

C.I.19. Probabilistic Risk Assessment and Severe Accident Evaluation

Chapter 19 of the final safety analysis report (FSAR) should provide an acceptable level of documentation to enable the NRC staff to determine the acceptability of the risks to public health and safety associated with plant licensing and operations, as derived from the results and insights of the applicant's (1) plant-specific probabilistic risk assessment (PRA)¹ and (2) severe accident evaluations.

A combined license (COL) application includes a plant-specific PRA, in accordance with the NRC's requirements of Title 10, Section 52.80(a), of the *Code of Federal Regulations* [10 CFR 52.80(a)] and the related guidance provided in Section C.II.1 of this regulatory guide. Toward that end, Chapter 19 of the FSAR should include the PRA-related information to support a conclusion that the objectives identified in Section C.II.1.2 of this guide are met. In addition, the information in Chapter 19 should (1) support the NRC's expectation, as stated in 10 CFR 52.79(a)(2), that reactors will reflect through their design, construction, and operation an extremely low probability of accidents that could result in the release of significant quantities of radioactive fission products; and (2) meet the objective, stated in 10 CFR 52.79(a)(5), to assess the risk to public health and safety resulting from facility operation, and ensure the adequacy of plant structures, systems, and components (SSCs) provided to prevent accidents and mitigate their consequences.

In addition, Chapter 19 of the FSAR should include sufficient information regarding severe accidents to meet the requirements in 10 CFR 52.79 and address the Commission's policy statements and positions related to PRA and severe accidents (Appendix A to Section C.II.1 of this guide provides a summary of applicable Commission documents). Relative to 10 CFR 52.79(a)(38), Chapter 19 should include a description and analysis of the design features to prevent and mitigate severe accidents. In addition, Chapter 19 should include information to satisfy the requirements of 10 CFR 52.79(a)(17), which invokes 10 CFR 50.34(f)(1)(i) to specify that a plant-specific PRA should be performed to seek improvements in the reliability of core and containment heat removal systems that are significant and practical and do not excessively impact the plant.

The applicant should use the results and insights of its PRA and severe accident evaluations to establish specifications and performance objectives for the plant design, construction, inspection, and operation. Chapter 19 should include the safety insights and their applications, as they relate to severe accidents. In addition, Chapter 19 should include a qualitative summary of the results and insights from the plant- and site-specific PRA (Section C.II.1 of this guide), and describe how the PRA influenced the design, construction, and operational features (e.g., technical specifications, operating procedures). The information in Chapter 19 should enable the NRC to conclude that the applicant has performed sufficiently complete and scrutable analyses, and the results support the COL application and will maintain acceptable risk throughout the life of the plant.

Although a quantitative plant-specific PRA is required as part of a COL application, the NRC does not expect the applicant to provide quantitative risk information in Chapter 19. Rather, the information provided in Chapter 19 should be descriptive, and should include qualitative results and insights derived by considering both qualitative and quantitative risk information.

¹References in this guide to the plant-specific probabilistic risk assessment (PRA) includes both PRA techniques and alternative approaches for addressing contributors to risk, per the Commission direction provided in the staff requirements memorandum (SRM), dated July 21, 1993, for SECY-93-087.

To support the NRC staff's timely review and assessment, the applicant should adhere to the recommended format and content for Chapter 19 provided herein. Chapter 19 should reference the applicable analyses and evaluations, as well as provide a summary description of the supporting information, needed to demonstrate compliance with the above identified regulatory requirements and Commission policies. References should be provided to relevant information contained in other FSAR chapters.

C.I.19.1 *Introduction*

This section of the FSAR should describe the purpose and objectives of the plant-specific probabilistic risk assessment (PRA) and severe accident evaluations and identify the structure of Chapter 19. This discussion should address the related requirements in 10 CFR Part 52, as well as the related Commission policies and positions. The discussion should also ensure that this chapter addresses the objectives identified in Section C.II.1.2 of this guide.

In addition, this section should identify the specific PRA information that is docketed, as opposed to information that is retained by the applicant, but available to support NRC reviews and audits.

C.I.19.2 *PRA Results and Insights*

C.I.19.2.1 Introduction

This section should summarize the scope and process used to develop the plant-specific PRA. This summary should include a reference to the plant-specific PRA and associated analyses that are available for review or docketed separately.

