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U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 3.8.3 CONCRETE AND STEEL INTERNAL STRUCTURES OF STEEL OR CONCRETE CONTAINMENTS

REVIEW RESPONSIBILITIES

Primary - Structural Engineering Branch (SEB)

Secondary - None

I. AREAS OF REVIEW

The following areas relating to the containment internal structures are reviewed:

1. Description of the Internal Structures

The descriptive information including plans and sections of the various internal structures is reviewed to establish that sufficient information is provided to define the primary structural aspects and elements relied upon to perform the safety-related functions of these structures. In order to perform the safety-related functions, these structures must be capable of resisting loads and load combinations to which they may be subjected and should not become the initiator of a loss of coolant accident (LOCA). If such an accident does occur however, they should be able to mitigate its consequences by protecting the containment and other engineered safety features from the effects induced by the accident such as jet forces and whipping pipes.

The major containment internal structures that are reviewed, together with the primary structural function of each structure, and the extent of descriptive information required for each structure, are indicated below. For equipment supports that are not covered by this SRP section, reference is made to Standard Review Plan Section 3.9.3.

a. For PWR Dry Containment Internal Structures

i. Concrete Supports for Reactor

The PWR vessel should be supported and restrained to resist normal operating loads, seismic loads, and loads induced by postulated pipe rupture including the loss of coolant accident. The support and restraint system should limit the movement of the vessel to within allowable limits under the applicable combinations of loadings.

The support system should nevertheless minimize resistance to the thermal movements expected during operation.

With these functional requirements in mind, the general arrangement and principal features of the reactor vessel supports are reviewed with emphasis on methods of transferring loads from the vessel to the support and eventually to the structure and its foundations.

ii. Concrete Supports for Steam Generator

Steam generators should be supported and restrained to resist normal operating loads, seismic loads, and loads induced by pipe rupture. The support system should prevent the rupture of the primary coolant pipes due to a postulated rupture in steam or feed water pipes and vice versa. The system should nevertheless minimize resistance to the thermal movements expected during operation.

With these functional requirements in mind, the general arrangement and principal features of the steam generator supports are reviewed with emphasis on methods of transferring loads from the vessel to the support and eventually to the structure and its foundations.

iii. Primary Shield Wall and Reactor Cavity

The primary shield wall forms the reactor cavity and usually supports and restrains the reactor vessel. It is usually a thick wall that surrounds the reactor vessel and may be anchored through the liner plate to the containment base slab.

The general arrangement and principal features of the wall and cavity are reviewed including the main reinforcement and anchorage system.

iv. Secondary Shield Walls

The secondary shield walls surround the primary loops, forming the steam generator compartments, and protecting the containment from the effects of pipe rupture accidents inside the compartment. They may also support intermediate floors and the operating floor. The general arrangement and principal features of these walls are reviewed with emphasis on the method of structural framing and expected behavior under compartment

pressure loads and jet forces, particularly those associated with the LOCA.

v. Other Interior Structures

The other major interior structures of PWR dry containments that are reviewed in a similar manner are the concrete refueling pool walls, the operating floor, other intermediate floors, and the polar crane supporting elements.

b. For PWR Ice-condenser Containment Internal Structures

For PWR plants where the ice-condenser containment system is utilized, in addition to the applicable structures reviewed in dry PWR containments, the following elements are also reviewed:

i. The Divider Barrier

In the PWR ice-condenser containment system, which utilizes the pressure-suppression concept, the divider barrier surrounds the reactor coolant system. The upper portion of the divider barrier is nearly surrounded by the ice-condenser which is bounded by the containment shell on the outside and by the divider barrier wall on the inside. Several venting doors connect the space inside the divider barrier to the ice-condenser.

In the event of a LOCA, the divider barrier will contain the steam released from the reactor coolant system and, temporarily acting as a pressure-retaining envelope, will channel the steam through the venting doors and into the ice-condenser. The ice will condense the steam and the energy released to the containment will thus be minimized.

Following such a LOCA and before blowdown is completed, the divider barrier will be subjected to differential pressure and possibly jet forced, and any structural failure in its boundary may result in steam bypassing the ice-condenser and flowing directly into the containment, possibly generating a containment pressure higher than that for which it has been designed.

With this functional requirement in mind, the general arrangement and principal features of the divider barrier are reviewed with emphasis on structural framing and expected behavior when subjected to the design loads.

ii. Ice-Condenser

A major feature of the ice-condenser containment which contains the baskets of ice forming the heat sink essential for pressure suppression. The structurally significant components of the ice-condenser reviewed are the vent doors, ice baskets, brackets, couplings and lattice framings, lower and upper supports, and insulating and cooling panels.

The general arrangement and principal features of these major components are reviewed with emphasis on the structural framing, supports, and expected behavior when subjected to design loads.

c. For BWR Containment Internal Structures

Since it is expected that future BWR applications will utilize the Mark III containment concept, this SRP Section is oriented towards and based on this type of containment. For other types of BWR containments, the review will be made on a case-by-case basis.

Among the major Mark III containment internal structures that are reviewed, together with the primary structural function of each structure, and the extent of descriptive information required for each structure, are the following:

i. Drywell

In the BWR Mark III containment system, which utilizes the pressure-suppression concept, the drywell surrounds the reactor coolant system. The lower portion of the drywell is surrounded by the suppression pool which is bounded by the containment shell on the outside and by a weir wall located just inside the drywell wall. A series of vent holes connect the drywell to the suppression pool. In the event of a loss-of-coolant accident, the drywell will contain the steam released from the reactor coolant system and, temporarily acting as a pressure-retaining envelope, will channel the steam through the vent holes and into the suppression pool. The pool water will condense the steam and the energy released to the containment will thus be minimized.

Following such a LOCA and before blowdown is completed, the drywell will be subjected to a differential pressure and possibly jet forces, and any structural failure in its boundary would result in steam bypassing the suppression pool and flowing directly into the containment, possibly generating a containment pressure higher than that for which it has been designed.

With this functional requirement in mind, the general arrangement and principal features of the drywell are reviewed with emphasis on structural framing and expected behavior under loads. Since the drywell geometrically resembles, to a certain degree, a containment, the descriptive information reviewed is similar to that reviewed for containments as delineated in subsection I.1 of SRP Section 3.8.1. The major components of the drywell that are so reviewed, other than the main body of the drywell, include the bottom vent region, the roof and drywell head, and major penetrations.

ii. Weir Wall

The weir wall forms the inner boundary of the suppression pool and is located inside the drywell. It completely surrounds the lower portion of the reactor coolant system. The general arrangement and principal features of the weir wall are reviewed with emphasis on structural framing and behavior under loads.

iii. Refueling Pool and Operating Floor

The refueling pool walls are located on top of the drywell. The outer walls form a rectangular pool that is usually subdivided by two interior crosswalls. The base slab of the pool is common to the drywell roof slab. The pool may be filled continuously with water for shielding purposes during operation.

The general arrangement and principal features of the refueling pool are reviewed with emphasis on structural framing and behavior under loads.

The operating floor is intended to provide laydown space for refueling operations and is usually a combination of reinforced concrete and structural steel framining. The containment walls and the refueling pool walls may support the floor.

