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U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

South Texas Project
Units 1 and 2
Docket Nos. STN 50-498, STN 50-499
FSAR Revisions Concerning
Section 3.8.1.4;
Design and Analysis Procedures (Concrete Containment)

Attached are revisions to FSAR section 3.8.1.4, "Design and Analysis Procedures (Concrete Containment)", which incorporate editorial corrections and clarification of the basis of initial compressive stress. These revisions do not reflect changes in design and analysis methodology.

HL&P believes that conclusions reached previously in the SER remain valid. If you should have any questions on this matter, please contact Mr. J. S. Phelps at (713) 993-1367.

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Attachment: Revised FSAR section 3.8.1.4

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Dead load is applied as a static gravity load. Prestressing load is established through a prestressing force analysis. The prestressing loads on the dome are computed by Bechtel standard computer program TENDON CE 239 (see Appendix 3.8.A). These prestressing loads are input into BSAP model as nodal loads on the dome. 40 The hoop tendon forces imposed on the containment wall are treated as axisymmetrical normal pressures on the wall. Design pressure load is applied as an outward pressure normal to the shell, dome and mat elements. Thermal loads (summer and winter) are obtained by subtracting the construction temperature (stressfree temperature) from the average of surface temperatures given in Section 3.8.1.3.1. 40 In addition, a linear gradient based on the difference of surface temperatures is considered. Q220. Accident temperature loading is considered as a non-linear profile in the analysis. 24N No thermal gradient is considered for the basemat due to accident temperature loading because of the insulating effect of the two foot fill slab covering the mat liner. The effect of the hot liner on the concrete wall is considered in the design stage by using the OPTCON module of BSAP program. Earthquake loads are applied as equivalent gravity accelerations on all structural elements for both horizontal directions and the vertical direction. Tornado loads are 10 applied as normal pressures on the dome and cylindrical walls. The structural response for earthquake and tornado loads applied in the direction normal to the plane of symmetry are obtained by picking the response of an element at 90° azimuth angle to the same load applied in the direction of the plane of symmetry.

A summary of stress analysis results at key sections is shown in Table 40 3.8.1-7. Key sections are as indicated on Figure 3.8.1-14. Q220. 34N

The tendon gallery is analyzed separately using manual methods. The top of the tendon gallery walls are considered fixed at the bottom of the containment, due to its relative stiffness. The design is performed using the 52 loading combinations that are consistent with the loading combinations of the containment.

3.8.1.4.1.2 Equipment Hatch and Personnel Air Lock Analysis - The Containment shell is provided with a 24-ft-0 in. inside diameter opening for 40 the equipment hatch and a 12-ft-1-in. inside diameter opening for the personnel lock. 32 These openings give rise to stress concentration in their vicinity due to Containment loadings. The Containment wall is thickened in this region to accommodate higher stresses. For equipment hatch, the shell wall is thickened to 8 ft at the center line of the opening while for personnel air lock, wall thickness provided is 6 ft (see Figure 3.8.1-4).

Stress analysis in the regions around equipment hatch and personnel air lock is based on finite element method using BSAP computer program and assuming that the concrete is elastic, isotropic, and homogeneous material. Post-tensioning tendons are draped around these penetrations. Effect of prestressing forces due to this tendon curvature in the plane of the shell wall is considered. For both openings, the finite element model includes at least an area within five times the radius of the penetration from the center of 52 penetration, beyond which the effect of opening is assumed to vanish. The boundary conditions applied to the models are obtained from Containment shell analysis as described in Section 3.8.1.4.1.1. Figure 3.8.1-15 (16) shows the boundaries of the mathematical model for equipment hatch opening analysis. Figure 3.8.1-16 (17) shows the corresponding finite element mesh.

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3.8.1.4.1.3 Buttresses and Tendon End Anchorage - Analysis and design of tendon and anchorage zones and reinforcement in buttresses are based on results of tests presented in Section 6.6 of BC-TOP-5A and conform to the requirements of the ASME-ACI 359, and Paragraph CC-3543. Refer to Figure 3.8.1-5 for buttress reinforcement. 52

3.8.1.4.1.4 Prestressing Force Analysis - The level of post-tensioning provided by prestressing tendons, after all predicted stress losses have taken place, is calculated by using a ratio of dead load plus prestress force to the accident pressure membrance force. 52

$$\text{ratio} = \frac{D + F}{Pa}$$

The ratio for vertical tendons: The critical section is at the apex of the dome; use = 1.3.

