NTB-1-2013

Training Program Reference Material for Use with ASME/ANS RA-Sa-2009

ASME

SETTING THE STANDARD

NTB-1-2013

Training Program Reference Material for use with ASME/ANS RA-Sa-2009

Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Application

Part 1: General Requirements
Part 2: Internal Events at Power
Part 3: Internal Flood at Power

Developed in cooperation with

U.S. Nuclear Regulatory Commission

PWR Owners Group

ASME Standards Technology LLC

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1.0 INTRODUCTION

Since 1998, ASME and ANS have been working on developing standards for a probabilistic risk assessment (PRA) for nuclear power plants. Their combined efforts resulted in joint publication of ASME/ANS RA-S-2008, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications" and the subsequent publication of ASME/ANS RA-Sa-2009 on February 2, 2009. This standard "sets for the requirements for probabilistic risk assessment (PRAs) used to support risk-informed decision for commercial light water reactor nuclear power plants" and "establishes requirements for a Level 1 PRA of internal and external events for all plant operating modes." (At this time, requirements addressing low power and shutdown conditions are not yet included.)

The requirements established in this standard, however, are not prescriptive. The standard establishes requirements that are defining "what" needs to be in a technically acceptable baseline PRA; the requirements do not define "how" to perform a technically acceptable baseline PRA.

This document provides the reference material that supports the training program (jointly developed by ASME, NRC and PWROG) on understanding and using the ASME/ANS PRA Standard.

2.0 OBJECTIVES OF THE TRAINING MATERIAL

The objective of this training material is to help clarify the intent and purpose of the requirements in the ASME/ANS RA-Sa-2009 Standard. Specifically, this document provides additional explanation for each technical requirement of the ASME/ANS PRA Standard. The material generated in this effort is intended to be used in the development, review and application of the ASME/ANS PRA Standard.

This standard is being used to support risk-informed activities, some of which are regulatory activities. For some of the requirements, the NRC staff has taken objection; that is, for each requirement, the staff has provided either "no objection," "no objection with clarification" or "no objection subject to the following qualification," and has defined these terms as:

- No objection. The staff has no objection to the requirement.
- No objection with clarification. The staff has no objection to the requirement. However, the staff believes that the requirement, as written, is either unclear or ambiguous, and therefore the staff has provided its understanding of the requirement.
- No objection subject to the following qualification. The staff has a technical concern with the requirement and has provided a qualification to resolve the concern.

To help the user, the staff position and resolution is also provided for each requirement.

3.0 SCOPE OF THE TRAINING MATERIAL

ASME/ANS Standard is divided into ten parts as follows.

Part 1: General Requirements for a Level 1 PRA, including Large Early Release Frequency
Part 2: Requirements for Internal Events At-Power PRA
Part 3: Requirements for Internal Flood At-Power PRA
Part 4: Requirements for Fires At-Power PRA
Part 5: Requirements for Seismic Events At-Power PRA
Part 6: Requirements for Screening and Conservative Analysis of Other External Hazards At-Power
Part 7: Requirements for High Wind Events At-Power PRA
Part 8: Requirements for External Flood Events At-Power PRA
Part 9: Requirements for Other External Hazards At-Power PRA
Part 10: Seismic Margin Assessment Requirements At-Power

At this time, the training material only covers Parts 1, 2 and 3.

4.0 DISCUSSION OF REQUIREMENTS IN PART 1 OF ASME/ANS RA-Sa-2009

The majority of Part 1 of the standard is self-explanatory and it is believed that further explanation is not necessary to understand the intent.

In Part 1, Section 1-2 of the standard, definitions of terms used in the standard are provided. Additional explanation of these definitions is not provided; however, it is important to note that these definitions apply to each part of the standard.

The technical requirements are established for different "hazard groups," and organized by the technical elements defining the PRA for each hazard group.

The technical requirements are provided as "high level requirements" (HLRs) that are expanded with associated supporting requirements." These supporting requirements may be defined to different "PRA Capability Categories."

This information is discussed in Section 1-1 of the standard, and additional explanation is provided in this chapter.

4.1 High Level Requirements (Section 1-1.3.2 of the ASME/ANS Standard)

A set of objectives and related HLRs are provided for each PRA technical element for each hazard group. The intent of the HLRs is to define the minimum requirements (at a high level) that are needed to meet the objectives of the technical element. Therefore, the HLRs also define the minimum requirements for meeting the ASME/ANS standard; as such, all PRAs based on the standard need to satisfy each of the HLRs. These HLRs are defined in general terms, need to be met regardless of the capability category, and accommodate different approaches. The HLRs are written as "shall" statements.

4.2 Supporting Requirements (Section 1-1.3.3 of the ASME/ANS Standard)

A set of associated SRs are provided for each HLR. The intent of SRs is to define the minimum requirements needed to meet the associated HLR. Therefore, for a given HLR, if the SRs are satisfied then the HLR will have been met. That is, determination of whether an HLR is met is based on whether the associated SRs are met. Whether or not every SR is needed for an HLR is application-dependent and is determined by the application process requirements.

The SRs are written as "action statements." That is, instead of writing an SR, for example, as "any dependency between the HFEs ***shall*** be…," the SR is written as "***ACCOUNT*** for any dependency between the HFEs…." The action verb provides the intent of the requirement and the verb is denoted in the standard in all capital letters.

In understanding the SRs, it is helpful to keep these verbs in mind and the intended general meaning within the context of the standard. A list of the action verbs used in the standard with a definition of their intent/meaning is provided below.

Action Verb	Meaning
ACCOUNT	To give an explanation (usually fol. by *for*)
ADDRESS	To deal with or discuss: to address the issues
ANALYZE	To examine carefully and in detail so as to identify causes, key factors, possible results, etc.
ASSESS	To estimate or judge the value, character, etc., of; evaluate
BASE	To make or form a base or foundation for
CALCULATE	To determine or ascertain by mathematical methods; compute
CHARACTERIZE	To describe the character or individual quality of
CHECK, CONFIRM, ENSURE	(CHECK) to investigate or verify as to correctness: She checked the copy against the original. (CONFIRM) to establish the truth, accuracy, validity or genuineness of; corroborate; verify: This report confirms my suspicions. (ENSURE) to make sure or certain: measures to ensure the success of an undertaking
COLLECT	To gather together; assemble: The professor collected the students' exams.
COMBINE, INTEGRATE	(COMBINE) to bring into or join in a close union or whole; unite (INTEGRATE) to bring together or incorporate (parts) into a whole.
CONDUCT	To direct in action or course; manage; carry on: to conduct a meeting; to conduct a test.
CREDIT (TAKE CREDIT, DO NOT TAKE CREDIT)	(bookkeeping) to enter upon the credit side of an account; give credit for or to.
DEFINE	to state or set forth the meaning of a particular attribute, or determine or fix the boundaries
DELINEATE	To describe, portray or set forth with accuracy or in detail
DERIVE	Receive or obtain ***from*** a source or origin; reach or obtain by reasoning; deduce; infer
DETERMINE	Conclude or ascertain, as after reasoning, observation, etc.
DEVELOP	Bring out the capabilities or possibilities of; elaborate or expand in detail
DOCUMENT	Support with evidence
ENSURE	To make sure or certain
ESTABLISH	Cause to be recognized and accepted
ESTIMATE	Form an approximate judgment; calculate approximately
EVALUATE	Examine and judge carefully to determine significance
EXAMINE	Inspect or scrutinize carefully: to examine a prospective purchase.

GROUP	Combine one or more together into a single entity
IDENTIFY	Recognize or establish with pre-defined characteristics
INCLUDE, INCORPORATE	1. To contain, as a whole does parts or any part or element: The package includes the computer, program, disks and a manual. 2. To place in an aggregate, class, category or the like. 3. To contain as a subordinate element; involve as a factor.
JUSTIFY	1. To show (an act, claim, statement, etc.) to be just or right 2. To defend or uphold as well-grounded
LIMIT	1. To restrict by or as if by establishing limits (usually fol. by *to*): Please limit answers to 25 words 2. To confine or keep within limits: to limit expenditures
PERFORM	1. To carry out; execute; do 2. To go through or execute in the proper, customary or established manner
PROPAGATE	To transmit (hereditary features or elements) to, or through
PROVIDE	1. To make available; furnish 2. To supply or equip
QUANTIFY	To give quantity to (something regarded as having only quality)
REVIEW	1. The process of going over a subject again in study in order to summarize the facts 2.A viewing of the past; contemplation or consideration of past events, circumstances or facts
SCREEN	1. Examine in order to test suitability; "screen these samples" 2. Check and sort carefully; "sift the information"
SPECIFY	State or name specifically or definitely; name or state as a condition
SUBSUME	Include as part of a more comprehensive one
TREAT	1. To consider or regard in a specified way, and deal with accordingly: to treat a matter as unimportant 2. To deal with (a disease, patient, etc.) in order to relieve or cure.
TRUNCATE	1. To shorten by cutting off a part; cut short: Truncate detailed explanations. 2. Mathematics, Computers. to shorten (a number) by dropping a digit or digits: The numbers 1.4142 and 1.4987 can both be truncated to 1.4
USE, UTILIZE	1. To employ for some purpose; put into service; make use of

4.3 Capability Categories (Section 1-1.4 of the ASME/ANS Standard)

In developing a PRA, within each technical element, the scope and level of detail, the plant-specificity and the realism of each technical aspect may vary. For example, not every system model in the PRA will necessarily be developed to the same level of detail. The development of the supporting requirements in the standard recognizes this variance and, therefore, a particular supporting requirement may also vary as to scope and level of detail, plant-specificity and realism. This variance is defined by "Capability Categories" which is illustrated below.

Attributes of PRA	Capability Categories		
	I	II	III
	Generally Increasing →		
Scope and level of detail: Degree of modeling plant design, operation and maintenance	System/train level/area level importance	significant contributors at component/compartment level importance	contributors at component/compartment level importance
Plant-specificity: Degree of as-built and as-operated plant information is addressed	generic data/models acceptable except for unique features	plant-specific data/models for significant contributors	plant-specific data/models for all contributors
Realism: Degree of real plant response is addressed – impact of departure from realism on insights and conclusions	moderate impact	small impact	negligible impact

The intent of the capability categories is that, generally in developing the supporting requirements from Capability Category I to Capability Category III, the degree of scope and level of detail, the degree of plant-specificity and the degree of realism increases.

It is important to note that there will not be a Capability Category I PRA, a Capability Category II PRA nor a Capability Category III PRA, for either the entire PRA model or the PRA model for a specific hazard group. The PRA model of the PRA hazard group model will have varying degrees of scope and level of detail, plant-specificity and realism. The required scope and level of detail, plant-specificity or realism for a given requirement is established by the needs of the application of the PRA model or the PRA hazard group model.

A supporting requirement is established that defines the minimum needed to meet each Capability Category. However, is some cases, a supporting requirement may be the same for all three capability categories or for two of the categories. When a supporting requirement spans multiple categories, it applies equally to each Capability Category. When this situation occurs, the differentiation between categories is made in other related supporting requirements. For example, there may be a supporting requirement to identify the initiating events that can challenge the plant. This requirement is the same for all three categories because, regardless of the category, all the events need to be identified. However, the treatment of the identified events can vary, and this degree of treatment is differentiated in the applicable, related requirement(s). This example is shown below.

Index No. IE-A	Capability Category I	Capability Category II	Capability Category III
IE-A1	IDENTIFY those initiating events that challenge normal plant operation and that require successful mitigation to prevent core damage using a structured, systematic process for identifying initiating events that account for plant-specific features. For example, such a systematic approach may employ master logic diagrams, heat balance fault trees or failure modes and effects analysis (FMEA). Existing lists of known initiators are also commonly employed as a starting point.		
IE-A5	PERFORM a systematic evaluation of each system, including support systems, to assess the possibility of an initiating event occurring due to a failure of the system. **PERFORM a qualitative review of system impacts to identify potential system initiating events.**	PERFORM a systematic evaluation of each system, including support systems, to assess the possibility of an initiating event occurring due to a failure of the system. **USE a structured approach [such as a system-by-system review of initiating event potential, or an FMEA (failure modes and effects analysis) or other systematic process] to assess and document the possibility of an initiating event resulting from individual systems or train failures.**	PERFORM a systematic evaluation of each system, including support systems, to assess the possibility of an initiating event occurring due to a failure of the system. **DEVELOP a detailed analysis of system interfaces. PERFORM an FMEA (failure modes and effects analysis) to assess and document the possibility of an initiating event resulting from individual systems or train failures**.

4.4 Addressing Multiple Hazard Groups (Section 1-1.7 of the ASME/ANS Standard)

As noted above, the standard "establishes requirements for a Level 1 PRA of internal and external events for all plant operating modes." These internal and external initiating groups are referred to in the standard as "hazard groups." **A hazard group** is a group of similar causes of initiating events that are assessed in a PRA using a common approach, methods, and likelihood-data for characterizing the effect on the plant. The hazard groups addressed in the standard include internal events, seismic events, internal fires, internal floods and high winds.

4.5 Determining Whether a Requirement is Met

An HLR is met via the associated SRs. However, determining whether or not an SR is met is not straight-forward. An SR may apply to several parts of the PRA model. In these situations, is the SR considered to be met only when in every case it is correctly performed? What if it is correctly performed 50% of the time, 90% of the time, etc.?

An SR requirement is considered to be met if there is not a systematic failure. That is, if there are a few errors that can be classified more as mistakes or oversights such that there is no evidence that there is a systematic failure, then the SR is considered to be met.

For example, the requirements for systems analysis apply to all systems modeled, and certain of the data requirements apply to all parameters for which estimates are provided. If, among these systems or parameter estimates, there are a few examples in which a specific SR has not been met, it is not necessarily indicative that this SR has not been met. If the SR has been met for the majority of the systems or parameter estimates, and the few examples can be put down to mistakes or oversights, the SR would be considered to be met. If, however, there is a systematic failure to address the SR (e.g., component boundaries have not been defined anywhere), then the SR has not been complied with.

5.0 DISCUSSION OF REQUIREMENTS IN PART 2 OF ASME/ANS RA-Sa-2009

Part 2 of the standard contains the technical requirements and the peer review requirements for a Level 1 and LERF analysis of internal events (excluding internal fire) while at power.

The technical requirements are organized by eight technical elements:

- Initiating events analysis (IE)
- Accident sequence analysis (AS)
- Success criteria (SC)
- Systems analysis (SA)
- Human reliability analysis (HRA)
- Data analysis (DA)
- Quantification (QU)
- LERF analysis (LE)

The peer review requirements are also organized by the above eight elements.

Part 3 of the standard contains the technical requirements and the peer review requirements for internal floods.

The technical requirements are organized by five technical elements:

- Internal Flooding Plant Partitioning (IFPP)
- Internal Flood Source Identification and Characterization (IFSO)
- Internal Flooding Scenarios (IFSN)
- Internal Flood-induced Events (IFEV)
- Internal Flooding Accident Sequences and Quantification (IFQU)

The peer review requirements are also organized by the above five elements.

For each technical element, high level requirements are defined in the standard, and for each HLR, supporting requirements are defined. A discussion of the intent of each SR requirement is provided, organized by each technical element and its associated HLRs.

5.1 Initiating Events Analysis Section 2-2.1 of the ASME/ANS RA-Sa-2009

The objectives of the initiating event analysis are to identify and quantify events that could lead to core damage in such a way that:

(a) Events that challenge normal plant operation and that require successful mitigation to prevent core damage are included.

(b) Initiating events are grouped according to the mitigation requirements to facilitate the efficient modeling of plant response.

(c) Frequencies of the initiating event groups are quantified.

To meet the above objectives, four HLRs are defined in the standard.

Designator	Requirement
HLR-IE-A	The initiating event analysis shall provide a reasonably complete identification of initiating events.
HLR-IE-B	The initiating event analysis shall group the initiating events so that events in the same group have similar mitigation requirements (i.e., the requirements for most events in the group are less restrictive than the limiting mitigation requirements for the group) to facilitate an efficient but realistic estimation of CDF.
HLR-IE-C	The initiating event analysis shall estimate the annual frequency of each initiating event or initiating event group.
HLR-IE-D	Documentation of the initiating event analysis shall be consistent with the applicable supporting requirements.

5.1.1 Supporting Requirements for HLR-IE-A

ASME/ANS Standard Section 2.2.1, Table 2.2.1-2(a), Supporting Requirements for HLR-IE-A

HLR-IE-A:	The initiating event analysis shall provide a reasonably complete identification of initiating events.
Intent:	To ensure potential initiating events are systematically captured for consideration in the PRA
SRs:	IE-A1 through IE-A10

Index No. IE-A	Capability Category I	Capability Category II	Capability Category III
IE-A1	IDENTIFY those initiating events that challenge normal plant operation and that require successful mitigation to prevent core damage using a structured, systematic process for identifying initiating events that account for plant-specific features. For example, such a systematic approach may employ master logic diagrams, heat balance fault trees or failure modes and effects analysis (FMEA). Existing lists of known initiators are also commonly employed as a starting point.		

EXPLANATION OF REQUIREMENT

The standard defines an initiating event as "any event, internal or external to the plant, that perturbs the steady state operation of the plant… initiating an abnormal event…." Events that are expected to result in an immediate plant trip or immediate shutdown requiring an operator to trip the plant during the shutdown process need to be considered. To satisfy this SR, a list of initiating events is established using a structured process. Although no specific process is defined, the PRA is expected to demonstrate that, by using a logical, documented and systematic process that it has considered events both within and beyond[1] the plant design basis, events typical of similar plants and events potentially unique to the plant. Unique plant-specific initiators typically arise from support system failures that would cause the plant to trip or create a need for an immediate plant shutdown and adversely impact mitigating equipment and are addressed in IE-A5.

The SR identifies three examples of systematic approaches for identifying initiating events: master logic diagrams, heat balance fault trees or failure modes and effects analysis (FMEA). The master logic diagram is a summary fault tree that can be constructed to guide the selection and grouping of initiating events. NUREG/CR-2300, "PRA Procedures Guides," Section 3.4.2.2 describes this process. Heat balance fault trees is a technique that considers the impact of changes in core thermal power, core heat removal capacity, heat transfer from primary to secondary system and secondary heat removal capacity on the initiating plant transients. No references were identified for the heat balance fault tree, nor is the use of this method for identifying initiating events a common practice. Failure Modes and Effects Analyses are particularly useful for identifying initiating events associated with support systems. This method is described in NUREG 1150 [see NUREG/CR-4550 Volume 1, Revision 1 Section 3.2, "Analysis of Core Damage Frequency Internal Events Methodology] and "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants."

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 2 has "no objection" to this SR.

1 Events within the design basis may exclude events that exceed the single failure criterion. In order to provide a sufficiently complete list of initiating events, events that exceed the single failure criterion and other limitations of the design basis are also to be considered in meeting this requirement.

<table>
<tr><th>Index No. IE-A</th><th>Capability Category I</th><th>Capability Category II</th><th>Capability Category III</th></tr>
<tr><td>IE-A2</td><td colspan="3">INCLUDE in the spectrum of internal-event challenges considered at least the following general categories.
(a) Transients. INCLUDE among the transients both equipment and human induced events that disrupt the plant and leave the primary system pressure boundary intact.
(b) LOCAs. INCLUDE in the LOCA category both equipment and human induced events that disrupt the plant by causing a breach in the core coolant system with a resulting loss of core coolant inventory. DIFFERENTIATE the LOCA initiators, using a defined rationale for the differentiation. Example of LOCA types includes:
(1) Small LOCAs. Examples: reactor coolant pump, seal LOCAs, small pipe breaks
(2) Medium LOCAs. Examples: stuck open safety or relief valves
(3) Large LOCAs. Examples: inadvertent ADS, component ruptures
(4) Excessive LOCAs. (LOCAs that cannot be mitigated by any combination of engineered systems). Example: reactor pressure vessel rupture
(5) LOCAs Outside Containment. Example: primary system pipe breaks outside containment (BWRs)
(c) SG TRs: INCLUDE spontaneous rupture of a steam generator tube (PWRs)
(d) ISLOCAs: INCLUDE postulated events in systems interfacing with the reactor coolant system that could fail or be operated in such a manner as to result in an uncontrolled loss of core coolant outside the containment [e.g., interfacing systems LOCAs (ISLOCAs)].
(e) Special initiators (e.g., support systems failures, instrument line breaks) [NOTE (1)].</td></tr>
</table>

NOTE (1): These initiators may result in either a transient or a LOCA type of sequence.

EXPLANATION OF REQUIREMENT

This SR requires the analyst to develop a comprehensive list of initiating events for inclusion in the PRA. In developing that list of events, the analyst should consider all the above categories that apply to the plant being analyzed. Note that the term “internal-event challenges” is used in this requirement to mean an initiating event due to causes originating within the plant. By historical convention (as stated in Section 1-2.2, Definitions, the loss of off-site power is considered to be an internal event except when the loss is caused by an external hazard that is treated separately (e.g., seismic-induced LOOP), and internal fire is considered to be an external hazard. Internal floods have sometimes been included with internal hazards and sometimes considered as external hazards. For the standard, internal floods are considered to be separate from internal hazards.

Special Initiators are initiating events that can be transients (excluding BOP systems and off-site power) or LOCA-like events that are not otherwise generically identified as initiating events and as a result of the unique plant design features. Such events can occur at the target plant and may contribute significantly to the core damage frequency. Often these initiating events involve support system failures. Some unique internal plant electrical system failures may be considered special initiators. The special initiator designation was used in NUREG/CR-4550 Volume 1, Revision 1 Section 3.2. The special initiator designations have been applied to initiators originating in HVAC, Instrument Air and cooling water systems as well as with events initiating with failures of the Vital AC/DC busses. NUREG/CR-4550 also considers Steam Generator Tube Rupture, Interfacing LOCA and Vessel Rupture as special initiators. While it is required that all relevant initiating events are identified, it is not required that any of these events be labeled as a special initiator.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 2 has “no objection” to this SR.

Index No. IE-A	Capability Category I	Capability Category II	Capability Category III
IE-A3	REVIEW the plant-specific initiating event experience of all initiators to ensure that the list of challenges accounts for plant experience. See also IE-A7.		

EXPLANATION OF REQUIREMENT

This SR requires that the operating experience, including recorded events and events that occurred at other than at-power operation (IE-A7) are considered in identifying the initiating events applicable to the plant. The purpose of this review is to identify the existence of, or potential for, any unique plant initiating events.

Operating experience may be obtained from such sources as plant operating logs, plant and industry LERs and plant condition reports. Only consider those challenges that are still applicable to the current plant design and mode of operation. Consider both "at power" and shutdown operation that could have resulted in an event at power operation that could have caused a plant trip or an exigent shutdown (see also IE-A7). Shutdown events that would otherwise have been averted by "at power" plant controls need not be considered. Events that are no longer possible resulting from past design or operational changes need not be included as long as justification is provided.

For Capability Category II and III, the review of operating experience should include initiating event precursors as addressed by SR IE-A9.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 2 has "no objection" to this SR.

Index No. IE-A4	Capability Category I	Capability Category II	Capability Category III
IE-A4	REVIEW generic analyses of similar plants to assess whether the list of challenges included in the model accounts for industry experience.		REVIEW generic analyses **and operating experience** of similar plants to assess whether the list of challenges included in the model accounts for industry experience.

EXPLANATION OF REQUIREMENT

This review is to ensure that events that could potentially occur at your plant (based on an occurrence at a similar plant) are considered for the identification of the plant's initiating events. The definition of "similar" as stated in this SR can be rather broad. Similar plants may be selected based on vendor, number of loops and power level. However, in some instances the potential for specific initiating events may be a result of similarity in specific systems or components (for example plant intake structure or RCP seal design, etc.), thus expanding the consideration of similar to a larger more generic group. Compilations of initiating events may be found in other plant PRAs, and several reports generated under the auspices of the NRC including NUREG/CR 4550 Vol 1, Revision 1 "Analysis of Core Damage Frequency: Internal Events Methodology," NUREG/CR-5750, "Rates of Initiating Events at U.S. Nuclear Power Plants: 1987 - 1995" and NUREG/CR-6928, "Industry-Average Performance for Component and Initiating Events at U.S. Commercial Nuclear Power Plants." Note that events occurring at "similar" plants may be excluded from consideration as an initiating event at the subject plant based on relevant differences in plant design and procedures.

Capability Category Differentiation

This identification can be performed to two different capabilities:

For Capability Category I and II

Requirement is self-explanatory.

For Capability Category III

In addition to reviewing available IE lists from PRAs for similarly designed plants (Category I and II), a review of operational events from generic material / issues and operating experience of other plants is also to be considered. The use of events occurring at other less similar plants is not expected to be exhaustive; however it would likely be expected to cover plants with similar systems or with design features typical of the target unit. Consider events that have occurred at power and shutdown where the event could have caused a plant trip. This task requires reviewing raw data from other plants. At this point in time no consolidated source of this information is available.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 2 has "no objection" to this SR.

Index No. IE-A	Capability Category I	Capability Category II	Capability Category III
IE-A5	PERFORM a systematic evaluation of each system, including support systems, to assess the possibility of an initiating event occurring due to a failure of the system. **PERFORM a qualitative review of system impacts to identify potential system initiating events.**	PERFORM a systematic evaluation of each system, including support systems, to assess the possibility of an initiating event occurring due to a failure of the system. **USE a structured approach [such as a system-by-system review of initiating event potential, or a failure modes and effects analysis (FMEA) or other systematic process] to assess and document the possibility of an initiating event resulting from individual systems or train failures.**	PERFORM a systematic evaluation of each system, including support systems, to assess the possibility of an initiating event occurring due to a failure of the system. **DEVELOP a detailed analysis of system interfaces.** **PERFORM a failure modes and effects analysis (FMEA) to assess and document the possibility of an initiating event resulting from individual systems or train failures**.

EXPLANATION OF REQUIREMENT

This SR requires a systematic review of all plant systems and their detailed design to determine if the system could trip the plant and thereby contribute to an initiating event. This evaluation may reveal previously unknown causes of initiating events. A systematic review can be performed at a sub-system or component level based on the level of detail and PRA capability category desired. See also IE-A6 for additional guidance. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This identification can be performed to three different capabilities. The bolded portions of the standard identify the differences in requirement expectations among the three categories. A discussion of the differences in capability categories follows.

Capability Category I

This category requires only a qualitative review. Such a review could be performed at the sub-system level and may be directed at assessing whether failure of the sub-system could lead to a reactor trip. This approach is expected to be structured, but may use screening out of sub-systems to reduce scope of the review. Conservative simplifications in the assessment are expected. Such an approach could be expected to result in conservatively biased initiating event frequencies for these events.

Capability Category II

This category uses a structured approach that is expected to support development of a realistic initiating event frequency. A methodology for evaluating support system initiating events, EPRI-TR-1016741,"Support System Initiating Events: Identification and Quantification Guideline," is publicly available at no charge from EPRI.com. Such guidance may be considered in developing a structured look for new initiating events. At the time of this writing, this report is believed to represent the best information source on the treatment of support system initiating events. This report has not been endorsed by the ASME and alternate strategies may be used provided they are justified.

Capability Category III

In addition to the requirement in Category II, this category requires performance of a detailed analysis of system interfaces.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 2 states that the search for initiators should go down to the subsystems/train level and that Capability Category III should consider the use of "other systematic processes."

Index No. IE-A	**Capability Category I**	**Capability Category II**	**Capability Category III**
IE-A6	When performing the systematic evaluation required in IE-A5, INCLUDE initiating events resulting from multiple failures, if the equipment failures result from a common cause.	When performing the systematic evaluation required in IE-A5, INCLUDE initiating events resulting from multiple failures, if the equipment failures result from a common cause, **and from routine system alignments.**	When performing the systematic evaluation required in IE-A5, INCLUDE initiating events resulting from multiple failures, **including equipment failures resulting from random and common causes, and from routine system alignments.**

EXPLANATION OF THE REQUIREMENT

This SR is tied to the system initiating event identification in IE-A5 and initiating event frequency calculation in IE-C2. This SR ensures that system failures consider common cause factors. For example, while failure of one CCW pump may not cause a reactor transient, failure of all CCW pumps may. This SR requires that failure modes are considered in a hierarchal fashion with increasing scope as capability category increases. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This identification can be performed to three different capabilities:

Capability Category I

This category is focused on ensuring that common cause failures with the plant system in a typical alignment are considered in the IE-A5 system initiating event review. Hence this failure mode and condition is expected to be included in the frequency assessment in IE-C2.

Capability Category II

In addition to the requirement in Category I, this category requires consideration of common cause and specifically requires that all routine plant configurations for that set of equipment be considered. Routine alignments include consideration of rotating equipment arrangements, periodic monthly and quarterly surveillances that disable PRA equipment and common maintenance configurations that occur periodically. Alignments that do not disable components in question or are very short (say under 15 minutes) may be excluded from detailed consideration. As an example, in a three pump system where two pump operation is required and one of the three pumps is routinely rotated into standby, the analyst needs to explicitly consider initiating event associated with A and B running with C in standby, B and C running with A in standby and A and C running with B in standby. It is expected that in quantifying initiating event frequencies, both the common cause failures and multiple operational alignments will be considered consistent with their utilization.

Capability Category III

This extends the Category II requirements by including multiple random failures, along with common cause failures, in assessing failure modes of all the routine system configurations. Inclusion of multiple random failures will capture lower frequency challenges. Such considerations will also be captured in IE-C2.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 R2 includes the following clarifications:

1. When discussing the impact of random and common cause effects, it is emphasized that both impacts should be considered separately (random **OR** common cause)
2. Clarification was added to both Category II and III which notes that the alignments to be considered include those which may result from preventive and corrective maintenance
3. For Category III the word normal has been deleted implying that both normal and non-normal alignments would need to be considered.

Index No. IE-A	Capability Category I	Capability Category II	Capability Category III
IE-A7	In the identification of the initiating events, INCORPORATE: (a) Events that have occurred at conditions other than at power operation (i.e., during low-power or shutdown conditions), and for which it is determined that the event could also occur during at power operation. (b) Events resulting in an unplanned controlled shutdown that includes a scram prior to reaching low-power conditions, unless it is determined that an event is not applicable to at power operation.		

EXPLANATION OF THE REQUIREMENT

This SR provides the requirement that shutdown and low power events be reviewed for potential applicability as an initiating event during power operation. That is, in reviewing the plant event experience, events occurring either during the shutdown process, while shutdown or during the power ascension process, cannot a priori be discounted as potential initiating events. Even if such events do not reveal the potential for a new initiator, the resulting information could be considered in determining the plant initiating event frequency (see IE-C2).

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-A	Capability Category I	Capability Category II	Capability Category III
IE-A8	No requirements for interviews.	INTERVIEW plant personnel (e.g., operations, maintenance, engineering, safety analysis) to determine if potential initiating events have been overlooked.	INTERVIEW plant operations, maintenance, engineering, and safety analysis personnel to determine if potential initiating events have been overlooked.

EXPLANATION OF THE REQUIREMENT

It is important that the list of initiating events analyzed in the plant PRA be as complete as practical. While generic plant reviews and past experience of other plants are very helpful (see also IE-A9), interviews with a wide range of plant personnel may add additional insights into plant capabilities and vulnerabilities. These may in turn help better understand the credibility of selected initiators.

Capability Category Differentiation

This identification can be performed to three different capabilities:

For Capability Category I

No requirement specified.

For Capability Category II

At this level the PRA staff is required to reach out to other plant disciplines to get a broader perspective on defining IEs. It is not prescriptive but includes recommendations on which plant areas may provide useful insights. This process is not as formalized as that performed for Category III.

For Capability Category III

This category explicitly defines a comprehensive process whereby an effort is made to contact multiple disciplines.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-A	Capability Category I	Capability Category II	Capability Category III
IE-A9	No requirement for precursor review.	REVIEW plant-specific operating experience for initiating event precursors, for the purposes of identifying additional initiating events **For example, plant-specific experience with intake structure clogging might indicate that loss of intake structures should be identified as a potential initiating event.**	REVIEW plant-specific **and industry** operating experience for initiating event precursors, for the purposes of identifying additional initiating events.

EXPLANATION OF THE REQUIREMENT

It is important that the list of initiating events analyzed in the plant PRA be as complete as practical. This SR is an extension of IE-A8. Whereas IE-A8 requires interviews, this SR specifically requires that the plant-specific operating history be reviewed for precursors. Such reviews may include review of condition reports. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This identification can be performed to three different capabilities: The specific differentiation among categories is self-explanatory.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-A	Capability Category I	Capability Category II	Capability Category III
IE-A10	For multi-unit sites with shared systems, INCLUDE multi-unit site initiators (e.g., multi-unit LOOP events or total loss of service water) that may impact the model.		

EXPLANATION OF THE REQUIREMENT

The extent of plant cross ties and interdependencies varies considerably among multi-unit sites. This SR requires that initiating events at multi-unit sites include the potential for unique site level initiators. Site level initiators differ from unit specific initiators in that common mitigating systems and resources that would be available if only one unit were in distress, may be unavailable to one of the affected units and hence the plant post accident response would be different. Specifically, this SR requires the PRA staff to look at the likelihood of common LOOP events, plus other coupling factors such as environmental challenges (river temperature, intake cooling water condition), common control rooms and shutdown operations ongoing at one unit to identify unique IEs that may impact multiple units on a single site.

This SR is not applicable to plants with a single unit site.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.1.2 Supporting Requirements for HLR-IE-B

ASME/ANS Standard Section 2.2.1, Table 2.2.1-2(b), Supporting Requirements for HLR-IE-B

HLR-IE-B:	The initiating event analysis shall group the initiating events so that events in the same group have similar mitigation requirements (i.e., the requirements for most events in the group are less restrictive than the limiting mitigation requirements for the group) to facilitate an efficient, but realistic, estimation of CDF.
Intent:	To ensure that the grouping of events does not bias the results of the PRA
SRs:	IE-B1 through IE-B5

Index No. IE-B	Capability Category I	Capability Category II	Capability Category III
IE-B1	COMBINE initiating events into groups to facilitate definition of accident sequences in the Accident Sequence Analysis element Section (2-2.2) and to facilitate quantification in the Quantification Section (2-2.7).		

EXPLANATION OF THE REQUIREMENT

An initiating event analysis of a nuclear power plant can result in thousands of specific initiating events depending on the scope and level of detail in the PRA. However, many will have similar impact on the plant and hence will require the same safety systems to respond in order to prevent core damage or a large early release of radioactive material. Grouping initiating events with similar impact, while preserving information about system-event dependencies makes the PRA more manageable by reducing the number of supporting analyses and cut-sets, and consequently the manpower to do the PRA. The attributes for grouping are addressed in IE-B2.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-B	Capability Category I	Capability Category II	Capability Category III
IE-B2	USE a structured, systematic process for grouping initiating events. For example, such a systematic approach may employ master logic diagrams, heat balance fault trees or failure modes and effects analysis (FMEA).		

EXPLANATION OF THE REQUIREMENT

Meeting this requirement ensures that the process for grouping the initiating events is clearly organized and that the criteria for grouping are clearly defined. Criteria for grouping initiating events include success criteria, discussed in Section 2-2.3 of the standard, variations in potential consequences and level of detail available. In order to meet this requirement, groups are defined so that all initiating events included therein share important attributes: similar plant thermal-hydraulic performance, same requirements for safety systems to maintain core cooling, similar timing of events, common operator actions expected during response, impact on Primary Coolant System integrity, similar potential end states, viz. high-pressure or low-pressure sequence. IE-B3 requires that the attributes of a group envelope the initiating events included therein. It is important that the groups be comprehensive, viz. all IEs are accounted for, but disjoint, i.e., non-overlapping, and no gaps. A systematic process not only ensures comprehensiveness but facilitates peer review and thereby imbues confidence in the end product. No specific process is required by the standard as long as it is structured and systematically employed. IE-B4 addresses other IEs, which have uniquely different success criteria or potentially large radioactive releases.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-B	Capability Category I	Capability Category II	Capability Category III
IE-B3	GROUP initiating events only when the following is true: (a) Events can be considered similar in terms of plant response, success criteria, timing and the effect on the operability and performance of operators and relevant mitigating systems; or (b) Events can be subsumed into a group and bounded by the worst-case impacts within the “new” group.	GROUP initiating events only when the following is true: (a) Events can be considered similar in terms of plant response, success criteria, timing and the effect on the operability and performance of operators and relevant mitigating systems; or (b) Events can be subsumed into a group and bounded by the worst-case impacts within the “new” group. **DO NOT SUBSUME scenarios into a group unless:** (1) The impacts are comparable to, or less than, those of the remaining events in that group AND (2) It is demonstrated that such grouping does not impact significant accident sequences.	GROUP initiating events only when the following is true: (a) Events can be considered similar in terms of plant response, success criteria, timing and the effect on the operability and performance of operators and relevant mitigating systems; or (b) Events can be subsumed into a group and bounded by the worst-case impacts within the “new” group. **DO NOT ADD initiating events to a group and DO NOT SUBSUME events into a group unless the impacts are comparable to those of the remaining events in that group.**

EXPLANATION OF THE REQUIREMENT

This SR requires the identification of the circumstances when grouping may be performed and when grouping is not appropriate. Grouping of the initiating events is performed to reduce the number of accident sequences to be quantified; therefore, the plant response for the initiating events in a group has to be similar so as not to miss a potential accident sequence, bury information about important dependencies or not to misrepresent the plant response. In addition, an event can be included (subsumed) in a group when the plant response represented by the group is more limiting. Such grouping of dis-similar events is acceptable so long as such grouping does not result in the inability to determine the risk significance of event sequences and cut-sets resulting from the grouped initiating event. Transients or LOCAs to be selected for inclusion in a particular group are to be represented (either directly or in a bounding way) by the same success criteria. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This grouping can be performed to three different Capability Categories. The capability categories are meant to reflect the different degrees to which the plant response can be modeled from a more functional response to a more refined systemic response.

Capability Category I

This grouping will establish a minimal number of functional initiating event groups that is sufficient to reasonably and conservatively represent the plant risk profile. It will reduce the complexity of the model at the expense of model detail. By selecting this grouping strategy, it is expected that the absolute risk predictions will be conservatively biased.

Capability Category II

This grouping will be more refined than Capability Category I for the purpose of resolving the significant contributors to risk. As stated in the SR, the criteria for sub-summation are more stringent. Therefore, the number of functional initiating event groups will be larger, the model complexity greater, but the absolute risk predictions will be less conservatively biased. Significant accident sequences are defined in Section 1.2 of the Standard.

Capability Category III

This grouping will be more refined than Capability Category II. An initiating event is subsumed by another group only when its plant response is comparable to other initiating events, e.g. same response systems and same success criteria. The number of functional initiating event groups will be even larger, the model complexity even greater, but the risk predictions will be as realistic as possible.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-B	Capability Category I	Capability Category II	Capability Category III
IE-B4	GROUP separately from other initiating event categories those categories with different plant response (i.e., those with different success rate criteria) impacts or those that could have more severe radionuclide release potential (e.g., LERF). This includes such initiators as excessive LOCA, interfacing systems LOCA, steam generator tube ruptures and unisolated breaks outside containment.		

EXPLANATION OF THE REQUIREMENT

Some initiating events have unique plant responses and as such need to be grouped separately in order to avoid masking significantly different risk impacts from different initiating events. For example, the criteria cited in IE-B2 for grouping are focused on the impact of IE on core damage frequency. However, some IEs might satisfy these criteria and be grouped accordingly but their radioactive release magnitudes are much larger for one reason or another. This SR requires the application of an additional criterion, viz. release magnitude, for grouping.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-B	Capability Category I	Capability Category II	Capability Category III
IE-B5	For multi-unit sites with shared systems, DO NOT SUBSUME multi-unit initiating events if they impact mitigation capability.		

EXPLANATION OF THE REQUIREMENT

For multi-unit sites with shared systems, it is possible that a failure in one of those systems can cause an IE at one or both of the units; such IEs are required to be treated separately. For example, when two units share a component cooling water system, its failure could trigger a transient at one or both units. Demands on reactor operators following such a multi-unit initiating event may be much more severe than would be the case for a similar single unit event. If emergency diesel generators are also shared, their availability to mitigate such events could be less. Initiating events at multi-unit sites with shared systems require careful analysis.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.1.3 Supporting Requirements for HLR-IE-C

ASME/ANS Standard Section 2.2.1, Table 2.2.1-2(c), Supporting Requirements for HLR-IE-C

HLR-IE-C:	The initiating event analysis shall estimate the annual frequency of each initiating event or initiating event group.
Intent:	To provide a realistic estimate of the frequency of each initiating event modeled in the PRA
SRs:	IE-C1 through IE-C15

Index No. IE-C	Capability Category I	Capability Category II	Capability Category III
IE-C1	CALCULATE the initiating event frequency accounting for relevant generic and plant-specific data unless it is justified that there are adequate plant-specific data to characterize the parameter value and its uncertainty. (See also IE-C13 for requirements for rare and extremely rare events)		

EXPLANATION OF THE REQUIREMENT

It is important that the statistical parameters that characterize the IE frequency (mean and variance) be based on sound statistics. The most relevant data to use as a basis for estimating the initiating event frequency is the plant-specific experience, i.e., the number of events and the number of reactor operating years of service experience at-power. Events, identified pursuant to IE-A5 for conditions other than at-power operation, should be included as appropriate in the plant experience. That is, an event that occurred during off-power as a result of conditions that are fully applicable to power operation and would, if the event had occurred at power, resulted in a plant transient, should be included as an event in the frequency calculation for the associated initiating event or initiating event group. For example, a loss of off-site power event that occurs during an outage and its cause is unrelated to the outage and could have occurred while the plant was in power operation, should be included in the calculation of the loss of off-site power frequency. However, plant-specific experience may be insufficient due to such situations as: too few operating years, non-occurrence of the event at the plant, changes or trends in plant performance that render part of the service experience no longer relevant to current plant conditions. For example, 10 years of plant operation with no occurrences of an event would be inadequate for determining an initiating event whose true frequency is, say 10^{-3} per year. For such IEs, this SR requires that plant-specific data be supplemented with relevant generic data. Such data is obtained from the service experience at plants, whose equipment and operating environment is similar to that of the subject plant. Sources of generic data include: NUREG/CR-5750 "Rates of Initiating Events at U.S. Nuclear Power Plants: 1987 - 1995," NUREG/CR-6928 "Industry-Average Performance for Component and Initiating Events at U.S. Commercial Nuclear Power Plants," EPRI's annual report on loss of off-site power, LERs and, to a lesser extent, foreign data. IE-C4 requires that plant-specific and generic data be combined by using a Bayesian update process. IE-C13 specifies requirements for rare and extremely rare initiating events.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-C	Capability Category I	Capability Category II	Capability Category III
IE-C2	When using plant-specific data, USE the most recent applicable data to quantify the initiating event frequencies. JUSTIFY excluded data that is not considered to be either recent or applicable (e.g., provide evidence via design or operational change that the data are no longer applicable.)		

EXPLANATION OF THE REQUIREMENT

Sources of plant-specific data include: plant incident or corrective action reports, Licensee Event Reports (LERs), summaries of operating experience, control room logs, interviews with plant operators. Annual frequencies of initiating events can vary from year-to-year or have positive or negative trends. For example, as a plant and its operating team mature, forced outages may become less frequent. If such a negative or positive trend is evident, it would be misleading to average in very old data and then assume that the initiating event frequency in the future is constant at this historical value. As another example, repeated failures may result in a corrective action such as a design change so that the prior failure data are not applicable to the plant performance today or in the near future. So applicability of plant-specific data requires analysis, e.g. time trend required in IE-C7 for Capability Category III, and judgment. Exclusions and inclusions of data are required to be justified, e.g. statistical tests, engineering judgment, consistent with current industry practices.

REGULATORY POSITION

Revision 2 of The NRC in Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-C	Capability Category I	Capability Category II	Capability Category III
IE-C3	CREDIT recovery actions [those implied in IE-C6(c), and those implied and discussed in IE-C8 through IE-C11] as appropriate JUSTIFY each such credit (as evidenced such as through procedures or training).		

EXPLANATION OF THE REQUIREMENT

Some potential initiating events, especially those associated with support systems or multiple trains, may not require an immediate shutdown of the plant. This delay allows time for recovery actions, which need to be credited in order to estimate a realistic initiating event frequency that accounts for the potential of recovery actions and the probability of failure to implement. Operator actions leading to recovery are required to be justified by reference to HRA techniques, prior approved procedures, training, and plant experience.

REGULATORY POSITION

Revision 2 of The NRC in Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-C	Capability Category I	Capability Category II	Capability Category III
IE-C4	When combining evidence from generic and plant-specific data, USE a Bayesian update process or equivalent statistical process. JUSTIFY the selection of any informative prior distribution used on the basis of industry experience. (see Reference [2-2])		

Reference 2-2, NUREG/CR-5750 “Rates of Initiating Events at U.S. Nuclear Power Plants: 1987 - 1995”

EXPLANATION OF THE REQUIREMENT

IE-C1 requires the use of generic and plant-specific data to estimate IE frequencies. This SR requires the use an accepted statistical method when combining such data. An accepted method for this purpose is Bayesian analysis. NUREG/CR-6823, “Handbook of Parameter Estimation for Probabilistic Risk Assessment,” provides guidance and examples on Bayesian updating. Uncertainty distributions that can be used to characterize the plant to plant variability in the industry service experience with initiating events are available in NUREG/CR-5750 “Rates of Initiating Events at U.S. Nuclear Power Plants: 1987 - 1995,” and NUREG/CR-6928, “Industry-Average Performance for Component and Initiating Events at U.S. Commercial Nuclear Power Plants.” The analyst is required to justify the selection of any informative prior distribution by showing that it is applicable to the event being estimated, i.e., the plant-specific information lies within the prior distribution.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-C	Capability Category I	Capability Category II	Capability Category III
IE-C5	CALCULATE initiating event frequencies on a reactor year basis. [NOTE (1)] INCLUDE in the initiating event analysis the plant availability, such that the frequencies are weighted by the fraction of time the plant is at power.		CALCULATE initiating event frequencies on a reactor year basis. [NOTE (1)] INCLUDE in the initiating event analysis the plant availability, such that the frequencies are weighted by the fraction of time the plant is at power. **INCLUDE differences between historical plant availability over the period of event occurrences in the plant database and existing or expected future plant availability that could be different from historical values.**

NOTE (1): For the computation of annual average core damage frequency/large early release frequency (i.e., for comparison to Reg. Guide 1.174 quantitative acceptance guidelines), the appropriate units for initiating event frequency are events per calendar year, commonly expressed as events per reactor-year, where a reactor-year is one full calendar year of experience for one reactor. However, when determining total annual plant CDF (or LERF), which includes contributions from events occurring during power operation as well as during other plant operating states, the calculation of the contribution for each operating state must account for the fraction of the year that the plant is in that operating state. Two simple examples follow:

- Loss of Bus Initiating Event – A loss of bus initiating event can be computed by annualizing the hourly failure rate of the bus and associated breakers, relays, etc. that could lead to loss of power on the bus during the time the plant is at power. For example, for the bus itself, the initiating event frequency over a full year would be calculated as:

  $$f_{bus\text{-}8760} = \lambda_{bus} * H_{year}$$

  where:

  $f_{bus\text{-}8760}$ = frequency of loss of bus over a full 8760-hour year

  λ_{bus} = failure rate of bus per hour, say $1x10^{-7}$/hr

  H_{year} = hours in 1 calendar- or reactor-year, 8760 hrs/yr.

  However, to calculate CDF (or LERF) for events at power only (i.e., for the scope of PRA covered by this Standard), it is necessary to adjust for the fraction of time the plant is at power. Thus, the result obtained from the above equation needs to be multiplied by an additional term, say $F_{at\ power}$,
  where:

  $F_{at\ power}$ = fraction of year that, on average, the plant is at power, for example 90%.

  Thus,

  $$f_{bus\ at\ power} = 1x10\text{-}7/hr * 8760\ hrs/yr * 0.90 = 7.9x10^{-4}/\text{reactor year.}$$

- Turbine Trip Initiating Event – Some initiating events, such as a turbine trip initiating event, may be computed based on plant-specific experience. In this case, the number of events classified as turbine trip events is in the numerator and the number of applicable calendar years of operation is in the denominator. The fraction of time at power is implicitly included in the numerator because the turbine trip experience is limited to at power experience by the nature of the event.

  Thus:

$f_{TT} = N_{TT}/Y_{OP}$

where

f_{TT} = frequency of turbine trip events per reactor year
N_{TT} = number of events classified as turbine trip events, for example 27 events
Y_{OP} = number of applicable calendar years of plant operation (regardless of operating mode), for example 23 years

f_{TT} = 27 events/23 years = 1.2/reactor-year

The number of applicable calendar years should be based on the time period of the event data being used and may exclude unusual periods of non-operation (i.e., if the plant was in an extended forced shutdown).

For some applications, such as configuration risk management or analyses that compare specific risks during different modes of operation, it may be appropriate to utilize initiating event frequencies that do not consider the fraction of time in the operating state. In these cases, the initiating event frequency should simply be per unit of time (i.e., per hour or per year). For at-power operation, this basis is sometimes referred to as per reactor critical year (i.e., assuming that the reactor operated continuously for a year). On a more general basis, it could be considered to be per reactor operating state year.

In the loss of bus initiating event example above, the term $F_{at\ power}$ would not be included in the computation of initiating event frequency for these kinds of applications.

In the turbine trip initiating event example above, the value must be adjusted by dividing f_{TT} by $F_{at\ power}$.

EXPLANATION OF THE REQUIREMENT

It is important that units be normalized to a common one, which is consistent with industry standards and NRC's regulatory requirements. This requirement establishes the common unit as number of events per reactor-year, where a reactor-year is one full calendar year of experience for one reactor weighted by the fraction of the year that the reactor is at power. The note in the Standard provides sufficient explanation. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This quantification can be performed to two different capabilities:

For Capability Category I and II

The requirement is stated above.

For Capability Category III

It is additionally required to compare projected plant availability to the historical record. This requirement ensures that the technical basis for the availability parameter is a good estimate of future plant performance and that historical trends have been adequately considered. If historical periods with poor plant availability performance are included in the averaged "at power" frequencies, the risk profile may become distorted.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement IE-C5, but has an objection, in the form of a clarification, to Note (1). The staff has proposed adding the following words to the note to resolve its objection:

"In the above example, it is assumed the bus failure rate is applicable for at-power conditions. It should be noted that initiating event frequencies may be variable from one operating state to another due to various factors. In such cases, the contribution from events occurring only during at-power conditions should be utilized."

<table>
<tr><th>Index No. IE-C</th><th>Capability Category I</th><th>Capability Category II</th><th>Capability Category III</th></tr>
<tr><td>IE-C6</td><td colspan="3">USE as screening criteria no higher than the following characteristics (or more stringent characteristics as devised by the analyst) to eliminate initiating events or groups from further evaluation:
(a) The frequency of the event is less than 1E-7 per reactor year (/ry) and the event does not involve either an ISLOCA, containment bypass or reactor pressure vessel rupture
(b) The frequency of the event is less than 1E-6/ry and core damage could not occur unless at least two trains of mitigating systems are failed independent of the initiator, or
(c) The resulting reactor shutdown is not an immediate occurrence. That is, the event does not require the plant to go to shutdown conditions until sufficient time has expired during which the initiating event conditions, with a high degree of certainty (based on supporting calculations), are detected and corrected before normal plant operation is curtailed (either administratively or automatically).
If either criterion (a) or (b) above is used, then CONFIRM that the value specified in the criterion meets the applicable requirements in the Data Analysis Section (2-2.6) and the Level 1 Quantification Section (2-2.8).</td></tr>
</table>

EXPLANATION OF THE REQUIREMENT

It is not practical to model all the initiating events that may be identified in the enumeration process and therefore some level of screening out of initiating events is normally necessary to complete a PRA. The intent of this requirement is to ensure that the screening out of an initiating event does not result in the screening out of a significant event sequence, if it were left in. A major goal of probabilistic risk assessment is the use of probability to focus on the more significant events. The screening out of less likely initiating events is an important activity. This Supporting Requirement specifies criteria for this screening process.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-C	Capability Category I	Capability Category II	Capability Category III
IE-C7	No requirement for time trend analysis.		USE time trend analysis to account for established trends (e.g., decreasing reactor trip rates in recent years). JUSTIFY excluded data that is not considered to be either recent or applicable (e.g., provide evidence via design or operational change that the data are no longer applicable). One acceptable methodology for time-trend analysis is found in NUREG/CR-5750 [2-2] and NUREG/CR-6928 [2-20]

EXPLANATION OF THE REQUIREMENT

This requirement supports IE-C2 in justifying the exclusion of data. In addition to NUREG/CR-5750 "Rates of Initiating Events at U.S. Nuclear Power Plants: 1987 - 1995," and NUREG/CR-6928, "Industry-Average Performance for Component and Initiating Events at U.S. Commercial Nuclear Power Plants," time trend analysis is also discussed in NUREG/CR-6823, "Handbook of Parameter Estimation for Probabilistic Risk Assessment."

