DELINEATE the possible accident sequences*…." It was changed to *"DIFFERENTIATE the possible accident sequences*…." "Differentiate" is not the correct action verb to describe the requirement and how it is performed. Although the standard does not prescribe the method and how to accomplish the SR, knowledge of how the SR is performed does

play a part in the formulation of the SR. Different methods can be used in the development of the accident sequences, but they are developed, not differentiated. Moreover, for AS-A5, the SR stated, *"DEFINE the accident sequence model in a manner*…." It was changed to *"DEVELOP the accident sequence model in a manner*…." This change was appropriate. In AS-A5, the term "model" is not needed; that is, the accident sequences are the accident sequence model such that AS-A5 could be written as *"DEVELOP the accident sequences in a manner*…." Moreover, AS-B5 uses the action verb "develop"; other places (e.g., parts) use the term "develop." The same action verb, "develop," should be used for these similar SRs.

- In QU-B9, the SR stated, *"When using logic flags, SET logic flag events to either TRUE or FALSE (instead of setting the event probabilities to 1.0 or 0.0), as appropriate*…." The SR was changed to *"When using logic flags, SPECIFY logic flag events to either TRUE or FALSE (instead of setting the event probabilities to 1.0 or 0.0), as appropriate*…." The original term "set" was the appropriate action verb and consistent with the entire SR. That is, changing "set" to "specify" was inconsistent with the remaining part of the SR, which states "…(*instead of setting the event probabilities*…."

- In FQ-A1, the SR stated, "…*TRANSLATE the equipment and cable failures…into basic events*…." It was changed to "…*CONVERT the equipment and cable failures…into basic events*…." The original action verb was not correct, however, "convert" is also not correct. Equipment and cable failures are not physically changed into basic events; a PRA model is constructed where the basic events of the model represent equipment failure, for example. An acceptable change would be "…*in the fire PRA plant response model, REPRESENT the equipment and cable failures as basic events."*

c. "Format" and "word usage." In some places in the standard, particularly in Part 5, where format and word usage differ, as shown in the following examples:

i. The CNRM discussed extensively the use of the term "dominate." The CNRM ultimately decided not to use this term in the standard because it could not reach consensus on the definition. For example, some definitions include any contributor above 1 percent, some above 15 percent, some above 90 percent, and some, any contributor surviving truncation. The CNRM agreed to use "significant" and provided a definition. However, the term "dominate" appears in Part 5. Note 3 to

SHA-C3 originally stated, "…*uncertainties in the hazard estimates dominate the uncertainties in the final seismic PRA results*…." The NRC provided the comment as part of the CNRM ballot, stating that the use of the term "dominate" was not in conformance with the CNRM consensus. The sentence was changed to read "*Uncertainties in the hazard estimates typically dominate the uncertainties in the final seismic PRA results*…." The term "dominate" remains, with no consensus definition. The term "dominate" also appears in other places in Part 5.

ii. The term "significant" is open to wide interpretation. The CNRM discussed this term in detail. It was to be defined, in Section 1-2, with the term it was modifying; for example, "significant contributor," "significant accident sequence," "significant basic event," and "significant cutset." A comment was provided during the CNRM ballot noting that in places the meanings are not consistent. In addition, one example was provided to illustrate the inconsistency (i.e., the definition of "significant contribution" in Note 2 of SHA-B2 is not consistent). The PM responded that "significant" was added based on the Surry pilot, and the note explains what is meant. The explanation in the note adds confusion rather than clarity. SHA-B2 states, "…*all credible seismic sources that may contribute significantly to the frequency*…." Rather than adding clarity, the note, which states, *"One definition of significant contribution used in the past has been that all modeled sources represent at least 99% of the hazard*…," provides a definition that implies that other definitions are equally acceptable.

iii. In Section 1-1.3.3, an insert has been added: *"Within the tables of SRs, boldface font is used to highlight the differences among the requirements."* The standard has always been formatted such that the differences in the CCs for a requirement are differentiated by bolding the unique part of the requirement for each CC; moreover, this bolding assists the analyst in understanding the differences in the CCs for a requirement. This text was added to the standard to explain the purpose of the bolding to the analyst. However, this differentiation does not occur in every part of the standard (e.g., in Part 5, the differences in the CCs for an SR are not bolded).

iv. Words have not been changed consistently. For example, Section 5.2.1 stated, "…*in connection with the recent early site permits*…." The word "recent" was changed to "new." However, the note to HLR-SHA-A uses the same sentence, but the word "recent" was not changed.

v. The parts of the standard are inconsistent in structure and format. For example, Part 1 states, *"A set of objectives and HLRs is provided for each PRA Element in the Technical Requirement Section of each respective*

Part of this Standard." However, this statement has not been implemented consistently in each subsequent part of the standard, as shown in the following examples:

- Part 2, Section 2-2, lists the technical elements, and each subsequent section for each technical element provides a brief discussion of the objective.

