C.I.6 Engineered Safety Features

Chapter 6 of the FSAR should provide a discussion of how the design of ESF meets the applicable regulatory requirements and available regulatory guidance.

ESFs are provided to mitigate the consequences of postulated accidents in the unlikely event that an accident occurs. Together with 10 CFR 50.55a the following GDC, as set forth in Appendix A to 10 CFR Part 50 require that certain systems must be provided to serve as ESF systems:

(1) GDC 1, "Quality standards and records"
(2) GDC 4, "Environmental and dynamic effects design bases"
(3) GDC 14, "Reactor coolant pressure boundary"
(4) GDC 31, "Fracture Prevention of Reactor Coolant Pressure Boundary"
(5) GDC 35, "Emergency Core Cooling"
(6) GDC 41, "Containment Atmosphere Cleanup"

To meet GDC 14, the fluids used in ESF systems, when interacting with the RCPB, should have a low probability of causing abnormal leakage, rapidly propagating failure, and gross rupture. Containment systems, RHR systems, ECCSs, containment heat removal systems (CHRSs), containment atmosphere cleanup systems, and certain cooling water systems are typical of the systems that are required to be provided as ESFs. The application should include information on the plant's ESF systems in sufficient detail to permit an adequate evaluation of the performance capability of these features.

The ESF systems provided in plant designs may vary. The ESF systems explicitly discussed in this chapter are those that are commonly used to limit the consequences of postulated accidents in light-water-cooled power reactors, and should be treated as illustrative of the ESF systems and of the kind of informative material that is needed. This section of the FSAR should list and discuss each system that is considered to be part of the ESF systems. The discussions on ESF designs should identify functional requirements, demonstrate how the functional requirements comply with regulatory requirements, and demonstrate how the ESF design meets or exceeds the functional requirements.

C.I.6.1 <u>Engineered Safety Feature Materials</u>

The applicant should discuss the materials used in ESF components, as well as the material interactions with ECCS fluids that could potentially impair operation of ESF systems. The intent of the information included in this section of the FSAR is to ensure compatibility of the materials with the specific fluids to which the materials are subjected. The application should include adequate and sufficient information to ensure compliance with the applicable Commission regulations in 10 CFR Part 50 (including applicable GDC), the positions of applicable regulatory guides and branch technical positions, and the applicable provisions of the ASME Code, including Sections II, III, and Xl.

C.I.6.1.1 *Metallic Materials*

C.I.6.1.1.1 <u>*Materials Selection and Fabrication*</u>

The applicant should provide information on the selection and fabrication of the materials in the plant's ESF systems, such as the ECCS, CHRS, and containment air purification and cleanup systems. This information should include materials treated, as well as the treatment processes used, to enhance corrosion resistance, strength, and hardness. Materials for use in ESF systems should be selected for compatibility with core coolant and containment spray solutions (CSS) as described in Section III of the ASME Code, Articles NC-2160 and NC-3120. The application should:

(1) List the material specifications for all pressure-retaining ferritic materials, austenitic stainless steels, and nonferrous metals, including bolting and welding materials, in each component (e.g., vessels, piping, pumps, valves) that are part of the ESF systems. The applicant should identify the grade or type and final metallurgical conditions of the materials placed in service. This section should also provide adequate and sufficient information to demonstrate that the materials proposed for the ESFs comply with Appendix I to ASME Code Section III; Parts A, B, and C of ASME Code Section II; or RG 1.84.

(2) Llist the ESF construction materials that would be exposed to the core cooling water and containment sprays in the event of a LOCA. Describe test data and service experience to show that the construction materials used are compatible with the core cooling and CSS.

(3) Provide the following information to demonstrate that the integrity of safety-related components of the ESF systems is maintained during all stages of component manufacture and reactor construction.

(a) Provide sufficient details regarding the means used to avoid significant sensitization during fabrication and assembly of austenitic stainless steel components of the ESF systems. In so doing, demonstrate that the degree of freedom from sensitization is comparable to that obtainable by following the recommendations of RG 1.44. This RG describes acceptable criteria for preventing intergranular corrosion and IGSCC of stainless steel components of the ESF systems. The application should discuss the measures in place to prevent furnace-sensitized material from being used in the ESF systems, and how methods described in this guide are followed in testing the materials prior to fabrication to ensure that no deleterious sensitization occurs during welding. It should also include sufficient information to verify that materials used in ESF portions of austenitic stainless steel piping comply with staff positions on BWR materials described in Attachment A to Generic Letter (GL) 88-01, "NRC Position on IGSCC in BWR Austenitic Stainless Steel Piping," or the recommendations of NUREG-0313, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping" (Revision 2), issued January 1988, for materials that are resistant to stress-corrosion cracking.

(b) Provide sufficient details on process controls used to limit the exposure of austenitic stainless steel ESF components to contaminants that are capable of causing stress-corrosion cracking. Show that the degree of surface cleanliness during all stages of component manufacture and reactor construction is comparable to that obtainable by following the recommendations of RGs 1.44 and 1.37.

(c) Cold-worked austenitic stainless steel should not be used for pressure boundary applications. It may be used for other applications when there is no proven alternative available. Use of such materials should be supported by service experience and laboratory testing that simulates the environment to which the components is exposed. Cold work should be controlled, measured, and documented during each fabrication process. Augmented ISI should be proposed to ensure the structural integrity of such components during service. Provide assurance that cold-worked austenitic stainless steels have a maximum 0.2-percent offset yield strength of 620 MPa (90,000 psi) to reduce the probability of stress-corrosion cracking in ESF systems.

(d) Provide sufficient information on the selection, procurement, testing, storage, and installation of nonmetallic thermal insulation to demonstrate that the leachable concentrations of chloride, fluoride, sodium, and silicate are comparable to those recommended in RG 1.36.

(e) Operating experience has indicated that certain nickel-chromium-iron alloys (e.g., Alloy 600 and Alloy 82/182) are susceptible to PWSCC attributable to corrosion. Alloy 690 has improved stress-corrosion cracking resistance in comparison to Alloy 600, which was previously used in reactor applications. If nickel-chromium-iron alloys are proposed for use as ESF materials, provide an acceptable technical basis, either by identification (based on demonstrated satisfactory use in similar applications) or by providing information to support use of the material under the expected environmental conditions (e.g., exposure to reactor coolant).

(f) Provide sufficient information to show the degree of agreement that the fracture toughness properties of the ferritic materials with the guidelines of the ASME Code.

(g) Describe the controls imposed on abrasive work performed on austenitic stainless steel surfaces to minimize cold working of surfaces and introduction of contaminants that promote stress-corrosion cracking of the materials.

(4) Provide sufficient information to determine that the corrosion allowances specified for ESF materials that are exposed to process fluids are supported by adequate technical bases, and that the specified corrosion allowances are adequate for the proposed design life of affected components and piping.

(5) Provide sufficient information to show that the preheat temperatures for welding low-alloy steel comply with RG 1.50; for welding carbon steel materials, the preheat temperatures should comply with Section III, Appendix D, Article D1000 of the ASME Code.

(6) Provide sufficient information to ensure that moisture control on low-hydrogen welding materials comply with the guidelines in Section III of the ASME Code, unless alternative procedures are justified.

(7) Provide sufficient information to show that the methods for qualifying welders for making welds at locations where access is limited, and the methods for monitoring and certifying such welds, are in accordance with RG 1.71.

(8) Provide sufficient information to show that the applicable guidance pertaining to material selection and fabrication provided in FSAR Chapters 5 and 10 is met.

C.I.6.1.1.2 ***Composition and Compatibility of Core Cooling Coolants and Containment Sprays***

The applicant should provide the following information described below regarding the composition and compatibility of the core cooling water and containment sprays and other processing fluids (i.e., fluids used during fabrication and cleaning), as they relate to the materials of the ESF systems. The applicant should provide the following information.

(1) Describe the method used to establish and control the pH of the ESF fluids during a LOCA to avoid stress-corrosion cracking of the austenitic stainless steel components and to avoid excessive generation of hydrogen attributable to corrosion of containment metals. For all

postulated DBAs involving release of water into the containment building the time-history of the pH of the aqueous phase in each drainage area of the building should estimated. All soluble acids and bases within the containment should be identified and quantified.

(2) Describe the process used to evaluate the compatibility of the materials used in ESF systems and the composition of the core cooling and spray solutions and any other fluids that might occur during operation of the ESF systems.

(3) Provide information to verify the compatibility of materials used in manufacturing ESF components with the ESF fluids.

(4) Describe the process used to verify that ESF components and systems are cleaned in accordance with RG 1.37.

(5) Describe the process used to determine whether nonmetallic thermal insulation is to be used on components of the ESF systems and, if so, how is it verified that the amount of leachable impurities in the specified insulation is within the "acceptable analysis area" in Figure 1 of RG 1.36.

(6) Provide information concerning the proposed approach to control the chemistry of the water used for the ECCS and CSS and during the operation of the systems. Describe the methods and bases to evaluate the short-term compatibility (during the mixing process) and long-term compatibility of the water used for the ECCS and CSS with all safety-related components within the containment.

(7) Describe the methods to be employed to store the ESF fluids to reduce deterioration, which may occur as a result of either chemical instability or corrosive attack on the storage vessel and the effects that such deterioration could have on the compatibility of these ESF coolants with both the ESF materials of construction and other materials within the containment.

(8) Describe how the release of hydrogen attributable to corrosion of metals by ECCS and CSS is controlled so that the amount released is in accordance with RG 1.7, "Control of Combustible Gas Concentrations in Containment Following a Loss-of-Coolant Accident," and outline the paths that solutions from the ECCS and CSS would follow in the containment to the sump, for both injection and recirculation, in order to verify that no areas accumulate very high to low pH solutions and to validate any assumptions regarding pH in modeling containment spray fission product removal.

(9) provide the following information to evaluate whether hydrogen release is controlled in accordance with RG 1.7:

   (a) a description of the experience, tests at simulated accident conditions, or conservative extrapolations from existing knowledge that supports the selection of component materials (to minimize adverse interaction) upon which the operation of the feature is based

   (b) evidence that the materials used in fabricating ESF components can withstand the postulated accident environment, including radiation levels, and radiolytic decomposition products that may occur does not interfere with it or other ESFs

   (c) adequate and sufficient information on compatibility of ESF fluids with organic materials (coatings) and use of coatings in containment, including their qualifications

(d) adequate and sufficient information to determine the adequacy of post-LOCA hydrogen control, including control of the volume of hydrogen gas expected to be generated by metal-water reaction involving the fuel cladding and radiolytic decomposition of the reactor coolant, and corrosion of metals by ECC and CSS

C.I.6.1.2 *Organic Materials*

The applicant should identify and quantify all organic materials that exist in significant amounts within the containment building. Such organic materials include wood, plastics, lubricants, paint or coatings, electrical cable insulation, and asphalt. Plastics, paints, and other coatings should be classified and references listed. Coatings not intended for 40-year service without overcoating should include total coating thicknesses expected to be accumulated over the service life of the substrate surface.

C.I.6.2 Containment Systems

C.I.6.2.1 *Containment Functional Design*

The applicant should describe how the basic functional design requirements for the containment meet GDC 4, GDC 16, "Containment Design," and GDC 50, "Containment Design Basis," in Appendix A to 10 CFR Part 50 and 10 CFR 50.46. GDC 4 provides the basic environmental and dynamic effects design requirements for all SSC important to safety. GDC 16 establishes the fundamental requirement to design a containment that is essentially a leaktight barrier against release of radioactivity to the environment. GDC 50, among other things, requires consideration of the potential consequences of degraded ESFs, such as the CHRS and ECCS, limitations in defining accident phenomena, and conservatism in the calculations of models and input parameters in assessing containment design margins. The applicant can find the methods and criteria for the analysis and design of the ECCS in 10 CFR 50.46.

The applicant should discuss the containment analyses, considering shutdown conditions, when appropriate, to provide a basis for procedures, instrumentation, operator response, equipment interactions, and equipment response. It should provide discussion to demonstrate that the issues identified in GL 88-17, "Loss of Decay Heat Removal," have been resolved or precluded in the design of the plant for new plant applicants and those PWRs that are subject to this guidance. Shutdown thermodynamic states and physical configurations to which the plant may be subjected during shutdown conditions (such as time to core uncovery during a loss of shutdown decay heat removal capability) should be included and sufficient depth to allow for the development of adequate bases should be provided.

C.I.6.2.1.1 ***Containment Structure***

(1) Design Bases

The applicant should discuss the design bases for the containment to withstand a spectrum of LOCA and main steamline break accidents. In particular, this discussion should include the following information.

(a) Discuss the postulated accident conditions and the extent of simultaneous occurrences (e.g., LOOP and single active failures) that determine the containment accident pressure (including both internal and external design pressure requirements). Applicants should credit only seismically qualified equipment for accident mitigation in containment safety analyses. The maximum calculated accident pressure and temperature should be stated.

(b) Discuss the postulated accident conditions and the extent of simultaneous occurrences (e.g., LOOP and single active failures) that determine the accident pressure and temperature requirements for the internal structures of pressure-suppression-type containments, with reference to the design evaluation in Item 3(b) of this section. Applicants should credit only seismically qualified equipment for accident mitigation in containment safety analyses.

(c) Discuss the sources and amounts of mass and energy that might be released into the containment and the postaccident time-dependence of the mass and energy releases, with reference to the design evaluations provided in FSAR Sections 6.2.1.3 and 6.2.1.4.

(d) Discuss the capability for energy removal from the containment under various postulated single-failure conditions in ESFs.

(e) Discuss the bases for establishing the containment depressurization rate, and justification (with references) of the assumptions used in the analysis of offsite radiological consequences of the accident.

(f) Discuss the bases for the analysis of the minimum containment pressure used in the ECCS performance studies for PWR reactor systems, with reference to the design evaluation in FSAR Section 6.2.1.5.

(g) Discuss other design bases, such as hydrodynamic loads unique to pressure-suppression-type containments, with reference to the design evaluation in Item 3(b) of this section.

(2) Design Features

In this section of the FSAR, the applicant should discuss the hydrodynamic loads experienced in the containment, describe the design features of the containment and internal structures, and include appropriate general arrangement drawings. It should provide the following information:

(a) Discuss the qualification tests proposed to demonstrate the functional capability of the SSC in pressure-suppression-type containments and nonpressure-suppression-type containments and a discussion of the status of any incomplete developmental test programs together with a schedule for test program completion and subsequent submittal of supplemental application information, as necessary. (FSAR Section 1.5 should also identify any incomplete developmental test programs.).

(b) Discuss the design provisions to protect the integrity of the containment structure under external pressure-loading conditions resulting from inadvertent operation of the CHRS or other possible modes of plant operation that could result in significant external structural loadings, and a discussion of the functional capability of these provisions. Specify the design values of the external design pressure of the containment and the lowest expected internal pressure.

(c) Identify locations in the containment where water may be trapped and prevented from returning to the containment sump, if the design uses traditional sump, and the quantity of water involved. How the retained water may affect the static head for recirculation pumps should be discussed as well as any provisions that permit the water entering the refueling canal to be drained to the sump (this item does not apply to applicants who do not use traditional sumps).

(3) Design Evaluation

The applicant should provide evaluations of the functional capability of the containment design. The information to be included depends on the type of containment being considered (i.e., dry containments or BWR water pressure-suppression-type containments), as indicated below. Information of a similar nature for new types of containment designs should be provided. The applicant should:

(a) PWR Dry Containment. Provide analyses of the containment pressure response to a spectrum of postulated RCS pipe ruptures (e.g., hot leg, cold leg (pump suction), and cold leg (pump discharge) breaks); specify the break size and location of each postulated LOCA analyzed; and graphically present the containment pressure and temperature response and the sump water temperature response as functions of time for each accident analyzed, up to the time that includes all important aspects of the transient.

Identify the containment computer codes used to determine the pressure and temperature response; discuss and justify the inherent conservatisms in the assumptions made in the analyses regarding initial containment conditions (e.g., pressure, temperature, free volume, humidity), containment heat removal, and ECCS operability.

Provide the results of a failure modes and effects analysis of the ECCS and containment cooling systems to determine single active failures that result in maximum accident pressure and temperature.