The general arrangement and principal features of the operating floor are reviewed.

iv. Concrete Supports for Reactor and Recirculation Pump

The support systems of the BWR vessel and recirculation pumps have the same functions as the support systems for PWR vessels and pumps are similarly reviewed.

v. Reactor Pedestal

The reactor pedestal is usually a cylindrical structure located below and supporting the reactor vessel, which is anchored to the top of the pedestal.

The general arrangement and principal features of the reactor pedestal are reviewed with emphasis on structural framining, main reinforcement and the manner in which the pedestal is anchored to the containment base slab.

vi. Reactor Shield Wall

This is usually a cylindrical wall surrounding the reactor vessel for radiation shielding purposes. It is supported on the reactor pedestal. The wall may be lined on both surfaces with steel plates which also may act as the main structural components of the wall. The wall may also be utilized as an anchor for pipe restraints.

The general arrangement and principal features of the wall are reviewed with particular emphasis on structure framing and behavior under loads.

vii. Other Interior Structures

The other major interior structures constructed of reinforced concrete or structural steel or combinations thereof that are also reviewed in a similar manner are the floors located inside the drywell and in the annulus between the drywell and the

containment, and the polar crane supporting elements. The general arrangement and principal features of these structures are reviewed.

2. Applicable Codes, Standards, and Specifications

The information pertaining to design codes, standards, specifications, and regulatory guides, and other industry standards that are applied in the design, fabrication, construction, testing, and surveillance of the containment structures, is reviewed. The specific edition, date, or addenda identified for each document are also reviewed.

3. Loads and Loading Combinations

a. Information pertaining to the applicable design loads and various load combinations thereof is reviewed. The loads normally applicable to contaiment internal structures include the following:

i. Those loads encountered during normal plant startup, operation, and shutdown, including dead loads, live loads, thermal loads due to operating temperature, and hydrostatic loads such as in refueling and pressure suppression pools in addition to hydrodynamic loads resulting from actuation of safety relief valves (SRV) and manifested as drag load, jet impingement and/or pressure loads should be considered.

ii. Those loads to be sustained during severe environmental conditions, includind those induced by the operating basis earthquake (OBE) specified for the plant site.

iii. Those loads to be sustained during extreme environmental conditions, including those induced by the safe shutdown earthquake (SSE) specified for the plant site.

iv. Those loads to be sustained during abnormal plant conditions. The most critical abnormal plant condition during which most of the containment internal structures have to perform their primary function is the design basis LOCA. Ruptures of other high-energy pipes should also be considered. Time-dependent and dynamic loads induced by such accidents include elevated temperatures and differential pressures across compartments, jet impingement, impact forces associated with the postulated ruptures of piping, and loads applicable to some structures such as drag forces in the PWR ice-condenser containment. In addition for structures or structural components located in or above the suppression pools of BWR Mark III containments the applicable LOCA-related or LOCA/SRV-related hydrodynamic loads manifested as jet loads and/or pressure loads should be considered.

The various combinations of the above loads that are normally postulated and reviewed include the following: normal operating loads; normal operating loads with severe environmental loads; normal operating loads with extreme environmental loads; normal operating loads with abnormal loads; normal operating loads with severe environmental and abnormal loads; and normal operating with extreme environmental and abnormal loads.

b. In addition, the following information is reviewed:

i. The extent to which the applicant's criteria comply with the Code Requirements for Nuclear Safety-Related Concrete Structures," ACI 349-76* (Ref. 2) for concrete, and with the AISC "Specification for Design," Fabrication and Erection of Structural Steel for Buildings" (Ref. 3) for steel, as applicable.

ii. For concrete portions of the divider barrier of the PWR ice-condenser containment and for concrete portions of the drywell of the Mark III BWR containment, the extent to which the applicant's loading criteria comply with Article CC-3000 of the ASME Section III, Division 2 Code for "Concrete Reactor Vessels and Containments," (Ref. 4). For steel pressure-resisting portions of these two structures, the extent to which the applicant's loading criteria comply with Article NE-3000 of Subsection NE of the ASME Code, Section III, Div. 1, (Ref. 5) as augmented by Regulatory Guide 1.57 (Ref. 9).

4. <u>Design and Analysis Procedures</u>

The design and analysis procedures utilized for the containment internal structures are reviewed with emphasis on the extent of compliance with the applicable codes as indicated in subsection I.3 of this SRP section, including those applicable to the following areas:

a. <u>For PWR Dry Containment Internal Structures</u>

i. <u>Concrete Supports for Reactor Coolant System</u>

The support system for the reactor vessel and steam generators, as described in Section I of this SRP Section, should be designed to resist various combinations of loadings, including normal operating loads, seismic loads, and loss of coolant and other pipe rupture accident loads.

Analytical procedures for determining seismic loads are as described in Standard Review Plan Section 3.7.3.

After the procedures for determining individual loads and combinations thereof are so reviewed, the design and analysis methods utilized for the supports are reviewed including the type of analysis, the methods of load transfer, and the assumptions of boundary conditions.

ii. <u>Primary Shield Wall and Reactor Cavity</u>

The primary shield wall should withstand all the applicable loads including those transmitted through the reactor supports. It is subjected to most of the loads described in Subsection I.3 of this SRP section and should be designed and analyzed for all the applicable load combinations. During normal plant operation,

*Whenever reference is made to ACI 349, it implies that the code is augmented by Regulatory Guide 1.142.

a thermal gradient across the wall is generated by the attenuation heat of gamma and neutron radiation originating from the reactor core. Insulation and cooling systems may be provided to reduce the severity of this gradient by limiting the rise in temperature to an acceptable level.

Procedures for determining seismic loads on the primary shield wall are reviewed in accordance with Standard Review Plan Section 3.7.2.

Loss of coolant accident loads that are applicable to the primary shield wall include a different pressure created across the reactor cavity by a pipe break in the vicinity of the reactor nozzles. Such a transient pressure may act on the entire cavity or on portions thereof. Procedures for determining such pressures are reviewed by the Containment Systems Branch (CSB).

Other loss of coolant accident loads that apply are those transmitted to the wall through the reactor supports including pipe rupture reaction forces which may induce simultaneous shear forces, torsional moments, and bending moments at the base of the wall. Further, the elevated temperature within and around the primary shield created by the accident may produce transient thermal gradients across the thick wall. Design and analysis procedures for such accident effects are accordingly reviewed.

iii. Secondary Shield Walls

The secondary shield walls surrounding the primary loops and supporting the operating floor should be designed for loads similar to those applicable to the primary shield wall including loads of fluid jets from a postulated break of a primary pipe which can impinge on these walls. The analytical techniques utilized for these walls are reviewed including their structural framing and behavior under loads. Where elasto-plastic behavior is assumed and the ductility of the walls is relied upon to absorb the energy associated with jet loads, the procedures and assumptions are reviewed with particular emphasis on such areas as modeling techniques, boundary conditions, force-time functions, and assumed ductility. For the time-dependent differential pressure, however, elastic behavior is required and the methods of determining an equivalent static load are accordingly reviewed.

iv. Other Interior Structures

Most of the other interior structures that are also reviewed are combinations of slabs, walls, beam and columns, classified as Category I structures and subject to most of the loads and combinations described in subsection I.3 of this SRP section. Analytical techniques for these structures are reviewed on the same basis as for the structures described above.

b. For PWR Ice-Condenser Containment Internal Structures

i. Divider Barrier

Since the divider barrier has to maintain a certain degree of leak-tightness during a LOCA and is thus a critical structure with respect to the proper functioning of the containment, it is treated on the same basis as the containment.