- Part 3, Section 3-2, lists the technical elements with a brief discussion, and each subsequent section for each technical element provides a brief discussion of the objective that is similar to the discussion provided in Section 3-2.

- Part 4, Section 4-2, lists the technical elements with a more lengthy discussion, and each subsequent section provides a lengthy discussion with the objective.

- Part 5, Section 5-2, lists the three technical elements. A very lengthy discussion is provided for the first technical element and the objective buried in the middle of the discussion; for the second and third elements, no clear objective is provided.

vi. Throughout the standard, the analyst is allowed to deviate from the requirement; however, justification is needed in these cases. The standard varies in how this justification is stated in the SR. For example, in places, the SR will state the following:

- *"JUSTIFY [the action being taken that deviates from the requirement] (e.g., [an example of acceptable justification is provided])."*

- *"SPECIFY a defined basis for [the action being taken that deviates from the requirement*]."

- *"If [the action being taken that deviates from the requirement], INCLUDE [the actual action* verbs *differ; for example*, *it may state* "*PERFORM*"] *on a documented basis."*

Using the term "justify" makes the intent of the SR clear to the analyst, and providing an example defines what is an acceptable justification. The phrases *"a defined* basis" and "a *documented basis"* are not clear. What is a "defined basis"? In addition, what is the difference between a "defined basis" and a "documented basis"?

d. Peer review. In Part 5, the purpose of the peer review is not consistent with that in the other parts. In addition, Section 5-3.3 is not consistent with the comparable section in the other parts. In the other parts, this section is organized by the technical elements; that is, for each technical element, the standard gives the general requirements for what the peer review is to include. Part 5 organizes the peer review requirements by topic; therefore, it is not clear whether the peer review adequately addresses the necessary aspects from the various technical elements in the standard.

e. Screening criteria. Across and sometimes within the various parts, inconsistent screening criteria are defined without a technical basis for the inconsistencies, as in the following examples:

   i. Differences exist in quantitative criteria, from using a small percentage to screen, to using a small initiating event frequency, to using a small CDF (e.g., SY-A15, IE-C6, EXT-C1, IFEV-A8).

   ii. Analysts are allowed to develop screening criteria.

   If there is a technical basis for the inconsistency, the standard should include it and provide additional clarity as to when it is acceptable for analysts to develop their own screening criteria. As part of addressing consistency, the criteria should also be examined to determine if they need to be revised.

f. Capability categories. Consistency is needed in how the capability philosophy is implemented. For example, the differences between the CCs in the SRs are not always based on the criteria in Table 1-1.3-2. For example, FSS-C1 provides requirements that explain how to do something rather than what is needed, and the different methodologies are used to differentiate between the CCs.

g. Documentation. At one time, for each technical element, the standard provided the documentation requirements under each HLR as part of the SRs. The CNRM decided to include all the documentation requirements under a documentation HLR for each technical element. However, the standard implements this decision inconsistently, as shown in the following examples:

   i. Part 5 is not consistent with this decision. For example, as part of the CNRM ballot, it was noted that SHA-F1 and SFR-E2 have documentation requirements in an inappropriate location; that is, the documentation requirements in SHA-F1 and SFR-E2 should be under the documentation requirements associated with HLR-SHA-J and HLR-SFR-G, respectively. The PM responded, *"No change. The documentation requirements here are special because typically the seismic hazard analyst does his/her work and goes away and is not involved in the rest of the seismic PRA nor its final documentation."* The response from the PM actually

addresses “how” the documentation is performed. The standard does not provide requirements as to “how” (e.g., when) the documentation is performed, only “what” needs to be documented. Further, the seismic PRA is not “special,” as noted by the PM. Not every analyst is involved throughout the entire hazard group PRA. For example, the data analyst typically performs his or her work and “goes away”; the analyst who performs the success criteria calculations also performs his or her work and “goes away.” Nonetheless, the documentation requirements are provided under a documentation HLR for each technical element. Inconsistency between one part of the standard and the other parts leads to confusion and potential misuse of the standard. For example, since an HLR on documentation with a few documentation requirements is located elsewhere in the standard, these latter requirements could easily be overlooked. The peer reviewer could miss documentation requirements that are not specified under the documentation HLR.

