NUREG-0800
(Formerly NUREG-75/087)

U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

3.8.2 STEEL CONTAINMENT

REVIEW RESPONSIBILITIES

Primary - Structural Engineering Branch (SEB)

Secondary - None

I. AREAS OF REVIEW

The following areas relating to steel containments or to other Class MC steel portions of steel/concrete containments, as applicable, are reviewed.

1. Description of the Containment

a. The descriptive information, including plans and sections of the structure, is reviewed to establish that sufficient information is provided to define the primary structural aspects and elements relied upon to perform the containment function. In particular, the type of steel containment is identified and its structural and functional characteristics are examined. Among the various types of steel containments reviewed are:

(i) Steel BWR containments utilizing the pressure-suppression concept, including the Mark I (lightbulb/torus), the Mark II (over/under), and the Mark III (with horizontal venting between a centrally located cylindrical drywell and a surrounding suppression pool).

(ii) Steel PWR containments utilizing the pressure-suppression concept with ice-condenser elements.

(iii) Steel PWR dry containments.

Various geometries have been utilized for these containments. The geometry most commonly encountered, however, is an upright cylinder topped with a dome and supported on either a flat concrete base mat covered with a liner plate, or on a concrete foundation built around the bottom portion of the steel shell, which is an inverted dome. Although applicable to any geometry, the specific provisions of this SRP section are best suited to the cylindrical-type steel containment surrounded by a Category I concrete shield building. If containments with other types of geometry are reviewed, the necessary modifications to this SRP section are made on a case-by-case basis.

The geometry of the containment is reviewed, including sketches showing plan views at various elevations and sections in at least two orthogonal directions. The arrangement of the containment and the relationship and interaction of the shell with its surrounding shield building and with its interior compartments, walls and floors, are reviewed to determine the effect which these structures could have upon the design boundary conditions and the expected behavior of the shell when subjected to the design loads.

b. General information related to the containment shell is reviewed including the following:

(i) The foundation of the steel containment including the following;

(a) *If the bottom of the steel containment is continuous* through an inverted dome, the method by which the inverted dome and its supports are anchored to the concrete foundation, which is covered by Standard Review Plan Section 3.8.5, is reviewed.

(b) If the bottom of the steel containment is not continuous, and where a concrete base slab topped with a liner plate is used for a foundation, the extent of descriptive information reviewed for the foundation is contained and is reviewed as stated in subsection I.1 of Standard Review Plan Section 3.8.1. Further, the method of anchorage of the steel cylindrical shell walls in the concrete base slab is reviewed, particularly the connection between the floor liner plate and the steel shell.

(ii) The cylindrical portion of the shell is reviewed including major structural attachments such as beam seats, pipe restraints, crane brackets, and shell stiffeners, if any, in the hoop and vertical directions.

(iii) The dome of the steel containment including any reinforcement at the dome/cylinder junction, penetrations or attachments made on the inside such as supports for containment spray piping, and any stiffening of the dome.

(iv) Major penetrations or portions thereof, of steel or concrete containments, to the limits defined by Subsection NE of the ASME Boiler and Pressure Vessel Code (hereafter "the Code"), Section III, Division 1 (Ref. 1), and portions of the penetrations that are intended to resist pressure but are not backed by structural concrete, including those of sleeved and unsleeved piping penetrations, mechanical systems penetrations such as fuel transfer tubes, electrical penetrations, and access openings such as the equipment hatch and personnel locks.

(v) The ice-condenser containments are reviewed with special emphasis on those areas which are unique to this type of design such as the connection between the ice-condenser and the containment.

(vi) The containment of floating nuclear power plants are reviewed with special emphasis on the connection between the platform and the containment, between the containment and the ice-condenser and associated penetration piping.

(vii) The BWR pressure suppression systems are reviewed with special attention on those piping which channel steam and air, and are necessary for the containment function. Such items include, but are not limited to, the torus, the vent header, the equalizing ring header and the downcomers. Also, the drywell/vent header junction, the vent header/downcomers junctions and the penetrations are reviewed to determine the expected behavior of the structure when subjected to the design loads.