The loads that usually govern the design of the divider barrier are those induced by the LOCA, including the time-dependent differential pressure across the barrier and any concurrent concentrated jet impingement loads. As the divider barrier is typically a combination of walls and slabs framed together, the design and analysis procedures are of the conventional type. They are accordingly reviewed with emphasis on the assumed boundary conditions and behavior under loads. Since the differential pressure and jet impingement loadings are dynamic impulsive loads that vary with time, the techniques utilized to determine their equivalent static loads are reviewed.

ii. Ice-Condenser

The design of the ice-condenser and its various components may be based on a combination of analysis and testing. The analytical and testing procedures that are reviewed include those for the ice baskets and brackets (couplings); the lattice frames and columns including attachments; the supporting structures comprising the lower supports; the wall panels and cooling duct and supports of various auxiliary components.

The ice-condenser and its components should be analyzed or tested for various loads and combinations thereof including dead and live loads, thermal loads induced by differential thermal expansion within the various elements, seismic loads and loads induced by the loss-of-coolant accident. Accident loads include pressure differential drag loads and loads induced by the change of momentum of the flowing steam.

Elastic analysis is usually utilized for the ice-condenser and its components. However, plastic analysis may also be used as an alternate. Accordingly, the load factors that are applied to each of the applicable loads and the basis and justification of these load factors are reviewed.

Where experimental verification of the design using simulated load conditions is used, the procedures used to account for similitude relationships which exist between the actual component and the test model are reviewed to assure that the results obtained from the test are a conservative representation of the load carrying capability of the actual component under the postulated loading.

c. For BWR Containment Internal Structures

i. Drywell

The drywell, which has to maintain a certain degree of leak-tightness during a LOCA, is critical with respect to the proper functioning of the containment. Accordingly, and since it geometrically resembles a containment, the design and analysis procedures utilized for the drywell are reviewed on a basis similar to those of containments as described in Subsection I.4 of Standard Review Plan Sections 3.8.1 and 3.8.2 for concrete and steel portions, respectively.

ii. Weir Wall

One of the major loads to which the weir wall may be subjected is a jet impingement load induced by a pipe rupture in a nearby recirculation loop. Under such a concentrated load, the weir wall should not deform to an extent that might impair or degrade the pressure-suppression performance. Accordingly, the procedures utilized to analyze the wall for such dynamic time-dependent loads are reviewed with particular emphasis on modeling techniques, assumptions on boundary conditions, and behavior under loads.

iii. Refueling Pool and Operating Floor

In the BWR Mark III containments reviewed recently, the refueling pool is continuously filled with water to provide biological shielding above the reactor. The operating floor, which may be supported on the walls of the refueling pool on one side an on the containment shell on the other side, is a combination of reinforced concrete and structural steel. The design and analysis procedures for the refueling pool and the operating floor are of the conventional type and are accordingly reviewed, with particular emphasis on the structural framing and behavior under loads. In cases where the floor beams are supported vertically on the containment shell, they should be laterally isolated to minimize interaction between the containment and its interior.

iv. Concrete Supports for Reactor and Recirculation Pump

The design and analysis procedures utilized for the reactor and recirculation pump supports are reviewed in a manner similar to that for PWR reactor and pump supports, as already described in this SRP section.

v. Reactor Pedestal

The reactor pedestal supports the reactor and has to withstand the loads transmitted through the reactor supports. It is thus subjected to most of the loads described in subsection I.3 of this SRP section and is designed and analyzed for all the applicable load combinations.

Because of the similarity in geometry and function of the BWR reactor pedestal to the PWR primary shield wall, the design and analysis procedures are similar and are reviewed accordingly as has already been discussed in this SRP section.

vi. Reactor Shield Wall

This cylindrical wall, which surrounds the reactor and provides biological shielding, is also subjected to most of the loads described in subsection I.3 of this SRP section. In most cases, the wall is utilized to anchor pipe restraints in the vicinity of the reactor nozzles may pressurize the space within the wall. The wall is usually lined on both faces with steel plates which may constitute the major structural elements relied upon to resist the design loads.

The analytical and design techniques utilized to determine the effect of the design loads on the wall are reviewed with particular emphasis on the assumed boundary conditions and the behavior of the wall under loads.

vii. Other Interior Structures

There are several platforms within the BWR Mark III containment some of which are inside the drywell and the others outside the annulus between the drywell and the containment. Platforms inside the drywell are usually of structural steel and their main structural function is to provide foundations for the pipe restraints inside the drywell. Platforms outside the drywell are usually combinations of steel and concrete and have to be designed to resist the various applicable loads particularly the effects of pool swell during a loss-of-coolant accident and/or safety relief valve actuation. The analytical procedures for determining pool swell loads are reviewed by the Containment Systems Branch (CSB). Design and analysis procedures for these plantforms are reviewed with particular emphasis on the framing and structural behavior under loads.

d. Design Reports

A design report described in Appendix C to subsection 3.8.4 of this SRP section is reviewed.

e. Structural Audit

A structural audit is conducted.

5. Structural Acceptance Criteria

The design limits imposed on the various parameters that serve to quantify the structural behavior of the various interior structures of the containment are reviewed, specifically with respect to stresses, strains, deformations, and factors of safety against structural failure, with emphasis on the extent of compliance with the applicable codes as indicated in subsection I.3 of this SRP section.

6. Materials, Quality Control, and Special Construction Techniques

Information provided on the materials that are used in the construction of the containment internal structures is reviewed. Among the major materials of construction that are reviewed are the concrete ingredients, reinforcing bars and splicers, and structural steel and various supports and anchors.

The quality control program that is proposed for the fabrication and construction of the containment interior structures is reviewed including nondestructive examination of the materials to determine physical properties, placement of concrete, and erection tolerances.

Special, new, or unique construction techniques, if proposed, are reviewed on a case-by-case basis to determine their effects on the structural integrity of the completed interior structure.

In addition, the following information should be provided.

(a) The extent to which the materials and quality control programs comply with the "Code Requirements for Nuclear Safety-Related Concrete Structures" ACI 349 (Ref. 2), for concrete, and with the AISC "Specifications for Design, Fabrication and Erection of Structural Steel for Buildings," (Ref. 3), for steel, as applicable.

(b) For quality control in general, the extent to which the applicant complies with ANSI N45.2.5 (Ref. 7).

(c) If welding of reinforcing bars is proposed, the extent to which the applicant complies with the applicable sections of the ASME Section III, Division 2 Code should be described and any exceptions taken should be justified.

7. Testing and Inservice Surveillance Programs

If applicable, any post-construction testing and in-service surveillance programs are reviewed on a case-by-case basis.

The structural test for the drywell of the BWR Mark III containment is reviewed in a similar manner to that of the containment.