ii. Section 1-1.3.3 now includes a new requirement that states, *“The use of any particular method for meeting an SR shall be documented*….” Part 1 does not provide any general requirements on documentation; moreover, this new requirement is redundant with the documentation requirements for each hazard group.

h. Notes and commentaries. The standard needs to use notes and commentaries consistently. Parts 4 through 10 have extensive notes and commentaries with the technical requirements, while Parts 2 and 3 do not have any extensive notes or commentaries. Furthermore, the notes and commentaries do not always provide clarity but rather introduce a level of confusion because it is easy to misinterpret them as requirements. Confusion also results because it is difficult to distinguish notes and commentaries that clarify the requirement itself from those that provide guidance on how to perform the requirement. In addition, the notes and commentaries are often essential to understanding the SRs in many places. That is, without the notes or commentaries, a large percentage of the SRs would not be comprehensible. Consequently, this adds confusion because, although the note or commentary is essential to understanding the SR, the note or commentary itself is not a requirement. These extensive notes and commentaries should be moved to a companion document or to a nonmandatory appendix so that the analyst can easily look them up when additional clarity is desired. The following examples illustrate this issue:

i. SPR-E1, Note 1, states, *“In the quantification of core damage frequency and large early release frequency, PERFORM the integration using the seismic hazard, fragility, and systems analyses.”*

Note 1 states the following:

The integration step is where the various earlier and supporting parts of the seismic PRA are brought together and integrated to produce and quantify the final results in terms of core damage frequency (CDF) and large early release frequency (LERF) and in terms of identifying the "important contributors."

Seismic-PRA practitioners possess different tools to accomplish this integration and quantification. Analysts usually use an iterative process in which an interim and approximate quantification is done, after which certain parts of the overall systems model are screened out on the basis that they do not contribute importantly to the results. The quantification is then finalized. Seismic screening of SSC (refer also to Requirements SPR-B4a and SFR-B1) can be done on the basis that its seismic capacity is very strong, so that it does not contribute importantly to any seismically induced accident sequences, above some defined cutoff level. Screening of a nonseismic failure or of a human-error basic event in the model can be done on the basis that its contribution to any seismically induced accident sequences is below a defined cutoff (refer also to Requirement SPR-B4a). Whatever the basis for the screening (see the supporting requirements below on this subject), that basis must be defined, and the selection of a cutoff should be done very carefully. – This paragraph could easily be interpreted as requirements.

While details vary, one typical systems-analysis approach is to add seismic-related basic events (or sometimes entire new "branches") to the internal-events fault tree models that are adapted from the internal-events-PRA Level 1 and Level 2 LERF analysis. Considerable screening out or "trimming" of the systems model is also a common practice. The quantification would then typically consist of a series of hazard-specific quantifications: the model is quantified several times for a range of different hazard intervals, and these quantifications are then summed. In this approach, for each hazard interval and for each SSC/basic event, the hazard, response, and fragility analyses are integrated to produce a "probability of seismically induced failure"—actually a distribution of the analyst's state of knowledge of that probability, taking into account the uncertainties in hazard, response, and fragility. This probability is then inserted into the relevant fault tree, which is solved. Typically, each fault tree would be solved separately, and then these would be integrated into the relevant

event tree(s) to produce a set of accident-sequence-specific values for CDF conditional on the hazard interval being evaluated. (Other methods are also in use in which the integration over the hazard is not done on a fault-tree-specific basis but rather at the event-tree level; logically, the outcome should be the same.) – This entire paragraph reads as instructions for performing the integration and not clarification of what is meant by integration.