2. <u>Applicable Codes, Standards, and Specifications</u>

The information pertaining to design codes, standards, specifications, and regulatory guides, and other industry standards that are used in the design, fabrication, construction, testing, and inservice surveillance of the steel containment, is reviewed. The specific editions, dates, or addenda identified for each document are also reviewed.

3. <u>Loads and Loading Combinations</u>

Information pertaining to the applicable design loads and various load combinations is reviewed with emphasis on the extent of compliance with Subsection NE of the Code, Section III, Division 1, and with Regulatory Guide 1.57 (Ref. 2). The loads normally applicable to steel containments include the following:

a. Those loads encountered during preoperational testing.

b. Those loads encountered during normal plant startup, operation, and shutdown, including dead loads, live loads, thermal loads due to operating temperatures, and hydrostatic loads such as those present in pressure-suppression containments utilizing water.

c. Those loads to be sustained during severe environmental conditions, including those induced by design wind (if not protected by a shield building) and the operating basis earthquake.

d. Those loads to be sustained during extreme environmental conditions, including those induced by the design basis tornado (if not protected by a shield building) and the safe shutdown earthquake specified for the plant site.

e. Those loads to be sustained during abnormal plant conditions, which include loss-of-coolant accidents (LOCA). The main abnormal plant condition for containment design is the design basis LOCA. Also to be considered are other accidents involving various high energy pipe ruptures. Loads induced on the containment by such accidents include elevated temperatures and pressures and possibly localized loads such as jet impingement and associated missile impact. Also included are external pressure loads generated by events inside or outside the containment.

f. Those loads to be sustained, if applicable, after abnormal plant conditions, including flooding of the containment subsequent to a LOCA for fuel recovery.

g. Those hydrodynamic loads which are associated with BWR suppression pool swell phenomena and are produced as a result of the purging of air and steam in the drywell and vent system into the subversion pool during a postulated LOCA and/or the actuation of safety relief valve (SRV) discharge. Such loads include bubble pressure, bulk swell, and froth swell loads, drag pressure, pool boundary chugging loads, and other pool well loads associated with these phenomena. Also, those loads which are resulting from fluid-structure interaction due to seismic and/or pool swell should be considered.

h. Those loads which are generated as a result of platform deformation and flexibility, towing of the platform and wave action in case of floating plants. Other loads associated with the nonsymmetric dynamic loads generated from LOCA and SRV actuation loads should also be considered.

i. Those loads which are generated as a result of the LOCA in the ice-condenser. These loads are categorized as nonsymmetric dynamic transient pressure loads which in the first few seconds might produce compressive stresses in the containment due to the differential pressure across the containment.

The various combinations of the above loads that are normally postulated and reviewed include the following: Testing loads; normal operating loads; normal operating loads with severe environmental loads; normal operating loads with severe environmental loads and abnormal loads; normal operating loads with extreme environmental loads and abnormal loads; and post-LOCA flooding loads with severe environmental loads, if applicable. Specific and more detailed information on these combinations are delineated in subsection II.3 of this SRP section.

Unless the steel containment is protected by a shield building, other site-related design loads might also be applicable, including those described in subsection I.3 of Standard Review Plan Section 3.8.1.

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

The design and analysis procedures utilized for the steel containment are reviewed with emphasis on the extent of compliance with Subsection NE of the Code, Section III, Division 1. Particular emphasis is placed on the following subjects:

a. Treatment of nonaxisymmetric and localized loads.
b. Treatment of local buckling effects.
c. The computer programs utilized in the design and analysis.
d. Ultimate capacity of steel containment.
e. Structural audit.
f. Design report.

5. Structural Acceptance Criteria

The design limits imposed on the various parameters that serve to quantify the structural behavior of the containment are reviewed, specifically with respect to allowable stresses, strains, and gross deformations, with emphasis on the extent of compliance with subsection NE of the Code, Section III, Division 1, and with Regulatory Guide 1.57. For each specified load combination, the proposed allowable limits are compared with the acceptable limits delineated in subsection II.5 of this SRP section. Included in these allowable limits are the following major parameters:

a. Primary stresses, including general membrane (P_m), local membrane (P_L), and bending (P_b) plus local membrane stresses.
b. Primary and secondary stresses (Q).
c. Peak stresses (F).
d. Buckling criteria.