SEB coordinates other branches evaluations that interface with structural engineering aspects of the review as follows: determination of structures which are subject to quality assurance programs in accordance with the requirements of Appendix B to 10 CFR Part 50 is performed by the Mechanical Engineering Branch (MEB) as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2. SEB will perform its review of safety-related structures on that basis. Determination of pressure loads from high energy lines located in safety related structures other than containment is performed by the Auxiliary Systems Branch (ASB) as described as part of its primary review responsibility for SRP Section 3.6.1. SEB accepts the loads thus generated as approved by the ASB to be included in the load combination equations of this SRP section. Determination of loads generated due to pressure under accident conditions is performed by the Containment Systems Branch (CSB) as part of its primary review responsibility for SRP Section 6.2.1. SEB accepts the loads thus generated, as

approved by the CSB to be included in the load combinations in this SRP section. The review for Quality Assurance is coordinated and performed by the Quality Assurance Branch as part of its primary review responsibility for SRP Section 17.0.

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

SEB acceptance criteria for the design of the containment and containment internal structures are based on meeting the relevant requirements of the following regulations:

A. 10 CFR Part 50.55a and General Design Criterion 1 as they relate to the containment and structures being designed, fabricated, executed, and tested to quality standards commensurate with the importance of the safety function to be performed.

B. General Design Criterion 2 as it relates to the design of the containment and containment internal structures being capable to withstand the most severe natural phenomena such as wind, tornadoes, floods, and earthquakes and the appropriate combination of all loads.

C. General Design Criterion 4 as it relates to the containment and containment internal structure being capable of withstanding the dynamic effects of equipment failures including missile pipe whips and blowdown loads associated with the loss of coolant accidents.

D. General Design Criterion 5 as it relates to sharing of structures important to safety unless it can be shown that such sharing will not significantly impair their validity to perform their safety functions.

E. General Design Criterion 50 as it relates to the containment and containment internal structures being designed with sufficient margin of safety to accommodate appropriate design loads.

The Regulatory Guides and industry standards identified in item 2 of this subsection provides information, recommendations and guidance and in general describes a basis acceptable to the staff that may be used to implement the requirements of 10 CFR Part 50, § 50.55a and GDC 1, 2, 4, 5 and 50. Also, specific acceptance criteria necessary to meet the relevant requirements of these regulations for the areas of review; described in subsection I of this SRP section are as follows:

1. Description of the Internal Structures

The descriptive information in the SAR is considered acceptable if it meets the minimum requirements set forth in Section 3.8.3.1 of the "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," (Ref. 8).

Deficient areas of descriptive information are identified by the reviewer and a request for additional information is initiated at the application acceptance review. New or unique design features that are not specifically covered in the "Standard Format" may require a more detailed review. The reviewer determines if additional information is required to accomplish a meaningful review of the structural aspects of such new or unique features.

2. Applicable Codes, Standards, and Specifications

The design, materials, fabrication, erection, inspection, testing, and in-service surveillance, if any, of interior structures of containments are covered by the following codes, standards, and guides that are either applicable in their entirety or in portions thereof.

Code, Standard, or Specification	Title
ACI 349	Code Requirements for Nuclear Safety-Related Concrete Structures
ASME	Code for Concrete Vessels and Containments, ASME Boiler and Pressure Vessel Code, Section III, Division 2
ASME	Boiler and Pressure Vessel Code, Section III, Subsections NE and NF
AISC	Specification for the Design, Fabrication and Erection of Structural Steel for Buildings
ANSI N45.2.5	Supplementary Quality Assurance Requirements for Installation, Inspection and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants
Regulatory Guides	
1.10	Mechanical (Caldwell) Splices in Reinforcing Bars of Category I Concrete Structures
1.15	Testing of Reinforcing Bars for Category I Concrete Structures
1.55	Concrete Placement in Category I Structures
1.57	Design Limits and Loading Combinations for Metal Primary Reactor Containment
1.94	Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete and Structural Steel During the Construction phase of Nuclear Power Plants.

1.142 Safety-Related Concete Structures for Nuclear Power Plants.

3. Loads and Load Combinations

With the exception of the divider-barrier and ice-condenser elements of the ice-condenser PWR containment and the drywell of the BWR Mark III containment, the loads and load combinations for all other containment interior structures described in subsection I.1 of this SRP section, are acceptable if found in accordance with the following:

a. Loads, Definitions, and Nomenclature

All the major loads to be encountered or to be postulated are listed below. All the loads listed, however, are not necessarily applicable to all the interior structures. Loads and the applicable load combinations for which each structure has to be designed will depend on the conditions to which that particular structure could be subjected.

Normal loads, which are those loads to be encountered during normal plant operation and shutdown, include:

D - Dead loads or their related internal moments and forces, inluding any permanent equipment loads and hydrostatic loads. For equipment supports, it also includes static and dynamic head and fluid flow effects.

L - Live loads or their related internal moments and forces, including any movable equipment loads and other loads which vary with intensity and occurrence. For equipment supports, it also includes loads due to vibration and any support movement effects.

T_o - Thermal effects and loads during normal operating or shutdown conditions, based on the most critical transient or steady state condition.

R_o - Pipe reactions during normal operating or shutdown conditions, based on the most critical transient or steady state condition.

Severe environmental loads include:

E - Loads generated by the operating basis earthquake.

Extreme environmental loads include:

E' - Loads generated by the safe shutdown earthquake.

Abnormal loads, which are those loads generated by a postulated high-energy pipe break accident, include:

P_a - Pressure equivalent static load within or across a compartment generated by the postulated break, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

T_a - Thermal loads under thermal conditions generated by the postulated break and including T_o.

R_a - Pipe reactions under thermal conditions generated by the postulated break and including R_o.

Y_r - Equivalent static load on the structure generated by the reaction on the broken high-energy pipe during the postulated break, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

Y_j - Jet impingement equivalent static load on a structure generated by the postulated break, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

Y_m - Missile impact equivalent static load on a structure generated by or during the postulated break, as from pipe whipping, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

In determining an appropriate equivalent static load for Y_r, Y_j, and Y_m, elasto-plastic behavior may be assumed with appropriate ductility ratios, provided excessive deflections will not result in loss of function of any safety-related system.

For structures or structural components subjected to hydrodynamic loads resulting from LOCA and/or SRV actuation, the consideration of such loads should be as indicated in the Appendix to SRP Section 3.8.1 fluid structure interaction associated with these hydrodynamic loads and those from earthquakes should be taken into account.

b. Load Combinations for Concrete Structures

For concrete interior structures, the load combinations are acceptable if found in accordance with the following:

(i) For service load conditions, either the working stress design (WSD) method as outlined in ACI 318 code or the strength design method may be used.

(a) If the WSD method is used, the following load combinations should be considered:

(1) $D + L$

(2) $D + L + E$

If thermal stresses due to T_o and R_o are present, the following combinations should be also considered:

(3) $D + L + T_o + R_o$

(4) $D + L + T_o + R_o + E$

Both cases of L having its full value or being completely absent should be checked.