Provide the types of information described in Tables 6-1 and 6-2 of this guide; summarize and tabulate the results of each LOCA analyzed as shown in Table 6-3 of this guide.

Provide analyses of the temperature and pressure response of the containment to postulated secondary-system pipe ruptures (e.g., steam and feedwater line breaks). The break size and location of each postulated break analyzed should be specified, the method of analysis described and the computer codes used (provide detailed mass and energy release analyses in Section 6.2.1.4 of the FSAR) described. The assumptions made regarding the operating conditions of the reactor, closure times of secondary-system isolation valves, single active failures, and ESF actuation times should be discussed and justified. The results of each accident analyzed as shown in Table 6-3 of this guide should be tabulated.

Tabulate the structural heat sinks within the containment in accordance with Tables 6-4A through 6-4D of this guide. With respect to modeling heat sinks for heat transfer calculations, the applicant should provide and justify the computer mesh spacing used for concrete, steel, and steel-lined concrete heat sinks. It should justify the steel-concrete interface resistance used for steel-lined concrete heat sinks, as well as the heat transfer correlations used in heat transfer calculations. The condensing heat transfer coefficient as a function of time for the most severe hot leg, cold leg (pump suction), cold leg (pump discharge), and steam or feedwater line pipe breaks should be graphically illustrated.

Discuss the provisions to protect the integrity of the containment structure against the consequences of inadvertent operation of the CHRS or other systems that could result in pressures lower than the external design pressure of the containment structure; provide a reference if discussed in Chapter 7 of the FSAR; discuss the administrative controls and/or electrical interlocks that would prevent such occurrences; identify the worst-case single failure that could result in inadvertent operation of the CHRS; discuss the analytical methods and assumptions used to determine the containment pressure response, and provide the results of analyses performed; the external design pressure of the containment, as well as the setpoint for actuation of the vacuum relief system should be provided.

for the most severe RCS hot leg, cold leg (pump suction), and cold leg (pump discharge) pipe breaks, provide accident chronologies; indicating the time of occurrence (in seconds after the break occurs) of events, such as the following:

- beginning of core flood tank injection
- beginning of the ECCS injection phase
- peak containment pressure during the blowdown phase
- end of the blowdown phase
- beginning of fan-cooler operation
- beginning of the containment spray injection phase (specify the water level in the water storage tank)
- peak containment pressure subsequent to the end of the blowdown phase
- end of the core reflood phase
- end of the ECCS injection phase and beginning of the recirculation phase (specify the water level in the water storage tank)
- end of the containment spray injection phase (specify the water level in the water storage tank)
- beginning of the containment spray recirculation phase (specify the water level in the water storage tank)
- end of steam generator energy release for the post-reflood phase
- time of depressurization of the containment at 50 percent of containment accident pressure for conventional dry containments

for the most severe RCS pipe breaks (i.e., the most severe pipe break in the hot-leg, cold-leg (pump discharge) and cold-leg (pump suction) lines and the most severe secondary coolant system pipe break), provide energy inventories that show the distribution of energy prior to the accident, at the time of peak pressure, at the end of the blowdown phase, at the end of the core reflood phase (for LOCAs), and steam generator energy release during the post-reflood phase (for LOCAs).

Describe the model for determining the distribution of mass and energy from the postulated break in the containment atmosphere and sump.

Provide a summary description of the instrumentation provided to monitor and record containment pressure, temperature, and sump or suppression pool temperature during the course of an accident within the containment with appropriate reference to Chapter 7 of the FSAR. The range, accuracy, and response of the instrumentation, as well as the tests conducted to qualify the instruments for use in the postaccident containment environment (or reference Chapter 7 of the FSAR) should be provided.

(b) BWR Containments. The applicant should provide the types of containment design information identified in Tables 6-5 and 6-6 of this guide.

The applicant should provide the results of analyses of the BWR drywell and wetwell responses to a postulated rupture of the recirculation line. The results of analyses of the drywell, wetwell, and containment pressure responses to postulated ruptures of the main steamline should be provided and the assumptions used in the analyses regarding the initial containment conditions, initial reactor operating conditions, energy sources, mass and energy release rates, and break areas specified and justified. The applicant should graphically illustrate the drywell and wetwell pressures, as well as containment pressure and deck differential pressure, where applicable, as functions of time and energy addition (e.g., blowdown, decay heat, sensible heat, pump heat) and energy removal (e.g., the RHR system, heat sinks) as a function of time.

Assumptions used in the analyses should be specified and justified and provisions for orificing and/or leak detection and isolation to limit the mass and energy released described. The applicant should discuss the functional capability of these provisions and graphically illustrate the containment and drywell pressures and temperatures as functions of time.

The applicant should provide tables showing the following:

- initial RCS and containment conditions as identified in Table 6-7 of this guide
- energy source information as identified in Table 6-8 of this guide
- mass and energy release data in the format given in Table 6-9 of this guide for each pipe break accident analyzed
- information identified in Table 6-10 of this guide on the passive heat sinks that may have been used
- results of the postulated pipe break accidents for each postulated line break in the format given in Table 6-11 of this guide

The applicant should provide the results of the analyses of transients that could lead to external pressure loads on the drywell and wetwell. It should show that the transient used for design purposes in each case is the controlling event for external pressure loading. The applicant should discuss and justify the conservatism in the assumptions used in the analyses and graphically illustrate the wetwell and drywell pressures as functions of time. For containments, it should describe how the wetwell-to-drywell vacuum relief system prevents backflooding of the suppression pool water into the lower drywell and protect the integrity of the steel diaphragm floor slab between the drywell and wetwell, and between the wetwell and drywell structures and liner plate.

The applicant should provide heat sink data and justify conservatism.

The applicant should provide the results of analyses of the containment's capability to tolerate direct steam bypass of the suppression pool for the spectrum of potential RCS break sizes discuss the measures planned to minimize the potential for steam bypass, and describe any systems provided to mitigate the consequences of steam bypass. The conservatism in the assumptions used in the analyses, should be discussed and demonstrated.

The applicant should describe the manner in which suppression pool dynamic loads resulting from postulated LOCAs and transients (e.g., relief valve actuation) have been integrated into the affected containment structures. It should illustrate all equipment and structural surfaces that could be subjected to pool dynamic loads in the containment drawings. For each structure or group of structures, the dynamic loads as a function of time, as well as the relative magnitude of the pool dynamic load compared to the design-basis load for each structure should be specified and each of the dynamic load histories should be justified by the use of appropriate experimental data and/or analyses.

The applicant should describe the manner by which the containment design considered potential asymmetric loads and characterize the types and magnitudes of possible asymmetric loads, as well as the capabilities of the affected structures to withstand such a load profile. Consideration of seismically induced pool motion that could lead to locally deeper submergences for certain drywell-to-wetwell vents (BWRs) should be included.

The applicant should describe in detail the analytical models used to evaluate the containment and drywell responses to the postulated accidents and transients identified above and discuss the conservatism in the models and the assumptions made. Reference to applicable test data should be made to support the selected analytical methods. The sensitivity of the analyses to changes in key parameters should be discussed.

The applicant should describe the instrumentation provided to monitor and record the drywell and wetwell pressures and temperatures and the suppression pool temperature during the course of an accident within the containment. The range, accuracy, and response of the instrumentation, as well as the tests conducted to qualify the instruments for use in the postaccident containment environment should be discussed. The recording system provided for these instruments, as well as the accessibility of the recorders to control room personnel during a LOCA should be described. For the above discussions, the applicant may reference the appropriate information in FSAR Chapter 7.

C.I.6.2.1.2 ***Containment Subcompartments***

(1) Design Bases

The applicant should discuss the design bases for the containment subcompartments and include the following information:

(a) synopsis of the pipe break analyses performed, as well as justification for the selection of the DBA (break size, considering LBB where applicable, and location) for each containment subcompartment

(b) extent to which pipe restraints are used to limit the break area of pipe ruptures.

(2) Design Features

The applicant should describe each subcompartment analyzed, and provide plan and elevation drawings showing component and equipment locations, routing of high-energy lines, and vent locations and configurations. The applicant should tabulate the subcompartment free volumes and vent areas and identify the vent areas that become available only after the occurrence of a postulated pipe break accident (e.g., as a result of insulation collapsing or blowing out, blowout panels being blown out, or hinged doors swinging open), and describe the manner in which they are treated. The availability of these vent areas should be justified. Dynamic analyses of the available vent area as a function of time should be provided and supported with appropriate test data.

(3) Design Evaluation

The applicant should identify the computer program(s) used, and/or provide or reference a detailed description of the analytical model, for subcompartment pressure response analyses. It should provide the results of the analyses, and include the following information:

(a) Describe the computer program used to calculate the mass and energy releases from a postulated pipe break. The applicant should provide the nodalization scheme for the system model and specify the assumed initial operating conditions of the system. It should discuss the conservatism of the blowdown model with respect to the pressure response of the subcompartment.

(b) Specify the assumed initial operating conditions of the plant, such as reactor power level and subcompartment pressure, temperature, and humidity.

(c) Describe and justify of the subsonic and sonic flow models used in vent flow calculations. The degree of entrainment assumed for the vent flow should be discussed and justified.

(d) Identify the piping system within a subcompartment that is assumed to rupture, the location of the break within the subcompartment, and the break size. The inside diameter of the ruptured line, as well as the locations and sizes of any flow restrictions within the line that is postulated to fail should be provided.

(e) Describe the subcompartment nodalization information, in accordance with the formats shown in Figure 6-1 and Tables 6-12 and 6-13 of this guide. It should be demonstrated that the selected nodalization maximizes differential pressures as a basis for design pressures for structures and component supports.

(f) Provide a graph showing the pressure response within a subcompartment as a function of time to permit evaluation of the effects on structures and component supports.

(g) Provide mass and energy release data for the postulated pipe breaks in tabular form, with time in seconds, mass release rate in lbm/s, enthalpy of mass released in Btu/lbm, and energy release rate in Btu/s.

(h) Provide for all vent flowpaths, specification of the flow conditions (subsonic or sonic) up to the time of peak pressure.

(i) Describe, in detail, the method used to determine vent loss coefficients and a table showing the vent paths and loss coefficients for each subcompartment.

C.I.6.2.1.3 ***Mass and Energy Release Analyses for Postulated Loss-of-Coolant Accidents***

The applicant should identify the computer codes used, and provide or reference detailed descriptions of the analytical models employed to calculate the mass and energy released following a postulated LOCA. It should discuss the analyses performed on various RCS pipe break locations (e.g., hot leg, cold leg (pump suction), and cold leg (pump discharge)) and a spectrum of pipe break sizes at each location to identify the most severe pipe break location and size (the design-basis LOCA). The discussion should be divided into the accident phases in which different physical processes occur, as follows:

(1) blowdown phase (i.e., when the primary coolant is being rapidly injected into the containment)

(2) refill phase

(3) core reflood phase (i.e., when the core is being re-covered with water)

(4) long-term cooling phase (i.e., when core decay heat and remaining stored energy in the primary and secondary systems are being added to the containment)

The following information should be included:

(1) Mass and Energy Release Data

Describe for each break location, the mass and energy release data for the most severe break size during the first 24 hours following the accident. (If a shorter time period is selected for some accidents, justification should be provided.) Using the tabular form shown in Table 6-14 of this guide, the applicant should provide this information with time in seconds, mass release rate in lbm/s, and enthalpy of mass released in Btu/lbm. The safety injection fluid volume (assumed to spill from the break directly to the containment floor) as a function of time should be provide in tabular form.

(2) Energy Sources

Identify the sources of generated and stored energy in the RCS and secondary coolant system considered in analyses of LOCAs, and a description of the methods used and assumptions made in calculations of the energy available for release from these sources. The conservatism in the calculation of the available energy for each source should be addressed. The stored energy sources and the amounts of stored energy should be tabulated. For each source of generated energy, curves showing the energy release rate and integrated energy released should be provided.

(3) Description of the Blowdown Model

Describe the procedure used to calculate the mass and energy released from the RCS during the blowdown phase of a LOCA (or reference as appropriate). All significant equations and correlations used in the analysis should be included. Conservatism in the mass and energy release calculations from the standpoint of predicting the highest containment pressure response, and justify any assumptions should be discussed. For example, the calculations used to determine the energy transferred to the primary coolant from heated surfaces, as well as the release of primary coolant to the containment during blowdown should be described. In addition, the heat transfer correlations used, and justify their application should be provided and justified.

(4) Description of the Core Reflood Model

Describe the calculations used to determine the mass and energy released to the containment during the core reflood phase of a LOCA (or reference as appropriate). All significant equations and correlations used in the analysis should be included. The conservatism in the mass and energy release calculations, from the standpoint of predicting the highest containment pressure response should be discussed and justified. For example, the methods used to calculate the energy transferred to the ECC injection water from primary system metal surfaces and the core, the core inlet and exit flow rates, and the energy transferred from the steam generators. The carryout fraction used to predict the mass flow rate out of the core should be justified by comparing it to experimental data. Any assumptions made regarding the quenching of steam by ECCS injection water should be justified by comparison to appropriate experimental data. The carryout fractions, core inlet flow rate, and core inlet temperature as a function of time. Should be provided.

(5) Description of the Long-Term Cooling Model

Describe the calculations used to determine the mass and energy released to the containment during the long-term cooling (or post-reflood) phase of a LOCA (or reference as appropriate).

Including (or referencing) all significant equations and correlations used in the analysis. The conservatism in the mass and energy release calculations, from the standpoint of predicting the highest containment pressure response should be discussed and justified. For example, discuss and justify the methods used to calculate (a) core inlet and exit flow rates and (b) removal of all sensible heat from primary system metal surfaces and the steam generators. The heat transfer correlations used should be described, and their application justified. Liquid entrainment correlations for fluid leaving the core and entering the steam generators should be described and justified, and by comparison with experimental data. Experimental data to justify any assumptions made regarding steam quenching by ECCS water should be provided.

(6) Single-Failure Analysis

Provide a failure modes and effects analysis of the ECCS to determine the single active failure that maximizes the energy release to the containment following a LOCA. Analyses for each postulated break location should be provided.

(7) Metal-Water Reaction

Describe the potential for additional energy being added to the containment as a result of metal-water reaction within the core. A conservative analysis of the containment pressure as a function of metal-water reaction energy addition should be provided, and it should be demonstrated that the metal-water reaction time is conservative.

(8) Energy Inventories

Describe for the worst hot-leg, cold-leg pump suction, and cold-leg pump discharge pipe breaks, inventories of the energy transferred from the primary and secondary systems to the containment, as well as the energy remaining in the primary and secondary systems, in a tabular form similar to that shown in Table 6-15 of this guide.

(9) Additional Information Required for Confirmatory Analysis

To enable confirmatory analyses to be performed, provide a tabulation of the elevations, flow areas, and friction coefficients within the primary system, that are used for the containment analyses, as well as the safety injection flow rate as a function of time. Representative values with justification for empirical correlations (such as those used to predict heat transfer and liquid entrainment) that are significant to the analysis should be provided.

C.I.6.2.1.4 ***Mass and Energy Release Analysis for Postulated Secondary-System Pipe Ruptures Inside Containment (PWR)***

The applicant should identify the computer code used, and provide (or reference) a detailed description of the analytical model used to calculate the mass and energy released following a secondary-system steam and feedwater line break inside containment. A spectrum of break sizes and various reactor operating conditions should be analyses to ensure that the most severe secondary-system pipe rupture has been identified. Entrainment should be considered as appropriate and the values assumed should be justified. The following information should be included:

(1) Mass and Energy Release Data

Provide mass and energy release data for the most severe secondary-system pipe rupture with regard to break size and location and operating power level of the reactor, in tabular form with time in seconds, mass flow rate in lbm/s, and corresponding enthalpy in Btu/lbm. Separate tables for the mass and energy released from each side of a double-ended break should be provided.

(2) Single-Failure Analysis

Provide a failure modes and effects analysis to determine the most severe single active failure for each break location, for the purpose of maximizing the mass and energy released to the containment and the containment pressure response. This analysis should consider, for example, the failure of a steam or feedwater line isolation valve, the feedwater pump to trip, and containment heat removal equipment.