Capability Category I and II

There is no requirement.

Capability Category III

Self-explanatory.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-C	Capability Category I	Capability Category II	Capability Category III
IE-C8	Some initiating events are amenable to fault tree modeling as the appropriate way to quantify them. These initiating events, usually support system failure events, are highly dependent upon plant-specific design features. If fault tree modeling is used for initiating events, USE the applicable systems-analysis requirements for fault tree modeling found in the Systems Analysis Section (2-2.4)		

EXPLANATION OF THE REQUIREMENT

As discussed under IE-B4, an effective way to determine the failure modes of support systems and to estimate their frequencies is the use of fault trees. If fault trees are used for such purposes, the models are required to satisfy the requirements presented in Section 2-2.4 for Systems Analysis. Additional requirements for the modeling of support system IE with fault trees are contained in IE-C9 through IE-C12.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-C	Capability Category I	Capability Category II	Capability Category III
IE-C9	If fault tree modeling is used for initiating events, QUANTIFY the initiating event frequency (as opposed to the probability of an initiating event over a specific time frame, which is the usual fault tree quantification model described in the Systems Analysis Section (2-2.4). MODIFY, as necessary, the fault tree computational methods that are used so that the top event quantification produces a failure frequency rather than a top event probability as normally computed. USE the applicable requirements in the Data Analysis Section (2-2.6) for the data used in the fault tree quantification.		

EXPLANATION OF THE REQUIREMENT

This requirement is to ensure that the fault tree methodology used to support the quantification of initiating event frequency uses a quantification algorithm that is appropriate for this purpose. The fault tree model for the frequency of an event is not the same as a fault tree model for a system unavailability in response to the initiating event. For example, a fault tree for two 100% capacity pumps may have a fault tree for the estimation of the system failure probability that would typically yield minimal cut sets for various independent failures and unavailabilities and common cause failures that would be used to model the top event probability of the fault tree. A fault tree for the loss of both pumps as an initiating event, however would be different as it would need to address unique features such as: a mission time of one year (8760 hours) as opposed to the typical 24 hours used for mitigation systems, operational and maintenance practices that are expected to occur during this extended mission time, operational common cause and recovery times for equipment failures that are consistent with that needed to prevent a trip. The resulting calculation of this model would yield not a probability of failure, but rather a frequency of failure. Owners Group activities associated with computing support system initiating events should be consulted for guidance. In addition, see recent EPRI Report 1016741 December 2008 for a discussion of this issue. This report is publicly available at no charge from EPRI.com. At the time of this writing, this report is believed to represent the best information source on the modification of the fault tree for addressing initiating events. This report has not been endorsed by the ASME.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-C	Capability Category I	Capability Category II	Capability Category III
IE-C10	If fault tree modeling is used for initiating events, CAPTURE within the initiating event fault tree models all relevant combinations of events involving the annual frequency of one component failure combined in a manner with the unavailability (or failure during the repair time of the first component) of other components.		

EXPLANATION OF THE REQUIREMENT

See **EXPLANATION OF THE REQUIREMENT** discussion for IE-C9.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-C	Capability Category I	Capability Category II	Capability Category III
IE-C11	If fault tree modeling is used for initiating events, USE plant-specific information in the assessment and quantification of recovery actions where available, in a manner consistent with the applicable requirements in the Human Reliability Analysis Section (2-2.5)		

EXPLANATION OF THE REQUIREMENT

Consistent with the requirements in IE-C1, IE-C2 and IE-C3, where available, plant-specific information shall be included in fault trees used to estimate frequencies, and to quantify recovery actions. Recovery actions stated in the SR refer to those actions taken for recovery from failures. The quantification of recovery actions is to be consistent with the applicable requirements in Section 2-2.5, Human Reliability Analysis. Specifically, High Level Requirement HLR-HR-H states "Recovery actions (at the cut-set or scenario level) shall be modeled only if it has been demonstrated that the action is plausible and feasible for those scenarios to which they are applied. Estimates of probabilities of failure for these actions shall address dependency on prior human failures in the scenario."

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-C	Capability Category I	Capability Category II	Capability Category III
IE-C12	COMPARE results and EXPLAIN differences in the initiating event analysis with generic data sources to provide a reasonableness check of the results.		

EXPLANATION OF THE REQUIREMENT

As stated for IE-C1, it is necessary to account for both plant-specific and generic evidence in the estimation of initiating event frequencies. Plant-specific data may be limited and as a result not all potential initiators may have been experienced. Therefore, it is important and required that the analyst compare them to the experience of other similar plants as stated in generic data bases, and in PRAs for comparable plants to ensure that the calculated frequencies are consistent or differences are explainable. Differences are expected. However, significant differences are to be explained. In particular, it is important to confirm that the predicted fault tree generated IE frequency is consistent with plant and/or industry observations. This process is commonly called "a sanity check."

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has an objection, in the form of a clarification, to the requirement. The staff has proposed adding the following words to the requirement to resolve its objection:

> "An example of an acceptable generic data sources is NUREG/CR-6928."

<table>
<tr><th>Index No. IE-C</th><th>Capability Category I</th><th>Capability Category II</th><th>Capability Category III</th></tr>
<tr><td>IE-C13</td><td colspan="2">For rare initiating events, USE industry generic data and INCLUDE plant-specific features to decide which generic data are most applicable. For extremely rare initiating events, engineering judgment may be used; if used, AUGMENT with applicable generic data sources. Refer to 1-4.3, Use of Expert Judgment, as appropriate.</td><td>For rare initiating events, USE industry generic data and AUGMENT with a plant-specific fault tree or other similar evaluation that accounts for plant-specific features. For extremely rare initiating events, engineering judgment may be used; if used, AUGMENT with applicable generic data sources. Refer to 1-4.3, Use of Expert Judgment, as appropriate.</td></tr>
<tr><td></td><td colspan="2">For this Requirement, a “rare event” might be expected to occur one or a few times throughout the world nuclear industry over many years. An “extremely rare event” would not be expected to occur even once throughout the industry over many years.</td><td>For this Requirement, a “rare event” might be expected to occur one or a few times throughout the world nuclear industry over many years. An “extremely rare event” would not be expected to occur even once throughout the industry over many years. INCLUDE in the quantification the plant-specific features that could influence initiating events and recovery probabilities. Examples of plant-specific features that sometimes merit inclusion are the following:
(a) Plant geography, climate and meteorology for LOOP and LOOP recovery
(b) Service water intake characteristics and plant experience
(c) LOCA frequency calculation</td></tr>
</table>

EXPLANATION OF THE REQUIREMENT

Generic data refers to industry references which consolidate data from multiple plants in order to provide a more complete representation of the uncertainty in the parameter value. Sources of such data include: NUREG/CR-5750 “Rates of Initiating Events at U.S. Nuclear Power Plants: 1987 - 1995,” NUREG/CR-6928 “Industry-Average Performance for Component and Initiating Events at U.S. Commercial Nuclear Power Plants,” EPRI’s annual report on loss of off-site power, LERs, foreign data (as applicable). The ASME Standard’s Section 1-2.2, Definition, states that rare events might be expected to occur only a few times throughout the world nuclear industry over may years (e.g., < 1E-4/r-yr) A review of the above references finds that only events such as large and medium

LOCAs have an estimated frequency in this range. For these events, expert elicitation has been used as documented in NUREG-1829, “Estimating Loss-of-Coolant Accident (LOCA) Frequencies through the Elicitation Process.” For extremely rare initiating events, which are defined as not being expected to occur even once throughout the world nuclear industry over many years (e.g., < 1E-6/r-yr), no data will likely to be available. In such a circumstance, engineering judgment may be used. Such judgment may consider industry practice (e.g., large and medium LOCA frequency). For non-generic issues plant-specific expert elicitations associated with rare events may be performed following the requirements in Section 1-4.3 of the standard. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This quantification can be performed to two different capabilities:

Capability Category I and II

Direct use of applicable industry and generic data is expected.

Capability Category III

For rare and extremely rare initiating events, industry generic data is required to be augmented with plant-specific considerations that may result in an event being more or less likely. For example large LOCA frequencies may be impacted by primary coolant material used (carbon steel vs. stainless steel) and pipe wall thickness. Detailed fracture mechanic analyses may also be used if degradation mechanisms are known, modeled and information regarding the flaw distribution is available.

Category III assessments may also directly consider Pressurized Thermal Shock (PTS) as an independent analytically established failure frequency. Typically in Category I and II assessments, this failure mode is subsumed into RV failure frequency.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

<table>
<tr><th>Index No. IE-C</th><th>Capability Category I</th><th>Capability Category II</th><th>Capability Category III</th></tr>
<tr><td>IE-C14</td><td colspan="2">In the ISLOCA frequency analysis, INCLUDE the following features of plant and procedures that influence the ISLOCA frequency:
(a) Configuration of potential pathways including numbers and types of valves and their relevant failure modes existence and positioning of relief valves
(b) Provision of protective interlocks
(c) Relevant surveillance test procedures
(d) The capability of secondary system piping
(e) Isolation capabilities given high flow/differential pressure conditions that might exist following breach of the secondary system.</td><td>In the ISLOCA frequency analysis, INCLUDE the following features of the plant and procedures that influence the ISLOCA frequency:
(a) Configuration of potential pathways including numbers and types of valves and their relevant failure modes, existence and positioning of relief valves.
(b) Provision of protective interlocks
(c) Relevant surveillance test procedures.
Also,
(1) EVALUATE surveillance procedure steps
(2) INCLUDE surveillance test intervals explicitly
(3) ASSESS on-line surveillance testing quantitatively
(4) QUANTIFY pipe rupture probability
(5) ADDRESS explicitly valve design (e.g., air operated testable check valves)
(6) INCLUDE quantitatively the valve isolation capability given the high-to-low- pressure differential.</td></tr>
</table>

EXPLANATION OF THE REQUIREMENT

ISLOCA needs to be treated separately because they represent challenges to the prevention of core damage and large early releases. The factors listed in this requirement have been determined in previous ISLOCA analyses to be important for a realistic ISLOCA model. The typical failure in an ISLOCA exposes low pressure secondary piping to high pressure fluids from the primary system. When calculating ISLOCA frequencies, IE-C14 requires consideration of the piping system and fragility, protective interlocks, relevant surveillance test procedures and isolation capability. Care also needs to be given to the establishment of the appropriate mission times for the plant features considered in the ISLOCA analysis. Consideration should be given to the expected failure sequences and the associated component exposure times during these sequences to full RCS pressure. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This quantification can be performed to two different capabilities:

Capability Category I and II

In addition to the items listed in the Explanation Categories I and II require consideration of the capability of secondary system piping and isolation capabilities following breach of the secondary system

Capability Category III

In addition to the items listed in the Explanation Categories I and II require a more rigorous examination of the items listed under Capability Categories I and II. Specifically, the surveillance testing procedure is to be assessed in detail, the probability of secondary piping rupture quantified, and isolation valves also assessed in detail.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-C	Capability Category I	Capability Category II	Capability Category III
IE-C15	CHARACTERIZE the uncertainty in the initiating event frequencies and PROVIDE mean values for use in the quantification of the PRA results.		

EXPLANATION OF THE REQUIREMENT

The characterization of uncertainty involves understanding how the PRA can be affected by the sources of model uncertainty and related assumptions. It includes the identification of the key sources of uncertainties to obtain an understanding of these sources of uncertainties on the acceptance criteria being used for the application. An acceptable approach to characterizing the uncertainty is provided in NUREG-1855, "Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decision Making" and EPRI-TR-1016737 "Treatment of Parameter and Modeling Uncertainty for Probabilistic Risk Assessments." Section 3 of EPRI-TR-1016737 provides guidance on characterizing uncertainties for the baseline PRA model. When characterizing the uncertainty for IE frequency, one would discuss assumptions identified in IE event selection, grouping and data selection process. The requirement also addresses the use of mean values in the quantification of the PRA results. Characterization of the IE frequency includes a determination of the mean value and the dispersion of the uncertainty. The EPRI report is publicly available at no charge from EPRI.com. At the time of this writing, this report is believed to represent the best information source on the treatment of parameter and modeling uncertainty. This report has not been endorsed by the ASME.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.1.4 Supporting Requirements for HLR-IE-D

ASME/ANS Standard Section 2-1.4.1, Table 2-1.4.1-2(d), Supporting Requirements for HLR-IE-D

HLR-IE-D:	Documentation of the initiating event analysis shall be consistent with the applicable supporting requirements.
Intent:	Intent: To ensure the results can be reviewed and appropriately referenced for applications
SRs:	IE-D1 through IE-D3

Index No. IE-D	Capability Category I	Capability Category II	Capability Category III
IE-D1	DOCUMENT the initiating event analysis in a manner that facilitates PRA applications, upgrades and peer review.		

EXPLANATION OF THE REQUIREMENT

It is important that the documentation includes sufficient information about the approach used for the initiating event identification, grouping and quantification, such that an analyst or peer reviewer who was not involved in the original process could come to similar conclusions regarding the validity of the results and the veracity of the initiating event analysis to the as-built and as-operated plant. In this way an analyst would be able to understand the approach and would be able to support applications, upgrades, and reviews of the PRA. Furthermore, the documentation is to be consistent with the applicable SRs as stated in High Level Requirement IE-D. Although examples are included in SR IE-D2, these do not represent a complete list of all required documentation. To facilitate the development of a complete list, a documentation mapping is provided in the explanation to SR IE-D2 showing the scope of documentation needed to achieve consistency with the applicable SRs.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-D	Capability Category I	Capability Category II	Capability Category III
IE-D2	DOCUMENT the processes used to select, group and screen the initiating events and to model and quantify the initiating event frequencies, including the inputs, methods, and results. For example, this documentation typically includes: (a) The functional categories considered and the specific initiating events included in each. (b) The systematic search for plant-unique and plant-specific support system initiators. (c) The systematic search for RCS pressure boundary failures and interfacing system LOCAs. (d) The approach for assessing completeness and consistency of initiating events with plant-specific experience, industry experience, other comparable PRAs and FSAR initiating events. (e) The basis for screening out initiating events. (f) The basis for grouping and subsuming initiating events. (g) The dismissal of any observed initiating events, including any credit for recovery. (h) The derivation of the initiating event frequencies and the recoveries used. (i) The approach to quantification of each initiating event frequency. (j) The justification for exclusion of any data.		

EXPLANATION OF THE REQUIREMENT

This SR addresses the process documentation used to implement the initiating event supporting requirements. It also provides examples of documentation associated with the initiating event processes and examples of documentation associated with the parameters, constraints and results from implementing these processes. Table 1 (IE-D2-1) provides a discussion of these examples. It should be noted that the documentation examples do not represent the complete list of all required documentation, but a list of many of the documents that are typically included. To facilitate the development of a complete list, a documentation mapping is provided in Table 2 (IE-D2-2) showing the scope of documentation needed to achieve consistency with the applicable SRs. Table 2 (IE-D2-2) also identifies each documentation item as either “process” or “SR.” A “process” documentation item primarily supports the process requirement which is the focus of this SR while an “SR” documentation item primarily supports documentation that is consistent with one or more supporting requirements as required by IE-D1. A mapping is also provided in Table 1 (IE-D2-1) between the examples and the documentation list shown in Table 2 (IE-D2-2) and in Table 2 (IE-D2-2) between the documentation items and the applicable SRs.

Table 1 IE-D2-1 SR Examples

SR Example	Discussion	Documentation Item
a	SR IE-A1 requires the identification of initiating events using a structure, systematic process. Several other SRs amplify the requirements including SR IE-A2 which provides a set of general initiating event categories.	1, 3, 5
b	This example addresses the initiating event identification process with a focus on support system initiators. It is expected that operating experience will be used to support this review.	1, 8, 9
c	This example addresses the initiating event identification process with a focus on RCS pressure boundary and interfacing system LOCAs.	1
d	The approach to review plant-specific operating experience is addressed by several SRs.	2
e	The approach to identify a complete set of initiating events should include, if applicable, any screening criteria.	1
f	Documentation of the approach to grouping events and the results of the grouping should be included.	3, 5
g	The dismissal of any observed operating events should be discussed in the approach and included in the documentation of operating experience.	2, 8
h	The derivation of the initiating event frequencies includes several key steps: the quantification approach and results, the process used to group the initiating events, the mapping of operating experience to these events, and the reasonableness check of the results.	4, 5, 6, 7, 8, 9, 10, 11
i	The approach to the quantification of the initiating event frequencies is addressed by many supporting requirements.	4
j	Documentation should identify both the approach to screening data and the data that was excluded.	2,9

Table 2 IE-D2-2 Documentation Mapping

Element	Type	Item	Documentation	Related SR	SR Examples
IE	Process	1	Document the approach used to include a complete spectrum of internal-event challenges. Include any initiating event screening out criteria.	A1, A2, A5, A6, A10, C6	a, b, c, e
IE	Process	2	Document the approach used to review operating experience for initiating event identification	A3, A4, A7, A8, A9	d, g, j
IE	Process	3	Document the approach used to group initiating events. Include the criteria for grouping events. Note that this is focused on the general process, the specific documentation of the bases for a grouped and/or subsumed event is addressed separately.	B1, B2, B3, B4, B5	a, f
IE	Process	4	Document the approach used to calculate each initiating event frequency.	C1, C2, C3, C4, C5, C7, C8, C9, C10, C11, C12, C13, C14, C15	h, i
IE	SR	5	List the identified initiating events and/or initiating event groups, their frequencies and associated plant impact(s) (success criteria). Include any events screened and their screening bases (see SR-C6)	A1, A2,A5, A6, A7, A10, B1, B2, C6	a, h
IE	SR	6	Document the frequency calculation for each initiating event and/or initiating event group	C1, C2, C3, C4, C5, C7, C8, C9, C10, C11, C13, C14, C15	h
IE	SR	7	Document the mapping of initiating events into groups and provide the associated bases	B3, B4, B5	h
IE	SR	8	List the plant-specific trips and show the mapping of these events to those events selected for PRA model. Provide the bases for screened events. Include initiating event precursor results (helpful, not required)	A3, A9	b, g, h
IE	SR	9	List the plants and/or industry experience reviewed and show the mapping of their events to those events selected for PRA model. Provide the bases for screened events.	A4	b, j
IE	SR	10	Document the initiating event frequency reasonableness check	C12	h
IE	SR	11	Document the plant personnel interviews used in the development of the initiating events (helpful, not required)	A8	h

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. IE-D	Capability Category I	Capability Category II	Capability Category III
IE-D3	DOCUMENT the sources of model uncertainty and related assumptions (as identified in QU-E1 and QU-E2) associated with the initiating event analysis.		

EXPLANATION OF THE REQUIREMENT

It is important to document the characterization the uncertainties with respect to plant risk. Guidance for characterizing uncertainties for the baseline PRA is included in NUREG-1855 "Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decision Making" and of EPRI-TR-1016737 "Treatment of Parameter and Modeling Uncertainty for Probabilistic Risk Assessments." These companion documents are intended to provide a technical basis for the identification and characterization of uncertainty in the baseline risk assessment. Section 3 of EPRI-TR-1016737 provides guidance on characterizing uncertainties for the baseline PRA model. Note that the EPRI report is publicly available at no charge from EPRI.com. This report is believed to represent the best information source on the treatment of parameter and modeling uncertainty at the time of this writing. This report has not been endorsed by the ASME.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.2 Accident Sequence Analysis Section 2-2.2 of the ASME/ANS RA-Sa-2009

The objectives of the accident sequence element are to ensure that the response of the plant's systems and operators to an initiating event is reflected in the assessment of CDF and LERF in such a way that

(a) Significant operator actions, mitigation systems and phenomena that can alter sequences are appropriately included in the accident sequence model event tree structure and sequence definition.

(b) Plant-specific dependencies are reflected in the accident sequence structure.

(c) Success criteria are available to support the individual function successes, mission times and time windows for operator actions for each critical safety function modeled in the accident sequences.

(d) End states are clearly defined to be core damage or successful mitigation with capability to support the Level 1 to Level 2 interface.

To meet the above objectives, three HLRs are defined in the standard.

Designator	Requirement
HLR-AS-A	The accident sequence analysis shall describe the plant-specific scenarios that can lead to core damage following each modeled initiating event. These scenarios shall address system responses and operator actions, including recovery actions that support the key safety functions necessary to prevent core damage.
HLR-AS-B	Dependencies that can impact the ability of the mitigating systems to operate and function shall be addressed.
HLR-AS-C	Documentation of the Accident Sequence analysis shall be consistent with the applicable supporting requirements.

5.2.1 Supporting Requirements for HLR-AS-A

ASME/ANS Standard Section 2.2.2, Table 2.2.2-2(a), Supporting Requirements for HLR-AS-A

HLR-AS-A:	The accident sequence analysis shall describe the plant-specific scenarios that can lead to core damage following each modeled initiating event. These scenarios shall address system responses and operator actions, including recovery actions that support the key safety functions necessary to prevent core damage.
Intent:	To ensure that the accident sequences appropriately include the equipment and human actions necessary to fulfill key safety functions
SRs:	AS-A1 through AS-A11

Index No. AS-A	Capability Category I	Capability Category II	Capability Category III
AS-A1	USE a method for accident sequence analysis that: (a) Explicitly models the appropriate combinations of system responses and operator actions that affect the key safety functions for each modeled initiating event; (b) Includes a graphical representation of the accident sequences in an "event tree structure" or equivalent such that the accident sequence progression is displayed; and (c) Provides a framework to support sequence quantification.		

EXPLANATION OF REQUIREMENT

As the accident sequences are a foundational element in determining the combinations of initiating events, safety functions and system and operator failures and successes that may lead to core damage or large release, it is important that they are faithful to expected plant response, and reasonably complete with regard to addressing the key safety functions. This supporting requirement states a general requirement regarding the overall accident sequence analysis methodology; subsequent support requirements expand on the details for the accident sequence analysis. The three sub-elements of this requirement address the methodology requirements for accident sequences. Each of these elements is discussed below.

(a) Explicitly models the appropriate combinations of system responses and operations actions that affect the key safety functions for each modeled initiating event.

Different approaches are used in the design of PRAs as to the split of information between that contained in the event trees and that contained in the fault trees. The term "appropriate" reflects the need to match the level of detail and boundary conditions of the system responses and operator actions included in the event tree with the selected event tree approach (i.e., small event tree - large fault tree, large fault tree - small event tree or other combinations) and its supporting analysis. To meet this requirement, the selected method is required to support the identification and modeling of all safety functions that can impact the risk metric quantification within the structure of the event tree. For small event trees, the explicit combinations of system responses and operator actions may be contained in fault trees that are supporting the event trees. Although use of the small event tree approach can be used to meet this requirement, care is needed to ensure that dependencies that can impact the ability of the mitigating systems or operating actions are addressed in the combined event tree/fault tree structure.

(b) Includes a graphical representation of the accident sequences in an "event tree structure" or equivalent such that the accident sequence progressions is displayed.

For small event trees, graphical representation of the accident sequences is expected. For large event trees, especially those that question every top event, alternative approaches to displaying the accident sequence progressions can be used. Alternatives can include event sequence diagrams that display the event tree structure at a summary level or a narrative description of the event tree structure.

(c) Provides a framework to support sequence quantification

The selected accident sequence analysis method needs to be able to support the quantification of core damage frequency and LERF including the ability to account for system dependencies.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has "no objection" to this SR.

Index No. AS-A	Capability Category I	Capability Category II	Capability Category III
AS-A2	For each modeled initiating event, IDENTIFY the key safety functions that are necessary to reach a safe, stable state and prevent core damage. [See NOTE 1]		

NOTE (1): Supporting requirements AS-A2 through AS-A4 deal with defining the model in terms of how the plant works, but do not address what the model should include. Requirements for modeling details are addressed in supporting requirements beginning with AS-A5.

EXPLANATION OF REQUIREMENT

As it is the expectation that initiating events are grouped such that they are similar in terms of plant response, success criteria, timing and the effect on the operability and performance of operators and relevant mitigating systems (IE-B3, IE-B4 and IE-B5), the plant impact that results from each initiating event group (referred to in this requirements as "initiating event") needs to be reflected in the identification of the key safety functions.

As defined in Section 1-2.2, Definitions, the key safety functions are the minimum set of high level functions that must be maintained to prevent core damage and large early release. These safety functions can be used to logically group the system success criteria to support the overall reactor core and containment success criteria. Typical functions as stated in the definitions section include: reactivity control, reactor pressure control, reactor coolant inventory control decay heat removal and containment integrity. These functions are similar to those included in NUREG-2300, "PRA (Probabilistic Risk Assessment) Procedures Guide: A Guide to the Performance of Probabilistic Risk Assessment for Nuclear Power Plants." To meet this requirement it is necessary to ensure that all safety functions pertinent to achieving a safe, stable state and preventing core damage, given a modeled initiating event, are identified, which will then enable the identification of a reasonably complete set of system (see AS-A3) and operator responses. As stated in Note 1, the identification of key safety functions is used as an input into SR AS-A5 process of defining the accident sequence model.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has "no objection" to this SR.

Index No. AS-A	Capability Category I	Capability Category II	Capability Category III
AS-A3	For each modeled initiating event, using the success criteria defined for each key safety function (in accordance with SR SC-A3), IDENTIFY the systems that can be used to mitigate the initiator. [See NOTE (1)]		

NOTE (1): Supporting requirements AS-A2 through AS-A4 deal with defining the model in terms of how the plant works, but do not address what the model should include. Requirements for modeling details are addressed in supporting requirements beginning with AS-A5.

EXPLANATION OF REQUIREMENT

PRA success criteria are used to distinguish between success and failure for components, human actions, trains, systems, structures, functions and sequences. In the development of accident sequences, functional success criteria are typically defined in terms of the minimum number of combinations of systems or components required to operate or minimum levels of operator or component performance during a specific period of time and under specific conditions. This supporting requirement addresses the systematic identification of systems and or components (i.e., plant hardware) that are necessary to support the identified safety functions.

This requirement needs to be considered with AS-A2 through AS-A4 and is intended to be used with these other requirements to capture the specification of the set of systems and human actions necessary to meet the key safety function success criteria. It should be noted that different success criteria may be required for a given system in order to mitigate all the accident scenarios for which they are credited as providing a mitigation function (e.g., number of pumps required to operate in some systems is dependent upon the modeled initiating event) (See SY-A10).

As stated in Note 1, the identification of systems used to mitigate the initiator is used as an input into SR AS-A5 process of defining the accident sequence model.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has "no objection" to this SR.

Index No. AS-A	Capability Category I	Capability Category II	Capability Category III
AS-A4	For each modeled initiating event, using the success criteria defined for each key safety function (in accordance with SR SC-A3), IDENTIFY the necessary operator actions to achieve the defined success criteria. [See NOTES (1) and (2)]		

NOTE (1): Supporting requirements AS-A2 through AS-A4 deal with defining the model in terms of how the plant works, but do not address what the model should include. Requirements for modeling details are addressed in supporting requirements beginning with AS-A5.

NOTE (2): The intent of this requirement is not to address specific procedures, but rather to identify, at a functional level, what is required of the operators for success.

EXPLANATION OF REQUIREMENT

PRA success criteria are used to distinguish between success and failure for components, human actions, trains, systems, structures, functions and sequences. In the development of accident sequences, functional success criteria are typically defined in terms of the minimum number of combinations of systems or components required to operate or minimum levels of operator or component performance during a specific period of time and under specific conditions. This requirement is to identify those operator actions using plant-specific emergency operating procedures, and other relevant procedures that are necessary to support the defined success criteria. Also see HR-E1 and HR-E2. Several responses may be grouped into one action if the impact of the failures is similar or can be conservatively bounded (See HR-F1).

This requirement needs to be considered with AS-A2 through AS-A4 and is intended to be used with these other requirements to capture the specification of the set of systems and human actions necessary to meet the key safety function success criteria. It should be noted that different success criteria are required for some actions in order to mitigate all the different accident scenarios for which they are credited as providing a mitigation function (e.g., the operator action timing to initiate feed and bleed given a normal trip may be much less for a trip due to the loss of main feedwater resulting in a reduced likelihood of success).

As stated in Note 2, the identification of the functional operator requirements is used as an input into SR AS-A5 process of defining the accident sequence model.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has “no objection” to this SR.

Index No. AS-A	Capability Category I	Capability Category II	Capability Category III
AS-A5	DEFINE the accident sequence model in a manner that is consistent with the plant-specific: system design, EOPs, abnormal procedures and plant transient response.		

EXPLANATION OF REQUIREMENT

While SR AS-A2 addresses the requirements for identification of the safety functions, SR AS-A3 the requirements for the identification of the supporting system functions and SR AS-A4 the requirements for the identification of the supporting operator functions, SR AS-A5 utilizes the input from these other SRs "to define" or in this context "to develop" the plant-specific accident sequences. The development may result in the addition or deletion of functions identified by SR AS-A2, 3 and 4 that are not consistent with the as-built, as-operated plant. As noted in these previous three SRs, their requirement is focused on how the plant works, not what the model should address. This current SR addresses the model.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has "no objection" to this SR.

Index No. AS-A	Capability Category I	Capability Category II	Capability Category III
AS-A6	Where practical, sequentially ORDER the events representing the response of the systems and operator actions according to the timing of the event as it occurs in the accident progression. Where not practical, PROVIDE the rationale used for the ordering.		

EXPLANATION OF REQUIREMENT

A unique feature of event trees and the resulting event sequences over that of fault trees is its ability to capture the order of events. At the highest level, an event sequence can be divided into three parts: 1) Initiating Event, 2) Mitigation Functions (system functions and operator actions) and 3) End State. Requirement AS-A6 is focused on the order of the mitigation functions and states that sequence timing of an accident scenario is a major consideration to the design of the event tree. For example, reactivity control functions are typically questioned early in an event sequence as they are associated with the initial plant response. The timing of interest is where the initial demand for the function is expected to occur for it is understood that many functions have a mission that spans the entire duration of the sequence (typically a 24-hour timeframe).

An example event tree for a general transient event associated with a PWR is shown in the table below to illustrate several points associated with the sequential ordering of events.

Top Event	Description
Initiating Event	General Transient
Reactivity Control	Reactor Protection System (RPS) shutdowns the reactor
Heat Removal	Main or Auxiliary Feedwater provides flow to the steam generators or RCS Feed and Bleed (once through cooling) is successful
RCS Integrity	Power Operated Relief Valves remain closed Reactor Coolant Pump Seals remain cooled and intact SG Tubes remain intact
RCS Inventory Control – Injection	If required, injection provides adequate makeup
RCS Cooldown	Control steaming (i.e., Atmospheric Dump Valves or Turbine Bypass Valves lower RCS pressure to Residual Heat Removal entry conditions)
Residual Heat Removal	Shutdown heat removal is maintained
Containment Isolation	Containment isolation is achieved
Containment Cooling	Containment pressure and temperature is maintained below containment integrity failure limits
RCS Inventory Control – Recirculation	Long-term injection is maintained through recirculation of water from the containment sump
End State	Defined by the path through the event tree

As can be seen from the above table, the sequence of events is expressed primarily at a functional level (typical for a small event tree) and reflects the general timing order that would be expected. It should be noted that in this small event tree two key functions have been split into separate top events. Heat Removal is divided between Heat Removal and Residual Heat Removal, and RCS Inventory

Control into Injection and Recirculation. Although not required, subdividing functions can enhance the sequential ordering of events. Residual Heat Removal is typically implemented late in the sequence through a separate system from that used for early heat removal and RCS Inventory Control has two clear modes where injection transitions to recirculation on depletion of stored injection inventory. Additional division of these functions can be made such as dividing heat removing into its key systems such as main feedwater, auxiliary feedwater and feed and bleed. These systems can also be ordered. In addition, key operator actions can be modeled as top events in the event tree. Adding operating actions or system functions to the event tree enhances the ability to reflect order in the accident sequences but also complicates the event tree structure. In the large event tree methodology, the event tree nodes are typically at the system or train level and include all key operator actions as top events. A large event tree can contain greater than a hundred top events.

It should also be noted that the event order may vary between or within paths of a given event tree. For example, in the above table, Heat Removal is sequenced before RCS Integrity. There are scenarios where the power-operated relief valves, an element of RCS Integrity, could be demanded to open immediately following a reactor trip and subsequently fail to close. There could also be cases where the RCP seals, also an element of RCP integrity, fails late, well after the demand for heat removal. These RCS integrity functions could be separated into their own top events.

Another key consideration in the order of events in an event tree is the treatment of dependencies between events. This becomes a significant consideration for models that contain support system event trees, but is also applicable to front-line event trees. For support system event trees, the top event order is typically arranged from least to most dependent. This enables the knowledge of functions questioned early in the event tree to serve as boundary conditions to those questioned later in the tree. For example, assume that a support system event tree is developed that includes the individual 4KV and 480V buses as top events. If a 4KV bus supports multiple 480V buses then questioning the 4KV bus before the 480V buses enables one to effectively establish the necessary boundary conditions for the 480V buses. If the 4KV bus fails, then the associated 480V buses are failed. If the 4KV bus is successful, then the associated 480V bus failure probabilities can be determined assuming its support bus is successful for those pathways where it is successful. If the opposite approach is taken, ordering the events with the more dependent top event questioned first, then additional care within the event tree would be required. Using the example above, if the 480V bus is questioned prior to the 4KV bus, then the status of the 480V cannot be finalized until the status of the associated 4KV bus is determined. Systems that are dependent on the 480V bus would always require both dependencies (480V and 4KV) to be questioned.

In summary, event sequence timing should be a key consideration when ordering the top event within the event tree. However, it is understood that other considerations such as managing the number of event tree nodes (top events), the variations in timing associated with different event tree paths and the dependencies between events that may result in variations in the order of events from that associated with the expected scenario timeline.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has “no objection” to this SR.

Index No. AS-A	Capability Category I	Capability Category II	Capability Category III
AS-A7	DELINEATE the possible accident sequences for each modeled initiating event, **unless the sequences can be shown to be a non-contribution using qualitative arguments**.		DELINEATE the possible accident sequences for each modeled initiating event.

EXPLANATION OF REQUIREMENT

This requirement addresses the need to ensure that the design of the event tree and its resulting accident sequences are established with accuracy and in detail, and are consistent with each modeled initiating event or initiating event group (see SR AS-A2 for a discussion on initiating event grouping). Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This identification can be performed to three different capabilities:

For Capability Category I and II, the requirement allows sequences that can be shown to be non-contributors to be excluded. To gain a perspective on this exclusion criterion, it is helpful to understand the definition of a significant sequence, which would clearly not meet this exclusion criterion. In the definition section of the Standard, a significant accident sequence is defined as one of the set of accident sequences, that when rank-ordered by decreasing frequency, aggregate to 95% or that individually contribute more than 1% of core damage frequency. Therefore, for a sequence to be considered a "non-contribution" sequence, it would need to be significantly less than this requirement. As AS-A7 is qualitative, there are two key questions to consider.

1) Is the excluded sequence bounded by other sequences? If bounded, then the risk contribution is being conservatively considered in the overall results. This bounding approach results in the loss of detail and potentially an overestimation of risk. Although potentially conservative, a bounding approach captures the issue and can be dissected if refinement of the results is required.

2) Is the frequency of the excluded event tree sequence unlikely? If the sequence is not bounded, then it is necessary to determine if the resulting frequency will not be consequential. Therefore, tree branches that are excluded should have a small split fraction probability (probability of that branch occurring) such that the expected contribution of resulting sequence is much less than 1% (0.01%) of core damage or large early release.

For Capability Category III, the analyst needs to ensure that the design of the event tree and its resulting accident sequences are established with accuracy and in detail.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has "no objection" to this SR.

Index No. AS-A	Capability Category I	Capability Category II	Capability Category III
AS-A8	DEFINE the end state of the accident progression as occurring when either a core damage state or a steady state condition has been reached.		

EXPLANATION OF REQUIREMENT

The sequence end state is the set of conditions at the end of an accident sequence that characterizes the impact of the sequence on the plant or the environment. In most PRAs, end states typically include success states (i.e., those states with negligible impact), plant damage states for Level 1 sequences and release categories for LERF sequences. End states that result in the uncovering and heat-up of the reactor core to the point at which prolonged oxidation and severe fuel damage involving a large fraction of the core is anticipated are to be considered core damage end states. As a minimum, these core damage end states need to be defined such that they enable the determination of LERF sequences. Sequences that are considered successful need to reach a steady state condition where core damage or the averted release is not anticipated for the conditions that are present at the end of the sequence. This steady state condition implies that the success criteria are satisfied and the accident is under control. It also assumes neither additional failures occur nor additional actions are needed within a reasonable time following the end of the sequence and that long-term actions that happen well beyond the end of the mission time, such as refilling water and fuel tanks, have been assessed as being able to be performed. Supporting Requirement SC-A5 states that the minimum mission time for PRA accident sequences is 24 hours, therefore recovery actions that occur much greater than 24 hours (e.g., greater than 48 hours) can be excluded. Recovery actions that need to occur shortly following the end of the mission time (e.g., within 30 hours) should be included. For these two limits and for the time in between, judgment needs to be used as to the significance of the potential actions considering that recovery and the potential for repair become more likely as additional time is considered. As stated by Support Requirement SC-A5, “for sequences in which stable plant conditions would not be achieved by 24 hr using the modeled plant equipment and human actions, **ASSUME core damage.”**

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has “no objection” to this SR.

Index No. AS-A	Capability Category I	Capability Category II	Capability Category III
AS-A9	**USE generic thermal hydraulic analyses (e.g., as performed by a plant vendor for a class of similar plants)** to determine the accident progression parameters (e.g., timing, temperature, pressure, steam) that could potentially affect the operability of the mitigating systems.	**USE realistic, applicable (i.e., from similar plants) thermal hydraulic analyses** to determine the accident progression parameters (e.g., timing, temperature, pressure, steam) that could potentially affect the operability of the mitigating systems.	**USE realistic, plant-specific thermal hydraulic analyses** to determine the accident progression parameters (e.g., timing, temperature, pressure, steam) that could potentially affect the operability of the mitigating systems.

EXPLANATION OF REQUIREMENT

Thermal-hydraulic analyses are performed to determine the conditions during the progression of the accident that could affect the operability of the mitigating systems, and therefore, influence that actual accident sequence development. These analyses are complex and resource intensive and detailed plant-specific calculations are not always necessary. This requirement specifies the degree of plant-specificity and realism needed. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This identification can be performed to three different capabilities. The capability categories are meant to reflect the different degrees to which the thermal-hydraulic analyses can be performed from a more generic to a plant-specific.

For Capability Category I, the requirement establishes the worst set of conditions that could affect the mitigating systems and that conservatively represent the accident progression. Capability Category I strategy reduces the complexity of the model at the expense of model detail. By using generic analyses, it is expected that the absolute risk predictions will be conservatively biased.

For Capability Category II, the requirement is more refined over Capability Category I. As such, while plant-specific analyses are not performed, the analyses used are ones for plants of similar design and operation – that is, similar reactor size, available mitigating systems and containment design. In this manner, the accident sequences developed are not conservative.

For Capability Category III, the requirement is for realistic plant-specific.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has “no objection with clarification” to this SR. The clarification notes that “The code requirements for acceptability need to be stated.” The RG 1.200 resolution is to reference SC-B4 in the Category II and III requirements. SC-B4 requires analysis models and computer codes to have sufficient capability to model the conditions of interest in the determination of success criteria.

Index No. AS-A	Capability Category I	Capability Category II	Capability Category III
AS-A10	In constructing the accident sequence models, INCLUDE, for each modeled initiating event, **individual events in the accident sequence sufficient to bound system operation, timing and operator actions necessary for key safety functions.**	In constructing the accident sequence models, INCLUDE, for each modeled initiating event, **sufficient detail that significant differences in requirements on systems and operator responses are captured. Where diverse systems and/or operator actions provide a similar function, if choosing one over another changes the requirements for operator intervention or the need for other systems, MODEL each separately.**	In constructing the accident sequence models, explicitly INCLUDE, for each modeled initiating event**, each system and operator action required for each key safety function.**

EXPLANATION OF REQUIREMENT

The PRA Standard Definitions section defines accident sequence as a representation in terms of an initiating event followed by a sequence of failures or successes that may lead to core damage or large early release. For the sequence of failures or successes, AS-A10 requires the modeling of individual events such that all credible system and operator responses are addressed. Accident sequence conditions could impact system response with respect to: system-level success criteria, system and train availability, component reliability, mission times, time windows for system-related operator actions and system modeling assumptions. Accident sequence conditions also could impact the proper performance of a required response consistent with the accident sequence specific timing cues and time window for successful completion of the action. The approach to modeling individual events varies from a Category I bounding approach to the explicit modeling of each system and operator action that is required by Category III. This variation is modeling is discussed below. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This identification can be performed to three different capabilities:

For Capability Category I, a bounding approach is used. When using a bounding approach the most limiting conditions should be used to ensure that the resulting sequence addresses all potential variations of system, equipment and operation actions. This approach should result in conservative results.

For Capability Category II, the requirement is to address all system operations or operator actions that result in significant differences in downstream response of other operations or actions. This category is a refinement of Category I in that the degree of conservatism is reduced with the addition of greater detail such that all system operations or operator actions that result in changes to the response of other systems are to be modeled. As with Category I, each model response should bound the scenarios it addresses. The difference between Category I and II is that Category I places no restrictions on the use of a bounding approach while Category II allows bounding modeling only when there is no downstream impact.

For Capability Category III, the requirement is to explicitly model all system and operator actions required for each system function.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has "no objection with clarification" to this SR. The clarification notes that "The modifier 'significant' does not have a clear definition. Examples provide a clear understanding." The RG 1.200 resolution is to modify the Category II language to: "In constructing the accident sequence models, INCLUDE, for each modeled initiating event, **sufficient detail that ~~significant~~ differences in requirements on systems and [required – added] operator ~~responses~~ [interactions (e.g., systems initiations or valve alignment) – added] are captured. Where diverse systems and/or operator actions provide a similar function, if choosing one over another changes the requirements for operator intervention or the need for other systems, MODEL each separately."**

Index No. AS-A	Capability Category I	Capability Category II	Capability Category III
AS-A11	Transfers between event trees may be used to reduce the size and complexity of individual event trees. DEFINE any transfers that are used and the method that is used to implement them in the qualitative definition of accident sequences and in their quantification. USE a method for implementing an event tree transfer that preserves the dependencies that are part of the transferred sequence. These include functional, system, initiating event, operator and spatial or environmental dependencies.		

EXPLANATION OF REQUIREMENT

Self-explanatory.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has “no objection” to this SR.

5.2.2 Supporting Requirements for HLR-AS-B

ASME/ANS Standard Section 2.2.2, Table 2.2.2-2(b), Supporting Requirements for HLR-AS-B

HLR-AS-B:	Dependencies that can impact the ability of the mitigating systems to operate and function shall be addressed.
Intent:	To ensure that functional dependencies are addressed
SRs:	AS-B1 through AS-B7

Index No. AS-B	Capability Category I	Capability Category II	Capability Category III
AS-B1	For each modeled initiating event, IDENTIFY mitigating systems impacted by the occurrence of the initiator and the extent of the impact. INCLUDE the impact of initiating events on mitigating systems in the accident progression either in the accident sequence models or in the system models.		

EXPLANATION OF REQUIREMENT

The identification of initiating event impact on mitigating systems includes consideration of the initiating events impact on key safety functions (SR AS-A2), mitigating systems and associated success criteria (SR AS-A3) and operator actions and associated success criteria (SR AS-A4). The term "mitigating systems" refers to those systems that can be used to mitigate the initiator as defined by SR AS-A3. These elements were considered and included, as appropriate, in the development of the accident sequence model (AS-A5).

It should be noted that different approaches are used in the design of PRAs as to the split of information between that contained in the event trees and that contained in the fault trees. This SR provides an option to include the initiating event impact in the accident sequence models (event trees) or the system models (fault trees). The expectation is to include the initiating event impact at the location where the level of detail and boundary conditions of the system responses and operator actions are modeled such that the impact is appropriately addressed. For example, SR IE-A2 identifies essentially two categories of initiating events: LOCAs (including SGTRS and ISLOCAs) and transients (including special initiators). LOCAs result in a direct challenge to RCS pressure and inventory and therefore will require makeup systems to mitigate these effects. A large break LOCA challenge to a PWR often requires accumulators (or injection tanks) to provide rapid core re-flood, a function not needed for other initiating events. Such a function is typically modeled at the accident sequence level. However, a transient that results from a failure of an electrical bus could be modeled at the event tree level if a large event tree method is being used. This event would be modeled within the fault tree for small event tree methods.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 2 has "no objection" to this SR.

Index No. AS-B	Capability Category I	Capability Category II	Capability Category III
AS-B2	IDENTIFY the dependence of modeled mitigating systems on the success or failure of preceding systems, functions and human actions. INCLUDE the impact on accident progression, either in the accident sequence models or in the system models. For example: *(a)* Turbine driven system dependency on SORV, depressurization and containment heat removal (suppression pool cooling); *(b)* Low pressure system injection success dependent on need for RPV depressurization.		

EXPLANATION OF REQUIREMENT

A unique feature of event trees and the resulting event sequences is their ability to capture the order of events. At the highest level, an event sequence can be divided into three parts: 1) Initiating Event, 2) Mitigation Functions (system functions and operator actions) and 3) End State. Requirement AS-A6 is focused on the order of the mitigation functions and states that sequence timing of an accident scenario is a major consideration to the design of the event tree. For example, reactivity control functions are typically questioned early in an event sequence as they are associated with the initial plant response. This requirement explicitly addresses the treatment of the dependent nature of event trees in the development of the accident sequence models and system models.

Two examples are provided in the supporting requirement. The first example refers to dependency associated with BWRs where the turbine-driven systems (RCIC and HPCI) required an adequate RCS pressure and heat sink to operate. A stuck open relief valve or depressurization of the RCS would reduce the available RCS pressure and may challenge the ability for these pumps to operate due to insufficient steam pressure. Suppression pool cooling is used as the heat sink for RCIC and HPCI. Inadequate suppression pool cooling could challenge the effectiveness of these systems to discharge their heat. The second example refers to the dependency of low pressure injection on the pressure of the RCS where injection is being provided. Often, these pumps require a reduction in RCS pressure to provide adequate makeup where the RCS pressure is significantly below the pump's shutoff head. Both examples highlight the dependency of a system on the actions of other systems and operator actions.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 2 has "no objection" to this SR.

Index No. AS-B	Capability Category I	Capability Category II	Capability Category III
AS-B3	For each accident sequence, IDENTIFY the phenomenological conditions created by the accident progression. Phenomenological impacts include generation of harsh environments affecting temperature, pressure, debris, water levels, humidity, etc. that could impact the success of the system or function under consideration [e.g., loss of pump net positive suction head (NPSH), clogging of flow paths]. INCLUDE the impact of the accident progression phenomena, either in the accident sequence models or in the system models.		

EXPLANATION OF REQUIREMENT

This requirement ensures that the accident sequences reflect the phenomenological conditions (i.e., expected observable conditions) that could occur during the accident progression. These conditions include unique or harsh environmental conditions and process-related conditions as a result of the conditions created as a result of the accident progression. The identification of the phenomenological conditions can be accomplished through a systematic assessment of each sequence. This assessment should include a review of the basis for the success criteria and estimated reliability of each top event in light of the environmental and process conditions expected in the accident progression. Top event success criteria or equipment reliability could change: (1) (unique environment) as the result of a reduction in containment pressure due to containment isolation failure (potential impact on NPSH as a result of lower pump suction pressure), (2) (harsh environment) as the result of a high temperature steam environment (potential impact on component reliability), (3) (process-related condition) as the result of abnormal process parameters (e.g., relief's valves ability to close when passing water as opposed to steam), (4) (process-related condition) LOCAs typically require recirculation of injection inventory from the containment sump through sump screen that may be subject to clogging. Therefore, the potential impacts on top event reliability (failure modes, failure rate, number of demands, mission time) need to be reflected in the accident sequence models and system models.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has "no objection" to this SR.

Index No. AS-B	Capability Category I	Capability Category II	Capability Category III
AS-B4	When the event trees with conditional split fraction method is used, if the probability of Event B is dependent on the occurrence or non-occurrence of Event A, where practical, PLACE Event A to the left of Event B in the ordering of event tops. Where not practical, PROVIDE the rationale used for the ordering.		

EXPLANATION OF REQUIREMENT

Split fractions are typically used in large event trees and containment event trees where each event tree top event may have one or more split fractions. Split fraction is defined in the glossary as “a unitless quantity that represents the conditional (on preceding event) probability of choosing one direction rather than the other through a branch point of an event tree.” The selection of a split fraction value can only be made based on information that proceeds (to the left of) the top event whose split fraction is being determined. For example, if Event B models a pump and Event A models a bus that is required for the pump to operate, the failure of the bus (Event A) results in failure of Event B (pump). The split fraction for this condition is 1.0. Success of the bus results in the questioning of the Event B split fraction that represents the pump’s failure probability given Event A is successful. The split fraction for this condition would be a value like 1×10^{-3} (a typical pump on-demand failure rate). If the status of the bus is not known when the pump is questioned, then at some point later in the event tree where the pump is being used to support a system or plant function, both the pump and bus should be questioned together where both must be successful for the pump to be successful. This approach of questioning both is one means of compensating for the reverse order.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has “no objection” to this SR.

Index No. AS-B	Capability Category I	Capability Category II	Capability Category III
AS-B5	DEVELOP the accident sequence models to a level of detail sufficient to identify intersystem dependencies and train level interfaces, either in the event trees or through a combination of event tree and fault tree models and associated logic.		

EXPLANATION OF REQUIREMENT

Intersystem dependencies addressed by this supporting requirement include: (1) functional dependencies where a system is not used unless other systems have failed, (2) time-phased dependencies where the dependency changes as the accident progresses due to such factors as depletion of resources, recovery of resources and changes in loads, (3) support systems necessary to achieve the modeled function, (4) shared dependencies where systems or trains are dependent on the same components, subsystems or auxiliary equipment (common failure mode), (5) indirect physical interactions, typically environmental in nature, where a failure causes a degraded or failed condition (e.g., ventilation cooling results in equipment failure due to high temperature), (6) maintenance and testing interactions where a train in maintenance or test may preclude the other redundant train from being in maintenance or test, (7) operator interactions where the failure of an action could prevent or degrade the function one or more systems and/or trains and (8) common cause dependencies between systems and trains. As noted in the SR, different approaches are used in the design of PRAs as to the split of information between that contained in the event trees and that contained in the fault trees. The term “through a combination of…” reflects the understanding that the requirement for sufficient level of detail is met as a result of an integrated modeling approach that considers both the event trees and fault trees. To meet the level of detail requirement, the development process for the event tree/fault tree models is required to include methods to identify and address each type of dependency. [2]

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has “no objection” to this SR.

2 Methods to address each type of dependency

(1) Functional Dependencies: It is expected that these dependencies will be explicitly incorporated into the event tree branching.

(2) Time-phased Dependencies: Addressed by SR AS-B7.

(3) Support Systems Dependencies: This dependency includes interfaces with various supporting system (e.g., as power, dc power, auxiliary cooling water systems, heating, ventilation and air-conditioning systems). Consistent with SR SY-B5, system dependencies should be explicitly modeled and consistent with SR-B6, engineering analyses should be performed to determine the need for support systems that are plant-specific and reflect the variability in the conditions present during the postulated accidents for which the system is required to function.

(4) Shared Dependencies: It is expected that shared dependencies will be explicitly incorporated into the event trees or fault trees.

(5) Indirect Physical Interaction Dependencies: SR SY-B11 and SY-B12 provide guidance on modeling support systems including HVAC.

(6) Maintenance and Testing Dependencies: Addressed by SR AS-B6.

(7) Operator Interactions: SR-B15 requires that operator interface dependencies be included across systems or trains, where applicable.

(8) Common Cause Dependencies: Common cause failures should be modeled when supported by generic or plant-specific data. Consistent with SR SY-B1 and SY-B2, intra-system common-cause failures (failure between trains) should be modeled while inter-system common-cause failures are only required for Category III when systems are performing the same function.

Index No. AS-B	Capability Category I	Capability Category II	Capability Category III
AS-B6	If plant configurations and maintenance practices create dependencies among various system alignments, DEFINE and MODEL these configurations and alignments in a manner that reflects these dependencies, either in the accident sequence models or in the system models.		

EXPLANATION OF REQUIREMENT

This requirement addresses system configurations that can change the system dependencies. For example, assume that a cooling water system has two heat exchangers (Heat Exchanger A and Heat Exchanger B) but only requires one for normal operation and for the mitigation of most events. Assume that Heat Exchanger A is supported by Pump A which is supported by Bus A, and Heat Exchanger B is supported by Pump B which is supported by Bus B. The objective of this requirement is to identify the system configurations that have the potential to impact the dependencies between systems and then model these alignments within the event trees or fault tree models.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has “no objection” to this SR.

