WM. H. ZIMMER POWER STATION

INSTRUCTIONS FOR UPDATING YOUR DESIGN ASSESSMENT REPORT

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CHAPTER 1.0 - INTRODUCTION

The purpose of this revision of the Design Assessment Report (DAR) is to demonstrate that the Wm. H. Zimmer Nuclear Power Station, Unit 1 (ZPS-1) containment can accommodate all hydrodynamic load phenomena associated with the SRV discharge and LOCA in the BWR Mark II containment, to provide evidence of conformance with the NRC Lead Plant Acceptance Criteria (NUREG-0487), and to provide a response to the formal questions posed by the Nuclear Regulatory Commission (NRC).

In the summer of 1979, the Wm. H. Zimmer Power Station (ZPS-1) design and construction status was such that additional load changes requiring plant modifications would seriously impact the construction schedule. To avoid this situation the ZPS-1 "three-pronged" approach was adopted. The three facets of this approach are:

a. Expedite construction based on conservative loads and upgrade immediately containment capability where possible.

b. Assess the plant for the Zimmer Empirical Load Design Basis which is expected to bound any future changes in pool dynamic loads.

c. Confirm adequacy of design with results of the Zimmer in-plant SRV test and the long-term Mark II program.

The Zimmer empirical loads are described in Section 2.1. This report describes the original design-basis for ZPS-1, subsequent reassessments for revised and newly identified loads, and finally the current reevaluation of the design using the Zimmer empirical loads to ensure the adequacy and conservatism of the containment structures, piping, and equipment.

This report also describes the conformance of the Zimmer design to the NRC Lead Plant Acceptance Criteria (NUREG-0487). Subsection 5.2.3 compares the design-basis T-quencher load with the criteria of NUREG-0487 and Supplement 1 of NUREG-0487. Subsection 5.3.2 compares the design-basis LOCA loads with the criteria in NUREG-0487. The loads defined in the NUREG-0487 were used for limited components as identified in Section 5.5. This report provides the NRC staff with all information necessary to continue and complete the licensing of the Wm. H. Zimmer Nuclear Power Station as scheduled. All pertinent information related to loads, load specification, load combinations, acceptance criteria, plant modification, plant margins, and confirmation of loads that apply to ZPS-1 has been compiled in this document. In addition, an in-plant SRV test will be performed to confirm the adequacy of loads used for design assessment.

In this report the individual loads and load combinations that are being utilized in the reassessment are identified and described in the first four sections. Reports defining the individual loads and providing justification for application to the ZPS-1 containment are referenced rather than repeated. This is consistent with the objective of this report.

The methods used in reevaluating the structures, piping systems, and equipment are described in Chapter 7.0. Fatigue analysis of the downcomers and SRV lines is included in Subsection 7.3.2. The plant modification and resultant changes that have been completed are described in Chapter 9.0. The plant margins and conservatisms are summarized in Chapter 10.0. To fulfill the requirements of NUREG-0487, a description of the assessments used to ensure functional capability of piping systems is included in Section E.4 of Appendix E.

The long-term Mark II program is expected to confirm that the plant, as presently designed and constructed, is completely safe and adequate. An assessment using loads derived from results of the 4TCO tests, described in Appendix I, provides additional assurance. However, additional design modifications and plant changes are being implemented to utilize the full containment capability. This ensures that the maximum possible margins are built into the plant, so that if load definitions should change later, they can be accommodated without plant hardware changes. The ZPS-1 plant startup should, therefore, proceed as scheduled.

CHAPTER 2.0 - ZIMMER EMPIRICAL LOADS

The original design of the Zimmer Power Station was based on loads developed in the Mark II Containment Program as documented in the Mark II Containment Dynamic Forcing Function Report (DFFR, Report NEDO/NEDE 21061-P). Although these loads were felt to be conservative, questions about the adequacy of the loads resulted in replacement of the rams head SRV discharge devices with quenchers in all Mark II plants and led the Mark II program to perform additional full-scale, single-vent LOCA tests (4TCO tests). As a result of these changes, the potential existed for Mark II pool dynamic loads of higher magnitude or altered frequency range.

In the summer of 1979, the status and schedule of construction and design work for the Zimmer station was such that any further changes in the pool dynamic loads would have a serious impact on the cost and the schedule for operation. It was recognized, at this time, that full results from the various tests would not be available in time for incorporation into the design basis. Therefore, Zimmer implemented a three-pronged approach to completion of the plant. This approach, although requiring a significant amount of additional design work and significant plant modifications, was felt to be advisable to minimize the risk of delays in plant operation and to maximize the safety of the plant.

The three-pronged approach was:

a. Expedite construction based on conservative loads and upgrade immediately the containment capability where possible.

b. Assess the plant for the Zimmer Empirical Load Design Basis which is expected to bound any future changes in pool dynamic loads.

c. Confirm adequacy of design with results of the Zimmer in-plant SRV test and the long-term Mark II program.

This chapter describes the Zimmer Empirical Load and demonstrates the capability of the Zimmer Power Station to accommodate these very conservative loads. This information was discussed with the NRC at a meeting on December 5, 1979. The remainder of the DAR provides more detail of the design of the Zimmer Plant including the original design methods and design work done subsequent to the December 5, 1979 meeting. Section 5.4 summarizes the conformance of the Zimmer Station to NUREG-0487, the Mark II Lead Plant Acceptance Criteria.

2.1 DESCRIPTION OF THE ZIMMER EMPIRICAL LOADS

The Zimmer Empirical Loads constitute a complete Mark II hydrodynamic load design basis. This design basis was formulated not only to meet or exceed the DFFR and NUREG-0487 (Lead Plant Acceptance Criteria) but to also contain additional conservatism in those areas where uncertainty remained in the Mark II loads. Since this approach was formulated in the summer of 1979, certain loads have been better defined and load reductions have been justified in some cases. With exceptions identified in Section 5.5 these reductions have not been incorporated into the Zimmer Empirical Load which ensures the high margin of safety in the design. The following subsections fully define the load and provide documentation of the material presented to the NRC in the December 5, 1979, meeting.

2.1.1 Vent Clearing

The vent clearing boundary load used in the Zimmer design is a 33 psi overpressure (above hydrostatic) applied uniformly below the vent exit and attenuated to zero at the pool surface. This exceeds both the Mark II Owners Group load and the NRC requirements demonstrating an increased safety margin in the Zimmer design.

2.1.2 Pool Swell

The pool swell methodology used in the Zimmer design meets or exceeds the NRC Acceptance Criteria. In those areas where the Acceptance Criteria were different from the original Zimmer design, the loads have been calculated using both methods and the more conservative load used for the design, thereby increasing the design margin. Zimmer has been modified to remove most piping and structures from the pool swell zone to eliminate pool swell loads.

2.1.3 Condensation Oscillation

Prior to implementation of the Zimmer Empirical Load approach, Zimmer had been designed to accommodate the condensation oscillation (CO) load specified in DFFR, Revision 3 (±3.75 psi, 2-7 Hz). This load was accepted by the NRC in NUREG-0487.

Certain questions were raised about the adequacy of this load definition because the original 4T tests (GE report NEDE-13442-01P5/76) were not entirely prototypical of Mark II containments. To resolve these questions, the Mark II Owners Group performed the 4TCO test (NEDE-24811-P, 5/80) with conservative single-cell representation of the Mark II drywell and appropriate vent length and geometries.

Because the schedule for availability of results from the 4TCO tests was not compatible with the design and construction schedule of Zimmer, the Zimmer Empirical CO Load was defined very conservatively based on existing steam condensation data. The following CO load definition was presented to the NRC at the December 5, 1979 meeting. Since condensation oscillation occurs over a wide range of blowdown conditions, two CO loads were defined. The first is a high mass flux CO load (CO1) which would correspond to the early portion of a large break LOCA. The main components of this load are defined as:

a. Sinusoidal Pressure Fluctuations

± 4.5 psi @ 2-7 Hz

± 2.2 psi @ 11-13 Hz

b. Random Pressure Fluctuations

Steam Bubble Collapse: 15-50 Hz

The 2 to 7 hertz component specified represents an increase of about 20% over the DFFR/NUREG-0487 load. The 11 to 13 hertz component is an additional load to account for any vent acoustic effects. The higher frequency portion of the load is added to bound random high frequencies which may appear in test data.

At lower mass fluxes there may be a possibility of a higher contribution from the vent acoustic effect with a corresponding decrease in the low frequency component. The main components of this second CO load (CO2) are defined as:

a. Sinusoidal Pressure Fluctuations

± 2.2 psi 2-7 Hz

± 3.8 psi 11-13 Hz

b. Random Pressure Fluctuations

Steam Bubble Collapse: 15-50 Hz

The 2 to 7 hertz component here is 50% of the low frequency component used in the high mass flux load while the vent acoustic amplitude has been conservatively assumed to be even higher than the amplitude apecified in the lower 2 to 7 hertz range in the DFFR. The Zimmer Empirical Condensation Oscillation Load used as the design-basis envelopes the above load definition and bounds the requirements of the NRC Lead Plant Acceptance Criteria (NUREG-0487), as demonstrated by Figure 2.1-1.

This Empirical Load is comprised of three components: Vent Exit (VE), Vent Acoustic (VA), and Nondeterministic (ND).

The vent exit component, as presented in Figure 2.1-4, is defined over a frequency range of 3 to 21 Hz but is extended to 1 Hz to account for 4TCO test facility data. The vent acoustic component, shown in Figure 2.1-5, is at the downcomer natural acoustic frequency which is then widened to a range $\pm$ 1 Hz of the natural acoustic frequency. The nondeterministic component, shown in Figure 2.1-6, consists of random frequencies between 15 and 50 Hz. Two CO loads are defined corresponding to different portions of the LOCA transient:

$$CO1 = VE+(0.2)VA+ND$$

$$CO2 = (0.5)VE+VA+ND$$

In addition to the loads acting in the wetwell, the drywell pressure fluctuates at a value equal to $\pm$ 10% of the wetwell pressure on the pool boundary.

2.1.4 Chugging

Chugging loads are divided into two areas. The chugging lateral load is the self loading of the downcomer vent during chugging and affects the design of the downcomers, bracing, and drywell floor. The chugging event also generates a hydrodynamic load which loads the submerged boundaries of the suppression pool.

2.1.4.1 Chugging Lateral Loads

Using the Zimmer Empirical Loads Approach, lateral loads are calculated as described in Subsection 5.3.1.1.7. This approach is more conservative than required by the NRC Acceptance Criteria (NUREG-0487). Subsection 7.1.3 describes the additional conservatism added in the method of drywell floor assessment.

2.1.4.2 Chugging Boundary Loads

The chugging load used was the DFFR methodology which meets the NRC Acceptance Criteria (NUREG-0487). The symmetric chugging load is obtained from the full-scale, single-cell 4T data and conservatively applied with all vents in-phase. An amplitude of +4.8/-4.0 psi and a 20-30 Hz frequency range is applied. The asymmetric load utilizes the same frequency range and a maximum magnitude of +20/-14 psi. Again, all vents were assumed to act in phase. The asymmetric distribution is shown in Figure 2.1-2.

2.1.5 SRV (Quencher) Loads

The Safety/Relief Valve (SRV) actuation loads used in the original design of Zimmer were based on the rams head discharge device. Quencher discharge devices have now been installed to eliminate concerns about discharge into high temperature pools and to reduce the magnitude of the SRV loads. The quencher load definition (Susquehanna DAR) is supported by full-scale, single-cell tests of an actual Mark II quencher. This load is included in the Zimmer Empirical Loads and constitutes the design-basis SRV load for the Zimmer plant. Because this load has been shown to be conservative by comparison to full-scale tests and because it includes a wider frequency range than the original rams head load, the quencher load definition provides a very conservative basis for plant design assessment.

Subsequent to adoption of the Zimmer Empirical Load, information has been provided to the NRC supporting an amplitude reduction of approximately 30% in the quencher load. Consistent with the Zimmer philosophy of retaining the maximum design margin, this load reduction has not been incorporated into the Zimmer Empirical Load, with the exceptions identified for limited components in Section 5.5.

The T-quencher load definition consists of three actual pressure time histories. The amplitude of these data traces are then increased by 50% to ensure conservatism and the frequency range is adjusted to give primary frequencies between 3.4 to 10 Hz. This load definition provides amplitude which bound both first and subsequent actuation loads. Since an all-valve case is used as the design basis, the Zimmer design basis will bound an all-valve subsequent actuation case (with all bubbles in-phase) although a maximum of 5 of the 13 valves are predicted to undergo subsequent actuation in the Zimmer plant. The quencher load definitions incorporate a very conservative representation of the spatial distribution of pressure on the boundary of the suppression pool. The Zimmer Empirical Load carries this conservatism even further and uses the all-valve case to represent the ADS case. To investigate the conservatism of this approach, a more realistic prediction of the Zimmer ADS load has been formulated utilizing the DFFR methodology to predict the spatial distribution. The conservatism of the Zimmer Empirical Load Approach is demonstrated by this comparison (Figure 2.1-3).

2.1.6 Submerged Structure Loads

Submerged structure loads have been calculated using forcing functions consistent with the boundary loads just described. The submerged structure methodology has also been modified to address the NRC Acceptance Criteria (NUREG-0487). This subsection will cover the submerged structure load definitions. The revised methodology is documented in Appendix G.

2.1.6.1 SRV Submerged Structure Loads

The actual quencher locations are used to define the position of the SRV air bubbles. The bubble size is conservatively predicted by utilizing the actual plant parameters (such as line length). The bubble pressure and typical load time history are calculated using the quencher correlations in the DFFR (NEDO 21061). The time history is then adjusted to give a frequency range of 3.4 to 10 Hz. Since the DFFR bubble pressure is derived on the basis of X-quencher and Zimmer has T-quencher discharge devices, an amplitude adjustment factor which is equal to or greater than 0.7 may be used with the SRV submerged structure loads. This amplitude factor accounts for the difference between the DFFR and KWU load definitions. Other aspects of submerged structure load calculation, such as, drag coefficients and nodalization of structures, are treated in accordance with NUREG-0487, as explained in Appendix G.

2.1.6.2 LOCA Submerged Structure Loads

The water jet, vent clearing, and pool swell submerged structure loads have been reassessed taking into consideration the NRC Lead Plant Acceptance Criteria (NUREG-0487) in both the forcing functions and application methodology. The methodology information in Appendix G is applicable to LOCA submerged structures also.

The chugging submerged structure load is derived from the chugging boundary load. This is described in more detail in Subsection 5.3.1.3.6. The only modification to the chugging load is to address the concerns in NUREG-0487.

The condensation oscillation submerged structure loads have been recalculated to be consistent with the Zimmer Empirical Loads (as described in Subsection 2.1.3 and NUREG-0487). A forcing function was derived from the original load specification (±3.75

psi, 2-7 Hz), but additional, lower pressure loads were defined up to 21 Hz to bound uncertainties in the load definition. The frequencies above 21 Hz in the boundary load specification result from acoustic pressure waves and were, therefore, not included in the fluid drag loads.

2.1.7 Load Combinations

The load combinations applicable to the design of the Zimmer Station are listed in Section 6.0. The Zimmer Empirical Loads Approach considers all these combinations. However, to expedite the assessment, some of the loads are combined in a more conservative way than is actually required. In addition, some of the individual load cases are replaced by more conservative loads to minimize the amount of analysis required.

As described in Subsection 2.1.5, the SRV loads are defined with a very conservative spatial distribution. Because of this, the ADS (6-valve) load is almost as large as the all-valve (13-valve) load. Additional margin is built into the design by using the all-valve case to represent the ADS case.

The largest loads generally result from the combination of an earthquake with the ADS discharge and either chugging or condensation oscillation. This is clearly an event with a very low probability. In spite of this low probability, the very conservative load definitions described in the section have been combined using the absolute sum method of load combination.

The combination of SRV and LOCA loads is particularly conservative in the case of the drag loads on submerged structures. The flow fields established by the quencher air bubble and the downcomer steam bubble collapse are superimposed as if they each had the worst possible phasing and direction at the same time. Because of the difference in the position, frequency, and shape of the forcing function, it is very unlikely that a significant reinforcement of the flow field will result. The method of combination used with the Zimmer Empirical Loads is the absolute sum method. The square root of the sum of the squares (SRSS) method is more appropriate and has been approved by the NRC, but at the time the Zimmer Empirical Load Approach was adopted, the acceptability of SRSS was unclear. Therefore, the conservative absolute sum method was used to ensure adequate margins. Exceptions are identified for limited components in Table 2.1-2.

2.1.8 Design Changes

In an effort to maximize the design margin, the Zimmer Empirical Loads were defined with sufficient conservatism, that in many cases, the design of the piping equipment and structures approaches the containment and embedment capacity. This approach has required a significant number of changes in the plant. The rest of Chapter 2.0 describes the assessments which were done to redesign or confirm the adequacy of the plant.

A list of plant changes is included in Table 2.1-1. This list shows that a large number of changes have been made in the wetwell and drywell as well as some changes outside containment. In the wetwell area, the addition of the bracing and quenchers resulted in the relocation and upgrading of virtually all the piping and supports, such that, the capability has been considerably increased. Similarly, the use of the governing building response (containment capability) in the drywell design resulted in a significant upgrading of the structural steel and pipe supports.