In addition, the applicant should provide a cross-reference to Section 19.4, regarding how the PRA will be maintained and upgraded, as necessary, to ensure that (1) it reasonably reflects the plant design, operation, and experience, and (2) its scope, level of detail, and technical adequacy are appropriate for its uses and risk-informed applications.

C.I.19.2.2 Uses of PRA

C.I.19.2.2.1 *Design Phase*

C.I.19.2.2.1.1 Use of PRA in Support of Design

Describe the use of the PRA in the design phase (through design certification, as appropriate). Include FSAR cross-references to specific program descriptions, as appropriate.

C.I.19.2.2.2 *COL Application Phase*

C.I.19.2.2.2.1 Use of PRA in Support of Licensee Programs

Describe the use of the PRA in the COL application phase, and specifically, its use in support of other licensee programs (e.g., human factors program, severe accident management program). Include FSAR cross-references to specific program descriptions, as appropriate.

C.I.19.2.2.2 Risk-Informed Applications

Identify and describe specific risk-informed applications being implemented during the COL application phase. Include FSAR cross-references to specific program descriptions (e.g., 10 CFR 50.69 implementation, NFPA-805 implementation), as appropriate.

C.I.19.2.2.3 *Construction Phase*

C.I.19.2.2.3.1 Use of PRA in Support of Licensee Programs

Describe the use of the PRA in the construction phase, and specifically, its use in support of other licensee programs (e.g., human factors program). Include FSAR cross-references to specific program descriptions, as appropriate.

At the time of COL application, the applicant should describe any planned uses of the PRA in support of other licensee programs during the construction phase. However, when in the construction phase, this section may need to be revised to reflect the actual uses of the PRA.

C.I.19.2.2.3.2 Risk-Informed Applications

Identify and describe specific risk-informed applications that will be implemented during the construction phase. Include FSAR cross-references to specific program descriptions (e.g., 10 CFR 50.69 implementation, NFPA-805 implementation), as appropriate.

At the time of COL application, the applicant should describe any planned risk-informed applications during the construction phase. However, when in the construction phase, this section may need to be revised to reflect the actual risk-informed applications being implemented.

C.I.19.2.2.4 *Operational Phase*

C.I.19.2.2.4.1 Use of PRA in Support of Licensee Programs

Describe the use of the PRA during plant operations, and specifically, its use in support of other licensee programs (e.g., Maintenance Rule, interface with the ROP, reliability assurance program, human factors program, severe accident management program). Include FSAR cross-references to specific program descriptions, as appropriate.

At the time of COL application, the applicant should describe any planned uses of the PRA in support of other licensee programs during the operational phase. However, when in the operational phase, this section may need to be revised to reflect the actual uses of the PRA.

C.I.19.2.2.4.2 Risk-Informed Applications

Identify and describe specific risk-informed applications that will be implemented during the operational phase. Include FSAR cross-references to specific program descriptions (e.g., risk-informed inservice inspection, risk-informed inservice testing, 10 CFR 50.69 implementation, NFPA-805 implementation), as appropriate.

At the time of COL application, the applicant should describe any planned risk-informed applications during the operational phase. However, when in the operational phase, this section may need to be revised to reflect the actual risk-informed applications being implemented.

C.I.19.2.3 Evaluation of Full-Power Operations

This section should provide the results and insights of the plant-specific PRA for full-power operations.

C.I.19.2.3.1 *Risk from Internal Events*

This section should provide the qualitative results and insights of the plant-specific PRA for internal initiating events under full-power operating conditions. In so doing, this section should identify and describe the internal events evaluated. If some internal events are screened out or incorporated into other evaluations (e.g., grouped events), this section should describe the screening/bounding/grouping. In addition, if information regarding specific internal events is provided in other sections of the FSAR, those sections should be cross-referenced.

For the internal events evaluated, provide the summary information addressed in the following subsections:

19.2.3.1.1 Significant Core Damage Sequences

- C Describe significant² core damage sequences.
- C Identify significant internal initiating events.
- C Identify significant functions, SSCs, and operator actions (typically determined by importance measures such as risk achievement worth (RAW) and Fussell-Vesely (F-V) importance measures).
- C Identify important assumptions (including PRA key assumptions³ and PRA-based insights⁴)
- C Document results/insights from importance, sensitivity, and uncertainty analyses.