Index No. AS-B	Capability Category I	Capability Category II	Capability Category III
AS-B7	MODEL time-phased dependencies (i.e., those that change as the accident progresses, due to such factors as depletion of resources, recovery of resources and changes in loads) in the accident sequences. Examples are: *(a)* For SBO/LOOP sequences, key time phased events, such as: *(1)* AC power recovery *(2)* DC battery adequacy (time dependent discharge) *(3)* Environmental conditions (e.g., room cooling) for operating equipment and the control room *(b)* For ATWS/failure to scram events (for BWRs), key time dependent actions such as: *(1)* SLCS initiation *(2)* RPV level control *(3)* ADS inhibit *(c)* Other events that may be subject to explicit time dependent characterization include: *(1)* CRD as an adequate RPV injection source *(2)* Long term make-up to RWST		

EXPLANATION OF REQUIREMENT

The following table amplifies the list of examples to better illustrate the requirements for modeling time-phased dependencies.

Example	Description	Type	Explanation
(a)(1)	AC power recovery	Recovery	Likelihood of AC off-site recovery increases as the accident progresses where the additional time enables resources to complete switchyard or highline restoration activities. The initial phase prior to off-site recovery establishes the mission time for on-site power sources. After off-site power is restored, on-site power sources are no longer needed in order to achieve a safe-stable state.
(a)(2)	DC battery adequacy	Depletion	For conditions where the IE batteries are providing load without chargers (SBO conditions), depletion will limit the battery mission-time. If depletion occurs during the phase prior to off-site power recovery, then additional and/or modified mitigation actions may be required to achieve a safe-stable state or, in some plants, core damage may result. The time available before battery depletion can be significantly increased by actions to shed non-critical loads.
(a)(3)	Environmental conditions (room cooling)	Heatup	Loss of room cooling could cause critical temperatures to be reached such that equipment failure results. The time phase before equipment failure could be used to initiate recovery actions. Following equipment failure, additional and/or modified mitigation actions may be required to achieve a safe-stable state.
(b)(1)	SLCS Initiation	Heatup	In response to an ATWS event, the Standby Liquid Control system is used to insert negative reactivity into the pressure vessel in order to shutdown the reactor and avoid exceeding safety limits. The time

Example	Description	Type	Explanation
			available to perform this action is dependent, in part, on the action to lower the reactor vessel level (discussed below). Therefore, the time-dependent success of this action is influenced by the timing of RPV level action.
(b)(2)	RPV level control	Heatup	In response to an ATWS event, reactor vessel level needs to be maintained at the top of the fuel in order maintain adequate inventory and to limit reactor power. Higher water levels result in higher power levels. This action requires timely action and is often performed in conjunction with the SLC injection action discussed above. The timing for this action interacts with the SLC action as discussed above.
(b)(3)	ADS inhibit	Depletion	In response to an ATWS event, the operation of the Automatic Depressurization system may occur automatically and it could result in depressurization of the reactor to below the shutoff head of low pressure injection systems such as LPCI and core spray inject. Action may be required to prevent ADS operation by inhibiting ADS. Action timing is important; however, action has limited phase dependence.
(c)(1)	CRD as an adequate RPV injection source	Decay Heat	The control rod drive (CRD) hydraulic pumps can provide high pressure or low pressure coolant makeup. However, flow capacity of the CRD pumps is relatively low and this injection source is typically used when other high pressure coolant injection systems are not available. If high pressure injection fails early, the CRD system may not be able to provide adequate makeup as the flow requirements shortly after shutdown are greater than the capability of the CRD system. However, later in the event, the CRD system may be effective.
(c)(2)	Long term make-up	Depletion	Replenishment of condensate storage tanks used to supply emergency or auxiliary feedwater pumps is an example of long-term make-up. The phase prior to depletion requires monitoring of the tank level to ensure adequate time is available to align an alternate source. The shifting of the condensate source marks the transition between phrases.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has “no objection” to this SR.

5.2.3 Supporting Requirements for HLR-AS-C

ASME/ANS Standard Section 2.2.2, Table 2.2.2-2(c), Supporting Requirements for HLR-AS-C

HLR-AS-C:	Documentation of the Accident Sequence analysis shall be consistent with the applicable supporting requirements.
Intent:	To provide documentation that supports review and update of the system models consistent with the requirements.
SRs:	AS-C1 through AS-C3

Index No. AS-C	Capability Category I	Capability Category II	Capability Category III
AS-C1	DOCUMENT the accident sequence analysis in a manner that facilitates PRA applications, upgrades and peer review.		

EXPLANATION OF REQUIREMENT

It is important that the documentation includes sufficient information about the approach used for the development of the accident sequences, such that an analyst or peer reviewer who was not involved in the original process could come to similar conclusions regarding the validity of the results and the veracity of the accident sequence analysis to the as-built and as-operated plant. In this way an analyst would be able to understand the approach and would be able to support applications, upgrades and reviews of the PRA. Furthermore, the documentation is to be consistent with the applicable SRs as stated in High Level Requirement AS-C. Although examples are included in SR AS-C2, these do not represent a complete list of all required documentation. To facilitate the development of a complete list, a documentation mapping is provided in the explanation to SR AS-C2 showing the scope of documentation needed to achieve consistency with the applicable SRs.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has “no objection” to this SR.

Index No. AS-C	Capability Category I	Capability Category II	Capability Category III
AS-C2	DOCUMENT the processes used to develop accident sequences and treat dependencies in accident sequences, including the inputs, methods and results. For example, this documentation typically includes: *(a)* The linkage between the modeled initiating event in the Initiating Event Analysis section and the accident sequence model; *(b)* The success criteria established for each modeled initiating event including the bases for the criteria (i.e., the system capacities required to mitigate the accident and the necessary components required to achieve these capacities); *(c)* A description of the accident progression for each sequence or group of similar sequences (i.e., descriptions of the sequence timing, applicable procedural guidance, expected environmental or phenomenological impacts, dependencies between systems and operator actions, end states and other pertinent information required to fully establish the sequence of events); *(d)* The operator actions reflected in the event trees, and the sequence specific timing and dependencies that are traceable to the HRA for these actions; *(e)* The interface of the accident sequence models with plant damage states; *(f)* [When sequences are modeled using a single top event fault tree] the manner in which the requirements for accident sequence analysis have been satisfied.		

EXPLANATION OF REQUIREMENT

This SR addresses the process documentation used to implement the accident sequence supporting requirements. It also provides examples of documentation associated with the accident sequence development processes and examples of documentation associated with the parameters, constraints and results from implementing these processes. Table 3 (AS-C2-1) provides a discussion of these examples. It should be noted that the documentation examples do not represent the complete list of all required documentation, but a list of many of the documents that are typically included. To facilitate the development of a complete list, a documentation mapping is provided in Table 4 (AS-C2-2) showing the scope of documentation needed to achieve consistency with the applicable SRs. Table 4 (AS-C2-2) also identifies each documentation item as either "process" or "SR." A "process" documentation item primarily supports the process requirement which is the focus of this SR while an "SR" documentation item primarily supports documentation that is consistent with one or more supporting requirements as required by AS-C1. A mapping is also provided in Table 3 (AS-C2-1) between the examples and the documentation list shown in Table 4 (AS-C2-2) and in Table 4 (AS-C2-2) between the documentation items and the applicable SRs.

Table 3 AS-C2-1 SR Examples

SR Example	Discussion	Documentation Item
a	SR AS-B1 requires the identification of the mitigating systems impacted by the occurrence of the initiator and SR AS-A5 addresses the development of plant-specific accident sequences.	7
b	The system response success criteria are address by SR AS-A3 and the development of plant-specific accident sequences is addressed by SR AS-A5.	3, 4, 6

SR Example	Discussion	Documentation Item
c	The description of the accident sequence progression should include the model structure (SR AS-A5), graphical representation (SR AS-A1), sequence timing, dependencies (SR AS-A3 and A4), and functional and system success criteria (SR AS-A2 and A3).	1, 2, 3, 6
d	SR AS-A4 addresses the identification of operator actions to achieve the defined success criteria. The overall accident sequence process should include a description of this process to incorporate operation actions into the accident sequence analysis.	1, 5
e	The interface of the accident sequence models with plant damage states should be included in the description of the overall accident sequence process or could be addressed by the documentation supporting SR LE-A4.	1, 6
f	The manner in which sequences are modeled when using single top event fault trees should be addressed in the description of the overall accident sequence process.	1

Table 4 AS-C2-2 Documentation Mapping

Element	Type	Item	Documentation	Related SR	SR Examples
AS	Process	1	Document the approach used to model the appropriate combination of system responses and operator actions. Include the approach used to incorporate safety functions and success criteria and the selection of thermal-hydraulic analyses. This documentation should also include the rationale used for ordering events and, if applicable, event tree transfers, and the approach used for accident sequence end states.	A1, A2, A4, A6, A8, A9, A11	c, d, e, f
AS	SR	2	Provide graphical representation of the event tree structure or equivalent.	A1	c
AS	SR	3	List the key safety functions and their bases used in the analysis for each modeled initiating event (can be included as part of the success criteria documentation).	A2, A5	b, c
AS	SR	4	Document the minimum system requirements to support each safety function for each modeled initiating event and their bases (can be included as part of the success criteria documentation).	A3, A5	b
AS	SR	5	Document that sequence specific timing and dependencies for the operator actions included in the accident analysis for each modeled initiating event and their bases.	A4, A5	d
AS	SR	6	Document the accident sequence structure and its bases. Include explanation of all event tree transfers.	A5	b, c, e
AS	SR	7	Document initiating event impacts on mitigating systems and their bases.	B1, A5	a

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has "no objection" to this SR.

Index No. AS-C	Capability Category I	Capability Category II	Capability Category III
AS-C3	DOCUMENT the sources of model uncertainty and related assumptions (as identified in QU-E1 and QU-E2) associated with the accident sequence analysis.		

EXPLANATION OF REQUIREMENT

It is important to document the characterization the uncertainties with respect to plant risk. Guidance for characterizing uncertainties for the baseline PRA is included in NUREG-1855 “Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decision Making” and of EPRI-TR-1016737 “Treatment of Parameter and Modeling Uncertainty for Probabilistic Risk Assessments.” These companion documents are intended to provide a technical basis for the identification and characterization of uncertainty in the baseline risk assessment. Section 3 of EPRI-TR-1016737 provides guidance on characterizing uncertainties for the baseline PRA model. Note that the EPRI report is publicly available at no charge from EPRI.com. This report is believed to represent the best information source on the treatment of parameter and modeling uncertainty at the time of this writing. This report has not been endorsed by the ASME.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 Revision 1 has “no objection with clarification” to this SR. The clarification notes that “All the sources or uncertainty and assumptions that can impact the risk profile of the base PRA need to be documented” and refers to the definition of key source of uncertainty for definition of source of uncertainty. The current version of the standard addresses this concern.

5.3 Success Criteria Analysis Section 2-2.3 of the ASME/ANS RA-Sa-2009

The objectives of the success criteria element are to define the plant-specific measures of success and failure that support the other technical elements of the PRA in such a way that

(a) Overall success criteria are defined (i.e., core damage and large early release)

(b) Success criteria are defined for critical safety functions, supporting systems, structures, components and operator actions necessary to support accident sequence development

(c) The methods and approaches have a firm technical basis

(d) The resulting success criteria are referenced to the specific deterministic calculations.

To meet the above objectives, three HLRs are defined in the standard:

Designator	Requirement
HLR-SC-A	The overall success criteria for the PRA and the system, structure, component and human action success criteria used in the PRA shall be defined and referenced, and shall be consistent with the features, procedures and operating philosophy of the plant.
HLR-SC-B	The thermal/hydraulic, structural and other supporting engineering bases shall be capable of providing success criteria and event timing sufficient for quantification of CDF and LERF, determination of the relative impact of success criteria on SSC and human actions and the impact of uncertainty on this determination.
HLR-SC-C	Documentation of Success criteria shall be consistent with the applicable supporting requirements.

5.3.1 Supporting Requirements for HLR-SC-A

ASME/ANS Standard Section 2-2.3, Table 2-2.3-2(a), Supporting Requirements for HLR-SC-A

HLR-SC-A:	The overall success criteria for the PRA and the system, structure, component and human action success criteria used in the PRA shall be defined and referenced, and shall be consistent with the features, procedures and operating philosophy of the plant.
Intent:	Specify the requirements for Success Criteria
SRs:	SC-A1 through SC-A6

Index No. SC-A	**Capability Category I**	**Capability Category II**	**Capability Category III**
SC-A1	USE the definition of *core damage* provided in Section 2 of this Standard. If core damage has been defined differently thangin Section 2: *(a)* IDENTIFY any substantial differences from the Section 2 definition *(b)* PROVIDE the bases for the selected definition		

EXPLANATION OF REQUIREMENT

Since success criteria are the minimum requirements for each function (and ultimately, the systems used to perform the functions) to prevent core damage (or to mitigate a radioactive release to the atmosphere) a precise understanding of what core damage means is needed for developing the success criteria.

Surrogates are often used by PRA analysts to represent core damage such as:

- Collapse Water Level below top of active fuel or some distance above bottom of active fuel (e.g., 2' above BAF is used by NUREG/CR-4550)
- Peak Cladding Temperature >2200F

It is incumbent upon the analyst to demonstrate that a selected surrogate is consistent with the definition of core damage. Note that this SR is focused on the overall core damage success criteria and the complete core damage definition should be identified. The surrogates or parameters listed above are addressed by SR SC-A2.

If the definition of core damage used is dissimilar to that in Section 1 of the Standard, this SR necessitates a justification for the different definition. In particular, it is important to identify any substantial deviations from the Section 1 definition because the analyses and results of the PRA depend on the definition. A definition of core damage that is more conservative than another one will lead to more stringent success criteria. For example, mitigating an accident scenario may require 3 out of 3 pumps of a system to operate given one definition of core damage, while a more relaxed statement only may require 2 of the 3 to operate. In addition, it is necessary to provide the bases for selecting the definition to ensure that it is technically sound and appropriate. When the chosen definition diverges from that in Section 1 of the Standard, this SR can be satisfied by identifying clearly and explicitly any substantial differences between them, and documenting the technical bases for the definition chosen.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. SC-A	Capability Category I	Capability Category II	Capability Category III
SC-A2	SPECIFY the plant parameters (e.g., highest node temperature, core collapsed liquid level) and associated acceptance criteria (e.g., temperature limit) to be used in determining core damage. **Examples of measures for core damage suitable for Capability Category I are defined in NUREG/CR-4550 [NOTE (1)].**	SPECIFY the plant parameters (e.g., highest node temperature, core collapsed liquid level) and associated acceptance criteria (e.g., temperature limit) to be used in determining core damage. **SELECT these parameters such that the determination of core damage is as realistic as practical, consistent with current best practice. DEFINE computer code-predicted acceptance criteria with sufficient margin on the code-calculated values to allow for limitations of the code, sophistication of the models and uncertainties in the results, consistent with the requirements specified under HLR-SC-B.** **Examples of measures for core damage suitable for Capability Category II / III, that have been used in PRAs, include:** **(a) Collapsed liquid level less than 1/3 core height or code-predicted peak core temperature >2,500°F (BWR)** **(b) Collapsed liquid level below top of active fuel for a prolonged period, or code-predicted core peak node temperature >2,200°F using a code with detailed core modeling; or code-predicted core peak node temperature >1,800°F using a code with simplified (e.g., single-node core model, lumped parameter) core modeling; or code-predicted core exit temperature >1,200°F for 30 min using a code with simplified core modeling (PWR)**	

NOTE (1): NUREG/CR-4550, Vol. 1, Rev. 1, page 3-8, uses the following simplified definitions of core damage to avoid the need for "detailed thermal-hydraulic calculations beyond the scope and resources of the work." For BWRs, "the core is considered to be in a damaged state when the reactor water level is less than 2 ft above the bottom of the active fuel." For PWRs, "the core is considered to be in a damaged state once the top of the active fuel assemblies is uncovered."

Reference: NUREG/CR-4550, "Analysis of Core Damage Frequency, Internal Events Methodology," Sandia National Laboratories, January 1990.

EXPLANATION OF REQUIREMENT

The intent of this SR is to specify the plant parameters to use in determining core damage, and the associated acceptance criteria, and should be consistent with the definition provided in SR SC-A2. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This SR distinguishes between Capability Category I and Categories II and III, as follows:

For Capability Category I, this SR allows a simplified definition of core damage, similar to those given in NUREG/CR-4550.

For Capability Categories II and III, the parameters are selected such that the determination of core damage is as realistic as practical, consistent with current best practice. To achieve this goal, thermal-hydraulics analyses are carried out under realistic assumptions about plant performance. They usually are conducted using best-estimate computer codes able to evaluate phenomena related to core damage; examples are the latest versions of TRACE, MELCOR and RELAP.

Each computer code has some limitations on the thermal-hydraulics phenomena that are within its scope, and the level of detail of its models for each particular phenomenon may differ from simplified to advanced. Further, the code's results have epistemic uncertainty due to uncertainties in the parameters used as input in the calculations in the code's models, in the models themselves and in the completeness of the analyses. Hence, for Capability Categories II and III, computer code-predicted acceptance criteria are defined with sufficient margin on the code-calculated values to allow for the codes' limitations, the models' sophistication and uncertainties in the results. For example, if a code is known to have a simplified model of the core, such as a single-node core model, then this SR directs using a greater margin for the code-predicted acceptance criteria than if the code modeled the core in more detail. Additional margin means that the criteria are somewhat more conservative in order to compensate for the uncertainty. This SR necessitates consistency between the definition of acceptance criteria and the requirements specified under HLR-SC-B.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. SC-A	Capability Category I	Capability Category II	Capability Category III
SC-A3	SPECIFY success criteria for each of the key safety functions identified per SR AS-A2 for each modeled initiating event, [NOTE (2)]		

NOTE (2): Requirements for specification of success criteria appear under high level requirements for other elements as well, e.g., AS-A, SY-A. These requirements are intended to be complementary, not duplicative. For example, for accident sequences, supporting requirements AS-A2, SC-A4, (SC-A4a, if applicable), AS-A3, AS-A4 are intended to be used together to capture the specification of the set of systems and human actions necessary to meet the key safety function success criteria.

EXPLANATION OF REQUIREMENT

As Note 2 above points out, this requirement and requirements in the accident sequence analysis (AS) and the system analysis (SY) are complementary and need to be implemented that way. Using the key safety functions (as defined in Section 1, the minimum set of safety functions that must be maintained to prevent core damage and large early release) identified per SR AS-A2, the requirement here, SC-A3, specifies that the success criteria for these functions needed to prevent core damage are developed. They are developed by carrying out evaluations determining the required performance of these functions to prevent core damage (CD). For example, if a medium LOCA is considered, a key safety function is reactor inventory control and a supporting system function is coolant injection. To determine the key safety function's success criteria, it is necessary to find out the flow rate of injection that is needed to avoid CD. Once these criteria are established, the system, or combination of systems, that can be used to implement these functions are identified in AS-A3 and the associated human actions identified as per AS-A4. Success criteria at the system level are then specified in conjunction with the requirements of the system analysis, such as SY-A2, SY-A10, SY-A-13, SY-B7 and SY-B9. The success criteria at this level are established by conducting evaluations proving that the system, or combination of systems, satisfy the criteria of the key safety functions. The success criteria need to be established in terms of hardware requirements, as well as human actions. Ideally, the timing at which these functions must be performed also is determined.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. SC-A	Capability Category I	Capability Category II	Capability Category III
SC-A4	IDENTIFY mitigating systems that are shared between units and the manner in which the sharing is performed should both units experience a common initiating event (e.g., LOOP)		

EXPLANATION OF REQUIREMENT

This SR only applies to multi-unit sites. At sites with more than one unit, the units may be configured to share mitigating systems. Accordingly, some initiating events (IEs) may affect some or all units concurrently. A typical example of this type of IE is a weather-induced LOOP that causes a loss of AC power to all units at a site where units share the emergency onsite AC power, whose main components usually are the emergency diesel generators (EDGs). Some EDGs may be dedicated to a particular unit, and hence, would not be immediately available to the other, though they may become so after some operator actions.

The mitigating systems shared between units can be identified by enumerating those systems that could mitigate each common IE of each unit at a site, and then determining if two or more units can use each system, given each common IE. This assessment usually involves engineering analyses, and, possibly, detailed calculations verifying that a system or some of its components can be shared by two or more units given a common IE. For example, engineering analyses already may be available, e.g., in the current Final Safety Analysis Report (FSAR) of a unit, establishing that an EDG can supply power to some loads in two units. The manner in which units share a system, given each common IE, depends on the specific IE, the system, and the accident scenario. Further, the components of a shared system may be available immediately to a unit, or after some delay.

If a dual-unit LOOP occurs, for example, the success criteria for AC power for a specific unit would involve relevant information, such as the number of EDGs available to the unit, and the minimum number of EDGs necessary to support mitigating the accident scenario triggered by this IE. The criteria also would encompass the operator's action(s) required to make swing EDG(s) (if they exist at the site) available to the unit, and the timing at which the different EDGs would become available. Assuming that only one EDG is needed at a unit for mitigating a dual-unit LOOP, simplified success criteria could be expressed as "1 of 1 dedicated EDG immediately available, or (1 of 2 swing EDGs with associated operator action(s) after this action(s) is completed)."

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. SC-A	Capability Category I	Capability Category II	Capability Category III
SC-A5	SPECIFY an appropriate mission time for the modeled accident sequences. For sequences in which stable plant conditions have been achieved, USE a minimum mission time of 24 hr. Mission times for individual SSCs that function during the accident sequence may be less than 24 hr, as long as an appropriate set of SSCs and operator actions are modeled to support the full sequence mission time. For example, if following a LOCA, low pressure injection is available for 1 hour, after which recirculation is required, the mission time for LPSI may be 1 hour and the mission time for recirculation may be 23 hours. For sequences in which stable plant conditions would not be achieved by 24 hr using the modeled plant equipment and human actions, **ASSUME core damage.**	SPECIFY an appropriate mission time for the modeled accident sequences. For sequences in which stable plant conditions have been achieved, USE a minimum mission time of 24 hr. Mission times for individual SSCs that function during the accident sequence may be less than 24 hr, as long as an appropriate set of SSCs and operator actions are modeled to support the full sequence mission time. For example, if following a LOCA, low pressure injection is available for 1 hour, after which recirculation is required, the mission time for LPSI may be 1 hour and the mission time for recirculation may be 23 hours. For sequences in which stable plant conditions would not be achieved by 24 hr using the modeled plant equipment and human actions, **PERFORM additional evaluation or modeling by using an appropriate technique. Examples of appropriate techniques include:** **(a) Assigning an appropriate plant damage state for the sequence;** **(b) Extending the mission time, and adjusting the affected analyses, to the point at which conditions can be shown to reach acceptable values; or** **(c) Modeling additional system recovery or operator actions for the sequence, in accordance with requirements stated in the Systems Analysis and Human Reliability sections of this Standard, to demonstrate that a successful outcome is achieved.**	

EXPLANATION OF REQUIREMENT

This SR addresses mission time at the accident-sequence level. For sequences wherein stable plant conditions have been achieved, this SR establishes using a minimum mission time of 24 hr. Consistent with the discussion in SR AS-A8, sequences that are considered successful need to reach a steady state condition (i.e., stable plant condition) where core damage or the averted release is not anticipated for the conditions that are present at the end of the sequence. This steady state condition implies that the success criteria are satisfied and the accident is under control. It also assumes neither additional failures occur nor additional actions are needed within a reasonable time following the end of the sequence and that long-term actions that happen well beyond the end of the mission time, such as refilling water and fuel tanks, have been assessed as being able to be performed. A stable condition, following an initiating event, can be interpreted as a hot-shutdown or a stable long-term-cooling condition. Each SSC in a sequence can have its own mission time, as explained in this SR. The definition of mission time in Section 1 of the Standard corresponds to this SSC-level mission time. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This SR distinguishes between Capability Category I and Categories II and III for sequences in which stable plant conditions would not be reached in 24 hours using the modeled plant equipment and human actions.

For Capability Category I, this SR simply directs assuming core damage for sequences where a stable state has not been achieved in 24 hours.

For Capability Category II and III, this SR establishes undertaking further evaluation or modeling via an appropriate technique, examples of which are the following:

a) Assigning to the sequence an appropriate plant damage state (PDS) after 24 hours. For instance, a PDS could indicate that the RCS pressure or temperature is increasing, among other characteristics of the sequence.

b) Extending the mission time for some specific period beyond 24 hours, and adjusting the affected analyses, when engineering analyses can show that the plant can reach a stable condition for a particular sequence. All the analyses of the sequence would have to be modified, as needed, to be consistent with the new mission time.

c) Modeling additional system recovery or operator actions for the sequence, in accord with the requirements in the Standard's Systems Analysis and Human Reliability sections, to show that such additions lead to a stable plant condition within the 24-hour mission time. For instance, for a sequence with an IE of a loss of a cooling system, it may be possible to demonstrate that the plant can attain this condition via operator actions to recover this system.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. SC-A	Capability Category I	Capability Category II	Capability Category III
SC-A6	CONFIRM that the bases for the success criteria are consistent with the features, procedures and operating philosophy of the plant.		

EXPLANATION OF REQUIREMENT

As stated in high level requirement SC-A, success criteria not only addresses the overall success for the PRA, but also that for systems, structures, components and human actions. This SR establishes the validity of the success criteria for all its applications and requires it to be consistent with the features, procedures and operating philosophy of the plant. This requirement applies to the success criteria used to support the development of accident sequences as discussed in SR AS-A5, systems analysis (SR SY-A10, A11, B7, B9), human reliability analysis (SR HR-E2, F2), data analysis (SR DA-A2), large early release analysis (SR LE-C5) and internal flood analysis (SR IFEV-A2).

The plant-specific focus of this SR is important in that different utilities with very similar plants may take different approaches for operating a plant and responding to an initiating event. A utility, for instance, may have installed additional equipment to mitigate some specific events. A typical example is the installation of additional emergency diesel generators, to better cope with partial or total LOOP scenarios. Another example is two similarly designed plants but with different strategies for mitigating the same or a similar initiating event. For instance, after a steam generator tube rupture (SGTR), a utility may credit the affected generator for decay-heat removal, but another may not. This difference causes dissimilar conditions in the analyses of the response of each plant to an SGTR (such as the rate of cool down and/or depressurization of the RCS), leading to different success criteria. Accordingly, it is important to verify the consistency of the evaluations and analyses supporting the success criteria with the features, procedures and operating philosophy of the specific plant.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.3.2 Supporting Requirements for HLR-SC-B

ASME/ANS Standard Section 2.2.3, Table 2.2.3-2(b), Supporting Requirements for HLR-SC-B

HLR-SC-B:	The thermal/hydraulic, structural and other supporting engineering bases shall be capable of providing success criteria and event timing sufficient for quantification of CDF and LERF, determination of the relative impact of success criteria on SSC and human actions and the impact of uncertainty on this determination.
Intent:	Specify requirements for the analyses supporting the SC
SRs:	SC-B1 through SC-B5

Index No. SC-B	Capability Category I	Capability Category II	Capability Category III
SC-B1	USE appropriate **conservative**, generic analyses/evaluations that are applicable to the plant.	USE appropriate **realistic** generic analyses/evaluations that are applicable to the plant **for thermal/hydraulic, structural and other supporting engineering bases in support of success criteria requiring detailed computer modeling. Realistic models or analyses may be supplemented with plant-specific/generic FSAR or other conservative analysis applicable to the plant, but only if such supplemental analyses do not affect the determination of which combinations of systems and trains of systems are required to respond to an initiating event.**	**USE realistic plant-specific models for thermal/hydraulic, structural and other supporting engineering bases in support of success criteria requiring detailed computer modeling. DO NOT USE assumptions that could yield conservative or optimistic success criteria.**

EXPLANATION OF REQUIREMENT

This SR provides a graduated approach to the engineering analysis used to support the plant's success criteria. It allows the analyst to use conservative analysis, more realistic analysis or plant-specific analysis depending on the selected capability category. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

The type of analyses and/or evaluations used in determining the success criteria depend on the three different capabilities, as follows:

For Capability Category I, appropriate conservative, generic analyses and/or evaluations applicable to the plant are used. For example, the analyses from Chapters 6 or 15 of the Final Safety Analysis Report (FSAR) of a unit are generally conservative. Generic analyses and evaluations imply that they were developed for several plants with some common characteristics, but they should be applicable to the plant, for example an Owners Group generic study. It is generally expected that the generic analysis will be conservatively bounding, i.e. the plants within a generic study may have different water levels, inventories and setpoints but the generic analysis uses bounding variables for these types of inputs.

For Capability Category II, appropriate realistic generic analyses and/or evaluations are used that are applicable to the plant for thermal/hydraulic, structural and other supporting engineering bases in support of success criteria requiring detailed computer modeling. For example, realistic thermal-hydraulics evaluations for establishing the success criteria associated with core damage usually are conducted with computer codes, such as TRACE, MELCOR and RELAP. It should be noted that the input decks for these codes can be established in a conservative or realistic manner and that care is required to ensure that the limitations of the codes, and the assumptions and inputs as well, are understood (See SR AS-B4). This SR allows supplementing realistic models or analyses with plant-specific and/or generic FSARs or other conservative analyses as long as it does not affect the combinations of systems and trains of systems required to respond to an initiating event.

For Capability Category III, realistic plant-specific models for thermal/hydraulic, structural and other supporting engineering bases are used to support success criteria requiring detailed computer modeling. In this case, the analyses and/or evaluations are not only required to be realistic, but also to be specific to the plant studied. For this Capability Category, this SR prohibits assumptions that could bias the success criteria conservatively or optimistically. For example, assuming that a component will operate normally in conditions in which it was not tested could optimistically affect the success criteria.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. SC-B	Capability Category I	Capability Category II	Capability Category III
SC-B2	No restrictions regarding the use of expert judgment, but requirements in SC-C2 must be met.	**DO NOT USE expert judgment except in those situations in which there is lack of available information regarding the condition or response of a modeled SSC, or a lack of analytical methods upon which to base a prediction of SSC condition or response. USE the requirements in para. 1-4.3 when implementing an expert judgment process.**	

EXPLANATION OF REQUIREMENT

SR SC-B2 establishes using this judgment as a function of the Capability Categories. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

Expert judgment may be used as follows:

For Capability Category I, there are no restrictions on employing expert judgment, but the requirements in SR SC-C2 are to be met. SR SC-C2 necessitates documenting the processes entailed in developing overall PRA success criteria and the supporting engineering bases, including the inputs, methods and results. In particular, an example of SR SC-C2 states that this documentation typically includes, among other things, reporting the uses of expert judgment within the PRA, and rationale for such uses.

For Capability Categories II and III, expert judgment is only allowed when there is no information on the condition or response of a modeled SSC, or a lack of analytical methods from which to predict SSC condition or response. For example, one situation wherein information and analytical methods may be absent is the failure of Emergency Core Cooling Systems due to venting or containment failure in BWRs. Actually, NUREG/CR-4550, Vol. 2 studied this issue using expert judgment, and found that after failure of containment heat removal, pressure in the containment would rise and the containment would fail. Further, the operator intentionally may vent the containment to relieve pressure. In each case, as a result of failure or venting of the containment, many mechanical and electrical components would be subjected to temperature and moisture environments far worse than those for which they are designed, and would be expected to have a larger failure probability than under normal conditions.

When implementing an expert judgment process, this SR also calls for using the requirements in paragraph 1-4.3, "USE OF EXPERT JUDGMENT," of the Standard for Capability Categories II and III. That paragraph provides requirements for using expert judgment outside of the PRA analysis team to resolve a specific technical issue.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. SC-B	Capability Category I	Capability Category II	Capability Category III
SC-B3	When defining success criteria, USE thermal/hydraulic, structural or other analyses/evaluations appropriate to the event being analyzed, and accounting for a level of detail consistent with the initiating event grouping (HLR-IE-B) and accident sequence modeling (HLR-AS-A and HLR-AS-B).		

EXPLANATION OF REQUIREMENT

This SR necessitates that the thermal/hydraulic, structural or other analyses and/or evaluations used for establishing success criteria are appropriate for the specific event or scenario assessed. For example, in a large LOCA scenario, a relevant analysis may be determining the success criteria of a low-pressure system providing makeup to the reactor vessel; then, thermal/hydraulic analyses and/or evaluations are suitable. On the other hand, in a LOOP scenario, the success criteria of the EDGs or other emergency sources of AC power are established. In this case, electrical engineering analyses and/or evaluations are adequate. In addition, if starting some emergency sources requires manual actions with the consequent delay, then the success-criteria assessments consider these aspects to adequately model the scenario.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. SC-B	Capability Category I	Capability Category II	Capability Category III
SC-B4	USE analysis models and computer codes that have sufficient capability to model the conditions of interest in the determination of success criteria for CDF, and that provide results representative of the plant. A qualitative evaluation of a relevant application of codes, models or analyses that has been used for a similar class of plant (e.g., Owners Group generic studies) may be used. USE computer codes and models only within known limits of applicability.		

EXPLANATION OF REQUIREMENT

The response of a nuclear power plant during accident conditions can be complex. Accordingly, the models and the computer codes employed for analyzing and evaluating such response for each initiating event or for a particular accident sequence need enough capability to model the conditions of interest for establishing the success criteria. For example, after a large LOCA, there will be a very rapid depressurization and reduction of water inventory in the reactor vessel, and low-pressure-injection (LPI) systems are required to mitigate this accident. A thermal-hydraulic computer code capable of modeling these events is used for determining the success criteria of these systems.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. SC-B	Capability Category I	Capability Category II	Capability Category III
SC-B5	CHECK the reasonableness and acceptability of the results of the thermal/hydraulic, structural or other supporting engineering bases used to support the success criteria. Examples of methods to achieve this include: *(a)* Comparison with results of the same analyses performed for similar plants, accounting for differences in unique plant features *(b)* Comparison with results of similar analyses performed with other plant-specific codes *(c)* Check by other means appropriate to the particular analysis.		

EXPLANATION OF REQUIREMENT

SR SC-B5 cites examples of methods to verify the reasonableness and acceptability of the results. Examples (a) and (b) are self-explanatory. One approach of example (c), checking by other means appropriate to the particular analysis, would be using available plant-specific or generic operating-experience relevant to the scenario being evaluated and applicable to the plant being studied. For example, if there is plant-specific operating experience related to small LOCAs, then the analyses and findings from the supporting engineering bases can be compared with this experience to verify that they are consistent.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.3.3 Supporting Requirements for HLR-SC-C

ASME/ANS Standard Section 2.2.3, Table 2.2.3-2(c), Supporting Requirements for HLR-SC-C

HLR-SC-C:	Documentation of success criteria shall be documented consistent with the applicable supporting requirements.
Intent:	Documentation must exist for the success criteria
SRs:	SC-C1 through SC-C3

Index No. SC-C	Capability Category I	Capability Category II	Capability Category III
SC-C1	DOCUMENT the success criteria in a manner that facilitates PRA applications, upgrades and peer review.		

EXPLANATION OF REQUIREMENT

It is important that the documentation includes sufficient information about the approach used for the development of the success criteria, such that an analyst or peer reviewer who was not involved in the original process could come to similar conclusions regarding the validity of the results and the veracity of the success criteria to the as-built and as-operated plant. In this way an analyst would be able to understand the approach and would be able to support applications, upgrades and reviews of the PRA. Furthermore, the documentation is to be consistent with the applicable SRs as stated in High Level Requirement SC-C. Although examples are provided in SR SC-C2, these do not represent a complete list of all required documentation. To facilitate the development of a complete list, a documentation mapping is provided in the explanation to SR SC-C2 showing scope of documentation needed to achieve consistency with the applicable SRs.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. SC-C	Capability Category I	Capability Category II	Capability Category III
SC-C2	DOCUMENT the processes used to develop overall PRA success criteria and the supporting engineering bases, including the inputs, methods and results. For example, this documentation typically includes: *(a)* The definition of core damage used in the PRA including the bases for any selected parameter value used in the definition (e.g., peak cladding temperature or reactor vessel level) *(b)* Calculations (generic and plant-specific) or other references used to establish success criteria, and identification of cases for which they are used *(c)* Identification of computer codes or other methods used to establish plant-specific success criteria *(d)* A description of the limitations (e.g., potential conservatisms or limitations that could challenge the applicability of computer models in certain cases) of the calculations or codes *(e)* The uses of expert judgment within the PRA, and rationale for such uses *(f)* A summary of success criteria for the available mitigating systems and human actions for each accident initiating group modeled in the PRA *(g)* The basis for establishing the time available for human actions *(h)* Descriptions of processes used to define success criteria for grouped initiating events or accident sequences		

EXPLANATION OF REQUIREMENT

This SR addresses the process documentation used to implement the success criteria supporting requirements. It also provides examples of documentation associated with the success criteria development processes and examples of documentation associated with the parameters, constraints and results from implementing these processes. Table 5 (SC-C2-1) provides a discussion of these examples. It should be noted that the documentation examples do not represent the complete list of all required documentation, but a list of many of the documents that are typically included. To facilitate the development of a complete list, a documentation mapping is provided in Table 6 (SC-C2-2) showing the scope of documentation needed to achieve consistency with the applicable SRs. Table 6 (SC-C2-2) also identifies each documentation item as either "process" or "SR." A "process" documentation item primarily supports the process requirement which is the focus of this SR while an "SR" documentation item primarily supports documentation that is consistent with one or more supporting requirements as required by AS-C1. A mapping is also provided in Table 5 (SC-C2-1) between the examples and the documentation list shown in Table 6 (SC-C2-2) and in Table 6 (SC-C2-2) between the documentation items and the applicable SRs.

Table 5 SC-C2-1 SR Examples

SR Example	Discussion	Documentation Item
a	SR SC-A1 and A2 address the development of the core damage definition and its associated parameters.	1
b	The requirements for the development of the analysis and calculations could be considered to be addressed by all the supporting requirements.	1, 2, 3, 4, 5, 6, 7
c	The use of computer codes is addressed by SR SC-B4.	5
d	The documentation for the supporting analysis should address inputs, assumptions, applicability and limitations as addressed by SR SC-B4	5

SR Example	Discussion	Documentation Item
e	The use of expert judgment is address by SR SC-B2. To satisfy SR SC-C2, it is also necessary to document the rationale for such uses.	e
f	The summary of the success criteria may be addressed by the accident sequence analysis documentation. See SR AS-A3, A4 and A5 and accident sequence Documentation Items 4 and 5.	1
g	The basis for establishing the time available for human actions should be included as part of the overall success criteria documents and is required by SR SC-A6.	3
h	The success criteria for initiating events and accident sequences are addressed by SR SC-A3 and A6.	2

Table 6 SC-C2-2 Documentation Mapping

Element	Type	Item	Documentation	Related SR	SR Examples
SC	SR	1	Document core damage definition, associated plant parameters and bases.	A1, A2	a, b
SC	SR	2	Document success criteria and basis for key safety functions and accident sequences including consideration of all the initiating event groups included within the analysis.	A3, A6	b, f, h
SC	SR	3	Document success criteria and basis for systems, human actions and components.	A6	b, f, g
SC	SR	4	Document the definition of safe stable state including mission time and basis.	A5	b
SC	SR	5	Document supporting analysis used to establish success criteria. Include a description of the approach, codes used, inputs, assumptions and their applicability and limitations	A6, B1, B2, B3, B4	b, c, d
SC	SR	6	Document the use of expert judgment and the rationale for such use.	B2	b, e
SC	SR	7	Document supporting analysis reasonableness and acceptability checks	B5	b

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

EXPLANATION OF REQUIREMENT

Model uncertainty arises because uncertainty exists about which models appropriately represent the aspects of the plant being modeled. In addition, there may be no model representing a particular aspect of the plant. This adds to uncertainty about the PRA findings because it may be unclear whether the PRA fails to consider a potentially significant contributor. The uncertainty associated with the model and its constituent parts typically is dealt with by making assumptions. In general, model uncertainties are addressed by determining the sensitivity of the PRA results to different assumptions or models.

NUREG-1855 [NRC 2009] gives guidance for addressing sources of model uncertainty and related assumptions in the context of the requirements in the ASME/ANS PRA Standard, and is specifically focused on accomplishing SRs QU-E1, QU-E2, QU-E4 and LE-F3 that are related to model uncertainty. The EPRI report 1016737, "Treatment of Parameter and Model Uncertainty for Probabilistic Risk Assessments," [EPRI 2008] also addresses this uncertainty, and in particular, its Appendix B identifies several sources of this uncertainty to support meeting SR SC-C3.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.4 System Analysis Section 2-2.4 of the ASME/ANS RA-Sa-2009

The objectives of the systems analysis element are to identify and quantify the causes of failure for each plant system represented in the initiating event analysis and accident sequence analysis in such a way that

(a) System-level success criteria, mission times, time windows for operator actions and assumptions provide the basis for the system logic models as reflected in the model. A reasonably complete set of system failure and unavailability modes for each system is represented.

(b) Human errors and operator actions that could influence the system unavailability or the system's contribution to accident sequences are identified for development as part of the HRA element.

(c) Different initial system alignments are evaluated to the extent needed for CDF and LERF determination.

(d) Intersystem dependencies and intra-system dependencies including functional, human, phenomenological and

(e) Common cause failures that could influence system unavailability or the system's contribution to accident-sequence frequencies are identified and included in the system models.

To meet the above objectives, three HLRs are defined in the standard:

Designator	Requirement
HLR-SY-A	The systems analysis shall provide a reasonably complete treatment of the causes of system failure and unavailability modes represented in the initiating events analysis and sequence definition.
HLR-SY-B	The systems analysis shall provide a reasonably complete treatment of common cause failures and intersystem and intra-system dependencies.
HLR-SY-C	Documentation of the systems analysis shall be consistent with the applicable supporting requirements.

5.4.1 Supporting Requirements for HLR-SY-A

ASME/ANS Standard Section 2.2.4, Table 2.2.4-2(a), Supporting Requirements for HLR-SY-A

HLR-SY-A:	The systems analysis shall provide a reasonably complete treatment of the causes of system failure and unavailability modes represented in the initiating events analysis and sequence definition.
Intent:	To provide the system logic and basic events (e.g., for component failures, unavailabilities, etc.) that represent the defined functions and mission success criteria for the as-built/as-operated plant.
SRs:	SY-A1 through SY-A24

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A1	DEVELOP system models for those systems needed to provide or support the safety functions contained in the accident sequence analyses.		

EXPLANATION OF REQUIREMENT

This is a general requirement that requires that system models be identified and developed for the frontline mitigating systems identified in the event trees (accident sequence analysis) used to model potential accident sequences. The success criteria for each safety function modeled in the event trees is identified per SR SC-A3 and used to identify the frontline systems modeled in the event trees (see SR AS-A4). In addition, models for the support systems required by the frontline mitigating systems and support systems required by other support systems are also identified and developed. Examples of support systems are identified in SY-B9. System models are required to support the quantification of potential accident sequences. System models typically are represented in the form of fault trees. A fault tree is a deductive model that identifies the credible ways a system can fail to meet a specified success criteria. The process for performing fault tree analysis is documented in NUREG-0492, "Fault Tree Handbook," U.S. Nuclear Regulatory Commission, January 1981.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A2	COLLECT pertinent information to ensure that the systems analysis appropriately reflects the as-built and as-operated systems. Examples of such information include system P&IDs, one-line diagrams, instrumentation and control drawings, spatial layout drawings, system operating procedures, abnormal operating procedures, emergency procedures, success criteria calculations, the final or updated SAR, technical specifications, training information, system descriptions and related design documents, actual system operating experience and interviews with system engineers and operators.		

EXPLANATION OF REQUIREMENT

For the PRA to provide realistic results, the system models need to reflect the actual configuration and operation of the system. The system analyst identifies the sources of information available at the plant for each system. Typical plant information sources needed to construct a system model are listed in this SR. The system analyst is responsible for collecting the most recent and accurate information on a system and to verify that information per the requirements in SY-A4.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A3	REVIEW plant information sources to define or establish: *(a)* System components and boundaries *(b)* Dependencies on other systems *(c)* Instrumentation and control requirements *(d)* Testing and maintenance requirements and practices *(e)* Operating limitations such as those imposed by Technical Specifications *(f)* Component operability and design limits *(g)* Procedures for the operation of the system during normal and accident conditions *(h)* System configuration during normal and accident conditions		

EXPLANATION OF REQUIREMENT

The system information identified in SY-A2 is reviewed to establish operational parameters necessary to construct the system model. The list of items in the SR provides guidance to the system analyst to identify the important inputs necessary for a complete system model. More specific information needs will be identified in the course of complying with the SY SRs that address the requirements for developing a system model.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A4	**CONFIRM that the system analysis correctly reflects the as-built, as-operated plant through discussions with knowledgeable plant personnel (e.g., engineering, plant operations, etc.).**	**PERFORM plant walkdowns and interviews with knowledgeable plant personnel (e.g., engineering, plant operations, etc.) to confirm that the systems analysis correctly reflects the as-built, as-operated plant.**	

EXPLANATION OF REQUIREMENT

The process of collecting the required system information and using it to generate a system model that reflects how the system can fail to perform its function is referred to as system analysis. Thus, this SR requires the analyst to confirm that the information used to construct the system model and the interpretation of that information accurately reflects the actual system configuration and operation. In addition, the system model needs to reflect the correct information. The confirmation can include an independent review of the model by plant personnel most familiar with the system operation and an independent verification of the system configuration by the system analyst by performing a plant walkdown. A peer review process will further confirm that the system model reflects the as-built, as-operated plant. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

The capability categories are meant to reflect the different level of detail, plant-specificity and realism that can be reflected in the system model. This requirement can be performed to two different capabilities:

For Capability Category I, minimal assurance that a system reflects the as-built, as-operated plant is provided by a review of the system model by knowledgeable plant personnel.

For Capability Categories II and III, additional assurance that a system model reflects the as-built, as-operated plant is provided by verifying the system configuration and location reflected in drawings used in the model construction are accurate by performing walkdowns and interviews.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A5	INCLUDE the effects of both normal and alternate system alignments, to the extent needed for CDF and LERF determination.		

EXPLANATION OF REQUIREMENT

This requirement ensures that system model reflects the as-operated system. For systems that can be operated successfully in different alignments to mitigate an accident, their configurations and respective mission success definitions have been identified in the accident sequence and success criteria analyses. Consistent with SR SY-A1 and A7, system models for these different alignments are required. Alternate system alignments refer to a system alignment that is different from the normal system alignment for some reason but is still capable of meeting the accident mitigation success criteria. One example of an alternate system alignment involves a multi-train service water system that may be capable of removing heat from essential loads with fewer operating trains if non-essential loads are isolated. A related subject, variable success criteria (i.e., success criteria that change as a function of plant status), is addressed in SY-A10.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A6	In defining the system model boundary [see SY-A3], INCLUDE within the boundary the components required for system operation, and the components providing the interfaces with support systems required for actuation and operation of the system components.		

EXPLANATION OF REQUIREMENT

Many components in a system are required for the operation of a system to mitigate an initiating event (e.g., normally open or closed motor-operated valves and pumps). Other components in the system are not required for the system operation (e.g., normally open or closed manual valves). This SR ensures the system boundary defines only those components that are needed for successful operation of the system, and therefore, are to be included in the system model. Those components within the system that can adversely impact the system (e.g., by causing a flow diversion) are also included in the model per SY-A11 and SY-A13. In addition, interfaces with required support systems needed for the system to actuate and operate are included per SY-B9.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A7	DEVELOP detailed systems models, **unless (a) sufficient system-level data are available to quantify the system failure probability, or (b) system failure is dominated by operator actions, and omitting the model does not mask contributions to the results of support systems or other dependent-failure modes.** For case (a), USE a single data value only for systems with no equipment or human-action dependencies, and if data exist that sufficient represent the unreliability or unavailability of the system and account for plant-specific factors that could influence unreliability and unavailability. Examples of systems that have sometimes not been modeled in detail include the scram system, the power-conversion system, instrument air and the keep-fill systems. JUSTIFY the use of limited (i.e., reduced or single data value) modeling.		**DEVELOP detailed system models.**

EXPLANATION OF REQUIREMENT

For some systems, the system unavailability can be reflected in a data value obtained from historical data (e.g., the reactor protection system). For other systems, a simple model can be generated that reflects dominant failure modes and support systems (e.g., the power conversion system). For most systems included in a PRA, detailed system models that include all of the possible component and human failures, common cause failures, support system failures and test and maintenance outage contributions that would lead to failure of the system to meet its success criterion are required. In general, detailed models are required unless the system unavailability can be determined at the system or train level without evaluating the contribution of all individual components; this generally means that the excluded components are unique to that system (i.e., there are no dependencies with other modeled systems). In some cases, a detailed model may not be possible due to limitations in data (e.g., common cause failure probabilities for reactor protection system components may not be available). The analyst provides justification when single data values or simple system models are used. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

The capability categories are meant to reflect the different level of detail, plant-specificity and realism that can be reflected in the system model. This requirement can be performed to two different capabilities:

For Capability Categories I and II, simple system models for some systems can be used when available information indicates the importance of individual components do not have to be determined. Detailed system models that include all of the components in the system boundary will allow for identification of the importance of each component and its failure mode.

For Capability Category III, a detailed model is always constructed to identify the importance of individual components and operator actions.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	**Capability Category I**	**Capability Category II**	**Capability Category III**
SY-A8	ESTABLISH the boundaries of the components required for system operation. MATCH the definitions used to establish the component failure data. For example, a control circuit for a pump does not need to be included as a separate basic event (or events) in the system model if the pump failure data used in quantifying the system model include control circuit failures. MODEL as separate basic events of the model, those sub-components (e.g., a valve limit switch that is associated with a permissive signal for another component) that are shared by another component or affect another component, in order to account for the dependent failure mechanism.		

EXPLANATION OF REQUIREMENT

To ensure the system model includes all components necessary for the system operation, individual component boundaries are generally defined and applied consistently in all of the system models. The component boundary may include or not include sub-components (e.g., a motor-driven pump could include both the motor and the pump or each as separate components). The defined component boundaries need to match those used in the data analysis (see DA-A2) to ensure there is coherence between the boundaries of the components modeled in the system models and the failure data used to quantify the component failure events. For example, failure data for a diesel generator typically includes not only failures of the diesel generator itself, but also failures of the fuel oil system, air start system and output breaker. In addition, sub-components that are shared between multiple components are uniquely defined as separate sub-components in order to properly capture their dependencies in those systems (this is also addressed in the modularization example in SY-A9(e)).

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

<table>
<tr><th>Index No. SY-A</th><th>Capability Category I</th><th>Capability Category II</th><th>Capability Category III</th></tr>
<tr><td>SY-A9</td><td colspan="3">If a system model is developed in which a single failure of a super component (or module) is used to represent the collective impact of failures of several components PERFORM the modularization process in a manner that avoids grouping events with different recovery potential, events that are required by other systems or events that have probabilities that are dependent on the scenario. Examples of such events include:
(a) Hardware failures that are not recoverable versus actuation signals, which are recoverable;
(b) HE events that can have different probabilities dependent on the context of different accident sequences;
(c) Events that are mutually exclusive of other events not in the module;
(d) Events that occur in other fault trees (especially common-cause events);
(e) SSCs used by other systems.</td></tr>
</table>

EXPLANATION OF REQUIREMENT

This requirement ensures that development of a system model is done in a fashion such that correct quantification of the plant model can be performed. Simplification of a system model by modularization introduces the potential to adversely affect the quantification process if done incorrectly. Factors to consider in the modularization process are identified in this SR and can influence the potential to correctly model dependencies, recovery potential and sequence-dependent probabilities. Additionally, grouping of out-of-service unavailability events (addressed in SY-A19 and SY-A20) into modules can prevent the elimination of combination of events prohibited by technical specifications during the quantification process. Logic flags also cannot be consumed into modules since doing so would prevent their proper application in the quantification process (see QU-D3).

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A10	INCORPORATE the effect of variable success criteria (i.e., success criteria that change as a function of plant status) into the system modeling. Example causes of variable system success criteria are: *(a)* *Different accident scenarios.* Different success criteria are required for some systems to mitigate different accident scenarios (e.g., the number of pumps required to operate in some systems is dependent upon the modeled initiating event); *(b)* *Dependence on other components.* Success criteria for some systems are also dependent on the success of another component in the system (e.g., operation of additional pumps in some cooling water systems is required if non-critical loads are not isolated); *(c)* *Time dependence.* Success criteria for some systems are time-dependent (e.g., two pumps are required to provide the needed flow early following an accident initiator, but only one is required for mitigation later following the accident); *(d)* *Sharing of a system between units.* Success criteria may be affected when both units are challenged by the same initiating event (e.g., LOOP).		