(3) Initial Conditions

Describe the analysis, including assumptions, to determine the fluid mass available for release into the containment. In general, the analysis should be performed in a manner that is conservative from a containment response standpoint (i.e., maximizes the fluid mass available for release).

(4) Description of Blowdown Model

Identify the computer code used should be identified, and the procedure used for calculations including all significant equations (or reference the appropriate report) should be described. Calculations of the energy transferred from the primary system to the secondary system, stored energy removed from the secondary system metal, break flow, and steam-water separation should be conservative for containment analysis. This conservatism should be discussed and justified. The correlations used to calculate the heat transferred from the steam generator tubes and shell should be provided and justified.

(5) Energy Inventories

Provide for the most severe secondary-system pipe rupture, the inventories of the energy transferred from the primary and secondary systems to the containment.

(6) Additional Information Required for Confirmatory Analyses

To permit confirmatory analyses to be performed, provide a tabulation of the elevations, flow areas, and friction coefficients within the secondary system, as well as the feedwater flow rate as a function of time. Representative values with justification for empirical correlations (such as those used to predict heat transfer and liquid entrainment) that are significant to the analysis should be provided.

C.I.6.2.1.5 *Minimum Containment Pressure Analysis for Performance Capability Studies of the Emergency Core Cooling System (PWR)*

The applicant should identify the computer codes used, or provide detailed descriptions of the analytical models used to calculate (1) mass and energy released from the RCS following a postulated LOCA and (2) containment pressure response for the purpose of determining the minimum containment pressure that should be used in analyzing the effectiveness of the ECCS. Plot the containment pressure and temperature responses, as well as the sump water temperature response, as functions of time. The following information should be provided:

(1) Mass and Energy Release Data

Provide for the most severe break, the size of the break should be stated and provide the mass and energy release data used for the minimum containment pressure analysis provided.
This information should be provided in a tabular form, with time in seconds, mass release rate in lbm/s, and enthalpy of mass released in Btu/lbm. The mass and energy of safety injection fluid that is assumed to spill from the break directly to the containment floor as a function of time and

discuss and justify the conservatism in the mass and energy release analysis, with regard to minimizing containment pressure.

(2) Initial Containment Internal Conditions

Provide the initial containment conditions (i.e., temperature, pressure, and humidity) assumed in the analysis. It should be shown that the initial conditions selected are conservative with respect to minimizing containment pressure.

(3) Containment Volume

Provide the assumed containment net free volume. It should be shown that the estimated free volume has been maximized to ensure conservative prediction of the minimum containment pressure. The uncertainty in determining the volume of the internal structures and equipment that should be subtracted from the gross containment volume to arrive at the net free volume should be discussed.

(4) Active Heat Sinks

Identify the CHRS and ECCS equipment that is assumed to be operative for the containment analyses. The conservatism of this assumption with respect to minimizing containment pressure should be discussed. The applicant should maximize the heat removal capacity of the engineered safeguards by using the minimum temperature of stored water and cooling water, and minimum delay times in bringing the equipment into service. A figure or table showing the heat removal rate of fan cooling units as a function of containment temperature should be provided and the containment spray flow rate and temperature assumed for the containment minimum pressure analyses should be stated. State and justify the assumptions used in establishing the actuation times for the active heat removal systems should be stated and justified.

(5) Steam-Water Mixing

Discuss the potential for mixing and condensation of containment steam with any spilled ECCS water during blowdown and core reflood. Comparisons with appropriate experimental data should be provided.

(6) Passive Heat Sinks

With regard to the heat sink data displayed in Tables 6-4A through 6-4D of this guide, provide a discussion of the uncertainty in accounting for heat sinks and determining the heat sink parameters (e.g., mass, surface area, thickness, volumetric heat capacity, thermal conductivity) in the plant.

(7) Heat Transfer to Passive Heat Sinks

Discuss and justify the condensing heat transfer coefficients between the containment atmosphere and passive heat sinks. Comparisons with appropriate experimental data should be provided (or referenced). The condensing heat transfer coefficients as a function of time for the passive heat sinks should be graphically illustrated.

(8) Other Parameters

Any other parameters that may have a substantial effect on the minimum containment pressure analysis, and a discussion of how they affect the analysis. If the containment purge system is used during plant power operations, a discussion of the effect of a LOCA during the plant purge operation on the minimum containment pressure analysis should be provided. Radiological consequences of a LOCA during containment purge in Chapter 15 of the FSAR should be discussed (or provide a reference to where it is discussed should be provided).

C.I.6.2.1.6 ***Testing and Inspection***

The applicant should provide information on the containment IST and ISI to meet the ASME Code guidelines with regard to preoperational testing and periodic inservice surveillance to ensure the functional capability of the containment and associated SSCs. The applicant should emphasize those tests and inspections that are considered essential to determine that performance objectives have been achieved, and performance capability is maintained above preestablished limits throughout the plant's lifetime. Such tests may include, for example, tests to ensure that suppression pool bypass leakage is within allowable limits, operability tests of vacuum relief systems and mechanical devices that are required to open to provide vent area following a pipe break accident within a subcompartment, and tests to ensure the integrity of the X-quencher or T-quencher anchors (or reference FSAR Chapter 3). The applicant should include information on the following:

(1) planned tests and inspections, including the need and purpose of each test and inspection
(2) selected frequency for performing each test and inspection, including justification
(3) the manner in which tests and inspections are conducted
(4) requirements and bases for acceptability
(5) action to be taken in the event that acceptability requirements are not met

The applicant should emphasize those surveillance-type tests that are of such importance to safety that they may become part of the TS of an operating license, and discuss the bases for such surveillance requirements.

C.I.6.2.1.7 ***Instrumentation Requirements***

The applicant should discuss the instrumentation proposed to be installed to monitor conditions inside the containment and to actuate safety functions when abnormal conditions are sensed. The appropriate FSAR section of the application that discusses the design details and logic of the instrumentation should be referenced.

C.I.6.2.2 *Containment Heat Removal Systems*

GDC 38, "Containment Heat Removal," requires that systems to remove heat from the reactor containment must be provided to rapidly reduce the containment pressure and temperature following a LOCA (consistent with the functioning of other associated systems) and to maintain them at acceptably low levels. In addition, GDC 39, "Inspection of Containment Heat Removal System," and GDC 40, "Testing of Containment Heat Removal System," require that the CHRS must be designed to permit appropriate periodic inspection and testing to ensure the system's integrity and operability. The systems provided for containment heat removal may include fan cooler and spray systems or passive systems. The applicant should describe the design and functional capability of these systems, as well as the capability to remove heat from the suppression pool in BWRs.

Similarly, GDC 41 requires that systems to control fission products that may be released to the containment must be provided (as necessary) to reduce the concentration and quantity of fission products released to the environs following postulated accidents (consistent with the functioning of other associated systems). The systems designed for containment heat removal may also possess the capability to meet this requirement. Section 6.5.2 of the FSAR should consider the fission product removal effectiveness of the CHRS.

C.I.6.2.2.1 ***Design Bases***

The applicant should discuss the design bases (i.e., the functional and mechanical and electrical design requirements) for the CHRS. These design bases should include considerations such as the following:

(1) sources of energy, energy release rates as a function of time, and integrated energy released following postulated LOCAs and steamline breaks for sizing each heat removal system

(2) extent to which operation of the heat removal systems is relied upon to attenuate the postaccident conditions imposed on the containment (i.e., the minimum required availability of the CHRS)

(3) required containment depressurization time

(4) capability to remain operable in the accident environment

(5) capability to remain operable assuming a single failure

(6) capability to withstand the SSE without loss of function

(7) capability to withstand dynamic effects

(8) capability for periodic inspection and testing of the systems and/or their components

C.I.6.2.2.2 ***System Design***

The applicant should describe the design features, and provide piping and instrumentation diagrams of the CHRS. A table with the design and performance data for each CHRS and its components should be provided. A discussion of the system design requirements for redundancy and independence to ensure single-failure protection, and a discussion of the system design provisions that facilitate periodic inspection and operability testing of the systems and their components should also be provided. The codes, standards, and guides applied in the design of the CHRS and system components should be provided. The applicant should specify the plant protection system signals and setpoints that actuate the CHRS; alternatively, the FSAR section in the application where this information is tabulated should be referenced. The applicant should provide the rationale for selecting the actuation signals and determining the setpoints.

The applicant should specify the times following postulated accidents that the containment heat removal systems are assumed to be fully operational. The applicant should discuss the delay times following receipt of the system actuation signals that are inherent in bringing the systems into service. Discuss the extent to which the CHRS and system components are required to be operated remotely or manually from the main control room, and the extent of operator intervention in the operation of the systems. Qualification tests that have been (or will be) performed on system components, such as spray nozzles, fan cooler heat exchangers, recirculation heat exchangers, pump and fan motors, valves, valve operators, and instrumentation should be described.

The applicant should provide the following additional information if it proposes to use a fan cooler system:

(1) Identify the ductwork and equipment housings that must remain intact following a LOCA or main steamline break.

(2) Discuss the design provisions (e.g., pressure relief devices, conservative structural design) that ensure that the ductwork and equipment housings remain intact.

(3) Provide plan and elevation drawings of the containment showing the routing of airflow guidance ductwork.

The applicant should describe the design features of the recirculation intake structures (sumps). It should provide plan and elevation drawings of the structures, show the level of water in the containment following a LOCA in relation to the structures and compare the design of the recirculation intake structures; and to the positions in RG 1.82, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant-Accident." The applicant should address how the design considers the following adverse effects:

(1) debris generation

(2) chemicals from buffering agents and metal interactions

(3) head loss attributable to severe blockage

(4) debris effects generated from the use of unqualified coatings (which may not adhere to the surface)

(5) downstream effects of small particles that penetrate the screen and cause blockage

The applicant should specify the mesh size of each stage of screening, as well as the maximum particle size that could be drawn into the recirculation piping. Of the systems that may receive water from the recirculation intake structures under postaccident conditions, the applicant should identify the system component that places the limiting requirement on the maximum particle size of debris that may be allowed to pass through the intake structure screening, and specify the limiting particle size that the component can circulate without impairing system performance. The applicant should describe how the screening is attached to the intake structures to preclude the possibility of debris bypassing the screening.

A discussion of the potential for the intake structure screening to become clogged with debris (e.g., insulation), in light of the effective flow area of the screening and approach velocity of the water should be provided. The kinds of debris that might be developed following a LOCA should be identified and discussed. The applicant should consider the following potential sources of debris:

(1) piping and equipment insulation
(2) sand plug materials
(3) all structures displaced by accident pressure to provide vent area
(4) loose insulation in the containment
(5) debris generated by failure of nonsafety-related equipment

The applicant should describe the precautions taken to minimize the potential for debris clogging the screens.

The applicant should discuss the types of insulation used inside the containment and identify where and in what quantities each type is used. The applicant should list the materials used in fabricating the identified insulation, and describe the behavior of the insulation during and after a LOCA. The applicant should describe the tests performed, or reference test reports available to the Commission that determined the behavior of the insulation under simulated LOCA conditions. The applicant should describe the methods used to attach the insulation to piping and components.

C.I.6.2.2.3 ***Design Evaluation***

The applicant should describe and provide the results of the spray nozzle test program to determine the drop size spectrum and mean drop size emitted from each type of nozzle as a function of pressure drop across the nozzles. The analytical method employed to determine the mean spray drop size should be described.

The applicant should provide plan and elevation drawings of the containment, showing the expected spray patterns, and discuss how the patterns were obtained. The applicant should specify the volume of the containment covered by the sprays, as well as the extent to which the sprays overlap. An analysis of the heat removal effectiveness of the sprays should be provided, as well as a justification for the parameter values used in the analysis (e.g., spray system flow rate as a function of time and mean spray drop size) for both full- and partial-spray system operation.

The applicant should graphically show the heat removal rate of the fan cooler as a function of the containment atmosphere temperature under LOCA conditions. The applicant should graphically depict the fan cooler heat removal rate as a function of the degrees of superheat for a family of curves that bound the expected containment steam-to-air ratio for the main steamline break accident. The applicant should describe the test program conducted to determine the heat removal capability of a fan cooler heat exchanger and discuss the potential for the cooling water to cause surface fouling on the secondary side of the fan cooler heat exchanger, as well as the effect on the heat removal capability of the fan cooler.

The applicant should provide analyses of the net positive suction head (NPSH) available to the recirculation pumps, in accordance with the recommendations of RG 1.82. The applicant should tabulate the values of containment pressure head, vapor pressure head of pumped fluid, suction head, and friction head used in the analyses. The applicant should describe the extent to which containment accident pressure is credited in determining the available NPSH and discuss the uncertainty in determining the NPSH. The applicant should compare the calculated values of available NPSH to the required NPSH for the recirculation pumps and demonstrate the conservatism of the analyses by assuming, for the postulated LOCA, conditions that maximize the sump temperature and minimize the containment pressure.

The applicant should provide failure modes and effects analyses of the CHRS.

The applicant should provide a graphic display of the integrated energy content of the containment atmosphere and recirculation water, as functions of time following the postulated design-basis LOCA. The applicant should graphically illustrate the integrated energy absorbed by the structural heat sinks and removed by the fan cooler and/or recirculation heat exchangers.

The applicant should provide an estimate of the amount of debris that could be generated during a LOCA, as well as the amount of debris to which sump inlet screens may be subjected during postulated pipe break accidents.

C.I.6.2.2.4 ***Tests and Inspections***

The applicant should describe the program for initial performance testing after installation, as well as subsequent periodic operability testing of the CHRS and system components. The applicant should discuss the scope and limitations of the tests. The applicant should describe the periodic inspection program for the systems and system components.

C.I.6.2.2.5 ***Instrumentation Requirements***

The applicant should describe the instrumentation provisions for actuating and monitoring the performance of the CHRS and system components. The applicant should identify the plant conditions and system operating parameters to be monitored, and justify the selection of the setpoints for system actuation or alarm annunciation. The applicant should specify the locations outside the containment for instrumentation readout and alarm and reference the discussion of the instrumentation design details and logic in Chapter 7 of the FSAR.

C.I.6.2.3 *Secondary Containment Functional Design*

The secondary containment system includes the secondary containment structure and safety-related systems provided to control the ventilation and cleanup of potentially contaminated volumes (exclusive of the primary containment) following a DBA. This section of the FSAR should discuss the secondary containment functional design. Section 6.5.3 and Chapter 15 of the FSAR should discuss the ventilation systems (i.e., systems used to depressurize and clear the secondary containment atmosphere).

C.I.6.2.3.1 ***Design Bases***

This section of the FSAR should discuss the design bases (i.e., the functional design requirements) of the secondary containment system, including the following considerations:

(1) conditions that establish the need to control leakage from the primary containment structure to the secondary containment structure

(2) functional capability of the secondary containment system to depressurize and/or maintain a negative pressure throughout the secondary containment structure and resist the maximum potential for ex-filtration under all wind-loading conditions that are characteristic of the site

(3) seismic design, leaktightness, and internal and external design pressures of the secondary containment structure

(4) capability for periodic inspection and functional testing of the secondary containment structure

C.I.6.2.3.2 ***System Design***

The applicant should describe the design features of the secondary containment structure, and provide plan and elevation drawings of the plant showing the boundary of the structure.

The applicant should tabulate the design and performance data for the secondary containment structure.

The applicant should discuss the performance objectives of the secondary containment structure and identify the codes, standards, and guides applied in the design of the secondary containment structure.

The applicant should describe the valve isolation features used in support of the secondary containment. The applicant should specify the plant protection system signals that isolate and/or activate the secondary containment isolation systems, or reference the FSAR section of the application that provides this information.

The applicant should discuss the design provisions that prevent primary containment leakage from bypassing the secondary containment filtration systems and escaping directly to the environment. A tabulation of potential bypass leakage paths should be included.

The applicant should provide an evaluation of potential bypass leakage paths, considering realistic equipment design limitations and test sensitivities. The following leakage barriers in paths that do not terminate within the secondary containment should be considered potential bypass leakage paths around the leakage collection and filtration systems of the secondary containment:

(1) isolation valves in piping that penetrates both the primary and secondary containment barriers

(2) seals and gaskets on penetrations that pass through both the primary and secondary containment barriers

(3) welded joints on penetrations (e.g., guard pipes) that pass through both the primary and secondary containment barriers

The applicant should specify and justify the maximum allowable fraction of primary containment leakage that may bypass the secondary containment structure. Chapter 16 of the FSAR should provide TS for identification and testing of bypass leakage paths and determination of the bypass leakage fraction.