19.2.3.1.2 Significant Large Release Sequences

- C Describe significant large release sequences.
- C Identify significant internal initiating events.
- C Identify significant functions, SSCs, and operator actions.

² In the context of the PRA results and insights, the term “significant” is intended to be consistent with its usage in the American Society of Mechanical Engineers (ASME) PRA Standard, ASME RA-Sb-2005 Addenda to ASME RA-S-2002, “Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications.”

³ In the context of the PRA, the phrase “key assumption” is intended to be consistent with its usage in ASME RA-Sb-2005 Addenda to ASME RA-S-2002, “Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications.”

⁴ “PRA-based insights” are those insights identified during design certification that ensures assumptions made in the PRA will remain valid in the as-to-be-built, as-to-be-operated plant and includes assumptions regarding SSC and operator performance and reliability, ITACs, interface requirements, plant features, design and operational programs, etc. The usage of this phrase is intended to be consistent with its use in referring to the information provided in Table 19.59-29 in the AP-600 and AP-1000 Design Control Documents (DCDs).

- C Describe containment performance.
- C Identify important assumptions.
- C Document results/insights from importance, sensitivity, and uncertainty analyses.

19.2.3.1.3 Significant Offsite Consequences (as appropriate)

- C Describe significant offsite consequence sequences.
- C Identify significant functions, actions, and site characteristics.
- C Identify important assumptions.
- C Document results/insights from importance, sensitivity, and uncertainty analyses.

19.2.3.1.4 Summary of Significant Results and Insights

- C Identify significant internal initiating events.
- C Identify significant operator actions.
- C Identify significant common-cause failures.
- C Identify significant functions and SSCs.
- C Identify important assumptions.
- C Document results/insights from importance, sensitivity, and uncertainty analyses.

C.I.19.2.3.2 *Risk from External Events*

This section should provide the qualitative results and insights of the plant-specific PRA for external initiating events under full-power operating conditions. In so doing, this section should identify and describe the external events evaluated. If some external events are screened out or incorporated into other evaluations, this section should describe the screening/bounding. In addition, if information regarding specific external events is provided in other sections of the FSAR, those sections should be cross-referenced.

For each external event evaluated, provide the summary information addressed by the following subsections:

19.2.3.2.x Evaluation of External Event X

19.2.3.2.x.1 *Significant Core Damage Sequences*

- C Describe significant core damage sequences.
- C Identify significant external initiating events.
- C Identify significant functions, SSCs, and operator actions.
- C Identify important assumptions.
- C Document results/insights from importance, sensitivity, and uncertainty analyses.

19.2.3.2.x.2 *Significant Large Release Sequences*

- C Describe significant large release sequences.
- C Identify significant external initiating events.
- C Identify significant functions, SSCs, and operator actions.
- C Describe containment performance.
- C Identify important assumptions.
- C Document results/insights from importance, sensitivity, and uncertainty analyses.

19.2.3.2.x.3 *Significant Offsite Consequences (as appropriate)*

- C Describe significant offsite consequence sequences.
- C Identify significant functions, actions, and site characteristics.
- C Identify important assumptions.
- C Document results/insights from importance, sensitivity, and uncertainty analyses.

19.2.3.2.x.4 *Summary of Significant Results and Insights*

- C Identify significant external initiating events.
- C Identify significant operator actions.
- C Identify significant common cause failures.
- C Identify significant functions and SSCs.
- C Identify important assumptions.
- C Document results/insights from importance, sensitivity, and uncertainty analyses.

C.I.19.2.4 Evaluation of Other Modes of Operation

This section should provide the qualitative results and insights of the plant-specific PRA for modes of operations other than full-power (including shutdown). In so doing, this section should identify and describe the other (non-full-power) modes of operations evaluated. If the evaluation of some modes is incorporated into (or bounded by) the evaluations of other modes, this section should describe the grouping/bounding. If information regarding specific operating modes is provided in other sections of the FSAR, those sections should be cross-referenced.