EXPLANATION OF REQUIREMENT

The success criteria for a system can change for different types of accident sequences and as an accident sequence progresses requiring the generation of multiple models for one system. This SR identifies example causes of variable system success criteria that need to be considered. Systems that can have different success criteria are identified in the accident sequence analysis (e.g., per AS-A10 and AS-B2) and during the review of system information required by SY-A3. Either multiple models for these systems are required, or logic flags or dependencies on other components/events can be used in a single model to incorporate variable success criteria.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A11	INCLUDE in the system model those failures of the equipment and components that would affect system operability (as identified in the system success criteria), except when excluded using the criteria in SY-A15. This equipment includes both active components (e.g., pumps, valves and air compressors) and passive components (e.g., piping, heat exchangers and tanks) required for system operation.		

EXPLANATION OF REQUIREMENT

This is a general requirement that specifies that a system model include all component failures that would prevent the system from achieving the required success criteria. Additional SY requirements in SY-A13, SY-A14, SY-A18, SY-B1, SY-B9 and SY-B10 provide more detail on what failures to include and also provide criteria for screening out failures. Specific requirements pertaining to human errors that can affect the system operation are addressed separately in SY-A16 and SY-A17. Component and system unavailability due to test and maintenance are addressed in SY-A19 and SY-A20.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A12	DO NOT INCLUDE in a system model component failures that would be beneficial to system operation, unless omission would distort the results. Example of a beneficial failure: A failure of an instrument in such a fashion as to generate a required actuation signal.		

EXPLANATION OF REQUIREMENT

Some failures can actually result in a positive effect on the operation of a system to mitigate an accident. However, beneficial failures cannot be counted on to occur during an accident scenario and thus generally are not included in a system model. This is often referred to as the "no miracles rule." However, this SR allows credit for a beneficial failure if not crediting it would substantially alter the results of the quantitative evaluation of the plant model. Justification for crediting the beneficial failure would have to be documented.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	**Capability Category I**	**Capability Category II**	**Capability Category III**
SY-A13	INCLUDE those failures that can cause flow diversion pathways that result in failure to meet the system success criteria.		

EXPLANATION OF REQUIREMENT

Some component failures (e.g., pump test line valves failing to close or spuriously opening) in a system can result in diverting the flow within the system. Sufficient flow diversion could result in failure of the system to meet its success criteria. A general screening criteria is that any flow path (or combination of flow paths) equal to 10% of the delivery flow path area is considered as a potential diversion path. However, actual system flow information is preferentially used when available to determine the potential for diversion paths, particularly when the flow diversion approaches or exceeds the 10% screening value. Consistent with SY-A11, this SR ensures the system boundary includes those components that can adversely affect the successful operation/function of a system, through flow diversions.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

<table>
<tr><th>Index No. SY-A</th><th>Capability Category I</th><th>Capability Category II</th><th>Capability Category III</th></tr>
<tr><td>SY-A14</td><td colspan="3">When identifying the failures in SY-A11 INCLUDE consideration of all failure modes, consistent with available data and model level of detail, except where excluded using the criteria in SY-A15.
For example:
(a) Active component fails to start
(b) Active component fails to continue to run
(c) Failure of a closed component to open
(d) Failure of a closed component to remain closed
(e) Failure of an open component to close
(f) Failure of an open component to remain open
(g) Active component spurious operation
(h) Plugging of an active or passive component
(i) Leakage of an active or passive component
(j) Rupture of an active or passive component
(k) Internal leakage of a component
(l) Internal rupture of a component
(m) Failure to provide signal/operate (e.g., instrumentation)
(n) Spurious signal/operation
(o) Pre-initiator human failure events (see SY-A16)
(p) Other failures of a component to perform its required function.</td></tr>
</table>

EXPLANATION OF REQUIREMENT

Consistent with SY-A11, this SR ensures that a system model considers all failure modes for component failures and human errors that would prevent the system from achieving the required success criteria. The SR provides examples of typical component failure modes. Additional failure modes to consider are identified in other SRs and include post-initiator human errors (SY-A17), component and system unavailability due to test and maintenance (SY-A19 and SY-A20) and common cause failures (SY-B1). Which failure modes are included is a function of compliance with the screening out process addressed in SY-A15.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

<table>
<tr><th>Index No. SY-A</th><th>Capability Category I</th><th>Capability Category II</th><th>Capability Category III</th></tr>
<tr><td>SY-A15</td><td colspan="3">In meeting SY-A11 and SY-A14, contributors to system unavailability and unreliability (i.e., components and specific failure modes) may be excluded from the model if one of the following screening criteria is met:
(a) A component may be excluded from the system model if the total failure probability of the component failure modes resulting in the same effect on system operation is at least two orders of magnitude lower than the highest failure probability of the other components in the same system train that results in the same effect on system operation;
(b) One or more failure modes for a component may be excluded from the systems model if the contribution of them to the total failure rate or probability is less than 1% of the total failure rate or probability for that component, when their effects on system operation are the same.</td></tr>
</table>

EXPLANATION OF REQUIREMENT

This SR provides criteria for excluding components and component failure modes from a system model. Some components may be excluded from the model without affecting the system reliability evaluation if their failure probabilities are low compared to other components in the system. For example, pipe breaks and other external component leaks or ruptures are low probability events and thus can be excluded in most system models if their effect on the system operation is negligible (i.e., less than 1%) compared to active component failures. External system leakage can have the same effect as loss of flow in the system. Similarly, specific component failure modes can also be excluded if their probability of occurrence is less than 1% of other failure modes for the same component that results in the same effect on the system. Consider the example of a normally-closed motor-operated valve (MOV) that must be open for system operation. A spurious closure of the MOV once it opens has the same effect on a system as failure of the MOV to open in the first place. However, the probability of a random spurious closure of an MOV is less than 1% of the failure probability for an MOV failing to open. However, if the MOV is normally open, then spurious closure of the MOV should be included in the model.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A16	In the system model, INCLUDE HFEs that cause the system or component to be unavailable when demanded. These events are referred to as pre-initiator human events. (See also Human Reliability Analysis, para. 2.2.5.)		In the systems analysis, INCLUDE HFEs that cause the system or component to be unavailable when demanded. These events are referred to as pre-initiator human events. **To avoid double counting, CHECK that the data within the equipment-failure data base that are used for the equipment failure rates do not include events that are captured in the pre-initiator-HEP calculation**. (See also Human Reliability Analysis, para. 2.2.5.)

EXPLANATION OF REQUIREMENT

Consistent with SY-A14 and the general requirement to include all failure modes that would prevent a system from meeting its required success criteria, pre-initiator human failure events (HFEs) are typically included in a system model. The pre-accident human errors are included in the system model unless they are screened per the requirements in HR-B1. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

The capability categories are meant to reflect the different level of detail, plant-specificity and realism that can be reflected in the system model. This requirement can be performed to two different capabilities:

For Capability Categories I and II, unscreened pre-initiator HFEs are explicitly included in the system model.

For Capability Category III, an additional effort is required to verify that component failure data do not include incidents of the type of events being modeled in the pre-accident HFEs. If the data reflect pre-initiator HFEs, the analyst has options in modeling to avoid double-counting.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A17	In the system model, INCLUDE HFEs that are expected during the operation of the system or component or that are accounted for in the final quantification of accident sequences unless they are already included explicitly as events in the accident sequence models. These HFEs are referred to as post-initiator human actions. [See also Human Reliability Analysis (para. 2.2.5) and Accident Sequence Analysis (para. 2.2.2)].		

EXPLANATION OF REQUIREMENT

Human failure events (HFEs) related to initiation or shutdown of systems or components can be modeled either in accident sequence or system models. The necessary operator actions are identified per AS-A4 and HR-E2. This SR ensures that the identified HFEs be included in the appropriate accident sequence or system model.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

<table>
<tr><th>Index No.
SY-A</th><th>Capability Category I</th><th>Capability Category II</th><th>Capability Category III</th></tr>
<tr><td>SY-A18</td><td colspan="3">INCLUDE in either the system model or accident sequence modeling those conditions that cause the system to isolate or trip, or those conditions that once exceeded cause the system to fail, or SHOW that their exclusion does not impact the results.
For example, conditions that isolate or trip a system include:
(a) System-related parameters such as a high temperature within the system
(b) External parameters used to protect the system from other failures [e.g., the high reactor pressure vessel (RPV) water level isolation signal used to prevent water intrusion into the turbines of the RCIC and HPCI pumps of a BWR]
(c) Adverse environmental conditions (see SY-A22).</td></tr>
</table>

EXPLANATION OF REQUIREMENT

Degraded component operation, external signals or adverse environmental conditions can result in protective signals that can trip or isolate a mitigating system. Examples of adverse conditions that can isolate or trip are listed in this SR. Other adverse conditions that can fail a system, but not result in tripping the system are addressed in SY-A21. This SR ensures that failure of support systems or other conditions that can lead to these protective signals be included in either the accident sequence development or the system models. These failures can be excluded from the system model if it can be shown that they do not impact the system unreliability or unavailability. The criteria in SY-A15 can be used to help make this decision.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

<table>
<tr><th>Index No. SY-A</th><th>Capability Category I</th><th>Capability Category II</th><th>Capability Category III</th></tr>
<tr><td>SY-A19</td><td colspan="3">In the systems model, INCLUDE out-of-service unavailability for components in the system model, unless screened, consistent with the actual practices and history of the plant for removing equipment from service.

INCLUDE:
(a) Unavailability caused by testing when a component or system train is reconfigured from its required accident mitigating position such that the component cannot function as required;
(b) Maintenance events at the train level when procedures require isolating the entire train for maintenance;
(c) Maintenance events at a sub-train level (i.e., between tagout boundaries, such as a functional equipment group) when directed by procedures.

Examples of out-of-service unavailability to be modeled:
(a) Train outages during a work window for preventive/corrective maintenance;
(b) A functional equipment group (FEG) removed from service for preventive/corrective maintenance;
(c) A relief valve taken out of service.</td></tr>
</table>

EXPLANATION OF REQUIREMENT

The unavailability of components, system trains or whole systems can occur due to either planned or unplanned test or maintenance. This SR ensures that test and maintenance unavailability is included in the system models when such unavailability results in the component, train or system being unable to perform its function. This is determined by the review of testing and maintenance requirements and practices specified in SY-A3. Out-of-service unavailability events for components can be subjected to the screening out criteria in SY-A15.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A20	INCLUDE events representing the simultaneous unavailability of redundant equipment when this is a result of planned activity (see DA-C14).		

EXPLANATION OF REQUIREMENT

Simultaneous unavailability of redundant trains (both within and between systems) may occur but generally are excluded in a system model unless actual experience shows that such events have occurred. Generally, common maintenance outages of multiple trains within a system do not occur due to Technical Specification constraints, but such occurrences can happen for unforeseen circumstances. Simultaneous maintenance of trains in different systems can occur particularly as part of planned maintenance schedules. Requirements for examining and quantifying these simultaneous maintenance events based on actual plant experience are provided in DA-C14. This SR ensures that the identified events are included in the affected system models using the same basic event name. Simultaneous outage events are given a unique event name that is different than the outage event name used for each train.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A21	IDENTIFY system conditions that cause a loss of desired system function, e.g., excessive heat loads, excessive electrical loads, excessive humidity, etc.		

EXPLANATION OF REQUIREMENT

As discussed in SR SY-A18, adverse environmental conditions can result in protective signals that can trip or isolate a system. In addition, adverse environmental conditions can lead directly to component or system failure. This SR ensures that adverse environmental conditions that can lead to component or system failure are identified. SY-A18 requires that the identified conditions be included in the system model.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A22	DO NOT TAKE CREDIT for system or component operability when the potential exists for rated or design capabilities to be exceeded.	TAKE CREDIT for system or component operability only if an analysis exists to demonstrate that rated or design capabilities are not exceeded.	**TAKE CREDIT for system or component operability, including credit for beyond design or rated capabilities, if supported by an appropriate combination of:** **(a) Test or operational data** **(b) Engineering analysis** **(c) Expert judgment.**

EXPLANATION OF REQUIREMENT

Some components or systems cannot operate beyond their design basis. The analyst identifies the basis for taking credit for operability of a system or component if the design basis is exceeded. Related to this SR is SY-B14, which requires identification of multiple structures, systems or components (SSCs) that may be required to operate in conditions beyond their environmental qualifications. It is possible to assess if the design basis conditions are exceeded for each accident sequence and use logic flags to fail the component or system when appropriate. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

The capability categories are meant to reflect the different level of detail, plant-specificity and realism that can be reflected in the system model. This requirement can be performed to three different capabilities:

For Capability Category I, credit for the operability of a system or component is not allowed when there is a potential that the rated or design capabilities would be exceeded. Capability Category I is assigned when the analyst chooses not to perform an analysis to demonstrate that the design capabilities will not be exceeded.

For Capability Category II, limits credit for operability to when the design capabilities would not be exceeded. An engineering analysis is required to verify that the design basis conditions are not reached.

For Capability Category III, allows credit for operation beyond design basis conditions but requires analysis to verify that the component or system can actually operate under those conditions. Depending upon the circumstances, any of the three methods or combination of the three methods identified in the SR may be required as a means for justifying operation beyond the design basis. If the system or component cannot operate under beyond-design-basis conditions, more rigorous analysis is required to verify that the design basis conditions are not reached.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A23	DEVELOP system model nomenclature in a consistent manner to allow model manipulation and to represent the same designator when a component failure mode is used in multiple systems or trains.		

EXPLANATION OF REQUIREMENT

Use of a consistent naming scheme is required to correctly quantify the system models and the accident sequences, e.g., ensure independent events have different basic event identifiers. The naming scheme also allows for ease in reviewing, understanding and interpreting the quantification results of the PRA. This SR requires that a consistent event naming scheme be developed and implies that it be used in generating the system models.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-A	Capability Category I	Capability Category II	Capability Category III
SY-A24	DO NOT MODEL the repair of hardware faults, unless the probability of repair is justified through an adequate analysis or examination of data. (See DA-C15.)		

EXPLANATION OF REQUIREMENT

System models generally do not credit repair of component failures since repair times can vary substantially depending on the actual component failure and generally can take longer than the mission time for the accident sequence. The availability of spare parts is another issue. This SR ensures that any credit for hardware repair is justified. Data analysis is often used to credit recovery of off-site power and diesel generators.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has an objection, in the form of a clarification, to the requirement. The staff has proposed the following clarification to resolve its objection:

> …is justified through an adequate analysis or examination of data **collected in accordance with DA-C15 and estimated in accordance with DA-D9**.

5.4.2 Supporting Requirements for HLR-SY-B

ASME/ANS Standard Section 2.2.4, Table 2.2.4-2(b), Supporting Requirements for HLR-SY-B

HLR-SY-B:	The systems analysis shall provide a reasonably complete treatment of common cause failures and intersystem and intra-system dependencies.
Intent:	To ensure correct identification of important support systems and components that can be masked if dependencies treatment is not thorough.
SRs:	SY-B1 through SY-B15

Index No. SY-B	Capability Category I	Capability Category II	Capability Category III
SY-B1	MODEL intra-system common-cause failures when supported by generic or plant-specific data (an acceptable model is the screening approach of NUREG/CR-5485 [Note (1)], which is consistent with DA-D5) or **SHOW that they do not impact the results**.	MODEL intra-system common-cause failures when supported by generic or plant-specific data**. An acceptable method is represented in NUREG/CR-5485 [Note (1)].**	

NOTE (1): NUREG/CR-5485, Guidelines on Modeling Common-Cause Failures in Probabilistic Risk Assessment, November 20, 1998

EXPLANATION OF REQUIREMENT

A common cause failure is a failure of two or more components of the same type during a short period of time that results from a single shared cause (e.g., common manufacturing error, maintenance error or service condition). Typically, intra-system common cause failures (i.e., within a system) are modeled in a PRA. Per this SR, intra-system common cause failures are to be included in a system model when supported by either generic or plant-specific data. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

The capability categories are meant to reflect the different level of detail, plant-specificity and realism that can be reflected in the system model. This requirement can be performed to two different capabilities:

For Capability Category I, intra-system common cause failures that are supported by either generic or plant-specific data are included in the model unless it can be shown that they do not impact the results of the PRA.

For Capability Categories II and III, intra-system common cause failures that are supported by either generic or plant-specific data are included in the model regardless of their importance to the results.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-B	Capability Category I	Capability Category II	Capability Category III
SY-B2	No requirement to model inter-system common cause failures.		MODEL inter-system common cause failures (i.e., across systems performing the same function) when supported by generic or plant-specific data, or SHOW that they do not impact the results.

EXPLANATION OF REQUIREMENT

Common cause failures of similar components across multiple systems (i.e., inter-system) performing the same function can also occur (i.e., in addition to intra-system common cause failures). Typically, these types of common cause failures have not been modeled in PRAs. This SR addresses the requirements for when to model inter-system common cause failures.

Capability Category Differentiation

The capability categories are meant to reflect the different level of detail, plant-specificity and realism that can be reflected in the system model. This requirement can be performed to two different capabilities:

For Capability Categories I and II, inter-system common cause failures do not have to be included in the system models.

For Capability Category III, a higher level of realism and detail is expected and inter-system common cause failures are to be included in the system models if such failures are supported by generic or plant-specific data, unless it can be shown that they do not impact the results of the PRA.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-B	Capability Category I	Capability Category II	Capability Category III
SY-B3	ESTABLISH common cause failure groups by using a logical, systematic process that considers similarity in: *(a)* Service conditions *(b)* Environment *(c)* Design or manufacturer *(d)* Maintenance JUSTIFY the basis for selecting common cause component groups. **Candidates for common-cause failures include, for example:** ***(a)* Motor-operated valves** ***(b)* Pumps** ***(c)* Safety-relief valves** ***(d)* Air-operated valves** ***(e)* Solenoid-operated valves** ***(f)* Check valves** ***(g)* Diesel generators** ***(h)* Batteries** ***(i)* Inverters and battery charger** ***(j)* Circuit breakers**		

EXPLANATION OF REQUIREMENT

Common cause failures are generally identified at the component level as indicated by the examples given in this SR. However, not all components in a system (or between systems) may be subject to common cause failure mechanisms due to differences in locations, manufacture, size or other factors. This SR ensures that the system and data analysts establish a logical, systematic structure for identifying common cause failure groups. Some examples of component characteristics are listed. Additional component characteristics are identified in NUREG/CR-5485, "Guidelines on Modeling Common-Cause Failures in Probabilistic Risk Assessment," U.S. Nuclear Regulatory Commission, November 1998.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-B	Capability Category I	Capability Category II	Capability Category III
SY-B4	INCORPORATE common cause failures into the system model consistent with the common cause model used for data analysis. (See DA-D6.)		

EXPLANATION OF REQUIREMENT

There are different models for estimating common cause failures (see SR DA-D5). Each of these models results in a different method for representing the common cause failure events in the system model. Typically, a conditional common cause failure probability is multiplied by the random component failure probability. To get the correct minimal common cause cut-sets when solving a system model, the common cause events are properly located at the same location as the random failure of the corresponding components. Furthermore, consistency with the component boundaries and failure modes (e.g., fail to start versus fail to run) used for evaluating both the random and common cause failures is required. This SR ensures that the identified common cause events are included in the system models in a fashion that is consistent with the common cause model used to obtain the failure probability.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

<table>
<tr><th>Index No. SY-B</th><th>Capability Category I</th><th>Capability Category II</th><th>Capability Category III</th></tr>
<tr><td>SY-B5</td><td colspan="3">ACCOUNT explicitly for the modeled system’s dependency on support systems or interfacing systems in the modeling process. This may be accomplished in one of the following ways:
(a) for the fault tree linking approach by modeling the dependencies as a link to an appropriate event or gate in the support system fault tree;
(b) for the linked event tree approach, by using event tree logic rules, or calculating a probability for each split fraction conditional on the scenario definition.</td></tr>
</table>

EXPLANATION OF REQUIREMENT

Frontline mitigating systems that are identified in the accident sequence analysis generally require the operation of support systems to provide essential functions, such as motive and control power, and cooling needed for component operation. In addition, the operation of support systems can also be dependent upon other support systems. Although most support systems are identified by the processes required in SY-A2 and SY-A3, some required support systems may be identified through the processes required in SY-A18 and SY-A21. This SR ensures that the system and accident sequence models include those dependencies (the action verb ACCOUNT in this SR means INCLUDE). The two approaches provided address how this is typically done in the fault tree linking and linked event tree models used to meet AS-A1 and QU-A1 for accident sequence delineation and quantification.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-B	Capability Category I	Capability Category II	Capability Category III
SY-B6	PERFORM engineering analyses to determine the need for support systems that are plant-specific and reflect the variability in the conditions present during the postulated accidents for which the system is required to function.		

EXPLANATION OF REQUIREMENT

The need for operation of a support system can be influenced by several factors including the mission time for the operation of the system(s) for which the support system is required, and the conditions (e.g., environmental, process) that would exist for different accident sequences. Consistent with the requirements in HLR SC-B, this SR requires performance of appropriate engineering analyses (e.g., thermal-hydraulic calculations) to establish the need for support systems for the different conditions represented in the accident sequences and their associated success criteria. The engineering analysis can also determine if and when adverse conditions would be reached that isolate or trip the system (see SY-A18) or result in conditions that fail the system (see SY-A21) and if the availability of support system inventories is adequate for the system mission time (per SY-B11).

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-B	Capability Category I	Capability Category II	Capability Category III
SY-B7	BASE support system modeling on the use of **conservative success criteria and timing.**	BASE support system modeling on **realistic success criteria and timing, unless a conservative approach can be justified, i.e. if their use does not impact risk significant contributors.**	BASE support system modeling on **realistic plant-specific success criteria and timing.**

EXPLANATION OF REQUIREMENT

Consistent with SC-B1, this SR combined with SY-B6 requires performance of either conservative or realistic engineering analysis (e.g., thermal-hydraulic calculations) to establish the success criteria for support systems for the different conditions represented in the accident sequences. Although timing is explicitly mentioned in the SR, other sequence-related conditions such as environmental conditions (e.g., temperature) or system loading (either electrical or cooling) may be important. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

The capability categories are meant to reflect the different level of detail, plant-specificity, and realism that can be reflected in the system model. This requirement can be performed to three different capabilities:

For Capability Category I, conservative assessments of support system success criteria are sufficient.

For Capability Category II, a realistic evaluation of success criteria is required for risk significant support systems. A conservative assessment is allowed for non-risk significant contributors.

For Capability Category III, a realistic evaluation of success criteria is required for all support systems.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-B	Capability Category I	Capability Category II	Capability Category III
SY-B8	IDENTIFY spatial and environmental hazards that may impact multiple systems or redundant components in the same system, and ACCOUNT for them in the system fault tree or the accident sequence evaluation. Example: Use results of plant walkdowns as a source of information regarding spatial/environmental hazards, for resolution of spatial/environmental issues, or evaluation of the impacts of such hazards.		

EXPLANATION OF REQUIREMENT

Spatial and environmental adverse conditions such as high humidity and temperatures that occur as a result of other component failures or the internal event accident progression can result in failure of multiple components in one or more systems. The impacts of these adverse conditions need to be included in the accident sequence or system models. The impact from specific hazard groups such as internal flooding, earthquakes and fires are handled separately in the modeling of those hazards. This SR, in conjunction with SY-A21, ensures that adverse conditions evolving over the course of an internal events initiator are identified that can cause dependent failure of components and are included in the PRA models, either in the system fault tree or the accident sequence logic (the action verb ACCOUNT means INCLUDE in this SR). Several other SRs also address adverse conditions. Per SY-A18, adverse environmental conditions that can result in tripping or isolating a system are to be included in the accident sequence or system model. AS-B3 addresses phenomenological conditions created by accident progression. LE-C6 requires development of system models used in the LERF assessment in a manner consistent with the requirements for modeling systems required to prevent core damage.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-B	Capability Category I	Capability Category II	Capability Category III
SY-B9	When modeling a system, INCLUDE appropriate interfaces with the support systems required for successful operation of the system for a required mission time (see also SY-A6). Examples of support systems include: *(a)* Actuation logic *(b)* Support systems required for control of components *(c)* Component motive power *(d)* Cooling of components *(e)* Any other identified support function (e.g., heat tracing) necessary to meet the success criteria and associated systems.		

EXPLANATION OF REQUIREMENT

Frontline mitigating systems that are identified in the accident sequence analysis generally require the operation of support systems that provide essential functions, such as motive and control power, and cooling needed for component operation. In addition, the operation of support systems can also be dependent upon other support systems. Consistent with SY-A11, this SR ensures that the system and accident sequence models include those dependencies. Typical types of support systems to consider are provided in the SR.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-B	Capability Category I	Capability Category II	Capability Category III
SY-B10	**IDENTIFY** those systems that are required for initiation and actuation of a system. **MODEL them unless a justification is provided. (e.g., the initiation and actuation system can be argued to be highly reliable and is only used for that system, so that there are no inter-system dependencies arising from failure of the system).** In the model quantification, INCLUDE the presence of the conditions needed for automatic actuation (e.g., low vessel water level). INCLUDE permissive and lockout signals that are required to complete actuation logic.	**MODEL** those systems that are required for initiation and actuation of a system. In the model quantification, INCLUDE the presence of the conditions needed for automatic actuation (e.g., low vessel water level). INCLUDE permissive and lockout signals that are required to complete actuation logic.	

EXPLANATION OF REQUIREMENT

One of the support systems identified in SY-B9 for possible inclusion in a system model is automatic actuation logic. Typically, safety systems have automatic actuation logic. The actuation logic is generally highly redundant such that it can involve multiple divisions and use multiple parameters for actuation. This redundancy ensures a high probability that the system responds when necessary and does not cause spurious actuation. In some cases, permissive signals are required to complete the actuation logic and lockout signals are used to help prevent spurious actuation (e.g., during maintenance activities). Failure of actuation logic can potentially result in failure of multiple components, trains or systems to automatically actuate. For some accident scenarios, all of the conditions for actuating the system may not be present and thus the reliability of the actuation logic could be reduced. Consistent with SY-A11, this SR ensures the modeling of actuation logic is included in a system model where appropriate, including any permissive and lockout signals. In the quantification process, the availability of the conditions leading to actuation is accounted for (e.g., by using logic flags that sets the part of the logic that is not met in an accident sequence to FALSE). Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

The capability categories are meant to reflect the different level of detail, plant-specificity and realism that can be reflected in the system model. This requirement can be performed to two different capabilities:

For Capability Category I, the systems required for actuating modeled systems are identified. The identified actuation logic does not have to be modeled if it can be shown that the logic is unique to one system and is highly reliable.

For Capability Categories II and III, actuation logic is to always be modeled regardless of the number of systems that are dependent on the logic.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-B	Capability Category I	Capability Category II	Capability Category III
SY-B11	MODEL the ability of the available inventories of air, power and cooling to support the mission time.		

EXPLANATION OF REQUIREMENT

An additional factor to consider when including support system dependencies in the accident sequence or system models is the adequacy of limited inventories to provide the necessary functions until a safe stable condition is reached. Some examples include battery life during a station blackout, air accumulator inventory when instrument air or nitrogen systems are lost and cooling when the ultimate heat sink is lost. Per SY-B6, engineering analyses are performed to ascertain if and when the inventories become inadequate. This SR requires that the results be incorporated into the accident sequence or system models.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-B	Capability Category I	Capability Category II	Capability Category III
SY-B12	DO NOT USE proceduralized recovery actions as the sole basis for eliminating a support system from the model; however, INCLUDE these recovery actions in the model quantification. For example, it is not acceptable to not model a system such as HVAC or CCW on the basis that there are procedures for dealing with losses of these systems.		

EXPLANATION OF REQUIREMENT

It is typical at most plants to have abnormal procedures that provide recovery actions for situations when a system fails. In most situations, these recovery actions are not included as part of the system model, but are included in the accident sequence quantification process (see QU-A5). The requirements for modeling recovery actions are provided in HLR-HR-H. This SR explicitly specifies that while there are procedures for dealing with the failure of the support system, it does not imply that the support system is not required to be modeled to support other components or system operation. A method for modeling these systems and recovery actions is to include support system models in the PRA and to include non-recovery probabilities in the accident sequence quantification process.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-B	Capability Category I	Capability Category II	Capability Category III
SY-B13	Some systems use components and equipment that are required for operation of other systems. INCLUDE components that, using the criteria in SY-A14, may be screened from each system model individually, if their failure affects more than one system (e.g., a common suction pipe feeding two separate systems).		

EXPLANATION OF REQUIREMENT

This SR ensures that components shared by multiple systems are included in those system models. A review of the components screened out from individual system models using the criteria in SY-A14 need to be performed to ascertain if any screened components are used by multiple systems. Shared components are not screened and are included in the multiple system models.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-B	Capability Category I	Capability Category II	Capability Category III
SY-B14	IDENTIFY SSCs that may be required to operate in conditions beyond their environmental qualifications. INCLUDE dependent failures of multiple SSCs that result from operation in these adverse conditions. Examples of degraded environments include: *(a)* LOCA inside containment with failure of containment heat removal *(b)* Safety relief valve operability (small LOCA, drywell spray, severe accident) (for BWRs) *(c)* Steam line breaks outside containment *(d)* Debris that could plug screens/filters (both internal and external to the plant) *(e)* Heating of the water supply (e.g., BWR suppression pool, PWR containment sump) that could affect pump operability *(f)* Loss of NPSH for pumps *(g)* Steam binding of pumps.		

EXPLANATION OF REQUIREMENT

Some components or systems cannot operate beyond their design basis. This requirement ensures the identification of structures, systems or components (SSCs) that may be subject to beyond-design-basis conditions during an accident sequence. As specified in SY-A22, an assessment is required to determine when individual components or systems may be subjected to beyond-design-basis conditions. This SR requires that the SSCs be considered (modeled) as failed if this is the result of the analysis. It is possible that the design-basis conditions will not be exceeded for each accident sequence where the SSCs are required. For such situations, logic flags can be used to fail the multiple SSCs when appropriate.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has an objection, in the form of a clarification, to the requirement. The staff has proposed the following clarification to resolve its objection:

> Under “Examples of degraded environments include:” add the following example:
>
> (h) Harsh environments induced by containment venting or failure that may occur prior to the onset of core damage.

Index No. SY-B	Capability Category I	Capability Category II	Capability Category III
SY-B15	INCLUDE operator interface dependencies across systems or trains, where applicable.		

EXPLANATION OF REQUIREMENT

Per SY-A16 and SY-A17, both pre-initiator and post-initiator human failure events (HFEs) are included in individual system models. This SR ensures that when these HFEs can impact multiple systems, the HFEs be included in each of the system models. If the identified HFEs are not completely dependent, the amount of dependency is addressed in the quantification of the associated human error probabilities (HEPs) (see HR-D5 and HR-G7).

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

5.4.3 Supporting Requirements for HLR-SY-C

ASME/ANS Standard Section 2.2.4, Table 2.2.4-2(c), Supporting Requirements for HLR-SY-C

HLR-SY-C:	Documentation of the systems analysis shall be consistent with the applicable supporting requirements.
Intent:	To provide documentation that supports review and update of the system models consistent with the requirements.
SRs:	SY-C1 through SY-C3

Index No. SY-C	Capability Category I	Capability Category II	Capability Category III
SY-C1	DOCUMENT the systems analysis in a manner that facilitates PRA applications, upgrades and peer review.		

EXPLANATION OF REQUIREMENT

It is important that the documentation includes sufficient information about the approach used for the development of the system analysis, such that an analyst or peer reviewer who was not involved in the original process could come to similar conclusions regarding the validity of the results and the veracity of the system analysis to the as-built and as-operated plant. In this way an analyst would be able to understand the approach and would be able to support applications, upgrades and reviews of the PRA. Furthermore, the documentation is to be consistent with the applicable SRs as stated in High Level Requirement SY-C. Although examples are provided in SR SY-C2, these do not represent a complete list of all required documentation. To facilitate the development of such a list, a documentation mapping is provided in the explanation to SR SY-C2 showing the scope of documentation needed to achieve consistency with the applicable SRs.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

<table>
<tr><th>Index No.
SY-C</th><th>Capability Category I</th><th>Capability Category II</th><th>Capability Category III</th></tr>
<tr><td>SY-C2</td><td colspan="3">DOCUMENT the system functions and boundary, the associated success criteria, the modeled components and failure modes including human actions and a description of modeled dependencies including support system and common cause failures, including the inputs, methods and results. For example, this documentation typically includes:

(a) System function and operation under normal and emergency operations
(b) System model boundary
(c) System schematic illustrating all equipment and components necessary for system operation
(d) Information and calculations to support equipment operability considerations and assumptions
(e) Actual operational history indicating any past problems in the system operation
(f) System success criteria and relationship to accident sequence models
(g) Human actions necessary for operation of system
(h) Reference to system-related test and maintenance procedures
(i) System dependencies and shared component interface
(j) Component spatial information
(k) Assumptions or simplifications made in development of the system models
(l) The components and failure modes included in the model and justification for any exclusion of components and failure modes
(m) A description of the modularization process (if used)
(n) Records of resolution of logic loops developed during fault tree linking (if used)
(o) Results of the system model evaluations
(p) Results of sensitivity studies (if used)
(q) The sources of the above information, (e.g., completed checklist from walkdowns, notes from discussions with plant personnel)
(r) Basic events in the system fault trees so that they are traceable to modules and to cut-sets.
(s) The nomenclature used in the system models.</td></tr>
</table>

EXPLANATION OF REQUIREMENT

This SR addresses the process documentation used to implement the system analysis supporting requirements. It also provides examples of documentation associated with the system analysis development processes and examples of documentation associated with the parameters, constraints and results from implementing these processes. Table 7 (SY-C2-1) provides a discussion of these examples. It should be noted that the documentation examples do not represent the complete list of all required documentation, but a list of many of the documents that are typically included. To facilitate the development of a complete list, a documentation mapping is provided in Table 8 (SY-C2-2) showing the scope of documentation needed to achieve consistency with the applicable SRs. Table 8 (SY-C2-2) also identifies each documentation item as either "process" or "SR." A "process" documentation item primarily supports the process requirement which is the focus of this SR while an "SR" documentation item primarily supports documentation that is consistent with one or more supporting requirements as required by SY-C1. A mapping is also provided in Table 7 (SY-C2-1) between the examples and the documentation list shown in Table 8 (SY-C2-2) and in Table 8 (SY-C2-2) between the documentation items and the applicable SRs.

Table 7 SY-C2-1 SR Examples

SR Example	Discussion	Documentation Item
a	SR SY-A1 requires the development of system models that support the accident sequence analyses and SR SY-A2 requires the collection of pertinent information to ensure that the systems analysis reflects the as-built and as-operated systems. SR SY-A5 requires the inclusion of normal and alternate systems alignments to the extent needed.	3
b	SR SY-A6 provides guidance on establishing the system model boundary	5
c	SR SY-A2 requires the collection of pertinent information to ensure that the systems analysis reflects the as-built and as-operated systems including P&IDs and one-line diagrams.	10
d	SR SY-A3 and B14 address component operating conditions.	7
e	SR SY-A19 addresses out-of-service unavailability for components in the system model and requires the model to be consistent with actual practices and history of the plant.	3
f	SR SY-A1 requires the development of system models that support the accident sequence analyses. Also, within the system analysis element there are many SRs addressing various aspects of success criteria.	4
g	Human actions are required to be included in the system models by SR SY-A17. The identification of the actions is primarily addressed by the accident sequence and human reliability elements.	1, 3, 13
h	SR SY-A3 requires the review of plant information sources to define or establish testing and maintenance requirements and practices.	1, 3, 13
i	There are multiple requirements addressing the need to treat dependencies including: SR-SY-A3, A6, B5, B6, B9, B12 and B15.	5
j	SR SY-B8 requires the identification of spatial and environmental hazards that may impact multiple systems or redundant components in the same systems.	6
k	The objective stated in Section 2-2.4.1 of the Standard include the expectation for capturing assumptions to provide the basis for the system logic models. There are no explicit requirements for assumptions within the system analysis SRs.	10, 13
l	SR SY-A14 requires the consideration of all failure modes, consistent with available data and model level of detail.	1, 3, 13
m	SR SY-A9 addresses the requirements for system modularization.	1, 13
n	The approach to resolving logic loops should be included in the description of the system analysis approach and in the applicable system models. There are no explicit requirements associated with system model logic loops in the system analysis element.	1, 13
o	The results of the system models should be included in the model documentation if they are quantified separately from the accident sequence quantification. There are no explicit requirements associated with system model results in the system analysis element.	13
p	The system analysis element of the ASME Standard has no requirement for the performance of sensitivity studies. However, if sensitivity studies are performed, they should be documented.	13
q	SR SY-A4 addresses the performance of plant walkdowns and interviews for Category II and III.	10, 11
r	SR SY-A8 requires the establishment of component boundaries and the matching the boundaries to the component failure data. Although there are no	13

SR Example	Discussion	Documentation Item
	explicit requirements associated with the need for traceability of basic events to cut- sets and modules, such traceability is needed to support the quantification element.	
s	SR SY-A23 requires the development of system model nomenclature.	12

Table 8 SY-C2-2 Documentation Mapping

Element	Type	Item	Documentation	Related SR	SR Examples
SY	Process	1	Document the approach used for developing the system analysis.	C2	g, h, l, m, n
SY	Process	2	Document the approach for establishing common cause failure groups.	B3	na
SY	SR	3	Document system functions and operation under normal and accident conditions, and applicable test and maintenance alignments and associated operating history review.	A1, A2, A3, A5	a, e, g, h, l
SY	SR	4	Document system (system function) success criteria including SSCs and operator actions required to support the modeled system functions.	A3, A6, A10, A16, A17, A18, A21, A22, B7, B10, B11, B15	f
SY	SR	5	Document system boundaries, dependencies and their bases.	A3, A6, B5, B6, B9, B12, B15	b, i
SY	SR	6	Document system spatial and environmental hazards.	B8	j
SY	SR	7	Document component operability and design limits.	A3, B14	d
SY	SR	8	Document component boundaries and applicable mapping to failure data.	A3, A8	na
SY	SR	9	Document component common cause failure groups and their members.	B1	na
SY	SR	10	Document inputs and assumptions (including simplifications).	A2	c. k, q
SY	SR	11	Document walkdowns and interviews.	A4	q
SY	SR	12	Document the system analysis nomenclature.	A23	s
SY	SR	13	Document the system models and their bases including: results, failure of equipment and components that would affect system functionality considering all applicable failure modes, human failures, unavailability due to test and maintenance, common cause failures, system dependencies and inputs and assumptions.	A1, A3, A7, A9, A11, A12, A13, A14, A15, A16, A17, A18, A19, A20, A24, B1, B4, B5, B9, B10, B11, B13, B15	g, h, k, l, m, n, o, p, r

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

Index No. SY-C	Capability Category I	Capability Category II	Capability Category III
SY-C3	DOCUMENT the sources of model uncertainty and related assumptions (as identified in QU-E1 and QU-E2) associated with the systems analysis.		

EXPLANATION OF REQUIREMENT

The assumptions and sources of model uncertainty are identified per the requirements in QU-E1 and QU-E2. This SR requires that they be documented. QU-E4 requires that the impact of these assumptions and model uncertainties on the PRA model be identified (e.g., introduces a new basic event, changes a basic event probability, changes success criteria or introduces a new initiating event). Further qualitative and quantitative assessment may be required for risk-informed applications using the PRA models.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA Standard RA-Sa-2009, has no objection to the requirement.

5.5 Human Reliability Analysis Section 2-2.5 of the ASME/ANS RA-Sa-2009

The objective of the human reliability element of the PRA is to ensure that the impacts of plant personnel actions are reflected in the assessment of risk in such a way that

(a) Both pre-initiating event and post-initiating event activities, including those modeled in support system initiating event fault trees, are addressed;

(b) Logic model elements are defined to represent the effect of such personnel actions on system availability/unavailability and on accident sequence development;

(c) Plant-specific and scenario-specific factors are accounted for, including those factors that influence either what activities are of interest or human performance;

(d) Human performance issues are addressed in an integral way so that issues of dependency are captured.

To meet the above objectives, seven HLRs are defined in the standard:

Designator	Requirement
Pre-Initiator HRA	
HLR-HR-A	A systematic process shall be used to identify those specific routine activities that, if not completed correctly, may impact the availability of equipment necessary to perform system function modeling in the PRA.
HLR-HR-B	Screening of activities that need not be addressed explicitly in the model shall be based on an assessment of how plant-specific operational practices limit the likelihood of errors in such activities.
HLR-HR-C	For each activity that is not screened, an appropriate human failure event (HFE) shall be defined to characterize the impact of the failure as an unavailability of a component, system or function modeled in the PRA.
HLR-HR-D	The assessment of the probabilities of the pre-initiator human failure events shall be performed by using a systematic process that addresses the plant-specific and activity-specific influences on human performance.
Post-Initiator HRA	
HLR-HR-E	A systematic review of the relevant procedures shall be used to identify the set of operator responses required for each of the accident sequences.
HLR-HR-F	Human failure events shall be defined that represent the impact of not properly performing the required responses, consistent with the structure and level of detail of the accident sequences.
HLR-HR-G	The assessment of the probabilities of the post-initiator HFEs shall be performed using a well-defined and self-consistent process that addresses the plant-specific and scenario-specific influences on human performance, and addresses potential dependencies between human failure events in the same accident sequence.

Designator	Requirement
HLR-HR-H	Recovery actions (at the cut-set or scenario level) shall be modeled only if it has been demonstrated that the action is plausible and feasible for those scenarios to which they are applied. Estimates of probabilities of failure shall address dependency on prior human failures in the scenario.
Pre- and Post-Initiator HRA	
HLR-HR-I	Documentation of the human reliability analysis shall be consistent with the applicable supporting requirements (HLR-HR-I).

It should be noted that the HRA is performed in an iterative and integral manner with other PRA elements, and in particular, the accident sequence, success criteria and systems analysis elements. Therefore, the individual SRs cannot be looked at in isolation. For example, the SRs associated with HLR-HA-A, HLR-HA-B, HLR-HA-C and HLR-SY-A, and in particular, SR SY-A16, are to be considered as a group. Similarly, the SRs associated with HLR-HR-E, HLR-HR-F and HLR-AS-A, and in particular, AS-A5 and AS-A6, are strongly related.

5.5.1 Supporting Requirements for HLR-HR-A

ASME/ANS Standard Section 2.2.5, Table 2.2.5-2(a), Supporting Requirements for HLR-HR-A

HLR-HR-A:	A systematic process shall be used to identify those specific routine activities that, if not completed correctly, may impact the availability of equipment necessary to perform system function modeling in the PRA
Purpose:	To ensure review of plant practices related to test, maintenance and calibration to identify opportunities for human error to render equipment modeled in the PRA unavailable.
SRs:	HR-A1 through HR-A3

NOTE: The tasks necessary to address this HLR are performed in an iterative and integral manner with those necessary to address HLR-HA-B, HLR-HA-C and HLR-SY-A, and in particular, SR SY-A16.

Index No. HR-A	Capability Category I	Capability Category II	Capability Category III
HR-A1	For equipment modeled in the PRA, IDENTIFY, through a review of procedures and practices, those test and maintenance activities that require realignment of equipment outside its normal operational or standby status.		

EXPLANATION OF REQUIREMENT

The focus of this SR is on the identification of test and maintenance activities that require equipment to be changed from its normal state, thus rendering a system or part of a system unavailable to perform the function required of it in the PRA. The concern is not with the unavailability while the equipment is being tested or maintained, since that is included in the basic events representing unavailability resulting from test or maintenance (SY-A19). Instead, as addressed in HR-B1, HR-C2 and SY-A16, the concern is with the potential that the system or part of a system could be left in an unrevealed unavailable state after the completion of the test or maintenance. The reason for identifying the activities that could lead to the misalignment is that if the nature of the activity and how it is performed is understood, this provides a basis for screening out from consideration or as a basis for assessing the probability of its occurrence.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-A	Capability Category I	Capability Category II	Capability Category III
HR-A2	IDENTIFY, through a review of procedures and practices, those calibration activities that if performed incorrectly can have an adverse impact on the automatic initiation of standby safety equipment.		

EXPLANATION OF REQUIREMENT

Another activity that can, if not performed correctly, lead to unavailability of equipment is miscalibration of the instruments that results in the associated equipment not operating as required following a demand. In this SR, the focus is on the identification of those calibration activities related to instruments that are necessary to activate or control the mitigating equipment modeled in the PRA. The instruments of interest are identified as part of requirement SY-A14, and specifically items (m) and (n). As with HR-A1, this SR is also related to SR SY-A16.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-A	Capability Category I	Capability Category II	Capability Category III
HR-A3	IDENTIFY which of those work practices identified above (HR-A1, HR-A2) involve a mechanism that simultaneously affects equipment in either different trains of a redundant system or diverse systems [e.g., use of common calibration equipment by the same crew on the same shift, a maintenance or test activity that requires realignment of an entire system (e.g., SLCS)].		

EXPLANATION OF REQUIREMENT

This SR recognizes that there can be some aspect of the way that maintenance or calibration activities are performed that could lead to the simultaneous unavailability of multiple trains in the same or in diverse systems as opposed to unavailability of a single train. The SR uses the phrase "involve a mechanism that simultaneously affects equipment in either different trains of a redundant system or diverse systems." What is meant by the term mechanism is the nature of the process used to perform the activity as clarified by the examples. Such an activity is a more significant concern than one that only affects one train. Although written as a separate SR, it is almost certainly the case that this activity will be performed as a part of the review of the relevant procedures.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.5.2 Supporting Requirements for HLR-HR-B

ASME/ANS Standard Section 2.2.5, Table 2.2.5-2(b), Supporting Requirements for HLR-HR-B

HLR-HR-B:	Screening of activities that need not be addressed explicitly in the model shall be based on an assessment of how plant-specific operational practices limit the likelihood of errors in such activities
Purpose:	To allow screening of those activities for which it can be demonstrated that the likelihood of error leading to unavailability of the equipment is small. This is done to avoid unnecessary complexity of models
SRs:	HR-B1 through HR-B2

Index No. HR-B	Capability Category I	Capability Category II	Capability Category III
HR-B1	If screening is performed, ESTABLISH rules for screening **classes** of activities from further consideration. Example: Screen maintenance and test activities from further consideration only if **the plant practices are generally structured to include independent checking of restoration of equipment to standby or operational status on completion of the activity.**	If screening is performed, ESTABLISH rules for screening individual **activities** from further consideration. Example: Screen maintenance and test activities from further consideration only if **(a) Equipment is automatically re-aligned on system demand, or** **(b) Following maintenance activities, a post-maintenance functional test is performed that reveals misalignment, or** **(c) Equipment position is indicated in the control room, status is routinely checked, and realignment can be affected from the control room, or** **(d) Equipment status is required to be checked frequently (i.e., at least once a shift).**	

EXPLANATION OF REQUIREMENT

Test, maintenance and calibration procedures are generally written to minimize the likelihood of equipment not being restored to the correct standby condition. This SR reflects the fact that it is common in PRAs to screen activities from consideration on the basis that the likelihood of failing to complete the activity correctly is sufficiently small that such failures would be insignificant contributors to system unavailability. The SR requires the screening out criteria to be established, and provides some examples. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This SR differentiates between Capability Category I and Capability categories II and III:

For Capability Category I, the screening out is done for a class of activity, e.g., maintenance activities as a class. The example rule provided relies on a demonstration that the same plant practices apply to the class of activities screened. The example screening criterion provided allows for screening of all maintenance and test activities under the specified conditions. No example is provided for screening calibration activities.

For Capability Category II and III, the screening out is typically performed on a specific activity level. This is a more comprehensive and detailed approach. Although not explicitly stated, this requirement does not preclude the grouping of activities into similar types, e.g., maintenance on redundant trains of a specific multi train system, or recognizing that the same restoration practices are used for all maintenance activities, and treating these as a group when they are known to have the same characteristics.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-B	Capability Category I	Capability Category II	Capability Category III
HR-B2	DO NOT screen activities that could simultaneously have an impact on multiple trains of a redundant system or diverse systems (HR-A3).		

EXPLANATION OF REQUIREMENT

An activity that could result in a single train of a system being unavailable may be screened under specified conditions. However, those activities that could result in multiple trains of a redundant system or of multiple, diverse systems becoming unavailable should not, because of their common cause failure potential, be screened without further analysis.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.5.3 Supporting Requirements for HLR-HR-C

ASME/ANS Standard Section 2.2.5, Table 2.2.5-2(c), Supporting Requirements for HLR-HR-C

HLR-HR-C:	For each activity that is not screened, and appropriate human failure event (HFE) shall be defined to characterize the impact of the failure as an unavailability of a component, system or function modeled in the PRA
Purpose:	To identify and define the basic events to include in the system logic models
SRs:	HR-C1 through HR-C3

Index No. HR-C	Capability Category I	Capability Category II	Capability Category III
HR-C1	For each unscreened activity, DEFINE a human failure event (HFE) that represents the impact of the human failure at the appropriate level, i.e., function, system, train or component affected.		

EXPLANATION OF REQUIREMENT

Each of the unscreened activities has the potential for a human error that results in equipment being unavailable to perform as needed in response to a plant transient or accident. The impacts of these errors are included in the system models as human failure events (HFEs), as required in SY-A16. The HFE is generally defined as leading to the unavailability of a component, train, system or function. The level at which the impact is modeled (i.e., component, train, system or function) is determined by an understanding of how the activity affects the operational configuration of the plant systems, and is addressed in SR HR-C2.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-C	Capability Category I	Capability Category II	Capability Category III
HR-C2	INCLUDE those modes of unavailability that, following completion of each unscreened activity, result from failure to restore: *(a)* Equipment to the desired standby or operational status *(b)* Initiation signal or set point for equipment start-up or realignment *(c)* Automatic realignment or power.	INCLUDE those modes of unavailability that, following completion of each unscreened activity, result from failure to restore: *(a)* Equipment to the desired standby or operational status *(b)* Initiation signal or set point for equipment start-up or realignment *(c)* Automatic realignment or power **ADD failure modes identified during the collection of plant-specific or applicable generic operating experience that leave equipment unavailable for response in accident sequences.**	

EXPLANATION OF REQUIREMENT

This SR identifies specific mechanisms for failure to return equipment to its operational state. This information is used in HLR-HR-D as the basis for estimating the likelihood of the failure occurring. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This SR differentiates between Capability Category I and Capability Categories II and III. For all three capability categories, three specific failure mechanisms are identified.

For Capability Category II and III, there is an additional requirement, namely the addition of failure modes that have been identified as a result of the analysis of operational experience.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-C	Capability Category I	Capability Category II	Capability Category III
HR-C3	INCLUDE the impact of miscalibration as a mode of failure of initiation of standby systems.		

EXPLANATION OF REQUIREMENT

Self-explanatory (See HR-A2).

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.5.4 Supporting Requirements for HLR-HR-D

ASME/ANS Standard Section 2.2.5, Table 2.2.5-2(d), Supporting Requirements for HLR-HR-D

HLR-HR-D:	The assessment of the probabilities of the pre-initiator human failure events shall be performed using a systematic process that addresses the plant-specific and activity-specific influences on human performance
Intent:	To evaluate HEPs to take into account specific plant practices
SRs:	HR-D1 through HR-D7

Index No. HR-D	Capability Category I	Capability Category II	Capability Category III
HR-D1	ESTIMATE the probabilities of human failure events using a systematic process. Acceptable methods include THERP [NOTE (1)] and ASEP [NOTE (2)].		

NOTE (1): NUREG/CR-1278, Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications; A.D. Swain and H.E. Guttmann; August 1983 (THERP)
NOTE (2): NUREG/CR-4772, Accident Sequence Evaluation Program Human Reliability Analysis Procedure; A.D. Swain; February 1987 (ASEP)

EXPLANATION OF REQUIREMENT

A systematic process is one that uses the same approach to quantify all the HEPs. Use of a systematic process ensures that the HEPs are assessed in a consistent manner and that the HEPs are ranked appropriately. This means, for example, that those HFEs for which there are multiple opportunities for error will have higher HEPs than those for which there is only a single opportunity for error. Similarly, HFEs for which there are multiple opportunities for recovery will have lower HEPs than those which have fewer or no opportunities for recovery. The most commonly used methods for the quantification of HEPs for pre-initiator HFEs are THERP and ASEP. However, SR HR-D2 for CC II allows the less significant HFEs to be addressed using screening values as opposed to a detailed analysis. Even though the non-risk-significant HEPs are treated differently from the risk-significant HEPs, this is still a systematic approach, since, within each group, the same method is used.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-D	Capability Category I	Capability Category II	Capability Category III
HR-D2	USE **screening estimates** in the quantification of the pre-initiator HEPs.	**For significant HFEs,** USE **detailed assessments** in the quantification of pre-initiator HEPs. **USE screening values based on a simple model, such as ASEP in the quantification of the pre-initiator HEPs for non-significant human failure basic events.** When bounding values are used, ENSURE they are based on limiting cases from models such as ASEP.	USE **detailed assessments** in the quantification of pre-initiator HEPs **for each system.**

EXPLANATION OF REQUIREMENT

Pre-initiator HFEs have rarely been found to be significant contributors to component, train or system failure, compared to mechanical failures or other modes of unavailability. Consequently, performing a detailed HRA for each pre-initiator HFE, which can be resource intensive, may not, in some cases, be the optimal use of resources. It is, therefore, acceptable to use screening values to estimate the HEPs for some pre-initiator HFEs. These screening estimates are expected to be somewhat conservative. This is evident in the final sentence in CC II, which uses the term bounding values that are to be based on limiting cases. Such limiting cases generally assume the most unfavorable conditions associated with the activity being evaluated consistent with the understanding of the activity. For example, the possibility of recovery would not be assumed if there was no clear evidence that it was possible. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This SR differentiates the three capability categories in a manner consistent with the Table 1-1.3-2:

For Capability Category I, screening estimates are sufficient for all pre-initiator HEPs.