6. Materials, Quality Control, and Special Construction Techniques

a. Information provided on the materials that are to be used in the construction of the steel containment is reviewed with emphasis on the extent of compliance with Article NE-2000 of Subsection NE of the Code, Section III, Division 1. Among the major materials reviewed are the following:

   (i) Steel plates used as shell components.
   (ii) Structural steel shapes used for stiffeners, beam seats, and crane brackets. Corrosion and corrosion protection procedures are reviewed by the Chemical Engineering Branch.

b. The quality control program proposed for the fabrication and construction of the containment is reviewed with emphasis on the extent of compliance with Article NE-5000 of Subsection NE of the Code, Section III, Division 1, including the following:

   (i) Nondestructive examination of the materials, including tests to determine their physical properties.
   (ii) Welding procedures.
   (iii) Erection tolerances.

Special contruction techniques, if proposed, are reviewed on a case-by-case basis to determine their effects on the structural integrity of the completed containment.

7. Testing and Inservice Surveillance Program

The preoperational structural test programs for the completed containment and for individual class MC components reviewed, including the objectives of the test, and the acceptance criteria with emphasis on the extent of compliance with Article NE-6000 of Subsection NE of the Code, Section III, Division 1. Structural tests for components such as personnel and equipment locks are also reviewed.

Inservice surveillance programs, if any, of components relied upon for containment structural integrity, are reviewed. Any inservice surveillance required in special areas subject to corrosion is reviewed by the Chemical Engineering Branch.

Special testing and inservice surveillance requirements proposed for new or previously untried design approaches are reviewed.

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 program 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 part of its primary described review responsiblity 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. This 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 steel containments are based on meeting the relevant requirements of the following regulations:

1. 10 CFR Part 50, §50.55a and General Design Criterion 1 as they relate to steel containments being designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed.

2. General Design Criterion 2 as it relates to the design of the steel containments being capable of withstanding the most severe natural phenomena such as winds, tornadoes, floods, and earthquakes and the appropriate combination of all loads.

3. General Design Criterion 4 as it relates to steel containments being capable of withstanding the dynamic effects of equipment failures including missiles pipe whip and blowdown loads associated with the loss-of-coolant accident.

4. General Design Criterion 16 as it relates to the capability of the steel containment to act as a leaktight membrane to prevent the uncontrolled release of radioactive effluents to the environment.

5. General Design Criterion 50 as it relates to steel containment 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 requirement of 10 CFR Part 50, §50.55a, and GDC 1, 2, 4, 16, and 50. Also, specific acceptance criteria necessary to meet these 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 Containment

The descriptive information in the safety analysis report (SAR) is considered acceptable if it meets the minimum requirements set forth in Section 3.8.2.1 of the "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants" (Ref. 3).

If the steel containment has new or unique features that are not specifically covered in the "Standard Format...", the reviewer determines that the information necessary to accomplish a meaningful review of the structural aspects of these new or unique features is presented.

2. Applicable Codes, Standards, and Specifications

The design, materials, fabrication, erection, inspection, testing, and inservice surveillance of steel containments are covered by codes, standards, and specifications which are either applicable in their entirety or in part. The following codes and guides are acceptable.

Code	Title
ASME	Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NE, "Class MC Components"
Regulatory Guide	
1.57	Design Limits and Loading Combinations for Metal Primary Reactor Containment System Components

3. Loads and Loading Combinations

Subsection NE of the Code, Section III, Division 1 and Regulatory Guide 1.57 are not explicit with respect to the loads and load combinations which should be considered in the design of steel containments. The specified loads and load combinations are acceptable if found to be in accordance with the following:

a. Loads

D --- Dead loads.

L --- Live loads including all loads resulting from platform flexibility and deformation, and crane loading if applicable.

P_t --- Test pressure.

T_t --- Test temperature.

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

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

P_o --- External pressure loads resulting from pressure variation either inside or outside containment.