TABLE 2.1-1

PLANT MODIFICATIONS

WETWELL

Add 79 embedments in walls and basemat
Add 6 pedestal bands for MSRV line supports
Add 226 supports for MSRV and non-MSRV lines
Upgrade sections of MSRV piping size and wall thickness
Replace rams heads with T-quenchers
Relocate T-quenchers for better distribution
Redesign support steel under drywell floor
Remove access hatch grating
Relocate DW-WW vacuum breakers
Add 13 wall embedments
Add downcomer bracing
Add structural steel beam in pedestal
Reroute all 24 non-MSRV lines
Upgrade sections of non-MSRV piping wall thickness
Remove all support attachments to columns
Remove downcomer bottom flange
Fill pedestal with concrete to water level

DRYWELL

Upgrade approximately 10% of drywell steel
Upgrade embedment capacity
Add 15% new snubbers
Upgrade 25% of snubbers and rigid struts
(Approximately 440 total snubbers and 180 rigids in drywell)
Reinforce HVAC supports

TABLE 2.1-1 (Cont'd)

OUTSIDE CONTAINMENT

Upgrade RBCCW Hx supports
Upgrade RHR Hx supports
Add 10% new snubbers
Upgrade 20% of snubbers and rigid struts
(Approximately 470 total snubbers and 600 rigids in Rx building)
Upgrade HVAC supports
Upgrade cable tray and conduit supports
All equipment and foundations
Upgrade all reactor building structures

TABLE 2.1-2

STRUCTURES ASSESSED BY SRSS LOAD COMBINATION OF PIPING LOADS

a. Downcomers

b. Downcomer Bracing

c. Drywell Structural Steel

d. RPV Holddown Bolts

e. Downcomer Reactor Loads on the Drywell Floor

f. Piping and Support Reaction Loads on the Pedestal

g. Selected Piping and Component Supports

h. Elevation 520 ft - Tube Steel Under Drywell Floor

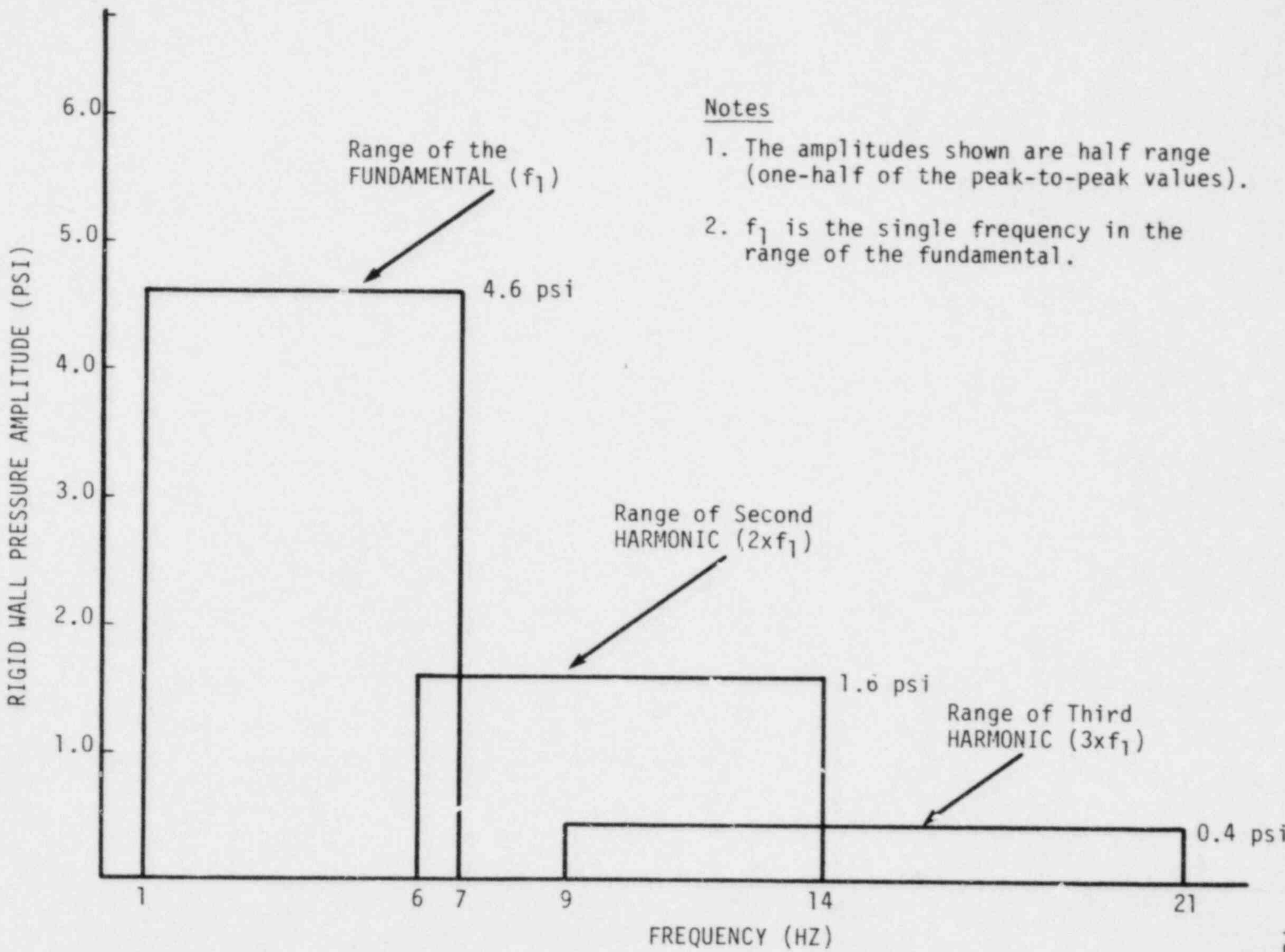

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FIGURE 2.1-4

VENT EXIT COMPONENT

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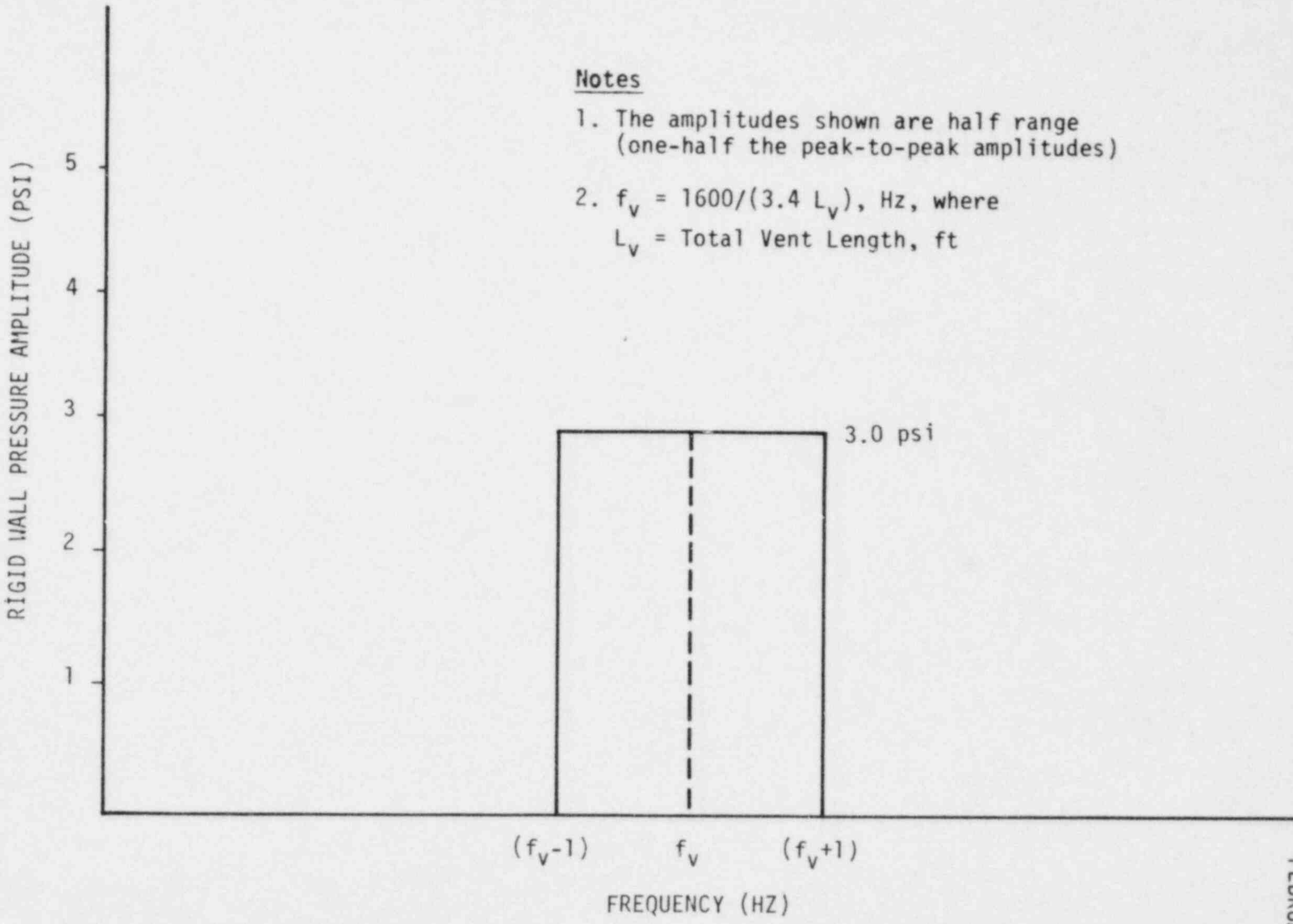

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FIGURE 2.1-5

VENT ACOUSTIC COMPONENT

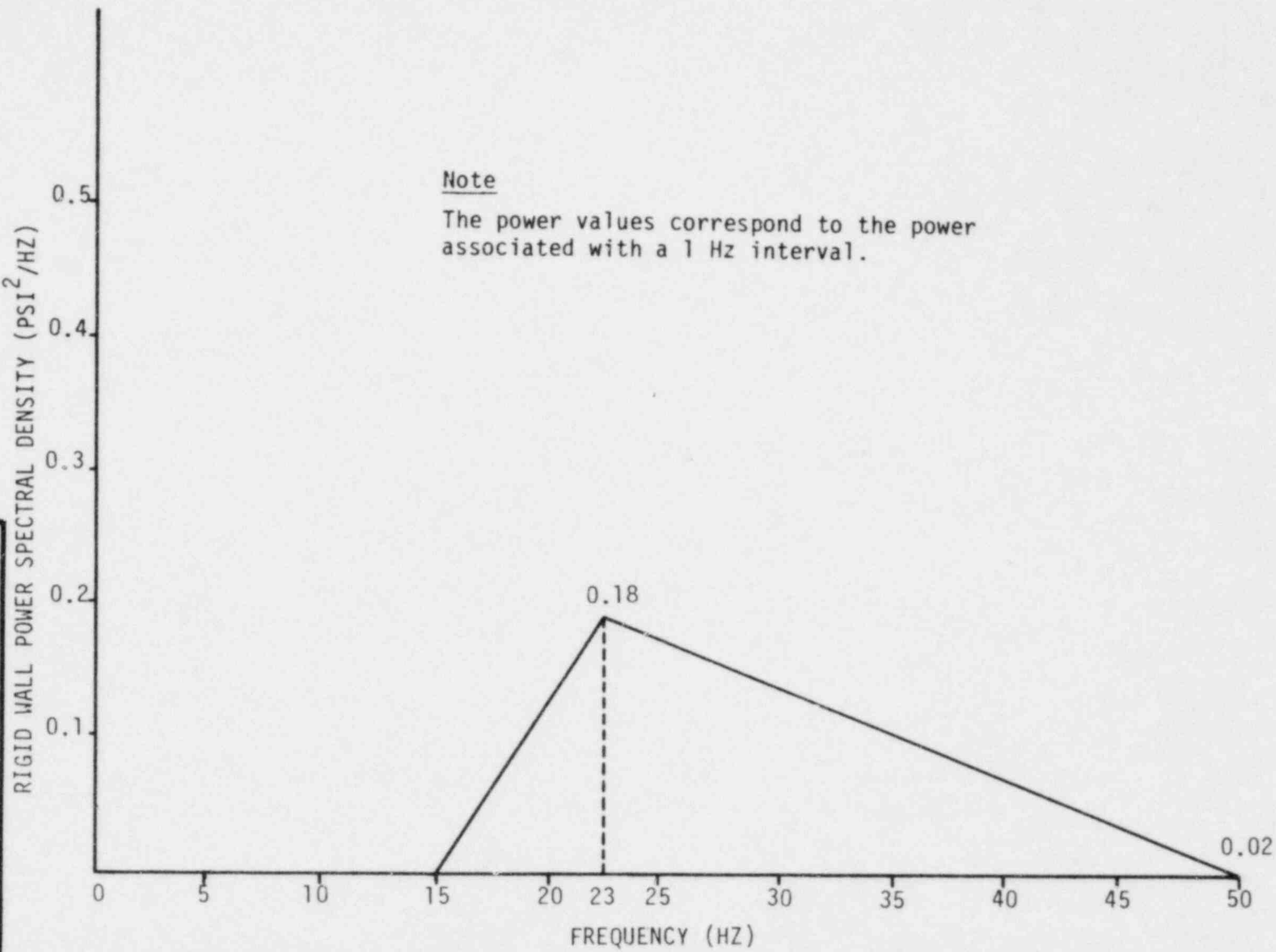

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FIGURE 2.1-6

POWER SPECTRAL DENSITY OF THE NONDETERMINISTIC OSCILLATION CONTENT

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2.2 PIPING ASSESSMENT - PRESENTATION TO NRC DECEMBER 5, 1979

The piping analysis for ZPS-1 was originally completed using the rams head response spectra as the design basis. The appropriate load combinations are defined in Table 2.2-1.

The Zimmer Empirical Loads Approach uses very conservative T-quencher load definitions. The plant had previously been assessed for rams head loads and has the capability to accomodate those loads. As the associated load definitions and response spectra became available, it became apparent that there were some differences between the rams head response spectra and the T-quencher response spectra. The following subsections describe two separate evaluations which were performed to compare the original design basis against 1) the NRC T-quencher loads and 2) the Zimmer Empirical Loads which include more conservative LOCA loads. With the modifications as implemented, the Zimmer plant is believed to be more than adequate. Using the Zimmer Empirical Loads for the KWU T-quencher discharge device, a detailed assessment was completed for the loads and load combinations, which meet or exceed those specified in the NRC Lead Plant Acceptance Criteria (NUREG-0487). These load combination cases are defined in Table 2.2-2 in the column labeled "T-quencher Assessment." Since several of these load combinations are bounded by other load combinations, a notation is provided in Table 2.2-2 to indicate this.

The results of the assessment indicated that all of the piping supports designed for rams head loads are adequate for the T-quencher load definitions. Additional design margins have been incorporated in the support design to accommodate uncertainties in the LOCA loads. Finally, all safety-related piping will be evaluated for adequacy using the LOCA load definitions from the long-term Mark II program based on the 4TCO test data and SRV load definitions, based on in-plant test results in order to confirm the existing design margins.

2.2.1 Comparison of Rams Head Design-Basis Response Spectra and T-Quencher Assessment Response Spectra

Figures 2.2-1, 2.2-2, 2.2-3, and 2.2-4, illustrate the typical differences between the rams head (original design basis) response spectra and the T-quencher assessment response spectra. It was found that the T-quencher assessment response spectra were typically less than the rams head design-basis response spectra in all horizontal directions. This is illustrated in Figure 2.2-3. It was also found that the vertical T-quencher assessment response spectra was higher in the low frequency range, i.e., below 7 hertz, as illustrated in Figures 2.2-1, 2.2-2, and 2.2-4. Since the majority of the safety-related piping in the Zimmer plant were designed to be relatively stiff, i.e., with fundamental frequencies greater than 7 hertz, it was not expected that this low frequency content would have significant impact. The assessment demonstrated that this is the case and is explained in detail in later sections.

2.2.2 T-quencher Assessment - Drywell Piping

A detailed assessment was made to evaluate the adequacy of the rams head design basis against the very conservative T-quencher load definitions. This assessment was completed by performing analyses of 13 of the 25 major piping subsystems in the drywell. The remaining piping subsystems in the drywell were either symmetric to the subsystems analyzed, or their design basis was governed by operating transients. Because of this, it was expected that the T-quencher load assessment would not have a significant impact on these subsystems. A few small diameter piping subsystems (nominal diameter less than 2 inches) and all instrumentation lines were not included in this assessment. All these lines will be included in the final design review of the Zimmer plant.

Both static and dynamic computer analyses were performed on these piping subsystems using techniques identical to production piping analysis. Representative piping systems were analyzed for all applicable load cases, and the governing load combinations were tabulated for comparison purposes. The results of these load combinations were compared to the equivalent rams head load combinations in both the support loads and in the piping stresses.

In general the results indicated that:

a. For load combinations currently required by the NRC, the support loads tend to decrease when rams head design-basis loads are replaced by the T-quencher loads.

b. The loads that did increase were all associated with small diameter (nominal O.D. less than 4 inches) piping systems and even these load increases were all within the rating of the snubber load capacity.

c. The load increases were primarily due to the increases in the lower frequency range of the response spectra.

d. The impact of the piping stresses was insignificant.

e. The impact of the Zimmer Empirical CO Load was significant on the piping systems. This impact was due to the larger amplitude in the higher frequency of the Empirical CO Load response spectra. In addition, the load combination with the CO Empirical could be resolved by using slightly more refined analysis techniques.

2.2.2.3 Summary of Drywell Piping Assessment

As reviewed in Subsections 2.2.2.1 and 2.2.2.2, the rams head design basis results were compared to the load combinations in the NRC acceptance criteria using the KWU T-quencher load definitions. The results of this assessment clearly indicate that the Zimmer design, based on rams head loads, is adequate for the Zimmer Empirical Loads.

2.2.3 Additional Piping Design Margins Obtained Using Zimmer Empirical Loads.

As discussed earlier, the DFFR condensation oscillation load was defined only in the 2 to 7 hertz frequency range. As described earlier, in order to obtain additional design margins, a new empirical limiting steam condensation oscillation load was selected. The impact of this Empirical Limiting Load definition was compared to the original design-basis load definition. Because of this, a criteria has been proposed for the Zimmer Power Station to upgrade the piping support design in order to accommodate the conservative Empirical Condensation Oscillation Loads. This upgrading was accomplished by selecting an Empirical Limiting CO Load with a modified high frequency content. The same piping systems that were assessed for the KWU T-quencher load, as described in Subsection 2.2.2, were also assessed for the Empirical CO Load. In the assessment, the load combination of CO (EL) + SSE + SRV T-quencher was compared to the rams head design-basis emergency load combination of 1.875 OBE + SRV_{ALL} rams head. In this assessment, which is discussed in the following subsection, the impact of the bounding Empirical Limiting CO Load was identified on both the support loads and on the piping stresses. The impact of this load combination is shown by the response spectra comparison in Figure 2.2-12.

2.2.3.1 Impact of the Empirical Limiting CO Load Definitions on Drywell Piping Support Loads

As can be seen in Figures 2.2-13 and 2.2-14, the Empirical Limiting CO Load definitions did have an impact on the piping support loads. While not all loads did increase, it was felt that in order to account for the uncertainties in the high frequency range it was necessary to increase all the loads on the drywell supports. These increased loads were evaluated against the existing support design to determine whether they could be accommodated. If required, these supports were upgraded to a larger size. The resulting design margins available in the drywell supports after the loads were upgraded is illustrated in Figure 2.2-15. Because of this upgrading, all drywell supports will accommodate the Zimmer Empirical Load Criteria and have

2.2.5 Wetwell Piping Assessment

Extensive modifications were made to the piping in the wetwell area including pipe rerouting for the following reasons:

a. installation of T-quencher,

b. addition of downcomer bracing, and

c. reduction of stress of wetwell columns.

The changes involved consisted of:

a. rerouting of all the wetwell piping,

b. replacement of the rams head with T-quencher discharge devices,

c. upgrading of the piping wall thicknesses to accommodate new loads,

d. addition of 226 wetwell supports, and

e. relocation of the T-quencher for better load distribution.

The wetwell piping is being evaluated for the load combinations defined in Table 2.2-8. Since the piping is essentially being redesigned for the Zimmer Empirical Loads, including the Empirical CO Limiting Load definition, no problems are expected in this area.

2.2.6 Final Piping Assessment

See Subsection 9.2.3.

2.3 BALANCE OF PLANT EQUIPMENT - PRESENTATION TO NRC DECEMBER 5, 1979

An assessment of safety-related balance of plant equipment has been performed to evaluate the impact of the Zimmer Empirical Loads. The results of this assessment were presented to the NRC Staff on December 5, 1979, and are summarized in this section.

2.3.1 Assessment and Requalification Procedure

The balance of plant equipment was originally qualified by a program of dynamic testing, analysis, and a combination of test and analysis. This assessment was performed by evaluating the new loads against the design-basis loads included in the existing qualification documentation.

2.3.1.1 Procedure for Equipment Originally Qualified by Testing

a. New required response spectra curves were generated by combining the individual response spectra to obtain one set of curves for each new loading combination.

b. The design-basis curves were compared against the new curves.

c. Where the new curves exceed the design-basis curves, requalification will consist of additional analytical work to supplement the testing in order to demonstrate adequacy.

d. If additional analytical work is not possible or fails to satisfy the acceptance criteria, additional testing will be performed. Limited scope testing, to supplement existing tests, will be considered before complete requalification testing.

e. If qualification cannot be adequately demonstrated, the component will be modified or replaced.