(b) If the strength design method is used, the following load combinations should be considered:

(1) $1.4D + 1.7L$

(2) $1.4D + 1.7L + 1.9E$

If thermal stresses due to T_o and R_o are present, the following combinations should also be considered:

(3) $(0.75) \quad (1.4D + 1.7L + 1.7T_o + 1.7R_o)$

(4) $(0.75) \quad (1.4D + 1.7L + 1.9E + 1.7T_o + 1.7R_o)$

(ii) For factored load conditions, which represent extreme environmental, abnormal, abnormal/severe environmental, and abnormal/extreme environmental conditions, the strength design method should be used and the following load combinations should be considered:

(1) $D + L + T_o + R_o + E'$

(2) $D + L + T_a + R_a + 1.5\ P_a$

(3) $D + L + T_a + R_a + 1.25\ P_a + 1.0\ (Y_r + Y_j + Y_m) + 1.25E$

(4) $D + L + T_a + R_a + 1.0\ P_a + 1.0\ (Y_r + Y_j + Y_m) + 1.0\ E'$

In combinations (2), (3), and (4), the maximum values of P_a, T_a, R_a, Y_j, Y_r, and Y_m, including an appropriate dynamic load factor, should be used unless a time-history analysis is performed to justify otherwise. Combinations (3) and (4) and the corresponding structural acceptance criteria of subsection II.5 of this SRP section should first be satisfied without Y_r, Y_j, and Y_m. When considering these loads, local section strength capacities may be exceeded under these concentrated loads, provided there will be no loss of function of any safety-related system.

Both cases of L having its full value or being completely absent should be checked.

c. <u>Load Combinations for Steel Structures</u>

For steel interior structures, the load combinations are acceptable if found in accordance with the following:

(i) For service load conditions, either the elastic working stress design methods for Part 1 of AISC, or the plastic design methods of Part 2 of AISC, may be used.

(a) If the elastic working stress design methods are used:

(1) $D + L$

(2) $D + L + E$

If thermal stresses due to T_o and R_o are present, the following combinations should be also considered:

(3) $D + L + T_o + R_o$

(4) $D + L + T_o + R_o + E$

(b) If the plastic design methods are used:

(1) $1.7D + 1.7L$

(2) $1.7D + 1.7L + 1.7E$

If thermal stresses due to T_o and R_o are present, the following combinations should also be considered:

(3) $1.3 (D + L + T_o + R_o)$

(4) $1.3 (D + L + E + T_o + R_o)$

(ii) For factored load conditions the following load combinations should be considered:

(a) If the elastic working stress design methods are used:

(1) $D + L + T_o + R_o + E'$

(2) $D + L + T_a + R_a + P_a$

(3) $D + L + T_a + R_a + P_a + 1.0 (Y_r + Y_j + Y_m) + E$

(4) $D + L + T_a + R_a + P_a + 1.0 (Y_r + Y_j + Y_m) + E'$

(b) If the plastic design methods are used:

(1) $D + L + T_o + R_o + E'$

(2) $D + L + T_a + R_a + 1.5 P_a$

(3) $D + L + T_a + R_a + 1.25 P_a + 1.0 (Y_r + Y_j + Y_m) + 1.25 E$

(4) $D + L + T_a + R_a + 1.0 P_a + 1.0 (Y_r + Y_j + Y_m) + 1.0 E'$

In the above combinations, thermal loads can be neglected when it can be shown that they are secondary and self-limiting in nature.

In combinations (2), (3), and (4), the maximum values of P_a, T_a, R_a, Y_j, Y_r, and Y_m, including an appropriate dynamic load factor, should be used unless a time-history analysis is performed to justify otherwise. Combinations (3) and (4) and the corresponding structural acceptance criteria of subsection II.5

of this SRP section should first be satisfied without Y_r, Y_j, and Y_m. When considering these loads, local section strength capacities may be exceeded under these concentrated loads, provided there will be no loss of function of any safety-related system..

For the divider barrier, ice-condenser elements and the Mark III containment drywell, the loading criteria are acceptable if found in accordance with the following:

d. Divider barrier

As the structural integrity of the divider barrier and, to a certain extent, its leak-tight integrity as well, are important to the proper functioning of the ice-condenser containment system, it is treated for design purposes similar to the containment itself.

Accordingly, for concrete pressure-resisting portions of the divider barrier, the loads and load combinations of Article CC-3000 of ASME Section III Division 2 Code (Ref. 4) will apply, with the following exceptions.

For Table CC-3230-1

(i) In the third combination 0.5 under E_{ss} should be replaced by the word "or."

(ii) It should be indicated that the maximum values of P_a, T_a, R_a, R_r, including an appropriate dynamic load factor, should be applied simultaneously, unless a time-history is performed to justify otherwise.

Steel portions of the divider barrier which resist the design differential pressure and are not backed by concrete, such as penetrations, hatches, locks and guard pipes, should be designed in accordance with the appropriate sections of Subsection NE of the ASME Code, Section III, Division 1, (Ref. 5), together with the applicable loads, load combinations, and acceptance criteria of Regulatory Guide 1.57 (Ref. 9).

e. Ice-Condenser Elements

In the ice-condenser containment system the structural integrity of the ice baskets, ice bed framing, and their supports, is important to the functional integrity of the containment system. The major loads that are applicable to the ice-condenser elements are: D, L, E, E', and P_a. For this structure, P_a is the LOCA pressure load induced by drag and change in momentum of the flowing air and steam. Load combinations for the ice-condenser elements are acceptable if found in accordance with the following:

(i) For service load conditions, if elastic working stress design methods are used:

(1) D + L

(2) $D + L + E$

(ii) For service load conditions, if plastic design methods are used:

(1) $1.7 D + 1.7 L$

(2) $1.7 D + 1.7 L + 1.7 E$

(iii) For service load conditions, if an experimental test verification of the design is used:

(1) $1.9 D + 1.9 L$

(2) $1.9 D + 1.9 L + 1.9 E$

If thermal stresses are significant and have to be considered, an acceptable procedure for accounting for such thermal loads is contained in item (a) of Subarticle NF-3231.1 of Subsection F of the ASME Code, Section III, Division 1 (Ref. 1).

(iv) For factored load conditions, if elastic working stress design methods are used:

(3) $D + L + E'$

(4) $D + L + P_a$

(5) $D + L + P_a + E'$

(v) For factored load coditions, if plastic design methods are used:

(3) $1.3 D + 1.3 L + 1.3 E'$

(4) $1.3 D + 1.3 L + 1.3 P_a$

(5) $1.2 D + 1.2 L + 1.2 P_a + 1.2 E'$

(vi) For factored load conditions, if an experimental test verification of the design is used:

(3) $1.4 D + 1.4 L + 1.4 E'$

(4) $1.4 D + 1.4 L + 1.4 P_a$

(5) $1.3 D + 1.3 L + 1.3 P_a + 1.3 E'$

f. BWR Mark III Containment Drywell

As the structural integrity of the drywell and, to a certain extent, its leak-tight integrity as well, are critically important to the proper functioning of the Mark III pressure-suppression system, the drywell is treated, for design and testing purposes only, similar to the containment itself.

Accordingly, for concrete pressure-resisting portions of the drywell, the loads and loading combinations of Article CC-3000 of ASME Code Section III, Division 2 (Ref. 4) will apply, with the exceptions listed for concrete portions of the PWR ice-condenser divider barrier.

For steel components of the drywell that resist pressure and are not backed by concrete, such as the drywell head, the appropriate sections of Subsection NE of the ASME Code, Section III, Division 1, (Ref. 5) should be used together with the applicable loads, load combinations, and acceptance criteria of Regulatory Guide 1.57 (Ref. 11). Specifically, the load combinations of subsection II.3 of Standard Review Plan Section 3.8.2 apply.