E --- Loads generated by the operating basis earthquake including sloshing effects, if applicable.

E' --- Loads generated by the safe shutdown earthquake including sloshing effects, if applicable.

P_a --- Pressure load generated by the postulated pipe break accident including P_o, pool swell and subsequent hydrodynamic loads.

T_a --- Thermal loads under thermal conditions generated by the postulated pipe break accident including T_o, pool swell, and subsequent hydrodynamic reaction loads.

R_a --- Pipe reactions under thermal conditions generated by the postulated pipe break accident including R_o, pool swell, and subsequent hydrodynamic reaction loads.

P_s --- All pressure loads which are caused by the actuation of safety relief valve discharge including pool swell and subsequent hydrodynamic loads.

T_s --- All thermal loads which are generated by the actuation of safety relief valve discharge including pool swell and subsequent hydrodynamic thermal loads.

R_s --- All pipe reaction loads which are generated by the actuation of safety relief valve discharge including pool swell and subsequent hydrodynamic reaction loads.

Y_r --- Equivalent static load on the structure generated by the reaction on the broken pipe during the design basis accident.

Y_j --- Jet impingement equivalent static load on the structure generated by the broken pipe during the design basis accident.

Y_m --- Missile impact equivalent static load on the structure generated by or during the design basis accident, such as pipe whipping.

F_L --- Loads generated by the post-LOCA flooding of the containment, if any.

b. Loading Combinations

These include all loading combinations for which the containment might be designed for or subjected to, during the expected life of the plant. The loading combinations include the following:

(i) Testing condition

This includes the testing condition of the containment to verify its leak integrity. The loading combination in this case includes:

$$D + L + T_t + P_t$$

(ii) Design conditions

These include all design loadings for which the containment vessel or portions thereof might be designed for, during the expected life of the plant. Such loads include design pressure, design temperature, and the design mechanical loads generated by the design basis accident. The loading combination in this case includes:

$$D + L + P_a + T_a + R_a$$

(iii) Service conditions

The load combinations in these cases correspond to and include Level A service limits, Level B service limits, Level C service limits, Level D service limits and the post-flooding condition. The loads may be combined by their actual time history of occurrence taking into consideration their dynamic effect upon the structure.

(a) Level A Service Limits

These service limits are applicable to the service loadings to which the containment is subjected including the plant or system design basis accident conditions for which the containment function is required excepting only those categorized as Level B, Level C, Level D, or Testing Loadings. The loading combinations corresponding to these limits include the following:

(1) Normal operating plant condition

$$D + L + T_o + R_o + P_o$$

(2) Operating plant condition in conjunction with multiple safety relief valves actuation

$$D + L + T_s + R_s + P_s$$

(3) Loss-of-coolant accident (LOCA)

$$D + L + T_a + R_a + P_a$$

(4) Multiple SRV actuations in combination with small-break accident or intermediate-break accident

$$D + L + T_a + R_a + P_a + T_s + R_s + P_s$$

(b) Level B Service Limits

These service limits include the loads subject to Level A service limits plus the additional loads resulting from natural phenomena during which the plant must remain operational. The loading combinations corresponding to these limits include the following:

(1) LOCA in combination with operating basis earthquake

$$D + L + T_a + R_a + P_a + E$$

(2) Operating plant condition in combination with operating basis eathquake

$$D + L + T_o + R_o + P_o + E$$

(3) Operating plant condition in combination with operating basis earthquake and multiple SRV actuations

$$D + L + T_s + R_s + P_s + E$$

(4) LOCA in combination with a single active component failure causing one SRV discharge

$$D + L + T_a + P_a + R_a + T_s + R_s + P_s$$

(c) Level C Service Limits

These service limits include the loads subject to Level A service limits plus the additional loads resulting from natural phenomena for which safe shutdown of the plant is required. The loading combinations corresponding to these limits include the following:

(1) LOCA in combination with safe shutdown earthquake

$$D + L + T_a + R_a + P_a + E'$$

(2) Operating plant condition in combination with safe shutdown earthquake

$$D + L + T_o + R_o + P_o + E'$$

(3) Multiple SRV actuations in combination with small-break accident or intermediate-break accident and safe shutdown earthquake

$$D + L + T_a + R_a + P_a + T_s + R_s + P_s + E'$$

(d) Level D Service Limits

These service limits include other applicable service limits and loadings of a local dynamic nature for which the containment function is required. The load combinations corresponding to these limits include the following:

(1) LOCA in combination with safe shutdown earthquake and local dynamic loadings

$$D + L + T_a + R_a + P_a + Y_r + Y_j + Y_m + E'$$

(2) Multiple SRV actuations in combination with small-break or intermediate-break accident, safe shutdown earthquake, and local dynamic loadings

$$D + L + T_a + R_a + P_a + Y_r + Y_j + Y_m + P_s + T_s + R_s + E'$$

(e) Post-Flooding Condition

This includes the post-LOCA flooding of the containment in combination with operating basis earthquake

$$D + L + F_L + E$$

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

Design and analysis procedures for steel containments are covered in Article NE-3000 of Subsection NE of the Code, Section III, Division 1. The procedures given in the Code, as augmented by the applicable provisions of Regulatory Guide 1.57, constitute an acceptable basis for design and analysis. Moreover, for the specific areas of review described in subsection I.4 of this SRP section, the following criteria are acceptable:

a. <u>Treatment of nonaxisymmetric and localized loads</u>

For most containments, the nonaxisymmetric loads which apply are the horizontal seismic and associated sloshing loads, pool swell and its related hydrodynamic loads caused either by LOCA or by SRV actuation. Other possible nonaxisymmetric and localized loads are those induced by pipe rupture such as reactions, jet impingement forces, and missiles. For the PWR ice-condenser containment, the design basis accident may result in a nonaxisymmetric pressure load due to compartmentation of the containment interior. For such localized loads, the analyses should include a determination of the local effects of the loads. These effects should then be superimposed on the overall effects. For the overall effects of nonaxisymmetric loads on shells of revolution, an acceptable general procedure is to expand the load by a Fourier series. Other methods are reviewed on a case-by-case basis for applicability to a large thin shell.

b. <u>Treatment of buckling effects</u>

Earthquake and localized pressure loads, such as those encountered in PWR ice-condenser containments, require consideration of buckling of the shell. An acceptable approach to the problem is to perform a nonlinear dynamic analysis. If a static analysis is performed, an appropriate dynamic load factor should be used to obtain the effective static load.

c. Computer programs

The computer programs used in the design and analysis should be described and validated by any of the procedures or criteria described in subsection II.4.e of Standard Review Plan Section 3.8.1.

d. Ultimate capacity of steel containment

An analysis should be performed to determine the ultimate capacity of the containment.

The pressure-retaining capacity of localized areas as well as of the overall containment structure should be determined.

The analysis should be made on the basis of the allowable material strength specified in the Code. However, if the actual material properties such as the tested material strength, strength variations indicated by mill test certificates and other material uncertainties, are available, the lower and upper bounds of the containment capacity may be established statistically.

The details of the analysis and the results should be submitted in a report form with the following identifiable information.

(1) The original design pressure, P, as defined in the Code, Subsubarticle NE-3220.

(2) Calculated static pressure capacity,

(3) Equivalent static pressure response calculated from dynamic pressure,

(4) The associated failure mode,

(5) The criteria governing the original design and the criteria used to establish failure;

(6) Analysis details and general results, and

(7) Appropriate engineering drawings adequate to allow verification of modeling and evaluation of analyses employed for the containment structure.

e. Structural Audit

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

f. Design Report

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

5. Structural Acceptance Criteria

Stresses at various locations of the shell of the containment for various design loads are determined by analysis. Total stresses for the combination of loads delineated in subsection II.3 of this SRP section are acceptable if found to be within limits defined by various sections of the Code, Section III, Subsection NE, as augmented by Regulatory Guide 1.57. An acceptable interpretation of these limits is contained in Table 3.8.2-1 where the notation is in accordance with the Code.