2.3.1.2 Procedure for Equipment Originally Qualified by Analysis

a. New required response spectra curves were generated by combining the individual response spectra to obtain one set of curves for each new loading combination.

b. Based upon the nature of the new curves, the validity of the model and methodology used in the original qualification was checked.

impedance testing, selected pieces of equipment will be tested as installed to determine their natural frequencies and mode shapes. To accomplish this, the equipment will be excited at as many locations as necessary. The input will be of sufficient intensity as to excite all significant modes in the frequency range of 1 to 100 hertz. The response will be measured at locations deemed necessary to detect natural frequencies and mode shapes.

2.3.4 Equipment Foundation Loads

The equipment foundation loads for all balance-of-plant equipment (safety-related and non-safety-related) located in safety-related structures have been recalculated and the adequacy of equipment anchor bolts or welds, equipment foundation, and floor slab has been demonstrated.

2.3.5 Results of Equipment Assessment

2.3.5.1 Valve Qualification Assessment

Of the 572 safety-related valves affected by the new SRV and LOCA loads, 143 were studied to evaluate the impact of the new loads. The basis of this study was to compare piping accelerations against the accelerations for which the valves were qualified. Cases where the piping accelerations exceed the valve qualified accelerations have been identified as requiring further action. It is important to point out that this does not imply that the valve is inadequate, but rather that the existing documentation does not demonstrate its adequacy. The results of the study are summarized below:

VALVE TYPE	NUMBER ACCEPTABLE	NUMBER FURTHER ACTION REQUIRED
Manual Operator	55	16
Motor Operator	20	23
Air Operator	2	8
Check	7	5
Relief	6	1
TOTAL	90	53

2.3.5.2 Equipment and Instrumentation Assessment

A total of 130 pieces was studied for the various loading combinations using both the absolute sum method and the square root of the sum of the squares method. The basis of this study is discussed in Subsection 2.3.1. The results are summarized below:

LOAD COMBINATION	COMBINATION METHOD: NUMBER ACCEPTABLE		NUMBER WHICH MAY REQUIRE REANALYSIS		NUMBER WHICH MAY REQUIRE RETEST		NUMBER IN PROGRESS
	ABS	SRSS	ABS	SRSS	ABS	SRSS	
$N+OBE+SRV_{ALL}$	126	128	2	0	0	0	2
$N+OBE+SRV_{ASY}$	128	128	0	0	0	0	2
$N+SSE+CO_{(DFFR\ def.)}$	126	126	2	2	0	0	2
$N+SSE+SRV_{ADS}+CO$ (Zimmer empirical)	100	110	21	11	4	4	5
$N+SSE+SRV_{ADS}+CHG$	104	110	17	11	4	4	5
$N+\sqrt{(SSE)^2+(AP)^2}$	130	130	0	0	0	0	0

2.3.6 BALANCE-OF-PLANT EQUIPMENT - FINAL ASSESSMENT

See Subsection 9.2.3.

2.4 STRUCTURAL ASSESSMENT

The Zimmer Empirical Loads have been used to assess the structures and components in the reactor building of the Wm. H. Zimmer Power Station. This assessment includes the primary containment, drywell structural steel, drywell floor, reactor pedestal, the downcomer and downcomer bracing system, pedestal straps supporting MSRV and non-MSRV piping, and the suppression pool columns. Only if the structures listed are not found adequate for the conservative Zimmer Empirical Load then a reassessment is made for the NRC Lead Plant Acceptance Criteria (NUREG-0487 and its two supplements).

2.4.1 Method of Assessment

The assessment was done in accordance with the load combinations listed in Chapter 6.0. These load combinations were considered conservatively, as explained in Subsection 2.1.7. Exceptions of limited components to the ABS load combination are listed in Table 2.1-2.

2.4.2 Primary Containment

The assessment of containment and internal concrete structures indicates that the containment wall, the basemat and the suppression pool columns are adequate for the Zimmer Empirical Load. The drywell floor and the reactor pedestal design is adequate to meet the Lead Plant Acceptance Criteria (NUREG-0487 and its two supplements).

2.4.3 Drywell Structural Steel

Piping support loads, based on formal analysis, were used to assess the drywell structural steel.

Approximately 30% of the beams, beam connections and beam supports required reinforcement to accommodate design loads. The piping reaction loads were combined by the SRSS method.

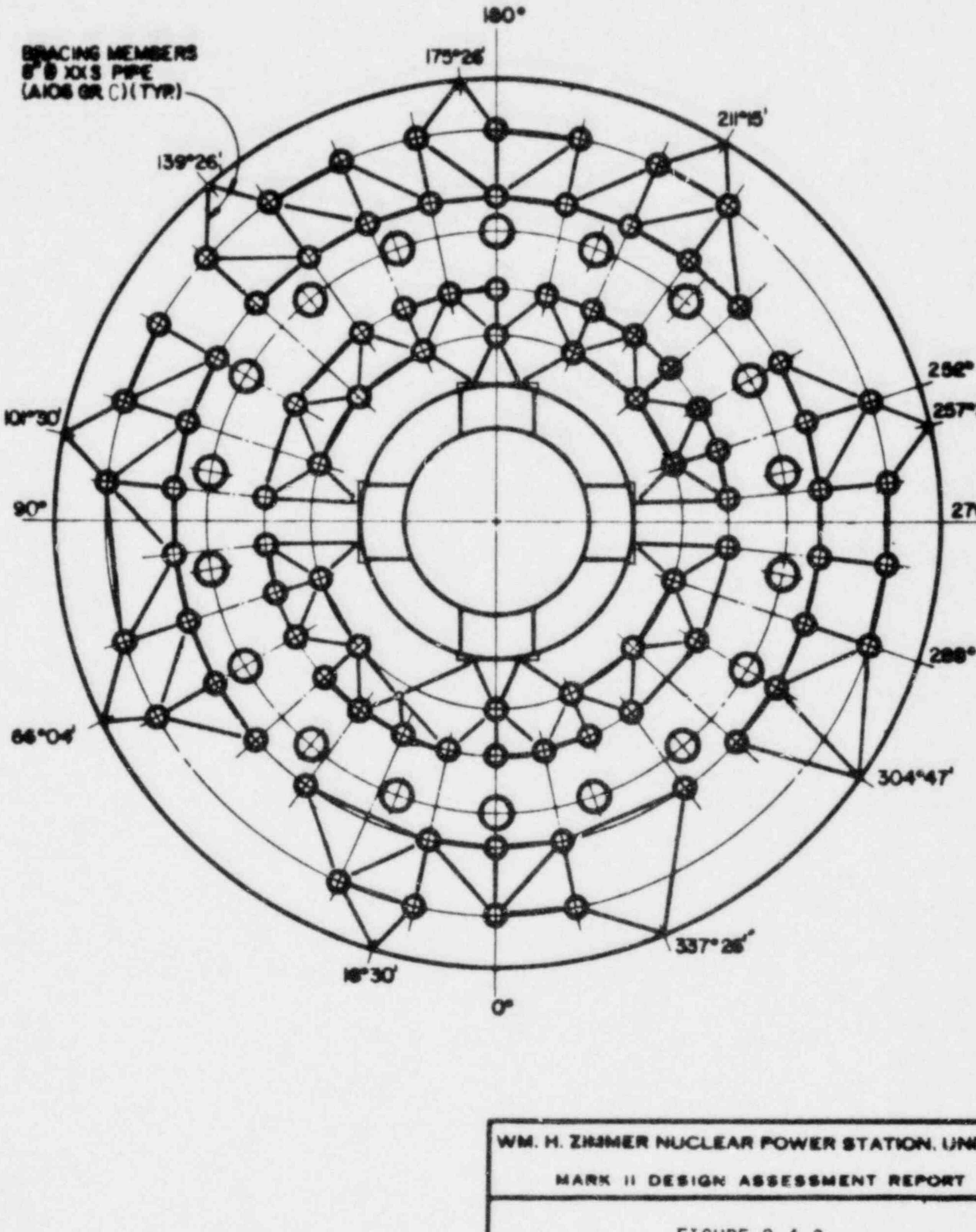
2.4.4 Downcomer Bracing System

The Zimmer Empirical Loads contain increased low frequency loads in both the SRV and condensation oscillation loads. This change had a significant effect on the original unbraced downcomers which had a relatively low natural frequency. In order to accommodate the Zimmer Empirical Loads and also to conform to the NRC Lead Plant Acceptance Criteria, a bracing system has been designed and installed near the pool surface. The bracing system is shown in Figures 2.4-3 and 2.4-4. This system required significant changes in the suppression pool, including additional embedments in the containment wall (Figure 2.4-5), installation of beams in the pedestal for bracing supports (Figure 2.4-6), and re-routing of wetwell piping.

A typical detail of connection of bracing to downcomer is shown in Figure 2.4-7.

2.4.5 Pedestal Straps Supporting Piping

The Safety Relief Valve (SRV) piping required complete re-routing when the rams heads were replaced by quenchers. The quenchers were rearranged from the original rams head positions to minimize containment loads and maximize pool mixing. Installation of the bracing required additional re-routing of the SRV and other piping in the suppression pool. Post-tensioned straps, as shown in Figure 2.4-8, were installed around the pedestal at the required elevations and the pipe supports were connected to these straps.