The ratio for hoop tendons: Use = 1.2. The average effective force is calculated by using the lowest average stress obtained from one of the following:

- Average stress in any three adjacent tendons at the face of the buttress
- Average stress over the length of a tendon
- Average stress in any three adjacent tendons at a section consisting of the midpoint of any one tendon

The thickness of the dome and cylindrical wall of the net section is also checked to satisfy the allowable concrete compressive stresses. The initial membrane compressive stress before losses is limited to 0.35 f'_c, where f'_c is the specified compressive strength of concrete ~~initial prestressing force of the net section~~. The net section is considered to be the gross cross-sectional area less the area of tendon sheathing.

The post-tensioning forces acting on the Containment due to hoop tendons are treated as axisymmetric loads for the verification of the shell analysis as described in Section 3.8.1.4.1.1. The prestressing forces imposed on the dome 52
by the two groups of vertical tendons and dome hoop tendons are calculated by the computer program TENDON, CE 239. (See Appendix 3.8.A for a detailed description). 52

3.8.1.4.2 Design Procedures for the Containment Structure: The design procedures and criteria for the Containment and its components, including the foundation mat and the steel liner plate, are in accordance with Article CC-3000 of the ASME-ACI 359 document with the exceptions described in Section 3.8.1.2.1. Computation of reinforcement is performed using the BSAP-POST 52
program OPTCON module described in Appendix 3.8.A. Concrete is assumed cracked whenever tensile stresses are present. The cracked section analysis is performed for critical sections shown in Figure 3.8.1-14. Special design considerations are described below.

3.8.1.4.2.1 Steel Liner Plate and Anchorage System Design - The RCB is lined inside with a 3/8-in. welded carbon steel plate to ensure a vessel leak-tight against the release of radioactive materials into the environment. The liner is also utilized as a concrete form during the construction stage.

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where:

γ_c = Nominal permissible shear stress carried by concrete, psi.

c. When inclined stirrups or bent bars are used as shear reinforcement in reinforced concrete members, the following provisions apply:

1) When inclined stirrups are used, the required area shall not be less than

$$A_v = \frac{(\gamma_u - \gamma_c)\ bs}{f_y\ (\sin\alpha + \cos\alpha)} \qquad \text{(Equation 3.8.1-8)}$$ 32

2) When shear reinforcement consists of a single bar or a single group of parallel bars, all bent at the same distance from the support, the required area shall be not less than 32

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$$A_v = \frac{(\gamma_u - \gamma_c)\ bd}{f_y\ (\sin\alpha)} \qquad \text{(Equation 3.8.1-9)}$$ 32

in which $(\gamma_u - \gamma_c)$ shall not exceed $3\sqrt{f'_c}$. 29 Q220.27N

3) When shear reinforcement consists of a series of parallel bent-up bars or groups of parallel bent-up bars at different distances from the support, the required area shall be not less than that computed by Equation 3.8.1-8.

4) Only the center three-fourths of the inclined portion of any bar that is bent shall be considered effective for shear reinforcement. 32

5) Where more than one type of shear reinforcement is used to reinforce the same portion of the section, the required area shall be computed as the sum of the various types separately. In such computations, γ_c shall be included only once. The value of $(\gamma_u - \gamma_c)$ shall not exceed $8\sqrt{f'_c}$. 32

6) Inclined stirrups and bent bars shall be so spaced that every 45-degree line extending toward the reaction from the mid-depth of the section, 0.50d, to the tension bars shall be crossed by at least one line of shear reinforcement. 32 32

d. Shear reinforcement shall extend to at least a distance, d, from the extreme compression fiber and shall be anchored at both ends to develop the design yield strength of the reinforcement.

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The lower portion of the primary shield wall provides support for the RPV. A 40
description of the Reactor Vessel Support System is provided in Section
3.8.3.1.8. The primary shield wall provides missile protection and biological
shielding and also serves as a support for pipe-whip restraints. Under seis-
mic loading, the primary shield walls serve to provide seismic shear resis- 40
tance and transmit loading from the upper internals down to the base mat. The
bottom of the primary shield wall is anchored into the Containment base slab 40 Editorial
as shown on Figure 3.8.3-~~2~~ 3

3.8.3.1.2 Secondary Shield Walls: The 3-ft-6-in.-thick secondary shield
walls form the exterior of the primary loop compartment. The primary loop
compartment is 82-ft-wide and 97-ft-long and extends from El. -11-ft-3-in. to
El. 83 ft. The primary shield and refueling pool walls form the interior
boundary. The bottom of the compartment is formed by the interior fill slab, 40
while the top is open to the Containment atmosphere. An individual compart-
ment to enclose the pressurizer is provided between SGs no. 1 and no. 4.