For the lower vent portion of the drywell:

(i) If the main reinforcement of the drywell is carried down between the vent holes and the reinforced concrete section is relied upon for structural purposes, the criteria that apply to concrete portions of the drywell as described above will apply.

(ii) If the main reinforcement of the drywell is terminated above the vent holes and two steel plates lining both faces of the drywell are a line utilized for structural purposes, the criteria that apply to steel portions of the drywell as described above will apply.

(iii) If other structural systems are used in the vent region, the loads and load combinations are reviewed and judged on a case-by-case basis.

4. <u>Design and Analysis Procedures</u>

The design and analysis procedures utilized for the interior structures of the containment are acceptable if found in accordance with the following:

a. <u>For PWR Dry Containment Internal Structures</u>

(i) <u>Primary Shield Wall and Reactor Cavity</u>

The design and analysis procedures utilized for the shield wall are acceptable if in accordance with the ACI 349 Code (Ref. 2). This code is based on the strength design method. However, the use of ACI 318 Code working stress design method where actual elastic/linear stresses in the concrete and reinforcement are determined and compared with their corresponding allowables, is considered acceptable.

Analyses for loss-of-coolant accident loads applicable to the primary shield wall, such as for the cavity differential pressure combined with pipe rupture reaction forces, are acceptable if these loads are treated as dynamic time-dependent loads whereby either a detailed time-history analysis is performed, or a static analysis utilizing the peak of the forcing function amplified by an appropriate chosen dynamic factor is utilized. Elastic behavior of the wall should be maintained under the

differential pressure. However, for the concentrated accident loads such as Y_r or Y_j, elasto-plastic behavior may be assumed as long as the deflections are limited to maintain functional requirements. Simplified methods for determining effective dynamic load factors for elastic behavior are acceptable if in accordance with recognized dynamic analysis methods.

(ii) Secondary Shield Walls

Design and analysis procedures utilized for the secondary shield walls are acceptable if in accordance with conventional beam/slab design and analysis procedures described in the ACI 349 Code (Ref. 2).

Similar to the primary shield wall, the secondary shield walls are also subject to dynamic loss-of-coolant accident loads and the same methods described in item (i) above are, therefore, applicable and acceptable.

(iii) Other Interior Structures

Most of the other interior structures that are reviewed are combinations of reinforced concrete slabs, walls, beams, and columns, and steel beams and columns, which are classified as Category I structures subject to the loads and load combinations described in subsection II.3 of this SRP section. Analytical techniques for these structures are acceptable if found in accordance with those described in the ACI 349 Code for concrete and with those in the AISC specifications for steel.

b. For PWR Ice-condenser Containment Internal Structures

(i) Divider Barrier

The most important loads that usually govern the design of the divider barrier are those induced by the loss-of-coolant accident, including the differential pressure across the barrier and any concentrated jet impingement loads. As the divider barrier is a combination of walls and slabs framed together, the design and analysis procedures are acceptable if in accordance with the ACI 318 Code for the concrete portions of the divider barrier. These methods are based on the elastic/linear working stress design method where actual stresses are determined.

For steel portions of the divider barrier that resist pressure but are not backed by structural concrete, the design and analysis procedures are acceptable if found in accordance with the applicable provisions of Subsection NE of the ASME Code, Section III, Division 1.

(ii) Ice-condenser Elements

The design and analysis procedures for the ice-condenser and its various components are acceptable if in accordance with either the elastic/linear design method of Part 1 of the AISC

Specifications or with the plastic design method of Part 2 of the same Specifications. For components where experimental testing is utilized to verify the design, the testing procedures are acceptable if in accordance with recognized protoype or model testing procedures where the effect of scaling and similitude are taken into consideration.

c. For BWR Containment Internal Structures

(i) Drywell

The design and analysis procedures utilized for concrete portions of the drywell are acceptable if in accordance with subsection II.4 of Standard Review Plan Section 3.8.1. For steel portions of the drywell that resist pressure but are not backed by structural concrete, the design and analysis procedures are acceptable if found in accordance with the applicable provisions of Subsection NE of the ASME Code, Section III, Division 1.

(ii) Weir Wall

One of the major loads to which the weir wall may be subjected is a jet impingement load induced by a pipe rupture in a nearby recirculation loop. The deflection of the wall under such a load must be limited so as not to impair the pressure-suppression performance. The procedures utilized to analyze the wall for such a dynamic time-dependent load are acceptable if a detailed time-history dynamic analysis is performed or if an equivalent static analysis is performed utilizing the peak of the jet load amplified by an appropriately chosen dynamic load factor.

(iii) Refueling Pool and Operating Floor

The refueling pool and the operating floor, wich may be supported on the walls of the refueling pool on one side and on the containment shell on the other side, are a combination of reinforced concrete and structural steel. The design and analysis procedures are acceptable if found in accordance with conventional methods described in the ACI 349 Code for concrete and in the AISC Specifications for structural steel.

(iv) Concrete Supports for Reactor

The linear support system for the reactor vessel, described in subsection I of this SRP section, should be designed to resist various combinations of loadings as indicated in subsection II.3 of this SRP section. Among the major loads that should be considered are normal operating loads, seismic loads, and loss-of-coolant accident loads.

(v) Reactor Pedestal

The reactor pedestal, which supports the reactor and has to withstand the loads transmitted through the reactor supports, should be subjected to most of the loads described in

subsection II.3 of this SRP section and should be designed for all applicable load combinations.

The design and analysis procedures are acceptable if found to be similar to those referenced for the primary shield wall of PWR containments in paragraph (i) under PWR dry containments.

(vi) Reactor Shield Wall

This cylindrical wall, which surrounds the reactor and provides biological shielding, should be subjected to most of the loads described in subsection II.3 of this SRP section. In most cases, the wall is utilized to anchor most of the pipe restraints placed around the reactor coolant system piping. A pipe rupture in the vicinity of the reactor nozzles may pressurize the space within the wall. The wall may be lined on both faces with steel plates which may constitute the major structural elements relied upon to resist the design loads.

Similar to the reactor pedestal, the biological shield all is also subjected to dynamic loss-of-coolant accident loads and the same methods are, therefore, applicable and acceptable.

(vii) Miscellaneous Platforms

Platforms inside the drywell are usually of structural steel and their main structural function is to provide foundations for the pipe restraints inside the drywell. Platforms outside the drywell are usually combinations of steel and concrete. The analytical and design procedures for these platforms are acceptable if in accordance with the ACI 349 Code for reinforced concrete, and with the AISC Specifications for structural steel. Of particular interest are the dynamic loads induced on these floors by pool swell during a LOCA.

Computer programs used in the design and analysis of containment interior structure should be described and validated by any of the procedures described in subsection II.4.e of Standard Review Plan Section 3.8.1.

d. Structural audit is conducted as described in Appendix B to SRP Section 3.8.4.

e. Design report is considered acceptable if it satisfies the guidelines of Appendix C to SRP Section 3.8.4.