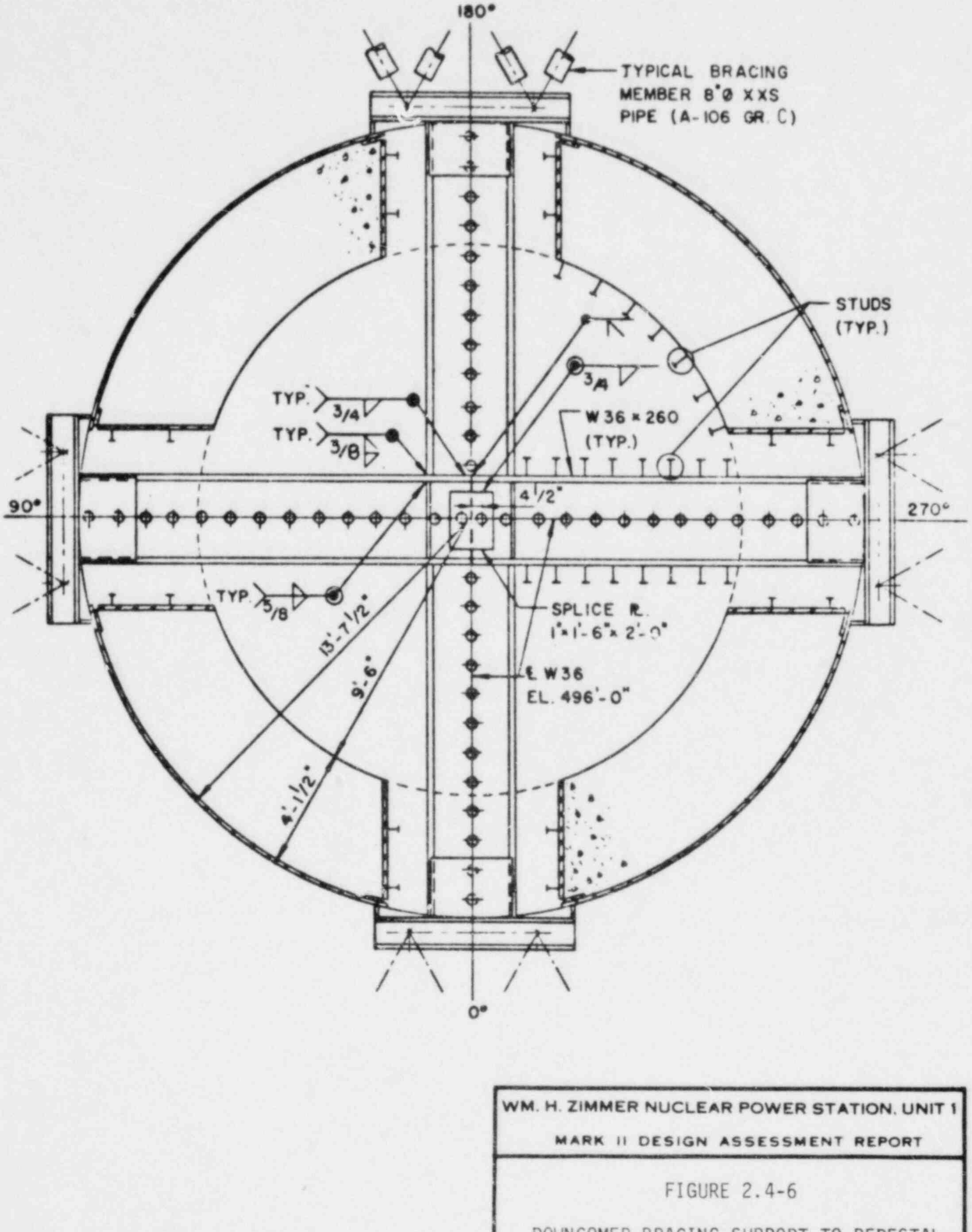


WM. H. ZIMMER NUCLEAR POWER STATION, UNIT 1

MARK II DESIGN ASSESSMENT REPORT

FIGURE 2.4-3

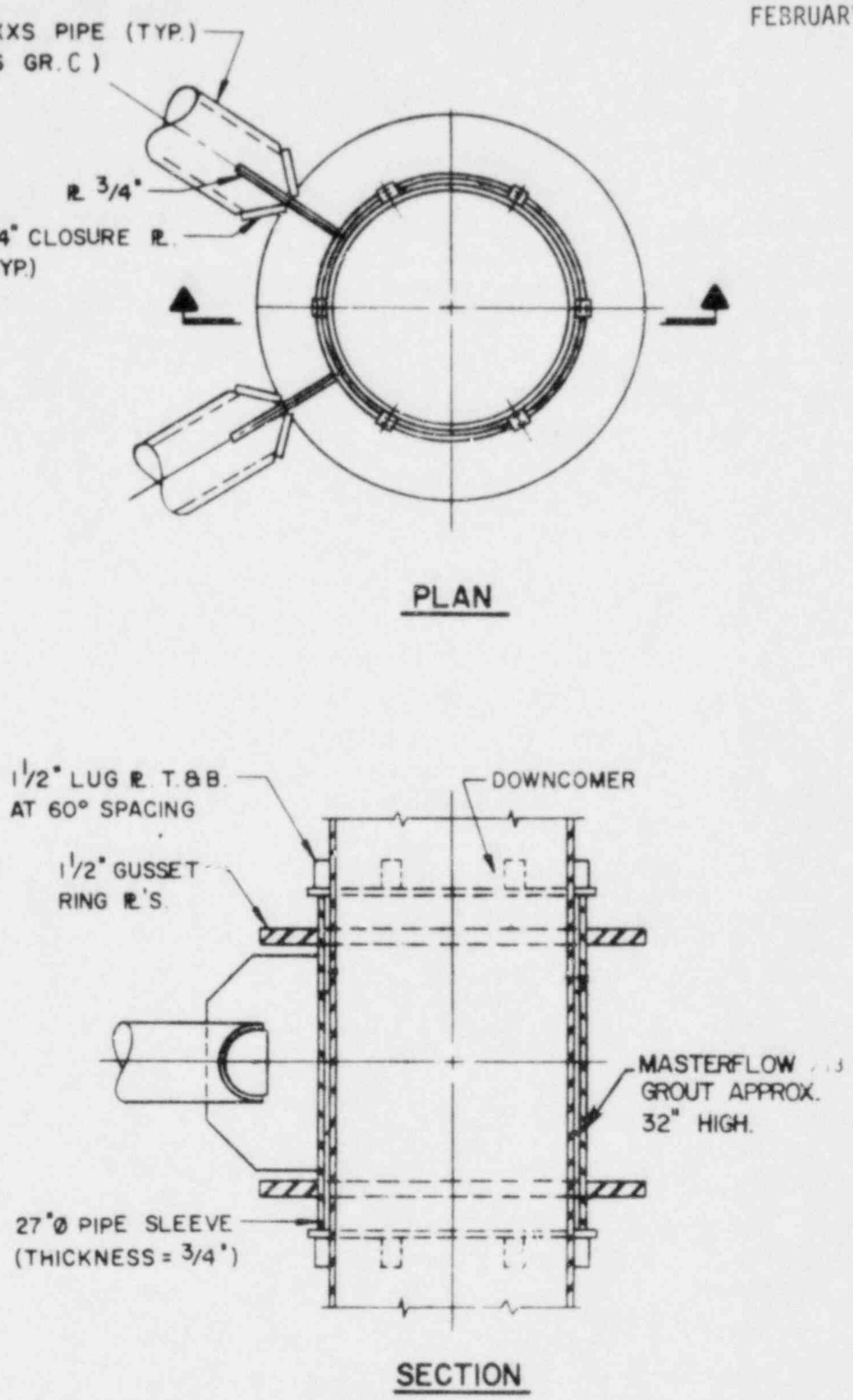
DOWNCOMER BRACING LAYOUT



WM. H. ZIMMER NUCLEAR POWER STATION, UNIT 1
MARK II DESIGN ASSESSMENT REPORT

FIGURE 2.4-6

DOWNCOMER BRACING SUPPORT TO PEDESTAL

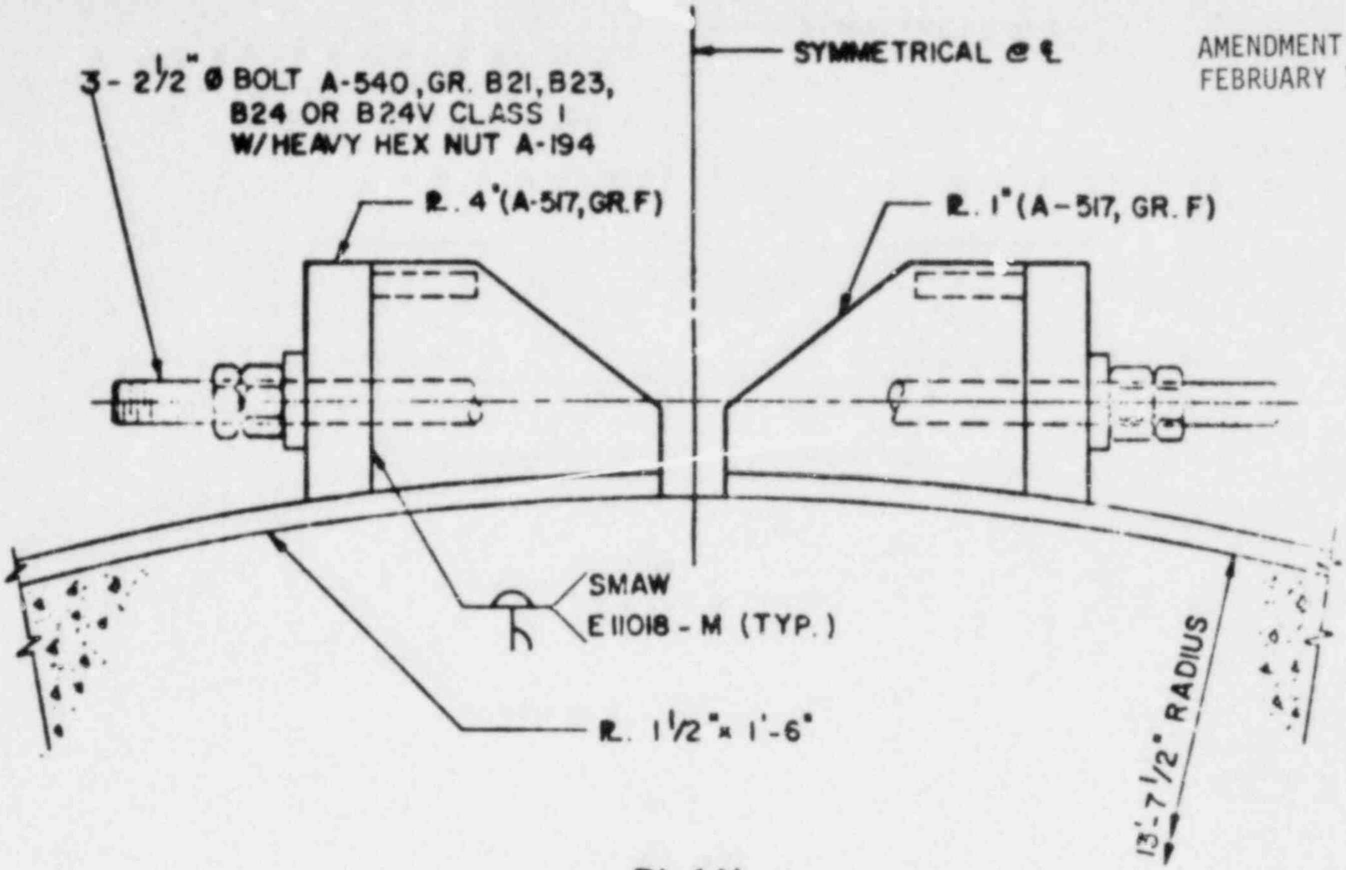


WM. H. ZIMMER NUCLEAR POWER STATION, UNIT 1

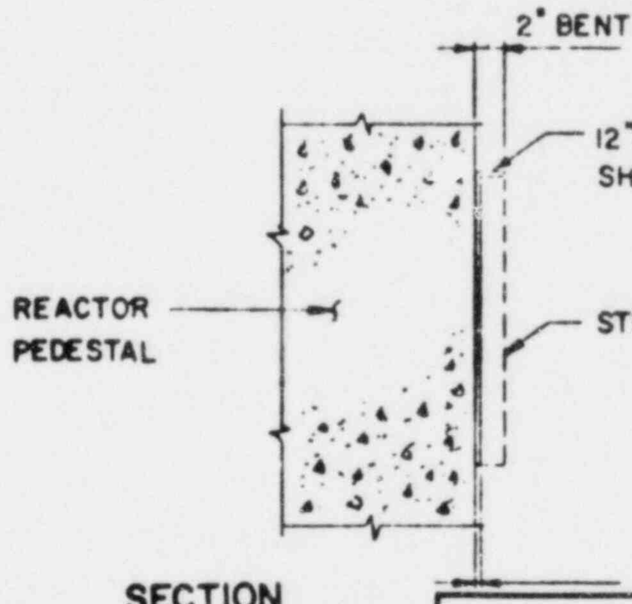
MARK II DESIGN ASSESSMENT REPORT

FIGURE 2.4-7

CONNECTION OF BRACING TO DOWNCOMER



PLAN



SECTION

WM. H. ZIMMER NUCLEAR POWER STATION, UNIT 1

MARK II DESIGN ASSESSMENT REPORT

FIGURE 2.4-8

CONNECTION OF MSRV RING PLATE

2.5 NSSS EQUIPMENT - PRESENTATION TO NRC DECEMBER 5, 1979

The NSSS equipment was originally designed for pressure loads, thermal loads, and seismic loads. Significantly, after the original design was completed, pool dynamic loads were identified. These loads were associated with SRV and LOCA phenomena. New building response spectra and LOCA response spectra were generated, as well as dynamic loads associated with annulus pressurization. The NSSS equipment and piping were reassessed for the combined effect of the original and additional new loads. These were presented to the NRC in November 1978.

Data became available in 1979 from domestic and foreign tests for which the applicant made a decision to upgrade the plant design basis as well as update the reassessment to reflect the installation of SRV T-quenchers. The results of the preliminary reassessment for the combined SRV T-quencher loads and Zimmer Empirical CO Load for the NSSS were also presented with the BOP assessment on December 5, 1979.

Table 2.5-1 summarizes the three different cases evaluated assuming various acceptance criteria and method of load combination (SRSS and Absolute Sum-ABS). Table 2.5-2 is a summary of load case definitions used in developing Table 2.5-1. Table 2.5-3 briefly summarizes the results of previous assessments for SRV rams head and earlier LOCA defined loads.

Tables 2.5-4 and 2.5-5 summarize the results for the RPV, RPV service equipment, and NSSS safety-related components, respectively. The preliminary assessments show that the RPV and RPV service equipment can accommodate the most current KWU, SRV T-quencher loads, and the Zimmer Empirical CO Load in both Case A & B combinations. The only overload identified for the RPV internals is the top guide hold-down latch for which a fix is in process. NSSS instrumentation and floor mounted equipment is being evaluated. It is expected that additional dynamic analysis will demonstrate adequacy for the increased loads. In addition, as noted in Table 2.5-5, the ECCS pumps will be modified to provide additional margin.

A preliminary assessment of the reactor recirculation, piping, main steam piping, and associated pipe mounted equipment is summarized in Table 2.5-5. The conclusion reached is that these components can accommodate the conservative Zimmer design loads. Tables 2.5-6 and 2.5-7 list the main steam and recirculation system snubbers, rating, previous governing load combination, and previous and current margin.

In summary, the NSSS systems design adequacy has been updated to reflect the final design and to provide increased margins. The evaluation was made using conservative criteria as applied to load definitions and acceptance criteria. Corrective action is being taken to increase design margin for the ECCS pump/motors

TABLE 2.5-2

LOAD CASE DEFINITIONS

OPERATING TRANSIENT (OT)

Structural Response to SRV Discharge

Acoustic Load Due to SRV Discharge

Acoustic Load Due to Turbine Stop Valve Closure

LOSS OF COOLANT ACCIDENT (LOCA)

Small/Large/Intermediate Breaks

SRV_{ADS} For Small/Intermediate

Chugging

Condensation Oscillation

Vent Clearing

ANNULUS PRESSURIZATION (AP)

Annulus Pressurization

Jet Loads

2.6 NSSS EQUIPMENT - FINAL ASSESSMENT

Section 2.5 summarized the NSSS equipment assessment completed in December 1979 and presented to the NRC on December 5, 1979. The assessment was based on the data available up to December 1979 and the status of reanalysis using the Zimmer Empirical Loads as well as the SRV T-quencher load definitions.

Reanalysis continued subsequent to the December 5, 1979 meeting using Zimmer unique dynamic loads to document the adequacy of structures, systems, and components for the Zimmer Empirical Loads and NRC acceptance criteria. The reanalysis for the NSSS equipment has been completed and design reports issued documenting the results. Table 2.6-1 summarizes the modifications which have been implemented beyond those committed to at the December 5, 1979 presentation.

Based on the reanalysis of the Zimmer NSSS equipment for the Zimmer Empirical Loads and SRV T-quencher load, the Zimmer plant meets or exceeds the load definitions summarized in the NRC Mark II Lead Plant Acceptance Criteria, NUREG-0487.

TABLE 2.6-1

NSSS EQUIPMENT FINAL ASSESSMENT

RPV	
Top Guide Holddown Latch	Modification incorporated
Other Internals	No change
RPV Shell and Skirt	No change
RPV Servicing Equipment	No change
FLOOR-MOUNTED EQUIPMENT	
ECCS Pumps/Motors	No change
RHR Heat Exchanger	High strength support bolts
MSIV Leakage Control Blower	Larger support bolts
NSSS Instrumentation	No change
PIPING AND PIPE-MOUNTED EQUIPMENT	
Recirculation Piping	4 additional snubbers
Recirculation Pump and Valves	No change
Main Steam Piping	No change
Main Steam Safety Relief Valves	No change
Main Steam Isolation Valves	No change

2.7 CONCLUSIONS

The Zimmer Empirical Load provides a conservative basis to continue the construction and licensing of the Zimmer Power Station. The approach taken includes adequate conservatism to accommodate any load increases which may be required due to test data or other information which is not now available.

As a result of the conservative approach taken, extensive modifications and additions have been made to the wetwell, drywell, and reactor building. In many cases, this has resulted in an upgrading of the plant capability and that of the containment itself. This work was undertaken with the purposes of avoiding costly and time consuming delays in the plant operation and to ensure that the plant design is as safe as possible.

This chapter demonstrates that the Zimmer Empirical Load Approach is an adequate basis to allow the continued construction and licensing of the Zimmer Power Station and has sufficient conservatism to account for any uncertainty in the load.

CHAPTER 3.0 - SRV IN-PLANT TEST PROGRAM

3.1 BACKGROUND

The Wm. H. Zimmer Station - Unit 1 was originally designed with rams head type safety/relief valve (SRV) discharge devices. After new pool dynamic loads were identified, the plant designs were reevaluated and modifications implemented.

After a large portion of the reevaluation effort had been completed, a decision was made to replace the rams head SRV discharge devices with T-quencher devices. This decision was based upon tests that indicated that the T-quencher exhibits better steam condensation stability at higher pool water temperatures than the rams head devices.

It is also expected that the T-quencher discharge will result in loads considerably below the loads used to assess the plant (Zimmer Empirical Loads). The results of the test will serve to quantify this conservatism.

The test matrix is shown in Table 3.3-1 and the definitions of abbreviations and footnotes are shown in Table 3.3-2.

Figures 3.3-1 through 3.3-10 show the actual sensor locations. Figure 3.3-1 illustrates the accelerometer locations. The suppression pool pressure sensors are shown in Figure 3.3-2. Figure 3.3-3 illustrates the suppression pool temperature sensors. Figure 3.3-4 shows some of the SRV discharge line temperature and pressure sensor locations. The suppression pool strain gauge locations appear in Figure 3.3-5. Figure 3.3-6 illustrates the locations of the SRV discharge line level sensors. Figures 3.3-7 through 3.3-10 show sensor locations on various submerged structures in the suppression pool.

3.7 USE OF ASME CODE CASE N-252

Low energy capacitive discharge welding in accordance with ASME Code Case N-252 dated, November 19, 1979, "Low Energy Capacitive Discharge Welding Method for Temporary or Permanent Attachments to Components and Supports, Section III, Division 1, and XI" will be used to install strain gages and thermocouples for the SRV in-plant test. This is in compliance with Regulatory Guide 1.147 (Revision 0). The specific application, materials to be joined, and the minimum thickness of the material to which the strain gage or thermocouple will be attached are as follows:

APPLICATION	TO BE JOINED	MINIMUM BASE MATERIAL THICKNESS
Strain gage attachment welds and cable holddown clip welds. Thermocouple cable holddown clip welds.	STRAIN GAGE FLANGE- SA 240 type 304 stainless steel, SA 106 Grade B or SA 516 Grade 60 steel. HOLDDOWN CLIP - ASTM A-240 type 321 SS BASE MATERIAL-SA 240 Type 304 stainless steel, Type 316L stainless steel, SA 106 Grade B, or SA 516 Grade 60 steel.	0.090 in.

CHAPTER 4.0 - GENERAL DESCRIPTION OF THE PLANT

The Wm. H. Zimmer Nuclear Power Station, Unit 1, employs a GE-BWR/5 housed in a Mark II type containment structure (see Figure 4.0-1). The unit has a rated core thermal power level of 2436 MWt. The Mark II primary containment is a steel-lined, post-tensioned concrete pressure-suppression system of the over-and-under configuration. Pertinent physical data on the containment is summarized in Table 4.0-1. The pressure-suppression design incorporates a total of 88 downcomers with a submergence of 10.1 feet below the low water level of the suppression pool.

The steam generated in the nuclear boiler is directly used by the Westinghouse main turbine-generator unit. The main turbine is an 1800 rpm, tandem-compound, four-flow nuclear steam unit. The nuclear boiler has 13 safety/relief valves to limit pressure buildup in the system as required by the ASME Boiler and Pressure Vessel Code. The valves are mounted on the four main steamlines upstream of the inboard main steam isolation valves and are located in the drywell portion of the primary containment. Six of the 13 safety/relief valves are part of the automatic depressurization system (ADS) which is designed for pressure relief following an intermediate line break. The discharge lines from all of the safety/relief valves are routed into the suppression pool. Each discharge line terminates with a T-quencher discharge device. Each quencher is located approximately 3.5 feet above the top of the suppression pool basemat; this is equivalent to a submergence of approximately 18.5 feet below the pool low water level.

As a result of the reassessment of the Wm. H. Zimmer Power Station to the bounding pool dynamic loads, many changes have been made to the structure, piping, and equipment. Some of the more significant modifications are:

a. Installation of quenchers and associated MSRV line rerouting.

b. Addition of downcomer bracing.

c. Filling of pedestal with concrete to elevation 497 feet 6 inches.

d. Additional supports and restaints for wetwell and drywell piping.

These modifications are listed and explained more completely in Chapter 9.0.

TABLE 4.0-1

PRIMARY CONTAINMENT PRINCIPAL DESIGN

PARAMETERS AND CHARACTERISTICS

I. DESIGN PRESSURES		
A. Containment Internal Design Pressure	45 psig	
B. Containment External Design Pressure	+2 psig	
C. Drywell Floor Differential Design Pressure		
1. downward	25 psi	
2. upward	9 psi	
II. VOLUMES		
A. Maximum Drywell Free Air Volume	180,000 ft^3	
	MAXIMUM	MINIMUM
B. Suppression Chamber Free Air Volume	96,300 ft^3	94,000 ft^3
C. Suppression Chamber Water Volume	95,300 ft^3	93,000 ft^3
III. DOWNCOMER SUPPRESSION VENTS		
A. Number of Downcomers	88	
B. Internal Diameter	2.0 ft	
C. Wall Thickness (Nominal)	0.5 in.	
D. Material	SA 516 Grade 60	
E. Length		
1. unembedded length	33 ft 6-3/4 in.	
2. total length	37 ft 3-3/4 in.	
3. submergence depth	10.1 ft	
IV. SAFETY/RELIEF VALVE DISCHARGE LINES		
A. Number of Discharge Lines	13	

3. Air clearing loads:
    a) on submerged structures;
    b) on containment structures; and
    c) on piping, equipment, RPV, and internals.
4. Pool swell loads:
    a) drag loads,
    b) impact loads, and
    c) fallback loads.
5. Condensation oscillation loads:
    a) on submerged structures;
    b) on containment structures; and
    c) on piping, equipment, RPV, and internals.
6. Chugging loads:
    a) on submerged structures;
    b) on containment structures; and
    c) on piping, equipment, RPV, and internals.
7. Downcomer lateral loads:
    a) static equivalent load, and
    b) dynamic load.
8. Loads on drywell floor:
    a) downward differential pressure,
    b) upward differential pressure, and
    c) loads due to forces on downcomers.
9. Annulus pressurization:
    a) on sacrificial shield, and
    b) on piping, equipment, RPV, and internals.

The original design loads are always considered to occur in combination, as appropriate, with the pool dynamic loads. It should be noted that these pool dynamic loads are relatively small compared to the original containment and reactor pressure vessel (RPV) design basis. Therefore, the original design contains adequate margin to accommodate these pool dynamic loads. These conservatisms are discussed in Chapter 10.0 of this report.

These additional pool dynamic loads are significant, however, when compared to the original design basis for the downcomer piping, and equipment. Therefore, design modifications have been implemented in these areas which will allow these additional loads to be safely accommodated by meeting all code requirements. These modifications are discussed in Chapter 9.0 of this report.

5.2 SAFETY/RELIEF VALVE (SRV) LOADS - PRESENT DESIGN LOADS (T-QUENCHERS)

Actuation of safety/relief valves (SRV) produces direct transient loads on components and structures in the suppression chamber region and the associated structural response produces transient loadings on piping systems and equipment in the containment region and reactor building. These transient SRV loadings are discussed in the following subsections.

Prior to actuation, the discharge piping of an SRV line contains atmospheric air and a column of water corresponding to the line submergence. Following SRV actuation, pressure builds up inside the piping as steam compresses the air in the line. The resulting high-pressure air bubble that enters the pool oscillates in the pool as it goes through cycles of overexpansion and recompression. The bubble oscillations resulting from SRV actuation and discharge cause oscillating pressures throughout the pool, resulting in dynamic loads on pool boundaries and submerged structures. These dynamic loads cause a dynamic structural response sufficient to affect piping systems and equipment in the containment and reactor buildings. The assessment of the affected systems for these responses is discussed in Chapter 7.0.

Steam condensation vibration phenomena can occur if high-pressure, high-temperature steam is continuously discharged at high-mass velocity from rams head devices into the pool, when the pool is at elevated temperatures. This phenomena is mitigated by installing quencher discharge devices and maintaining a low pool temperature as discussed in Chapter 8.0.

The characteristics of the SRV actuation load vary depending on the piping configuration and the discharge device (rams head or quencher) located at the exit of the SRV line. Typically, the quencher device produces lower dynamic loads. Zimmer Power Station used a bounding load calculated for a rams head device as an original design basis for structures, equipment, and piping systems. A bounding quencher load is now used. To provide increased plant safety margins for containment SRV loads and to increase the threshold temperature limit for steam condensation vibration, SRV quencher devices are installed in the plant.

Pool temperature transients for several postulated cases involving a stuck-open SRV are presented in Section 8.2. The calculated maximum pool temperature for a rams head device was found to be a few degrees below the threshold temperature limit for steam condensation instability.

In order to increase the margin between the calculated maximum temperature and this threshold temperature limit, it was decided to install a quencher device having a higher suppression pool temperature limit as reported in NEDE 21078, October 1975, rather than to perform additional testing with the rams head discharge device. The quencher device provides an additional benefit, since the peak pressure amplitude of the containment structural loads due to the oscillating air bubble are reduced below the corresponding design-basis values for the rams head device. Therefore, it was concluded that a quencher discharge device not only provides an increased margin for the threshold pool temperature limit, but that the plant will generally experience lower loads than those used in the rams head design basis.

The quencher device being used is the two-arm "T"-quencher developed for the Mark II Susquehanna Plant by KWU. This device has been tested in a full-scale, single-cell facility as reported in Chapter 8 of the Susquehanna Design Assessment Report. The test facility is prototypical of the Susquehanna plant. Parameters were varied to include a range of initial conditions and the longest and shortest lines of Susquehanna. The tests were conducted to duplicate expected operating conditions including first and subsequent actuations. The geometry and initial conditions tested closely simulate those for the Zimmer Power Station. These tests showed that the device will condense steam without significant loads at pool temperatures up to and even above 200° F. In addition, the tests showed that the actual quencher loads are conservatively bounded by the design loads given in Chapter 4 of the Susquehanna DAR. Since ZPS-1 is being assessed for these design loads in addition to the rams head loads, this demonstrates again the conservatism of the ZPS-1 design.

Quenchers with four arms (X-quenchers) have been installed and tested at Caorso, a Mark II plant in Italy. This test included single valve first and subsequent actuations, multiple valve actuations (up to eight valves), and an extended blowdown thermal mixing test. The results of these tests are reported in NEDE 25100P, "Mark II Containment Supporting Program Caorso Safety Relief Valve Discharge Tests, Phase I Test Report" (May 1979), and by GE letter MFN-090-79 (L. J. Sobon to J. F. Stolz, March 1979). The measured loads were much less than those predicted by the analytical models in DFFR. The increase in load between single and multiple valve discharge was less than predicted. The extended blowdown indicated good mixing with a final bulk to local temperature differential of about 10° F.