For Capability Category II, detailed estimates are expected for the significant HFEs, where significance is determined by their importance to the results (see definition of significant basic event).

For Capability Category III, all estimates are performed using detailed analyses.

The subsequent SRs for HR-D give more details on what is required of the quantification process.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-D	Capability Category I	Capability Category II	Capability Category III
HR-D3	No requirement for evaluating the quality of written procedures, administrative controls or human-machine interfaces.	For each detailed human error probability assessment, INCLUDE in the evaluation process the following plant-specific information: *(a)* The quality of written procedures (for performing tasks) and administrative controls (for independent review) *(b)* The quality of the human-machine interface, including both the equipment configuration and instrumentation and control layout.	

EXPLANATION OF REQUIREMENT

The operator's ability to successfully perform the needed action is generally considered to be dependent on the quality of the written procedure, administrative controls and human-machine interface. The SR requires that these be assessed when estimating the HEPs.

Since, in SR HR-D2, for Capability Category I, a screening estimate is used for the probability of the operator failing to successfully perform the action, the evaluation of the quality of the written procedures, etc., is not required in HR-D3 for Capability Category I.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, provides the following clarification. The intent of the clarification is to provide additional guidance, in the form of examples, of what is meant by quality of procedures, administrative controls and the human-machine interface:

<u>Cat II, III</u>:

(a) The quality (e.g., format, logical structure, ease of use, clarity and comprehensiveness) of written procedures (for performing tasks) and the type of administrative controls that support independent review (e.g., configuration control process, technical review process, training processes and management emphasis on adherence to procedures) of administrative controls (for independent review)

(b) The quality of the human-machine interface (e.g., adherence to human factors guidelines [Note (3)] and results of any quantitative evaluations of performance per functional requirements), including both the equipment configuration and instrumentation and control layout.

Note (3) NUREG-0700, Rev. 2, Human-System Interface Design Review Guidelines; J.M. O'Hara, W.S. Brown, P.M. Lewis, and J.J. Persensky, May 2002.

Index No. HR-D	Capability Category I	Capability Category II	Capability Category III
HR-D4	When taking into account self-recovery or recovery from other crew members in estimating HEPs for specific HFEs, USE pre-initiator recovery factors consistent with selected methodology. If recovery of pre-initiator errors is credited: *(a)* ESTABLISH the maximum credit that can be given for multiple recovery opportunities *(b)* USE the following information to assess the potential for recovery of pre-initiator *(1)* Post-maintenance or post-calibration tests required and performed by procedure *(2)* Independent verification, using a written check-off list, which verify component status following maintenance/testing *(3)* Original performer, using a written check-off list, makes a separate check of component status at a later time *(4)* Work shift or daily checks of component status, using a written check-off list.		

EXPLANATION OF REQUIREMENT

THERP and ASEP are the most commonly used approaches to the quantification of pre-initiating event HEPs. Both of these approaches are based on performing a task analysis. Plant procedures for test, maintenance and calibration activities generally include provisions for checking and/or verification that may be taken into account in the quantification. This SR provides details of the information that can be used in assessing the potential for recovery that is provided by these provisions.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-D	Capability Category I	Capability Category II	Capability Category III
HR-D5	ASSESS the joint probability of those HFEs identified as having some degree of dependency (i.e., having some common elements in their causes, such as performed by the same crew in the same time-frame).		

EXPLANATION OF REQUIREMENT

A single cut-set could contain a number of HFEs, each representing the failure to restore redundant trains of a single system to operability. Assuming that these HFEs are independent is potentially non-conservative. There may be factors that could increase the likelihood of multiple failures, and therefore, these HFEs may not be statistically independent. For there to be a dependency, there needs to be some common elements in the reasons for failure. Examples include a fault in a procedure which is a hard-wired common failure cause, or a simple error on the part of the crew, that is more likely to affect multiple trains when the activities on the separate trains are performed by the same crew within the same shift. This SR requires that in those cases the causes of dependency should be identified, and their impact assessed.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-D	Capability Category I	Capability Category II	Capability Category III
HR-D6	PROVIDE an assessment of the uncertainty in the HEPs consistent with the quantification approach. USE mean values when providing point estimates of HEPs.		

EXPLANATION OF REQUIREMENT

The uncertainty characterization is needed to comply with requirement QU-E3 to provide uncertainty characterization of the total CDF associated with parameter uncertainties.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, provides the following clarification.

This SR should be written similarly to HR-G9: CHARACTERIZE the uncertainty in the estimates of the HEPs consistent with the quantification approach, and PROVIDE mean values for use in the quantification of the PRA results.

Index No. HR-D	Capability Category I	Capability Category II	Capability Category III
HR-D7	No requirement to check reasonableness of HEPs in light of the plant's experience		CHECK the reasonableness of the HEPs in light of the plant's experience.

EXPLANATION OF REQUIREMENT

Checking that the estimates of basic event probabilities are consistent with experience, i.e., a reasonableness check is considered good PRA practice. However, data on pre-initiator errors is typically scarce, and since they do not usually play a significant role in the determination of CDF, the check for reasonableness is not required for Capability Categories I and II**.**

***For Capability Category III*,** a search for plant experience is required. To perform the reasonableness check would require processing of this data.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.5.5 Supporting Requirements for HLR-HR-E

ASME/ANS Standard Section 2.2.5, Table 2.2.5-2(e), Supporting Requirements for HLR-HR-E

HLR-HR-E:	A systematic review of the relevant procedures shall be used to identify the set of operator responses required for each of the accident sequences
Intent:	To understand the role of the operators in responding to plant upset conditions and identify opportunities for error
SRs:	HR-E1 through HR-E4

Index No. HR-E	Capability Category I	Capability Category II	Capability Category III
HR-E1	When identifying the key human response actions, REVIEW: *(a)* The plant-specific emergency operating procedures and other relevant procedures (e.g., AOPs, annunciator response procedures) in the context of the accident scenarios. *(b)* System operation such that an understanding of how the system(s) functions and the human interfaces with the system is obtained.		

EXPLANATION OF REQUIREMENT

The identification of the responses required of the plant operators in response to an initiating event is a crucial element in the development of the logic model. Some of the responses are included in developing the accident sequence models, while others are included in the system models. As such, this SR is related to SRs AS-A1, AS-A5 and SY-A17 in that they all address the inclusion of key human response actions in the PRA logic model. In this context the key human response actions are those that influence the accident sequence development (see, in particular, SR AS-A5). The HRA for post-initiator events, the development of the accident scenarios and the system models all depend on an understanding of the plant operating procedures.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-E	Capability Category I	Capability Category II	Capability Category III
HR-E2	IDENTIFY: *(a)* Those actions required to initiate (for those systems not automatically initiated), operate, control, isolate or terminate those systems and components used in preventing or mitigating core damage as defined by the success criteria (e.g., operator initiates RHR) *(b)* Those actions performed by the control room staff either in response to procedural direction or as skill-of-the-craft to recover a failed function, system or component that is used in the performance of a response action as identified in HR-H1.		

EXPLANATION OF REQUIREMENT

The responses that are required to be taken into account when developing the plant logic model are those that have an impact on the initiation and operation of the systems that are required to respond to the initiating event. These are typically identified in the various procedures, such as the EOPs, AOPs and annunciator response procedures. In addition to those actions that are required to initiate, operate, control, isolate or terminate systems in accordance to procedural direction, there are those that are designed to recover from a failure that are not necessarily addressed by procedure. In general, only those that can be considered skill-of-the-craft are credited in PRAs.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-E	Capability Category I	Capability Category II	Capability Category III
HR-E3	**REVIEW the interpretation of the procedures with plant operations or training personnel to confirm that interpretation is consistent with plant operational and training practices.**	**TALK THROUGH (i.e., review in detail) with plant operations and training personnel the procedures and sequence of events to confirm that interpretation of the procedures is consistent with plant observations and training procedures.**	

EXPLANATION OF REQUIREMENT

Plant emergency operating procedures are written in a relatively consistent format across similar plants, in accordance with the vendor's guidelines. However, the manner in which they are applied can differ in subtle ways that can only be identified by discussions with plant operations staff. There may be even more variability in the other procedures that are developed in a plant-specific manner. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This requirement is different for Capability Category I and Capability Categories II and III:

For Capability Category I, the requirement is to review the interpretation with operations or training staff in enough detail that it can be established that the plant operational practices and training practices are understood, in order that the intent of the procedures is captured correctly in developing the plant logic model.

For Capability Category II and III, the requirement is to specifically include a talk through of the procedures as they are applied to specific accident sequences.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-E	Capability Category I	Capability Category II	Capability Category III
HR-E4	No requirement for using simulator observations or talk-throughs with operators to confirm response models.	USE simulator observations or talk-throughs with operators to confirm the response models for scenarios modeled.	

EXPLANATION OF REQUIREMENT

In addition to discussions with training staff and plant operations staff, observations in the training simulator and talking through the scenarios of interest with the control room operating staff to ascertain how it would respond given the specific scenarios modeled in the accident sequences give additional information that adds to the credibility of the representation of human responses in the PRA logic model.

Capability Category Differentiation

This requirement is different for Capability Category I and Capability Categories II and III:

For Capability Category I, there is no requirement to observe simulator actions or perform talk-throughs with the plant operating staff.

For Capability Category II and III, the additional insights that can be gained by the required activities result in a more robust and credible logic model that reflects the plant operating staff's perspectives.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.5.6 Supporting Requirements for HLR-HR-F

ASME/ANS Standard Section 2.2.5, Table 2.2.5-2(f), Supporting Requirements for HLR-HR-F

HLR-HR-F:	Human failure events shall be defined that represent the impact of not properly performing the required responses, consistent with the structure and level of detail of the accident sequences
Intent:	To define the HFEs so that they are included appropriately in the plant logic model, and to ensure that the evaluation of HEPs is performed on a plant- and scenario-specific basis
SRs:	HR-F1 through HR-F2

Index No. HR-F	Capability Category I	Capability Category II	Capability Category III
HR-F1	DEFINE human failure events (HFEs) that represent the impact of the human failures at the function, system, train or component level as appropriate**. Failures to correctly perform several responses may be grouped into one HFE if the impact of the failures is similar or can be conservatively bounded.**		DEFINE human failure events (HFEs) that represent the impact of the human failures at the function, system, train or component level as appropriate.

EXPLANATION OF REQUIREMENT

The human failure events are the events that represent the impact of the failures of the operators to respond appropriately as required by the procedures. The representation of a human failure in the PRA model can be in terms of the failure of a function (e.g., depressurization) or of a specific component, train or system as appropriate. In some cases, the response may require a succession of different actions. The failures to perform these different actions may have the same or different impacts on the plant. The failures to perform several actions can be grouped into a single HFE when their impact on the accident sequence development is the same or similar. The decision of when it is appropriate to group human failures is done as part of the accident sequence development since it is necessary to know the consequences of not performing each of the responses correctly to determine whether there are potential differences that should be captured in the model. This will be a function of the level of detail required. For example, to control power in an ATWS in a BWR, the procedures direct the operators to lower the RPV water level, inject boron, and then raise the level again. Because ATWS scenarios are low frequency scenarios, it is sometimes assumed that failure of any of these actions results in loss of control of power, and they are combined into one HFE.

This requirement does not specifically call out errors of commission. It has been accepted practice that errors of commission are not modeled.

Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This requirement is different for Capability Categories I and II and Capability Category III:

For Capability Category I and II, grouping of individual human failures is allowed as long as it can be argued that the impact of each of the failures on the plant and the scenario development is the same, or the impact on the plant and the scenario development is modeled as the bounding impact taken over the group.

Capability Category III represents a more detailed model of the human failures and plant response in that it does not allow the grouping of response failures. Each response failure is its own HFE.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-F	Capability Category I	Capability Category II	Capability Category III
HR-F2	COMPLETE THE DEFINITION of the HFEs by specifying *(a)* Accident sequence specific timing of cues, and time window for successful completion *(b)* Accident sequence specific procedural guidance (e.g., AOPs and EOPs) *(c)* The availability of cues and other indications for detection and evaluation errors **(d) The complexity of the response.** **(Task analysis is not required.)**	COMPLETE THE DEFINITION of the HFEs by specifying *(a)* Accident sequence specific timing of cues, and time window for successful completion *(b)* Accident sequence specific procedural guidance (e.g., AOPs and EOPs) *(c)* The availability of cues and other indications for detection and evaluation errors **(d) The specific high level tasks (e.g., train level) required to achieve the goal of the response.**	COMPLETE THE DEFINITION of the HFEs by specifying *(a)* Accident sequence specific timing of cues, and time window for successful completion *(b)* Accident sequence specific procedural guidance (e.g., AOPs and EOPs) *(c)* The availability of cues and other indications for detection and evaluation errors **(d) The specific detailed tasks (e.g., at the level of individual components, such as pumps or valves) required to achieve the goal of the response.**

EXPLANATION OF REQUIREMENT

HR-F1 essentially addresses the failure mode represented by the HFE, i.e., the impact of the human failure as the unavailability of a component, train, system or function in a manner consistent with the accident sequence definition. The contextual information addressed in this requirement is needed for the assessment of the probability of the HFE, i.e., the HEP. (a) For each response action, the operators must have some indication that they need to respond (i.e., a cue), and must complete the action within a time that prevents the undesirable irreversible impact on the plant component, system or function. The timing of the cues, and the time available, varies from accident sequence to accident sequence. The detailed timing itself is addressed in HR-G4, and will draw on information addressed in SC-B3. (b) The procedural guidance has already been used in HLR HR-E and HR-F1 to identify the failure modes that can occur, but is also the source for identifying the cues. (c) Because plant conditions change relatively slowly in many scenarios, there is opportunity to identify and rectify initial errors as long as there are cues or other indications that the plant is not behaving as expected. This is an important factor in determining the HEP. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

For this SR, the capability categories are differentiated with respect to item (d) which is related to the complexity of the response:

For Capability Category I, it is sufficient to assess the complexity in a holistic manner. In the context of this SR, the term complexity is to be understood as being determined by a qualitative, high level of assessment of what is required, but something less than the high level task analysis performed for CC II.

For Capability Category II, a relatively high level task analysis is required. This can be done at the train level, for example.

For Capability Category III, a detailed task analysis is required.

This distinction is primarily related to the characterization of the HFE in preparation for quantification, since even for Capability Category I it is necessary to understand how the task is to be performed in order to identify the items in (a) through (c). For Capability Category I, the quantification approach can be at a relatively high level, whereas for Capability Categories II and III, the task analyses need to be taken into account.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.5.7 Supporting Requirements for HLR-HR-G

ASME/ANS Standard Section 2.2.5, Table 2.2.5-2(g), Supporting Requirements for HLR-HR-G

HLR-HR-G:	The assessment of the probabilities of the post-initiator HFEs shall be performed using a well-defined and self-consistent process that addresses the plant-specific and scenario-specific influences on human performance, and addresses potential dependencies between human failure events in the same accident sequence.
Intent:	To evaluate the HEPs so that their relative values are consistent taking into account the scenario-specific factors that influence human performance
SRs:	HR-G1 through HR-G8

Index No. HR-G	Capability Category I	Capability Category II	Capability Category III
HR-G1	USE conservative estimates (e.g., screening values) for the HEPs of the HFEs in accident sequences that survive initial quantification.	PERFORM detailed analyses for the estimation of HEPs for significant HFEs. USE screening values for HEPs for non-significant human failure basic events.	PERFORM detailed analyses for the estimation of human failure basic events.

EXPLANATION OF REQUIREMENT

This SR defines the nature of the approach to quantification of the HEPs. Requirements for the quantification process are provided in the subsequent HR-G SRs. Performing a detailed HRA for each post-initiator HFE is resource intensive, and, depending on the intended use of the PRA, may not be the optimal use of resources. It is, therefore, acceptable to use screening values to estimate the HEPs for some post-initiator HFEs depending on the capability category. As indicated in the requirement for capability Category I, in this context a screening value is intended to be a conservative value.

Capability Category Differentiation

This SR differentiates the three capability categories in a manner consistent with the Table 1-1.3-2:

For Capability Category I, screening estimates are sufficient for all HEPs. Screening estimates are expected to be somewhat conservative.

For Capability Category II, detailed estimates are expected for the significant HFEs, where significance is determined by their importance to the results (see definition of significant basic event).

For Capability Category III, all estimates are performed using detailed analyses.

The subsequent SRs for HR-G give more details on what is required of the quantification process.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-G	Capability Category I	Capability Category II	Capability Category III
HR-G2	USE an approach to estimation of HEPs that addresses failure in cognition as well as failure to execute.		

EXPLANATION OF REQUIREMENT

This SR recognizes that for all response actions there is some element of cognition involved. As a simple example, incorrectly interpreting a cue or not seeing a cue can lead to failure, in the same way as failing to take an action or taking an incorrect action can. The cognitive activities include detection of a problem, diagnosis and decision-making. Some level of cognitive activity is required even for symptom based procedures in that there has to be an understanding of the plant condition as indicated by the monitored parameters and of the course of action specified in the procedures. One of the reasons for including the cognitive failures is that they can be a cause of dependency between HFEs.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-G	Capability Category I	Capability Category II	Capability Category III
HR-G3	**USE an approach that takes the following into account.** (a) The complexity of the response (b) The time available and time required to complete the response **(c) Some measure of scenario-induced stress.** The ASEP Approach is an acceptable approach.	**When estimating HEPs EVALUATE the impact of the following plant-specific and scenario-specific performance shaping factors.** **(a) Quality [type (classroom or simulator) and frequency] of the operator training or experience** **(b) Quality of the written procedures and administrative controls** **(c) Availability of instrumentation needed to take corrective actions** **(d) Degree of clarity of cues/indications** **(e) Human-machine interface** *(f)* Time available and time required to complete the response *(g)* Complexity of the required response **(h) Environment (e.g., lighting, heat, radiation) under which the operator is working** **(i) Accessibility of the equipment requiring manipulation** **(j) Necessity, adequacy and availability of special tools, parts, clothing, etc.**	

EXPLANATION OF REQUIREMENT

The quantification of the HEPs should be performed to take account of the performance shaping factors that are generally accepted as being important, with a distinction being made between what is required for Capability Category I and for Capability Categories II and III. Note that bold text within the SR indicates text that is different between the categories.

For Capability Category I, a high level approach is acceptable that identifies only four PSFs, namely complexity, time available, time required and stress. These are consistent with the ASEP approach which is identified as an acceptable approach.

For Capability Category II and III, a broader scope of PSFs is included that is more appropriate to the more detailed HRA methods. These PSFs are generally accepted as being a reasonably comprehensive, though not exhaustive set. See NUREG-1792 for more discussion.

REGULATORY POSITION

The NRC in Rev. 2 to Regulatory Guide 1.200 has the following clarification,

In item (d) of CC II, III, clarify that "clarity" refers the meaning of the cues, etc.

In item (a) of CC I and item (g) of CC II, III, clarify that complexity refers to both determining the need for and executing the required response,

with the following proposed resolution.

<u>Cat I:</u>

(a) The complexity of **detection, diagnosis, decision-making and executing** the **required** response

(b) …

Cat II, and III:

(d) Degree of clarity of the cues/indications **in supporting the detection, diagnosis and decision-making give the plant-specific and scenario-specific context of the event.**

(g) Complexity of **detection, diagnosis and decision-making and executing** the required response.

Index No. HR-G	Capability Category I	Capability Category II	Capability Category III
HR-G4	BASE the time available to complete actions on **applicable generic studies (e.g., thermal/ hydraulic analysis for similar plants)**. SPECIFY the point in time at which operators are expected to receive relevant indications.	BASE the time available to complete actions **on appropriate realistic generic thermal/ hydraulic analyses, or simulation from similar plants (e.g., plant of similar design and operation).** SPECIFY the point in time at which operators are expected to receive relevant indications.	BASE the time available to complete actions on **plant-specific thermal/hydraulic analysis, or simulations.** SPECIFY the point in time at which operators are expected to receive relevant indications.

EXPLANATION OF REQUIREMENT

The operator actions required to respond to a plant disturbance have to be completed before an irreversible change of the plant state takes place. The time available to complete the response is an important element of the success criterion associated with an HFE. The time available is determined using the same thermal-hydraulic analyses used to generate the functional success criteria (See SC-B). The last sentence of the requirement for each capability category recognizes that, while the plant disturbance may occur at a specific point in time, the time at which the operators receive the cues that initiate their response may occur at a later time. Thus the time available for successful response may be shorter than the time evaluated from the initiation of the plant disturbance. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This SR has three different capabilities, and is similar to the differentiation in SR SC-B1:

For Capability Category I, generic studies are acceptable,

For Capability Category II, either generic studies as long as they are realistic as opposed to being conservative with respect to the calculation of time, or simulation from similar plants are acceptable and

For Capability Category III, plant-specific studies are required.

REGULATORY POSITION

The NRC in Rev. 2 to Regulatory Guide 1.200 has the following clarification.

Requirements concerning the use of thermal/hydraulic codes should be cross-referenced. Therefore, for each CC, include after the first sentence a reference to SC-B4, as follows.

BASE…. **(See SC-B4.)** SPECIFY the point in time….

Index No. HR-G	Capability Category I	Capability Category II	Capability Category III
HR-G5	When needed, **ESTIMATE** the time required to complete actions. **The approach described in ASEP is an acceptable approach.**	When needed, **BASE** the required time to complete actions **for significant HFEs on action time measurements in either walkthroughs or talk-throughs of the procedures or simulator observations.**	When needed, **BASE** the required time to complete actions **on action time measurements in either walkthroughs or talk-throughs of the procedures or simulator observations.**

EXPLANATION OF REQUIREMENT

For many HFEs it is necessary to assess the time required to carry out the actions. This may be needed, for example, so that the time available for diagnosis can be evaluated by subtracting the time required for execution from the time available (see HR-G4). Estimating the time required is important for the more complex tasks, such as performing the switchover to sump recirculation. However, for some **tasks**, the time needed to actually carry out the task once it has been decided to do so is very short. This would be the case for activating the depressurization system in a BWR for example. Thus the requirement recognizes, by the use of the words "when needed," that this may not always be necessary. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This SR has three different capabilities:

For Capability Category I, the time required is estimated,

For Capability Category II, the time is evaluated in plant-specific manner, using actual walkthroughs, talk-throughs (see HR-E4) or simulator observations for the significant HFEs and

For Capability Category III, the time is evaluated in a plant-specific manner for all HFEs.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-G	Capability Category I	Capability Category II	Capability Category III
HR-G6	CHECK the consistency of the post-initiator HEP quantifications. REVIEW the HFEs and their final HEPs relative to each other to check their reasonableness given the scenario context, plant history, procedures, operational practices and experience.		

EXPLANATION OF REQUIREMENT

The quantification of HEPs using any of the commonly used HRA methods involves the exercising of judgment. The performance of the complete quantification may take place over a prolonged period of time. Therefore, it is considered good practice to perform a review for internal consistency to make sure that the HEPs are ranked appropriately with respect to the difficulty associated with the contextual information provided by the definition of the HFEs performed to meet HLR HA-F.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-G	Capability Category I	Capability Category II	Capability Category III
HR-G7	For multiple human actions in the same accident sequence or cut set, identified in accordance with supporting requirement QU-C1, ASSESS the degree of dependence, and calculate a joint human error probability that reflects the dependence. ACCOUNT for the influence of success or failure in preceding human actions and system performance on the human event under consideration including: *(a)* Time required to complete all actions in relation to the time available to perform the actions *(b)* Factors that could lead to dependence (e.g., common instrumentation, common procedures, increased stress, etc.) *(c)* Availability of resources (e.g., personnel) [NOTE (1)]		

NOTE (1): The state of the art in HRA is such that the assessment of dependency is largely based on the analyst's judgment. While it should be expected that there will be a progressively more detailed treatment of dependency in going from CC I to CC III, the distinction is not made at the level of this SR. Instead, it is expected to follow from the increase in the level of detail in the analysis of HFEs in going from CC I to CC III.

EXPLANATION OF REQUIREMENT

HRA models provide estimates of HEPs for individual HFEs. Since many HEP values are quite low, when multiple HFEs occur in the same cut-set, multiplying their HEPs together independently could result in very low cut-set frequencies. It is generally accepted that the probability of failure of an operator action in a sequence of events will be influenced by the prior operator successes and failures, i.e., the HEPs in a cut set are not necessarily independent. Therefore the joint human error probability will generally be different, and higher, than the product of the individual HEPs. This SR does not specify an approach to incorporating this joint probability in the PRA quantification. As the note associated with this SR recognizes, there is no accepted approach to addressing this dependency. Therefore, this SR requires that the analyst provide his assessment of dependency and in the third sentence, beginning with "ACCOUNT for" identifies some factors that need to be taken into account when assessing the dependency.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-G	Capability Category I	Capability Category II	Capability Category III
HR-G8	CHARACTERIZE the uncertainty in the estimates of the HEPs consistent with the quantification approach, and PROVIDE mean values for use in the quantification of the PRA results.		

EXPLANATION OF REQUIREMENT

The uncertainty in the HEPs is required so that the treatment of HEPs is consistent with that of the other basic events in the model. Furthermore, an assessment of the uncertainty of the HEPs is necessary in order to meet SRs QU-A3 and QU-E3.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement, except to point out that the action verb "characterize" should be capitalized.

5.5.8 Supporting Requirements for HLR-HR-H

ASME/ANS Standard Section 2.2.5, Table 2.2.5-2(h), Supporting Requirements for HLR-HR-H

HLR-HR-H:	Recovery actions (at the cut-set or scenario level) shall be modeled only if it has been demonstrated that the action is plausible and feasible for those scenarios to which they are applied. Estimates of probabilities of failure shall address dependency on prior failures in the scenario. (Note 1)
Intent:	To limit consideration of recovery actions to those that can be reasonably expected to be performed and that dependency on those HFEs already in the model is addressed
SRs:	HR-H1 through HR-H3

NOTE (1): Recovery actions are actions taken in addition to those normally identified in the review of emergency, abnormal and system operating procedures, which would normally be addressed in HR-E through HR-G. They are included to allow credit for recovery from failures in cut-sets or scenarios when failure to take credit would distort the insights from the risk analysis. The potential for recovery (e.g., manually opening a valve that had failed to open automatically) may well differ from scenario to scenario or cut-set to cut-set. In this context, recovery is associated with work-arounds but does not include repair, which is addressed in SY-A24 and DA-C15.

Index No. HR-H	Capability Category I	Capability Category II	Capability Category III
HR-H1	INCLUDE operator recovery actions that can restore the functions, systems or components on an as needed basis to provide a more realistic evaluation of **CDF and LERF.**	INCLUDE operator recovery actions that can restore the functions, systems or components on an as needed basis to provide a more realistic evaluation of **significant accident sequences.**	INCLUDE operator recovery actions that can restore the functions, systems or components **to provide a realistic evaluation of modeled accident sequences.**

EXPLANATION OF REQUIREMENT

This SR acknowledges that potential recovery actions can be identified for many of the failures identified as contributing to the accident sequences. Recovery actions are included as corrections to specific cut-sets rather than included at a higher level in the model, when they would be addressed by HLR-HF. The SR permits their inclusion on an as-needed basis, when not including them would lead to unrealistic results. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This SR is written to three different capabilities; represent different degrees of credit for recovery actions:

For Capability Category I, recovery actions are included to "provide a more realistic evaluation of CDF and LERF" which could be achieved by recovering failures in the dominant cut-sets, i.e., those that contribute the greatest contribution to CDF/LERF.

For Capability Category II, the recovery actions are included "to provide a more realistic evaluation of significant accident sequences," which, with the definition of significant accident sequence, would require recovery actions for relatively low frequency sequences.

For Capability Category III, the requirement extends to all sequences.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-H	Capability Category I	Capability Category II	Capability Category III
HR-H2	CREDIT operator recovery actions only if, on a plant-specific basis: *(a)* A procedure is available and operator training has included the action as part of crew's training, or justification for the omission for one or both is provided *(b)* "cues" (e.g., alarms) that alert the operator to the recovery action provided procedure, training or skill-of-the-craft exist *(c)* Attention is given to the relevant performance shaping factors provided in HR-G3 *(d)* There is sufficient manpower to perform the action.		

EXPLANATION OF REQUIREMENT

This SR limits the type of recovery actions that can be considered in the final evaluation of the PRA results. The conditions are self-explanatory. For the allowed recovery actions, it is expected that an HFE representing a failure to perform the recovery will be defined, and the corresponding HEP evaluated.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-H	Capability Category I	Capability Category II	Capability Category III
HR-H3	ACCOUNT for any dependency between the HFE for operator recovery and any other HFEs in the sequence, scenario or cut-set to which the recovery is applied (see HR-G7).		

EXPLANATION OF REQUIREMENT

This SR recognizes that, in principle, a recovery action is no different from the post-initiating event actions considered in HLR-HR-F, in that the probability of failure will be dependent on prior operator successes and failures, or the associated activity may be affected by similar PSFs. Therefore, the dependency between the HFE associated with recovery and those associated with the response actions addressed in HR-E through HR-G are to be assessed.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.5.9 Supporting Requirements for HLR-HR-I

ASME/ANS Standard Section 2.2.5, Table 2.2.5-2(i), Supporting Requirements for HLR-HR-I

HLR-HR-I:	Documentation of the human reliability analysis shall be consistent with the applicable governing supporting requirements.
Intent:	To ensure that the basis for the analysis is reproducible and can be reviewed and updated as necessary
SRs:	HR-I1 through HR-I3

Index No. HR-I	Capability Category I	Capability Category II	Capability Category III
HR-I1	DOCUMENT the human reliability analysis in a manner that facilitates PRA applications, upgrades and peer review.		

EXPLANATION OF REQUIREMENT

It is important that the documentation includes sufficient information about the approach used for the development of the pre-initiating and post-initiating human reliability analysis, such that an analyst or peer reviewer who was not involved in the original process could come to similar conclusions regarding the validity of the results and the veracity of the human reliability analysis to the as-built and as-operated plant. In this way an analyst would be able to understand the approach and would be able to support applications, upgrades and reviews of the PRA. Furthermore, the documentation is to be consistent with the applicable SRs as stated in High Level Requirement HR-I. Although examples are included in SR HR-I2, these do not represent a complete list of all required documentation. To facilitate the development of a complete list, a documentation mapping is provided in the explanation to SR HR-I2 showing the scope of documentation needed to achieve consistency with the applicable SRs.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-I	Capability Category I	Capability Category II	Capability Category III
HR-I2	DOCUMENT the processes used to identify, characterize and quantify the pre-initiator, post-initiator and recovery actions considered in the PRA, including the inputs, methods and results. For example, this documentation typically includes: *(a)* HRA methodology and process used to identify pre- and post-initiator HEPs *(b)* Qualitative screening rules and results of screening *(c)* Factors used in the quantification of the human action, how they were derived (their bases), and how they were incorporated into the quantification process *(d)* Quantification of HEPs, including: *(1)* Screening values and their bases *(2)* Detailed HEP analyses with uncertainties and their bases *(3)* The method and treatment of dependencies for post-initiator actions *(4)* Tables of pre- and post-initiator human actions evaluated by model, system, initiating event and function *(5)* HEPs for recovery actions and their dependency with other HEPs.		

EXPLANATION OF REQUIREMENT

This SR addresses the process documentation used to implement the human reliability analysis supporting requirements. It also provides examples of documentation associated with the human reliability analysis development processes and examples of documentation associated with the parameters, constraints and results from implementing these processes. Table 9 (HR-I2-1) provides a discussion of these examples. It should be noted that the documentation examples do not represent the complete list of all required documentation, but list of many of the documents that are typically included. To facilitate the development of a complete list, a documentation mapping is provided in Table 10 (HR-I2-2) showing the scope of documentation needed to achieve consistency with the applicable SRs. Table 10 (HR-I2-2) also identifies each documentation item as either "process" or "SR." A "process" documentation item primarily supports the process requirement which is the focus of this SR while an "SR" documentation item primarily supports documentation that is consistent with one or more supporting requirements as required by HR-I1. A mapping is also provided in Table 9 (HR-I2-1) between the examples and the documentation list shown in Table 10 (HR-I2-2) and in Table 10 (HR-I2-2) between the documentation items and the applicable SRs.

Table 9 HR-I2-1 SR Examples

SR Example	Discussion	Documentation Item
a	The identification process of pre-initiator, post-initiator and recovery actions is addressed by several SRs including: SR HR- A3, C1, C2, C3 and E2, F1, F2, H1. In addition, the identification of response and recovery actions is addressed by SRs within the accident sequence element.	1, 6
b	SR HR-B1 addresses screening rules for pre-initiators and SR HR-D2 and G1 address the use of screening values.	2, 7
c	The quantification process for pre-initiator, post-initiator and recovery actions is addressed by several SRs including: SR HR- A1, A2, A3, B1, B2, C1, C2, C3, D1, D2, D3, D4, D5, LE-C7 and E1, E2, E3, E4, F1, F2, G1, G2, G3, G4, G5, G7, G8, H1, H2, H3	2, 4, 7, 9
d(1)	SR HR-D2 and G1 address the use of screening values.	2, 7

SR Example	Discussion	Documentation Item
d(2)	The quantification of the HEPs is addressed by high level requirements D, G and H, and their associated supporting requirements.	4, 9
d(3)	The treatment of dependencies is addressed by SR HR-D5 for pre-initiator actions, SR HR-G7 for post-initiator actions and SR HR-H3 for recovery actions.	2, 4, 7, 9
d(4)	Although there are no explicit requirements for presenting the HR results in a tabular fashion, it is expected that the results will be presented in a manner that supports the understanding of the approach and supports applications, upgrades and reviews.	4, 9
d(5)	High Level Requirement HR-H addresses recovery actions and the assessment of dependencies with other HFEs.	7, 9

Table 10 HR-I2-2 Documentation Mapping

Element	Type	Item	Documentation	Related SR	SR Examples
HR	Process	1	Pre-initiators - Document the approach for identifying maintenance, test and calibration errors including mechanism impacting multiple trains, failure to restore equipment and miscalibration.	A3, C1, C2, C3	a
HR	Process	2	Pre-initiators - Document the screening rules and the approach used for quantification.	A1, A2, A3, B1, B2, C1, C2, C3, D1, D2, D3, D4, D5, LE-C7	b, c, d3
HR	SR	3	Pre-initiators - Document the review of procedures and practices.	A1, A2	
HR	SR	4	Pre-initiators - Document HEPs and supporting calculations including an assessment of the uncertainty.	D1, D2, D3, D4, D5, D6	c, d1, d2, d3, d4, d5
HR	SR	5	Pre-initiators - Document the plant experience reasonableness check (Category III only).	D7	na
HR	Process	6	Post-initiators - Document the approach for identification of post-initiator Response and Recovery Actions.	E2, F1, F2, H1	a
HR	Process	7	Post-Initiators - Document the approach for post-initiator action screening (rules) and the approach used for quantification.	E1, E2, E3, E4, F1, F2, G1, G2, G3, G4, G5, G7, G8, H1, H2, H3	b, c, d3
HR	SR	8	Post-Initiators - Document the review of procedures and system operation.	E1, E3, E4	na
HR	SR	9	Post-Initiators - Document HEPs and supporting calculations including uncertainty.	G1, G2, G3, G4, G5, G7, G8, H2, H3, LE-C7	c, d1, d2, d3, d4, d5
HR	SR	10	Post-Initiators - Document the consistency and reasonableness check.	G6	na

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. HR-I	**Capability Category I**	**Capability Category II**	**Capability Category III**
HR-I3	DOCUMENT the sources of model uncertainty and related assumptions (as identified in QU-E1 and QU-E2) associated with the human reliability analysis.		

EXPLANATION OF REQUIREMENT

Model uncertainty arises because uncertainty exists about which models appropriately represent the aspects of the plant being modeled. In addition, there may be no model representing a particular aspect of the plant. This adds to uncertainty about the PRA findings because it may be unclear whether the PRA fails to consider a potentially significant contributor. The uncertainty associated with the model and its constituent parts typically is dealt with by making assumptions. In general, model uncertainties are addressed by determining the sensitivity of the PRA results to different assumptions or models.

NUREG-1855 [NRC 2009] gives guidance for addressing sources of model uncertainty and related assumptions in the context of the requirements in the ASME/ANS PRA Standard, and is specifically focused on accomplishing SRs QU-E1, QU-E2, QU-E4, and LE-F3 that are related to model uncertainty. The EPRI report 1016737, "Treatment of Parameter and Model Uncertainty for Probabilistic Risk Assessments," [EPRI 2008] also addresses this uncertainty, and in particular, its Appendix B identifies several sources of this uncertainty to support meeting SR HR-I3.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.6 Data Analysis Section 2-2.6 of the ASME/ANS RA-Sa-2009

The objectives of the data analysis elements are to provide estimates of the parameters used to determine the probabilities of the basic events representing equipment failures and unavailabilities modeled in the PRA in such a way that

(a) Parameters, whether estimated on the basis of plant-specific or generic data, appropriately reflect that configuration and operation of the plant

(b) Component or system unavailabilities due to maintenance or repair are accounted for

(c) Uncertainties in the data are understood and appropriately accounted for.

To meet the above objectives, five HLRs are defined in the standard:

Designator	Requirement
HLR-DA-A	Each parameter shall be clearly defined in terms of the logic model, basic event boundary and the model used to evaluate event probability.
HLR-DA-B	Grouping components into a homogeneous population for parameter estimation shall consider both the design, environmental and service conditions of the components in the as-built and as-operated plant.
HLR-DA-C	Generic parameter estimates shall be chosen and plant-specific data shall be collected consistent with the parameter definitions of HLR-DA-A and the grouping rationale of HLR-DA-B.
HLR-DA-D	The parameter estimates shall be based on relevant generic industry or plant-specific evidence. Where feasible, generic and plant-specific evidence shall be integrated using acceptable methods to obtain plant-specific parameter estimates. Each parameter estimate shall be accompanied by a characterization of the uncertainty.
HLR-DA-E	Documentation of the data analysis shall be consistent with the applicable supporting requirements.

5.6.1 Supporting Requirements for HLR-DA-A

ASME/ANS Standard Section 2.2.6, Table 2.2.6-2(a), Supporting Requirements for HLR-DA-A

HLR-DA-A:	Each parameter shall be clearly defined in terms of the logic model, basic event boundary and the model used to evaluate event probability.
Intent:	To define each parameter in terms of the piece of equipment and failure mode to which it applies, and the data required for its estimation (e.g., # failures and # demands). This definition needs to clearly describe the relationships between the parameter, the basic events in the PRA model associated with the parameter and the probability model used to calculate the basic event probability using the parameter. The term "boundary" is used to ensure consistency between component boundaries implied in the definition of the basic event and the component boundaries assumed in the collection and analysis of data supporting the estimation of the parameter.
SRs:	DA-A1 through DA-A4

Index No. DA-A	Capability Category I	Capability Category II	Capability Category III
DA-A1	IDENTIFY from the systems analysis the basic events for which probabilities are required. Examples of basic events include: *(a)* Independent or common cause failure of a component or system to start or change state on demand *(b)* Independent or common cause failure of a component or system to continue operating or provide a required function for a defined time period *(c)* Equipment unavailable to perform its required function due to being out of service for maintenance *(d)* Equipment unavailable to perform its required function due to being in test mode *(e)* Failure to recover a function or system (e.g., failure to recover off-site-power) *(f)* Failure to repair a component, system or function in a defined time period		

EXPLANATION OF REQUIREMENT

Meeting this SR determines the scope of the parameter estimation task to ensure that a probability will be estimated for every basic event in the PRA model.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-A	Capability Category I	Capability Category II	Capability Category III
DA-A2	ESTABLISH definitions of SSC boundaries, failure modes and success criteria consistent with corresponding basic event definitions in Systems Analysis (SY-A5, SY-A7, SY-A8, SY-A9 through SY-A14 and SY-B4) for failure rates and common cause failure parameters, and ESTABLISH boundaries of unavailability events consistent with corresponding definitions in Systems Analysis (SY-A19).		

EXPLANATION OF REQUIREMENT

The purpose of this SR is to establish a traceable interface between the systems analysis task and the data analysis task. The data analyst needs to know how each basic event is defined to ensure that the parameters estimated are appropriate for determining the probabilities of those basic events. For a component failure for example, the data analyst needs to understand what piece parts are included within a component boundary and how failure is defined (i.e., what failure criterion is used to analyze data to determine the number of failures) so that he can determine that the data collected or generic estimates are appropriate. As indicated by the way the SR is written, the definitions are addressed further in other SRs, such as SY-A8 for component boundaries, and SY-A14 and DA-C4 for failure modes and failure definition respectively. For common cause failure parameters, the analyst needs to identify the common cause component grouping (SY-B3) in addition to the component boundaries and the definition of failure. The component boundaries and definition of failure used to derive common cause failure parameters need to be the same as those for the individual components within the group (See DA-D6).

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-A	Capability Category I	Capability Category II	Capability Category III
DA-A3	USE an appropriate probability model for each basic event. Examples include: *(a)* binomial distributions for failure on demand *(b)* Poisson distributions for standby and operating failures and initiating events.		

EXPLANATION OF REQUIREMENT

The purpose of this SR is to ensure that the appropriate probability model is used for data analysis that is used to support the estimation of parameters associated with basic events. Two examples are given. The probability models referred to here are probability models for predicting the likelihood of the number of failures that are expected over a number of component demands for (a) or a number of component hours of service for (b). For the failure mode of failure on demand, the generally accepted assumption is that of a constant probability of failure on demand, the underlying model for which is that, in successive series of trials, the failures are binomially distributed. It is necessary to understand this to determine what data is needed to estimate the parameter, whether one is using a classical statistical approach or the Bayesian approach ensure. When using the Bayesian approach, knowledge of the underlying statistical model is necessary to ensure that the appropriate likelihood function is used when applying Bayes' theorem. In either case, the data required for estimation is the number of failures in the total number of trials. For operating failures or initiating events the typical assumptions is that they are uniformly distributed in time. The underlying probability model for this is that, in successive series of trials, failures are distributed according to the Poisson distribution. The data required for parameter estimation is then the number of failures in the total time on trial. Details of the estimation process can be found, for example, in NUREG/CR-6823.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

<table>
<tr><th>Index No.
DA-A</th><th>Capability Category I</th><th>Capability Category II</th><th>Capability Category III</th></tr>
<tr><td>DA-A4</td><td colspan="3">IDENTIFY the parameter to be estimated and the data required for estimation. Examples are as follows:
(a) For failures on demand, the parameter is the probability of failure, and the data required are the number of failures given a number of demands;
(b) For standby failures, operating failures and initiating events, the parameter is the failure rate, and the data required are the number of failures in the total (standby or operating) time;
(c) For unavailability due to test or maintenance, the parameter is the unavailability on demand, and the alternatives for the data required include:
(1) The total time of unavailability OR a list of the maintenance events with their durations, together with the total time required to be available; OR
(2) The number of maintenance or test acts, their average duration and the total time required to be available.</td></tr>
</table>

EXPLANATION OF REQUIREMENT

The purpose of this SR is to ensure that, when data is collected for parameter estimation, it is of the correct form in terms of the information required to estimate each type of parameter, given the underlying probability model for the basic event, which is required to meet DA-A3. The three examples given are for the most commonly used models for basic events. When generic estimates only are used, the parameter estimates may be provided directly, without providing details of the underlying data. Further requirements related to the collection of plant data are dealt with under HLR-DA-C.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.6.2 Supporting Requirements for HLR-DA-B

ASME/ANS Standard Section 2.2.6, Table 2.2.6-2(b), Supporting Requirements for HLR-DA-B

HLR-DA-B:	Grouping components into a homogeneous population for parameter estimation shall consider both the design, environmental and service conditions of the components in the as-built and as-operated plant.
Intent:	To enable sparse data to be grouped where possible to provide a basis for parameter estimation without masking significant variability in performance among the components.
SRs:	DA-B1 through DA-B2

Index No. DA-B	Capability Category I	Capability Category II	Capability Category III
DA-B1	For parameter estimation, GROUP components according to type (e.g., motor-operated pump, air-operated valve).	For parameter estimation, GROUP components according to type (e.g., motor-operated pump, air-operated valve) and **according to the characteristics of their usage to the extent supported by data:** ***(a)*** **Mission type (e.g., standby, operating)** ***(b)*** **Service condition (e.g., clean vs. untreated water, air)**	For parameter estimation, GROUP components according to type (e.g., motor-operated pump, air-operated valve**) and according to the detailed characteristics of their usage to the extent supported by data:** **(a) Design/size** **(b) System characteristics** **(1) Mission type (e.g., standby, operating)** **(2) Service condition (e.g., clean vs. untreated water, air)** **(3) Maintenance practices** **(4) Frequency of demands** **(c) Environmental conditions** **(d) Other appropriate characteristics**

EXPLANATION OF REQUIREMENT

The purpose of this requirement is to define a component group for which the parameter(s) will be the same for all members of that group. This means that the performance of components within a group in terms of their reliability and availability characteristics is not expected to vary significantly. This is important because once the grouping is fixed the data parameter estimates will be the same for each member of the group and such averaging could mask a significant variability if not done properly. Grouping has an advantage in that it broadens the pool of data available for parameter estimation. Inappropriate grouping can result in estimating a failure probability of a component group that does incorrectly represent the reliability of an individual component within the group. The grouping can be more high level to more detailed, but still needs to encompass components with similar characteristics. At a minimum level, only components of the same type are to be grouped. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

The capability categories are meant to reflect the different degree of realism that will be estimated for the component reliability and availability.

For Capability Category I, the intent of the grouping is meant to establish the minimum characteristics defining a component group. Capability Category I strategy will reduce the complexity of the model at the expense of model detail. By selecting this grouping strategy it is expected that the absolute risk predictions will be conservatively biased.

For Capability Category II, the intent of the grouping is meant to be more refined over Capability Category I. As such, a component group is defined by the type of component under consideration **and** two general characteristics of the component usage: mission type and service condition.

For Capability Category III, the intent of the grouping is meant to be more refined over Capability Category II. As such, a component group is defined by the type of component under consideration **and** seven detailed characteristics of the component usage: (1) design and size, (2) mission type, (3) service condition, (4) maintenance practices, (5) frequency of demands, (6) environments conditions and (7) other appropriate characteristics.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-B	Capability Category I	Capability Category II	Capability Category III
DA-B2	DO NOT INCLUDE outliers in the definition of a group (e.g., do not group valves that are never tested and unlikely to be operated with those that are tested or otherwise manipulated frequently)		DO NOT INCLUDE outliers in the definition of a group (e.g., do not group values that are never tested and unlikely to be operated with those that are tested or otherwise manipulated frequently). **When warranted by sufficient data, USE appropriate hypothesis tests to ensure that data from grouped components are from compatible populations.**

EXPLANATION OF REQUIREMENT

The grouping characteristics in DA-B1 are fairly general for capability categories I and II. The purpose of this requirement is to exclude from the groups identified according to SR DA-B1, those components that are sufficiently different in some aspect of their design or operation, that their reliability would not be representative of that group. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

For all three capability categories, the requirement is written in terms of what not to include in a group based on the identification of the component being an outlier.

For Capability Category III, there is an additional requirement to perform hypothesis tests to ensure that the grouping of components is appropriate, when sufficient data is available to make those tests feasible. The hypothesis tests would give statistical weight to the lack or existence of outlier behavior.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.6.3 Supporting Requirements for HLR-DA-C

ASME/ANS Standard Section 2.2.6, Table 2.2.6-2(c), Supporting Requirements for HLR-DA-C

HLR-DA-C:	Generic parameter estimates shall be chosen and plant-specific data shall be collected consistent with the parameter definitions of HKR-DA-A and the grouping rationale of HLR-DA-B.
Intent:	To ensure that the data collected is consistent with the requirements for the parameter estimation and that there is consistency between the generic and plant-specific data with respect to failure modes, success criteria and basic event boundaries.
SRs:	DA-C1 through DA-C16

The scope of parameters for which plant-specific data is to be collected is determined by HLR-DA-D, and specifically SR DA-D1, and differs with capability category. Thus, SRs DA-C2 through DA-C-16 are applied to the parameters within the scope determined by DA-D1.

Within this HLR, it is helpful to group some of the SRs by the aspect of data collection they address.

- DA-C4 and DA-C5 address counting the number of failures
- DA-C6 and DA-C7 address counting the number of demands which is needed for the estimation of the probability of failure on demand for standby components
- DA-C11 through DA-C14 are related to the estimation of unavailability due to planned activities such as maintenance.

Index No. DA-C	Capability Category I	Capability Category II	Capability Category III
DA-C1	OBTAIN generic parameter estimates from recognized sources. ENSURE that the parameter definitions and boundary conditions are consistent with those established in response to DA-A1 to DA-A4. [Example: some sources include the breaker within the pump boundary, whereas others do not.] DO NOT INCLUDE generic data for unavailability due to test, maintenance and repair unless it can be established that the data is consistent with the test and maintenance philosophies for the subject plant. Examples of parameter estimates and associated sources include: *(a)* Component failure rates and probabilities: NUREG/CR-4639 [NOTE (1)], NUREG/CR-4550 [NOTE (2)] *(b)* Common cause failures: NUREG/CR-5497 [NOTE (3)], NUREG/CR-6268 [NOTE (4)] *(c)* AC off-site power recovery: NUREG/CR-5496 [NOTE (5)], NUREG/CR-5032 [NOTE (6)] *(d)* Component recovery.		

NOTE (1): NUREG/CR-4639, Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR), Vols. 1-5, 1994

NOTE (2): NUREG/CR-4550, Vol. 1, Analysis of Core Damage Frequency: Internal Events Methodology, January 1990

NOTE (3): NUREG/CR-5497, Common-Cause Failure Parameter Estimations

NOTE (4): NUREG/CR-6268, Common Cause Failure Database and Analysis System, Vols. 1–4, 1998

NOTE (5): NUREG/CR-5496, Evaluation of Loss of Offsite Power Events at Nuclear Power Plants: 1980–1986

NOTE (6): NUREG/CR-5032, Modeling Time to Recover and Initiate Even Frequency for Loss-of-Offsite Power Incidents at Nuclear Power Plants, March 1988

EXPLANATION OF REQUIREMENT

When choosing parameter estimates from generic sources, they need to be compatible with the needs of the PRA model. As the example given illustrates, the parameters in various sources may represent different boundary conditions for the events. Some generic data may not apply if there are significant difference in design between the plants represented in the generic data and the plant being analyzed in the PRA. The requirement not to use generic data for unavailability due to test, maintenance and repair, unless it can be established that the data is consistent with the test and maintenance philosophies of the plant, is simply a reflection of the potential differences between plant practices.

In order to meet this requirement, the applicability and consistency of the generic data in terms of failure modes, success criteria and component boundaries needs to be justified.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-C	Capability Category I	Capability Category II	Capability Category III
DA-C2	COLLECT plant-specific data for the basic event/parameter grouping corresponding to that defined by requirement DA-A1, DA-A3, DA-A4, DA-B1 and DA-B2.		

EXPLANATION OF REQUIREMENT

The collection of plant-specific data is done in such a way as to be compatible with the estimation of the parameter appropriate to the definition of the basic event. For basic events representing component failures, the definition includes the boundary of the component, the failure mode and the success criteria. The success criteria are addressed more fully in DA-C4. For basic events related to unavailability resulting from test or maintenance, the unit to which the unavailability is applied, e.g., component, segment or train needs to be defined. The requirements under DA-B determine which plant-specific data can be grouped for the purposes of parameter estimation. For example, the data for all pumps in the same system are typically grouped. The advantage of grouping the data for like components is that it expands the pool of data, which in turn reduces the statistical uncertainty on the parameter estimate. This is particularly important because nuclear power plant components are generally highly reliable, and there are typically very few failures.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-C	Capability Category I	Capability Category II	Capability Category III
DA-C3	COLLECT plant-specific data, consistent with uniformity in design, operational practices and experience. JUSTIFY the rationale for screening or disregarding plant-specific data (e.g., plant design modifications, changes in operating practices).		