The secondary shield walls provide radiation shielding, isolate the RCS, laterally restrain the SGs, RCPs, and pressurizer, support the Nuclear Steam Supply Auxiliary System, serve as pipe-whip restraint supports, and safeguard the electrical and mechanical systems.

3.8.3.1.3 Refueling Cavity: The refueling cavity is a reinforced con- 40
crete structure about 21-ft-wide by 75-ft-long, consisting of the reactor 55
cavity surrounding the upper portion of the RPV and the refueling canal, which
connects the fuel storage area and the fuel transfer penetration to the
reactor cavity. The reactor cavity and the refueling canal are separated by a
stainless steel, manually operated, double-bulkhead gate. The refueling 40
cavity walls are 3-ft-6 in. thick and are lined with stainless steel plate.

The refueling cavity is used during refueling operations to provide shielded 40
access for transferring the new and spent fuel elements between the RPV and
the fuel transfer penetration. The reactor cavity is filled with borated
water to El. 66-ft-6-in. during those brief periods when a fuel assembly is
being transferred over the RPV flange. The refueling cavity also serves as a
shielded laydown area for the RPV upper and lower internals.

3.8.3.1.4 Operating Floor: The operating floor at El. 68 ft covers the
space between the secondary shield walls and the Containment wall. The floor 32
slab is supported by the secondary shield walls and by beams and columns. A
2 inch gap is left between the Containment wall and the edges of the operating 40
floor and the intermediate floors below to ensure that the only interaction
between the Containment wall and the internal structure is through the common
foundation base mat.

The function of the operating floor is to provide a working and access floor during refueling, maintenance, and repair operations.

3.8.3.1.5 Intermediate Floors: Intermediate floors between the secon-
dary shield walls and the Containment wall are provided at the following ele-
vations: -2 ft, 19 ft, 37-ft-3-in., and 52 ft. These floors are supported by
structural steel framing spanning between the secondary shield walls and col-
umns and extending up from the base slab at El. -11 ft 3 in. Various access,
maintenance and in-service inspection platforms are also provided around 40
equipment.

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other high energy piping are reviewed to verify that the effects are bounded by the current analyses. The seal plates located at the upper reactor cavity are used to provide shielding from neutron and gamma streaming. 57

The blowdown analysis which determines the adequacy of the reactor vessel supports is comprehensive in that it includes the effects of the hydraulic forces in the loop piping. 57

3.8.3.1.8.2 Steam Generator - The vertical supports for the SG (see Figure 3.8.3-3) consist of four vertical columns bolted at top to the vendor-supplied columns and at bottom to the floor slab. The lower lateral supports consist of supports attached to the walls of each SG subcompartment and bolted to the vendor-supplied beams. The upper lateral supports consist of supports attached to the walls of each SG subcompartment and bolted to the vendor-supplied ring girder around the generator shell connected to hydraulic snubbers and supported by struts on the compartment walls. Loads are transferred from the equipment to the ring girder by means of a number of bumper blocks between the girder and generator shell. 40 40

3.8.3.1.8.3 Reactor Coolant Pump - The RCP vertical supports consist of three vertical columns (see Figure 3.8.3-4) bolted at top to the vendor supplied columns and at bottom to the floor slab. The lateral supports consist of three supports attached to the compartment walls and bolted to the vendor-supplied tie-rod supports. 40

3.8.3.1.8.4 Pressurizer - The pressurizer (see Figure 3.8.3-5) is supported at its base by bolting the flange ring to the supporting floor slab. In addition, four lateral supports are provided which are attached to the compartment walls and bolted to the vendor-supplied supports which bear against the vessel lugs. 40 40

3.8.3.2 Applicable Codes, Standards and Specifications.

3.8.3.2.1 Codes, Specifications and Standards: The following codes, standards, and specifications are used as a basis for the design, fabrication, construction, testing, and surveillance of the Containment internal structure. Different issue dates of these documents may be used provided they meet the minimum requirements stated herein. 40

1. American Concrete Institute

ACI 211.1-70 - "Recommended Practice for Selecting Proportions for Normal Weight Concrete"

ACI 214-65 - "Recommended Practice for Evaluation of Compression Test Results of Field Concrete" 29

ACI 304-73 - "Recommended Practice for Measuring, Mining, Transporting and Placing Concrete"

ACI 305-72 - "Recommended Practice for Hot-Weather Concreting"

ACI 306-72 - "Recommended Practice for Cold-Weather Concreting"