In the following subsections several current licensing issues are discussed and the methods used to predict loads for the ZPS-1 plant design reassessment are summarized.

5.2.1 Design-Basis SRV Loads - Rams Head

The original design basis for reassessment of the structure, attached piping systems, RPV, and equipment was based upon dynamic loads calculated for a rams head discharge device. The

5.2.2.2.1 Single Valve

The load distribution on the containment walls for a single valve actuation is shown in Figure 4-26 of the Susquehanna DAR. This load is better described as a subsequent actuation of a single valve.

5.2.2.2.2 Asymmetric SRV Load

The asymmetric quencher load is defined as a three-valve discharge rather than the two-valve discharge used in the rams head asymmetric load. Although this condition is not realistic it gives a maximized asymmetric distribution as depicted in Figure 4-25 of the Susquehanna DAR.

5.2.2.2.3 Automatic Depressurization System (ADS)

Figure 4-27 of the Susquehanna DAR shows the ADS pressure distribution. This distribution was constructed by combining single valve discharge loads at typical quencher locations. This would yield the expected distribution of more or less evenly spaced peaks but because of a conservative increase in the azimuthal angle of the single valve load, this results in an almost uniform distribution. For additional conservatism, the all valve distribution is used in most cases.

5.2.2.2.4 All Valve Discharge

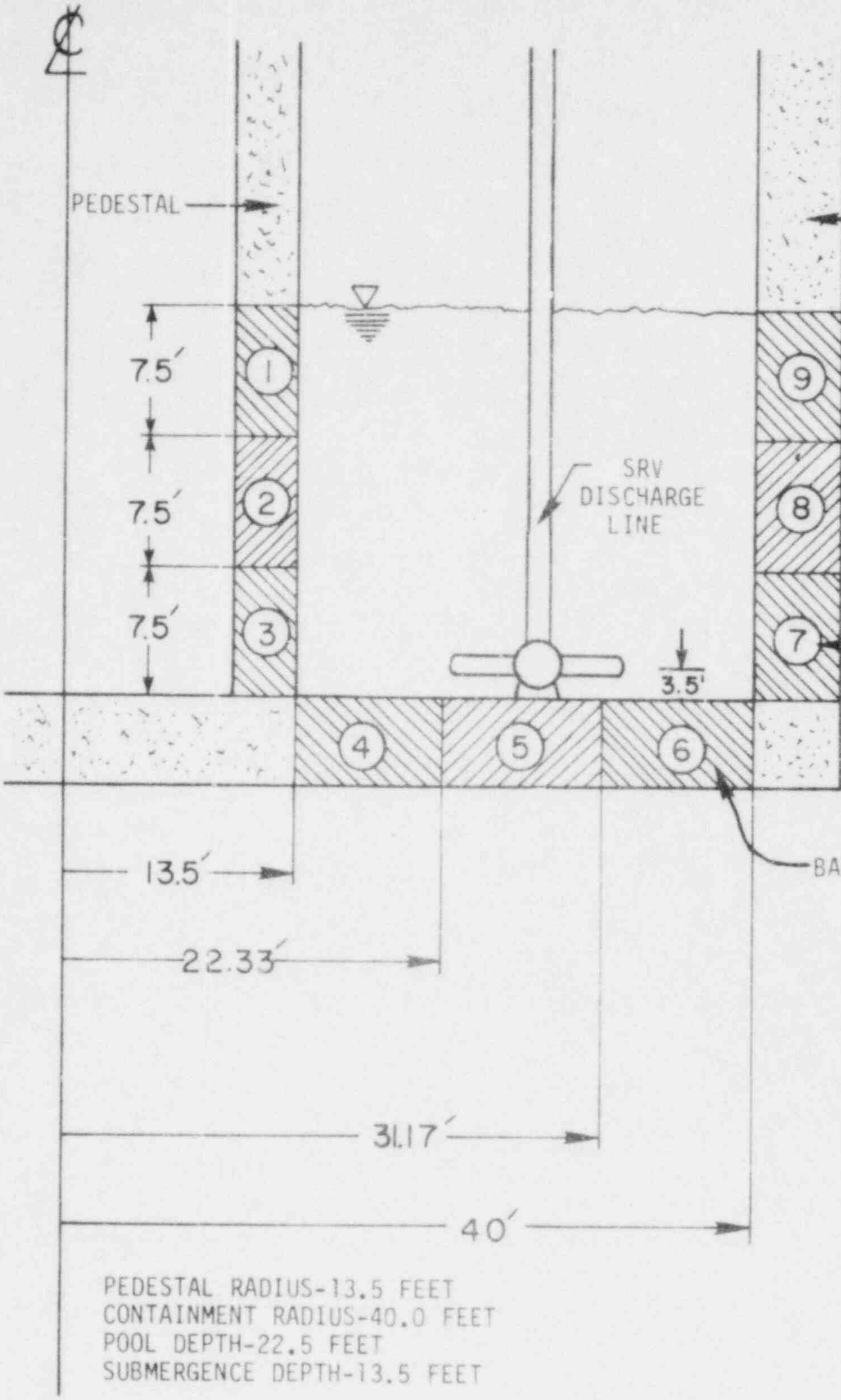
The all valve T-quencher discharge case is defined as the single valve discharge load applied uniformly throughout 360°. The physical interpretation of this load would be a subsequent actuation of all valves with all bubbles entering the pool simultaneously and oscillating in phase.

5.2.2.3 Quencher Boundary Loads

The above described quencher load definitions have been applied to the suppression pool wetted boundaries to assess the structure, piping, and equipment. This assessment is documented in Chapter 7.0.

5.2.2.4 Quencher Submerged Structure Loads

Submerged structure loads are affected by geometric changes in the pool because these loads are local loads. The change in discharge device location was assessed by using the existing submerged structure methodology with pressure amplitude, frequencies, and bubble locations appropriate to the KWU quenchers. The bubble pressure amplitude is determined for both first and subsequent actuation using the correlation in NEDO 21061, Revision 3 (DFFR). An amplitude adjustment factor to account for the difference in rams head and X-quencher devices is used as described in Subsection 2.1.6.2. The bubble frequency range is reported in Subsection 5.2.2.1.



NOTE: DRAWING NOT TO SCALE.

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FIGURE 5.2-4

CROSS SECTION OF SUPPRESSION POOL AND DEFINITION OF SUPPRESSION CHAMBER WALLS' LOADING ZONES

5.5 ALTERNATE LOAD DEFINITIONS AND LOAD COMBINATIONS

Since the original formation of the Zimmer design basis, the NRC has relaxed some of the requirements for Mark II hydrodynamic load definitions. Additional test data has also become available which supports modification of some of the loads. The original design basis based on Zimmer Empirical Loads provides a conservative design basis. The purpose of this section is to identify those reduced loads and load combinations used for components which could not accommodate the conservative Zimmer Empirical Load. The alternate load definitions and combinations are not used for any portion of the Zimmer design except for specific components noted in Table 5.5-1.

5.5.1 SRV Load Definitions

In NUREG-0487, Supplement 1, the NRC accepted a reduction in the amplitude of the KWU T-quencher load for first actuation cases. The original load definitions, as documented in the Susquehanna DAR, employed a set of time-histories with the amplitudes increased by a factor of 1.5 for all discharge cases. The NRC allowed this factor be changed to 1.1 for all cases except subsequent actuation. The NRC specifically approved use of the 1.1 factor for the all-valve, ADS, asymmetric and first actuation cases.

Application of this load reduction to Zimmer is complicated by the predicted five-valve multiple subsequent actuation (MSA) case. This case was originally not a design controlling case because the 1.5 amplitude factor was applied to the all-valve case. Because of the very conservative geometric distribution used with the T-quencher load definitions, the multiple subsequent actuation becomes the bounding symmetric load if the amplitude multiplier on the all-valve case is reduced to 1.1. After investigation it has been determined that the all-valve case with an amplitude multiplier of 1.31 would yield the same symmetric results as the MSA case with a 1.5 multiplier. In addition, the conservatism of the asymmetric distribution is sufficient to ensure that the maximum asymmetric loads from both first and subsequent actuation cases are bounded by the asymmetric case with a 1.1 multiplier.

A summary of the revised SRV load magnitudes is provided in the load combination Subsection 5.5.3.

5.5.2 LOCA Load Definitions

Recently, test data became available from the 4TCO (full-scale single-vent) steam condensation tests. These tests were more prototypical to Mark II plants in geometry and blowdown transients tested than the original data base. The 4TCO tests provided more realistic Condensation Oscillation (CO) and Chugging Loads.

Load definitions have been developed from this data (Subsection 5.5.4) and used to generate response spectra. In many cases, these loads are less than the original design-basis loads (Appendix I). Both the design-basis and the 4TCO LOCA loads are considered adequately conservative design bases. However, the 4TCO loads are not direct replacements for the Zimmer design-basis load. The design-basis loads are empirical loads formulated to bound potential load changes. In comparison to the actual data, it appears the CO load was excessively conservative while the design-basis chugging load was too restricted in its range. Analysis of structures and components listed in Table 5.5-1 was performed with the 4TCO CO and chugging loads.

5.5.3 Load Combinations

Only the applicable substitutions are listed. It should be noted that these substitutions are different for cases involving LOCA loads than those without. Also the factors listed for the SRV loads are revised amplitude factors for the original T-quencher load definition. A factor of 1.5 was used for all original cases. Therefore, any factor less than 1.5 is a load reduction. Tables 5.5-2 and 5.5-3 list the alternate loads available for the various load combinations.

5.5.4 References

1. General Electric Company and S. Levy, Inc., "Condensation Oscillation (CO) Load Data for LaSalle," July 1980,

2. Creare (Report No. TN-322) and S. Levy, Inc., (Report No. SLI-8075-1), "Chugging Loads for Assessment of the 4TCO Data," September 1980.

TABLE 5.5-1

APPLICATION OF ALTERNATE LOAD DEFINITIONS AND LOAD COMBINATIONS

The following components utilized the load definitions and combinations contained in Section 5.5.

COMPONENTS

NSSS:

Core Support Plate (RPV Internals)

Top Guide (RPV Internals)

BOP:

Drywell Floor

Reactor Pedestal

TABLE 5.5-2

LOAD COMBINATIONS (NON-LOCA)

DESIGN-BASIS LOAD	REVISED LOAD
All-Valve (1.5)	All-Valve (1.31)
ADS (1.5)	ADS (1.1)
Asymmetric (1.5)	Asymmetric (1.1)
Low Setpoint Actuation (1.5)	Low Setpoint Subsequent Actuation (1.5)
	Low Setpoint First Actuation (1.5)
Single-Valve (1.5)	Single-Valve Subsequent Actuation (1.5)
	Single-Valve First Actuation (1.1)

TABLE 5.5-3

LOAD COMBINATIONS (LOCA)

LOCA LOAD*	SRV LOAD** SYMMETRIC COMPONENT	SRV LOAD** ASYMMETRIC COMPONENT
CO-1***	Low Setpoint (1st Actuation)	Single-Valve (1st Actuation)
CO-2	ADS	Asymmetric
	Low Setpoint (Subsequent Actuation)	Single-Vent (Subsequent Actuation)
Chugging	ADS	Asymmetric
	Low Setpoint (Subsequent Actuation)	Single-Valve (Subsequent Actuation)

* LOCA loads may be design basis or 4TCO, but CO-1, CO-2, and vertical chugging must be from the same data base.

** All SRV loads use 1.1 factor except subsequent actuation loads which use 1.5 factor.

*** CO-1 and CO-2 are defined in Subsection 2.1.3.

SRV-Single Actuation of one valve.

The LOCA loads are denoted by P_A and P_B in the load combination table and represent three possible pipe break accidents:

a. DBA - design-basis large break accident

b. IBA - intermediate break accident

c. SBA - small break accident.

Wherever applicable the following loads associated with LOCA are included whenever P_A or P_B occur in the load combinations:

a. LOCA pressure

b. accident temperature

c. pipe break reactions

d. vent clearing and pool swell

e. condensation-oscillation

f. chugging.

Even though the SRV and LOCA loads used for design are bounding loads as discussed in Subsection 5.2.1.3, additional load factors are applied to these loads (see load combination in Table 6.1-1) to assure conservatism.

The load factors adopted are based upon the degree of certainty and probability of occurrence for the individual loads as discussed in the DFFR. The relation between the different times of occurrence of various time-dependent loads as presented in the DFFR were combined and accounted for to determine the most critical loading conditions. In any load combination, if the effect of any load other than dead load (such as thermal loads) reduces the net design forces, it is deleted from the combination to maximize the design loads.

The reversible nature of the structural responses due to the pool dyanmic loads and seismic loads is accounted for by considering for each the peak positive and negative magnitudes of the response forces and maximizing the total positive and negative forces and moments governing the design.

Seismic and pool dynamic load effects are combined by summing the peak responses of each load by the ABS method with the exception of AP + SSE case where SRSS method is used. This is conservative, and the SRSS method is more appropriate, since the peak responses of all loads do not occur simultaneously. However, except for limited components as noted in Table 2.1-2, the conservative ABS method is used in the design

6.3 OTHER STRUCTURAL COMPONENTS

6.3.1 Load Combinations

The load combinations, including pool dynamic loads considered in the reassessment of concrete structures (other than containment and internal concrete structures) such as shear walls, slabs, beams, and block walls are shown in Table 6.3-1.

The load combinations, including pool dynamic loads considered in the reassessment of steel structures such as framing, containment galleries, embedments, hangers for cable trays, conduits, and ducts are listed in Table 6.3-2 and the downcomers and downcomer bracing system are listed in Table 6.3-3.

For concrete structures, the peak effects resulting from seismic and pool dynamic loads were combined by the conservative ABS method, even though the SRSS method is more appropriate, since the probability of all peak effects occurring at the same time is very small.

Likewise for steel structures, except for limited components as noted in Table 2.1-2, the peak effects resulting from seismic and pool dynamic loads were combined by the ABS method.

6.3.2 Acceptance Criteria

The acceptance criteria used in the reassessment of reinforced concrete structures other than containment and internal concrete structures are the same criteria defined in Subsection 3.8.4.5 of the ZPS-1 FSAR and are identified in Table 6.3-1 for each load combination. The stresses and strains are limited to those specified in ACI 318-1971. As indicated in Table 6.3-1, working stress design is used for load combinations 2 through 6. The ultimate strength design of ACI 318-1971 is used for extreme environmental category load combinations 7, 8, and 9. As stated in the FSAR, when a LOCA occurs outside the containment, as in load combinations 10, 11, and 12, yield line theory is used to design reinforced concrete walls and slabs. The masonry walls are designed per the SEB Interim Criteria for Safety-related Masonry Wall Evaluation, Revision 1, dated July 1981, except as follows:

a. Load combination Table 6.3-1 is used for combining the effects of different loads.

b. An allowable stress of 12 psi for tension perpendicular to bed joint is permitted.

For steel structures, stress and strains in accordance with the 1969 AISC specifications are used for load combinations 2 through 6 defined in Table 6.3-2. For load combinations involving abnormal or extreme environmental loads, as in load combinations 7 through 12 of Table 6.3-2, the steel stresses were conservatively limited to 0.95 F_y.

TABLE 6.3-2 (Cont'd)

NOTES:

a. Loads not applicable to a particular structure or system are deleted.

b. If for any combination, the effect of any load other than D reduces the load, it is deleted from the combination.

c. For SRV, the resultant effects for both horizontal and vertical components shall be determined by combining the individual effects by the square root of the sum of the squares.

d. For DBA (annulus pressurization), loads are combined by SRSS method.

e. Plastic section modulus of steel member shapes is used for stress computation for load combinations 11, 11a, 11b, 12, 12a, and 12b.

f. Conduit hangers, electrical cable tray hangers and HVAC hangers have been designed for load combinations 3, 11, 11a, 11b, 12, 12a and 12b only.

g. SRSS pipe support loads are used for the design of drywell structural steel.

TABLE 6.3-3

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA FOR DOWNCOMER AND DOWNCOMER BRACING

LOAD CASE	NRC LOAD COMBINATION (NUREG-0487)	T-QUENCHER DESIGN-BASIS	ASME STRESS CRITERIA
1	$N+SRV_X$	N+SRV	B (UPSET)
2	$N+SRV_X+OBE$	$N+\sqrt{(SRV)^2+(OBE)^2}$	B (UPSET)
3	$N+SRV_X+SSE$	$N+\sqrt{(SRV)^2+(SSE)^2}$	C (EMERGENCY)
4	$N+SRV_{ADS}+IBA(SBA)$	$N+\sqrt{(SRV)^2+(CHUG)^2}$	C (EMERGENCY)
5	$N+SRV_{ADS}+OBE+IBA(SBA)$	$N+\sqrt{(SRV)^2+(OBE)^2+(CHUG)^2}$	C (EMERGENCY)
6	$N+SRV_{ADS}+SSE+IBA(SBA)$	$N+\sqrt{(SRV)^2+(SSE)^2+(CHUG)^2}$	C (EMERGENCY)
7	N+SSE+DBA	$N+\sqrt{(SSE)^2+(CO)^2}$	C (EMERGENCY)
8	N	N	A (NORMAL)
9	N+OBE	N+OBE	B (UPSET)
10	$N+SRV_X+SSE+DBA$	- CONTAINMENT STRUCTURE ONLY JUSTIFICATION PROVIDED BY GE.	

CHAPTER 7.0 - REEVALUATION AND DESIGN ASSESSMENT

7.1 CONTAINMENT AND INTERNAL CONCRETE STRUCTURES

The containment and internal concrete structures were reevaluated for the pool dynamic loads to insure structural adequacy. Dynamic structural analyses using finite-element models were performed for the reevaluation. Details of the analyses and reevaluation are summarized in this section.

7.1.1 Structural Analysis for SRV Loads

The structural response of the reactor containment to the dynamic safety/relief valve (SRV) discharge loads was determined by a detailed dynamic analysis of the system, including the effects of soil structure interaction. The structure was analyzed by a finite-element model which was subjected to the SRV load time histories described in Chapter 5.0, and the dynamic response was obtained by numerical integration of the governing differential equations. The SRV discharge cases were analyzed separately and the results were used to check the structural integrity in combination with all other simultaneous loads in accordance with the applicable load combinations (Section 6.1).

For the purpose of analysis, the containment structures were modeled by axisymmetric finite elements (Figure 7.1-1). The structural model includes the basemat, primary containment, reactor pedestal, drywell floor, the reactor pressure vessel (RPV), the foundation soil, and the fluid in the pool. The fluid was simulated as described in Reference 2. Also included in the model were the suppression chamber columns, RPV stabilizer truss, and refueling bellows, as well as the containment building and spent fuel pool slab. Different material properties were used to describe the different characteristics of the various components.

The RPV was represented by shell elements. Drywell floor support columns were modeled as orthotropic shell elements. Containment building walls and spent fuel pool slab were included as axisymmetric shells to account for their mass and stiffness contribution.

The soil was modeled by axisymmetric solid finite elements in nine horizontal layers to the bedrock level at elevation 400 feet. The dynamic strain-dependent stiffness and damping characteristics of the soil were used to determine a stable set of material properties for the soil elements. Refer to Table 7.1-1 for the factors to be used on the modulus and damping curves of Figures 7.1-2 and 7.1-3, respectively.