C.I.6.2.3.3 *Design Evaluation*

The applicant should provide analyses of the functional capability of the ventilation and/or cleanup systems to depressurize and/or maintain a uniform negative pressure throughout the secondary containment structure following the design-basis LOCA. These analyses should include the effect of single active failures that could compromise the performance objective of the secondary containment system. For example, for containment purge lines that have three isolation valves in series and a leakoff valve that can be opened to the secondary containment volume between the two outboard valves, the applicant should show that the failure of the outboard isolation valve to close does not prevent a negative pressure from being maintained in the secondary containment structure or result in leakage from the primary containment across the inboard valve to the environment.

If the secondary containment design leakage rate is in excess of 100 percent per day, the applicant should provide an evaluation of the secondary containment system's ability to function as intended under adverse wind-loading conditions that are characteristic of the plant site.

For analyses of the secondary containment system, the applicant should provide the following information for each secondary containment volume:

(1) pressure and temperature as functions of time

(2) primary containment wall temperature as a function of time

(3) purge flow rate and recirculation flow rate as a function of fan differential pressure

(4) manner in which heat transfer from the primary containment atmosphere to the secondary containment atmosphere is calculated, including the heat transfer coefficients and material properties

(5) initial conditions assumed for the secondary containment structure and atmosphere (and justification thereof)

(6) manner in which equipment heat loads within the secondary containment are considered

(7) decrease in the secondary containment volume as a result of thermal and pressure expansion of the primary containment structure, and the methods used to calculate the volume reduction (and justification thereof)

The applicant should identify all high-energy lines within the secondary containment structure, and provide analyses of line ruptures for any lines that are not equipped with guard pipes.

C.I.6.2.3.4 ***Tests and Inspections***

The applicant should describe the program for initial performance testing and subsequent periodic functional testing of the secondary containment structures and secondary containment isolation system and system components. The scope and limitations of the tests should be discussed and the inspection program for the systems and system components described.

C.I.6.2.3.5 ***Instrumentation Requirements***

This section of the FSAR should describe the instrumentation to be employed to monitor and actuate the ventilation and cleanup systems associated with the secondary containment. Chapter 7 of the FSAR should discuss design details and logic of the instrumentation.

C.I.6.2.4 *Containment Isolation System*

GDC 54, "Piping Systems Penetrating Containment," GDC 55, "Reactor Coolant Pressure Boundary Penetrating Containment," GDC 56, "Primary Containment Isolation," and GDC 57, "Closed System Isolation Valves," address design and isolation requirements for piping systems that penetrate the primary reactor containment. This section of the FSAR should provide the design and functional capability of the containment isolation system.

C.I.6.2.4.1 ***Design Bases***

The applicant should discuss the design bases for the containment isolation system, including the following:

(1) governing conditions under which containment isolation becomes mandatory

(2) criteria used to establish the isolation provisions for fluid systems that penetrate the containment

(3) criteria used to establish the isolation provisions for fluid instrument lines that penetrate the containment

(4) design requirements for containment isolation barriers

C.I.6.2.4.2 ***System Design***

The applicant should provide a table of design information regarding the containment isolation provisions for fluid system and instrument lines that penetrate the containment. This table should include the following information:

(1) containment penetration number

(2) GDC or regulatory guide recommendations that have been met (or other defined bases for acceptability)

(3) system name

(4) fluid contained

(5) line size (inches)

(6) ESF system (yes or no)

(7) through-line leakage classification (dual containments)

(8) reference to a figure in the application showing arrangement of containment isolation barriers

(9) isolation valve number

(10) location of valve (inside or outside containment)

(11) 10 CFR Part 50, Appendix J, Type C leakage test (yes or no)

(12) length of pipe from containment to outermost isolation valve (or the maximum length that will not be exceeded)

(13) valve type and operator

(14) primary mode of valve actuation

(15) secondary mode of valve actuation

(16) normal valve position

(17) shutdown valve position

(18) postaccident valve position

(19) power failure valve position

(20) containment isolation signals

(21) valve closure time

(22) power source

The applicant should specify the plant protection system signals that initiate closure of the containment isolation valves, or refer to the FSAR section of the application that provides this information.

The applicant should provide justification for any containment isolation provisions that differ from the explicit requirements of GDC 55 through 57.

The applicant should discuss the bases for the containment isolation valve closure times and, in particular, the closure times of isolation valves in system lines that can provide an open path from the containment to the environs (e.g., containment purge system).

The applicant should describe the extent to which the containment isolation provisions for fluid instrument lines meet the recommendations of RG 1.11, "Instrument Lines Penetrating Primary Reactor Containment," and justify any alternative approaches taken by the applicant to this guidance.

The applicant should discuss the design requirements for containment isolation barriers, including the following:

(1) extent to which the quality standards and seismic design classification of the containment isolation provisions follow the recommendations of RG 1.26 and RG 1.29, and justify any alternative approaches taken by the applicant to this guidance

(2) assurance of protection against loss of function from missiles, jet forces, pipe whip, and earthquakes and the provisions taken to ensure that closure of the isolation valves is not prevented by debris that could become entrained in the escaping fluid

(3) assurance of the operability of valves and valve operators in the containment atmosphere under normal plant operating conditions and postulated accident conditions

(4) qualification of closed systems inside and outside the containment as isolation barriers

(5) qualification of a valve as an isolation barrier

(6) required isolation valve closure times and effect of water hammer at penetrations

(7) mechanical and electrical redundancy to preclude common-mode failures

(8) primary and secondary modes of valve actuation

The applicant should discuss the provisions to detect leakage from a remote manually controlled system (such as an ESF system) for the purpose of determining when to isolate the affected system or system train.

The applicant should discuss the design provisions to test the operability of the isolation valves and the leakage rate of the containment isolation barriers. The applicant should show on system drawings the design provisions to test the leakage rate of the containment isolation barriers. The applicant should discuss the design and functional capability of associated containment isolation systems (such as isolation valve seal systems) that provide a sealing fluid or vacuum between isolation barriers, as well as the design and functional capability of fluid-filled systems that serve as seal systems.

The applicant should describe the environmental qualification tests that have been (or will be) performed on mechanical and electrical components that may be exposed to the accident environment inside the containment. The applicant should discuss the test results and demonstrate that the environmental test conditions (temperature, pressure, humidity, and radiation) are representative of conditions that would be expected to prevail inside the containment following an accident. The applicant should graphically show the environmental test conditions as functions of time, or refer to the section of the FSAR where this information can be found.

The applicant should identify the codes, standards, and regulatory guides applied in the design of the system and its components.

C.I.6.2.4.3 ***<u>Design Evaluation</u>***

The applicant should provide an evaluation of the functional capability of the containment isolation system, in conjunction with a failure modes and effects analysis of the system.

The applicant should provide evaluations of the functional capability of isolation valve seal systems and fluid-filled systems that serve as seal systems.

C.I.6.2.4.4 *Tests and Inspections*

The applicant should describe the program for initial functional testing and subsequent periodic operability testing of the containment isolation system and associated isolation valve seal systems (if they are provided). The applicant should discuss the scope and limitations of the tests and describe the inspection program for the isolation system and its components.

C.I.6.2.5 *Combustible Gas Control in Containment*

GDC 41 requires that systems must be provided, as necessary, to control the concentrations of hydrogen and oxygen that may be released into the containment following postulated accidents to ensure that containment integrity is maintained.

The systems provided for combustible gas control include systems to mix the containment atmosphere, monitor combustible gas concentrations within containment regions, and reduce combustible gas concentrations within the containment. This section of the FSAR should provide the design and functional capability of these systems.

C.I.6.2.5.1 *Design Bases*

The applicant should discuss the design bases for the combustible gas control systems (i.e., the conditions under which combustible gas control may be necessary) and the functional and mechanical design requirements of the systems. The design bases should include considerations such as the following:

(1) generation and accumulation of combustible gases within the containment

(2) capability to uniformly mix the containment atmosphere for as long as accident conditions require and to prevent high concentrations of combustible gases from forming locally

(3) capability to monitor combustible gas concentrations within containment regions, and to alert the operator in the main control room of the need to activate systems to reduce combustible gas concentrations

(4) capability to prevent combustible gas concentrations within the containment from exceeding the concentration limits in RG 1.7

(5) capability to remain operable, assuming a single failure

(6) capability to withstand dynamic effects

(7) capability to withstand the SSE without loss of function

(8) capability to remain operable in the accident environment

(9) capability to periodically inspect and test systems and/or system components

(10) sharing of combustible gas control equipment between nuclear units at multiunit sites

(11) capability to transport portable hydrogen recombiner units after a LOCA

(12) protection of personnel from radiation in the vicinity of the operating hydrogen recombiner units

(13) capability to purge the containment as a backup means for combustible gas control

C.I.6.2.5.2 ***System Design***

The applicant should describe the design features and provide piping and instrumentation diagrams of the systems (or portions thereof) that comprise the combustible gas control systems and the backup purge system.

The applicant should tabulate the design and performance data for each system and its components.

The applicant should discuss system design requirements in terms of redundancy and independence. The applicant should discuss the design provisions that facilitate periodic inspection and operability testing of the systems and their components and identify the codes, standards, and guides applied in designing the systems and their components.

The applicant should specify the plant protection system signals that actuate the combustible gas control systems, and backup purge system, and their components, or refer to the FSAR section of the application that provides this information.

The applicant should discuss the extent to which systems or system components are required to be manually operated from the main control room or another point outside the containment that is accessible following an accident.

The applicant should describe the environmental qualification tests that have been (or will be) performed on systems (or portions thereof) and their components that may be exposed to the accident environment. The applicant should provide a schedule for completion of environmental qualification tests, as applicable, and subsequent submittal of supplemental application information. The applicant should describe the test results and their applicability to the system design and demonstrate that the environmental test conditions (temperature, pressure, humidity, radiation) are representative of conditions that would be expected to prevail inside the containment following a LOCA. The applicant should graphically show the environmental test conditions as functions of time, or refer to the FSAR section of the application that provides this information.

With regard to the fan systems that are relied on to mix the containment atmosphere, the applicant should provide the following additional information:

(1) identification of the ductwork that must remain intact following a LOCA

(2) discussion of the design provisions (e.g., pressure relief devices, conservative structural design) that ensure that the ductwork and equipment housings will remain intact

(3) plan and elevation drawings of the containment, showing the routing of the airflow guidance ductwork

The applicant should describe the design features of the containment internal structures that promote and permit mixing of gases within the containment and subcompartments. The subcompartments that are dead-ended or would not be positively ventilated following a LOCA should be identified, and analyses, assumptions, and mathematical models to ensure that combustible gases do not accumulate within those subcompartments should be provided.

With regard to the system provided to continuously monitor combustible gas concentrations within the containment following a LOCA, the applicant should provide the following information:

(1) operating principle and accuracy of the combustible gas analyzers

(2) tests conducted to demonstrate the performance capability of the analyzers (or a reference to the report where such information may be found)

(3) locations of the multiple sampling points within the containment

(4) capability to monitor combustible gas concentrations within the containment independent of the operation of the combustible gas control systems

(5) failure modes and effects analyses of the containment combustible gas concentration monitoring systems

With regard to the recombiner system provided to reduce combustible gas concentrations within the containment, the applicant should provide the following additional information:

(1) operating principle of the system

(2) developmental program conducted to demonstrate the performance capability of the system, as well as the program results (or a reference to the report where this information can be found)

(3) any differences between the recombiner system on which the qualification tests were conducted and the recombiner system that is proposed

(4) extent to which equipment is shared between nuclear power units at a multiunit site, and the availability of the shared equipment

C.I.6.2.5.3 ***Design Evaluation***

The applicant should provide an analysis of the production and accumulation of combustible gases within the containment following a postulated LOCA, including the following information:

(1) assumed corrosion rate of aluminum plotted as a function of time

(2) assumed corrosion rate of zinc plotted as a function of time

(3) inventory of aluminum inside the containment, with the mass and surface area of each item

(4) inventory of zinc inside the containment, with the total mass and surface area

(5) mass of Zircaloy fuel cladding or other similar cladding materials that contribute to the generation of combustible gases

(6) quantities of hydrogen and oxygen contained in the RCS

(7) total fission product decay power as a fraction of operating power plotted versus time after shutdown, with a comparison to the decay power (specify the reactor core thermal power rating and the assumed operating history of the reactor core)

(8) beta, gamma, and beta plus gamma energy release rates and integrated energy releases plotted as functions of time for the fission product distribution model based on the thermal power rating and operating history of the reactor core assumed in Item 7 above (indicate the extent to which the model provided in Table 1 of RG 1.7 is utilized)

(9) integrated production of combustible gas within the containment, plotted as a function of time for each source, as well as the concentration of combustible gas in the containment, plotted as a function of time for all sources

(10) combustible gas concentration in the containment, plotted as a function of time with operation of the combustible gas reduction system assumed at full and partial capacity, as well as combustible gas concentration in the containment, plotted as a function of time with operation of the backup purge system assumed

(11) basis (time or combustible gas concentrations) for activation of the combustible gas reduction and backup purge systems, as well as the design flow rates and the flow rates used in the analysis for both systems

(12) analyses of the functional capability of the spray and/or fan systems to mix the containment atmosphere and prevent accumulation of combustible gases within containment subcompartments (provide plan and elevation drawings of the containment, showing the airflow patterns that would be expected to result from operation of the spray and/or fan systems with a single failure assumed)

(13) analyses or test results that demonstrate the capability of the airflow guidance ductwork and equipment housings to withstand, without loss of function, the external differential pressures and internal pressure surges that may be imposed on them following a LOCA

The applicant should provide failure modes and effects analyses of the combustible gas control systems.

C.I.6.2.5.4 ***Tests and Inspections***

The applicant should describe the program for initial performance testing and subsequent periodic operability testing of the combustible gas control systems and system components. The applicant should discuss the scope and limitations of the tests and describe the inspection programs for the systems and their components. For equipment that is shared between nuclear power units at multiunit sites, the applicant should describe the program that ensures the equipment can be transported safely and by qualified personnel within the allotted time.

C.I.6.2.5.5 ***Instrumentation Requirements***

The applicant should discuss the instrumentation provisions to actuate the combustible gas control systems and backup purge system (e.g., automatically or remote manually) and monitor the performance of the systems and their components. The applicant should identify the plant conditions and system operating parameters to be monitored, and justify the selection of setpoints for system actuation or alarm annunciation. The applicant should specify the instrumentation readout and alarm location(s) outside the containment. The applicant should reference the discussion on design details and logic of the instrumentation in Chapter 7 of the FSAR.

C.I.6.2.6 ***Containment Leakage Testing***

GDC 52 through 54 require that the reactor containment, containment penetrations, and containment isolation barriers must be designed to permit periodic leakage rate testing. In addition, Appendix J, "Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors," to 10 CFR Part 50, specifies the leakage testing requirements for the reactor containment, containment penetrations, and containment isolation barriers.

Containment leakage testing is an operational program as defined in SECY-05-0197. As such, this section of the FSAR should fully describe the proposed testing program that complies with the requirements of the GDC and Appendix J to 10 CFR Part 50 and its implementation. Any exemptions from the explicit requirements of the GDC and Appendix J should be identified and justified.

C.I.6.2.6.1 ***Containment Integrated Leakage Rate Test***

The applicant should specify the maximum allowable containment integrated leakage rate. The applicant should describe the testing sequence for the containment structural integrity test and the containment leakage rate test.

The applicant should discuss the pretest requirements, including the requirements for inspecting the containment, taking corrective action and retesting in the event that structural deterioration of the containment is found, and reporting. In addition, the applicant should discuss the criteria for positioning isolation valves, the manner in which isolation valves is positioned, and the requirements for venting or draining fluid systems prior to containment testing.

Fluid systems that are vented or opened to the containment atmosphere during testing should be listed, and systems that are not vented should be identified and justified.