The one issue that requires great care is the treatment of seismic-related dependencies/correlations among the seismic failures: in particular (a) the linking of the various basic events to capture their correlated failures, and (b) the screening out of SSCs and other nonseismic basic events in light of these correlations/dependencies (see Supporting Requirements SPR-B4a, SPR-E4, and SPR-E6 on these subjects). The relevant seismic correlations/dependencies arise, of course, because in a given earthquake event, every SSC in the plant is exposed to the exact same earthquake input motion (although modified—amplified, damped, frequency shifted, etc.—as the earthquake energy propagates from the earth below the site to the location of the SSC at issue). There are a number of different approaches in use to treat these correlations/dependencies, and this standard does not single out any one of them. Acceptable methods can be found in references [5-17] and [5-26]. – This paragraph also reads as an instruction and not as clarification.

ii. The note for WHA-A states, *"GENERAL NOTE: The models used for frequency and intensity calculations should not be unduly influenced by recent, short-term trends in the frequencies of high-wind events. They should incorporate at least the worst weather conditions experienced historically at the site."* The note, as written, does not provide clarification; instead, it reads as a requirement, although it uses the term "should."

iii. In some places, the text includes excessive discussion; that is, the discussion focuses on the technical basis behind the requirement or instructions for performing the analysis. Similar to the notes and commentaries, these lengthy discussions obscure the actual requirements. For example, Section 3-2 contains a very lengthy commentary," moreover, much of the discussion is not unique to internal flood.

iv. The difference between a "note" and a "commentary" is unclear. In Parts 4, 5, 7, and 8, the various SRs have notes, while in Parts 6, 9, and 10, the SRs have commentaries. Moreover, in some places, the notes

and commentaries appear at the end of the SRs of the HLR, but in other places, the commentary appears with each SR. The reason for these distinctions is not clear; is the standard intending to communicate something different if the information is in a "note" as opposed to a "commentary," and if that note or commentary is a particular place as opposed to another?

i. Similar requirements. The standard contains requirements that are similar. In this particular example, a change was inconsistently made across the standard for similar requirements. For Section x-3.2 (in each part), as part of the ballot, a comment was provided with regard to two phrases and it was noted that the comment was global; that is, it was applicable to each of the hazard parts. The wording in the standard was consistently addressed in Sections 6-3.2, 7-3.2, 8-3.2 and 9-3.2; however, it was addressed differently in Sections 2-3.2, 3-3.2, 4-3.2 and 5-3.2. There does not appear to be any basis for the difference.

4. "What to do" Versus "How to do" in the Standard. The standard is supposedly written at the "what to do" level and not at the "how to do" level. However, as noted above, the majority of the notes and commentaries do not clarify the SRs but instead provide guidance on how to accomplish the SR. Moreover, the text of the standard contains requirements apart from the HLRs and SRs. Some places contain extensive text that does not clarify the requirement but provides guidance how to accomplish the requirements; in some cases, this text is written as a requirement. For example, Section 4-2.1.1 provides a lengthy discussion that serves as guidance.

5. Capability Categories and Conservatism. It has been the tendency to assume that as the category increases (i.e., from CC I to CC III), the level of conservatism decreases (i.e., CC I is a more conservative PRA). This assumption is incorrect. This assumption is made because in Section 1-1.3-3, the interpretation can be made that the potential decrease in conservatism from CC II to CC III is only for internal fire.

Section 1-1.3-3 states the following:

> *The intent of the delineation of the Capability Categories within the SRs is generally that the degree of scope and level of detail, the degree of plant-specificity, and the degree of realism increases from Capability Category I to Capability Category III. However, the Capability Categories are not based on the level of conservatism (i.e., tendency to overestimate risk due to simplifications in the PRA) in a particular aspect of the analysis. The level of conservatism may decrease as the Capability Category increases and more detail and more realism are introduced into the analysis. However, this is not true for all requirements and should not be assumed. Specific examples where a lower Capability Category may be less conservative are those requirements associated with the treatment of spurious operations in Fire PRA. As the Capability Category*

increases, the depth of the analysis required also increases. Hence, for a system train that is analyzed with less spurious operation considerations such as in Capability Category I, increasing the depth of the analysis in this case for Capability Categories II and III will identify additional spurious operations that will increase risk and thus the lower Capability Category will yield a lower (less conservative) estimated risk. Realism, however, does increase with increasing a Capability Category.

This part of the explanation of the CCs is confusing. It correctly states above that (1) the CCs are not based on the level of conservatism, and (2) the level of conservatism may decrease as the CC increases. However, the next statement introduces confusion because it states that *"this is not true for all requirements and should not be assumed."* The referenced statement did not state that the level of conservatism will decrease, but that it may decrease, which implies that it may increase in some cases. As written, the example implies that an increase in the CC may lead to increased conservatism only for spurious operations in the fire PRA. The criteria that distinguish the CCs relate more to refinement of the PRA model, which does not necessarily result in less conservatism. For example, the use of generic information in CC I does not automatically result in a more conservative analysis than when plant-specific data are used.