The containment structure model was analyzed by the Sargent & Lundy version of the finite-element computer program DYNAX (Appendix A, Section A.1). This program was suitable to analyze axisymmetric shells and solids subjected to arbitrary static or dynamic loads.

SRV discharge loads were specified by individual time history variations for the pressure Fourier harmonics in nine zones along the containment basemat and reactor support. Figure 7.1-4 shows the zones used to define the various pressure time-histories. These SRV discharge loads depend upon the devices used at the discharge end of the SRV lines. Two cases of SRV loading, rams head loading and T-quencher loading, were considered.

Rams Head Loading

Typical pressure time history plots for the rams head discharge case, which is described in Subsection 5.2.1, are shown in Figure 7.1-5 and 7.1-6 for Zone 4 on the basemat due to resonant sequential discharge of all valves and asymmetric discharge, respectively.

Different pressure time histories for the various zones and the various harmonics were, therefore, used to represent the pressure fluctuations on the suppression pool walls. The effect of the varying circumferential and meridional pressure distributions was accounted for in this manner.

The dynamic response of the structure to the hydrodynamic pressure loads was then determined by direct numerical integration of the governing differential equations. The response time histories were thus established and the time-wise maximum values were obtained at each element or node location.

The acceleration response time-histories were then used to determine the response spectra at the desired locations and direction using the computer program RSG (Appendix A, Section A.5).

The resulting structural responses to the various SRV loads were combined with the other appropriate loads as per the load combinations shown in Table 6.1-1. The margin factors from these load combinations are presented in Table 7.1-2 through 7.1-16.

T-quencher Loading

Typical pressure time histories for the T-quencher are described in Subsection 5.2.2.

The method of direct integration is not suitable for the T-quencher case because the frequency of the dynamic load is a variable and can assume any value in a defined range. Therefore, a dynamic analysis was performed in the frequency domain rather than in the time domain. The method of such an analysis is known as the "Fourier Transform Method" or "Frequency Response Method." Essentially this method is analogous to the influence line method used in static analyses.

The dynamic response of a particular component k (acceleration, force, displacement) can be expressed as:

$$R_k (\omega) = T_k (\omega) F (\omega)$$

in which

$R_k (\omega)$ = structural response of the k^{th} component,

$T_k (\omega)$ = transfer function of the k^{th} component, and

$F (\omega)$ = Fourier transform of the external load.

It should be noted that all quantities in the above equation are scalars and are only functions of the harmonic frequency.

Transfer function, also known as complex frequency response function $T_k (\omega)$ by definition, is the response of the k^{th} component for unit harmonic load of frequency ω. The transfer function is dependent upon the structural properties (mass, stiffness, damping) alone and is thus unique for a given structure. This is analogous to an influence line which is the response of a component (moment, shear) due to an applied unit load to the structure.

The external load which is usually expressed in the time domain can be expressed in the frequency domain also, using "Fast Fourier Transform" algorithm. Using this algorithm, a given function can be transformed from time domain to frequency domain and vice versa.

The analysis was performed in the following steps:

1. The containment structures were modeled by axisymmetric finite elements. The containment structural model was analyzed by the Sargent & Lundy version of the finite-element program DYNAX which was capable of analyzing axisymmetric shells and solids subjected to arbitrary symmetric and asymmetric static or dynamic loads. The symmetric and asymmetric SRV loads were applied as Fourier sine and/or cosine harmonics for each case. A bank-limited white-noise time history was used for the analysis. The Fourier transform of such a time history has a constant magnitude at all values within the frequency range (0 to 45 hertz) of interest.

2. The response (force, moment, acceleration, etc.) time histories obtained from the above white-noise analysis were stored in electronic files.

3. The transfer functions of the response were obtained by the computer program FAST.

   From Equation (1)

$$T_k(\omega) = \frac{R_k(\omega)}{F(\omega)}$$

   in which $R_k(\omega)$ was the Fourier transform of the responses saved in step (2) and $F(\omega)$ is the Fourier transform of the white noise load used in step (1) of the above.

4. For steady-state solution of the harmonic load, by definition from Equation (1), the transfer function itself was the response.

   For SRV loads with variable frequency, the transfer functions were scanned in the frequency range of the loading. The responses were then obtained as the product of the transfer functions and the Fourier transforms of the load, using the FAST program. Response acceleration time histories were further input into RSG program to generate response spectra.

   In order to consider a conservative frequency content, three KWU time history traces reported in the SSES DAR were expended into longer and shorter time history durations by multiplying the time scales by a factor of 2.0 and 0.9, respectively. In addition, the pressure scales were multiplied by a factor of 1.5 for each of the three traces.

   The resulging structural responses to the various SRV T-quencher loads were combined with the other appropriate loads as per the load combinations shown in Table 6.1-1. The margin factors from these load combinations are presented in Table 7.1-17 through 7.1-24.

7.1.2 Structural Analysis of LOCA Loads

The analysis of the structure for the LOCA loads was performed as a set of analyses covering each LOCA related phenomenon separately. The methods used for each analysis are summarized in the following for the LOCA-induced loads of vent clearing, pool swell chugging, and condensation oscillation.

7.1.2.1 Vent Clearing Analysis

The description of vent clearing load for analysis is presented in Section 5.3 and in DFFR Section 4.2. The spatial distributions of the LOCA vent clearing load on the wetted surface of the suppression pool are shown in Figure 7.1-17 for the rams head case and in Figure 7.1-8 for the T-quencher case. The magnitude of the load for T-quencher case is 33 psig below the vent exit attenuated linearly to zero at the pool surface.

The model used in the analysis of the vent clearing loads was the earlier version of the one described in Subsection 7.1.1. The model used in this analysis is shown in Figure 7.1-9. This model was similar to the one used in Subsection 7.1.1 but excluded nodes and elements for the fluid in suppression pool.

The containment structure was analyzed for the effects of the vent clearing load statically using Sargent & Lundy's axisymmetric finite-element computer program DYNAX. See Appendix A, Section A.1 for a description of the computer program.

The resulting structural response to the vent clearing load is combined with the other loads as per the load combinations shown in Table 6.1-1.

7.1.2.2 Pool Swell Analysis

The postulated pool swell phenomena induced loads are described in Subsection 5.3.1.3.3 and in DFFR Subsection 4.2.4.4.

Using the model described in Subsection 7.1.2.1, the containment structure was analyzed for two load cases for the LOCA pool swell load, the symmetric and the asymmetric loads.

For the symmetric load, the loading was applied over the entire 360° of the containment wall. The pressure history of the drywell and wetwell air space is given in Figure 7.1-10. Curve A of this figure applies to the drywell, and Curve B applies to the portion of the wetwell wall which is above the pool water surface. The LOCA-pool swell portion of these curves ends at time 2.97 seconds.

The peak wetwell air space pressure during this event was 23 psig, while the peak drywell pressure was 21 psig.

For the portion of the wetwell walls which is below the water surface, the load definition is given in Figure 7.1-11. This load was 22 psig at the basemat level which decreased linearly to 16 psig at the elevation of the vent exit, and then increased linearly to 23 psig at the maximum pool swell elevation.

For the asymmetric load, the peak drywell pressure of 4.2 psig was applied uniformly over the entire drywell.

Figure 7.1-12 shows the pressure distribution of the pool swell asymmetric load for the wetwell.

The asymmetric pool swell load of 4.6 psig was applied over a sector of 180°, in addition to the hydrostatic load.

The containment structure was analyzed for the effects of the pool swell loads statically using Sargent & Lundy's axisymmetric finite-element computer program DYNAX. See Appendix A Section A.1 for a description of the computer program.

The spatial pressure load distributions in the circumferential direction were represented by using Fourier harmonics.

The resulting forces and moments on the structure's design sections were obtained directly from the DYNAX computer output.

The resulting structural responses to the pool swell loads were combined with the other appropriate loads as per the load combinations shown in Table 6.1-1.

7.1.2.3 Condensation Oscillation Analysis

Following the pool swell transient, steam flows through the main vent system into the suppression pool, where it condenses. Evaluation of the steam-condensation phase of the 4T test results revealed the existence of a dynamic load during high and medium steam mass flux into the suppression pool. This load, called condensation oscillation (CO), is a low-amplitude, symmetric, sinusoidal pressure fluctuation occurring over a range of frequencies.

The ZPS-1 containment was assessed for the following CO load definitions:

The spatial distributions of the condensation oscillation loads are shown in Figure 7.1-13 for rams head design basis and in Figure 7.1-14 for T-quencher design basis. The load consisted of ± 13.3 psig acting at a frequency 10 to 15 hertz for the rams head case and ± 3.75 psig acting at a frequency 2 to 7 hertz on the basemat, containment, and reactor pedestal for the quencher case.

The structural model described in Subsection 7.1.2.1 was used for the rams head design basis, and the one described in Subsection 7.1.1 was used for the T-quencher design basis.

The load was assumed to be harmonic in time, and only the steady-state response was considered as being of interest. For this purpose, frequency response variations were determined for all response components of interest using the computer program FAST, Appendix A, which obtained the complex frequency response by calculation of the discrete Fourier transform of both load and response. The relevant frequency range on the frequency response was considered in evaluating the structural response.

The resulting structural responses to the condensation oscillation loads were combined with the other appropriate loads as per the load combinations shown in Table 6.1-1. The margin factors are presented in Table 7.1-2 through 7.1-24.

In addition to the above CO load (2 to 7 hertz), an empirical limiting CO load was also considered in combination with the T-quencher design-basis loads for the ZPS-1 containment assessment. This load is a best estimate of the conservative load specification which resulted from the full-scale condensation oscillation test to be conducted in the 4T facility. All the details for this load are described in Chapter 2.0.

This ZPS-1 empirical CO load was incorporated for the T-quencher design basis. The spatial distributions of this load are shown in Figure 7.1-14.

The resulting structural responses to this empirical CO load were combined with the other appropriate loads as per the load combinations shown in Table 6.1-1. The margin factors for these load combinations are presented in Table 7.1-25 through 7.1-28.

The CO load based on the Lead Plant Acceptance Criteria (NUREG-0487, Supplement 2) was also considered for the assessment of the containment structures. The load is described in Appendix I. The structural model, described in Subsection 7.1.1, was used. The resulting responses to this CO load were used only for the drywell floor, the reactor pedestal, and the RPV internals.

For the assessment of the drywell floor and the reactor pedestal, the forces due to this CO load based on the Lead Plant Acceptance Criteria were combined with the other appropriate loads as per the load combinations shown in Table 6.1-1. The margin factors for these load combinations are presented in Tables 7.1-31 through 7.1-38.

7.1.2.4 Chugging Analysis

The chugging loads used in the analysis are described in Section 5.3 and presented in Figure 7.1-15. The finite-element model used in the analysis is described in Subsection 7.1.2.

The method used for T-quencher loading described in Subsection 7.1.1 was used for the chugging load due to the variation of frequency of the load.

The typical pressure time history is shown in Figure 7.1-16.

The resulting structural responses to the chugging loads are combined with the other appropriate loads as per the load combinations shown in Table 6.1-1.

The chugging load based on the Lead Plant Acceptance Criteria (NUREG-0487, Supplement 2) was also considered for the assessment of the containment structures. The load is described in Appendix I. The structural model, described in Subsection 7.1.1, was used. The resulting responses to this chugging load were used only for the drywell floor, the reactor pedestal, and the RPV internals.

For the assessment of the drywell floor and the reactor pedestal, the forces due to this chugging load based on the Lead Plant Acceptance Criteria were combined with the other appropriate loads as per the load combination shown in Table 6.1-1. The margin factors for these load combinations are presented in Tables 7.1-31 through 7.1-38.

7.1.3 Effects of Downcomers on the Drywell Floor

The downcomer vents are now subjected to a variety of submerged structure dynamic loads resulting from SRV and LOCA loads. By assuming, conservatively, that the maximum responses from the various dynamic loads occur simultaneously and in the same direction, the magnitude of the resulting moments and forces being transmitted to the drywell floor becomes significant with respect to the known existing loads on the design sections. Even though the downcomers are braced at elevation 496 feet in order to reduce loads on the drywell floor, the analysis that is summarized in this subsection proves that the drywell floor has maintained its structural adequacy despite the addition of new loads.

The loads on the downcomers resulting from submerged hydrodynamic forces are described in Subsection 5.3.1.1.7.

In addition to the pool dynamic loads on the downcomers, the seismic loads were also considered in the analysis. These considerations assumed that all of the downcomers were loaded equally, simultaneously, and in the same direction by using the response spectra generated from the various loads on the drywell floor and performing a modal analysis.

The drywell floor is modeled as a thin elastic circular plate with a circular hole in the middle. The slab is assumed to be fully restrained at the pedestal and containment walls and simply supported at the columns. The model of the drywell floor is shown in Figure 7.1-17.

The locations of the downcomers lie along four rings at radii 18 feet 3 inches, 22 feet 3 inches, 30 feet 9 inches, and 35 feet 3 inches.

A concentrated radial or circumferential moment, in the form of Fourier harmonics, is applied at a point on each one of the downcomer rings.

Figure 7.1-18 shows the circumferential distribution of floor moments induced by a concentrated radial moment applied at radius 22 feet 3 inches. For computational convenience, the ordinates are normalized to make the induced radial moment equal to unity.

$\beta_{\phi\phi n}$ = normalized radial moment along the radius through the point where $M_{\theta n}$ is applied;

$\beta_{\phi\theta n}$ = normalized radial moment along the n^{th} ring due to $M_{\phi n}$;

$\beta_{\phi\theta n\theta}$ = normalized radial moment along the n^{th} ring due to $M_{\theta n}$;

$\beta_{\theta\theta n\theta}$ = normalized circumferential moment along the n^{th} ring due to $M_{\theta n}$; and

$\beta_{\theta\phi n\theta}$ = normalized circumferential moment along the n^{th} ring due to $M_{\phi n}$.

The absolute values of the moment coefficients are used to account for the random direction of the downcomer lateral loads and to obtain the absolute maximum values of m_ϕ and m_θ for design assessment.

Figure 7.1-22 shows the variation of radial moment at critical design Section 2 (see Figure 4-10 of Reference 1) as the number of loaded downcomers is increased from 1 to 88 (all). The maximum design moment of 52 ft.k/ft occurs when all the downcomers are loaded simultaneously with 8.8 kips each.

The conservatism included in the design assessment of the drywell floor is best illustrated by a comparison of Figures 7.1-22 and 7.1-23. Figure 7.1-23 shows the plot of the design radial moment at Section 2 versus the number of downcomers loaded as per Figure 4-10a of DFFR (Reference 1), Proprietary Supplement Revision 2, which defines the probable load on multiple downcomers as decreasing with increasing number of loaded downcomers. The maximum moment thus obtained is only 29 ft.k/ft, whereas a conservative value of 52 ft.k/ft is obtained by the bounding load definition used in the ZPS-1 drywell floor design assessment.

The assessment of this subsection was based on rams head design basis.

The assessment for the T-quencher design-basis is based on the SRV and LOCA loads described in Subsections 5.2 and 5.3, respectively, and modified to take credit of the NRC Lead Plant Acceptance Criteria (NUREG-0487 and its two supplements). The details of alternate loads and load combinations used for the assessment are described in Subsection 5.5.

The forces in the drywell floor due to the SRV and LOCA boundary loads are obtained from the structural analyses described in Subsections 7.1.1 and 7.1.2, respectively.

The analysis of the drywell floor for the reactions resulting from the application of the submerged structure loads on the downcomers is described herein.

The drywell floor is represented by a three-dimensional finite-element model. The model includes 18 suppression pool columns supporting the drywell floor slab. The slab and the columns are modeled as quadrilateral plate elements and beam elements, respectively. The slab is assumed to be fully restrained at the pedestal and containment walls and the columns are considered fully restrained at the basemat junction. The model of the drywell floor is shown in Figure 7.1-37. The Sargent & Lundy program, SLSAP, was used for the analyses of these static loads.

Nodal coordinates are given at the locations of all 88 downcomers. The design reaction forces at each downcomer are computed based on the load combinations in Table 7.3.1. The reaction load at each downcomer location is applied in different combinations in meridional and the circumferential directions.

For each element, the maximum value of each meridional and circumferential force (shear, axial, and moments) components occurring in any combination is obtained. The design foce at each of the design sections is obtained by enveloping the resulting maximum forces in elements along all aximuthal directions.

7.1.4 Design Assessment Margin Factors

7.1.4.1 Critical Design Sections

The primary containment and internal structures have been checked as to the structural capacity to withstand the dynamic loads due to SRV discharges and LOCA in addition to the other appropriate loads described in the FSAR. The methods of analysis used have been described in the preceding subsections, and the design load combinations are given in Table 6.1-1. The structural capacity acceptance criteria are the same as in the FSAR, for which all design sections have been evaluated using the computer program TEMCO (described in Appendix A.7).

Figure 4.0-1 shows a cross section of the primary containment and internal structures. Figures 7.1-24 through 7.1-31 illustrate the reinforcing steel and prestressing tendon layout. Figure 7.1-29 shows the reinforcing in the pedestal prior to modification. Details of the concrete-filled portion of the pedestal are shown in Figure 7.1-28.

Figures 7.1-32 through 7.1-34 show the design sections in the basemat, containment, reactor support, drywell floor, and drywell floor column considered for structural assessment. Figures 7.1-35 and 7.1-36 give typical design section capacity interaction diagrams of the basemat and containment for the T-quencher design basis.

7.1.4.2 Design Forces and Margin Factors

The design forces in the critical design sections were obtained by combining with the ABS method the peak effects of all the loads according to the load combinations defined in Table 6.1-1.

The material stresses in the critical design sections were obtained using the computer program TEMCO described in Appendix A.

Margin factors, defined as the ratio between the allowable stress and the actual stress in the section, were computed for each design section. If any of the loads (such as temperature) other than dead load reduced the design forces, it was deleted from the load combination to obtain the most conservative margin factor.

Margin factors for the basemat, containment wall, reactor support, drywell floor, and the drywell floor column are reported in the following tables:

RAMS HEAD DESIGN BASIS

a.	Basemat	Tables 7.1-2 through 7.1-5
b.	Containment wall	Tables 7.1-6 through 7.1-9
c.	Reactor support	Tables 7.1-10 through 7.1-13
d.	Drywell floor	Table 7.1-14
e.	Drywell floor column	Tables 7.1-15 and 7.1-16

These tables give the calculated design margin factors for the load combinations, including each of the four modes of SRV discharge for which the structures were analyzed (resonant sequential symmetric discharge, ADS, and two valves) and LOCA hydrodynamic effects combined with the single-valve discharge case.

The forces of reactor support margin factor were obtained by analysis using the model described in Subsection 7.1.2.1.

Margins shown in Table 7.1-14 for loading conditions 4a, 5a, and 7a on the drywell floor are for the LOCA effects, including the lateral loads on the downcomers. As per DFFR Subsection 4.4.6.6, a net upward load of 9 psid acting on the drywell floor has been considered.

Margins shown in Table 7.1-14 for loading conditions 1, 2, 3, and 6 on the drywell floor are for the all-valves discharge loading which clearly governs the design of the drywell floor rather than the asymmetric two valve discharge loading.