For each mode of operation evaluated (other than full-power), provide the summary information addressed in the following subsections:

C.I.19.2.4.y *Evaluation of Mode Y*

19.2.4.y.1 Significant Core Damage Sequences

- C Describe significant core damage sequences.
- C Identify significant initiating events.
- C Identify significant functions, SSCs, and operator actions.
- C Identify important assumptions.
- C Document results/insights from importance, sensitivity, and uncertainty analyses.

19.2.4.y.2 Significant Large Release Sequences

- C Describe significant large release sequences.
- C Identify significant initiating events.
- C Identify significant functions, SSCs, and operator actions.
- C Describe containment performance.
- C Identify important assumptions.
- C Document results/insights from importance, sensitivity, and uncertainty analyses.

19.2.4.y.3 Significant Offsite Consequences (as appropriate)

- C Describe significant offsite consequence sequences.
- C Identify significant functions, actions, and site characteristics.
- C Identify important assumptions.
- C Document results/insights from importance, sensitivity, and uncertainty analyses.

19.2.4.y.4 Summary of Significant Results and Insights

- C Identify significant initiating events.
- C Identify significant operator actions.
- C Identify significant common cause failures.
- C Identify significant functions and SSCs.
- C Identify important assumptions.
- C Document results/insights from importance, sensitivity, and uncertainty analyses.

C.I.19.2.5 Summary of Overall Plant Risk Results and Insights

This section should provide the overall results and insights from the plant-specific PRA. In particular, this discussion should identify the significant plant features (including non-safety-related systems) and operator actions that are important to reduce risk and confirm that the plant will meet the expectation⁵ stated in 10 CFR 52.79(a)(2). In addition, this section should include a table to highlight the PRA-based insights, which ensure that the assumptions and plant operational features addressed in the PRA will remain valid in the as-to-be-built, as-to-be-operated plant. This table should indicate the disposition of each insight by cross-referencing to the appropriate FSAR section, as appropriate.

C.I.19.3 *Severe Accident Evaluations*

This section should include a description and analysis of the design features to prevent and mitigate severe accidents, in accordance with the requirements in 10 CFR 52.79(a)(38). This description and analysis should specifically address the issues identified below, as well as other issues identified in SECY-90-016 and SECY-93-087, which the Commission approved in related staff requirement memoranda (SRMs), dated June 26, 1990, and July 21, 1993, respectively.

In addition, this section should include information to satisfy the requirements of 10 CFR 52.79(a)(17). In particular, that regulation invokes 10 CFR 50.34(f)(1)(i) to specify that a plant-specific PRA should be performed to seek improvements in the reliability of core and containment heat removal systems that are significant and practical and do not excessively impact the plant.

If a specific feature is described and analyzed elsewhere in the FSAR, this section should provide the relevant cross-references.

⁵Proposed 10 CFR 52.79(a)(2) states “It is expected that reactors will reflect through their design, construction and operation an extremely low probability for accidents that could result in the release of significant quantities of radioactive fission products.”

C.I.19.3.1 Severe Accident Preventive Features

C.I.19.3.1.1 *Anticipated Transients Without Scram*

C.I.19.3.1.2 *Mid-Loop Operation*

C.I.19.3.1.3 *Station Blackout*

C.I.19.3.1.4 *Fire Protection*

C.I.19.3.1.5 *Intersystem Loss-of-Coolant Accident*

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C.I.19.3.2 Severe Accident Mitigative Features

C.I.19.3.2.1 *Hydrogen Generation and Control*

C.I.19.3.2.2 *Core Debris Coolability*

C.I.19.3.2.3 *High-Pressure Core Melt Ejection*

C.I.19.3.2.4 *Containment Performance*

C.I.19.3.2.5 *Dedicated Containment Vent Penetration*

C.I.19.3.2.6 *Equipment Survivability*

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C.I.19.3.2.n ...

C.I.19.3.3 Improvements in Reliability of Core and Containment Heat Removal Systems

C.I.19.3.3.1 *Improvements in Reliability of Core Heat Removal Systems*

C.I.19.3.3.2 *Improvements in Reliability of Containment Heat Removal Systems*

C.I.19.4 *PRA Maintenance*

C.I.19.4.1 Description of PRA Maintenance and Upgrade Program

Describe the PRA maintenance and upgrade program. This description should identify how the PRA will be maintained to ensure that it reasonably reflects as-designed, as-to-be-built, and as-to-be-operated conditions. If the applicant uses a screening process that allows insignificant changes to be deferred or not incorporated during the next scheduled PRA maintenance update, the applicant should describe the process and criteria, including documentation requirements. Likewise, if the process includes conditions that require an immediate maintenance update or upgrade of the PRA prior to the next scheduled PRA maintenance update, the applicant should describe the related process and criteria.