6. Materials, Quality Control, and Special Construction Techniques

a. The materials of construction are acceptable if in accordance with Article NE-2000 of Subsection NE of the Code, Section III, Division 1. Corrosion protection are reviewed by the Chemical Engineering Branch.

b. Quality control programs are acceptable if in accordance with Articles NE-4000 and NE-5000 of Subsection NE of the Code, Section III, Division 1.

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

7. Testing and Inservice Surveillance Requirements

a. Procedures for the preoperational structural proof test are acceptable if found in accordance with Article NE-6000 of Subsection NE of the Code, Section III, Division 1.

b. Inservice surveillance requirements for steel containments are currently under development. Acceptance criteria for inservice surveillance programs in areas subject to corrosion are established by the Chemical Engineering Branch, as required.

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 Containment

After the type of containment and its functional characteristics are identified, information on similar and previously licensed applications is obtained for reference. Such information, which is available in safety analysis reports and amendments of previous license applications, enables identification of differences for the case under review which requires additional scrutiny and evaluation. New and unique features that have not been used in the past are of particular interest and are thus examined in greater detail. The information furnished in the SAR is reviewed for completeness in accordance with the "Standard Format..." (Ref. 3). A decision is then made with regard to the sufficiency of the descriptive information provided. Any additional required information not provided 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 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. Loading conditions that are unique and not specifically covered in subsection II.3, are treated on a case-by-case basis. 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 assures himself that the applicant is committed to the design and analysis procedures delineated in Article NE-3000 of Subsection NE of the Code, Section III, Division 1. Any exceptions to these procedures are reviewed and evaluated on a case-by-case basis. In particular, the areas of review contained in subsection I.4 of this SRP section are evaluated for conformance with the acceptance criteria, and the reviewer assures that the provisions of subsection II.4 of this SRP section are met.

5. Structural Acceptance Criteria

The limits on allowable stresses in the steel shell and its components are reviewed and compared with the acceptable limits 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 of the structure, the justification, provided to show that the structural integrity of the containment will not be affected, is reviewed and evaluated. If such justification is unacceptable, the applicant is required to comply with the acceptance criteria delineated in subsection II.5 of this SRP section.

6. Materials, Quality Control, and Special Construction Techniques

The information provided on materials, quality control programs, and special construction techniques, if any, is compared with that referenced in subsection II.6 of this SRP section. If a material not covered by the Code is utilized, the applicant is requested to provide sufficient test and user data to establish the acceptability of the 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 containment and its various components.

7. Testing and Inservice Surveillance Requirements

The initial structural overpressure test program is reviewed and compared with that indicated as acceptable in subsection II.7 of this SRP section. Any proposed deviations are considered on a case-by-case basis. Inservice surveillance programs, if any, as presented in the Technical Specifications of the Operating License, are similarly reviewed.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided in accordance with the requirements of this SRP section, and concludes that his evaluation is sufficiently complete 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 steel containment is acceptable and meets the relevant requirements of 10 CFR Part 50, §50.55a, and General Design Criteria 1, 2, 4, 16, 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 steel containment is 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 steel containment 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 steel containment is capable of withstanding the dynamic effects associated with missiles, pipe whipping, and discharging fluids.

4. The applicant has met the requirements of GDC 16 by designing the steel containment so that it is an essentially leaktight barrier to prevent the uncontrolled release of radioactive effluents to the environment.

5. The applicant has met the requirements of GDC 50 by designing the steel containment 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 demonstrates that the ultimate capacity of the containment will not be exceeded and establishes the minimum margin of safety for the design.

The criteria used in the analysis, design, and construction of the steel containment structure to account for anticipated loadings and postulated conditions that may be imposed upon the structure during its service lifetime are in conformance with established criteria, codes, standards, and guides acceptable to the Regulatory staff. These include meeting the position of Regulatory Guide 1.57 and industry standard ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NE.

The use of these criteria as defined by applicable codes, standards, and guides; 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 inservice surveillance requirements, provide reasonable assurance that, in the event of earthquakes and various postulated accidents occurring within and outside the containment, the structure will withstand the specified conditions without impairment of structural integrity or safety function. A Category I concrete shield building protects the steel containment from the effects of wind and tornadoes and various postulated accidents occurring outside the shield building.