Loading conditions 4, 5, and 7 in Table 7.1-14 include all loads resulting from a small pipe break combined with the loads due to the discharge of all 13 SRV's. This was done for reasons of analytical expediency, since the discharge of all 13 SRV's transmits significantly more energy to the drywell floor than the 6 valve ADS discharge. Since ZPS-1 can take this higher loading case, the actual loading from the ADS valves was not considered. For the drag loads on the downcomer, the maximum load described in Section 5.2 was used for all loading combinations which include SRV loads irrespective of the discharge mode (ALL, ASYMMETRIC, or ADS).

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LOAD COMBINATION WITH NRC CO LOAD (DFFR)

a.	Basemat	Tables 7.1-17 through 7.1-20
b.	Containment wall	Tables 7.1-21 through 7.1-24

LOAD COMBINATION WITH EMPIRICAL LIMITING CO LOAD

a.	Basemat	Tables 7.1-25 and 7.1-26
b.	Containment wall	Tables 7.1-27 and 7.1-28
c.	Supression Pool Column	Tables 7.1-29 and 7.1-30

Since the drywell floor and the reactor pedestal could not accommodate the conservative Zimmer Empirical Loads, these structures were assessed for the NRC Lead Plant Acceptance Criteria (Reference 3). The NRC accepted loads and load combinations considered for the assessment are described in Section 5.5.

LOAD COMBINATION WITH LEAD PLANT ACCEPTANCE CRITERIA LOADS

a. Drywell Floor — Tables 7.1-31 through 7.1-34

b. Reactor Pedestal — Tables 7.1-35 through 7.1-38

The margin factors were calculated as results of the assessment based on the NRC acceptance criteria (modified for the T-quencher).

All the margin factors were greater than 1.0.

These safety margins are in addition to the overload factors used in the load equations given in Table 6.1-1 and the material understrength factors built into the allowable stress criteria. Therefore, the safety margins between the actual internal moments and forces and the ultimate strength of the structures are considerably higher than those given in Tables 7.1-2 through 7.1-38.

As stated in FSAR Table 3.8-3, if in any load combination, the effect of any load (such as temperature) other than dead load reduces the design forces, it will be deleted from the combination. Safety margins are thus calculated with and without temperature load, and only the smallest margins obtained are given in Tables 7.1-2 through 7.1-38.

7.1.5 References

1. "Evaluation of Fluid Structure Interaction Effects on BWR Mark II Containment Structures," NEDE-21936-P.

2. A. J. Kalinowski, "Transmission of Shock Waves into Submerged Fluid Filled Vessels," ASME Conference on FSI Phenomena in Pressure Vessel and Piping Systems, TVP-TB-026, 1977.

3. Mark II Containment Lead Plant Program Load Evaluation Report, NUREG-0487, October 1978, Supplement No. 1, September 1980, and Supplement No. 2, February 1981.

TABLE 7.1-1

DYNAMIC SOIL PROPERTIES*

ELEVATION (ft)	OVERBURDEN SOIL PRESSURE σ_m' (KSF)	FACTOR ON DAMPING CURVE
466-469	5.18	1.0
463-466	5.42	1.0
460-463	5.66	1.0
456-460	5.94	1.0
448-456	6.42	1.0
440-448	7.06	1.0
430-440	7.78	1.0
420-430	8.58	1.0
400-420	9.78	1.0

*These values are to be used in conjunction with Figures 7.1-2 and 7.1-3 for the average shear modulus and damping curves.

TABLE 7.1-2

MARGIN TABLE FOR BASEMAT - RESONANT SEQUENTIAL SYMMETRIC DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	1.8	2	4.0	3	1.5	2
2	2.3	1	3.3	3	2.4	3
3	1.9	1	3.3	3	1.2	2
4	NA	NA	NA	NA	NA	NA
4a	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA
5a	NA	NA	NA	NA	NA	NA
6	1.9	1	3.3	3	1.3	2
7	NA	NA	NA	NA	NA	NA
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: RAMS HEAD DESIGN BASIS

TABLE 7.1-3

MARGIN TABLE FOR BASEMAT - ADS VALVE DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	1.3	1	2.2	3	1.2	3
4a	NA	NA	NA	NA	NA	NA
5	1.3	1	2.4	3	1.3	3
5a	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA
7	1.3	1	2.3	3	1.3	2
7a	NA	NA	NA	NA	NA	NA

NOTE: RAMS HEAD DESIGN BASIS

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

TABLE 7.1-4

MARGIN TABLE FOR BASEMAT - TWO-VALVE DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	2.5	2	4.5	3	1.8	2
2	2.3	1	3.6	3	2.6	3
3	1.9	1	3.0	3	1.4	2
4	1.3	1	2.2	3	1.2	3
4a	NA	NA	NA	NA	NA	NA
5	1.2	1	2.3	3	1.4	3
5a	NA	NA	NA	NA	NA	NA
6	1.9	1	2.9	3	1.4	2
7	1.3	1	2.3	3	1.3	2
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1

**Margin Factor = Allowable Stress/Actual Stress

***Refer to Figure 7.1-32

NA = Not Applicable

NOTE: RAMS HEAD DESIGN BASIS

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TABLE 7.1-5

MARGIN TABLE FOR BASEMAT - LOCA PLUS ONE SRV

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA
4a	1.4	1	2.1	3	1.2	3
5	NA	NA	NA	NA	NA	NA
5a	1.3	1	2.2	3	1.2	3
6	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA
7a	1.3	1	2.2	3	1.2	3

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: RAMS HEAD DESIGN BASIS

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TABLE 7.1-6

MARGIN TABLE FOR CONTAINMENT - RESONANT SEQUENTIAL SYMMETRIC DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	103.9	13	3.4	1	1.7	6
2	8.5	9	2.8	13	1.3	6
3	4.8	11	2.7	1	1.3	6
4	NA	NA	NA	NA	NA	NA
4a	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA
5a	NA	NA	NA	NA	NA	NA
6	4.6	11	2.7	1	1.3	6
7	NA	NA	NA	NA	NA	NA
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: RAMS HEAD DESIGN BASIS

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TABLE 7.1-7

MARGIN TABLE FOR CONTAINMENT - ADS VALVE DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	4.0	10	2.9	12	1.6	6
4a	NA	NA	NA	NA	NA	NA
5	3.7	11	2.9	13	1.6	6
5a	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA
7	3.3	11	2.9	13	1.6	6
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: RAMS HEAD DESIGN BASIS

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TABLE 7.1-8

MARGIN TABLE FOR CONTAINMENT - TWO-VALVE DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	3.6	1	1.3	6
2	8.6	11	2.8	13	1.3	6
3	4.8	11	2.8	1	1.3	6
4	4.0	10	2.9	13	1.6	6
4a	NA	NA	NA	NA	NA	NA
5	3.7	11	2.9	13	1.6	6
5a	NA	NA	NA	NA	NA	NA
6	4.4	11	2.8	1	1.3	6
7	3.3	11	2.9	13	1.5	6
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: RAMS HEAD DESIGN BASIS

TABLE 7.1-9

MARGIN TABLE FOR CONTAINMENT - LOCA PLUS ONE SRV

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA
4a	3.5	10	2.8	13	1.3	6
5	NA	NA	NA	NA	NA	NA
5a	3.7	11	2.8	13	1.4	6
6	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA
7a	3.2	13	2.8	13	1.4	6

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: RAMS HEAD DESIGN BASIS

TABLE 7.1-10

MARGIN TABLE FOR REACTOR SUPPORT-RESONANT SEQUENTIAL SYMMETRIC DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	4.4	9	11.9	9	3.0	9
2	2.5	6	6.6	9	1.7	9
3	1.3	7	4.8	9	1.7	9
4	NA	NA	NA	NA	NA	NA
4a	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA
5a	NA	NA	NA	NA	NA	NA
6	1.1	7	4.6	9	1.8	9
7	NA	NA	NA	NA	NA	NA
7a	NA	NA	NA	NA	NA	NA

NOTE: RAMS HEAD DESIGN BASIS

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

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TABLE 7.1-11

MARGIN TABLE FOR REACTOR SUPPORT - ADS VALVE DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	1.3	1	4.0	2	1.6	9
4a	NA	NA	NA	NA	NA	NA
5	1.2	2	4.4	2	1.7	9
5a	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA
7	1.01	7	4.4	2	1.7	9
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: RAMS HEAD DESIGN BASIS

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TABLE 7.1-12

MARGIN TABLE FOR REACTOR SUPPORT - TWO-VALVE DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	5.3	9	12.1	9	6.5	9
2	2.4	6	6.7	9	2.8	9
3	1.5	4	5.5	8	2.7	9
4	1.3	1	4.1	2	2.2	9
4a	NA	NA	NA	NA	NA	NA
5	1.2	2	4.6	2	2.2	9
5a	NA	NA	NA	NA	NA	NA
6	1.19	7	4.7	9	2.6	9
7	1.0	4	4.5	2	2.2	9
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: RAMS HEAD DESIGN BASIS

TABLE 7.1-13

MARGIN TABLE FOR REACTOR SUPPORT - LOCA PLUS ONE SRV

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA
4a	1.3	2	4.1	2	1.8	1
5	NA	NA	NA	NA	NA	NA
5a	1.15	2	3.4	5	1.8	1
6	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA
7a	1.06	2	3.2	5	1.8	1

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: RAMS HEAD DESIGN BASIS

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TABLE 7.1-14

MARGIN TABLE FOR DRYWELL FLOOR - SRV ONLY AND LOCA PLUS ONE SRV

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	3.6	3	6.4	3	7.1	1
2	5.7	3	5.2	3	10.8	4
3	4.4	3	4.2	3	10.9	4
4	1.8	3	4.0	3	4.1	6
4a	1.5	2	1.6	1	3.3	1
5	3.3	1	6.4	1	4.7	6
5a	1.7	1	1.4	1	2.7	3
6	9.7	6	7.7	3	11.7	4
7	2.4	3	6.5	3	5.3	6
7a	1.4	2	1.5	1	2.1	2

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-33

NOTE: RAMS HEAD DESIGN BASIS

TABLE 7.1-15

MARGIN TABLE FOR DRYWELL FLOOR COLUMN - ALL VALVE AND ADS DISCHARGE

LOAD COMBINATION EQUATION* \ LOAD COMPONENT	AXIAL COMPRESSION		MOMENT		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	1.40	1	1.10	1	1.22	1
2	1.94	1	1.25	1	1.41	1
3	1.84	1	1.10	1	1.25	1
4****	2.26	1	1.90	1	2.09	1
4a	NA	NA	NA	NA	NA	NA
5****	2.46	1	1.71	1	1.90	1
5a	NA	NA	NA	NA	NA	NA
6	1.78	1	1.28	1	1.46	1
7****	1.78	1	1.49	1	1.43	1
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Ultimate Load/Actual Load
***Refer to Figure 7.1-34
****ADS Discharge Case
NA = Not Applicable

NOTE: RAMS HEAD DESIGN BASIS

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TABLE 7.1-16

MARGIN TABLE FOR DRYWELL FLOOR COLUMN - TWO-VALVE DISCHARGE

LOAD COMPONENT / LOAD COMBINATION EQUATION*	AXIAL COMPRESSION		MOMENT		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	1.98	1	1.87	1	2.09	1
2	2.26	1	2.15	1	2.42	1
3	2.14	1	1.71	1	1.93	1
4	2.26	1	2.24	1	2.51	1
4a	NA	NA	NA	NA	NA	NA
5	2.15	1	1.94	1	2.20	1
5a	NA	NA	NA	NA	NA	NA
6	2.08	1	1.93	1	2.20	1
7	2.08	1	1.69	1	1.58	1
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Ultimate Load/Actual Load
***Refer to Figure 7.1-34
NA = Not Applicable

NOTE: RAMS HEAD DESIGN BASIS

TABLE 7.1-17

MARGIN TABLE FOR BASEMAT - ALL-VALVE SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	1.20	2	3.55	3	2.35	3
2	2.20	2	2.95	3	3.29	3
3	1.61	2	2.38	3	1.59	2
4	NA	NA	NA	NA	NA	NA
4a	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA
5a	NA	NA	NA	NA	NA	NA
6	1.69	2	2.40	3	1.60	2
7	NA	NA	NA	NA	NA	NA
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1

**Margin Factor = Allowable Stress/Actual Stress

***Refer to Figure 7.1-32

NA = Not Applicable

NOTE: LOAD COMBINATION WITH NRC CO LOAD (DFFR)

TABLE 7.1-18

MARGIN TABLE FOR BASEMAT - ADS SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	1.20	2	2.18	2	1.64	3
4a	NA	NA	NA	NA	NA	NA
5	1.09	2	2.04	2	1.27	3
5a	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA
7	1.11	2	2.08	2	1.25	3
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: LOAD COMBINATION WITH NRC CO LOAD (DFFR)

TABLE 7.1-19

MARGIN TABLE FOR BASEMAT - ASYMMETRIC (THREE-VALVE) SRV QUENCHER DISCHARGE
(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	1.47	2	3.78	3	2.43	3
2	2.37	3	3.08	3	3.42	3
3	1.89	3	2.46	3	1.59	2
4	1.59	2	2.88	2	1.73	3
4a	NA	NA	NA	NA	NA	NA
5	1.40	2	2.57	2	1.32	3
5a	NA	NA	NA	NA	NA	NA
6	1.88	3	2.47	3	1.60	2
7	1.39	2	2.58	2	1.28	3
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: LOAD COMBINATION WITH NRC CO LOAD (DFFR)

TABLE 7.1-20

MARGIN TABLE FOR BASEMAT - SINGLE-VALVE SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA
4a	1.37	2	2.48	2	1.59	3
5	NA	NA	NA	NA	NA	NA
5a	1.20	2	2.23	2	1.24	3
6	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA
7a	1.20	2	2.25	2	1.21	3

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: LOAD COMBINATION WITH NRC CO LOAD (DFFR)

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TABLE 7.1-21

MARGIN TABLE FOR CONTAINMENT - ALL-VALVE SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	83.02	1	2.68	1	1.55	13
2	6.46	9	2.64	13	2.26	6
3	3.01	11	2.63	13	2.23	6
4	NA	NA	NA	NA	NA	NA
4a	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA
5a	NA	NA	NA	NA	NA	NA
6	2.70	11	2.64	13	2.23	6
7	NA	NA	NA	NA	NA	NA
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: LOAD COMBINATION WITH NRC CO LOAD (DFFR)

TABLE 7.1-22

MARGIN TABLE FOR CONTAINMENT - ADS SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	1.62	10	2.64	13	1.93	12
4a	NA	NA	NA	NA	NA	NA
5	1.45	12	2.64	13	1.99	12
5a	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA
7	1.29	12	2.64	13	2.05	12
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: LOAD COMBINATION WITH NRC CO LOAD (DFFR)

TABLE 7.1-23

MARGIN TABLE FOR CONTAINMENT - ASYMMETRIC (THREE-VALVE) SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	2.86	1	1.81	13
2	6.73	9	2.65	13	2.25	6
3	2.95	11	2.64	13	2.24	6
4	1.72	10	2.68	13	2.25	12
4a	NA	NA	NA	NA	NA	NA
5	1.82	9	2.67	13	2.30	12
5a	NA	NA	NA	NA	NA	NA
6	2.85	11	2.65	13	2.23	6
7	1.67	12	2.67	13	2.53	6
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: LOAD COMBINATION WITH NRC CO LOAD (DFFR)

TABLE 7.1-24

MARGIN TABLE FOR CONTAINMENT - SINGLE-VALVE SRV QUENCHER DISCHARGE
(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA
4a	1.55	10	2.37	1	2.0	2
5	NA	NA	NA	NA	NA	NA
5a	1.62	12	2.42	1	2.07	2
6	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA
7a	1.40	12	2.44	1	2.13	1

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: LOAD COMBINATION WITH NRC CO LOAD (DFFR)

TABLE 7.1-25

MARGIN TABLE FOR BASEMAT - ADS SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	1.28	2	2.23	2	1.61	3
4a	NA	NA	NA	NA	NA	NA
5	1.15	2	2.08	2	1.26	3
5a	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA
7	1.16	2	2.12	2	1.23	3
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: LOAD COMBINATION WITH EMPIRICAL LIMITING CO LOAD

TABLE 7.1-26

MARGIN TABLE FOR BASEMAT - SINGLE-VALVE SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA
4a	1.28	2	2.27	2	1.51	3
5	NA	NA	NA	NA	NA	NA
5a	1.14	2	2.08	2	1.20	3
6	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA
7a	1.15	2	2.10	2	1.17	3

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: LOAD COMBINATION WITH EMPIRICAL LIMITING CO LOAD

TABLE 7.1-27

MARGIN TABLE FOR CONTAINMENT - ADS SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	1.54	10	2.64	13	1.93	12
4a	NA	NA	NA	NA	NA	NA
5	1.41	12	2.64	13	1.99	12
5a	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA
7	1.26	12	2.64	13	2.06	12
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: LOAD COMBINATION WITH EMPIRICAL LIMITING CO LOAD

TABLE 7.1-28

MARGIN TABLE FOR CONTAINMENT - SINGLE-VALVE SRV QUENCHER DISCHARGE
(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA
4a	1.45	10	2.37	1	2.00	2
5	NA	NA	NA	NA	NA	NA
5a	1.10	1	2.42	1	2.07	2
6	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA
7a	1.18	12	2.44	1	2.13	1

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: LOAD COMBINATIONS WITH EMPIRICAL LIMITING CO LOAD

TABLE 7.1-29

MARGIN TABLE FOR SUPPRESSION POOL COLUMN - RESONANT SEQUENTIAL SYMMETRIC DISCHARGE

STRESS COMPONENT / LOAD COMBINATION EQUATION**	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	9.12	1	4.64	1	6.22	1
2	11.08	1	5.45	1	6.85	1
3	4.31	1	3.16	1	5.02	1
4	2.16	1	2.03	1	2.24	1
4a	NA	NA	NA	NA	NA	NA
5	1.76	1	1.79	1	2.24	1
5a	NA	NA	NA	NA	NA	NA
6	3.53	1	2.78	1	5.13	1
7	1.55	1	1.65	1	2.27	1
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-34
NA = Not Applicable

NOTE: LOAD COMBINATION WITH EMPIRICAL LIMITING CO LOAD

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TABLE 7.1-30

MARGIN TABLE FOR SUPPRESSION POOL COLUMN - SINGLE VALVE SUBSEQUENT ACTUATION

LOAD COMBINATION EQUATION* \ STRESS COMPONENT	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA
4a	2.30	1	2.10	1	2.12	1
5	NA	NA	NA	NA	NA	NA
5a	1.73	1	1.76	1	2.05	1
6	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA
7a	1.49	1	1.60	1	2.02	1

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-34
NA = Not Applicable

NOTE: LOAD COMBINATION WITH EMPIRICAL LIMITING CO LOAD

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TABLE 7.1-31

MARGIN TABLE FOR DRYWELL FLOOR - ALL VALVE SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	1.22	6	3.20	6	1.52	1
2	1.32	6	2.70	6	1.75	1
3	1.36	6	2.71	6	1.82	1
4	NA	NA	NA	NA	NA	NA
4a	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA
5a	NA	NA	NA	NA	NA	NA
6	1.54	6	3.02	6	2.27	1
7	NA	NA	NA	NA	NA	NA
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-33
NA = Not Applicable

NOTE: Load Combination with Lead Plant Acceptance Criteria Loads.