The NRC staff expects the plant-specific PRA to reasonably reflect the plant as it was constructed, in preparations for startup, and therefore, the plant-specific PRA should be upgraded prior to initial operations to incorporate those changes that were deferred (i.e., screened as not being significant) during the design, COL application, and construction phases, and to address findings during the PRA-related plant walkdowns. The applicant should describe their approach for ensuring that the plant-specific PRA will reasonably reflect the plant prior to initial operations.

In addition, the applicant should describe how the applicant will ensure that the PRA maintains the appropriate scope, level of detail, and technical adequacy, consistent with the prevailing PRA standards, guidance, and good practices, as needed to support its uses and applications identified in Section 19.2. In addressing the technical adequacy of the PRA, the applicant should include (1) a discussion of prior NRC staff review of the PRA (e.g., during design certification), findings (i.e., facts and observations) from that review, disposition to those findings, and the relevance of that review to the technical adequacy of the current plant-specific PRA; (2) a discussion of the scope, level of detail, and technical adequacy needed to support the specific uses and applications identified in Section 19.2, as appropriate to the current plant phase (i.e., an applicant in the COL application phase would need to address the PRA uses and applications identified for the COL application phase, while an applicant in the operational phase would need to address the PRA uses and applications identified for the operational phase); (3) a discussion regarding how technical adequacy is determined for pertinent PRA scope areas in which the NRC has not endorsed PRA standards (i.e., identify the guidance and good practices documents relied upon to determine the technical adequacy of the PRA); (4) a discussion on the use of and criteria for industry peer reviews; and (5) a discussion on the process for dispositioning industry peer review findings and maintaining or upgrading the PRA, as appropriate.

In addition, identify how the plant-specific PRA will be maintained up-to-date, as needed to support its uses and applications. This section should describe the PRA maintenance update frequency from the COL application phase through the plant startup phase and then describe the frequency of scheduled maintenance updates following initial operations. For example, in addressing the frequency of scheduled maintenance updates following initial operations, the FSAR section may state “the plant-specific PRA will be updated to reflect plant, operational, experience (data), and PRA modeling changes, consistent with the NRC-endorsed standards appropriate for the uses and applications of the plant-specific PRA and the information available 6 months prior to the issuance of the maintenance update, which will be scheduled to occur every other fuel cycle, not to exceed 5 years.”

C.I.19.5 PRA-Related ITAAC, COL Action Items, and Other Commitments

This section should describe the PRA-related inspections, tests, analyses, and acceptance criteria (ITAACs), COL action items, and other commitments, and should summarize the actions taken to address them. If an ITAAC or COL action item is addressed elsewhere in the FSAR, a cross-reference should be identified in this section as well as in the PRA-based insights table provided in Section 19.2.5. If an item cannot be resolved until after the COL application phase, describe any commitments regarding the resolution of the given item, and identify when the item will be resolved.

C.I.19.5.1 PRA-Related Inspections, Tests, Analyses, and Acceptance Criteria (ITAACs)

C.I.19.5.1.1 ITAAC Item 1

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C.I.19.5.1.n ITAAC Item N

C.I.19.5.2 PRA-Related COL Action Items

C.I.19.5.2.1 *COL Action Item 1*

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C.I.19.5.2.*n* *COL Action Item N*

C.I.19.5.3 Other PRA-Related Commitments

C.I.19.5.3.1 *Commitment Item 1*

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C.I.19.5.3.*n* *Commitment Item N*

C.I.19.6 *Conclusions*

This section should provide a summary discussion that explicitly addresses the objectives identified in the introduction (Section 19.1, which should include the objectives for the plant-specific PRA identified in Section C.II.1.2 of this guide). This discussion should clearly describe how each objective has been met by the analyses. In addition, this section should identify any commitments associated with unresolved items, including those identified in Section 19.5.