The applicant should describe the measures taken to ensure stabilization of containment conditions (temperature, pressure, humidity) prior to containment leakage rate testing.

The applicant should describe the methods and procedures to be used during containment leakage rate testing, including local leakage testing methods, test equipment and facilities, period of testing, and verification of leak test accuracy.

The applicant should identify the acceptance criteria for containment leakage rate tests and verification tests, and discuss the provisions for additional testing in the event acceptance criteria cannot be met.

C.I.6.2.6.2 ***Containment Penetration Leakage Rate Test***

The applicant should provide a list of all containment penetrations. The containment penetrations that are exempt from leakage rate testing and the reasons noting the exemptions.

The applicant should describe the test methods used to determine containment penetration leakage rates, and specify the test pressure to be used.

The applicant should provide the acceptance criteria for containment penetration leakage rate testing, and specify the leakage rate limits for the containment penetrations.

C.I.6.2.6.3 ***Containment Isolation Valve Leakage Rate Test***

The applicant should provide a listing of all containment isolation valves. The containment isolation valves that are not included in the leakage rate testing should be identified and a justification provided.

The applicant should describe the test methods used to determine isolation valve leakage rates, and specify the test pressure to be used.

The applicant should provide the acceptance criteria for leakage rate testing of the containment isolation valves and specify the leakage rate limits for the isolation valves.

C.I.6.2.6.4 ***Scheduling and Reporting of Periodic Tests***

The applicant should provide the proposed schedule for performing preoperational and periodic leakage rate tests for each of the following:

(1) containment integrated leakage rate
(2) containment penetrations
(3) containment isolation valves

The applicant should describe the test reports to be prepared, and include provisions for reporting test results that fail to meet acceptance criteria.

C.I.6.2.6.5 ***Special Testing Requirements***

The applicant should specify the maximum allowable leakage rate for the following:

(1) in-leakage to subatmospheric containment
(2) in-leakage to the secondary containment of dual containments

The applicant should describe the test procedures for determining the above in-leakage rates. A description of the leakage rate testing to be conducted to determine the leakage from the primary containment that bypasses the secondary containment and other plant areas that are maintained at a negative pressure following a LOCA should be provided. The maximum allowable bypass leakage should be specified.

The applicant should describe the test procedures for determining the effectiveness (following postulated accidents) of isolation valve seal systems and fluid-filled systems that serve as seal systems.

C.I.6.2.7 *Fracture Prevention of Containment Pressure Vessel*

COL applicants that reference a certified design do not need to include additional information.

C.I.6.3 Emergency Core Cooling System

C.I.6.3.1 *Design Bases*

The applicant should provide a summary description of the ECCS, and identify all major subsystems of the ECCS, such as active high- and low-pressure safety injection systems; passive safety injection tanks in the evolutionary design; and passive RHR system, core makeup tanks, pools, accumulators, automatic depressurization system, and in-containment RWST in the passive ECCS design. Applicable reference(s) to nuclear plants or designs that employ the same ECCS design and are operating or have been licensed or certified should be provided. Describe the purpose of the ECCS, and identify each accident or transient for which the required protection includes actuating the ECCS.

The applicant should describe how the ECCS design complies with relevant rules, regulations, and regulatory requirements, including the following:

(1) GDC 2, "Design bases for protection against natural phenomena"
(2) GDC 4, "Environmental and dynamic effects design bases"
(3) GDC 5, "Sharing of structures, systems, and components"
(4) GDC 17, "Electric power systems"
(5) GDC 27, "Combined Reactivity Control Systems Capability"
(6) GDC 35, "Emergency core cooling"
(7) GDC 36, "Inspection of emergency core cooling system"
(8) GDC 37, "Testing of Emergency Core Cooling System"
(9) 10 CFR 50.46

The applicant should describe how the ECCS design meets relevant items of TMI Action Plan requirements specified in 10 CFR 50.34(f), including, for example, Items II.K.3.15, II.K.3.18, II.K.3.21, II.K.3.28, II.K.3.45, and III.D.1.1.

The applicant should describe how the ECCS design and analysis incorporate the resolutions of the relevant USIs, and medium- and high-priority GSIs that are specified in the version of NUREG-0933, that is current 6 months before the application submittal date. Examples include USIs (Task Action Plan Items) A-1, A-2, A-24, A-40, A-43, and B-61, and GSIs 23, 24, 105, 122.2, 185, and 191.

The applicant should describe how the ECCS design incorporates operating experience insights from generic letters and bulletins issued up to 6 months before the application submittal date. Examples include the following generic letters and bulletins:

(1) GL 80-014, "LWR Primary Coolant System Pressure Isolation Valves," February 23, 1980

(2) GL 80-035, "Effect of a DC Power Supply Failure on ECCS Performance," April 25, 1980

(3) GL 81-021, "Natural Circulation Cooldown," May 5, 1981

(4) GL 85-16, "High Boron Concentrations," August 23, 1985

(5) GL 86-07, "Transmittal of NUREG-1190 Regarding the San Onofre Unit 1 Loss of Power and Water Hammer Event," March 20, 1986

(6) GL 89-10, "Safety-Related Motor-Operated Valve Testing and Surveillance"

(7) GL 91-07, "GI-23, "Reactor Coolant Pump Seal Failures' and Its Possible Effect on Station Blackout," May 2, 1991

(8) GL 98-04, "Boiling Water Reactor Licensees Use of the BWRVIP-05 Report to Request Relief from Augmented Examination Requirements on Reactor Pressure Vessel Circumferential Shell Welds," July 14. 1998

(9) BL 80-01, "Operability of ADS Valve Pneumatic Supply," January 11, 1980

(10) BL 80-18, "Maintenance of Adequate Minimum Flow thru Centrifugal Charging Pumps Following Secondary Side High Energy Line Rupture," July 31, 1980

(11) BL 86-03, "Potential Failure of Multiple ECCS Pumps due to Single Failure of Air-Operated Valve in Minimum Flow Recirculation Line," October 8, 1986

(12) BL 88-04, "Potential Safety-Related Pump Loss," May 5, 1988

(13) BL 93-02, "Debris Plugging of Emergency Core Cooling Suction Strainers," May 11, 1993

(14) BL 95-02, "Unexpected Clogging of a Residual Heat Removal," October 17, 1995

(15) BL 96-03, "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling-Water Reactors," May 6, 1996

(16) BL 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles," August 3, 2001

(17) BL 2002-01, "Reactor Pressure Vessel Head Degradation and Reactor Coolant Pressure Boundary Integrity," March 18, 2002

The applicant should be noted that the items listed in the above lists of GDC, TMI Action Items, USIs, GSIs, generic letters, and bulletins may not constitute the total sets of relevant documents. The applicant is the COL applicant's responsibility to identify all relevant items applicable to their reactor designs.

The applicant should specify the design bases for selecting the functional requirements, such as emergency core decay heat removal, RCS emergency makeup and boration, safety injection, safe shutdown, long-term cooling, and containment pH control, for each ECCS subsystem. The applicant should discuss the bases for selecting such system parameters as operating pressure, ECC flow delivery rate, ECC storage capacity, boron concentration, and hydraulic flow resistance of ECCS piping and valves.

The applicant should specify the design bases concerned with reliability requirements. It should describe the protection against single failure in terms of piping arrangement and layout, selection of valve types and locations, redundancy of various system components, redundancy of power supplies, redundant sources of actuation signals, and redundancy of instrumentation. It should also describe how ECCS actuation and operation are protected against valve motor flooding and spurious single failures.

The applicant should specify the requirements that have been established to protect the ECCS from physical damage. This discussion should include design bases for ECCS support structure design, pipe whip protection, missile protection, and protection against such accident loads as LOCA or seismic loads.

The applicant should specify the environmental design bases concerned with the high-temperature steam atmosphere and containment sump water level that might exist in the containment during ECCS operation.

C.I.6.3.2 System Design

C.I.6.3.2.1 ***Schematic Piping and Instrumentation Diagrams***

The applicant should provide piping and instrumentation diagrams showing the location of all components, piping, storage facilities, points where connecting systems and subsystems tie together and into the reactor system, and instrumentation and controls associated with subsystem and component actuation for all modes of ECCS operation, along with a complete description of component interlocks.

C.I.6.3.2.2 ***Equipment and Component Descriptions***

The applicant should describe each component of the system, and identify its significant design parameters. The applicant should state the design and operating pressure and temperature of components for various portions of the system, and explain the bases for their selection. The applicant should state the available quantity of coolant (e.g., in each safety injection tank, pools, RWST, condensate storage tank, torus) and provide pump characteristic curves and pump power requirements. The applicant should specify the available and required NPSH for the ECCS pumps, and identify any exceptions along with suitable justification to the regulatory position stated in RG 1.82. The applicant should provide elevations of tanks and pools in the passive systems, with reference to core elevation. Heat exchanger characteristics, including design flow rates, inlet and outlet temperatures for the cooling fluid and the fluid being cooled, the overall heat transfer coefficient, and the heat transfer area should be described.

The applicant should state the relief valve capacity and settings or venting provisions included in the system. Specify design requirements for ECCS delivery lag times. Describe provisions with respect to control circuits for motor-operated isolation valves in the ECCS, including consideration of inadvertent actuation prior to or during an accident. This description should include discussions of the controls and interlocks for these valves (e.g., intent of IEEE Std 603, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations,") and considerations for automatic valve closure (e.g., RCS pressure exceeds design pressure of RHR system), automatic valve opening (e.g., preselected RCS pressure or ECCS signal), valve position indications, valve interlocks, and alarms.

C.I.6.3.2.3 ***Applicable Codes and Classifications***

The applicant should identify the applicable industry codes and classifications for the design of the system. An acceptable method to implement safety and pressure integrity classification of ECCS components is to use ANSI/ANS-58.14-1993 (or later version).

C.I.6.3.2.4 ***Material Specifications and Compatibility***

The applicant should identify the material specifications for the ECCS, and discuss material compatibility and chemical effects of all expected conditions. The applicant should list the materials used in or on the ECCS by their commercial names, quantities (estimate where necessary), and chemical composition and show that the radiolytic or pyrolytic decomposition products, if any, of each material will not interfere with the safe operation of this or any other ESF.

C.I.6.3.2.5 ***System Reliability***

The applicant should discuss the reliability considerations incorporated in the design to ensure that the system starts when needed and delivers the required quantity of coolant within specified lag times (e.g., redundancy and separation of components, transmission lines, and power sources). The applicant should provide a failure modes and effects analysis of the ECCS, identifying the functional consequences of each possible single failure, including the effects of any single failure or operator error that causes any manually controlled electrically operated valve to move to a position that could adversely affect the ECCS. The applicant should discuss how all potential passive failures of fluid systems, as well as single failures of active components, were considered for long-term cooling (refer to SECY-77-0439 for additional guidance on single failure application to ECCS).

Applicants for PWR plants should discuss how the single-failure analysis for the potential boron precipitation problem was considered an integral part of the requirement to provide for long-term core cooling. They should identify the specific equipment arrangement for the plant design, and provide an evaluation to ensure that valve motor operators located within containment will not become submerged following a LOCA. All equipment in the ECCS or any other system that may be needed to limit boric acid precipitation in the reactor vessel during long-term cooling, or may be required for containment isolation should be included.

The applicant should describe how containment sump recirculation (PWR) and suppression pool recirculation (BWR) design meets the guidelines of RG 1.82, Revision 3 with respect to the LOCA-generated debris.

The applicant should describe how the design considered the adverse impact of gas accumulation in the ECCS piping on the ECCS operability, including water hammer and pump operability.

For a passive safety system design that relies exclusively on natural forces to perform design-basis safety functions, and includes active systems to provide defense-in-depth capabilities for reactor coolant makeup and decay heat removal, the applicant should describe how the passive system reliability and the impact of adverse system interactions on the safety functions were considered. The applicant should describe how the regulatory oversight of the active nonsafety systems was considered in using the process of "regulatory treatment of nonsafety systems" described in SECY-94-084. The SECY guidance states an approved position that passive advanced LWR designs need not assume passive component failures in addition to the initiating failure in the application of single-failure criterion to assure safety of the plant. On a long-term basis, in addition to initiating events the staff considers passive component failures in fluid systems as potential accident initiators. For example, the check valves in the passive safety systems (except those for which proper function can be demonstrated and documented) are considered components subject to single-failure consideration (see Section C.IV.10 of this guide for additional guidance on RTNSS).

The applicant should discuss the bases for not treating check valves in the passive ECCS design that operate with low-differential pressure and require repositioning to perform their safety function as active components subject to single-failure consideration (justifying any assumptions).

C.I.6.3.2.6 ***Protection Provisions***

The applicant should describe the provisions to protect the system (including connections to the RCS or other connecting systems) against damage that might result from movement (between components within the system and connecting systems), from missiles, thermal stresses, or other causes (e.g., LOCA, seismic events).

C.I.6.3.2.7 ***Provisions for Performance Testing and Inspection***

The applicant should describe the provisions to facilitate performance testing and inspection of components (e.g., bypasses around pumps, sampling lines).

C.I.6.3.2.8 ***Manual Actions***

The applicant should identify all manual actions that an operator is required to take in order for the ECCS to operate properly. The applicant should identify all process instrumentation available to the operator in the control room to assist in assessing postaccident conditions. The applicant should discuss the information available to the operator, the time delay during which the operator's failure to act properly has no unsafe consequences, and the consequences if the operator fails to perform the action at all.

C.I.6.3.3 ***Performance Evaluation***

The applicant should discuss the ECCS performance through the safety analyses of a spectrum of postulated accidents. These analyses should be included in FSAR Chapter 15. In this section of the

FSAR, the applicant should list the accidents discussed in Chapter 15 will results in ECCS operation. The applicant should summarize the conclusions of the accident analyses. The applicant should provide the bases for any operational restrictions, such as minimum functional capacity or testing requirements that might be appropriate for inclusion in the TS of the license. The applicant should indicate all existing criteria that are used to judge the adequacy of ECCS performance, including those contained in 10 CFR 50.46. ECCS cooling performance evaluation should include an evaluation of single failures, potential boron precipitation (PWRs), submerged valve motors, and containment pressure assumptions (PWRs) used to evaluate the ECCS performance capability.

The applicant should provide simplified functional flow diagrams showing the alignment of valves, flow rates in the system, and the capacity of the ECC water supply for typical accident conditions (e.g., small- and large-break LOCA, steamline break). The applicant should provide typical flow delivery curves as a function of time for the various accidents, and discuss the time sequence of ECCS operation for short- and long-term cooling. Valve opening time, pump starting time, and other pertinent parameters in the analysis supporting the selection of lag times (e.g., the period between the time an accident has occurred and the time ECC is discharged into the core) should be included and if credit is taken for operator action should be indicated.

The applicant should discuss the extent to which components or portions of the ECCS are required for operation of other systems, and the extent to which components or portions of other systems are required for operation of the ECCS. In the analysis of how these dependent systems would function, the applicant should include system priority (which system takes preference) and conditions under which various components or portions of one system function as part of another system (e.g., when the water level in the reactor is below a limiting value, the recirculation pumps (i.e., residual or decay heat removal pumps) or feed pumps supply water to the ECCS and not to the containment spray system). Any limitations on operation or maintenance included to ensure minimum capability (e.g., the storage facility common to both core cooling and containment spray systems should have provisions to ensure that the quantity available for core cooling is not less than some specified quantity) should be delineated.

The applicant should state the bounds within which principal system parameters need to be maintained in the interest of constant standby readiness (e.g., the minimum poison concentrations in the coolant, minimum coolant reserve in storage volumes, maximum number of inoperable components, maximum allowable time period for which a component can be out of service). The failure modes and effects analysis provided in FSAR Section 6.3.2.5 identifies possible degraded ECCS performances caused by single component failures. The accident analyses provided in Chapter 15 of the FSAR consider each of the degraded ECCS cases in the selection of the worst single failure to be analyzed. The applicant should discuss the conclusions of the various accident analyses to show that the ECCS is adequate to perform its intended function.