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 NE, "Class MC Components," American Society of Mechanical Engineers.

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

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

4. 10 CFR Part 50, Appendix A, General Design Criterion 1, "Quality Standard and Records."

5. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

6. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Missile Design Bases."

7. 10 CFR Part 50, Appendix A, General Design Criterion 16, "Containment Design."

8. 10 CFR Part 50, Appendix A, General Design Criterion 50, "Containment Design Basis."

9. 10 CFR Part 50, §50.55a, "Codes and Standards."

Table 3.8.2-1

Stress Intensity Limits For Steel Containments

SECTION II.3.6 Load Categories		Primary Stresses: Gen. Mem. P_m	Primary Stresses: Local Mem. P_L	Primary Stresses: Bending & Local Mem. $P_b + P_L$ (6)	Primary & Secondary Stresses $P_L + P_b + Q$	Peak Stresses $P_L + P_b + Q + F$	Buckling
Testing Condition	Pneumatic	$0.75S_y$	$1.15S_y$	$1.15S_y$	N/A(2)	Consider for (5) fatigue evaluation	See Note (9)
Design Condition		$1.0S_{mc}$	$1.5S_{mc}$	$1.5S_{mc}$	N/A	N/A	See Note (9)
Level A Service Limit(1)		1.0Smc	$1.5S_{mc}$	$1.5S_{mc}$	$3.0S_{mi}$	Consider for fatigue evaluation	See Note (9)
Level B Service Limit		$1.0S_{mc}$	$1.5S_{mc}$	$1.5S_{mc}$	$3.0S_{mi}$	Consider for fatigue evaluation	See Note (9)
Level C Service Limit	Not Integral and Continuous	$1.0S_{mc}$	$1.5S_{mc}$	$1.5S_{mc}$	$3.0S_{mi}$	N/A	See Note (9)
	Integral and Continuous(4),(7)	$1.2S_{mc}$ or * 1.0Sy	$1.8S_{mc}$ or * $1.5S_y$	$1.8S_{mc}$ or * $1.5S_y$	N/A	N/A	See Note (9)
Level D Service Limit	Not Integral and Continuous(4)	$1.2S_{mc}$ or * 1.0Sy	$1.8S_{mc}$ or * $1.5S_y$	$1.8S_{mc}$ or * $1.5S_y$	N/A	N/A	See Note (9)
	Integ. & Con. Elas. Analysis(3)	S_f	$1.5S_f$	$1.5S_f$	N/A	N/A	
	Integ. & Con. Inelas. Analysis(3)	S_f	S_f	S_f			See Note (9)
Post-Flooding Condition(4)		$1.2S_{mc}$ or * 1.0Sy	$1.8S_{mc}$ or * $1.5S_y$	$1.8S_{mc}$ or * $1.5S_y$	$3S_{mi}$	N/A(2)	See Note (9)

NOTES:

(1) The allowable stress intensity S_{mi} shall be the S_m listed in Tables I-1.0 and the allowable stress intensity S_{mc} shall be the S_m listed in Tables I-10.0 of Appendix I of the ASME Code.

(2) N/A - No evaluation required.

(3) S_f is 85% of the general primary membrane allowable permitted in Appendix F. In the application of the rules of Appendix F, S_{mi}, if applicable, shall be as specified in Tables I-1.0.

(4) These limits identified by (*) sign indicate a choice of the larger of two limits.

(5) The number of test sequences shall not exceed 10 unless a fatigue evaluation is considered.

(6) Values shown are for a solid rectangular section. Sec. NE-3220 for other than a solid rectangular section.

(7) These stress intensity limits apply also to the partial penetration welds.

(8) Values shown are applicable when $P_L \leq 0.67S_y$. When $P_L > 0.67S_y$, use the larger of the two limits, $[2.5 - 1.5 (P_L/S_y)]\ 1.2S_{mc}$ or $[2.5 - 1.5 (P_L/S_y)]\ S_y$.

(9) The applicant is required to demonstrate that any axisymmetric techniques proposed are applicable to a vessel having large asymmetric openings, and that the overall margin of safety used to prevent buckling is adequate.