EXPLANATION OF REQUIREMENT

A PRA model is typically developed to represent the as-built, as-operated plant. Therefore, the plant-specific data should correspond to the current status of the plant. Because the PRA modeling approach typically assumes constant parameter values, the analyst needs to have confidence that the parameters are effectively constant over the time collection period. This has to be balanced against expanding the time frame of data collection to enlarge the pool of data, in order to reduce the uncertainty in parameter estimates. However, it is recognized that plant practices may have changed, or design modification made, that would have an effect on the failure probabilities or unavailability. This SR provides the conditions for expanding the time base for data collection. It also requires that, if some data is not included, the reason for its exclusion should be given, and it should relate to distinct changes in plant practices or design. Hence, meeting this requirement requires a balancing of interests between the desire on the one hand to collect statistically significant data to minimize uncertainty, and on the other hand the downside associated with masking significant trends in equipment or plant performance.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-C	Capability Category I	Capability Category II	Capability Category III
DA-C4	When evaluating maintenance or other relevant records to extract plant-specific component failure event data, DEVELOP a clear basis for the identification of events as failures. **DISTINGUISH between those degraded states for which a failure, as modeled in the PRA, would have occurred during the mission and those for which a failure would not have occurred (e.g., slow pick up to rated speed).** Include all failures that would have resulted in failure to perform the mission as defined in the PRA.		

EXPLANATION OF REQUIREMENT

Maintenance records are typically the best source of data on equipment failures. The majority of maintenance records are not representative of the failures assumed in the PRA, although they are used to estimate unavailability due to maintenance (see DA-C11). Counting all the maintenance records would give a very conservative estimate of failure probabilities or failure rates. Component failures in PRA models are associated with a failure to perform the function required to meet the success criteria assumed in the PRA. Catastrophic failures are clearly counted as failures, some degraded states may be, but incipient failures, i.e., very slight degradation, would typically not be. Some judgment is needed to interpret whether the degree of degradation would constitute failure in the PRA sense. For example, if a pump is only delivering 300 gpm, when the success criteria would require 500 gpm, it can be classified as a failure, but when the pump is delivering 490 gpm, it is not so clearly such, particularly if the success criteria are somewhat conservative.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-C	Capability Category I	Capability Category II	Capability Category III
DA-C5	COUNT repeated plant-specific component failures occurring within a short time interval as a single failure if there is a single, repetitive problem that causes the failures. In addition, COUNT only one demand.		

EXPLANATION OF REQUIREMENT

In some cases, there may be a number of related failure records that are reflective of the fact that the problem was not fixed at a first attempt, and counting them as separate failures would be conservative. This is because the PRA models for basic events assume that each component is brought back to an "as good as new" condition following maintenance or repair. The situations addressed in this SR are indicative of a single failure that was not adequately repaired. The alternative provided here is to regard this series of failures as evidence of a single cause of failure, one of the many causes that could result in failure, as long as it can be ascertained that there is indeed only one cause for each of the successive failures. In this context, a short time interval is one that is less than the expected time between demands for the component for a standby component or less than its normal operating cycle for an operating component.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-C	Capability Category I	Capability Category II	Capability Category III
DA-C6	DETERMINE the number of plant-specific demands on standby components on the basis of the number of: *(a)* Surveillance tests *(b)* Maintenance acts *(c)* Surveillance tests or maintenance on other components *(d)* Operational demands. DO NOT COUNT additional demands from post-maintenance testing; that is part of the successful renewal.		

EXPLANATION OF REQUIREMENT

The term "standby component," as used in this and other requirements in this section of the standard, is used to identify those components whose failure probability is evaluated as a failure on demand. As indicated in DA-A4(a), the number of demands is needed to estimate the probability of failure on demand. This SR gives a list of the sources of demands that should be taken into account. Demands that are part of the repair process, such as from post-maintenance testing are excluded because they just provide confirmation that that component is brought back to as "good as new" condition as assumed in PRA modeling.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-C	Capability Category I	Capability Category II	Capability Category III
DA-C7	**ESTIMATE** number of surveillance tests and planned maintenance activities on **plant requirements.**	**BASE** number of surveillance tests on **plant surveillance requirements and actual practice. BASE** number of planned maintenance activities **on plant maintenance plans and actual practice. BASE number of unplanned maintenance acts on actual plant experience.**	

EXPLANATION OF REQUIREMENT

This SR elaborates on the estimation of the number of surveillance tests and plant maintenance activities identified as being required in DA-C6. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

For Capability Category I, the requirement is to estimate the number of tests and maintenance activities on the basis of the documents that specify the required frequency of the associated activities. For maintenance activities in particular, this would result in a potential underestimate of the total demands, since only planned maintenance activities are specified. Such an approach would result in a conservative assessment of failure probabilities, all other things being equal. However, the number of unplanned maintenance activities is typically not large for reliable components.

For Capability Category II and III, the estimation is based on the specific plant practices. The most accurate source for this information would be the plant surveillance and maintenance records that would include both planned and unplanned events involving unavailability. The plant experience is specified as the source for unplanned maintenance activities. This provides a more accurate estimation of the number of demands.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-C	Capability Category I	Capability Category II	Capability Category III
DA-C8	When required, **ESTIMATE** the time that components were configured in their standby status.	When required, **USE plant-specific operational records to determine** the time that components were configured in their standby status.	

EXPLANATION OF REQUIREMENT

Two approaches are frequently used for the modeling of standby component failures; the failure on demand model or the standby failure rate model. Either approach is sufficient for most purposes, but the latter is used less frequently than the former, hence the phrase "when required." As indicated in DA-A4(b), the total number of component hours in the standby mode is needed to estimate the (standby) failure rate for standby components. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

For Capability Category I, an estimation of the time in standby is adequate, whereas,

For Capability Category II and III, plant-specific records are required to be reviewed. This will be a more accurate assessment of the time on standby.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-C	Capability Category I	Capability Category II	Capability Category III
DA-C9	**ESTIMATE** operational time from surveillance test **practices** for standby components, and from actual operational data.		**DETERMINE** operational time from surveillance test **records** for standby components, and from actual operational data.

EXPLANATION OF REQUIREMENT

As indicated in DA-A4(b), the total operating time is needed to estimate the operating failure rate for components both for normally operating components and for standby components when they are in operation. For standby components, the operating time consists of two contributions; first there is some operating time associated with the surveillance tests on the systems themselves in which case the total time in operation during the tests needs to be determined, and second, there is operating time when the standby system is in operation as a result of an actual demand, whether it be automatically or a manually initiated. For example, the suppression pool cooling system in a BWR is a standby system, but may be used to cool the pool in hot weather and also used during testing of steam driven systems such as HPCI and RCIC. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

For Capability Category I and II, the component associated with the surveillance tests for standby components can be estimated on the basis of test practices. The test procedures may or may not specify the minimum duration of the test. These tests typically provide a short amount of operating time. When standby components are operated as a result of a demand, the times are typically longer, though the instances may be considerably fewer.

For Capability Category III, a more accurate estimate for standby components is based on supplementing the operational history with data from actual plant surveillance test records.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-C	Capability Category I	Capability Category II	Capability Category III
DA-C10	When using surveillance test data, REVIEW the test procedure to determine whether a test should be credited for each possible failure mode. COUNT only completed tests or unplanned operational demands as success for component operations.	When using surveillance test data, REVIEW the test procedure to determine whether a test should be credited for each possible failure mode. COUNT only completed tests or unplanned operational demands as success for component operation. **If the component failure mode is decomposed into sub-elements (or causes) that are fully tested, then USE tests that exercise specific sub-elements in their evaluation. Thus, one sub-element sometimes has many more successes than another.** [Example: a diesel generator is tested more frequently than the load sequencer. IF the sequencer was to be included in the diesel generator boundary, the number of valid tests would be significantly decreased.]	When using surveillance test data, REVIEW the test procedure to determine whether a test should be credited for each possible failure mode. COUNT only completed tests or unplanned operational demands as success for component operation. **DECOMPOSE the component failure mode into sub-elements (or causes) that are fully tested, and USE tests that exercise specific sub-elements in their evaluation. Thus, one sub-element sometimes has many more successes than another.**

EXPLANATION OF REQUIREMENT

This SR provides additional requirements associated with using surveillance test data to estimate the number of demands. The motivation behind this SR is that there are different types of surveillance tests for a particular component, and not all of them necessarily test each piece part of the component as it is defined in the PRA (DA-A2). Furthermore, a particular test may only reveal a specific failure mode of the component and not other failure modes. In addition, a given test on a system or train may not provide an indication that all the components in the system or train have successfully performed their functions. For example a pump discharge check valve that is supposed to reclose following a pump test may not provide a positive indication that the valve had reclosed during the test. Therefore, the nature of the test has to be understood to correctly count the number of demands associated with a component, piece part or failure mode whose occurrence can actually be observed during the test.

One approach to addressing the differences between piece parts would be to decompose the basic event representing a component failure mode into different basic events corresponding to the failure modes of the sub-components. However, this requirement is written as if the subcomponents are all included in the component boundary, and the failure probability (or rate) would be composed of different contributions, each estimated with the appropriate data. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

For Capability Category I, the SR only addresses the applicability of the test to the failure mode. It also specifies that for a test to be counted as a success, the test had to be completed.

For Capability Category II, in addition to what is required for CC I, this requirement addresses the possibility that different tests may only exercise certain piece parts of the component, and that the number of successes for the piece parts can be different. The classic example is that of the diesel generator component, for which the boundary is often defined to include the load sequencer. The sequencer is typically only tested on the "station blackout" test, and not on the manual starts that are performed more frequently. For capability category II, the decomposition is optional.

For Capability Category III, the decomposition is required.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-C	Capability Category I	Capability Category II	Capability Category III
DA-C11	When using data on maintenance and testing durations to estimate unavailabilities at the component, train or system level, as required by the system model, only INCLUDE those maintenance or test activities that could leave the component, train or system unable to perform its function when demanded.		

EXPLANATION OF REQUIREMENT

DA-C11 through DA-C14 can be considered together. SR DA-C11 is focused on identification of the activities that lead to unavailability. DA-C12 and DA-C14 are focused on how to account for different maintenance durations, and DA-C13 is addressing the evaluation of the unavailable time. The data required to estimate the unavailability due to test or maintenance is identified in DA-A4(c). The only way to get an accurate estimate is through plant records. However, not all maintenance or test activities leave the component, train or system unavailable to perform its function should it be demanded, and such records should not be used to determine the unavailable time. Only those time periods when the component, train or system was unable to perform its function in accordance with the specified success criteria used in the PRA model should be counted in the estimation of test or maintenance unavailability.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-C	Capability Category I	Capability Category II	Capability Category III
DA-C12	When an unavailability of a front line system component is caused by an unavailability of a support system, COUNT the unavailability towards that of the support system and not the front line system, in order to avoid double counting and to capture the support system dependency properly.		

EXPLANATION OF REQUIREMENT

This is self-explanatory.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

<table>
<tr><th>Index No.
DA-C</th><th>Capability Category I</th><th>Capability Category II</th><th>Capability Category III</th></tr>
<tr><td>DA-C13</td><td>EVALUATE the duration of the actual time that the equipment was unavailable for each contributing activity. Since maintenance outages are a function of the plant status, INCLUDE only outages occurring during plant at power. Special attention should be paid to the case of a multi-plant site with shared systems, when the Technical Specifications (TS) requirements can be different depending on the status of both plants. Accurate modeling generally leads to a particular allocation of outage data among basic events to take this mode dependence into account. In the case that reliable estimates of the start and finish times of periods of unavailability are not available, provide conservative estimates.</td><td colspan="2">EVALUATE the duration of the actual time that the equipment was unavailable for each contributing activity. Since maintenance outages are a function of the plant status, INCLUDE only outages occurring during plant at power. Special attention should be paid to the case of a multi-plant site with shared systems, when the Specifications (TS) requirements can be different depending on the status of both plants. Accurate modeling generally leads to a particular allocation of outage data among basic events to take this mode dependence into account. In the case that reliable estimates or the start and finish times are not available, INTERVIEW the knowledgeable plant personnel (e.g., engineering, plant operations, etc.) to generate estimates of ranges in the unavailable time per maintenance act for components, trains or systems for which the unavailabilities are significant basic events.</td></tr>
</table>

EXPLANATION OF REQUIREMENT

This requirement is largely self-explanatory. It does recognize that the maintenance practices can vary significantly with plant operating status. For example, some plants may do major overhauls on critical equipment during an outage, whereas others may do them on-line. Since this standard is for at-power status, only the unavailable times during at-power operations should be counted.

It also recognizes that the start and end times that are obtained from plant records, such as the control room logs, may not provide an accurate assessment of the unavailable time. For example, the entries in the log may refer to the period the equipment was tagged out, rather than the period in which the equipment was physically unavailable. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

For all three capability categories, the major part of the requirement is common. The only difference between the capability categories is in response to the recognition that in very many cases, the precise starting and ending time of the activities of interest is unknown.

For Capability Category I, conservative estimates of the duration of the activity should be provided

For Capability Category II and III, a more thorough assessment is obtained by interviewing knowledgeable plant staff, to try to establish more realistic ranges of times of unavailability. Because this could be very time consuming, this is only required for the cases that are significant basic events.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-C	Capability Category I	Capability Category II	Capability Category III
DA-C14	EXAMINE coincident unavailability due to maintenance for redundant equipment (both intrasystem and intersystem) **that is a result of a planned, repetitive activity** based on actual plant experience. CALCULATE coincident maintenance unavailabilities that are **a result of a planned, repetitive activity** that reflect actual plant experience. Such coincident maintenance unavailability can arise, for example, for plant systems that have "installed spares," i.e., plant systems that have more redundancy than is addressed by tech specs. For example **(intrasystem case)**, the charging system in some plants has a third train that may be out of service for extended periods of time coincident with one of the other trains and yet is in compliance with tech specs. **Examples of intersystem unavailability include plants that routinely take out multiple components on a "train schedule" (such as AFW train A and HPI train A at a PWR, or RHR train A and LPCS train A at a BWR).**		

EXPLANATION OF REQUIREMENT

This SR is self-explanatory, and is related to SY-A20.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-C	Capability Category I	Capability Category II	Capability Category III
DA-C15	For each SSC for which repair is to be modeled (see SY-A22), IDENTIFY instances of plant-specific or applicable industry experience and for each repair, COLLECT the associated repair time with the repair time being the period from identification of the component failure until the component is returned to service.		

EXPLANATION OF REQUIREMENT

Repair of component failures is typically only modeled for a limited number of systems, and for scenarios in which there is a significant time before the effect of the failure becomes irreversible relative to the expected repair time. Repair is sometimes modeled for diesel generators and for RHR systems where the time available to effect the repair is several hours. Data on repair is relatively scarce on a plant-specific basis and a broader industry perspective may be necessary to obtain a statistically meaningful sample. This SR focuses on specifying how the data should be collected based on the underlying assumption that the repair model is applied from the time that the failure is identified. If the repair model used in the PRA is applied from the time of component failure, then the repair time needs to also include the time to detect the need for repair.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has provided the following qualification. This SR provides a justification for crediting equipment repair (SY-A24). As written, it could be interpreted as allowing plant-specific data to be discounted in favor of industry data. In reality, for such components as pumps, plant-specific data is likely to be insufficient and a broader base is necessary. Therefore, the qualification is to rewrite the SR in the following way: …IDENTIFY instances of plant-specific **experience** ~~or~~ **and, when that is insufficient to estimate failure to repair consistent with DA-D9,** applicable industry experience and for each repair, COLLECT….

Index No. DA-C	Capability Category I	Capability Category II	Capability Category III
DA-C16	Data on recovery from loss of off-site power, loss of service water, etc. are rare on a plant-specific basis. If available, for each recovery, COLLECT the associated recovery time with the recovery time being the period from identification of the system or function failure until the system or function is returned to service.		

EXPLANATION OF REQUIREMENT

The first sentence is a simple recognition that this type of data is not expected to be abundant on a plant-specific basis. However, if it is available and is to be used, this requirement addresses the specification of the end points of the time intervals required.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.6.4 Supporting Requirements for HLR-DA-D

ASME/ANS Standard Section 2.2.6, Table 2.2.6-2(d), Supporting Requirements for HLR-DA-D

HLR-DA-D:	The parameter estimates shall be based on relevant generic industry or plant-specific evidence. Where feasible, generic and plant-specific evidence shall be integrated using acceptable methods to obtain plant-specific parameter estimates. Each parameter estimate shall be accompanied by a characterization of the uncertainty.
Intent:	To ensure that the most relevant evidence is used as a basis for deriving the parameter estimates and that the estimation techniques are used appropriately and provide a characterization of uncertainty. The estimates need to be accountable to both generic and plant-specific experience both respect to the point estimate and the uncertainty. One component of uncertainty is plant to plant variability which requires the use of generic data.
SRs:	DA-D1 through DA-D8

Index No. DA-D	Capability Category I	Capability Category II	Capability Category III
DA-D1	USE plant-specific parameter estimates for events modeling the unique design or operational features if available, or use generic information modified as discussed in DA-D2; USE generic information for the remaining events.	CALCULATE realistic parameter estimates **for significant basic events** based on relevant generic and plant-specific evidence unless it is justified that there are adequate plant-specific data to characterize the parameter value and its uncertainty. When it is necessary to combine evidence from generic and plant-specific data USE a Bayes update process or equivalent statistical process that assigns appropriate weight to the statistical significance of the generic and plant-specific evidence and provides an appropriate characterization of uncertainty. CHOOSE prior distributions as either non-informative, or representative of variability in industry data. **CALCULATE parameter estimates for the remaining events by using generic industry data.**	CALCULATE realistic parameter estimates based on relevant generic and plant-specific evidence unless it is justified that there are adequate plant-specific data to characterize the parameter value and its uncertainty. When it is necessary to combine evidence from generic and plant-specific data USE a Bayes update process or equivalent statistical process that assigns appropriate weight to the statistical significance of the generic and plant-specific evidence and provides an appropriate characterization of uncertainty. CHOOSE prior distributions as either non-informative, or representative of variability in industry data.

EXPLANATION OF REQUIREMENT

This SR recognizes that there are a number of approaches to parameter estimation. However, it is only for capability categories II and III that the approaches are identified. The SR also addresses the use of generic versus plant-specific data. Plant-specific data is preferable for a realistic assessment of the plant risk. However, because of the high reliability of the system components, it is not plentiful, and therefore, may be supplemented by generic industry wide data. In addition, some parameters exhibit a high degree of plant to plant variability which contributes to the uncertainty for the parameter at a specific plant. Hence, even though the best evidence available for the point estimate may be the plant-specific evidence, generic data is useful to characterize the plant to plant variability. When both generic and plant-specific evidence is applied, there needs to be an acceptable method to place statistical weight on each source. Bayes' methods provide one acceptable approach to accomplish this objective. When using Bayes' methods it is acceptable to use a non-informative prior, or when an informative prior is used it should be representative of the plant to plant variability in the industry data. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

The differentiation between the capability categories follows precisely the differentiation under plant-specificity in Table 1.11-3.2. In addition:

For Capability Category I, there is no requirement related to the approach to be used for parameter estimation.

For Capability Categories II and III, a Bayes or equivalent approach to combining plant-specific and generic data is specified. Furthermore the types of prior distribution for a Bayes approach are specified.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-D	Capability Category I	Capability Category II	Capability Category III
DA-D2	If neither plant-specific data nor generic parameter estimates are available for the parameter associated with a specific basic event, USE data or estimates for the most similar equipment available, adjusting if necessary to account for differences. Alternatively, USE expert judgment and document the rationale behind the choice of parameter values.		

EXPLANATION OF REQUIREMENT

For some plants, there might be unique systems for which there are no generic industry data. Furthermore, if the system is reliable, there may be no plant-specific data. In this case, other means are required to generate the estimate. This SR identifies two different methods that are acceptable together with a requirement to provide the necessary justification. Requirements for the use of expert judgment are presented in Section 1-4.3 of the standard.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-D	Capability Category I	Capability Category II	Capability Category III
DA-D3	PROVIDE a **characterization (e.g., qualitative discussion) of the uncertainty intervals for the estimates of those parameters used for estimating the probabilities of the significant basic events.**	PROVIDE a **mean value of, and a statistical representation of the uncertainty intervals for, the parameter estimates of significant basic events. Acceptable systematic methods include Bayesian updating, frequentist method or expert judgment.**	PROVIDE a **mean value of, and a statistical representation of the uncertainty intervals for, the parameter estimates. Acceptable systematic methods include Bayesian updating, frequentist method or expert judgment.**

EXPLANATION OF REQUIREMENT

Parameter uncertainty is one of the three classes of epistemic uncertainty identified as needing to be addressed in an application of the PRA results. This characterization of parameter uncertainty is needed to meet SR QU-E3 and, by reference, LE-E4. When uncertainty is quantified using a probability distribution, there is a requirement that the mean value be used as a primary parameter for use in the subsequent point estimate quantification of CDF and LERF as specified in the QU and L2 requirements. The reason for this is that point estimate quantification using mean values will provide an approximation of the mean CDF and LERF when full uncertainty quantification is used. Other parameters such as medians and specific percentiles when used for point estimates of CDF and LERF do not relate the same parameters of the CDF and LERF uncertainty distributions. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

For Capability Category I, a qualitative discussion is sufficient, and that only for the significant basic events.

For Capability Category II, in addition to specifying the mean value of the parameter, statistical representation of the uncertainty in parameter estimates is required for the significant basic event.

For Capability Category III, in addition to specifying the mean value of the parameter, a statistical representation of the uncertainty is required for all parameters.

For capability categories II and III, acceptable methods are identified. However, the mean value only makes sense in the subjectivist or Bayesian framework. This is the generally accepted practice for parameter estimation in PRAs.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-D	Capability Category I	Capability Category II	Capability Category III
DA-D4	No requirement for use of Bayesian approach.	When the Bayesian approach is used to derive a distribution and mean value of a parameter, CHECK that the posterior distribution is reasonable given the relative weight of evidence provided by the prior and the plant-specific data. Examples of tests to ensure that the updating is accomplished correctly and that the generic parameter estimates are consistent with the plant-specific application include the following. *(a)* Confirmation that the Bayesian updating does not produce a posterior distribution with a single bin histogram *(b)* Examination of the cause of any unusual (e.g., multimodal) posterior distribution shapes *(c)* Examination of inconsistencies between the prior distribution and the plant-specific evidence to confirm that they are appropriate *(d)* Confirmation that the Bayesian updating algorithm provides meaningful results over the range of values being considered *(e)* Confirmation of the reasonableness of the posterior distribution mean value.	

EXPLANATION OF REQUIREMENT

The SR addresses the need to make sure that the posterior distribution is reasonable. It is included because there have instances in the past where applying the Bayesian approach without sufficient care has resulted in posterior distributions that do not make sense. The specific checks listed in this SR are intended to identify situations in which the generic data may not be applicable to the plant-specific parameter being estimated, the uncertainty in the generic data may have been underestimated, the computer program used to apply Bayes' theorem may have a bug or may have been applied to parameters that are out of range of the program, or the parameter scale into bins has not been properly set up.

Capability Category Differentiation

This SR differentiates between capability categories in the following way:

For Capability Category I, since DA-D1 and DA-D3 do not require the Bayesian approach, there is no requirement.

For Capability Category II and III, the requirement is the same. The scope of the application of the Bayesian approach is differentiated between Capability Categories II and III in DA-D1 and DA-D3.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-D	Capability Category I	Capability Category II	Capability Category III
DA-D5	USE **the Beta-factor approach (i.e., the screening approach in NUREG/CR-5485) or an equivalent for** estimating CCF parameters.	USE **one of the following models** for estimating CCF parameters **for significant CCF basic events:** **(a) Alpha Factor Model** **(b) Basic Parameter Model** **(c) Multiple Greek Letter Model** **(d) Binomial Failure Rate Model** **JUSTIFY the use of alternative methods (i.e., provide evidence of peer review or verification of the method which demonstrates its acceptability).**	USE **one of the following models for estimating CCF parameters:** **(a) Alpha Factor Model** **(b) Basic Parameter Model** **(c) Multiple Greek Letter Model** **(d) Binomial Failure Rate Model** **JUSTIFY the use of alternative methods (i.e., provide evidence of peer review or verification of the method which demonstrates its acceptability).**

EXPLANATION OF REQUIREMENT

There are a number of approaches for modeling common cause failure. The simplest is the Beta-factor approach which models the CCF as always affecting all trains of a multi-train system simultaneously. The more sophisticated models, such as the ones identified for CC II and CC III, include CCF terms for two trains of a three or four train system, and three trains for a four train system, as well as the so-called global CCF term that affects all redundancies. Each of the models has a defined approach to estimating the CCF parameters. Alternative methods may be used as long as justification is provided. This SR is referred to in SY-B4, which requires that the CCF events be included in the system models in a manner consistent with the approach to parameter estimation addressed in this SR. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

For Capability Category I, the simple Beta-factor approach is adequate

For Capability Category II, a number of different models may be used, but they are only required for the significant CCF basic events.

For Capability Category III, consistent with Table 1-1.3-2, the detailed modeling, using one of the identified models, is required to be used for all CCF basic events.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-D	Capability Category I	Capability Category II	Capability Category III
DA-D6	USE **generic common cause failure beta factors or equivalent. ENSURE** that **the beta factors** are evaluated consistently with the component boundaries.	USE **generic common cause failure probabilities consistent with available plant experience.** EVALUATE **the common cause failure probabilities** consistent with the component boundaries.	USE **realistic common cause failure probabilities consistent with available plant-specific data, supported by plant-specific screening and mapping of industry-wide data for significant common-cause events. An example approach is provided in NUREG/CR-5485 [NOTE (1)].** EVALUATE **the common cause failure probabilities** consistent with the component boundaries.

NOTE (1): NUREG/CR-5485, Guidelines on Modeling Common-Cause Failures in Probabilistic Risk Assessment, November 20, 1998

EXPLANATION OF REQUIREMENT

Common cause failure probabilities can be significant contributors to the PRA results. Typically, the data or generic parameter estimates for CCF probabilities or rates are obtained from specific CCF related documents, and the data or parameter estimates for the independent failure probabilities or rates are obtained from a different set of documents. For the PRA model to be internally consistent, it is necessary that the component boundary and failure mode definitions are the same for both the basic events representing the independent failures and for the members of the corresponding CCF component groups. This is addressed in the last sentence of the SR for each capability category. NUREG/CR-5485 provides additional guidance on how to calculate CCF probabilities and how to estimate the CCF model parameters. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This SR differentiates between the three capability categories:

For Capability Category I, generic parameter values are acceptable. They are generally regarded as potentially conservative for plant-specific application, unless the plant in question has a particular vulnerability to CCFs.

For Capability Category II, generic CCF probabilities are acceptable, but a check is needed to ensure that the estimates are consistent with available plant experience. The motivation for this additional phrase is to make sure that there is no evidence of an increased or otherwise unique CCF potential by comparison with the generic experience.

For Capability Category III, a plant-specific approach to parameter estimation, such as that described in NUREG/CR-5485, is required. As discussed in SR DA-D7, this requires an analysis of the independent failures and the CCF failures to be acceptable. This type of analysis is resource intensive, and requires considerable judgment. This in turn leads to a significant uncertainty on these parameter values.

Recognizing the importance of CCFs and the significant uncertainty in the parameter values, the guidance for risk-informed applications of PRAs typically includes the need to perform sensitivity analysis on the CCF parameters, to make sure that important risk insights are not obscured by CCF parameters that are too conservative, or too optimistic.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-D	Capability Category I	Capability Category II	Capability Category III
DA-D7	If screening of generic event data is performed for plant-specific estimation, ENSURE that screening is performed on both the CCF events and the independent failure events in the database used to generate the CCF parameters.		

NOTE (1): NUREG/CR-5485, Guidelines on Modeling Common-Cause Failures in Probabilistic Risk Assessment, November 20, 1998

EXPLANATION OF REQUIREMENT

The approach to parameter estimation addressed by this SR involves the review of event data on common cause failures to identify those events that are applicable to the plant in question. This typically results in removing some of the events from the database used for quantification. The CCF parameters are estimated using the relative numbers of CCF to independent failure events. The independent events therefore also need to be screened for causes that are not relevant to the plant in question. Alternatively, if a CCF event from a given plant is screened out, then all the CCF and independent events from that same plant may be screened out to avoid biasing the results. Otherwise, the CCF parameters would be non-conservative, since the numerator would be decreased whereas the denominator would not.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-D	Capability Category I	Capability Category II	Capability Category III
DA-D8	If modifications to plant design or operating practice lead to a condition where past data are no longer representative of current performance, LIMIT the use of old data: *(a)* If the modification involves new equipment or a practice where generic parameter estimates are available, USE the generic parameter estimates updated with plant-specific data as it becomes available **for unique design or operational features; or** *(b)* If the modification is unique to the extent that generic parameter estimates are not available and only limited experience is available following the change, then ANALYZE the impact of the change and assess the hypothetical effect on the historical data to determine to what extent the data can be used.	If modifications to plant design or operating practice lead to a condition where past data are no longer representative of current performance, LIMIT the use of old data: *(a)* If the modification involves new equipment or a practice where generic parameter estimates are available, USE the generic parameter estimates updated with plant-specific data as it becomes available **for significant basic events**; or *(b)* If the modification is unique to the extent that generic parameter estimates are not available and only limited experience is available following the change, then ANALYZE the impact of the change and assess the hypothetical effect on the historical data to determine to what extent the data can be used.	If modifications to plant design or operating practice lead to a condition where past data are no longer representative of current performance, LIMIT the use of old data: *(a)* If the modification involves new equipment or a practice where generic parameter estimates are available, USE the generic parameter estimates updated with plant-specific data as it becomes available; or *(b)* If the modification is unique to the extent that generic parameter estimates are not available and only limited experience is available following the change, then ANALYZE the impact of the change and assess the hypothetical effect on the historical data to determine to what extent the data can be used.

EXPLANATION OF REQUIREMENT

This SR recognizes that, as plant design or operating practices change, some historical data may become irrelevant. Counting data from time periods that are no longer representative of the plant configuration or performance may yield inaccurate estimates and also may result in understating the uncertainty. This is true because if Bayes' updating is being performed the resulting posterior distributions may be too narrow as well as incorrect if evidence from unrepresentative time periods is counted. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This SR differentiates between the three capability categories in item (a) consistent with the plant-specificity line of Table 1-1.3-2:

For Capability Category I, use plant-specific data for unique items,

For Capability Category II, use plant-specific data for significant basic events, and

For Capability Category III, use plant-specific data for all basic events.
In all other aspects the requirement is identical.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-D	Capability Category I	Capability Category II	Capability Category III
DA-D9 (RG 1.200)	For each SSC for which repair is to be modeled, ESTIMATE, based on the data collected in DA-C15, the probability of failure to repair the SSC in time to prevent core damage as a function of the accident sequence in which the SSC failure appears.		

EXPLANATION OF REQUIREMENT

Regulatory Guide 1.200, Revision 2 includes a new requirement, DA-D9, which states, for all three capability categories, "**For each SSC for which repair is to be modeled, ESTIMATE, based on the data collected in DA-C15, the probability of failure to repair the SSC in time to prevent core damage as a function of the accident sequence in which the SSC failure appears.**"

The intent of this new SR is to complement DA-C15, which only requires that the data on repair be collected, but not that the probability of failure to repair be estimated on the basis of that data.

5.5.5 Supporting Requirements for HLR-DA-E

ASME/ANS Standard Section 2.2.6, Table 2.2.6-2(e), Supporting Requirements for HLR-DA-E

HLR-DA-E:	Documentation of the data analysis shall be consistent with the applicable supporting requirements. (HLR-DA-E).
Intent:	To ensure that the basis for the analysis is reproducible and can be reviewed and updated as necessary
SRs:	DA-E1 through DA-E3

Index No. DA-E	Capability Category I	Capability Category II	Capability Category III
DA-E1	DOCUMENT the data analysis in a manner that facilitates PRA applications, upgrades and peer review.		

EXPLANATION OF REQUIREMENT

It is important that the documentation includes sufficient information about the approach used for the data analysis, such that an analyst or peer reviewer who was not involved in the original process could come to similar conclusions regarding the validity of the results and the veracity of the data analysis to the as-built and as-operated plant. In this way an analyst would be able to understand the approach and would be able to support applications, upgrades and reviews of the PRA. Furthermore, the documentation is to be consistent with the applicable SRs as stated in High Level Requirement DA-E. Although examples are included in SR DA-E2, these do not represent a complete listing of all required documentation. To facilitate the development a complete list, a documentation mapping is provided in the explanation to SR DA-E2 showing the scope of documentation needed to achieve consistency with the applicable SRs.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-E	Capability Category I	Capability Category II	Capability Category III
DA-E2	DOCUMENT the processes used for data parameter definition, grouping and collection including parameter selection and estimation, including the inputs, methods and results. For example, this documentation typically includes: *(a)* System and component boundaries used to establish component failure probabilities *(b)* The model used to evaluate each basic event probability *(c)* Sources for generic parameter estimates *(d)* The plant-specific sources of data *(e)* The time periods for which plant-specific data were gathered *(f)* Justification for exclusion of any data *(g)* The basis for the estimates of common cause failure probabilities, including justification for screening or mapping of generic and plant-specific data *(h)* The rationale for any distributions used as priors for Bayesian updates, where applicable *(i)* Parameter estimate including the characterization of uncertainty, as appropriate.		

EXPLANATION OF REQUIREMENT

This SR addresses the process documentation used to implement the data analysis supporting requirements. It also provides examples of documentation associated with the data analysis development processes and examples of documentation associated with the parameters, constraints and results from implementing these processes. Table 11 (DA-E2-1) provides a discussion of these examples. It should be noted that the documentation examples do not represent the complete list of all required documentation, but a list of many of the documents that are typically included. To facilitate the development of a complete list, a documentation mapping is provided in Table 12 (DA-E2-2) showing the scope of documentation needed to achieve consistency with the applicable SRs. Table 12 (DA-E2-2) also identifies each documentation item as either “process” or “SR.” A “process” documentation item primarily supports the process requirement which is the focus of this SR while an “SR” documentation item primarily supports documentation that is consistent with one or more supporting requirements as required by DA-E1. A mapping is also provided in Table 11 (DA-E2-1) between the examples and the documentation list shown in Table 12 (DA-E2-2) and in Table 12 (DA-E2-2) between the documentation items and the applicable SRs.

Table 11 DA-E2-1 SR Examples

SR Example	Discussion	Documentation Item
a	SR DA-A2 requires the establishment of SSC boundaries, failure modes and success criteria.	5
b	SR DA-D1 requires the calculation of parameter estimates. SR DA-D5, D6 and D7 address the requirements for quantifying common cause.	1, 2, 3
c	SR DA-C1 provides the requirement for obtaining generic parameter estimates from recognized sources.	7
d	Several SRs address the requirements for collection and use of plant-specific data. These requirements include: SR DA- A4, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16 and D8	2, 8
e	SR DA-C3 provides requirements for the collection of plant-specific data. The requirement does not explicitly identify the need for the data collection time-frame however it does provide the expectation for the design, operational	9

SR Example	Discussion	Documentation Item
	practices and experience and as such the identification of the data collection time frame would be expected.	
f	SR DA-C3 provides requirements for the collection of plant-specific data and explicitly requires the rationale for screening or disregarding data.	9
g	SR DA-D5, D6 and D7 address the requirements for quantifying common cause.	3, 4
h	SR DA-D4 provides the requirement for checking that the posterior distributions are reasonable.	1, 10
i	The requirement to calculate parameter estimates, SR DA-D1, includes a requirement to provide the appropriate characterization of uncertainty.	4

Table 12 DA-E2-2 Documentation Mapping

Element	Type	Item	Documentation	Related SR	SR Examples
DA	Process	1	Document the approach for quantifying independent failure and unavailability basic events including the bases for selection of models used for quantification.	A2, A3, A4, B1, B2, C1, C2, C4, C15, C16, D1, D2, D3, D4	b, h
DA	Process	2	Document the approach for plant-specific data collection.	A4, C2, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16	b, d
DA	Process	3	Document the approach for quantifying common cause.	D5, D6, D7	b, g
DA	SR	4	List the probabilities - independent, common cause, unavailability, recovery and repair, and their associated uncertainties and their associated bases.	A1, D1	g, i
DA	SR	5	Document SSC boundaries, failure modes and success criteria.	A2, C4	a
DA	SR	6	Document the basic event/parameter grouping (i.e., component mapping to parameters) used for plant-specific data collection.	B1	na
DA	SR	7	Document the Generic Data and associated sources.	C1	c
DA	SR	8	Document plant-specific data and associated sources.	C2, C3, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, D8	d
DA	SR	9	Document plant-specific data collection applicability (including collection period(s))and exclusions.	C3	e, f
DA	SR	10	Document the verification that posterior distribution is reasonable, when Bayesian approach is used (Category II and III only).	D4	h

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. DA-E	Capability Category I	Capability Category II	Capability Category III
DA-E3	DOCUMENT sources of model uncertainty and related assumptions (as identified in QU-E1 and QU-E2) associated with the data analysis.		

EXPLANATION OF REQUIREMENT

Model uncertainty arises because uncertainty exists about which models appropriately represent the aspects of the plant being modeled. In addition, there may be no model representing a particular aspect of the plant. This adds to uncertainty about the PRA findings because it may be unclear whether the PRA fails to consider a potentially significant contributor. The uncertainty associated with the model and its constituent parts typically is dealt with by making assumptions. In general, model uncertainties are addressed by determining the sensitivity of the PRA results to different assumptions or models.

NUREG-1855 [NRC 2009] gives guidance for addressing sources of model uncertainty and related assumptions in the context of the requirements in the ASME/ANS PRA Standard, and is specifically focused on accomplishing SRs QU-E1, QU-E2, QU-E4 and LE-F3 that are related to model uncertainty. The EPRI report 1016737, "Treatment of Parameter and Model Uncertainty for Probabilistic Risk Assessments," [EPRI 2008] also addresses this uncertainty, and in particular, its Appendix B identifies several sources of this uncertainty to support meeting SR DA-E3.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.7 Quantification Section 2-2.7 of the ASME/ANS RA-Sa-2009

The objectives of the quantification element are to provide an estimate of CDF based upon the plant-specific core damage scenarios, in such a way that:

- The results reflect the design, operation and maintenance of the plant.
- Significant contributors to CDF are identified such as initiating events, accident sequences, and basic events (equipment unavailability and human failure events).
- Dependencies are accounted for.
- Uncertainties are understood.

To meet the above objectives, six HLRs are defined in the standard:

Designator	Requirement
HLR-QU-A	The Level 1 quantification shall quantify core damage frequency and shall support the quantification of LERF.
HLR-QU-B	The quantification shall use appropriate models and codes, and shall account for method-specific limitations and features.
HLR-QU-C	Model quantification shall determine that all identified dependencies are addressed appropriately.
HLR-QU-D	The quantification results shall be reviewed and significant contributors to CDF, such as initiating events, accident sequences, basic events (equipment unavailabilities and human failure events) shall be identified. The results shall be traceable to the inputs and assumptions made in the PRA.
HLR-QU-E	Uncertainties in the PRA results shall be characterized. Sources of model uncertainty and related assumptions shall be identified, and their potential impact on the results understood.
HLR-QU-F	Documentation of the quantification shall be consistent with the applicable supporting requirements.

5.7.1 Supporting Requirements for HLR-QU-A

ASME/ANS Standard Section 2.2.7, Table 2.2.7-2(a), Supporting Requirements for HLR-QU-A

HLR-QU-A:	The Level 1 quantification shall quantify core damage frequency and shall support the quantification of LERF.
Intent:	Provide the key metrics used for PRA applications
SRs:	QU-A1 through QU-A5

Index No. QU-A	Capability Category I	Capability Category II	Capability Category III
QU-A1	INTEGRATE the accident sequence delineation, system models, data and HRA in the quantification process for each initiating event group, accounting for system dependencies, to arrive at accident sequence frequencies.		

EXPLANATION OF REQUIREMENT

The integrated accident sequence delineation results in a Boolean expression that yields the combinations of system failures and unsuccessful operator actions (i.e., cut-sets) that are required to achieve a core damage end-state through the event tree, and a numerical quantification of those Boolean expressions that yields an estimate of the core damage frequency. System models are incorporated into the event tree top events through the incorporation of system level Boolean solutions of system fault trees that model the failure of each safety function defined by the event tree top events. System dependencies are accounted for by the sequencing of top events in the event tree in accordance with the SRs for the Accident Sequence analysis (AS). For example, in transient initiating event trees, top events for low pressure injection systems are incorporated "downstream" from high pressure injection top events. In event trees for LOOP, top events for systems requiring AC electrical power are located "downstream" from the top events for the emergency power systems.

HRA events are either embedded into the specific system fault trees in accordance with the SRs for both pre-initiator and post initiator HRAs or are incorporated after the development of the accident sequence Boolean solution at the cut-set level, in accordance with the SRs of HLR-HR-H for recovery actions.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 has stated no objections to the SR as written.

Index No. QU-A	Capability Category I	Capability Category II	Capability Category III
QU-A2	PROVIDE estimates of the individual sequences in a manner consistent with the estimation of total CDF to identify significant accident sequences/cut-sets and confirm the logic is appropriately reflected. The estimates may be accomplished by using either fault tree linking or event trees with conditional split fractions.		

EXPLANATION OF REQUIREMENT

This SR is to quantify estimates of the core damage frequency for individual sequences. The solution of accident event trees results in numerous core damage end-states, each with a specific accident sequence equation. The total core damage model is the combination of all accident sequence equations, and the CDF estimate is the numerical quantification of that total core damage model. Within each initiating event group, accident sequences are evaluated to ensure that non-minimal and duplicate cut sets are eliminated from the combined equation for each initiating event group. The result is that the total core damage model can be represented as the sum of all individual accident sequence frequencies, each sequence being a unique combination of cut-sets, and each cut-set is a unique combination of an IE, basic events and HRAs. Consequently, each sequence can represent a specific portion of the core damage model, and its associated frequency can be used to identify its numerical contribution to the total CDF. Similarly cut-sets can be ranked as to their contribution to CDF.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-A	Capability Category I	Capability Category II	Capability Category III
QU-A3	**ESTIMATE the point estimate CDF**	**ESTIMATE the mean CDF accounting for the "state-of-knowledge" correlation between event probabilities when significant [NOTE (1)].**	**CALCULATE the mean CDF by propagating the uncertainty distributions, ensuring that the "state-of-knowledge" correlation between event probabilities is taken into account.**

NOTE (1): When the probabilities of a number of basic events are estimated by using the same data, the probabilities of the events will be identical. When an uncertainty analysis is performed by using a Monte Carlo sampling approach, the same sample value should be used for each basic event probability, since the state of knowledge about the parameter value is the same for each event. This is called the state of knowledge correlation and it results in a mean value for the joint probability that is larger than the product of the mean values of the event probabilities. This result is most important for cut-sets that contain multiple basic events whose probabilities are based on the same data, and in particular when the uncertainty on the parameter value is large. It has been found to be significant in cut-sets contributing to ISLOCA frequency that involve rupture of multiple valves, for example. [Ref. G. Apostolakis and S. Kaplan, "Pitfalls in Risk Calculations," Reliability Engineering, Vol. 2, pp. 135-145, 1981]

EXPLANATION OF REQUIREMENT

The intent for this SR is to quantify the core damage frequency and to provide, to different degrees, the level of realism in the quantification for the various Capability Categories. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This grouping can be performed to three different capabilities.

For Capability Category I, only a point estimate calculation is being performed. Previous SRs for Capability Category I, for example, do not require a mean value of, and a statistical representation of the uncertainty interval for, the parameter estimates. Further, generic data, conservative grouping, etc. is allowed in previous related SRs for Capability Category I. It is expected that the absolute risk predictions will be conservatively biased as a result of this quantification.

For Capability Category II, this quantification is meant to be more refined over Capability Category I. Previous SRs for Capability Category II, for example, do require a mean value of, and a statistical representation of the uncertainty interval for, the parameter estimates; however, only for the significant basic events. As such, it is the intent that the CDF quantified is as realistic as can be achieved if, at a minimum, a mean is quantified taking into the SOKC for significant basic events.

For Capability Category III, this quantification is meant to be more refined over Capability Category II. Previous SRs for Capability Category III, for example, do require a mean value of, and a statistical representation of the uncertainty interval for, the parameter estimates. As such, it is the intent that the CDF quantified is realistic without any bias. Therefore, a mean is quantified by propagating the uncertainty distributions taking into account the SOKC for the event probabilities.

REGULATORY POSITION

The NRC in Regulatory Guide 1.200 has provided two clarifications:

- A clarification that the requirements in QU-A2 apply to both CDF and LERF; and
- The State of Knowledge Correlation is accounted for all probabilities (not just "when significant" as noted for the Category II requirement statement).

Index No. QU-A	Capability Category I	Capability Category II	Capability Category III
QU-A4	SELECT a method that is capable of discriminating the contributors to the CDF commensurate with the level of detail in the model.		

EXPLANATION OF REQUIREMENTS

The accident sequence quantification method creates results that can be analyzed to identify which types of failures that dominate the CDF and to develop an understanding of why those failures are dominate. The process allows for the identification of the contribution of individual sequences to CDF, the contribution of accident sequence types (e.g., Large LOCAs, LOOP) and the contribution of individual cut-sets and basic events. The process is capable of identifying the contribution of sequences, cut-sets, initiating events and basic events regardless of the level of detail of the modeling (e.g., detailed component basic events vs. system train level events, specific initiating events vs. initiating event types). The process allows for the calculation of important measures for basic events.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-A	Capability Category I	Capability Category II	Capability Category III
QU-A5	INCLUDE recovery actions in the quantification process in applicable sequences and cut sets. [see HR-H1, HR-H2 and HR-H3)]		

EXPLANATION OF REQUIREMENTS

HRA events that represent recovery actions by plant personnel to restore lost or degraded safety functions are incorporated into the accident sequence models according to the SRs HR-H1, HR-H2 and HR-H3. The intent of this requirement is to recognize, consistent with the SRs for HLR-HR-H, that recovery actions should be identified on a cut-set by cut-set basis, although the nature of accident sequence models often results in common failures and plant damage conditions such that some recovery actions can be applied to large numbers of cut-sets within a particular accident sequences or even groups of accident sequences. Care is taken to ensure that assumptions associated with any particular recovery action are realistic given the dependencies between failure modeled in the cut-sets and other plant equipment and the physical environment resulting from the failures defined by the cut-set (e.g., ingress and egress into areas by equipment operators must be achievable and not inhibited by life-threatening conditions).

HR-H1 delineates the scope of the recovery analysis for each Capability Category, HR-H2 identifies certain criteria regarding plant-specific practices for procedures, alarms and staffing that are considered when defining recovery actions and HR-H3 addresses the need to consider dependencies between any proposed recovery actions and other HFEs in a sequence, scenario or cut-set.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

5.7.2 Supporting Requirements for HLR-QU-B

ASME/ANS Standard Section 2.2.7, Table 2.2.7-2(b), Supporting Requirements for HLR-QU-B

HLR-QU-B: The quantification shall use appropriate models and codes, and shall account for method-specific limitations and features.

Intent: To ensure that the results can be interpreted and validated by the stakeholder community

SRs: QU-B1 through QU-B10

Index No. QU-B	Capability Category I	Capability Category II	Capability Category III
QU-B1	PERFORM quantification using computer codes that have been demonstrated to generate appropriate results when compared to those from accepted algorithms. IDENTIFY method-specific limitations and features that could impact the results.		

EXPLANATION OF REQUIREMENTS

Computer codes for solving fault tree and event tree models into integrated accident sequence CDF equations need to have the appropriate capabilities to generate useful results to meet the intent of the PRA analysis. For example, meeting SR QU-A2 and QU-A4 requires the ability to identify and rank individual sequences and cut-sets based on their contribution to CDF. The contribution of basic events to CDF is identified by the calculation of important measures. To meet SR QU-A3, a code that is capable of propagating uncertainty through the solutions using sampling methods such as Monte Carlo or LHS is required.

Codes can have limited capabilities for certain features that can impact the way analysts address certain issues. For example, if a code is being used for a flood or fire analysis but the code lacks a spatial transformation feature, then the spatial transformation of basic events into spatially-dependent events would have to be performed manually at the cut-set level. This type of limitation is identified and the manual process needs to be developed.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-B	Capability Category I	Capability Category II	Capability Category III
QU-B2	TRUNCATE accident sequences and associated system models at a sufficiently low cutoff value that dependencies associated with significant cut-sets or accident sequences are not eliminated. NOTE: Truncation should be carefully assessed in cases where cut-sets are merged to create a solution (e.g., where system level cut-sets are merged to create sequence level cut-sets).		

EXPLANATION OF REQUIREMENTS

The quantification of accident sequence equations can cause the generations of an enormous number of cut-sets, such that the solution can impose computational limitations on computer resources or result in an unmanageable number of cut-sets for post-quantification review and documentation. For certain codes, this may not be an issue if the codes have been developed to take advantage of state-of-the-art programming and hardware capabilities.

In order to make the sequence quantification practical, it may be necessary to truncate the analysis; that is, to consider only those cut-sets whose probability is above some cutoff value, which is termed the truncation value. Truncation can be used in both the screening and in the final quantification. However, for simplification, truncation can be performed without the application of recovery or even initiating events. Since, with the exception of certain transient initiators, initiating event frequencies are less than 1.0/yr and recovery action probabilities are less than 1, the final frequency of the truncated cut-sets – if they were retained for the complete solution – would only be even less than the value of their probability when truncated. Hence, the major quantitative portion of the cut-sets, and the resulting accident sequence solutions, will be retained if the truncation level is selected properly.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-B	Capability Category I	Capability Category II	Capability Category III
QU-B3	ESTABLISH truncation limits by an iterative process of demonstrating that the overall model results converge and that no significant accident sequences are inadvertently eliminated. For example, convergence can be considered sufficient when successive reductions in truncation value of one decade result in decreasing changes in CDF or LERF, and the final change is less than 5%.		

EXPLANATION OF REQUIREMENTS

Calculate initial point estimate CDF estimation by using a non-conservatively high truncation value, without application of recovery actions. Then, lower the truncation value by a decade. Compare the results. If the CDF estimate increased by 5% or more reduce the truncation factor by another decade. Continue this iterative process until subsequent reductions in the truncation value result in an increase in CDF estimate of less than 5%.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-B	Capability Category I	Capability Category II	Capability Category III
QU-B4	Where cut-sets are the means used in quantification, USE the minimal cut-set upper bound or an exact solution. The rare event approximation may be used when basic event probabilities are below 0.1.		

EXPLANATION OF REQUIREMENTS

For solving system fault tree equations, it is preferential to use the exact solution for calculating cut-set probabilities. That is, all applicable probabilistic cross-terms are included in the quantification of the cut-sets. This yields the most accurate numerical solution. However, this can be beyond the capabilities of the code being used for accident sequence quantification.

Another accepted method for quantifying cut-set probabilities for solving system fault trees is the minimal cutest upper bound method. The minimal cut set upper bound calculation is an approximation to the probability of the union of the minimal cut sets for the fault tree.

The equation for the minimal cut set upper bound is:

$$S = 1 - \prod_{i=1}^{m} (1 - C_i)$$

where
S = minimal cut set upper bound for the fault tree unavailability,
C_i = probability of the ith cut set, and
m = the number of cut sets.
Example: If the cut sets for a fault tree are X = A □ B □ C (i.e., the union of three events, A, B, and C); then the cut sets can be written as X = A + B + C with the plus symbol indicating union. The fault tree unavailability computed from the minimal cut set upper bound approximation is then X = 1 - (1 - A)(1 - B)(1 - C).

The minimal cut set upper bound works well with fault trees containing only AND and OR gates without complemented events or NOT gates. With noncoherent fault trees, that is, trees that contain NOT gates and/or complemented events, the minimal cut set upper bound can produce results that are conservative. The magnitude of the overestimation will depend upon the structure of the tree.

The rare event approximation method, in which the probabilistic cross-terms are dropped out of the calculation, can be used when the basic event probabilities for the events in the cut-sets are all less than 0.1. The net effect of this method is that the sequence probability (before the inclusion of the initiating event) is calculated by summing the probabilities of all of the cut-sets in the sequence Boolean expression.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-B	Capability Category I	Capability Category II	Capability Category III
QU-B5	Fault tree linking and some other modeling approaches may result in circular logic that must be broken before the model is solved. BREAK the circular logic appropriately. Guidance for breaking logic loops is provided in NUREG/CR-2728 [Note (1)]. When resolving circular logic, AVOID introducing unnecessary conservatisms or non-conservatisms.		

NOTE (1): NUREG/CR-2728, Interim Reliability Evaluation Program Procedures Guide, March 3, 1983

EXPLANATION OF REQUIREMENTS

Support system dependencies upon other support systems can introduce circular logic situations that result in unsolvable equations for accident sequence quantification codes. In fact, most PRA quantification codes would generate an error message in such case. For example, it is a common feature that diesel generators require water cooling provided by the SWS. In such cases, when constructing the EDG fault tree the SWS is modeled as a support system to the EDG. However, within the SWS the electrical systems are modeled as a support system to the SWS. Hence, in LOOP sequences a logic loop in which the EDGs depend upon the SWS which depends upon the EDGs would be created.