C.I.6.3.4 *Tests and Inspections*

C.I.6.3.4.1 ***ECCS Performance Tests***

The applicant should provide a description, or reference the description of the preoperational test program performed for the ECCS. The program should provide for testing each train of the ECCS under both ambient and simulated hot operating conditions. The tests should demonstrate that the flow rates delivered through each injection flowpath using all pump combinations are within the design specifications. The applicant should describe how the testing under maximum startup loading conditions was performed to verify the adequacy of the electric power supply. Recirculation tests in the program to demonstrate system capability to realign valves and injection pumps to recirculate coolant from the containment sump should be included. Any exceptions to the regulatory position in RG 1.79, "Preoperational Testing of Emergency Core Cooling Systems for Pressurized-Water Reactors," should be justified.

C.I.6.3.4.2 ***Reliability Tests and Inspections***

The ECCS is a standby system that is not normally operating. Consequently, tests and inspections are used to measure the system's readiness to operate in the event of an accident. The applicant should identify the periodic test and inspection program, and explain the reasons why the planned program is believed to be appropriate. This discussion should include the following information:

(1) description of planned tests

(2) considerations that led to periodic testing and the selected test frequency

(3) test methods to be used

(4) requirements and bases for acceptability of observed performance

(5) description of the program for ISI, including items to be inspected, accessibility requirements, and the types and frequency of inspection

The applicant should provide a cross-reference if information about planned tests is available anywhere else in the application; repetition is not necessary.

The applicant should emphasize those surveillance-type tests that are of such importance to safety that they may become part of the TS of an operating license. The applicant should provide the bases for such surveillance requirements as part of the application.

C.I.6.3.5 *Instrumentation Requirements*

The applicant should discuss the instrumentation provisions for various actuation methods (e.g., automatic, manual) and locations. It should include the conditions requiring system actuation, as well as the bases for their selection (e.g., during periods when the system is to be available, whenever the RCS pressure is less than some specified pressure, the core spray system actuates automatically using equipment designed to IEEE Std 603 standards). The discussion of design details and logic of the instrumentation provided in Chapter 7 of the FSAR should be referenced.

C.I.6.4 Habitability Systems

The term "habitability systems" refers to the equipment, supplies, and procedures provided to ensure that control room operators can remain in the control room and take actions to operate the nuclear power unit safely under normal conditions, and maintain it in a safe condition under accident conditions, including LOCAs, as required by GDC 19. Habitability systems should include systems and equipment to protect control room operators against such postulated releases as radioactive materials, toxic gases, smoke, and steam, and should provide materials and facilities to permit them to remain in the control room for an extended period.

As defined in RG 1.197, "Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors," on page 1.197-2, the "control room" is the plant area, defined in the facility licensing basis, in which actions can be taken to operate the plant safely under normal conditions and to maintain the reactor in a safe condition during accident situations. It encompasses the instrumentation and controls necessary for a safe shutdown of the plant and typically includes the critical document reference file, the computer room (if used as an integral part of the emergency response plan), shift supervisor's office, the operator washroom and kitchen, and other critical areas to which frequent personnel access or continuous occupancy may be necessary in the event of an accident.

In addition, as defined in RG 1.197 on page 1.197-2, the "control room envelope (CRE)" is the plant area, defined in the facility licensing basis, that in the event of an emergency can be isolated from the plant areas and the environment external to the CRE. This area is served by an emergency ventilation system, with the intent of maintaining the habitability of the control room. This area encompasses the control room and may encompass other noncritical areas to which frequent personnel access or continuous occupancy is not necessary in the event of an accident.

Habitability systems for the control room should include shielding, air purification systems, control of climatic conditions, storage capacity for food and water, and kitchen and sanitary facilities. The application should include detailed descriptions of these systems as well as an evaluation of their performance. The evaluation should provide assurance that the systems operate under all postulated conditions to permit the control room operators to remain in the control room and take appropriate actions as required by GDC 19. The applicant should provide sufficient information to permit an independent evaluation of the systems' adequacy. The applicant should provide reference to information and evaluations in other FSAR sections of the application that relate to adequacy of the habitability systems (see FSAR Sections 6.5.1, 9.4.1, and 15.6.5, paragraph 5).

C.I.6.4.1 *Design Basis*

In this section of the FSAR, the applicant should summarize the bases for the functional design of the habitability systems and their features. For example, the applicant should provide the criteria used to establish the following:

(1) CRE
(2) period of habitability
(3) capacity (number of people)
(4) food, water, medical supplies, and sanitary facilities
(5) radiation protection
(6) toxic or noxious gas protection
(7) respiratory, eye, and skin protection for emergencies
(8) habitability system operation during emergencies
(9) emergency monitors and control equipment

Food, water, medical supplies, and sanitary facilities should be located inside an accessible area within the CRE.

C.I.6.4.2 *System Design*

C.I.6.4.2.1 ***Definition of Control Room Envelope***

The applicant should identify the areas, equipment, and materials to which the control room operator could require access during an emergency. The applicant should list those spaces requiring continuous or frequent operator occupancy. The selection of those spaces included in the CRE should be based on need during postulated emergencies. This information should be summarized in this section of the FSAR.

C.I.6.4.2.2 *Ventilation System Design*

The applicant should provide a discussion of the design features and fission product removal and protection capability of the control room ventilation system. Although this discussion should emphasize the emergency ventilation portion of the system, the normal ventilation system and its components should also be discussed insofar as they may affect control room habitability during a DBA. Specifically, the applicant should include the following information, which is pertinent to the evaluation of control room ventilation:

(1) schematic of the control room ventilation system, including equipment, ducting, dampers, and instrumentation, and highlight the airflows for both normal and emergency modes, with references to all dampers and valves by FSAR section number if portions of this information appear elsewhere in the application with appropriate labeling (e.g., normally open or closed, manually or motor operated, fail closed, or fail open)

(2) list of major components, with their flow rates, capacities, and major design parameters including isolation dampers, as well as the leakage characteristics and closure times of the isolation dampers

(3) seismic classifications of components, instrumentation, and ducting, as well as identification of components that are protected against missiles

(4) layout drawings of the control room, showing doors, corridors, stairwells, shielded walls, and the placement and type of equipment within the control room

(5) elevation and plan views, showing building dimensions and locations, locations of potential radiological and toxic gas releases, and locations of control room air inlets

(6) description and placement of ventilation system controls and instruments, including instruments that monitor the control room for radiation and toxic gases

(7) description of the charcoal filter train, including design specifications, flow parameters, and charcoal type, weight, and distribution; high-efficiency particulate air filter type and specifications; specifications for any additional components; and the extent to which the recommendations of RG 1.52, "Design, Testing, and Maintenance Criteria for Post-Accident Engineered-Safety-Feature Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants," are followed and claimed filter efficiencies listed (reference may be made to FSAR Section 6.5.1)

C.I.6.4.2.3 *Leaktightness*

The applicant should summarize the exfiltration and infiltration analyses performed to determine unfiltered in-leakage or pressurization airflow requirements. The applicant should include a listing of all potential leak paths (e.g., cable, pipe, and ducting penetrations; doors; dampers; construction joints; construction materials) and their appropriate leakage characteristics. The applicant should describe precautions and methods used to limit leakage out of or into the control room. Periodic leakage rate testing is normally required, and FSAR Section 6.4.5 should include a summary of the test procedures.

C.I.6.4.2.4 *Interaction with Other Zones and Pressure-Containing Equipment*

The applicant should provide a sufficiently detailed discussion to show that the following interactions have been considered:

(1) potential adverse interactions between the control room ventilation zone and adjacent zones that may enhance the transfer of toxic or radioactive gases into the control room (it should identify any other heating, ventilation, and air conditioning equipment (e.g., ducts, air handling units) that may service other ventilation zones (e.g., cable spreading room, battery room) but may be physically located within the control room habitability zone; it should describe any leak paths with respect to such equipment (e.g., pilot traverse holes, hatch covers in ducts) and provide the direction and magnitude of the pressure difference across these leak paths)

(2) isolation from the control room of all pressure-containing tanks, equipment, or piping (e.g., CO_2 firefighting containers, steamlines) that, upon failure, could cause transfer of hazardous material to the control room

C.I.6.4.2.5 ***Shielding Design***

The applicant should consider DBA sources of radiation other than that attributable to airborne contaminants within the control room. Principal examples include fission products released to the reactor containment atmosphere, airborne radioactive contaminants surrounding the control room, and sources of radiation attributable to potentially contaminated equipment (e.g., control room charcoal filters and steamlines) in the vicinity of the control room. The applicant should include a description of radiation attenuation by shielding and separation. It should provide the corresponding evaluation of DBA doses to control room operators in Section 15.6.5, paragraph 5, of the FSAR. Specifically, the applicant should describe the radiation shielding for the control room in a DBA, and should include the following information:

(1) accident radiation source description in terms of its origin, strength, geometry, radiation type, energy, and dose conversion factors (sources should include primary and secondary containments, ventilation systems, external cloud, and adjacent building air spaces)

(2) radiation attenuation parameters (i.e., shield thickness, separation distances, and decay considerations) with respect to each source

(3) description of potential sources of radiation streaming that may affect control room operators and the measures taken to reduce streaming to acceptable levels

(4) isometric drawing of the control room and associated structures identifying distances and shield thicknesses with respect to each radiation source identified in item (1), above

The applicant should reference any information pertinent to this FSAR section appearing elsewhere in the application.

C.I.6.4.3 *System Operational Procedures*

The applicant should discuss the method of operation during normal and emergency conditions. It should discuss the automatic actions and manual procedures required to ensure effective operation of the system. The applicant more than one emergency mode of operation is possible, how the optimum mode is selected for a given condition should be indicated.

C.I.6.4.4 *Design Evaluations*

C.I.6.4.4.1 ***Radiological Protection***

Section C.I.15.6.5, “Radiological Consequences,” of this guide sets forth the documentation guidelines for the evaluation of radiological exposures to plant operators from DBAs. This section (i.e., C.1.6.4.4.1) should reference the information provided in Chapter 15.

C.I.6.4.4.2 ***Toxic Gas Protection***

The applicant should perform a hazards analysis as recommended in RG 1.78 for each toxic material identified in NUREG/CR-6624, "Recommendations for Revision of RG 1.78.”

For any of these materials that are used in the operation of the nuclear power plant, the applicant should describe the container types and methods of connection to the system serviced. The distances between the storage locations and air intakes to the control room should be listed, along with the storage quantities. An analysis of the severity of postulated accidents involving these materials should be provided, and the steps to mitigate accident consequences should be discussed. The applicant should include descriptions of the following:

(1) principal toxic gas detector characteristics, such as sensitivity, response time, principle of operation, testing and maintenance procedures, environmental qualifications, and physical location relative to the outside air intake

(2) isolation damper transient characteristics (time to open and close) and leakage

(3) the number and type of individual respiratory devices, type of operator training for respirator use, estimated time for deploying or donning the equipment, length of time the equipment can be used, and testing and maintenance procedures

(4) special ventilation system operation modes, if any, provided specifically for toxic or noxious gas conditions (e.g., bottled air pressurization, manually selected control room air purge periods)

The description of the analyses should clearly list all assumptions and follow guidance found in RG 1.78 for calculational methods. The applicant can find information/staff recommendation in RG 1.78 if chlorine is identified as potential hazard.

C.I.6.4.5 *Testing and Inspection*

The applicant should provide information about the test and inspection program applicable to (1) preoperational testing and (2) inservice surveillance to ensure continued integrity.

The applicant should emphasize those tests and inspections that are considered essential to determine that performance objectives have been achieved and performance capabilities are maintained above preestablished limits throughout the plant lifetime. For example, this section of the FSAR should include the following information:

(1) planned tests and their purposes
(2) considerations that led to the selected test frequency
(3) test methods to be used, including a sensitivity analysis
(4) requirements and bases for acceptability of observed performance
(5) action to be taken if acceptability requirements are not met

C.I.6.4.6 *Instrumentation Requirement*

The applicant should describe the instrumentation to be used to monitor and actuate the habitability systems. The applicant should reference the discussion of design details and logic of the instrumentation provided in Chapter 7 of the FSAR.

C.I.6.5 <u>Fission Product Removal and Control Systems</u>

The applicant should provide information in sufficient detail to permit the NRC staff to evaluate the performance capability of the fission product removal and control systems. Design criteria for other safety functions of the systems should be provided in other appropriate sections of this FSAR chapter. Fission product removal and control systems are considered to be those systems for which credit is taken in reducing accidental release of fission products.

FSAR Section 6.5.1 and 6.5.2 discuss the filter systems and containment spray systems for fission product removal, and FSAR Section 6.5.3 discusses the fission product control systems.

C.I.6.5.1 *ESF Filter Systems*

The applicant should discuss all ESF filter systems that are required to perform a safety-related function following a DBA. This could include filter systems internal to the primary containment, control room filters, filters on secondary confinement volumes, fuel-handling-building filters, and filters for areas containing ESF components. (Chapter 15 should indicate which of these filters are used in mitigating the consequences of accidents.) Applicants should provide the types of information outlined below for each of the systems. Although other FSAR sections may describe in detail some systems (e.g., Section 9.4), this section should list these systems with specific references to the locations of the information requested in each of the following sections.

C.I.6.5.1.1 <u>*Design Bases*</u>

The applicant should provide the design bases for each filter, including (for example) the following:

(1) conditions that establish the need for the filters
(2) bases employed for sizing the filters, fans, and associated ducting
(3) bases for the fission product removal capability of the filters

C.I.6.5.1.2 <u>*System Design*</u>

The applicant should compare the design features and fission product removal capability of each filter system to each position detailed in RG 1.52. For each ESF atmosphere cleanup system, it should provide (in tabular form) a comparison between the features of the proposed system and the appropriate acceptable methods and/or characteristics provided in RG 1.52. For each design item for which an exception is taken, the acceptability of the proposed design should be justified in detail.

C.I.6.5.1.3 <u>*Design Evaluation*</u>

The applicant should provide evaluations of the filter systems to demonstrate their capabilities to attain the claimed filter efficiencies under the relevant accident conditions.

C.I.6.5.1.4 ***Tests and Inspections***

The applicant should provide information concerning the test and inspection program applicable to preoperational testing and inservice surveillance to ensure a continued state of readiness required to reduce the radiological consequences of an accident, as discussed in RG 1.52.

C.I.6.5.1.5 ***Instrumentation Requirements***

The applicant should describe the instrumentation to be employed to monitor and actuate the filter system, including the extent to which the recommendations of RG 1.52 are followed. The discussion of design details of the instrumentation and logic provided in Chapter 7 of the FSAR should be referenced.

C.I.6.5.1.6 ***Materials***

The applicant should list by commercial name, quantity (estimate where necessary), and chemical composition of the materials used in or on the filter system. The applicant should show that the radiolytic or pyrolytic decomposition products, if any, of each material does not interfere with the safe operation of this or any other ESF.

C.I.6.5.2 *Containment Spray Systems*

The applicant should provide a detailed description of the fission product removal function of the containment spray system, if the system is relied upon to perform this function following a DBA.

C.I.6.5.2.1 ***Design Bases***

The applicant should provide the design bases for the fission product removal function of the containment spray system, including (for example) the following:

(1) postulated accident conditions that determine the design requirements for fission product scrubbing of the containment atmosphere

(2) list of the fission products (including the species of iodine) that the system is designed to remove, and the extent to which credit is taken for the cleanup function in the analyses of the radiological consequences of the accidents discussed in Chapter 15 of the application

(3) bases employed for sizing the spray system and any components required for execution of the atmosphere cleanup function of the system

C.I.6.5.2.2 ***System Design (for Fission Product Removal)***

The applicant should provide a description of systems and components employed to carry out the fission product removal function of the spray system, including the method of additive injection (if any) and delivery to the containment. This description should include the following details:

(1) methods and equipment used to ensure adequate delivery and mixing of the spray additive (where applicable)

(2) source of water supply during all phases of spray system operation

(3) spray header design, providing the number of nozzles per header, nozzle spacing, and nozzle orientation (include a plan view of the spray headers, showing nozzle location and orientation)

(4) spray nozzle design, including information on the drop size spectrum produced by the nozzles, with a histogram of the observed drop size frequency for the spatial drop size distribution; if a mean diameter is used in calculating spray effectiveness, all assumptions used for the conversion to a temporal drop size mean should be stated

(5) operating modes of the system, including the time of system initiation, time of first additive delivery through the nozzles, length of injection period, time of initiation of recirculation (if applicable), and length of recirculation operation (spray and spray additive flow rates should be supplied for each period of operation, assuming minimum spray operation coincident with maximum and minimum safety injection flow rates, and vice versa)

(6) regions of the containment covered by the spray, including a list of containment volumes that are not covered by the spray and an estimate of forced or convective postaccident ventilation of these unsprayed volumes (the extent to which credit is taken for the operability of ductwork, dampers, and the like should be indicated)

C.I.6.5.2.3 ***Design Evaluation***

The applicant should provide an evaluation of the fission product removal function of the containment spray system. Applicants should evaluate the system for fully effective and minimum safeguards operation, including the condition of a single failure of any active component. If the calculation of spray effectiveness is performed for a single set of postaccident conditions, the applicant should give attention to the effects of such parameters as temperature, spray and sump pH (and the resulting change in iodine partition), drop size, and pressure drop across the nozzle, in order to ascertain whether the evaluation has been performed for a conservative set of these parameters.