5. Structural Acceptance Criteria

With the exception of the divider barrier and ice-condenser elements of the ice condenser PWR containment, and the drywell of the BWR Mark III containment, the structural acceptance criteria for all other interior structures of the containment described in subsection I.1 of this SRP section are acceptable if found in accordance with the following:

For each of the loading combinations delineated in the beginning of subsection II.3 of this SRP section, the following defines the allowable limits which constitute the structural acceptance criteria:

In Combinations for Concrete Internal Structures		Limit
b(i)(a)	(1), (2).	S[1]
b(i)(a)	(3), (4).	1.3 S
b(i)(b)	(1), (2).	U[2]
b(i)(b)	(3), (4).	U
(b)(ii)	(1), (2), (3), (4).	U

In Combinations for Steel Internal Structures		Limit
c(i)(a)	(1), (2).	S[1]
c(i)(a)	(3), (4).	1.5 S
c(i)(b)	(1), (2).	Y[3]
c(i)(b)	(3), (4).	Y
c(ii)(a)	(1), (2), (3)[4].	1.6 S
c(ii)(a)	(4)[4].	1.7 S
c(ii)(b)	(1), (2), (3), (4).	0.9 Y

Notes

(1) S - For concrete structures, S is the required section strength based on the working stress design method and the allowable stresses of ACI 318 Code.

For structural steel, S is the required section strength based on the elastic design methods and the allowable stresses defined in Part 1 of the AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings."

The 33-1/3% increase in allowable stresses for steel due to seismic loadings is not permitted.

(2) U - For concrete strcutres, U is the section strength required to resist design loads based on the strength design methods described in ACI 349 Code with the exception of divider barrier.

(3) Y - For structural steel, Y is the section strength required to resist design loads and based on plastic design methods described in Part 2 of the AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings."

(4) - For these two combinations, in computing the required section strength, S, the plastic section modulus of steel shapes may be used.

For the divider barrier, ice-condenser elements, and the drywell, the structural acceptance criteria are acceptable if found in accordance with the following:

a. Divider Barrier

(i) For concrete portions of the divider barrier, the specified limits for stresses and strains are acceptable if found in accordance with Subsection CC3430 of ASME Code Section III, Division 2. The 33-1/3% increase in allowable stresses is permitted only for temperature loads and not for OBE seismic or wind loads.

(ii) For steel portions of the divider barrier which resist the design differential pressure and are not backed by concrete, the design should be similar to that of steel containments. Accordingly, the load combinations and stress limits of subsection II.3 of Standard Review Plan Section 3.8.2 apply.

b. Ice-Condenser Elements

For load combination delineated in subsection II.3 of this SRP section for the ice-condenser elements, the stress limits are acceptable if found in accordance with the following:

For Combinations		Limit
e(i)	(1), (2).	S(1)
e(ii)	(1), (2).	Y(2)
e(iii)	(1)	C(3)
e(iv)	(3), (4).	1.3S
e(iv)	(5)	1.6S
e(v)	(3), (4), (5)	Y
e(vi)	(3), (4), (5)	C

Notes

(1) S - As defined in "Notes" under first tables in Subsection II.5 above.

(2) Y - As defined in "Notes" under first tables in Subsection II.5 above.

(3) C - Where experimental testing is used for verification of the design, C shall be the ultimate load carrying capacity of the member. Size effects and any similitude relationship which may exist between the actual component and the test model shall be accounted for in the evaluation of C.

c. BWR Mark III Containment Drywell

(i) For concrete portions of the drywell, the acceptance criteria of item II.3.d.(a)(i) as described for the divider barrier apply.

(ii) For steel portions of the drywell that resist pressure and are not backed by structural concrete, the acceptance criteria of item II.3.d(a)(ii) as described for the divider barrier apply.

(iii) For the lower vent portion of the drywell:

- If the main reinforcement of the drywell is carried down between the vent holes and the reinforced concrete section is relied upon for structural purposes, the structural acceptance criteria is the same as for item (i) above.

- If the main reinforcement of the drywell is terminated above the vent holes and two steel plates lining both faces of the wall are utilized for structural purpoes, the acceptance criteria for item (ii) above will apply.

- If other structural systems are used in the vent region, the acceptance criteria are reviewed on a case-by-case basis.

6. Materials, Quality Control, and Special Construction Techniques

The specified materials of construction and quality control programs are acceptable if in accordance with the public code or standard as indicated in subsection I.6 of this SRP section.

Special construction techniques, if any, are treated on a case-by-case basis.

7. Testing and In-Service Surveillance Requirements

Each BWR Mark II containment drywell should be subjected to a structural proof test. Such a test is acceptable if in accordance with the following:

a. The drywell should be subjected to an acceptance test that increases the drywell internal pressure in three or more approximately equal pressure increments from atmospheric pressure to at least the design pressure. The drywell should be depressurized in the same number of increments. Measurements should be recorded at atmospheric pressure and at each pressure level of the pressurization and depressurization cycles. At each level, the pressure should be held constant for at least one hour before the deflections and strains are recorded.

b. So that the overall deflection pattern can be determined in prototype drywells, radial deflections should be measured at least three points along each of at least three meridians equally spaced around the drywell, including locations with varying stiffness characteristics. Radial deflections should be measured at the lower vent region, at about mid-height and at near the top of the cylindrical

wall. The measurement points may be relocated depending on the distribution of stresses and deformations anticipated in each particular design.

c. In prototype drywells only, strain measurements sufficient to permit an evaluation of strain distribution should be recorded at least at two opposing meridians at the following locations on the wall:

(1) at the bottom of the wall, and

(2) at mid-height of the wall.

These strain measurements should be made at least at three positions within the wall section; one at the center and one each near the inner and outer surfaces.

d. In nonprototype drywells, deflection and strain measurements need not be made if strain levels have been correlated with deflection measurements during the acceptance test of a prototype drywell if measured strains and deflections are within the predefined tolerance of their predicted responses.

e. Any reliable system of displacement meters, optical devices, strain gauges, or other suitable apparatus may be used for the measuremens.

f. If the test pressure drops due to unexpected conditions to or below the next lower pressure level, the entire test sequence should be repeated. Significant deviations from the previous test should be recorded and evaluated.

g. If any significant modifications or repairs are made to the drywell following and because of the initial test, the test should be repeated.

h. A description of the proposed acceptance test and instrumentation requirements should be included in the preliminary safety analysis report.

i. The following information should be submitted prior to the performance of the test:

(i) The numerical values of the predicted responses of the structure which will be measured.

(ii) The tolerances to be permitted on the predicted responses.

(iii) The bases on which the predicted responses and the tolerances thereon were established.

j. The following information should be included in the final test report:

(i) A description of the actual test and instrumentation.

(ii) A comparison of the test measurements with the allowable limits (predicted response plus tolerance) for deflections and strains.

(iii) An evaluation of the accuracy of the measurements.

(iv) An evaluation of any deviations (i.e., test results that exceed the allowable limits), the disposition of the deviations, and the need for corrective measures.

(v) A discussion of the calculated safety margin provided by the structure as deduced from the test results.

For steel linear supports of the reactor coolant system, testing and in-service surveillance requirements are acceptable if in accordance with Subsection NF of the ASME Section III Code, Division 1.

III. REVIEW PROCEDURES

The reviewer selects and emphasizes material from the review procedures described below, as may be appropriate for a particular case.