To remedy this issue, the electrical dependency loop is “broken” by developing a special SWS fault tree that is used to model the SWS function just for the EDG fault tree. In this SWS fault tree the system’s dependency on electrical power is eliminated. This practice is valid because in LOOP sequences the sources of AC power for the SWS are the EDGs. So, the only way for the SWS to lose AC power (and hence fail the EDGs) is for the EDGs themselves to fail. There are many ways in which the EDGs could fail, but the EDGs cannot fail due to a loss of AC power to their support systems like the SWS because the EDGs themselves are the sources of power to their support systems.

The breaking of this circular logic is done carefully to avoid losing important and still valid potential faults in the LOOP sequence. For example, electrical power supplied by the EDGs reaches its loads through many of the same electrical cables, buses, switchgear and motor control centers as for the normal emergency AC power. Thus, if such SSCs are explicitly modeled in the system models, these features need to be kept in the model when breaking the circular logic. The loss of such SSCs during a LOOP sequence could still be a valid failure mechanism for the SWS, and hence ultimately for the EDGs and other SSCs.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-B	Capability Category I	Capability Category II	Capability Category III
QU-B6	ACCOUNT for system successes in addition to system failures in the evaluation of accident sequences to the extent needed for realistic estimation of CDF. This accounting may be accomplished by using numerical quantification of success probability, complementary logic or a delete term approximation and includes the treatment of transfers among event trees where the "successes" may not be transferred between event trees.		

EXPLANATION OF REQUIREMENTS

This SR addresses the need to explicitly incorporate the probability of success of systems in accident sequence solutions. If the appropriate system success probabilities were not included in the quantification of a sequence solution, then the resulting CDF estimate could be conservatively high.

Generally, there are three ways to account for success of an event tree function such that the successes are propagated through the accident sequence solutions as well as the failures:

- Numerical quantification of success probabilities,
- Complementary logic and
- Cut set matching (delete term) approximation.

Numerical quantification of success probabilities can be problematic for PRAs using the Large-Fault-Tree/Small-Event-Tree approach due to the large dependencies between system faults trees typical to that approach. Numerical quantification of success probabilities can be straightforward if the Small-Fault-Tree/Large-Event-Tree approach is employed. For that method, the individual fault trees are typically fully independent, and the success of a top event can simply be calculated by subtracting the failure probability of that top event by 1.0. It is crucial, though, that independence between event trees is verified.

The use of Boolean complementary logic, wherein the success of events is explicitly modeled in the fault trees through the use of Boolean complements to the failure events, is valid but can be computationally cumbersome. However, that issue can be alleviated through the use of NOT AND and NOT OR gates, which allow the use of regular failure events to model success.

A cut set matching approximation – also referred to as "delete term" – is the most straightforward approach for many computer code packages. In a delete term approximation, all solutions involve only failure events. If an accident sequence end-state involves the success of top event A and the failure of top event B, then the equation for that end state can be calculated by a two-step process. First, the cut-sets for "Failure of B" are solved for minimal cut-sets. Then, the fault tree for "Failure of A" is solved for minimal cut-sets. The cut-sets for A are compared – in an automated fashion using the accident sequence quantification software – with the cut-sets for B. If any of the cut-sets for A form a subset of any cut-set for B, then that cut-set in the solution for B is deleted from the solution.

Lastly, care is taken to ensure that if accident sequence solutions are being transferred from one event tree to another, then the successes embodied in the former trees are likewise embodied in the subsequent trees. For example, in the case where certain end states of a Transient-Stuck-Open-Relief-Valve result in a small LOCA, the accident sequence equations quantified in the Transient tree for those end states are transferred to the small LOCA event tree for the accident sequence quantification to continue. The small LOCA event tree (or more specifically, the system fault trees relevant to that event tree) is modified as necessary so that all successes in the initial transient tree are replicated in the small LOCA tree.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-B	Capability Category I	Capability Category II	Capability Category III
QU-B7	IDENTIFY cut-sets (or sequences) containing mutually exclusive events in the results.		
QU-B8	CORRECT cut-sets containing mutually exclusive events by either: *(a)* Developing logic to eliminate mutually exclusive situations, or *(b)* Deleting cut-sets containing mutually exclusive events.		

EXPLANATION OF REQUIREMENTS

Depending on how system fault trees are constructed, it is possible to generate cut-sets that contain within the same cut-set two events that are mutually exclusive. Mutually exclusive events are defined in the Standard as: *a set of events where the occurrence of any one precludes the simultaneous occurrence of any remaining event in the set.* A typical example is in a multiple train system wherein a test-and-maintained outage failure event is modeled as one of the failure mechanism for each train. In such cases it is possible to generate cut-sets that would involve the “failure” of multiple trains out for test or maintenance at the same time. However, if such combinations violate the technical specifications for a plant, then such cut-sets, although logically valid as far as Boolean algebra is concerned, are not realistic from an operational sense. Hence the multiple T&M failures within the same system are considered mutually exclusive. SR QU-B7 directs the analyst to investigate the results of accident sequence quantification to ensure that cut-sets with mutually exclusive events are identified if they exist. SR QU-B8 directs the analyst to correct this issue, either by deleting such cut-sets from the results or changing the logic models to preclude the occurrence of such cut-sets in the sequence solution. However, such changes to logic models are carefully implemented and verified to ensure that other valid cut-sets are not lost. This can be done by performing a comparison of system or sequence level cut-sets as appropriate between the original and altered models to verify that all legitimate cut-sets remain. The analysts can also choose to retain the original logic and address the issue by identifying and deleting from the solution all such cut-sets.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirements.

Index No. QU-B	Capability Category I	Capability Category II	Capability Category III
QU-B9	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 for each accident sequence, prior to the generation of cut-sets.		

EXPLANATION OF REQUIREMENTS

The primary intent here is to develop a more realistic representation of the accident sequence equations, but another attribute of this SR is to simplify the computational burden of the solution and also to simplify the results of the analysis. Logic flags that set basic events to logical values of TRUE or FALSE are actually changing basic events from random variables to actual statements of fact. Since fault trees are failure models, a basic event set to TRUE indicates that the SSC, HRE has absolutely no possibility of impacting the accident progression. Hence, it is as though the SSC or HRE does not even exist. A basic event set to FALSE is an indication that that particular SSC, HRE or event CANNOT contribute to a core damage sequence, and in effect is preventing a core damage end state from occurring.

The use of logic flags can reduce the computational resources needed for sequence solutions. If an event probability is set to 1.0 instead of TRUE, that event will still appear in cut-sets along with other events. However, setting the event probability to TRUE results in the generation of the same cut-sets except that the term evaluated as TRUE does not appear in the cut-sets. Conversely, if an event probability is set to 0.0, the logical solution involving all cut-sets with that event will still be generated and quantified, and the basic event will appear in all relevant cut-sets, regardless of the fact that the cut-set probability is 0.0. Even with truncation, the code will still generate and quantify cut-sets before eliminating them from the output. However, if the event probability is set to FALSE, then all logical combinations of events involving that event are eliminated from the solution without quantification.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-B	**Capability Category I**	**Capability Category II**	**Capability Category III**
QU-B10	If modules, sub-trees or split fractions are used to facilitate the quantification, USE a process that allows: *(a)* Identification of shared events *(b)* Correct formation of modules that are truly independent *(c)* Results interpretation based on individual events within modules (e.g., risk significance).		

EXPLANATION OF REQUIREMENTS

The use of modules, sub-trees and split fractions represent a less granular level of modeling detail than highly detailed system fault trees. When such model simplifications are used, the power of Boolean reduction for accounting for dependencies between top events is lost. Extreme care is taken to ensure that the underlying attributes of each module, sub-tree or split fraction represent truly independent SSCs and failures. Such simplifications can be implemented with confidence if the accident sequence quantification software has features that allow for independence to be verified, for example, a feature that can identify sub-trees within larger fault trees as truly independent and solve them.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

5.7.3 Supporting Requirements for HLR-QU-C

ASME/ANS Standard Section 2.2.7, Table 2.2.7-2(c), Supporting Requirements for HLR-QU-C

HLR-QU-C: Model quantification shall determine that all identified dependencies are addressed appropriately.

Intent: To ensure that the impact of dependencies are adequately understood in the results (support systems, HFEs, data)

SRs: QU-C1 through QU-C3

Index No. QU-C	Capability Category I	Capability Category II	Capability Category III
QU-C1	IDENTIFY cut-sets with multiple HFEs that potentially impact significant accident sequences/cut-sets by requantifying the PRA model with HEP values set to values that are sufficiently high that the cut-sets are not truncated. The final quantification of these post-initiator HFEs may be done at the cut-set level or saved sequence level.		

EXPLANATION OF REQUIREMENTS

Cut-sets that include more than two HFEs require special attention. Since cut-sets often involve the failure of multiple SSCs it is possible to identify numerous human actions and recovery actions that could address the multiple safety function losses represented in any particular cut-set. However, it is generally recognized that allowing for multiple recovery actions and human actions simultaneously could result in an unrealistic reliance on recovery actions to correct all problems associated with a particular cut-set or accident sequence. Adding multiple HREs to a cut-set could result in its probability falling below the truncation limit, resulting in the loss of important insights to potential contributors to CDF. To prevent this, the PRA model is requantified with HEP values set to sufficiently higher values to ensure that the cut-sets are not truncated.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-C	Capability Category I	Capability Category II	Capability Category III
QU-C2	ASSESS the degree of dependency between the HFEs in the cut-set or sequence in accordance with HR-D5 and HR-G7.		

EXPLANATION OF REQUIREMENTS

The intent of this SR is to bring to the analyst's attention the importance of addressing dependency between multiple HFEs within the same cut-set or sequence. It is not assumed that HFEs in the same cut-set or sequence are independent. For example, it is generally accepted that the probability of failure of an operator action in a sequence of events will be influenced by the prior operator action successes and failures. Thus if HFEs occur in the same cut-set it is not assumed that they are independent. The discussion in Section 5.5 Human Reliability Analysis for HR-D5 and HR-G7 address this issue.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-C	Capability Category I	Capability Category II	Capability Category III
QU-C3	When linking event trees, TRANSFER the sequence characteristics (e.g., failed equipment, flag settings) that impact the logic or quantification of the subsequent accident development, as well as the sequence frequency. For example, sequence characteristics can be transferred to another event tree by using the appropriate cut-sets.		

EXPLANATION OF REQUIREMENTS

All successes, flags and conditions of initial events are ensured to be accurately modeled as well in subsequent fault trees when linking event trees. For example, in the case of a Transient-Stuck-Open-Relief-Valve event tree end state that transfers to a small LOCA tree, care is be taken to ensure that the small LOCA tree reflects the circumstances of the transient tree. Take the case of HPI activation in a BWR. HPI activation is designed to happen for low reactor water level or high drywell pressure as protection against LOCAs. However, if the source of inventory loss is a stuck-open relief valve, then there would be no cause for a high drywell pressure indication as the relief valve would blow down into the suppression pool. So, the settings on the HPI fault tree used in the small LOCA event tree are appropriately modified from typical LOCA conditions to the special circumstances of the stuck-open relief-valve sequence.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

5.7.4 Supporting Requirements for HLR-QU-D

ASME/ANS Standard Section 2.2.7, Table 2.2.7-2(d), Supporting Requirements for HLR-QU-D

HLR-QU-D: The quantification results shall be reviewed and significant contributors to CDF, such as initiating events, accident sequences, basic events (equipment unavailabilities and human failure events) shall be identified. The results shall be traceable to the inputs and assumptions made in the PRA.

Intent: To identify and understand metrics which provide risk insights, and to ensure that the analysis is providing logical results

SRs: QU-D1 through QU-D7

Index No. QU-D	Capability Category I	Capability Category II	Capability Category III
QU-D1	REVIEW a sample of the significant accident sequences/cut-sets sufficient to determine that the logic of the cut-set or sequence is correct.		

EXPLANATION OF REQUIREMENTS

This is a most important and useful way to perform a quality check on the fault trees, event trees and accident sequence quantification. A review of a sample of the cut-sets can yield good and problematic results: on the one hand "obvious" or "expected" cut-sets can reaffirm the analyst's approach to developing the models; on the other hand peculiar or unexpected cut-sets can raise questions regarding the validity of models and assumptions. In the former case, even though the cut-sets may appear "obvious" it is an important to verify the results against the fault tree and event tree models. In the latter case, the results are investigated to determine if an error exists in the models or to determine if the results, though unexpected, are in fact correct. This process of inspecting cut-sets against the actual models can lead to some of the most insightful revelations regarding system interactions.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-D	Capability Category I	Capability Category II	Capability Category III
QU-D2	REVIEW the results of the PRA for modeling consistency (e.g., event sequence models consistency with systems models and success criteria) and operational consistency (e.g., plant configuration, procedures and plant-specific and industry experience).		

EXPLANATION OF REQUIREMENTS

The intent of this SR is to direct the analyst to review the PRA results, especially the cut-sets and sequences, to ensure that the results reflect accurately the as-built, as-operated configuration of the plant as well as the operational procedures and philosophy of the plant. Cut-sets and accident sequence solutions that are logically correct given the models are still validated for correctness against the actual plant. Seeing the results in the form of cut-sets and sequence equations can be a more powerful way of verifying the veracity of the models than when one only has fault tree drawings to review.

As an example, BWR systems have multiple pathways for low pressure injection, but the operational philosophy of the reactor operators might dictate certain preferences by operators in certain situations, even though other pathways may seem perfectly acceptable. Thus, a review of cut-sets may reveal the existence of what are essentially unrealistic cut-sets involving injection paths that the operators would only use to recover from the loss of other – preferred – injection paths.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-D	Capability Category I	Capability Category II	Capability Category III
QU-D3	REVIEW results to determine that the flag event settings, mutually exclusive event rules and recovery rules yield logical results.		

EXPLANATION OF REQUIREMENTS

The intent of this SR is to direct the analyst to review the PRA results, especially the cut-sets and sequences, to ensure that the results reflect accurately the assumptions regarding flag event settings, mutually exclusive event rules and recovery rules as intended by the analysts. Seeing the results in the form of cut-sets and sequence equations can be a more powerful way of verifying the veracity of the models than when one only has fault tree drawings to review.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-D	Capability Category I	Capability Category II	Capability Category III
QU-D4	No requirements to compare results to those from similar plants.	COMPARE results to those from similar plants and IDENTIFY causes for significant differences. For example: Why is LOCA a large contributor for one plant and not another?	

EXPLANATION OF REQUIREMENTS

The intent of this SR is to establish a readily available check for potential issues in the results. It is desirable that differences between PRA results for similar plants are well understood as they could either indicate potential flaws in a PRA or they could be indicators of subtle system design or operational practices, the understanding of which will enhance the utility of the PRA results.

Capability Category Differentiation

This identification can be performed to three different capabilities:

For Capability Category I, No requirement for comparing results is required.

For Capability Category II and III, This SR is a natural way to check for potential issues in the results. By comparing the results of a PRA for one plant with those for other similar plants, tremendous insights can be gathered regarding possible flaws in the PRA as well as insights regarding subtle differences in system design and configurations that lead to unexpected differences between PRA results of similar plants. Additionally, results are checked for plants of dissimilar design but that share commonalities for certain aspects of the PRA. For example, some plants may have different fundamental designs, but they may have similar designs for key safety features, such as emergency AC power, or certain weather related and initiating event characteristics may be similar.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-D	Capability Category I	Capability Category II	Capability Category III
QU-D5	REVIEW a sampling of non-significant accident cut-sets or sequences to determine they are reasonable and have physical meaning.		

EXPLANATION OF REQUIREMENTS

QU-D1 focuses on reviewing significant cut-sets and sequences. However, the logic here is the same, reviewing non-significant cut-sets or sequences is also a most important and useful way to perform a quality check on the fault trees, event trees and accident sequence quantification. First, this allows the analyst to validate the results and ensure that these cut-sets or sequences are, indeed, non-significant because the plant has been correctly modeled. Secondly, if non-significant cut-sets or sequences represent results that appear to be illogical, contrary to plant design or operations practices, or peculiar, these are indicators of potential flaws in either the actual models or assumptions that were made to construct the models. Such results are investigated to determine if errors exist. Additionally, the review of non-significant cut-sets or sequences can lead to insightful revelations regarding system interactions. This can lead to a greater understanding as to why certain plant features are not significant to the PRA results, a perspective that is just as valuable as understanding why certain features are significant.

A review of a sample of the cut-sets will both reaffirm the analyst's approach to developing the models and raise questions as well when peculiar or unexpected combinations of events are observed. In the former case it important to verify the results against the fault tree and event tree models despite the obvious nature of the cut-sets. In the latter case, the results are investigated to determine if an error exists in the models or to determine if the results, though unexpected, are in fact correct. This process of inspecting cut-sets against the actual models can lead to some of the most insightful revelations regarding system interactions.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-D	Capability Category I	Capability Category II	Capability Category III
QU-D6	IDENTIFY significant contributors to CDF, such as initiating events, accident sequences, equipment failures, common cause failures and operator errors.	IDENTIFY significant contributors to CDF, such as initiating events, accident sequences, equipment failures, common cause failures and operator errors. **INCLUDE SSCs and operator actions that contribute to initiating event frequencies and event mitigation.**	

EXPLANATION OF REQUIREMENTS

The intent of this SR is to develop an understanding of what the results are and why the results are what they are in the context of the models that were built and assumptions made that are fundamental to the PRA. A true understanding of the PRA results involves more than just knowing what is significant and what is not, it involves understanding why things are so. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This identification can be performed to three different capabilities:

For Capability Category I, The significant contributors to CDF are identified in terms of the specific accident sequences, types of accident sequences (e.g., LOOP, Loss-of-Feedwater), equipment failures, operator errors and special types of failures such as common cause failures. Initiating events and accident sequences can be assessed directly by comparing the overall CDF to the percent of the CDF that is accounted for by certain sequences individually or by groups of sequences. The significance of specific equipment, human actions or special events (e.g., common cause) can be developed through the use of importance measures such as Fussell-Vessely.

For Capability Category II and III, The idea is the same as for Capability Category I, except that a greater level of understanding is required. SSCs and operator actions, the failure of which can be linked to certain significant initiating events, are identified. This requires that root causes of initiating events be sufficiently understood so that the failure of specific components and/or operator actions can be identified as contributors to the occurrence of the initiating event or to the failure to mitigate the initiating event.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-D	**Capability Category I**	**Capability Category II**	**Capability Category III**
QU-D7	REVIEW the importance of components and basic events to determine that they make logical sense.		

EXPLANATION OF REQUIREMENTS

The intent of this SR is similar to that of QU-D1. Just as it is useful to review the results in terms of cut-sets and sequences to verify the underlying models or to identify potential flaws in the models, studying the significant contributors to CDF in terms of the individual SSCs and basic events is useful as well. This is another SR designed to facilitate an intimate understanding of not just what is significant, but why it is significant and that its significance (or non-significance) is logical within the context of a plant's design, actual layout and operation. As with cut-sets and sequences, certain basic events and SSCs would be expected to be significant for specific types of accident sequences and for the overall CDF. It is verified that such events and SSCs are significant, or, if not, the models are investigated to ascertain if their low significance is correct or an indication of a flaw in the model or regarding an assumption. Likewise, unexpected significant basic events and SSCs are investigated to ascertain whether their significance reveals a subtle but crucial role in plant safety or a subtle dependency, or a potential flaw in a model or assumption.

Importance measures are a useful tool for this type of review.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objections to the requirement.

5.7.5 Supporting Requirements for HLR-QU-E

ASME/ANS Standard Section 2.2.7, Table 2.2.7-2(e), Supporting Requirements for HLR-QU-E

HLR-QU-E: Uncertainties in the PRA results shall be characterized. Sources of model uncertainty and related assumptions shall be identified, and their potential impact on the results understood.

Intent: To ensure the results are appropriate for use in applications

SRs: QU-E1 through QU-E4

Index No. QU-E	Capability Category I	Capability Category II	Capability Category III
QU-E1	IDENTIFY sources of model uncertainty.		

EXPLANATION OF REQUIREMENTS

The understanding and treatment of sources of model uncertainty and assumptions (see QU-E2) are a critical part of an accurate understanding of the potential range within which the actual estimation of risk metrics, such as CDF and LERF, actually exists. The NRC has issued NUREG-1855, which provides guidance on what the NRC views as acceptable and good practices for the treatment of both parameter uncertainties and model uncertainties in PRA. EPRI has published a companion document, TR 1016737, which presents an application of the ideas and concepts presented in NUREG-1855. The NRC and EPRI worked closely in the development of both documents.

There are two fundamental types of uncertainties – aleatory, or random, and epistemic uncertainties – in the formulation of the PRA model (that is, uncertainty in the knowledge of something). This SR focuses on epistemic uncertainty, as the purely random uncertainty associated with well understood but random variables is accounted for in QU-A3, DA-D3 and DA-D4. In Chapter 2 of NUREG-1855, three types of epistemic uncertainty are defined:

- parameter
- model
- completeness

Parameter uncertainty relates to the uncertainty in the computation of the input parameter values used to quantify the probabilities of the events in the PRA logic model. The random nature of the failure probability or the frequency of many basic events and initiating events is well known for many events, and in those cases the uncertainty is aleatory, not epistemic. The probability distributions used for those events are well characterized and accepted among PRA analysts and do not represent uncertainty regarding the analysts' knowledge. However, for numerous basic events, epistemic uncertainty exists as to what is the actual characterization of uncertainty. For such basic events, the propagation of uncertainty through the accident sequence quantification for CDF estimation represents a source of model uncertainty. The use of a different characterization of uncertainty for a particular parameter could yield different PRA results. Such parameter sources of model uncertainty need to be identified.

Model uncertainty arises because different approaches may exist to represent certain aspects of plant response and none is clearly more correct than another. Examples of such assumptions include those made concerning: 1) how a reactor coolant pump in a PWR would fail following a loss-of-seal cooling, 2) the approach used to address common cause failure in the PRA model and 3) the approach used to identify and quantify operator errors.

Completeness uncertainty relates to risk contributors that are not in the PRA model. These types of uncertainties either are ones that are unknown but not included in the PRA or ones that are not known and therefore not in the PRA model. Both types are important. Examples of the former are: The scope of the PRA does not include certain classes of initiating events, hazards or modes of operation. Examples of the latter are: No agreement exists on how a PRA addresses certain effects, such as the effects on risk resulting from aging or organizational factors, or the analysis may have omitted phenomena, failure mechanisms or other factors because they are unknown.

NUREG-1855 discusses all three types of model uncertainty, and EPRI TR 1016737 provides a list of example sources of model uncertainty. However, the process of reviewing the PRA results according to the SRs for HLR-QU-D provides an excellent opportunity to revisit the choices made for parametric and model uncertainties and to contemplate possible completeness issues.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objections to the requirement.

Index No. QU-E	Capability Category I	Capability Category II	Capability Category III
QU-E2	IDENTIFY assumptions made in the development of the PRA model.		

EXPLANATION OF REQUIREMENTS

In NUREG-1855 the phrase "sources of model uncertainty and related assumptions" is frequently used. This illustrates that inherent to any model uncertainty are the impacts of underlying assumptions made by the PRA analysts in formulating models to address the uncertainty. The intent of this SR is that the analyst fully understands not just how, but why, a model uncertainty was treated in a particular manner and how the characterization of that model uncertainty might be impacted by a different assumption.

The discussion under QU-E1 applies completely for QU-E2.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objections to the requirement.

Index No. QU-E	Capability Category I	Capability Category II	Capability Category III
QU-E3	ESTIMATE the uncertainty interval of the CDF results**. Provide a basis for the estimate consistent with the characterization of parameter uncertainties. (DA-D3, HR-D6, HR-G8, IE-C15).**	ESTIMATE the uncertainty interval of the CDF results. **ESTIMATE the uncertainty intervals associated with parameter uncertainties (DA-D3, HR-D6, HR-G8, IE-C15), taking into account the "state-of-knowledge" correlation.**	**PROPAGATE parameter uncertainties (DA-D3, HR-D6, HR-G8, IE-C15), and those model uncertainties explicitly characterized by a probability distribution using the Monte Carlo approach or other comparable means. PROPAGATE uncertainties in such a way that the "state-of-knowledge" correlation between event probabilities is taken into account.**

EXPLANATION OF REQUIREMENTS

SRs DA-D3, HR-D6, HR-G8 and IE-C15 direct that the uncertainty of estimates for the probabilities of basic event parameters, including failure of SSCs and human actions, and for the frequencies of initiating events, be characterized by a representation of an uncertainty range and a point estimate value. In conjunction with QU-A3, those SRS allow the requirements of QU-E3 to be achieved, which is the characterization of the uncertainty in the PRA calculation of CDF, which represents the propagation of the basic event, HFE and initiating event uncertainties through the accident sequence quantification process. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This identification can be performed to three different capabilities:

For Capability Category I, the parameter uncertainty of the basic events, HFEs and initiating events is not explicitly propagated through the accident sequence quantification. DA-D3 allows for a qualitative characterization of uncertainty intervals, and SRs HR-D6, HR-G8 and IE-C15 allow for an uncertainty characterization *"in a manner consistent with the quantification approach..."* across all three Capability Categories. Hence, for Capability Category I, the foundation for the characterization of parameter uncertainty is DA-D3. DA-D3 stipulates that some sort of characterization of the uncertainty interval for each significant event (qualitative treatments are allowed) is required. However, HR-D6, HR-G8 and IE-C15 also dictate that the point estimate value used for each relevant parameter (i.e., HFE or initiating event) in the quantification of the PRA results be a mean value of that event based on a characterization of its uncertainty.

QU-AE requires that a point estimate of the CDF be calculated. However, as indicated by this SR (QU-E3) an estimate of the uncertainty intervals for this CDF point estimate is developed consistent with the manner by which the parameter uncertainties were characterized (e.g., qualitative discussion).

For Capability Category II, DA-D3 requires a mean value and a statistical representation of the parameter uncertainty interval (see DA-D3 for details). Thus, according to HR-D6, HR-G8 and IE-C15, the HFE and initiating event uncertainty intervals are characterized in a manner consistent with the quantification approach, and thus all basic events have a mean value and a statistical representation of their uncertainty. QU-A3 requires that a mean value of CDF be calculated (using the mean values for parameter values is allowed for the estimate of the CDF mean) and that the state-of-knowledge correlation be accounted for in the quantification of basic events (see Note (1) for QU-A3), as does this SR (QU-E3). Since the underlying SRs for the basic events, HFEs and initiating events require that their uncertainty intervals be characterized with a statistical distribution the uncertainty inherent to those parameters will be accounted for in the calculation of their mean values. These mean values are used to calculate CDF in the accident sequence quantification. Thus, through the use of mean parameter values calculated from statistical uncertainty representations and the state-of-knowledge correlation, the uncertainty of the parameters will be accounted for in the estimate of the CDF.

For Capability Category III, DA-D3 requires a mean value and a statistical representation of the parameter uncertainty interval (see DA-D3 for details). Thus, according to HR-D6, HR-G8 and IE-C15, the HFE and initiating event uncertainty intervals are characterized in a manner consistent with the quantification approach, and thus all basic events have a mean value and a statistical representation of their uncertainty. QU-A3 requires a mean value for CDF be calculated by propagating the parameter uncertainties through the accident sequence quantification process. That requirement is corroborated by this SR (QU-E3) by the requirement that a statistical sampling method such as Monte Carlo be used to sample the uncertainty distributions of the parameters to facilitate the propagation of uncertainty through to the estimate of CDF. Further, the state-of-knowledge correlation is accounted for in the quantification of basic events (see Note (1) for QU-A3). The result of propagation the parameter uncertainty through the accident sequence quantification will be a statistical characterization of the uncertainty intervals of CDF and an estimate of various statics on CDF such as the mean and median.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objections to the requirement.

Index No. QU-E	Capability Category I	Capability Category II	Capability Category III
QU-E4	For each source of model uncertainty and related assumption identified in QU-E1 and QU-E2, respectively, IDENTIFY how the PRA model is affected (e.g., introduction of a new basic event, changes to basic event probabilities, change in success criterion, introduction of a new initiating event) [NOTE (1)].		

NOTE (1): For specific applications, key assumptions and parameters should be examined both individually and in logical combinations.

EXPLANATION OF REQUIREMENTS

Consistent with the philosophy of all of the SRS for HLR-QU-D, it is not sufficient to simply identify and catalog the sources of model uncertainty and related assumptions (QU-E-1 and QU-E2). The ramifications and potential impacts of other possible models and assumptions upon the PRA results are understood. Hence, for each source of model uncertainty and related assumptions, the nature of the impact of a different hypothesis or a different assumption is identified. That is, would a different hypothesis or assumption result in a change in the probability distribution of one (or more) basic events, would new basic events be introduced into the logic models, would changes to success criteria (and hence fault trees) be introduced or would new accident sequences be introduced either through changes in current event trees or the introduction of new initiating events?

Note (1) refers to key assumptions and parameters, and that they are examined both individually and in logical combinations. The concept of analyzing a PRA model for key sources of model uncertainty and related assumptions (as well as the definition of "key") is discussed in NUREG-1855, and illustrated in both NUREG-1855 and EPRI TR 1016737. The idea of examining assumptions and parameters "in logical combinations" refers to the situation when numerous aspects of a PRA model (for example, the probabilities for several basic events) are characterized on the basis of the same hypothesis or assumption. This concept also is discussed in NUREG-1855.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

5.7.6 Supporting Requirements for HLR-QU-F

ASME/ANS Standard Section 2.2.7, Table 2.2.7-2(f), Supporting Requirements for HLR-QU-F

HLR-QU-F: Documentation of the quantification shall be documented with the applicable supporting requirements.

Intent: To ensure the results can be reviewed and appropriately referenced for applications.

SRs: QU-F1 through QU-F6

Index No. QU-F	Capability Category I	Capability Category II	Capability Category III
QU-F1	DOCUMENT the model quantification in a manner that facilitates PRA applications, upgrades and peer review.		

EXPLANATION OF REQUIREMENTS

It is important that the documentation includes sufficient information about the approach used for the quantification of CDF (and support the quantification of LERF), such that an analyst or peer reviewer who was not involved in the original process could come to similar conclusions regarding the validity of the results and the veracity of the quantification to the as-built and as-operated plant. In this way an analyst would be able to understand the approach and would be able to support applications, upgrades, and reviews of the PRA. Furthermore, the documentation is to be consistent with the applicable SRs as stated in High Level Requirement QU-F. Although examples are included in SR QU-F2, these do not represent a complete listing of all required documentation. To facilitate the development of a complete list, a documentation mapping is provided in the explanation to SR QU-F2 showing scope of documentation needed to achieve consistency with the applicable SRs.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

<table>
<tr><th>Index No.
QU-F</th><th>Capability Category I</th><th>Capability Category II</th><th>Capability Category III</th></tr>
<tr><td>QU-F2</td><td colspan="3">DOCUMENT the model integration process including any recovery analysis, and the results of the quantification including uncertainty and sensitivity analyses. For example, documentation typically includes:
(a) Records of the process/results when adding non-recovery terms as part of the final quantification
(b) Records of the cut-set review process
(c) A general description of the quantification process including accounting for systems successes, the truncation values used, how recovery and post-initiator HFEs are applied
(d) The process and results for establishing the truncation screening values for final quantification demonstrating that convergence towards a stable result was achieved
(e) The total plant CDF and contributions from the different initiating events and accident classes
(f) The accident sequences and their contributing cut-sets
(g) Equipment or human actions that are the key factors in causing the accidents to be nondominant
(h) The results of all sensitivity studies
(i) The uncertainty distribution for the total CDF
(j) Importance measure results
(k) A list of mutually exclusive events eliminated from the resulting cut-sets and their bases for elimination
(l) A symmetries in quantitative modeling to provide application users the necessary understanding regarding why such asymmetries are present in the model
(m) The process used to illustrate the computer code(s) used to perform the quantification will yield correct results process.</td></tr>
</table>

EXPLANATION OF REQUIREMENTS

This SR addresses the process documentation used to implement the quantification supporting requirements. It also provides examples of documentation associated with the quantification processes and examples of documentation associated with the parameters, constraints and results from implementing these processes. Table 13 (QU-F2-1) provides a discussion of these examples. It should be noted that the documentation examples do not represent the complete list of all required documentation, but a list of many of the documents that are typically included. To facilitate the development of a complete list, a documentation mapping is provided in Table 14 (QU-F2-2) showing the scope of documentation needed to achieve consistency with the applicable SRs. Table 14 (QU-F2-2) also identifies each documentation item as either “process” or “SR.” A “process” documentation item primarily supports the process requirement which is the focus of this SR while an “SR” documentation item primarily supports documentation that is consistent with one or more supporting requirements as required by QU-F1. A mapping is also provided in Table 13 (QU-F2-1) between the examples and the documentation list shown in Table 14 (QU-F2-2) and in Table 14 (QU-F2-2) between the documentation items and the applicable SRs.

Table 13 QU-F2-1 SR Examples

SR Example	Discussion	Documentation Item
a	SRs QU-C1 and QU-C2 describe the area of quantification that this element addresses.	5
b	SR DA- D1, D2, D3, D5 and D7 provide review requirements to ensure that the sequences / cut-sets / basis events are correct.	14
c	This element is a broad requirement that addresses the scope of all of the HLRs for Quantification, but there is a strong emphasis on HLR-QU-B and HLR-QU-C, which underscores the importance that the models and codes used in the quantification process are used appropriately and their limitations are accounted for.	1
d	SR QU-B2 and B3 provide the requirements for establishing the truncation limit.	2, 3
e	The value of PRA results lies not simply in the estimating of a single risk metric such as CDF, but in understanding the nature of the various accident sequences that lead to that estimation is crucial for understanding the dynamics of plant systems and their responses to initiating events. To this end the types of accidents and their contributors to the risk metric are be reported. Note that there is no SR that requires the development of accident classes.	8
f	This element is similar to *(e)*. The granularity of the presentation of results is at a finer level of detail, going down from the types of accidents to the specific accidents and the dominant combinations of failures (cut-sets) that make up these sequences.	8
g	All of the SRs in support of HLR-QU-D are designed to facilitate the understanding of not only what are the dominant contributors to CDF, but also why and how those contributors are dominant. Sensitivity studies may be required to determine key equipment or human actions.	11, 13
h	QU-E4 directs that key assumptions and sources of model uncertainty are examined. NUREG-1855 presents a method for determining what constitutes key model uncertainties and assumptions. Basically, model uncertainties and assumptions that have the potential to impact a regulatory decision regarding a risk-informed application using the results of a PRA are key. That is, the uncertainty associated with the issue could result in significantly different PRA results if the issue was treated differently.	13
i	For Capability Category I, a qualitative treatment of the uncertainty range of the CDF estimate is adequate, as specified in QU-E3 through DA-D3. For Capability Category II and III a statistical representation of the uncertainty of the CDF estimate is required by QU-E3 and DA-D3.	9
j	QU-D6 requires the identification of significant contributors to CDF and Importance Measures are useful tools for this.	10
k	QU-B8 requires that cut-sets containing mutually exclusive events be corrected, the actual cut-sets deleted from the analysis and the basis for their elimination is documented.	4
l	No explicit guidance is provided in the SRs for the treatment of asymmetries beyond that provided in this example. However, the SRs do require the identification of assumptions and evaluation of how these affect the PRA.	13
m	SR QU-B1 requires quantification to be performed using computer codes that have been demonstrated to provide appropriate results.	12

Table 14 QU-F2-2 Documentation Mapping

Element	Type	Item	Documentation	Related SR	SR Examples
QU	Process	1	Document the approach for CDF (and LERF) quantification including treatment of circular logic, system failures and successes, mutually exclusive events and logic flags (if applicable)	A1, A4, A5, B4, B5, B6, B7, B8, B9, B10, C3	c
QU	Process	2	Document the approach for selecting the truncation limit	B2, B3	d
QU	SR	3	Document the truncation limit	B2	d
QU	SR	4	Document all mutually exclusive events and the bases for their elimination.	B7, B8	k
QU	SR	5	Document the identification and assessment of Sequences/Cut-sets with multiple HFEs	C1,C2	a
QU	SR	6	Document assumptions	E2	na
QU	SR	7	Document the sources of model uncertainty	E1	na
QU	SR	8	Results - Document CDF and its contributions from initiating events, accident sequences, cut-sets	A2, A3, A5	e, f
QU	SR	9	Results - Document CDF Uncertainty distribution	E3	i
QU	SR	10	Results - Document Importance measures	D7	j
QU	SR	11	Results - Document Significant contributors to CDF	D6	g
QU	SR	12	Document Quantification Computer Code validation	B1	m
QU	SR	13	Sensitivity Studies - Document sources of model uncertainty and related assumptions and how the PRA model is affected	E4	g, h, l
QU	SR	14	Review - Document sequence/cut-set/basic event Review to confirm logic is appropriate and sequences are consistent with system models and success criteria. Include a review of non-significant sequences/cut-sets.	A2, D1, D2, D3, D5, D7	b
QU	SR	15	Review - Document results comparison to those from similar plants (Category II and III only)	D4	na

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-F	Capability Category I	Capability Category II	Capability Category III
QU-F3	DOCUMENT the significant contributors (such as initiating events, accident sequences, basic events) to CDF in the PRA results summary.	DOCUMENT the significant contributors (such as initiating events, accident sequences, basic events) to CDF in the PRA results summary. **PROVIDE a detailed description of significant accident sequences or functional failure groups.**	

EXPLANATION OF REQUIREMENTS

The intent of this SR is to ensure that the results of the accident sequence quantification achieved through the requirements of HLR-QU-A, HLR-QU-B, HLR-QU-C and the insights gained through the review and study of those results as required through HLR-QU-D and HLR-QU-E are clearly and well documented.

Capability Category Differentiation

This identification can be performed to three different capabilities:

For Capability Category I, the significant contributors to the CDF estimate are documented, in terms of initiating events, basic events, as well as significant accident sequences. A detailed description of the accident sequences is not required.

For Capability Category II and III, the significant contributors to CDF, including initiating events, basic events and accident sequences are documented. Significant accident sequence or functional failure groups are provided so that it is clearly documented that not only what sequences are significant, but why and how those sequences are significant is documented.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-F	Capability Category I	Capability Category II	Capability Category III
QU-F4	DOCUMENT the characterization of the sources of model uncertainty and related assumptions (as identified in QU-E4).		

EXPLANATION OF REQUIREMENTS

QU-E4 directs that key assumptions and sources of model uncertainty are examined. NUREG-1855 presents a method for determining what constitutes key model uncertainties and assumptions. Basically, model uncertainties and assumptions that have the potential to impact a regulatory decision regarding a risk-informed application using the results of a PRA are key. That is, the uncertainty associated with the issue could result in significantly different PRA results if the issue was treated differently. The results of any sensitivity studies performed to assess whether or not sources of model uncertainty and assumptions are key or not are documented.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-F	Capability Category I	Capability Category II	Capability Category III
QU-F5	DOCUMENT limitations in the quantification process that would impact applications.		

EXPLANATION OF REQUIREMENTS

The limitations of the accident sequence quantification method and computer tools identified as required by QU-B1 are documented.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

Index No. QU-F	Capability Category I	Capability Category II	Capability Category III
QU-F6	DOCUMENT the quantitative definition used for significant basic event, significant cut-set and significant accident sequence. If other than the definition used in Section 2, JUSTIFY the alternative.		

EXPLANATION OF REQUIREMENTS

The term "significant" is used repeatedly throughout the SR for Quantification. Contributors that are significant to CDF are identified and the reasons for their significant contributions are determined for basic events, initiating events, accident sequences, human actions and equipment. The definition of significant accident sequence, significant basic event and significant contributor to a cut-set are defined quantitatively in Section 1-2 of the Standard. The use of these definitions as the basis for defining significant contributors is stated in the documentation. If significant is defined differently than as it is in Section 1-2, then the alternative definition is documented, and the basis for that alternative definition is explained and justified.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200 in its endorsement of ASME/ANS PRA standard RA-Sa-2009 has no objections to the requirement.

5.8 LERF Analysis Section 2-2.8 of the ASME/ANS RA-Sa-2009

The objectives of the LERF analysis element are to identify and quantify the contributors to large early release, based upon the plant-specific core damage scenarios, in such way that

(a) The methodology is clear and consistent with the Level 1 evaluation, and creates an adequate transition from Level 1.

(b) Operator actions, mitigation systems, and phenomena that can alter sequences are appropriately included in the LERF event tree structure and sequence definition.

(c) Dependencies are reflected in the accident sequence model structure, if necessary.

(d) Success criteria are available to support the individual function successes, mission times and time windows for operator actions and equipment recovery for each critical safety function modeled in the accident sequences.

(e) End states are clearly defined to be LERF or non-LERF.

To meet the above objectives, seven HLRs are defined in the standard:

Designator	Requirement
HLR-LE-A	Core damage sequences shall be grouped into plant damage states based on their accident progression attributes.
HLR-LE-B	The accident progression analyses shall include an evaluation of contributors (e.g., phenomena, equipment failures and human actions) to a large early release.
HLR-LE-C	The accident progression analysis shall include identification of those sequences that would result in a large early release.
HLR-LE-D	The accident progression analyses shall include an evaluation of the containment structural capability for those containment challenges that would result in a large early release.
HLR-LE-E	The frequency of different containment failure modes leading to a large early release shall be quantified and aggregated.
HLR-LE-F	The quantification results shall be reviewed and significant contributors to LERF, such as plant damage states, containment challenges and failure modes shall be identified. Sources of model uncertainty and related assumptions shall be identified and their potential impact on the results understood.
HLR-LE-G	The documentation of LERF analysis shall be consistent with the applicable supporting requirements.

5.8.1 Supporting Requirements for HLR-LE-A

ASME/ANS Standard Section 2-2.8, Table 2-2.8-2(a), Supporting Requirements for HLR-LE-A

HLR-LE-A: Core damage sequences shall be grouped into plant damage states based on their accident progression attributes.

Intent: To ensure that the appropriate information is transferred from the Level 1 model to the LERF model.

SRs: LE-A1 through LE-A5

Index No. LE-A	Capability Category I	Capability Category II	Capability Category III
LE-A1	IDENTIFY those physical characteristics at the time of core damage that can influence LERF. Examples include: *(a)* RCS pressure (high RCS pressure can result in high pressure melt ejection) *(b)* Status of emergency core coolant systems (failure in injection can result in a dry cavity and extensive Core Concrete Interaction) *(c)* Status of containment isolation (failure of isolation can result in an unscrubbed release) *(d)* Status of containment heat removal (e) Containment integrity (e.g., vented, bypassed or failed) (f) Steam generator pressure and water level (PWRs) (g) Status of containment inerting (BWRs)		

EXPLANATION OF REQUIREMENT

This SR identifies those characteristics (RCS pressure, RCS/containment integrity, water levels, containment inerting) of plant systems that are likely to be important for the accident progression and therefore in the determination of LERF. These states are selected based on the impact of these conditions on the potential for containment challenges and radiological releases. Some of these characteristics will become attributes of the plant damage states. The list identified in the SR is common, but not exhaustive. Plant unique conditions may be added to this list. An example is the status of the isolation condenser in a BWR plant that is so equipped or igniters for ice condenser designed PWRs.

The identification of the relevant characteristics fulfills a need to reduce the number of accident progression scenarios developed from the large number of Level 1 cut-sets so as to make the number of deterministic analyses used in the large early release calculations practical. Ultimately, many Level 1 sequences with similar characteristics relevant for LERF will lead to a similar accident progression, i.e., they can be grouped together as discussed in LE-A5.

This SR and the others under this HLR are the same across all three capability categories. However, this and the other SRs are related to many subsequent LE SRs that do differentiate among Capability Categories. Therefore the level of detail at which these SRs are met should be commensurate with the Capability Categories selected to support subsequent SRs (for instance those in HLR-LE-B). For example, if the LERF analysis is carried out in accordance with NUREG/CR-6595, as is permissible for Category I, the analyst can ascertain the characteristics referred to in LE A-1 by looking at the questions asked in the simplified containment event tree template in NUREG/CR-6595 for the containment type being analyzed. For the other categories a more thorough search for characteristics is needed. In any case, a search for plant unique characteristics is always necessary.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-A	Capability Category I	Capability Category II	Capability Category III
LE-A2	IDENTIFY the accident sequence characteristics that lead to the physical characteristics identified in LE-A1. Examples include: *(a)* Type of initiator *(1)* Transients can result in high RCS pressure *(2)* LOCAs usually result in lower RCS pressure *(3)* ISLOCAs, SGTRs can result in containment bypass. *(b)* Status of electric power: loss of electric power can result in loss of ECC injection *(c)* Status of containment safety systems such as sprays, fan coolers, igniters, or venting systems: operability of containment safety systems determines status of containment heat removal The references in Notes (1) and (2) provide example lists of typical characteristics.		

NOTE (1): Nuclear Power Plant Response to Severe Accident, IDCOR Technical Summary Report, Atomic Industrial Forum, November 1984

NOTE (2): NUREG 1150, Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants, December 1990

EXPLANATION OF REQUIREMENT

The identification of the accident sequence characteristics that result in the physical characteristics identified in LE-A1 facilitates the "binning" of the Level 1 sequences into plant damage states. All Level 1 sequences are to be propagated and binned consistently. The operability of systems that played a role in the core damage sequences, as well as systems which did not, but could be important for events beyond core damage, are examined. Some systems which failed to prevent core damage may still provide benefit by allowing for potential reduction in the release of fission products. If the reduction is sufficiently great this may impact the binning of the event as a LERF contributor. The influence of accident sequence characteristics on the status of barriers to, and mitigators of, fission product release include: accident timing, pathways for fission products transport and deposition, energy released into containment. As in LE-A1, some of these characteristics will become PDS attributes. Plant unique accident sequence characteristics are also addressed in the examination that leads to the identification.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-A	Capability Category I	Capability Category II	Capability Category III
LE-A3	IDENTIFY how the physical characteristics identified in LE-A1and the accident sequence characteristics identified in LE-A2 are addressed in the LERF analysis. For example, (a) Which characteristics are addressed in the level 1 event trees, (b) Which characteristics, if any, are addressed in bridge trees and (c) Which characteristics, if any, are addressed in the containment event trees. JUSTIFY any characteristics identified in LE-A1 or LE-A2 that are excluded from the LERF analysis.		

EXPLANATION OF REQUIREMENT

This SR assures that the characteristics identified in LE-A1 and LE-A2 as important to the LERF assessment can be explicitly linked to Level 1 parameters or containment systems status information in such a manner that the accident progression characteristics may be either passed on to, or ascertained in, the accident progression analysis which leads to the LERF determination. Level 1 analysis may be used to characterize RCS conditions and the status of some plant systems and power availability. Level 1 analyses do not consider containment systems that are not involved in preventing core damage, therefore the status of these systems needs to be defined separately. The SR calls for a systematic accounting of how and where the characteristics identified in LE-A1 and LE-A2 will be developed for use in the LERF analysis. If a previously identified characteristic is dropped from consideration, justification for the omission needs to be provided. For example, it may be possible to subsume a particular characteristic under another one.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-A	Capability Category I	Capability Category II	Capability Category III
LE-A4	PROVIDE a method to explicitly account for the LE-A1 and LE-A2 characteristics and ensure that dependencies between the Level 1 and Level 2 models are properly treated. Examples include: treatment in Level 2, expanding Level 1, construction of a bridge tree, transfer of the information via PDS or a combination of these.		

EXPLANATION OF REQUIREMENT

This SR develops the process for integrating the Level 1 results with supporting information for containment and beyond core damage characteristics identified in LE-A1 and LE-A2 and transferring the information to the containment event tree developed in HLR-LE-C. Level 2 aspects required for this SR are related only to LERF. That is all non-LERF states associated with intact and late containment failures are not required to be differentiated.

The mechanism for integrating and transferring this information is to be adapted based on the user preference. Example means of transferring this information include manual assembly and PDS (LE-A5) mapping, creation of bridge trees to integrate Level-1 information with required Level 2 information and direct linking of Level 1 information with Level 2 fault trees. There is likely to be some iteration between the decisions made for LE-A3 and the methods developed for LE-A4, i.e., the analyst may change the way some characteristics are handled based on the ease or convenience of method development.

Regardless of the method used, the dependencies between the Level 1 and Level 2 models need to be included in the model. Information from the core damage sequences needs to be coupled with containment system availability information to arrive at the initial and boundary conditions used for accident sequence progression development to determine LERF. Level 1 sequence information needs to be extended to account for dependencies of the systems important for LERF, such as shared components (containment spray system and low pressure injection, for example), support systems (including possible recovery of some lost systems like AC power) and prior human actions. It may not be sufficient to classify system status as simply operating or failed. For example, a low pressure system may be dead-headed at core damage because of high reactor pressure, but may be available after vessel failure to flood the reactor cavity.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-A	Capability Category I	Capability Category II	Capability Category III
LE-A5	DEFINE plant damage states consistent with LE-A1, LE-A2, LE-A3 and LE-A4.		

EXPLANATION OF REQUIREMENT

This SR requires that the characterizations of the plant status used to carry out the accident progression analysis are carried out in a manner consistent with those attributes identified as important for LERF determination in LE-A1 through LE-A4. Often this is accomplished by explicitly defining plant damage states (PDSs), using the characteristics and dependencies identified in LE-A1 through LE-A4, and binning the Level 1 core damage sequences into the appropriate PDSs, but other methods, such as direct linking of the Level 1 and Level 2 analysis can be used as well. In these other approaches, plant states at core damage that have similar characteristics may only be implicitly grouped for eventual use in display of end results. When PDSs are used, each PDS ought to represent a unique set of initial and boundary conditions (i.e., conditions at core damage) from which the accident progression sequences for the LERF analysis are developed. Each PDS ought to be defined in a way that all the accident sequences binned into it can be treated in a similar manner in the LERF analysis. In most cases this means that their progression can be analyzed with the same containment event tree. All the information from the plant model that is important for assessing the likelihood of a large early release needs to be brought to the LERF analysis via the PDSs. The analyst may need some deterministic calculations to properly group similar accident sequences. The summed frequency of the PDSs ought to account for the entire core damage frequency from the Level 1 analysis. The binning of the Level 1 information usually needs to be carried out at the cut-set level in order to account properly for such issues as: (1) support system failures and other dependencies, (2) recoverable versus non-recoverable failures and (3) operator actions modeled in the Level 1 analysis.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.8.2 Supporting Requirements for HLR-LE-B

ASME/ANS Standard Section 2-2.8, Table 2-2.8-2(b), Supporting Requirements for HLR-LE-B

HLR-LE-B: The accident progression analyses shall include an evaluation of contributors (e.g., phenomena, equipment failures and human actions) to a large early release.

Intent: To ensure that the model includes a reasonably complete set of LERF contributors.

SRs: LE-B1 through LE-B3

Index No. LE-B	Capability Category I	Capability Category II	Capability Category III
LE-B1	IDENTIFY LERF contributors from the set identified in Table 2-2.8-9. **An acceptable approach for identifying contributors that could influence LERF for the various containment types is contained in NUREG/CR-6595, October 2004.** INCLUDE as appropriate, unique plant issues as determined by expert judgment and/or engineering analyses.	IDENTIFY LERF contributors from the set identified in Table 2-2.8-9. INCLUDE as appropriate, unique plant issues as determined by expert judgment and/or engineering analyses.	**INCLUDE LERF contributors sufficient to support development of realistic accident progression sequences. ADDRESS those contributors identified by IDCOR [2-14] and NUREG-1150 [2-15].** INCLUDE as appropriate, unique plant issues as determined by expert judgment and/or engineering analyses.

EXPLANATION OF REQUIREMENT

The objective of this supporting requirement is to systematically identify (i.e., establish or determine) the large early release frequency (LERF) contributors by examining the factors that can influence the likelihood and magnitude of a large early release of fission products to the environment (and therefore the large early release *frequency*), given that a severe accident has occurred. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This identification can be performed to three different capabilities:

For Capability Category I, the establishment or determination of the possible contributors to LERF is expected to be simplistic and can be performed from a pre-established list as shown in Table 2-2.8-9 of the standard, or using the approach contained in NUREG/CR-6595 (October 2004). This approach is expected to be conservatively biased.

For Capability Category II, the establishment or determination of the possible contributors to LERF is intended to be more inclusive than Capability Category I. The simplified methods of NUREG/CR-6595 do not produce sufficient resolution for meeting the SR at this Capability Category Level. At this level a realistic treatment of most important large early release contributors is expected.

For Capability Category III, the establishment or determination of the possible contributors to LERF is intended to be more inclusive than Capability Category II. To meet Capability Category III, the search for possible contributors needs to go beyond Table 2-2.8-9 to ensure a realistic development of the accident sequences can be performed. Further, the IDCOR and NUREG-1150 studies are considered to be state-of-the-art in this area, and, as such, the contributors identified in these studies need to be examined to determine if they are applicable.