C.I.6.5.2.4 ***Tests and Inspections***

The applicant should provide a description of provisions to test all essential functions required for iodine-removal effectiveness of the system. In particular, this section of the FSAR should include the following information:

(1) description of the tests to be performed to verify the capability of the systems, as installed, to deliver the spray solution with the required concentration of spray additives to be used for iodine removal (if the test fluids are not the actual spray additives, the liquids of similar density and viscosity to be employed should be described and the correlation of the test data with the design requirements should be discussed)

(2) description of the provisions made for testing the containment spray nozzles

(3) provisions for periodic testing and surveillance of any of the spray additives to verify their continued state of readiness

The applicant should provide bases for surveillance, test procedures, and test intervals deemed appropriate for the system.

C.I.6.5.2.5 ***Instrumentation Requirements***

The applicant should provide a description of any spray system instrumentation required to actuate the system and monitor its fission product removal function. Chapter 7 of the application should discuss instrumentation design details and logic.

C.I.6.5.2.6 *__Materials__*

The applicant should specify and discuss the chemical composition, concentrations in storage, susceptibility to radiolytic or pyrolytic decomposition, and corrosion properties of the spray additives (if any), spray solution, and containment sump solution.

C.I.6.5.3 *Fission Product Control Systems*

Fission product control systems are considered to be those systems that control the release of fission products following a DBA. These systems are exclusive of the containment isolation system and any fission product removal system, although they may operate in conjunction with fission product removal systems. The applicant should provide a detailed discussion of the operation of all fission product control systems following a DBA. Both anticipated and conservative operation should be described. Reference should be made to other FSAR sections when appropriate.

C.I.6.5.3.1 *__Primary Containment__*

The applicant should summarize information regarding the ability of the primary containment to control fission product releases following a DBA. Information such as that provided in Table 6-16 of this guide should be included and layout drawings of the primary containment and the hydrogen purge system provided.

The applicant should discuss operation of containment purge systems prior to and during an accident. It should describe operation of the primary containment (e.g., anticipated and conservative leak rates as a function of time after initiation of the accident), as it applies to fission product control following a DBA. Where applicable, the applicant should indicate when fission product removal systems are effective relative to the time sequence for operation of the primary containment following a DBA.

C.I.6.5.3.2 *__Secondary Containments__*

The applicant should provide a discussion of the operation of each system used to control the release of fission products leaking from the primary containment following a DBA. The applicant should include the time sequence of events assumed in performing the dose estimates. The applicant should provide a table of events related to time following the DBA, including various parameters. For each time interval, it should indicate which fission product removal systems are effective.

The applicant should indicate both anticipated and conservative assumptions. The applicant should provide drawings that show each secondary containment volume and its associated ventilation system. The applicant should indicate the locations of intake and return headers for recirculation systems, as well as exhaust intakes for once-through ventilation systems. Applicants should reference non-ESF systems that are used to control pressure in the volume.

C.I.6.5.4 *Ice Condenser as a Fission Product Cleanup System*

No nuclear power plant designs are currently anticipated to include ice condensers; therefore, no specific guidance is provided in this section.

C.I.6.5.5 *Pressure Suppression Pool as a Fission Product Cleanup System*

The applicant should consider the fission product cleanup function separately from its heat removal aspects; it should be described in this section of the FSAR only if credit is taken in the accident analysis in Chapter 15.

C.I.6.5.5.1 ***Design Bases***

The applicant should provide the design bases for the fission product removal function, including (for example) the following:

(1) postulated accident conditions and the extent of simultaneous occurrences that determine the design requirements for fission product removal

(2) list of fission products (including the species of iodine) that the system is designed to remove, and the extent to which credit is taken for the cleanup function in the analyses of radiological consequences of the accidents discussed in Chapter 15

C.I.6.5.5.2 ***System Design (for the Fission Product Removal)***

The applicant should describe aspects of the design that significantly affect the system's fission product removal function. This description should include (for example) the following information:

(1) Specify the concentrations of all additives to the containment sump solution following an accident.

(2) Provide an evaluation of the system's fission product removal function. The system should be evaluated for fully effective and minimum safeguards operation, including the condition of a single failure of any active component. If the calculation of effectiveness is performed for a single set of postaccident conditions, the applicant should give attention to the effects of such parameters as recirculation flow rate, temperature, pressure, and sump pH (and the resulting change in iodine partition), in order to ascertain that the evaluation has been performed for a conservative set of these parameters.

C.I.6.5.5.4 ***Tests and Inspections***

The applicant should provide a description of provisions to test all essential functions for iodine-removal effectiveness and surveillance of the system.

C.I.6.6 Inservice Inspection of Class 2 and 3 Components

The applicant should discuss the ISI program for Quality Group B and C components (i.e., Class 2 and 3 components in Section III of the ASME Code).

C.I.6.6.1 *Components Subject to Examination*

The applicant should indicate whether all Quality Group B components, including those listed in Table IWC-2500 of Section XI of the ASME Code is examined in accordance with ASME Code guidelines. The applicant should indicate the extent to which Quality Group C components, including those listed in Subarticle IWD-2500 of Section XI, is examined in accordance with the ASME Code.

C.I.6.6.2 *Accessibility*

The applicant should indicate whether the design and arrangement of Class 2 and 3 system components provide adequate clearances to conduct the examinations at the ASME Code-defined inspection interval. The applicant should describe any special design arrangements for those components that are to be examined during normal reactor operation.

C.I.6.6.3 *Examination Techniques and Procedures*

The applicant should indicate the extent the examination techniques and procedures described in Section XI of the ASME Code are used. The applicant should describe any special examination techniques and procedures that might be used to meet the ASME Code guidelines.

C.I.6.6.4 *Inspection Intervals*

The applicant should indicate whether an inspection schedule for Class 2 system components is in accordance with the guidance in Section XI, Subarticle IWC-2400, of the ASME Code, and whether a schedule for Class 3 system components is developed according to Subarticle IWD-2400.

C.I.6.6.5 *Examination Categories and Requirements*

The applicant should indicate whether the ISI categories and guidelines for Class 2 components are in agreement with Section XI and IWC-2500 of the ASME Code. The applicant should indicate the extent to which ISI categories and guidelines for Class 3 components are in agreement with Section XI, Subarticle IWD-2500.

C.I.6.6.6 *Evaluation of Examination Results*

The applicant should indicate whether the evaluation of Class 2 component examination results are in agreement the guidelines in Article IWA-3000 of Section XI of the ASME Code. The applicant should describe the method to be used in evaluating examination results for Class 3 components and indicate the extent to which these methods are in agreement with the guidelines in Article IWA-3000 of Section XI. In addition, it the applicant should indicate whether repair procedures for Class 2 components are in agreement with the guidelines in Article IWC-4000 of Section XI. The applicant should describe the procedures to be used to repair Class 3 components and indicate the extent to which these procedures are in agreement with Article IWD-4000 of Section XI.

C.I.6.6.7 *System Pressure Tests*

The applicant should indicate whether the program for Class 2 system pressure testing is in agreement with Article IWC-5000 of Section XI of the ASME Code, and whether the program for Class 3 system pressure testing is in agreement with Article IWD-5000.

C.I.6.6.8 *Augmented ISI to Protect against Postulated Piping Failures*

The applicant should provide an augmented ISI program for high-energy fluid system piping between containment isolation valves or, where no isolation valve is used inside containment, between the first rigid pipe connection to the containment penetration or the first pipe whip restraint inside containment and the outside isolation valve. This program should contain information concerning areas subject to examination, method of examination, and extent and frequency of examination.

C.I.6.7 <u>Main Steamline Isolation Valve Leakage Control System (BWRs)</u>

The applicant should describe the design bases and criteria to be applied, as well as the preliminary system design and operation, and describe how these criteria are met.

C.I.6.7.1 *Design Bases*

The applicant should provide design bases for the main steam isolation valve leakage control system (MSIVLCS), in terms of the following considerations:

(1) safety-related function of the system

(2) system functional performance requirements, including the ability to function following a postulated LOOP

(3) seismic and quality group classification of the system

(4) requirements for protection from missiles, pipe whip, and jet forces, as well as the system's ability to withstand adverse environments associated with a postulated LOCA

(5) requirements of the MSIVLCS to function following an assumed single active failure

(6) system capabilities to provide sufficient capacity, diversity, reliability, and redundancy to perform its safety function consistent with the need to maintain containment integrity for as long as postulated LOCA conditions require

(7) requirements for the system to prevent or control radioactive leakage from component parts or subsystems, including methods of processing, diluting, and discharging any leakage to minimize contribution to site radioactive releases

(8) requirements for system initiation and actuation consistent with the requirements for instrumentation, controls, and interlocks provided for engineered safety systems

(9) requirements for inspection and testing during and subsequent to power operations

For new BWR plants that do no incorporate a MSIVLCS and for which turbine bypass system holdup and plateout of fission products are credited in the analysis of DBA radiological consequences, the applicant should demonstrate conformance with the seismic analysis described in SECY 93-087.

C.I.6.7.2 *System Description*

The applicant should provide a detailed description of the MSIVLCS, including piping and instrumentation diagrams, system drawings, and location of components in the station complex. The description and drawings should also include subsystems, system operation (function), system interactions, components utilized, connection points, and instrumentation and controls utilized.

C.I.6.7.3 *System Evaluation*

The applicant should provide an evaluation of the capability of the MSIVLCS to prevent or control the release of radioactivity from the main steamlines during and following a LOCA. This evaluation should include the following considerations:

(1) ability of the system to maintain its safety function when subjected to missiles, pipe whip, jet forces, adverse environmental conditions, and LOOP coincident with the LOCA

(2) ability of the system to withstand the effects of a single active failure (including the failure of any one main steam isolation valve to close)

(3) protection afforded the system from the effects of failure of any nonseismic Category I system or component

(4) capability of the system to provide effective isolation of components and nonessential systems or equipment

(5) capability of the system to detect and prevent or control leakage of radioactive material to the environment, as well as the quantity of material that could be released and the time release for each release path (provide an analysis of radiological consequences associated with performance of this system following a design-basis LOCA in Chapter 15)

(6) failure modes and effects analysis to demonstrate that appropriate safety-grade instrumentation, controls, and interlocks will provide safe operating conditions, ensure system actuation following a LOCA, and preclude inadvertent system actuation

(7) assurance that a system malfunction or inadvertent operation has not adverse effect on other safety-related systems, components, or functions

C.I.6.7.4 *Instrumentation Requirements*

The applicant should describe the system instrumentation and controls and demonstrate the adequacy of safety-related interlocks to meet the single-failure criterion.

C.I.6.7.5 *Inspection and Testing*

The applicant should provide the inspection and testing requirements for the MSIVLCS and describe the provisions to accomplish such inspections and testing.

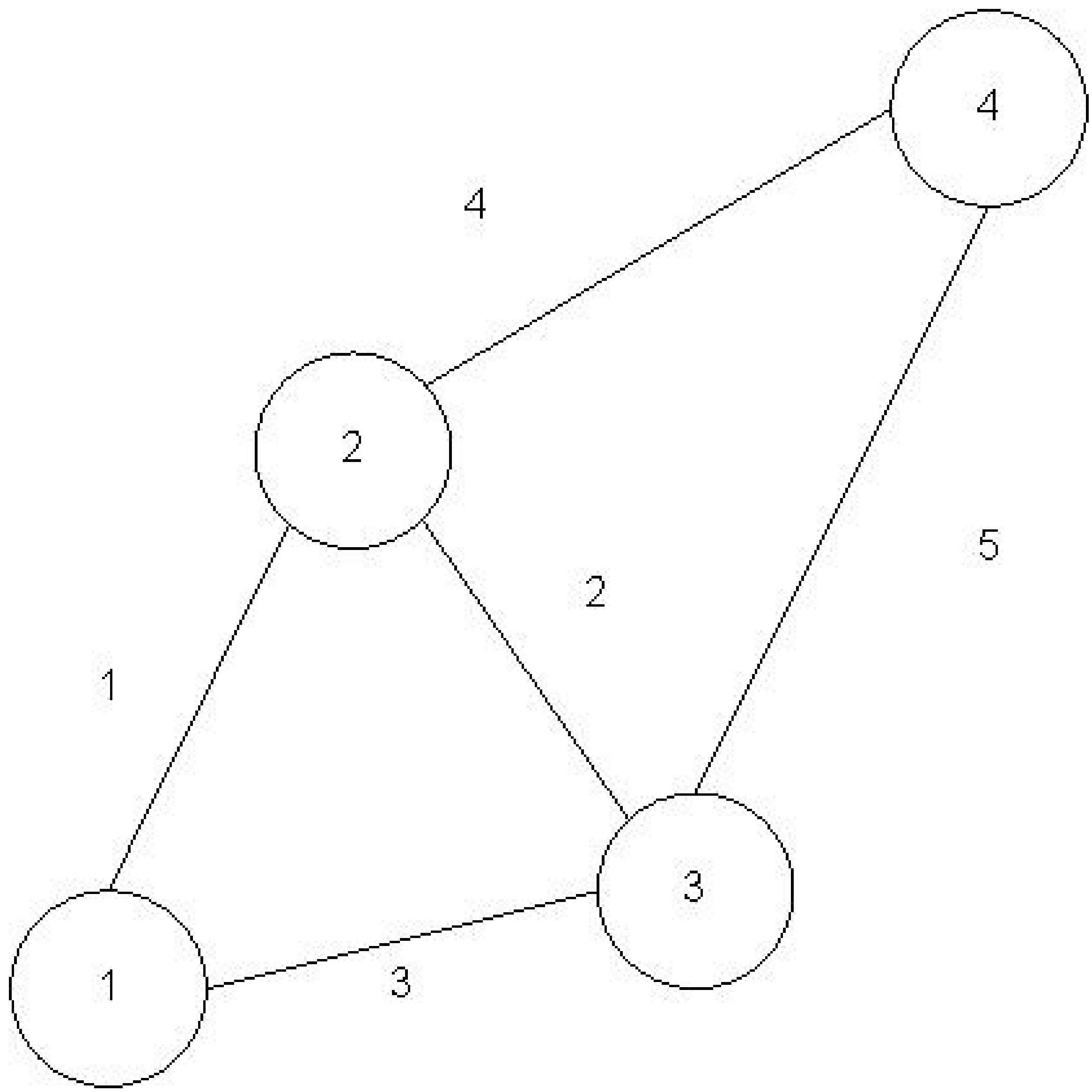

Figure 6-1. Example of Subcompartment Nodalization Diagram

Table 6-1. Information to Be Provided for PWR Dry Containments (Including Subatmospheric Containments)

I. General Information

A. External Design Pressure, psig
B. Internal Design Pressure, psig
C. Design Temperature, °F
D. Free Volume, ft^3
E. Design Leak Rate, %/day @ psig

II. Initial Conditions

A. Reactor Coolant Systems (at design overpower of 102% and at normal liquid levels)

1. Reactor Power Level, MWt
2. Average Coolant Temperature, °F
3. Mass of Reactor Coolant Systems Liquid, 1bm
4. Mass of Reactor Coolant Systems Steam, 1bm
5. Liquid Plus Steam Energy,* Btu

B. Containment

1. Pressure, psig
2. Temperature, °F
3. Relative Humidity, %
4. Service Water Temperature, °F
5. Refueling Water Temperature, °F
6. Outside Temperature, °F

C. Stored Water (as applicable)

1. Borated-Water Storage Tank, ft^3
2. All Accumulators (safety injection tanks), ft^3
3. Condensate Storage Tanks, ft^3

* All energies are relative to 32 °F.