However, in some places, the standard contains the intent for a decrease in conservatism, which has not occurred, as illustrated in the following examples of conservatism not decreasing from CC I to CC II to CC III:

a. SC-B2, for CC I, states that there are no restrictions on the use of expert judgment; however, CC II/III does impose restrictions. In this situation, CC I is not necessarily conservative as compared to CC II/III. Moreover, this SR CC is not consistent with SC-B1.

b. HR-A2, for CC I/II, requires the analyst to identify the initiation of standby equipment, while for CC III, the analyst is limited to identifying the initiation of standby safety equipment.

c. HR-D3, for CC I, contains no requirement for evaluating the quality of the procedures, for example, while for CC II/III, the analyst is required to evaluate the quality of the procedures.

d. HR-H1, for CC I, requires the analyst to include operator actions to provide a more realistic evaluation of CDF and LERF; for CC II, the analyst is required to provide a more realistic evaluation of significant accident sequences; and for CC III, the analyst is required to provide a realistic evaluation of modeled accident sequences. CC I and III could easily be interpreted as the same, since the evaluation of CDF and LERF involves evaluating the modeled accident sequences. If the modeled accident sequences are different between CCs, so that the difference in the modeled accident sequences is the differentiation between the CCs for this SR, then the SR should be the same across all the CCs.

6. Construct of Human Reliability Analysis Across the Standard. Part 2 provides the requirements for a PRA for internal events, and, as noted in Section x-1.2 ("Coordination with Other Parts of This Standard"), Part 2 is the starting point for the development of the PRA model for each of the subsequent parts. The HRA structure for the various parts (e.g., internal flood, internal fire, seismic) is not similar; that is, they do not have a parallel structure for developing the HRA requirements. This leads to confusion and lack of cohesiveness in the model, making it difficult for the analyst to determine the importance of human events for a particular hazard and for the entire PRA, for example.

7. Noninformative Text and Requirements. In some places in the standard, as shown in the following examples, the requirements are sufficiently vague such that it is possible for the analyst to misinterpret them:

   a. QU-D6 repeats the HLR statements in CC I and part of CC II/III. The new text added to the requirement for CC II/III does not provide clarity. Instead, it refers to an evaluation that has not been required; that is, no SR requires an evaluation of the significant contributors. QU-D6 requires the identification of significant contributors, and "event mitigation features" is new terminology that is not defined. It is particularly confusing in light of the new text discussing the terms "hazard event," "internal event," and "initiating event."

   b. Objective statements, in many cases such as Sections 3-2.2 and 3-2.3, are often repetitive, nearly repeating the title of the technical element, and do not provide information to the analyst on the purpose of the element.

8. Application. The standard establishes the requirements for a base PRA independent of an application. Section 1-3 recognizes this scope and provides a process for applying the technical requirements for an application. Part 5, in particular, stipulates the requirements with regard to an application. Consequently, identifying the requirements needed to develop a seismic PRA can be confusing when some of the requirements are qualified against an application. For example, HLR-SHA-J states, *"A screening analysis shall be performed to assess whether…other seismic hazards…need to be included in the seismic PRA for the specific application."* The base PRA is to be complete, and the analyst, via the process in Section 1-3, can then determine whether a particular requirement is needed for the application.

9. Objective of Standard. Section 1-1.1 states, *"This Standard sets forth the requirements for probabilistic risk assessements (PRAs) used to support risk-informed decisions*…." Part 10 of the standard is not consistent with this objective statement. A seismic margin is not a PRA and therefore should not be included in this standard. Instead, it should be covered in its own standard.

10. Minimal Requirements. In some places, the standard provides no minimal requirement. This situation generally occurs with CC I, where the text simply states, “no requirement,” as in the following examples:

    a. IFSN-A8, for CC I, states, *“No requirement for inter-area propagation given that flood areas are independent (see SR-IFPP-A1).”* It should state, *“ASSUME no inter-area propogation if flood areas are independent (see SR-IFPP-A1).”*

    b. FSS-D9, for CC I, states, “No requirement.” Considering CC II/III, it should state, *“ASSUME there is no smoke damage to FPRA equipment with regard ot the definition of fire scenario targets sets.”*