For all three capability categories, it is necessary to search for unique plant factors that may influence a large early release given the as-designed, as-built and as-operated plant. An example would be the identification of a containment/reactor cavity floor drain whose location may make it vulnerable to core debris impingement and whose consequential failure could provide a path to the environment.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-B	Capability Category I	Capability Category II	Capability Category III
LE-B2	DETERMINE the containment challenges (e.g., temperature, pressure loads, debris impingement) resulting from contributors identified in LE-**B1** **using applicable generic analyses. Where applicable generic analyses are not available, conservative plant-specific analyses may be used. An acceptable alternative is the approach in NUREG/CR-6595, October 2004 [NOTE (1)].**	DETERMINE the containment challenges (e.g., temperature, pressure loads, debris impingement) resulting from contributors identified in LE-B1 **using applicable generic or plant-specific analyses for significant containment challenges. USE conservative treatment or a combination of conservative and realistic treatment for non-significant containment challenges. If generic calculations are used in support of the assessment, JUSTIFY applicability to the plant being evaluated.**	DETERMINE the containment challenges (e.g., temperature, pressure loads, debris impingement) resulting from contributors identified in LE-B1 **in a realistic manner. CONSIDER differential pressure loadings on the RCS and support vessel capabilities during vessel failure and blowdown, in order to address whether RCS motions may impact containment integrity.**

NOTE (1) Document referenced is a revised version of NUREG/CR-6595 issued January, 1999.

EXPLANATION OF REQUIREMENT

Once applicable LERF contributors have been identified in LE-B1, the challenges to the plant being analyzed resulting from the severe accident phenomena they represent need to be established. The type and magnitude of the containment challenges for the plant being examined are determined under this SR, using appropriate supporting engineering analyses as required in LE-B3. The challenges determined here include direct containment pressure challenges where peak containment pressure will be compared to the containment structural capability determined in HLR-LE-D. This SR also involves identification of other containment failure modes, as applicable for the capability category. Since severe accident phenomena contain significant uncertainties, assumptions in modeling their effects are necessary and these will need to be identified to meet the requirements of LE-F3. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This determination can be performed to three different capabilities:

For Capability Category I, the containment challenges from the identified contributors to LERF can be derived from generic analyses performed for similar plants with a similar containment type. Similar containment types can be characterized by containment type, size, wall thickness and design pressure. Use of generic analyses is expected to be conservatively biased and, where gaps exist, can be supplemented with conservative plant-specific analyses. Such conservative plant-specific analysis is expected to be needed for plant unique issues, for example. When the approach contained in NUREG/CR-6595 is used, the challenges are embedded in the simplified event trees developed in that document. Low probability containment failure modes (such as those associated with in vessel steam explosions and “rocket” failure) can be included with more likely failure modes and not explicitly tracked.

For Capability Category II, the determination of the containment challenges is to be more realistic for the significant challenges than for Capability Category I. Requirements for Capability Category II are self-explanatory.

For Capability Category III, the determination of the containment challenges is intended to be more inclusive than Capability Category II. All the challenges to containment integrity are treated in a realistic manner. In most cases plant-specific analyses of the severe accident phenomena will be needed. Structural interactions between the RCS and its connections to the containment with surrounding systems need to be addressed as they may create a loss of containment isolation condition. When expert judgment is used a formal process should be utilized. The NUREG-1150 study is considered to be state-of-the-art in this area.

For all three capability categories, unique plant factors identified in LE-B1 that may influence a large early release are required to be addressed and the corresponding challenges determined. Also, for all three categories the assumptions used in the analyses of the challenges need to be tracked.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-B	**Capability Category I**	**Capability Category II**	**Capability Category III**
LE-B3	UTILIZE supporting engineering analyses in accordance with the applicable requirements of Table 2-2.3-3(b).		

EXPLANATION OF REQUIREMENT

Analyses/evaluations are utilized to determine the containment challenges in LE-B2, and may also be utilized in the identification of LERF contributors in B1. SR LE-B3 ensures that the basis for the contributors and their challenges rests on engineering analyses or evaluations, including extrapolations of representative experiments (if available). The needed technical analyses can cover a wide range of technical areas, including RCS thermal hydraulics and heat transfer, hydrogen burns and containment pressurization, fuel behavior and chemistry, as well as material science and structural analysis (both RCS and containment). In many instances, integrated computer codes such as MAAP, MELCOR and RELAP-SCDAP can provide considerable engineering guidance. Computer tools should be used within their range of applicability. Experimental information may be used to supplement predictions of computer simulations.

Capability Category Differentiation

The capability category differentiation is stated in Table 2-2.3-3(b). However, for LE-B3 the following should be noted about using the SC-B guidance of Table 2-2.3-3(b):

In Capability Category II the use of conservative (or a combination of conservative and realistic) analyses/evaluation for non-significant containment challenges is acceptable, i.e., not only realistic analyses/evaluations, as stated in SC-B1, are acceptable.

The use of expert judgment is likely to be more prevalent when dealing with severe accident phenomena that challenge containment than it is for the Level 1 analysis.

While no explicit category definition is provided, the information provided should be consistent with the capability category used to support LE-B1 and LE- B2.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.8.3 Supporting Requirements for HLR-LE-C

ASME/ANS Standard Section 2-2.8, Table 2-2.8-2(c), Supporting Requirements for HLR-LE-C

HLR-LE-C: The accident progression analysis shall include identification of those sequences that would result in a large early release.

Intent: To ensure that a reasonably complete set the accident sequences is included in the LERF model.

SRs: LE-C1 through LE-C13

Index No. LE-C	Capability Category I	Capability Category II	Capability Category III
LE-C1	DEVELOP accident sequences to a level of detail to account for the potential contributors identified in LE-B1 and analyzed in LE-B2. **Containment event trees developed in NUREG/CR-6595 [NOTE (1)] (with plant-specific modifications, if needed) are acceptable.**	DEVELOP accident sequences to a level of detail to account for the potential contributors identified in LE-B1 and analyzed in LE-B2. **Compare the containment challenges analyzed in LE-B with the containment structural capability analyzed in LE-D and identify accident progressions that have the potential for a large early release.** **JUSTIFY any generic or plant-specific calculations or references used to categorize releases as non-LERF contributors based on release magnitude or timing. NUREG/CR-6595, App. A [NOTE (1)] provides an acceptable definition of LERF source terms.**	DEVELOP accident sequences to a level of detail to account for the potential contributors identified in LE-B1 and analyzed in LE-B2. **Compare the containment challenges analyzed in LE-B with the containment structural capability analyzed in LE-D and identify accident progressions that have the potential for a large early release.** **CALCULATE source terms for accident progressions that have the potential for large early releases.**

NOTE (1): NUREG/CR-6595, Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events, October, 2004.

EXPLANATION OF REQUIREMENT

This SR requires the development and modeling of the accident progression sequences to be used in the LERF analysis. The model logic for the accident progression sequences is developed at the level of detail appropriate for the Capability Category being pursued (consistent with the Capability Category used for LE-B1 and LE-B2). The remaining LE-C SRs support this accident sequence development. The level of detail of the development differs considerably from one capability category to another. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This development can be performed to three different capabilities:

For Capability Category I, simplified event trees, such as those found in NUREG/CR-6595, are used.

For Capability Category II, the simplified event trees of the NUREG/CR-6595 type are insufficient and accident progression sequences need to be developed to a level of detail that allows the contributors identified in LE-B1 and their challenges, as identified in LE-B2, to be accounted for as either leading to a large early release or not. An essential part of this analysis is the comparison of the identified challenges to containment integrity with the containment structural capacity analyzed in HLR- LE-D. Since Capability Category II does not require the calculation of source terms, by default LERF consists of the total frequency of all releases that occur due to early containment failure or containment bypass. Releases in these containment failure mode categories designated as non-LERF contributors should be justified as such. Justification could be based on either magnitude and/or timing of the release or both. Therefore the accident progression sequence development needs to be at a level of detail which allows mitigating factors for both magnitude and timing to be analyzed. Containment release estimates may be established based on MAAP or MELCOR scenarios, or results of prior generic studies for similar plants.

For Capability Category III, the level of detail of the accident progression sequences is even greater than that discussed for Category II, since in Category III source terms that have the potential for a large early release need to be calculated. Therefore the level of detail is to include aggravating as well as mitigating factors for both magnitude and timing of source terms, such as release location, source term composition, magnitude and duration of release.

For all three capability categories, plant-specific factors, if significant for large release determination, must be included.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-C	Capability Category I	Capability Category II	Capability Category III
LE-C2	INCLUDE **conservative** treatment of feasible operator actions following the onset of core damage. **An acceptable conservative treatment of operator actions is provided in the event trees of NUREG/CR-6595 [NOTE (1)].**	INCLUDE **realistic** treatment of feasible operator actions following the onset of core damage **consistent with applicable procedures, e.g., EOPs/SAMGs, proceduralized actions, or Technical Support Center guidance.**	

NOTE (1): NUREG/CR-6595, Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events, October 2004.

EXPLANATION OF REQUIREMENT

This SR supports the accident progression sequence development by requiring the identification and inclusion of those operator actions in the development that can have a significant effect on LERF. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This identification and inclusion can be performed to different capabilities:

For Capability Category I, operator actions subsequent to core damage are treated conservatively. The simplified event trees of NUREG/CR-6595 have built into their structure some top events which can be influenced by operator actions, for example, the top event of "RCS Depressurized." The discussion in the document of the top events or questions indicates where operator actions may be considered. NUREG/CR-6595 calls for justification whenever an operating procedure is assumed to be carried out.

For Capability Category II and III, this SR calls for realistic treatment of feasible operator actions subsequent to core damage so that realism in the development of the accident progression sequences is preserved. In order for operator actions to be considered feasible, they need to be demonstrated not to be improvised, i.e., they must be documented in plants EOPs, SAMGs or other established guidance. RIS-2008-15 notes that B.5.b actions can also be considered if actions have been trained on.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-C	Capability Category I	Capability Category II	Capability Category III
LE-C3	No requirement to address repair.	REVIEW significant accident progression sequences resulting in a large early release to determine if repair of equipment can be credited. JUSTIFY credit given for repair (i.e., ensure that plant conditions do not preclude repair and actuarial data exists from which to estimate the repair failure probability [see SY-A24, DA-C15 and DA-D8]). AC power recovery based on generic data applicable to the plant is acceptable.	

EXPLANATION OF REQUIREMENT

In the Capability Categories where this SR applies, it refers to significant accident progression sequences, which are defined in the Glossary as one of the set of accident sequences contributing to large early release frequency resulting from the analysis of a specific hazard group that, when rank-ordered by decreasing frequency, sum to a specified percentage of the large early release frequency, or that individually contribute more than a specified percentage of large early release frequency for that hazard group. For the current version of the Standard, ASME/ANS RA-Sa-2009, the summed percentage is 95% and the individual percentage is 1% of the applicable hazard group. (See Part 2 Requirements LE-C3, LE-C4, LE-E5, LE-C10, LE-C12, LE-D1, LE-D4, LE-D5, LE-D7 and LE-E2.) For hazard groups that are analyzed using methods and assumptions that can be demonstrated to be conservative or bounding, alternative numerical criteria may be more appropriate, and, if used, should be justified.

Capability Category Differentiation

This determination can be performed to different capabilities:

For Capability Category I, there is no requirement to address repair of equipment and this means that if any credit for repair is taken it has to be carried out in a manner that satisfies at least Category II requirements.

For Capability Category II and III, this SR calls for realistic treatment of equipment repair consistent with requirements for repair used under Level 1 the core damage sequences SRs listed above, i.e., SY-A24, DA-C15 and DA-D8. Note that SR DA-D8 differentiates in its requirement between Capability Category II and III.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement. In evaluating the compliance with this SR, also review the regulatory positions for SY-A24, DA-C15 and DA-D8.

Index No. LE-C	Capability Category I	Capability Category II	Capability Category III
LE-C4	INCLUDE model logic necessary to provide **accident progression sequences resulting in a large early release. Containment event trees developed in NUREG/CR-6595 [NOTE (1)] (with plant-specific modifications, if needed) are acceptable.**	INCLUDE model logic necessary to **provide a realistic estimation of the significant accident progression sequences resulting in a large early release. INCLUDE mitigating actions by operating staff, effect of fission product scrubbing on radionuclide release and expected beneficial failures in significant accident progression sequences. PROVIDE technical justification (by plant-specific or applicable generic calculations demonstrating the feasibility of the actions, scrubbing mechanisms or beneficial failures) supporting the inclusion of any of these features.**	INCLUDE model logic necessary to provide **a realistic estimation of the accident progression sequences resulting in a large early release. INCLUDE mitigating actions by operating staff, effect of fission product scrubbing on radionuclide release and expected beneficial failures. PROVIDE technical justification (by plant-specific or applicable generic calculations demonstrating the feasibility of the actions, scrubbing mechanisms or beneficial failures) for the inclusion of any of these features.**

NOTE (1): NUREG/CR-6595, Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events, October 2004.

EXPLANATION OF REQUIREMENT

This SR requires that the model logic used in the PRA representation of accident progression sequences that lead to a large early release is detailed enough to provide the level of realism demanded in the Capability Category being pursued. Model logic consists of the event tree and associated fault tree logic necessary to support the development of the model to propagate the plant states determined in HLR-LE-A, through the accident progression to the LERF end states. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This model logic can be developed for three different capabilities. In general the Category I model logic is less complex than that of Category II or III.

For Capability Category I, simplified event trees with their simplified model logic, such as those found in NUREG/CR-6595, are used. The simplified trees of NUREG/CR-6595, developed for the various plant and containment types, contain conservative model logic for the plant and containment under analysis. They may need to be modified to account for plant unique features which are not captured in the generic model logic.

For Capability Category II, the accident progression sequences that result in a large early release need to be developed to a level of detail that allows the mitigating factors in the significant accident sequences to be modeled in a way that leads to a realistic estimate. The mitigating factors can be operator actions, various fission product scrubbing mechanisms or beneficial failures such as failures that depressurize the RCS before vessel failure, for example. The mitigating factors credited in an accident progression sequence need to be justified with appropriate calculations demonstrating their applicability under the conditions produced by the sequence under consideration. If generic, rather than plant-specific, calculations are used, their applicability to the analysis being conducted has to be demonstrated.

For Capability Category III, the level of detail of the accident progression sequences resulting in a large early release is even greater than that discussed for Category II, since in Category III a realistic estimate is needed not only for significant accident progression sequences, but for all those that have a non-negligible impact on LERF.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-C	Capability Category I	Capability Category II	Capability Category III
LE-C5	USE appropriate **conservative**, generic **analyses/evaluations of** system success criteria **that are applicable to the plant**.	USE appropriate **realistic** generic or **plant-specific analyses** for system success criteria for **the significant accident progression sequences. USE conservative or a combination of conservative and realistic system success criteria for non-risk significant accident progression sequences.**	USE **appropriate realistic plant-specific** system success criteria.

EXPLANATION OF REQUIREMENT

This SR requires engineering analyses to establish the success criteria at the appropriate level of detail for the capability category. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

These analyses can be carried out for three different capabilities:

For Capability Category I, conservative, generic analyses may be used.

For Capability Category II, the success criteria analyses, whether generic or plant-specific, are realistic for the significant accident progression sequences, but can be conservative for the non-risk significant accident progression sequences.

For Capability Category III, the success criteria analyses are both realistic and plant-specific for all the accident progression sequences. Post core damage success criteria can use state-of-the-art tools and experiments.

It is acceptable to use the capability category differentiation found in Table 2-2.3-2(b) as guidance for the level of detail of the analysis appropriate for the different categories. However, if the guidance of Table 2-2.3-2(b) is used for LE-C5 the following should be noted:

In Capability Category II the use of conservative (or a combination of conservative and realistic) analyses/evaluation for success criteria is acceptable, i.e., not only realistic analyses/evaluations, as stated in SC-B1, are acceptable.

The use of expert judgment is likely to be more prevalent when dealing with system success criteria under severe accident environments than it is for the Level 1 analysis.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-C	Capability Category I	Capability Category II	Capability Category III
LE-C6	DEVELOP system models that support the accident progression analysis consistent with the applicable requirements for para. 2-2.4, as appropriate for the level of detail of the analysis.		

EXPLANATION OF REQUIREMENT

For the accident progression analysis, additional system models need to be developed for systems not used in the core damage analysis, or models may need to be extended for Level 1 systems that also play a role in the accident progression. Such systems may include igniters, containment purge and isolation, and B.5.b components. This SR ensures that the development or extension of these models is consistent with the HLRs and SRs of the System Analysis requirements in paragraph 2-2.4.

Capability Category Differentiation

The System Analysis (SY) capability category differentiation is stated in the SRs listed in Tables 2-2.4-2(a) through 2-2.4-4(c). It should be noted that the system analysis capability category to be met is the capability category of the LERF model, which may be a different capability category from the core damage frequency (Level 1) model.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement. In evaluating the compliance with this SR, also review the regulatory position on the Systems Analysis related SRs for applicability.

Index No. LE-C	Capability Category I	Capability Category II	Capability Category III
LE-C7	In crediting HFEs that support the accident progression analysis, USE the applicable requirements of para. 2-2.5 as appropriate for the level of detail of the analysis.		

EXPLANATION OF REQUIREMENT

For the accident progression analysis additional plant personnel actions may be credited that play a role in the LERF determination. LE-C7 ensures that the analysis of the impact of additional personnel actions is performed in a manner consistent with the HLRs and SRs of the Human Reliability Analysis requirements in paragraph 2-2.5.

Capability Category Differentiation

The Human Reliability Analysis (HR) capability category differentiation is stated in the SRs listed in Tables 2-2.5-2(a) through 2-2.5-10(i). It should be noted that the human reliability capability category to be met is the capability category of the LERF model, which may be a different capability category from the core damage frequency (Level 1) model.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement. In evaluating the compliance with this SR, also review the regulatory position on the Human Reliability Analysis related SRs for applicability.

Index No. LE-C	Capability Category I	Capability Category II	Capability Category III
LE-C8	INCLUDE accident sequence dependencies in the accident progression sequences consistent with the applicable requirements of para. 2-2.2, as appropriate for the level of detail of the analysis.		

EXPLANATION OF REQUIREMENT

For the accident progression analysis dependencies will play a role in the LERF determination. The intent of LE-C8 is to ensure that the dependencies are accounted for consistent with the HLRs and SRs of the Accident Sequence Analysis requirements in paragraph 2-2.2.

Capability Category Differentiation

The Accident Sequence Analysis (AS) capability category differentiation is stated in the SRs listed in Tables 2-2.2-2(a) through 2-2.2-4(c). It should be noted that the accident sequence analysis capability category to be met is the capability category of the LERF model, which may be a different capability category from the core damage frequency (Level 1) model.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement. In evaluating the compliance with this SR, also review the regulatory position on the Accident Sequence Analysis related SRs for applicability.

Index No. LE-C	Capability Category I	Capability Category II	Capability Category III
LE-C9	DO NOT TAKE CREDIT for continued equipment operation or operator actions in adverse environments (i.e., beyond equipment qualification limits). **An acceptable approach is NUREG/CR-6595, October 2004 [NOTE (1)].**	**JUSTIFY any credit given for equipment survivability or human actions under adverse environments.**	

NOTE (1): NUREG/CR-6595, Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events, October, 2004.

EXPLANATION OF REQUIREMENT

This SR requires that in developing realistic analyses, credit should be given, when appropriate and justified, for equipment operation or operator actions in the presence of severe accident conditions prevailing at the time of the accident progression that the equipment is assumed to function or the operator action is assumed to be carried out. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This crediting of equipment survivability or human actions can be performed to different capabilities:

For Capability Category I, no credit is taken for equipment operation beyond qualification limits or for operator actions in adverse environments. This is consistent with the approach of NUREG/CR-6595.

For Capability Category II and III, credit for continued equipment operation in harsh environments, or the initiation of equipment operation in conditions beyond the qualification limits of the equipment is be justified as required in LE-C10.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-C	Capability Category I	Capability Category II	Capability Category III
LE-C10	No requirement; credit for equipment survivability or human actions in adverse environments is precluded by LE-C9.	**REVIEW significant accident progression sequences resulting in a large early release to determine if engineering analyses can support continued equipment operation or operator actions during accident progression that could reduce LERF. USE conservative or a combination of conservative and realistic treatment for non-significant accident progression sequences.**	**TREAT containment environmental impacts on continued operation of equipment and operator actions in a realistic manner based on engineering analyses.**

NOTE (1): NUREG/CR-6595, Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events, October, 2004.

EXPLANATION OF REQUIREMENT

This SR requires engineering analyses to justify credit for mitigating equipment operation or human actions under severe accident conditions credited in LE-C9. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

These engineering analyses can be performed to three different capabilities:

For Capability Category I, no credit is taken for equipment operation beyond qualification limits or for operator actions in adverse environments. This is consistent with the approach of NUREG/CR-6595.

For Capability Category II, equipment survivability or human actions in a harsh environment that provide mitigating factors in the significant accident sequences need to be justified with appropriate calculations or reference materials (manufacturer specifications, experimental results) supporting their applicability under the conditions produced by the sequence under consideration. The SRs found in Table 2-2.3-2(b) for this category could be used as example guidance for the appropriate level of detail of the analysis (but note that for LE-C10 the use of conservative analyses/evaluation for non-significant LERF sequences is acceptable).

For Capability Category III, the engineering analyses supporting equipment survivability or human actions under adverse environments are conducted in a realistic manner. Realistic analyses should be based on best estimate containment conditions. The MAAP or MELCOR codes may be used for realistic beyond design basis containment atmosphere analyses. The SRs found in Table 2-2.3-2(b) for this category could be used as example guidance for the appropriate level of detail of the analysis.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-C	Capability Category I	Capability Category II	Capability Category III
LE-C11	DO NOT TAKE CREDIT for continued operation of equipment and operator actions that could be impacted by containment failure. **An acceptable alternative is the approach in NUREG/CR-6595 October 2004 [Note (1)].**	**JUSTIFY any credit given for equipment survivability or human actions that could be impacted by containment failure.**	

NOTE (1): NUREG/CR-6595, Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events, October, 2004.

EXPLANATION OF REQUIREMENT

This SR focuses on a special case of the adverse environments considered under LE-C9, for the particularly harsh environment created by containment failure. Containment failure results in rapid depressurization of the containment and flashing of fluid in the sump. Such conditions create many equipment challenges including potential cavitation of liquid in the emergency sump. Human actions under conditions of containment failure would be expected to take place under an extreme level of stress. As such it requires that credit given for equipment operation or operator actions credited under containment failure conditions address the impact of containment failure on such operation or action. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This crediting of equipment survivability or human actions can be performed to different capabilities:

For Capability Category I, no credit is taken for equipment operation or operator actions that could be impacted by containment failure. This is consistent with the approach of NUREG/CR-6595.

For Capability Category II and III, credit for continued equipment operation that could be impacted by containment failure is to be justified as required in LE-C12.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-C	Capability Category I	Capability Category II	Capability Category III
LE-C12	No requirement; credit for post-containment failure operability of equipment or operator actions is precluded by LE-C11.	**REVIEW significant accident progression sequences resulting in a large early release to determine if engineering analyses can support continued equipment operation or operator actions after containment failure that could reduce LERF. USE conservative or a combination of conservative and realistic treatment for non-significant accident progression sequences.**	TREAT containment failure impacts on continued operation of equipment and operator actions in a **realistic** manner based on engineering analyses.

EXPLANATION OF REQUIREMENT

This SR requires engineering analyses to justify credit for equipment operation or human actions that could be impacted by containment failure and credited in LE-C11. Analyses include calculations, equipment capability assessments and manufacturer evaluations. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

These analyses can be performed to three different capabilities:

For Capability Category I, no credit is taken for equipment operation beyond qualification limits or operator actions impacted by containment failure. This is consistent with the approach of NUREG/CR-6595.

For Capability Category II, equipment survivability or human actions that could be impacted by containment failure and that provide mitigating factors in the significant accident sequences need to be justified with appropriate calculations demonstrating their applicability under containment failure conditions. The SRs found in Table 2-2.3-2(b) for this category could be used as example guidance for the appropriate level of detail of the analysis (but note that for LE-C12 the use of conservative analyses/evaluation for non-significant LERF sequences is acceptable).

For Capability Category III, the engineering analyses supporting equipment survivability or human actions that could be impacted by containment failure are conducted in a realistic manner. The SRs found in Table 2-2.3-2(b) for this category could be used as example guidance for the appropriate level of detail of the analysis.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

<table>
<tr><th>Index No. LE-C</th><th>Capability Category I</th><th>Capability Category II</th><th>Capability Category III</th></tr>
<tr><td>LE-C13</td><td>TREAT containment bypass events in a conservative manner. DO NOT TAKE CREDIT for scrubbing. An acceptable alternative is the approach in NUREG/CR-6595 [NOTE (1)].</td><td colspan="2">PERFORM a containment bypass analysis in a realistic manner. JUSTIFY any credit taken for scrubbing (i.e., provide an engineering basis for the decontamination factor used).</td></tr>
</table>

NOTE (1): NUREG/CR-6595, Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events, October, 2004.

EXPLANATION OF REQUIREMENT

This SR requires that containment bypass events be considered in the LERF assessment. Containment bypass events are likely to be LERF contributors as they lead to the potential for core releases to bypass the containment into the environment. Containment bypass events include the interfacing system LOCA and the SGTR with a stuck open secondary side safety relief valve in the broken SG. Whether or not bypass events will contribute to LERF is dependent on the size of the radiation release and the potential for effective scrubbing. In selected events scrubbing of fission products via water pools, sprays or filters may be sufficient to assess a bypass event as non-LERF. This SR provides requirements in treating this class of LERFs and requires that exclusion of potential LERF bypass events by consideration of fission product filtering mechanisms be justified. Justification may include analysis, applicable experimental results or a combination of both. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This analysis can be performed to different capabilities:

For Capability Category I, no credit is taken for scrubbing for containment bypass events. This is consistent with the approach taken in NUREG/CR-6595.

For Capability Category II and III, bypass analysis is carried out in a realistic manner which requires that scrubbing of the release is accounted for in the analysis. This also means that justification for the credited scrubbing is required. The decontamination factors used needs to be consistent with pool scrubbing models and/or reactor building retention models used in analyses applicable to the plant and conditions being analyzed.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.8.4 Supporting Requirements for HLR-LE-D

ASME/ANS Standard Section 2-2.8, Table 2-2.8-2(d), Supporting Requirements for HLR-LE-D

HLR-LE-D: The accident progression analyses shall include an evaluation of the containment structural capability for those containment challenges that would result in a large early release

Intent: To ensure that the containment structural capabilities are appropriately addressed with respect to LER

SRs: LE-D1 through LE-D7

Index No. LE-D	Capability Category I	Capability Category II	Capability Category III
LE-D1	DETERMINE the containment ultimate capacity for the containment challenges that result in a large early release. **USE a conservative** containment capacity analysis for the significant containment challenges. If generic **assessments formulated for similar plants** are used, JUSTIFY applicability to the plant being evaluated. Analyses may consider use of similar containment designs or estimating containment capacity based on design pressure and a conservative multiplier relating containment design pressure and median ultimate failure pressure. Quasi-static containment capability evaluations are acceptable unless hydrogen concentrations are expected to result in potential detonations. Such considerations need to be included for small volume containments, such as the ice-condenser type. **An acceptable alternative is the approach in NUREG/CR-6595 [NOTE (1)].**	DETERMINE the containment ultimate capacity for the containment challenges that result in a large early release. **PERFORM a realistic** containment capacity analysis for the significant containment challenges. **USE a conservative or a combination of conservative and realistic evaluation of containment capacity for non-significant containment challenges. If generic calculations are used in support of the assessment**, JUSTIFY applicability to the plant being evaluated. Analyses may consider use of similar containment designs or estimating containment capacity based on design pressure and a realistic multiplier relating containment design pressure and median ultimate failure pressure. Quasi-static containment capability evaluations are acceptable unless hydrogen concentrations are expected to result in potential detonations. Such considerations need to be included for small volume containments such as the ice-condenser type.	DETERMINE the containment ultimate capacity for the containment challenges that result in a large early release. **PERFORM a realistic containment capacity analysis for containment challenges by using plant-specific input.** PROVIDE static and dynamic failure capabilities, as appropriate.

NOTE (1): NUREG/CR-6595, Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events, January 1999.

EXPLANATION OF REQUIREMENT

This SR requires the determination of the containment capacities to establish containment fragility curves. Fragility curves relate containment pressure to the probability of containment failure. Capacity analyses can be established via plant-specific structural response calculations or extrapolations based on structural analyses of similar containments. The level of detail of the analyses necessary to characterize containment performance limits is consistent with that of the containment load analyses against which containment capacity will be compared. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This determination of containment capacity can be performed to three different capabilities:

For Capability Category I, a conservative analysis is used and can be based on analyses performed for similar plants if the applicability to the containment being analyzed is sufficiently justified.

Quasi-static analyses are sufficient for assessing containment capacity to withstand loads including hydrogen combustion. Dynamic analyses are relevant only if hydrogen detonations are a possibility. Assumptions such as assuming containment failure upon a detonation are consistent with this capability category I. If the approach in NUREG/CR-6595 is used, conservative conditional probabilities of containment failure (split fractions) are provided for some events in the simplified containment-type-specific CETs.

For Capability Category II, the analyses of the containment ultimate capacity is realistic for the significant containment challenges, but can include conservatisms in the analyses for non-significant challenges. The analyses are focused on plant-specific containment performance, and while the application of reference plant analyses may be useful for some loads, strong justification of applicability is needed, otherwise it is likely to be inadequate. The analyses consider design details of the containment structure such as free-standing steel shell, concrete-backed steel shell, pre-stressed, post-tensioned or reinforced concrete. Discontinuities in the containment structure due to shape transitions, wall anchorage to floors, changes in steel shell thickness or concrete reinforcement are also considered, as are the interactions between the containment structure and neighboring structures such as the reactor vessel and pedestal, auxiliary buildings and other internal walls. Quasi-static analyses are sufficient for assessing containment capacity to withstand loads including hydrogen combustion. Dynamic analyses are relevant only if hydrogen detonations are a possibility. When hydrogen detonations in containment are low probability, conservative assumptions with regard to containment integrity following detonation are acceptable.

For Capability Category III, state-of-the-art analyses of the containment ultimate pressure capacity is performed using a plant-specific, finite-element model of the containment pressure boundary including sufficient detail to represent major discontinuities. Plant-specific data for structural materials and their properties are used. The influence of time-varying containment atmospheric temperatures and pressures is taken into account. To the extent that internal temperatures are anticipated to be elevated for long periods of time (e.g., during the period of aggressive core-concrete interactions), thermal growth and creep rupture of steel containment structures is taken into account. Quasi-static analyses are supplemented with dynamic analyses as appropriate.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-D	Capability Category I	Capability Category II	Capability Category III
LE-D2	EVALUATE the impact of containment seals, penetrations, hatches, drywell heads (BWRs) and vent piping bellows and INCLUDE as potential containment challenges, as required. **An acceptable alternative is the approach in NUREG/CR-6595 [NOTE (1)].**	EVALUATE the impact of containment seals, penetrations, hatches, drywell heads (BWRs), and vent pipe bellows and INCLUDE as potential containment challenges, as required. **If generic analyses are used in support of the assessment, JUSTIFY applicability to the plant being evaluated.**	**EVALUATE plant-specific behavior of:** **(a) Containment seals** **(b) Penetrations** **(c) Hatches** **(d) Drywell head (BWRs)** **(e) Vent pipe bellows (BWRs) for beyond the design basis temperature and pressure conditions.**

NOTE (1): NUREG/CR-6595, Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events, January 1999.

EXPLANATION OF REQUIREMENT

The ultimate containment capacity can be impacted by the capacity of the containment penetrations, hatches, drywell heads and vent pipe bellows to withstand the identified potential challenges that could result in a large early release. This SR calls for evaluating this impact, since it may govern the ultimate containment capacity for certain challenges. The analysis assesses the full range of penetration sizes, types and their distribution (equipment and personnel hatches, piping penetrations, electrical penetration assemblies, ventilation penetrations), and looks at penetration seal configuration and materials. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This evaluation can be performed to three different capabilities: Category specific requirements are self- explanatory.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-D	Capability Category I	Capability Category II	Capability Category III
LE-D3	When containment failure location [NOTE (2)] affects the classification of the accident progression as a large early release, DEFINE failure location based on a **conservative** containment assessment **which accounts for plant-specific features. JUSTIFY applicability of generic and other analyses. Analyses may consider comparison with similar failure locations in similar containment designs. An acceptable alternative is the approach in NUREG/CR-6595 [NOTE (1)].**	When containment failure location [NOTE (2)] affects the event classification of the accident progression as a large early release, DEFINE failure location based on a **realistic** containment assessment **which accounts for plant-specific features. If generic analyses are used in support of the assessment, JUSTIFY applicability to the plant being evaluated.**	When containment failure location [NOTE (2)] affects the event classification of the accident progression as a large early release, DEFINE failure location based on a **realistic plant-specific** containment assessment.

NOTE (1): NUREG/CR-6595, Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events, January 1999.

NOTE (2): Containment failures below ground level may not be a large early release even if the timing is early. Such failures may arise as a result of failures in the basemat region.

EXPLANATION OF REQUIREMENT

This SR addresses the fact that it may be important to assess the location of the containment failure because of the implications the location may have for LERF. For example, given the same in-vessel and ex-vessel releases inside containment, an early failure in the drywell of a Mark II containment could typically result in a large early release to the environment, while an early failure in the wetwell airspace may allow justification that the release is sufficiently scrubbed so as not to contribute to LERF. As noted in the note of the SR basemat melt-through can often be treated as not contributing to LERF because of the protracted times involved as well as the predicted radionuclide retention in the soil. For large dry containments, early above ground containment structural failures resulting from a core damage event are considered contributors to LERF regardless of the postulated break size. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This identification of failure location can be performed to three different capabilities and the SR is self-explanatory in the differentiation:

For Capability Category I, a conservative assessment, which can use applicable generic analyses if justified, but accounts for plant-specific features, is used. If the approach in NUREG/CR-6595 is used, the location evaluation is conservatively subsumed in the split fraction values assigned to certain top events in the containment-type-specific CETs. Plant-unique issues are still required to be addressed.

For Capability Category II, a realistic assessment, which can use applicable generic analyses if justified, and accounts for plant-specific features, is used.

For Capability Category III, a realistic, plant-specific assessment is used.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-D	Capability Category I	Capability Category II	Capability Category III
LE-D4	**USE a conservative evaluation of** interfacing system failure probability for significant accident progression sequences resulting in a large early release. **If generic analyses generated for similar plants are used, JUSTIFY applicability to the plant being evaluated. Analyses may consider comparison with similar interfacing systems in similar containment designs.**	**PERFORM a realistic** interfacing system failure probability **analysis** for the significant accident progression sequences resulting in a large early release. **USE a conservative or a combination of conservative and realistic evaluation of interfacing system failure probability for non-significant accident progression sequences resulting in a large early release. INCLUDE behavior of piping relief valves, pump seals and heat exchangers at applicable temperature and pressure conditions.**	**PERFORM a realistic** interfacing system failure probability **analysis** for the accident progression sequences resulting in a large early release. **USE plant-specific input. INCLUDE behavior of piping, relief valves, pump seals and heat exchangers at applicable temperature and pressure conditions. PROVIDE static and dynamic failure capabilities, as appropriate.**

EXPLANATION OF REQUIREMENT

This SR requires the evaluation of potential containment bypass scenarios arising from failures of barriers between low and high pressure systems that can result in a pathway for a large early release to the environment. If a bypass of containment, such as an interfacing systems LOCA, is predicted to occur, then its effective size and location (e.g., probability that the break is submerged in water) are also estimated in order to determine if it is a contributor to LERF.

Size can be credited as a basis for binning accident sequences as non-LERF when the geometry of the release path to the environment is known (such as through a non-isolated or ruptured pipe). For this situation the LERF/ non-LERF boundary size would consider the source of the release (RCS/containment) and other factors (See for example LE-D4). The basis for the binning should include consideration of the definition of LERF and the basis should be documented.

Evaluation of ISLOCAs assumes the ISLOCA pathway considers the statistical issues associated with the failure of common valves. Specifically, at all capability category levels, the ISLOCA model is expected to consider the state-of-knowledge correlation in assigning the correct failure probability to the ISLOCA line failure rate. When the probabilities of a number of basic events are estimated by using the same data, the probabilities of the events will be identical. When an uncertainty analysis is performed by using a Monte Carlo sampling approach, the same sample value should be used for each basic event probability, since the state of knowledge about the parameter value is the same for each event. This is called the state-of-knowledge correlation, and it results in a mean value for the joint probability that is larger than the product of the mean values of the event probabilities. This result is most important for cut-sets that contain multiple basic events whose probabilities are based on the same data, and in particular when the uncertainty on the parameter value is large. It has been found to be significant in cut-sets contributing to ISLOCA frequency that involve rupture of multiple valves. Additional information on the state-of-knowledge (or epistemic) correlation can be found in NUREG-1855 or EPRI 1016737. The requirement for considering the state-of-knowledge correlation arises from the LE –F3 SR, which refers back to Table 2-2.7-6(e) of the Standard.

Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This evaluation can be performed to three different capabilities:

For Capability Category I, conservative, generic analyses can be used if shown to be applicable.

For Capability Category II, realistic analyses are used for the significant accident progression sequences, while conservative elements can be introduced for the analysis of non-significant accident progression sequences. Plant-specific input for the type of system interfaces and capacities, as well as appropriate temperatures and pressures are preferred.

For Capability Category III, realistic analyses with plant-specific data are used for all the accident progression sequences. Dynamic effects, such as water hammer, may also be analyzed here, as applicable.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-D	Capability Category I	Capability Category II	Capability Category III
LE-D5	**USE a conservative evaluation of** secondary side isolation capability for **significant** accident progression sequences caused by SG tube failure resulting in a large early release. **If generic analyses generated for similar plants are used, JUSTIFY applicability to the plant being evaluated. Analyses may consider comparison with similar isolation capability in similar containment designs.**	**PERFORM a realistic** secondary side isolation capability **analysis** for the **significant** accident progression sequences caused by SG tube failure resulting in a large early release. **USE a conservative or a combination of conservative and realistic evaluation of secondary side isolation capability for non-significant accident progression sequences resulting in a large early release. JUSTIFY applicability to the plant being evaluated. Analyses may consider realistic comparison with similar isolation capability in similar containment designs**.	**PERFORM a realistic** secondary side isolation capability **analysis** for the accident progression sequences caused by SG tube failure resulting in a large early release. **INCLUDE behavior of relief and isolation valves at applicable temperatures and pressure conditions.**

EXPLANATION OF REQUIREMENT

This SR evaluates the ability to isolate the secondary side in accident progression sequences with steam generator tube failures. The ability to isolate the secondary side in a timely manner has an important impact on whether a large early release will occur. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This evaluation can be performed to three different capabilities:

For Capability Category I, conservative estimates for secondary side isolation are used throughout, resulting in a conservative contribution to LERF from SG tube rupture sequences.

For Capability Category II, realistic estimates for secondary side isolation is used for significant accident progression sequences with SG ruptures to obtain a more realistic contribution of these sequences to LERF.

For Capability Category III, realistic analyses for secondary side isolation capability are carried out for all SG tube rupture sequences resulting in the most realistic estimate of the contribution of these sequences to LERF.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-D	Capability Category I	Capability Category II	Capability Category III
LE-D6	PERFORM **a conservative** analysis of thermally-induced SG tube rupture that includes plant-specific procedures. **An acceptable alternative is the approach in NUREG/CR-6595 [NOTE (1)].**	PERFORM **an** analysis of thermally-induced SG tube rupture that includes plant-specific procedures **and design features and conditions that could impact tube failure. An acceptable approach is one that arrives at a plant-specific split fractions by selecting the SG tube conditional failure probabilities based on NUREG -1570 [NOTE (2)] or similar evaluation for induced SG failure of a similarly designed SGs and loop piping. SELECT failure probabilities based on:** ***(a)*** **RCS and SG post-accident conditions to sufficient to describe the important risk outcomes,** ***(b)*** **Secondary side conditions including plant-specific treatment of MSSV and ADV failures.** **JUSTIFY assumptions and selection of key inputs. An acceptable justification can be obtained by the extrapolation of the information in NUREG-1570 to obtain plant-specific models, use of reasonably bounding assumptions or performance of sensitivity studies indicating low sensitivity to changes in the range in question.**	PERFORM **a realistic** analysis of thermally-induced SG tube rupture that includes plant-specific procedures and **key design features. Use appropriate computer codes to calculate the plant-specific conditions.**

NOTE (1): NUREG/CR-6595, Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events, January 1999.

NOTE (2): NUREG-1570, Risk Assessment of Severe Accident-Induced Steam Generator Tube Rupture, March 1998.

EXPLANATION OF REQUIREMENT

The TI-SGTR is a highly complex issue. The SR ensures that thermally induced steam generator tube rupture (TI-SGTR) is treated appropriately since such an event can provide a containment bypass path and thus be an important contributor to LERF. TI-SGTR event analyses may require analyses to determine the weakest RCS components and likelihood of a stuck open ADV. Such analyses may be performed by a variety of severe accident analysis computer codes. Analyses simulate the post core-damage RCS temperature distribution and creep failure properties of materials exposed to high RCS pressures and temperatures. A significant resource for the understanding and modeling of TI-SGTR issues is NUREG-1570. Other sources of information are available from EPRI and the PWROG as well as in some plant-specific PRA submittals. As knowledge in this area is still evolving, in developing TI-SGTR models the developer may include insights from recent scenario simulations. Uncertainties associated with TI-SGTR are considered in LE-F3. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This analysis can be performed to three different capabilities:

For Capability Category I, a conservative analysis is carried out. If the approach in NURE/CR-6595 is used the containment-specific simplified event trees contain conservative analyses of ISGTR.

For Capability Category II, the SR is self-explanatory and the guidance in NUREG-1570 can be followed to obtain acceptable results.

For Capability Category III, a realistic analysis under plan-specific conditions is called for.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-D	Capability Category I	Capability Category II	Capability Category III
LE-D7	PERFORM containment isolation analysis in a **conservative** manner. INCLUDE consideration of both the failure of containment isolation systems to perform properly and the status of safety systems that do not have automatic isolation provisions.	PERFORM containment isolation analysis in a **realistic** manner **for the significant accident progression sequences resulting in a large early release. USE conservative or a combination of conservative or realistic treatment for the non-significant accident progression sequences resulting in a large early release.** INCLUDE consideration of both the failure of containment isolation systems to perform properly and the status of safety systems that do not have automatic isolation provisions.	PERFORM containment isolation analysis in a realistic manner. INCLUDE consideration of both the failure of containment isolation systems to perform properly and the status of safety systems that do not have automatic isolation provisions.

EXPLANATION OF REQUIREMENT

The objective of this SR is to ensure that containment isolation failures contribute to LERF in the plant being analyzed. The proper performance of the containment isolation system should be ascertainable from the plant damage state analysis carried out under the LE-A SRs. One of the physical characteristics which can influence LERF that LE-A1 requires to be identified is the status of containment isolation. Similarly, the status of most safety systems in terms of operability is ascertained for the plant damage state analysis. In the LE-D7 SR the safety systems may be further examined regarding their isolation status if their failure to isolate represents a potential release pathway. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

The isolation analysis can be performed to three different capabilities and the differentiation is clearly stated in the SR and is self-explanatory.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

5.8.5 Supporting Requirements for HLR-LE-E

ASME/ANS Standard Section 2-2.8, Table 2-2.8-2(e), Supporting Requirements for HLR-LE-E

HLR-LE-E: The frequency of different containment failure modes leading to a large early release shall be quantified and aggregated.

Intent: To ensure that important contributors to LER are included and quantified

SRs: LE-E1 through LE-E4

Index No. LE-E	Capability Category I	Capability Category II	Capability Category III
LE-E1	SELECT parameter values for equipment and operator response in the accident progression analysis consistent with the applicable requirements of paras. 2-2.5 and 2-2.6 including consideration of the severe accident plant conditions, as appropriate for the level of detail of the analysis.		

EXPLANATION OF REQUIREMENT

This SR requires that the equipment and human failures in the accident progression analysis are appropriately quantified, consistent with the HR and DA requirements found in the Standard. The SR also cautions that plant conditions, which are likely to be more severe post-core-damage than they were pre-core-damage, be kept in mind when parameter values are selected.

Capability Category Differentiation

While this SR is the same for all Capability Categories, the level of detail and realism appropriate for the Capability Category to which LERF is determined will be affected by the level of detail and realism of HR and DA requirements which this SR refers to. Note that the Capability Category of the LERF determination may differ from that of the CDF determination.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa2009, has no objection to the requirement. In evaluating the compliance with this SR, also review the regulatory position on the Human Reliability and Data related SRs for applicability.

Index No. LE-E	Capability Category I	Capability Category II	Capability Category III
LE-E2	USE **conservative** parameter estimates to characterize accident progression phenomena. **A conservative data set for some key parameters is included in NUREG/CR-6595 [NOTE (1)].**	USE **realistic** parameter estimates to characterize accident progression phenomena **for significant accident progression sequences resulting in a large early release. USE conservative or a combination of conservative and realistic estimates for non-significant accident progression sequences resulting in a large early release.**	USE **realistic** parameter estimates to characterize accident progression phenomena.

NOTE (1): NUREG/CR-6595, Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events, January, 1999.

EXPLANATION OF REQUIREMENT

This SR requires appropriate parameter estimates for severe accident phenomena. Characterization of severe accident parameters is often complex and involves significant uncertainty. Parameters characterizing severe accident phenomenological processes are used in the determination of split fractions/basic events and associated quantification of the accident progression analysis. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This estimation can be performed to three different capabilities:

For Capability Category I, conservative parameter estimates are used and if the approach of NUREG/CR-6595 is used then the split fractions provided in the containment-specific simplified event trees already provide conservative estimates for much of the phenomena.

For Capability Category II, realistic parameter estimates are needed for the significant accident progression sequences leading to a large release. Therefore, parameter estimates for phenomena are based on appropriately realistic generic or plant-specific analyses regarding thermal/hydraulic or chemical processes and structural capacities in these significant sequences.

For Capability Category III, realistic parameter estimates are needed for the all accident progression sequences. Therefore, parameter estimates for phenomena are based on appropriately realistic generic or plant-specific analyses regarding thermal/hydraulic or chemical processes and structural capacities.

For all three capability categories, the use of expert judgment is likely to be prevalent when dealing with the complexities of severe accident phenomena.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-E	Capability Category I	Capability Category II	Capability Category III
LE-E3 (new)	INCLUDE as LERF contributors potential large early release (LER) sequences **in a conservative manner; i.e., designate early containment failures, bypass sequences and isolation failures as LERF contributors. The LER sequences identified in NUREG/CR-6595 [NOTE (1)] provide an acceptable alternative.**	INCLUDE as LERF contributors potential large early release (LER) sequences **identified from the results of the accident progression analysis of LE-C except those LER sequences justified as non-LERF contributors in LE-C1.**	INCLUDE as LERF contributors potential large early release (LER) sequences **from the results of the accident progression analysis by carrying out the appropriate source term calculations.**

NOTE (1): NUREG/CR-6595, Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events, January, 1999.

EXPLANATION OF REQUIREMENT

This SR ensures that accident progression sequences with the potential for a large early release are appropriately included as LERF contributors. LERF contributors are to be consistent with the model developed in HLR-LE-B and HLR-LE-C. Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This identification can be performed to three different capabilities:

For Capability Category I, all sequences with a potential early release to the environment are designated as LER F contributors. If the approach of NREG/CR-6595 is used LER sequences are identified from the containment-specific simplified event trees.

For Capability Category II, all accident progression sequences identified as potential large early release sequences in LE-C are considered LERF contributors unless there was justification provided in LE-C1 that a sequence can be excluded because of release magnitude or timing. In this Capability Category release magnitudes are not based on actual source term calculations, but on coarser estimates based on scrubbing, hold-up, etc.

For Capability Category III, actual source terms are calculated for the accident progression sequences and their magnitude and timing determines their contribution to LERF.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-E	Capability Category I	Capability Category II	Capability Category III
LE-E4	QUANTIFY LERF consistent with the applicable requirements of Tables 2-2.7-2(a), 2-2.7-3(b) and 2-2.7-4(c). *NOTE: The supporting requirements in these tables are written in CDF language. Under this requirement, the applicable quantification requirements in Tables 2-2.7-2(a) through 2-2.7-5(d) should be interpreted based on the approach taken for the LERF model. For example, supporting requirement QU-A2 addresses the calculation of point estimate/mean CDF. Under this requirement, the application of QU-A2 would apply to the quantification of point estimate/mean LERF.*		

EXPLANATION OF REQUIREMENT

This SR requires quantification of LERF consistent with the QU-A, QU-B and QU-C requirements of the Standard. The requirement applies only to the quantification of LERF states. Non-LERF states, although not explicitly discussed, may be tracked to help validate the solution scheme by demonstrating that the sum of LERF and non-LERF states are sufficiently close to the CDF value. A strict equality may be established for a PDS approach, however alternate numerical schemes will typically lose sequences due to roundoff.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement. In evaluating the compliance with this SR, also review the regulatory position on the Quantification related SRs for applicability.

5.8.6 Supporting Requirements for HLR-LE-F

ASME/ANS Standard Section 2-2.8, Table 2-2.8-2(f), Supporting Requirements for HLR-LE-F

HLR-LE-F: The quantification results shall be reviewed and significant contributors to LERF, such as plant damage states, containment challenges and failure modes shall be identified. Sources of model uncertainty and related assumptions shall be identified, and their potential impact on the results understood.

Intent: To identify and understand metrics that provide risk insights, and to ensure that the analysis is providing logical results

SRs: LE-F1 through LE-F3

Index No. LE-F	Capability Category I	Capability Category II	Capability Category III
LE-F1	**IDENTIFY the significant contributors to large early releases (e.g., plant damage states, containment failure modes).**	**PERFORM a quantitative evaluation of the relative contribution to LERF from plant damage states and significant LERF contributors from Table 2-2.8-9.**	

EXPLANATION OF REQUIREMENT

This SR requires that results be reviewed to determine insights regarding the plant risk in terms of the significant contributors to LERF. LERs are important from the perspective of public safety and therefore insights at this level can help formulate better emergency response procedures and identification of areas where procedure improvement or modest design changes may be helpful. Results at this level also provide a basis for a sanity check (see also LE-F2). Note that bold text within the SR indicates text that is different between the categories.

Capability Category Differentiation

This identification can be performed to three different capabilities:

For Capability Category I, a qualitative assessment of the contributors is carried out to provide insights regarding plant vulnerability from a particular plant damage state or containment failure mode.

For Capability Category II and III, quantitative contributions to LERF are provided according to different groupings, e.g., by plant damage states, by containment failure modes, by contributors from Table 2-2.8-9, by phenomena, etc.

For all three capability categories, any plant unique contributors are identified.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-F	**Capability Category I**	**Capability Category II**	**Capability Category III**
LE-F2	REVIEW contributors for reasonableness (e.g., to assure excessive conservatisms have not skewed the results, level of plant-specificity is appropriate for significant contributors, etc.).		

EXPLANATION OF REQUIREMENT

This SR ensures that the analysis is providing logical results so that the insights gained are legitimate. This task is a formal sanity check of the LERF results. The SR also implies a check that the level of plant-specificity is appropriate for the Capability Category to which the LERF analysis has been performed.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.

Index No. LE-F	Capability Category I	Capability Category II	Capability Category III
LE-F3	IDENTIFY and CHARACTERIZE the LERF sources of model uncertainty and related assumptions, consistent with the applicable requirements of Tables 2-2.7-5(d) and 2-2.7-6(e). *NOTE: The supporting requirements in these tables are written in CDF language. Under this requirement, the applicable requirements of Table 2-2.7 should be interpreted based on LERF, including characterizing the sources of model uncertainty and related assumptions associated with the applicable contributors from Table 2-2.8-9. For example, supporting requirement QU-D6 addresses the significant contributors to CDF. Under this requirement, the contributors would be identified based on their contribution to LERF.*		

EXPLANATION OF REQUIREMENT

This SR requires identification and characterization of sources of model uncertainty and related assumptions consistent with the QU-E requirements of the Standard. The uncertainty assessment is focused on characterize the uncertainties so that the plant staff understands the implications of assumptions and parameter selections embedded in the LERF model. Sensitivity studies may be used to demonstrate impact of parameter selection alternatives. Guidance for the treatment of model uncertainty can be found in NUREG 1855 and EPRI 1016737.

REGULATORY POSITION

Revision 2 of Regulatory Guide 1.200, in its endorsement of ASME/ANS PRA standard RA-Sa-2009, has no objection to the requirement.