Table 6-2. PWR Engineered Safety Feature Systems Information

As indicated below, applicants should provide this information for (1) full-capacity operation and (2) the capacities used in the containment analysis.

	Full Capacity	Value Used for Containment Analysis
I. Passive Safety Injection Systems		
A. Number of Accumulators (Safety Injection Tanks)		
B. Pressure Setpoint, psig		
II. Active Safety Injection Systems		
A. High-Pressure Safety Injection		
1. Number of Lines		
2. Number of Pumps		
3. Flow Rate, gpm		
B. Low-Pressure Safety Injection		
1. Number of Lines		
2. Number of Pumps		
3. Flow Rate, gpm		
III. Containment Spray System		
A. Injection Spray		
1. Number of Lines		
2. Number of Pumps		
3. Number of Headers		
4. Flow Rate, gpm		
B. Recirculation Spray		
1. Number of Lines		
2. Number of Pumps		
3. Number of Headers		
4. Flow Rate, gpm		

Table 6-2 (Continued)

	Full Capacity	Value Used for Containment Analysis
IV. Containment Fan Cooler System		
A. Number of units		
B. Air-Side Flow Rate, cfm		
C. Heat Removal Rate at Design Temperature, 10^6 Btu/hr		
D. Overall Heat Transfer Coefficient, Btu/hr-ft^2-°F		
V. Heat Exchangers		
A. Recirculation Systems		
1. Systems		
2. Type		
3. Number		
4. Heat Transfer Area, ft^2		
5. Overall Heat Transfer Coefficient, Btu/hr-ft^2-°F		
6. Flow Rate:		
a. Recirculation Side, gpm		
b. Exterior Side, gpm		
7. Source of Cooling Water		
8. Flow Begins, seconds		
VI. Other		

Table 6-3. Summary of Calculated Containment Pressure and Temperatures

	Calculated Value
Pipe Break Location and Break Area, ft^2	
Peak Pressure, psig	
Peak Temperature, °F	
Time of Peak Pressure, seconds	
Energy Released to Containment up to the End of Blowdown, 10^6 Btu	

Table 6-4. Passive Heat Sinks

A. Listing of Passive Heat Sinks*

The following structures, components, and equipment are examples of passive heat sinks that should be included in the submittal, as appropriate:

Containment Building

(1) Building/liner
(2) External concrete walls
(3) Building liner steel anchor
(4) Building floor and sump
(5) Personnel hatches
(6) Equipment hatches

Internal Structures

(7) Internal separation walls and floors
(8) Refueling pool and fuel transfer pit walls and floors
(9) Crane wall
(10) Primary shield walls
(11) Secondary shield walls
(12) Piping tunnel
(13) Pressurizer room
(14) Reheat exchanger room
(15) Value room
(16) Fuel canal shielding
(17) Jet impingement deflectors
(18) Regenerative heat exchanger shield
(19) Other
(20) Lifting rig
(21) Refueling machine
(22) Vessel head lifting rig
(23) Polar crane
(24) Manipulator crane
(25) Other supports
(26) Reactor vessel supports
(27) Steam generator supports
(28) Fuel canal support

* Provide best estimates of these heat sinks in the COL application and a commitment to update the FSAR based on as-built information (this should be consistent with the values in containment analyses).

Table 6-4 (Continued)

(29) Reactor coolant pump supports
(30) Safety injection tank supports
(31) Pressure relief tank supports
(32) Drain tank supports
(33) Fan cooler support
(34) Other

Storage Racks

(35) Fuel storage
(36) Head storage
(37) Other

Gratings, Ladders, etc.

(38) Ladders, stairways
(39) Floor plates
(40) Steel handrails and plates railings
(41) Steel gratings
(42) Steel risers
(43) Steel tread and stringers

Electrical Equipment

(44) Cables, conduits
(45) Cable trays
(46) Instrumentation and control equipment, electrical boxes
(47) Electric penetrations

Piping Support Equipment

(48) Restraints
(49) Hangers
(50) Piping penetrations

Components

(51) Reactor heat removal pumps and motors
(52) Reactor coolant pump motors
(53) Hydrogen recombiners
(54) Fan coolers
(55) Reactor cavity and support cooling units
(56) Air filter units
(57) Air blowers

Table 6-4 (Continued)

(58) Air heating equipment
(59) Safety injection tanks
(60) Pressurizer quench tank
(61) Reactor drain tank
(62) Other

Uninsulated Cold-Water-Filled Piping and Fittings

(63) Reactor heat removal system
(64) Service water system
(65) Component cooling water system
(66) Other

Drained Piping and Fittings

(67) Containment spray piping and headers
(68) Other

Heating, Ventilation, and Air Conditioning

(69) Ducting
(70) Duct dampers

Table 6-4 (Continued)

B. Modeling of Passive Heat Sinks

Applicants should provide the following data for the passive heat sinks listed in Table 6-4A:

					Updated Material		
Passive Heat Sink	**Paint Material Thickness, ft**	**Material**	**Exposed Surface Area by Thickness Group,* 1 2...6,ft^2**	**Total Mass, lb**	**Concrete Exposed Surface by Thickness Groups, ^{a}ft^2 a**	**b**	**Total Surface, ft^2**
1. Vessel steel plate							
2. External concrete walls							
3. Vessel liner steel anchors							
Totals							
Painted Surfaces							
Unpainted Surfaces							

*See Table 6-4c

Table 6-4 Passive Heat Sinks

C. Thickness Groups

Material	**Group Designation**	**Thickness Range, in.**
	1	0–0.125
	2	0.125–0.25
	3	0.25–0.5
	4	0.5–1.00
	5	1.00–2.50
	6	>2.50
	a	0–3.0
	b	>3.0

Table 6-4 (Continued)

D. Thermophysical Properties of Passive Heat Sink Materials

Material	Density, 1b/ft^3	Specific Heat Btu/1b-°F	Thermal Conductivity Btu/hr-ft^2 °F

Table 6-5. Information to Be Provided for Water Pool Pressure-Suppression Containments

A. Drywell

1. Internal Design Pressure, psig
2. Drywell Deck Design Differential Pressure, psid
3. Drywell Design Differential Pressure, psid
4. External Design Pressure, psig
5. Design Temperature, °F
6. Free Volume, ft^3
7. Design Leak Rate, %/day @ psig

B. Containment (Wetwell)

1. Internal Design Pressure, psig
2. External Design Pressure, psig
3. Design Temperature, °F
4. Air Volume (min/max), ft^3
5. Wetwell Air Volume, ft^3
6. Pool Volume (min/max), ft^3
7. Suppression Pool Makeup Volume, ft^3
8. Pool Surface Area, ft^2
9. Pool Depth (min/max), ft
10. Design Leak Rate, %/day @ psig
11. Hydraulic Control Unit Floor Flow Restriction, % restricted

C. Vent System

1. Number of Vents
2. Vent Diameter, ft
3. Net Free Vent Area, ft^2
4. Vent Submergence(s) (min/max), ft
5. Vent System Loss Factors
6. Drywell Wall to Weir Wall Distance, ft
7. Net Weir Annulus Cross-Sectional Area, ft^2

Table 6-6. Engineered Safety Feature Systems Information for Water-Pool Pressure-Suppression Containment

Applicants should provide this information for (1) full-capacity operations and (2) the capacities used in the containment analysis.

A. Containment Spray System

1. Number of Spray Pumps
2. Capacity per Pump, gpm
3. Number of Spray Headers
4. Spray Flow Rate—Drywell, lb/hr
5. Spray Flow Rate—Wetwell, lb/hr
6. Spray Thermal Efficiency, %

B. Containment Cooling System

1. Number of Pumps
2. Capacity per Pump, gpm
3. Number of Heat Exchangers
4. Heat Exchanger Type
5. Heat Transfer Area per Exchanger, ft^2
6. Overall Heat-Transfer Coefficient, Btu/hr ft^2 °F
7. Secondary Coolant Flow Rate per Exchanger, lb/hr
8. Design Service Water Temperature (min/max), °F

Table 6-7. Initial Conditions for Analysis of Water-Pool Pressure-Suppression Containment

A. Reactor Coolant System (at design overpower of 102% and at normal liquid levels)

1. Reactor Power Level, Mwt
2. Average Coolant Pressure, psig
3. Average Coolant Temperature, °F
4. Mass of Reactor Coolant System Liquid, lb
5. Mass of Reactor Coolant System Steam, lb
6. Volume of Water in Reactor Vessel, ft^3
7. Volume of Steam in Reactor Vessel, ft^3
8. Volume of Water in Recirculation Loops, ft^3

B. Drywell

1. Pressure, psig
2. Temperature, °F
3. Relative Humidity, %

C. Containment (suppression chamber)

1. Pressure, psig
2. Air Temperature, °F
3. Water Temperature, °F
4. Relative Humidity, %
5. Water Volume, ft^3
6. Vent Submergence, ft

Table 6-8. Energy Sources for Water-Pool Pressure-Suppression Containment Accident Analysis

A. Decay heat rate, Btu/s, as a function of time

B. Primary system sensible heat release to containment, Btu/s, as a function of time

C. Metal-water reaction heat rate, Btu/s, as a function of time

D. Heat release rate from other sources, Btu/s, as a function of time

Table 6-9. Mass and Energy Release Data for Analysis of Water-Pool Pressure-Suppression Containment Accidents

A. Recirculation Line Break

1. Pipe I.D., in.
2. Effective Total Break Area, ft^2, versus time
3. Name of Blowdown Code
4. Blowdown Table

Time, s	Flow, lb/s	Enthalpy, Btu/lb	Reactor Vessel Pressure, psig
0			
t_1			
t_2			
t_n		-BLOWDOWN COMPLETED-	

B. Main Steamline Break

1. Pipe I.D., in.
2. Effective Total Break Area, ft^2, versus time
3. Name of Blowdown Code
4. Blowdown Table

Time, s	Flow, lb/s	Enthalpy, Btu/lb	Reactor Vessel Pressure, psig
0			
t_1			
t_2			
.			
.			
t_n			

Table 6-10. Passive Heat Sinks Used in the Analysis of BWR Pressure-Suppression Containments (If Applicable)

A. Listing of Passive Heat Sinks

List all structures, components, and equipment used as passive heat sinks (see Table 6-4A).

B. Detailed Passive Heat Sink Data

Tables 6-4B, 6-4C, and 6-4D list the information to be provided and give the appropriate format.

C. Heat Transfer Coefficients

Graphically show the condensing heat sink transfer coefficients as functions of time for the design-basis accident.

Table 6-11. Results of Water-Pool Pressure-Suppression Containment Accident Analyses

A. Accident Parameters

	Recirculation Line Break	Steamline Break
1. Peak Drywell Pressure, psig		
2. Peak Drywell Deck Design Differential Pressure, psid		
3. Drywell Design Differential Pressure, psid		
4. Time(s) of Peak Pressures, s		
5. Peak Drywell Temperature, °F		
6. Peak Containment (Suppression Chamber) Pressure, psig		
7. Time of Peak Containment Pressure, s		
8. Peak Wetwell Pressure, psig		
9. Time of Peak Wetwell Pressure, s		
10. Peak Containment Atmospheric Temperature, °F		
11. Peak Suppression Pool Temperature, °F		

The applicant should supplement the above tabulation by plots of containment and drywell pressure and temperature, vent flow rate, energy release rate, and energy removal rate as functions of time to at least 10^6 seconds.

Table 6-11 (Continued)

B. Energy Balance of Sources and Sinks

	Time, s			
	Initial	Drywell Peak Pressure	End of Blowdown	Long-Term Peak Pressure
	0			
		Energy, 10^6 Btu		
1. Reactor Coolant				
2. Fuel and Cladding				
3. Core Internals				
4. Reactor Vessel Metal				
5. Reactor Coolant System Piping, Pumps, and Valves				
6. Blowdown Enthalpy				
7. Decay Heat				
8. Metal-Water Reaction Heat				
9. Drywell Structures				
10. Drywell Air				
11. Drywell Steam				
12. Containment Air				
13. Containment Steam				
14. Suppression Pool Water				
15. Heat Transferred by Heat Exchangers				
16. Passive Heat Sinks				

Table 6-12. Subcompartment Vent Path Description

VENT PATH NO.	FROM VOL. NODE NO.	TO VOL. NODE NO.	DESCRIPTION OF VENT PATH FLOW		AREA ft^2	LENGTH ft	HYDRAULIC DIAMETER ft	HEAD LOSS, K				
			CHOKED	UNCHOKED				FRICTION K, ft/d	TURNING LOSS, K	EXPAN- SION, K	CONTRAC- TION, K	TOTAL

Table 6-13. Subcompartment Nodal Description

				INITIAL CONDITIONS			DBA BREAK CONDITIONS				CALC.	DESIGN	DESIGN
VOLUME NO.	DESCRIPTION	HEIGHT, ft	CROSS-SECTIONAL AREA, ft^2	TEMP. °F	PRESS. psia	HUMID. %	BREAK LOC. VOL. NO.	BREAK LINE	BREAK AREA ft^2	BREAK TYPE	PEAK PRESS DIFF. psid	PEAK PRESS DIFF. psid	MARGIN, %

Table 6-14. Mass and Energy Release Rate Data for Postulated Loss-of-Coolant Accidents

Pipe I.D., in.

Break Area, ft^2

Time, s	Mass Release Rate, lbm/s	Enthalpy, Btu/lbm	Reactor Vessel Pressure, psig
0			
$^t1$			
$^t2$	Blowdown Phase		
.			
.			
.			
^{t} End of Blowdown			
.			
.			
.	Core Reflood Phase		
^{t} End of Core Reflood			
.			
.			
.	Post-Reflood Phase		
^{t} End of Post-Reflood			
.			
.			
.	Post-Post-Reflood (or Decay Heat) Phase		
. End of Problem			

Table 6-15. Reactor Containment Building Energy Distribution
Pipe Break Location and Pipe Break Area

Note: The datum temperature is 32 °F unless otherwise noted.

	Energy, 10^6 Btu					
	Prior to LOCA	At Peak Pressure Prior to End of Blowdown	End of Blowdown	At Peak Pressure after End of Blowdown	End of Core Reflood	1 Day into Recirc.
Reactor Coolant Internal Energy						
Core Flood Tank Coolant Internal Energy						
Energy Stored in Core						
Energy Stored in RV Intervals						
Energy Generated during Shutdown from Decay Heat						
Energy Stored in Pressurizer, Primary Piping, Valves, and Pumps						
Energy Stored in Steam Generator Metal						
Secondary Coolant Internal Energy (in Steam Generators)						
Energy Content of RCB Atmosphere*						

Table 6-15 (Continued)

	Energy, 10^6 Btu					
	Prior to LOCA	At Peak Pressure Prior to End of Blowdown	End of Blowdown	At Peak Pressure after End of Blowdown	End of Core Reflood	1 Day into Recirc.
Energy Content of RCB and Internal Structures **						
Energy Content of Recirculation Intake Water						
Energy Content of BWST Water						
Energy Removed by Decay Heat Removal Coolers						
Energy Removed by Reactor Containment Building Fan Coolers						

* Atmospheric constituent data are 120 °F for air and 32 °F for water vapor.

** Datum for energy content of reactor containment building and internal structures is 120 °F.

Table 6-16. Primary Containment Operations Following a Design-Basis Accident

General

Type of Structure
Appropriate Internal Fission Product Removal Systems
Free Volume of Primary Containment
Mode of Hydrogen Purge (e.g., direct to environs, to recirculation system, to annulus)

Time-Dependent Parameters	Anticipated	Conservative
Leak Rate of Primary Containment		
Leakage Fractions to Volumes Outside the Primary Containment (including the environment)		
Effectiveness of Fission Product Removal Systems		
Initiation of Hydrogen Purge		
Hydrogen Purge Rate		