1. Description of the Internal Structures

After each structure and its functional characteristics are identified, information or similar structures of previously licensed applications is obtained for reference. Such information, which is available in safety analysis reports and amendments of licensed plants enables identification of differences for the case under review which require additional scrutiny. New or unique features that have not been used in the past are of particular interest. The information furnished in the SAR is reviewed for sufficiency in accordance with the "Standard Format. . ." A decision is then made with regard to the sufficiency of the descriptive information provided in the SAR. Any additional required information is requested from the applicant at an early stage of the review process.

2. Applicable Codes, Standards, and Specifications

The list of codes, standards, guides, and specifications is checked against the list in subsection II.2 of this SRP section. The reviewer assures himself that the applicable edition and stated effective addenda are utilized.

3. Loads and Loading Combinations

The reviewer verifies that the loads and load combinations are as conservative as those specified in subsection II.3 of this SRP section. Any deviations from the acceptance criteria for loads and load combinations that have not been adequately justified are identified as unacceptable and transmitted to the applicant for further consideration.

4. Design and Analysis Procedures

The reviewer familiarizes himself with the design and analysis procedures that are generally utilized for the type of structures being reviewed. Since the assumptions made on the expected behavior of the structure and its various elements under loads may be significant, the reviewer determines that they are conservative. The behavior of the structure under various loads and the manner in which these loads are treated in conjunction with other coexistent loads, are reviewed to establish

compliance with procedures delineated in subsection II.4 of this SRP section.

5. <u>Structural Acceptance Criteria</u>

The limits on allowable stresses and strains in the concrete, reinforcement, structural steel, etc., are compared with those specified in subsection II.5 of this SRP section. Where the applicant proposes to exceed some of these limits for some of the load combinations and at some localized points on the structure, the justification provided to show that the functional integrity of the structure will not be affected is evaluated. If such justification is not acceptable, a request for the required additional justification and bases are made.

6. <u>Materials, Quality Control, and Special Construction Techniques</u>

The information provided on materials, quality control programs, and special construction techniques, if any, is reviewed and compared with that specified in subsection II.6 of this SRP section. If a new material not used in prior license applications is utilized, the applicant is requested to provide sufficient test and user data to establish the acceptability of such a material. Similarly, any new quality control programs or construction techniques are reviewed and evaluated to assure that there will be no degradation of structural quality that might affect the structural integrity of the structure.

7. <u>Testing, and In-service Surveillance Requirements</u>

Procedures for the structural test of the BWR Mark III containment drywell are reviewed and compared with the procedures described in subsection II.7 of this SRP section. Any other proposed testing and in-service surveillance programs are reviewed on a case-by-case basis.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided in accordance with the requirements of this review plan, and concludes that his evaluation is sufficiently complete and adequate to support the following type of conclusive statement to be included in the staff's safety evaluation report:

The staff concludes that the design of the containment internal structures are acceptable and meets the relevant requirements of 10 CFR Part 50, §50.55a, and General Design Criteria 1, 2, 4, 5, and 50. This conclusion is based on the following:

1. The applicant has met the requirements of Section 50.55a and GDC 1 with respect to assuring that the containment internal structures are designed, fabricated, erected, constructed, tested and inspected to quality standards commensurate with its safety function to be performed by meeting the guidelines of Regulatory Guides and industry standards indicated below.

2. The applicant has met the requirements of GDC 2 by designing the containment internal structure to withstand the most severe earthquake that has been established for the site with sufficient margin and the

combinations of the effects of normal and accident conditions with the effects of environmental loadings such as earthquakes and other natural phenomena.

3. The applicant has met the requirements of GDC 4 by assuring that the design of the internal structures are capable of withstanding the dynamic effects associated with missiles, pipe whipping and discharging fluids.

4. The applicant has met the requirements of GDC 5 by demonstrating that structure systems and components are not shared between units or that if shared they have demonstrated that sharing will not impair their ability to perform their intended safety function.

5. The applicant has met the requirements of GDC 50 by designing the containment internal structures to accommodate, with sufficient margin, the design leakage rate, calculated pressure and temperature conditions resulting from accident conditions and by assuring that the design conditions are not exceeded during the full course of the accident condition. In meeting these design requirements, the applicant has used the recommendations of Regulatory Guides and industry standards indicated below. The applicant has also performed appropriate analysis which demonstrate the ultimate capacity of the structures will not be exceeded and establishes the minimum margin of safety for the design.

   The criteria used in the design, analysis, and construction of the containment internal structures to account for anticipated loadings and postulated conditions that may be imposed during the structures during their service lifetime are in conformance with established criteria, and with codes, standards, and specifications acceptable to the Regulatory staff. These include meeting the positions of Regulatory Guides 1.10, 1.15, 1.55, 1.57, 1.94 and 1.142 and industry standards ACI-349, ASME, "ASME Boiler and Pressure Vessel Code, Section III, Division 2, Code for Concrete Reactor Vessels and Containments," ASME, "Boiler Pressure Vessel Code, Section III, Subsections NE and NF," AISC, "Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings and ANSI N45.2.5.

   The use of these criteria as defined by applicable codes, standards, and specifications, the loads and loading combinations; the design and analysis procedures; the structural acceptance criteria; the materials, quality control programs, and special construction techniques; and the testing and in-service surveillance requirements provide reasonable assurance that, in the event of earthquakes and various postulated accidents occurring within the containment, the interior structures will withstand the specified design conditions without impairment of structural integrity or the performance of required safety functions.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

VI. REFERENCES

1. ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NF, "Requirements for Component Supports," American Society of Mechanical Engineers.

2. ACI 349, "Requirements for Nuclear Safety-Related Structures," American Concrete Institute.

3. AISC, "Specification for Design, Fabrication and Erection of Structural Steel for Buildings," American Institute of Steel Construction.

4. ASME Boiler and Pressure Vessel Code, Section III, Division 2 (ACI-359), "Code for Concrete Reactor Vessels and Containments," American Society of Mechanical Engineers.

5. ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NE, "Class MC Components," American Society of Mechanical Engineers.

6. Regulatory Guide 1.10, "Mechanical (Cool Weld) Splices in Reinforcing of Category I Concrete Structures."

7. Regulatory Guide 1.15, "Testing of Reinforcing Basis for Category I Concrete Structures."

8. Regulatory Guide 1.55, "Concrete Placement in Category I Structures."

9. ANSI N45.2.5, "Supplementary Quality Assurance Requirements for Installation, Inspection and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants," American National Standards Institute.

10. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants."

11. Regulatory Guide 1.57, "Design Limits and Loading Combinations for Metal Primary Reactor Containment System Components."

12. Regulatory Guide 1.94, "Quality Assurance Requirements for Installation Inspection and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants."

13. Regulatory Guide 1.142, "Safety-Related Concrete Structures for Nuclear Power Plants."

14. 10 CFR Part 50, §50.55a, Codes and Standards.

15. 10 CFR Part 50, Appendix A, General Design Criterion 1, "Quality Standards and Records."

16. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

17. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Missile Design Bases."

18. 10 CFR Part 50, Appendix A, General Design Criterion 5, "Sharing of Structures,"

19. 10 CFR Part 50, Appendix A, General Design Criterion 50, "Containment Design Bases."