TABLE 7.1-32

MARGIN TABLE FOR DRYWELL FLOOR -
ASYMMETRIC (THREE-VALVE) SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	1.51	2	4.28	6	1.52	1
2	1.78	6	3.32	6	1.75	1
3	1.76	2	3.32	6	1.82	1
4	1.01	6	2.61	1	1.25	1
4a	NA	NA	NA	NA	NA	NA
5	1.23	6	2.83	1	1.40	1
5a	NA	NA	NA	NA	NA	NA
6	1.94	2	3.62	6	2.27	1
7	1.34	6	3.02	1	1.53	1
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-33
NA = Not Applicable

NOTE: Load Combination with Lead Plant Acceptance Criteria Loads.

TABLE 7.1-33

MARGIN TABLE FOR DRYWELL FLOOR - ADS SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	1.01	6	2.45	1	1.25	1
4a	NA	NA	NA	NA	NA	NA
5	1.13	6	2.66	1	1.40	1
5a	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA
7	1.24	6	2.84	1	1.53	1
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-33
NA = Not Applicable

NOTE: Load Combination with Lead Plant Acceptance Criteria Load.

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TABLE 7.1-34

MARGIN TABLE FOR DRYWELL FLOOR - SINGLE VALVE SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA
4a	1.00	6	2.74	1	1.02	1
5	NA	NA	NA	NA	NA	NA
5a	1.11	6	2.93	1	1.12	1
6	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA
7a	1.20	6	3.09	1	1.20	1

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-33
NA = Not Applicable

NOTE: Load Combination with Lead Plant Acceptance Criteria Loads.

TABLE 7.1-35

MARGIN TABLE FOR REACTOR SUPPORT-ALL VALVE SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	2.47	9	6.57	9	2.04	9
2	2.42	9	4.59	9	1.98	9
3	1.03	9	4.69	9	2.15	9
4	NA	NA	NA	NA	NA	NA
4a	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA
5a	NA	NA	NA	NA	NA	NA
6	1.15	9	4.93	9	2.44	9
7	NA	NA	NA	NA	NA	NA
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: Load Combination with Lead Plant Acceptance Criteria Loads.

TABLE 7.1-36

MARGIN TABLE FOR REACTOR SUPPORT - ADS SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	2.11	9	4.15	9	1.72	9
4a	NA	NA	NA	NA	NA	NA
5	1.16	9	4.53	9	1.96	9
5a	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA
7	1.11	9	4.79	9	2.10	9
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: Load Combination with Lead Plant Acceptance Criteria Loads.

TABLE 7.1-37

MARGIN TABLE FOR REACTOR SUPPORT - ASYMMETRIC (THREE-VALVE) SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	4.0	9	11.13	9	1.76	9
2	3.23	1	6.51	9	1.85	9
3	1.21	9	5.0	9	1.51	9
4	2.16	9	4.76	9	1.56	9
4a	NA	NA	NA	NA	NA	NA
5	1.16	9	5.41	9	1.79	9
5a	NA	NA	NA	NA	NA	NA
6	1.33	9	5.07	9	2.02	9
7	1.11	9	5.38	9	1.92	9
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: Load Combination with Lead Plant Acceptance Criteria Loads.

TABLE 7.1-38

MARGIN TABLES FOR REACTOR SUPPORT - SINGLE VALVE SRV QUENCHER DISCHARGE

(WITH PLANT-UNIQUE FSI, ACTUAL MINIMUM CONCRETE STRENGTH, AND SSI SEISMIC FORCES)

STRESS COMPONENT / LOAD COMBINATION EQUATION*	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA
4a	2.45	9	3.12	9	1.22	9
5	NA	NA	NA	NA	NA	NA
5a	1.24	9	3.19	9	1.36	9
6	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA
7a	1.14	9	3.36	9	1.44	9

*Refer to Table 6.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 7.1-32
NA = Not Applicable

NOTE: Load Combination with Lead Plant Acceptance Criteria Loads.

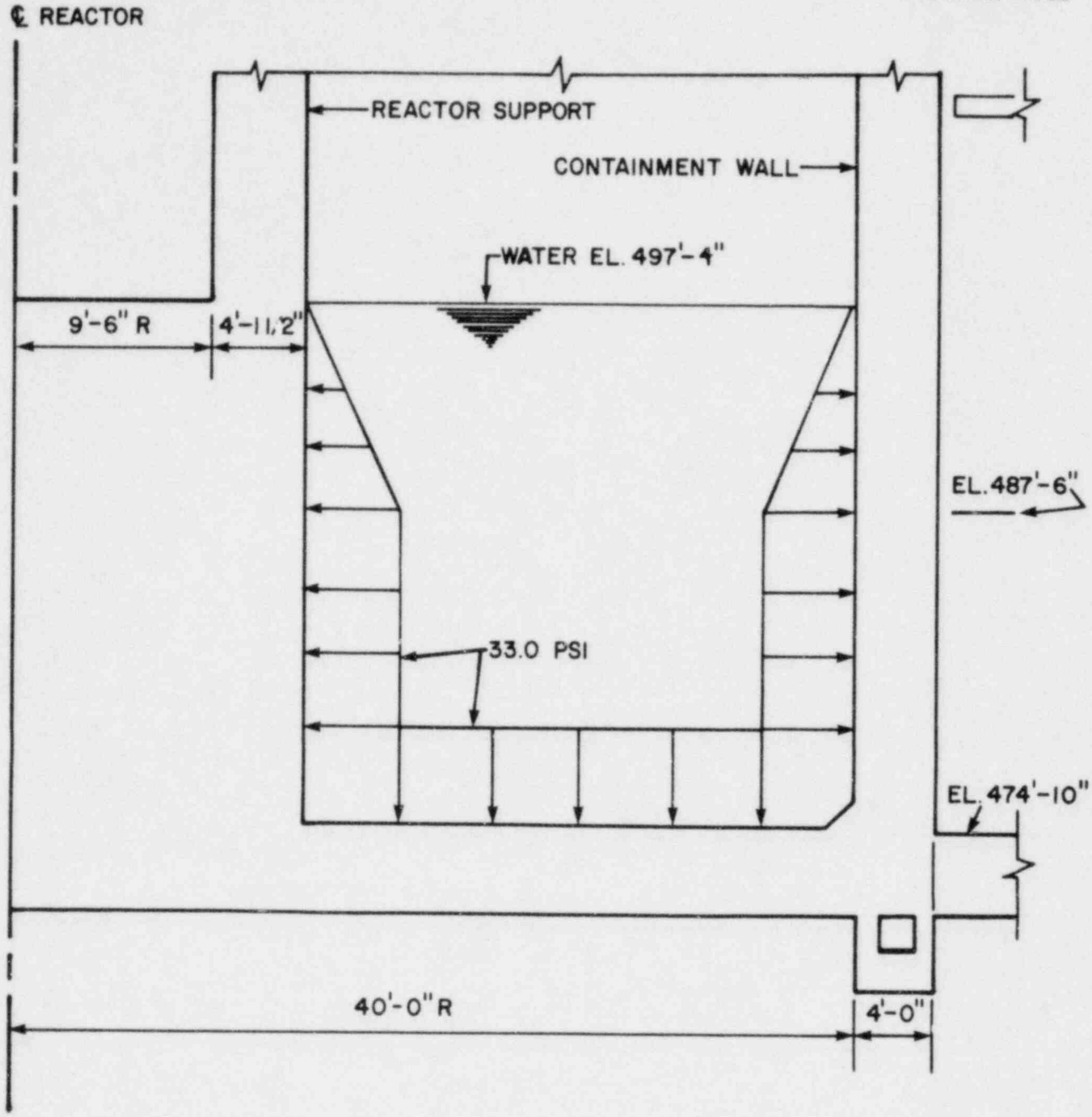

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FIGURE 7.1-8

LOCA VENT CLEARING PRESSURE DISTRIBUTION

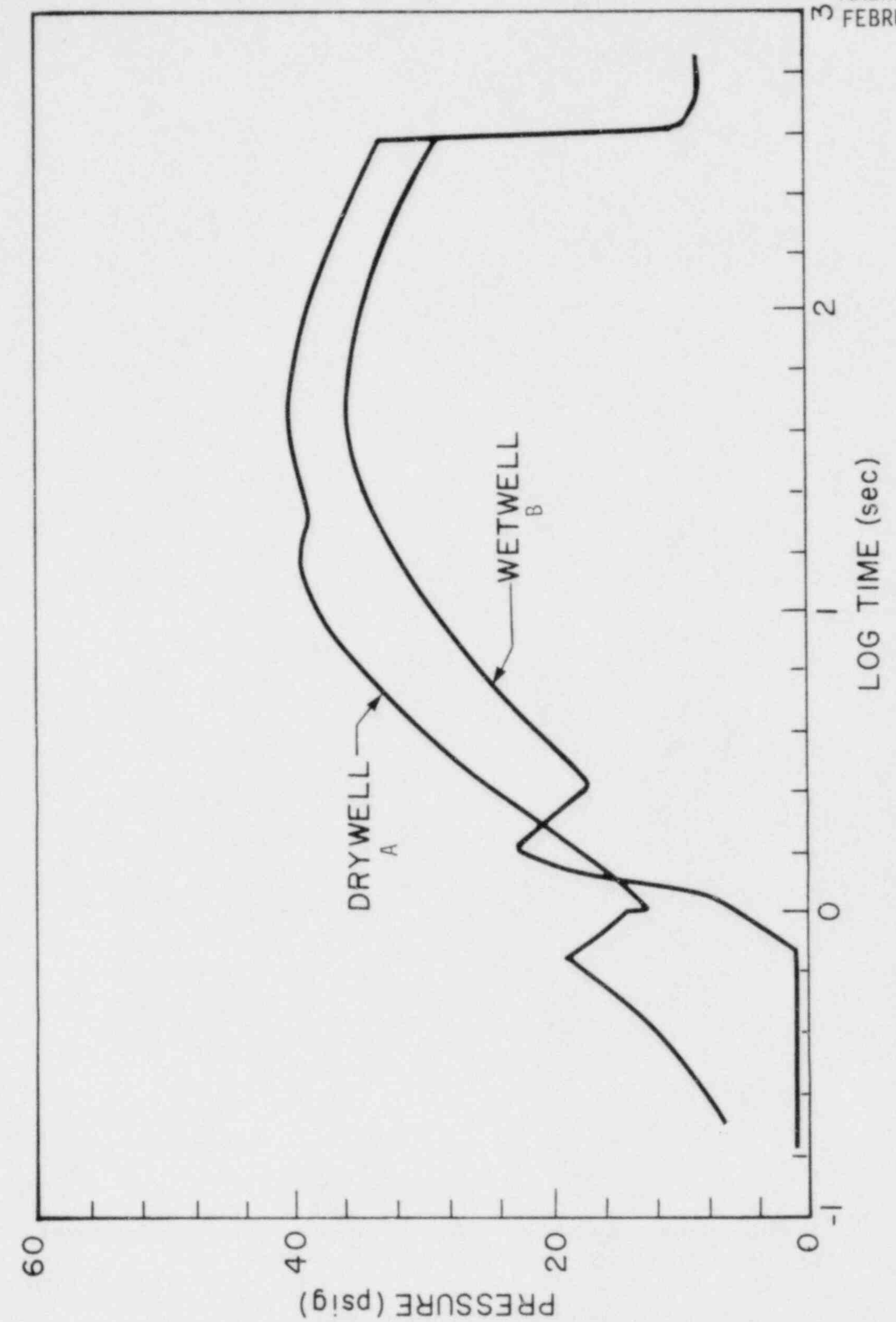

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FIGURE 7.1-10

DRYWELL/WETWELL PRESSURE HISTORY FOR MAIN STEAMLINE BREAK

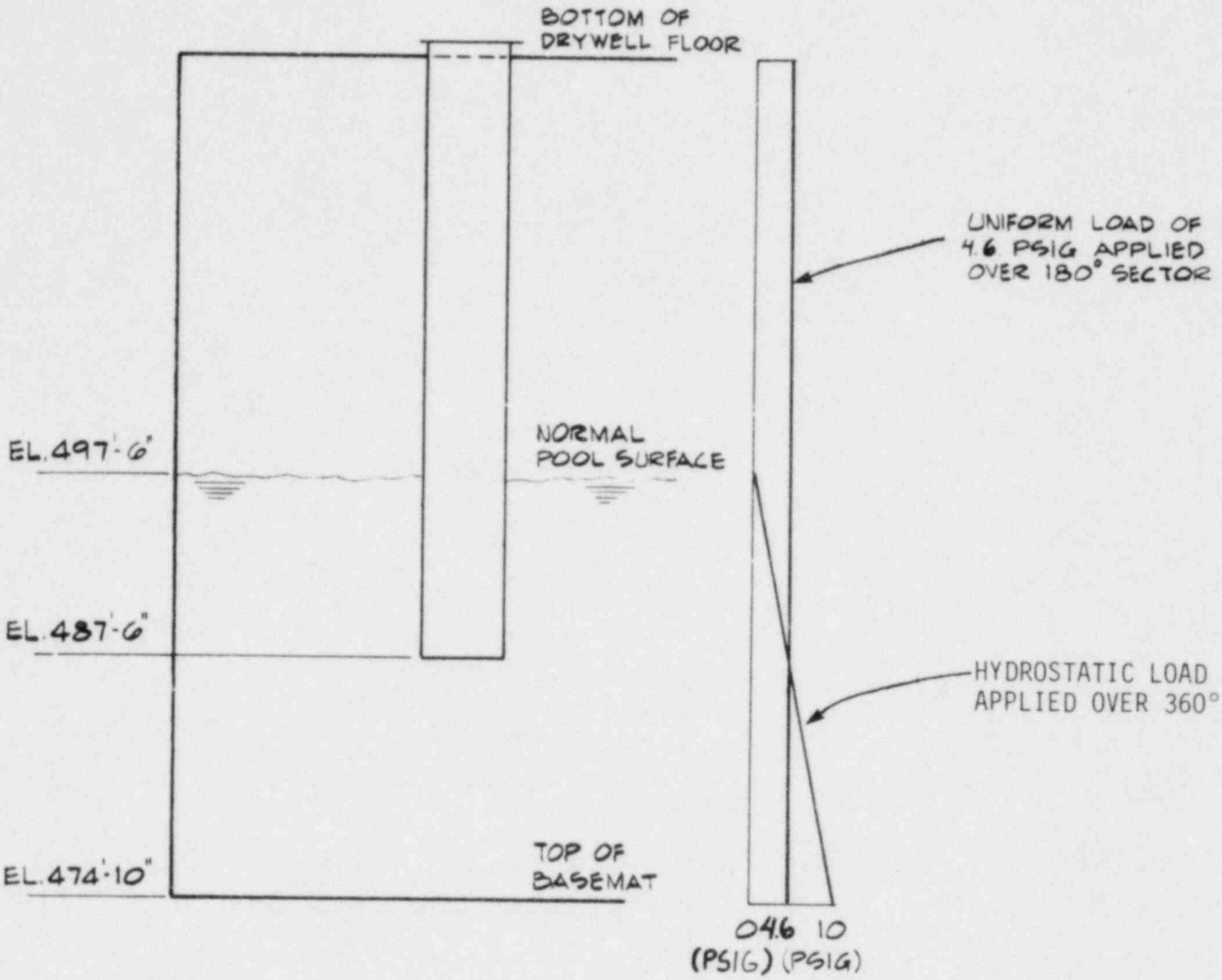

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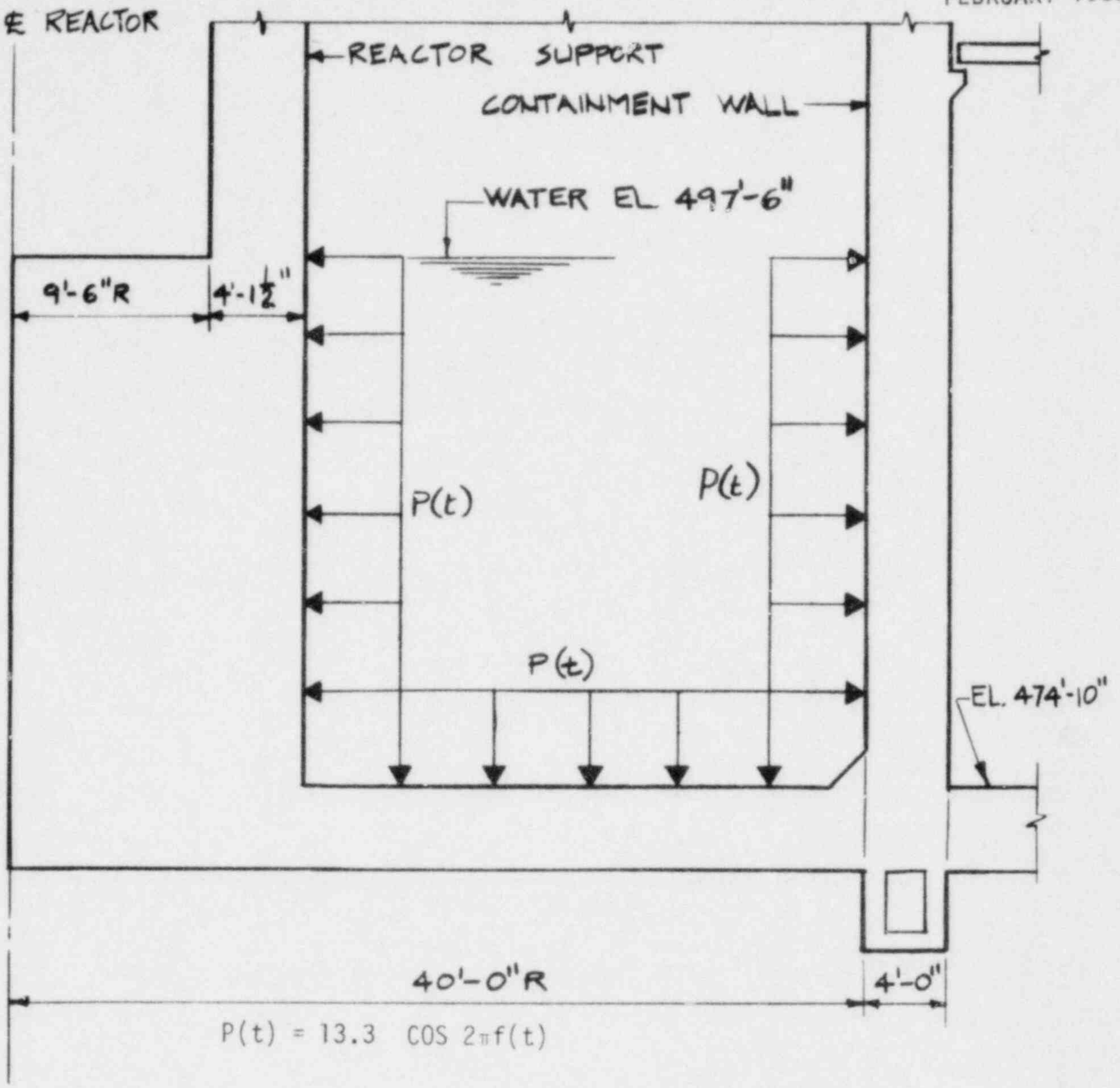
FIGURE 7.1-12

POOL SWELL ASYMMETRIC LOAD



$P(t) = 13.3 \ \cos 2\pi f(t)$

NOTE:

CYCLIC CONDENSATION LOAD OF 13.3 PSI AT 10-15 HZ ON PEDESTAL, CONTAINMENT AND BASE MAT UP TO SUPPRESSION POOL WATER ELEVATION

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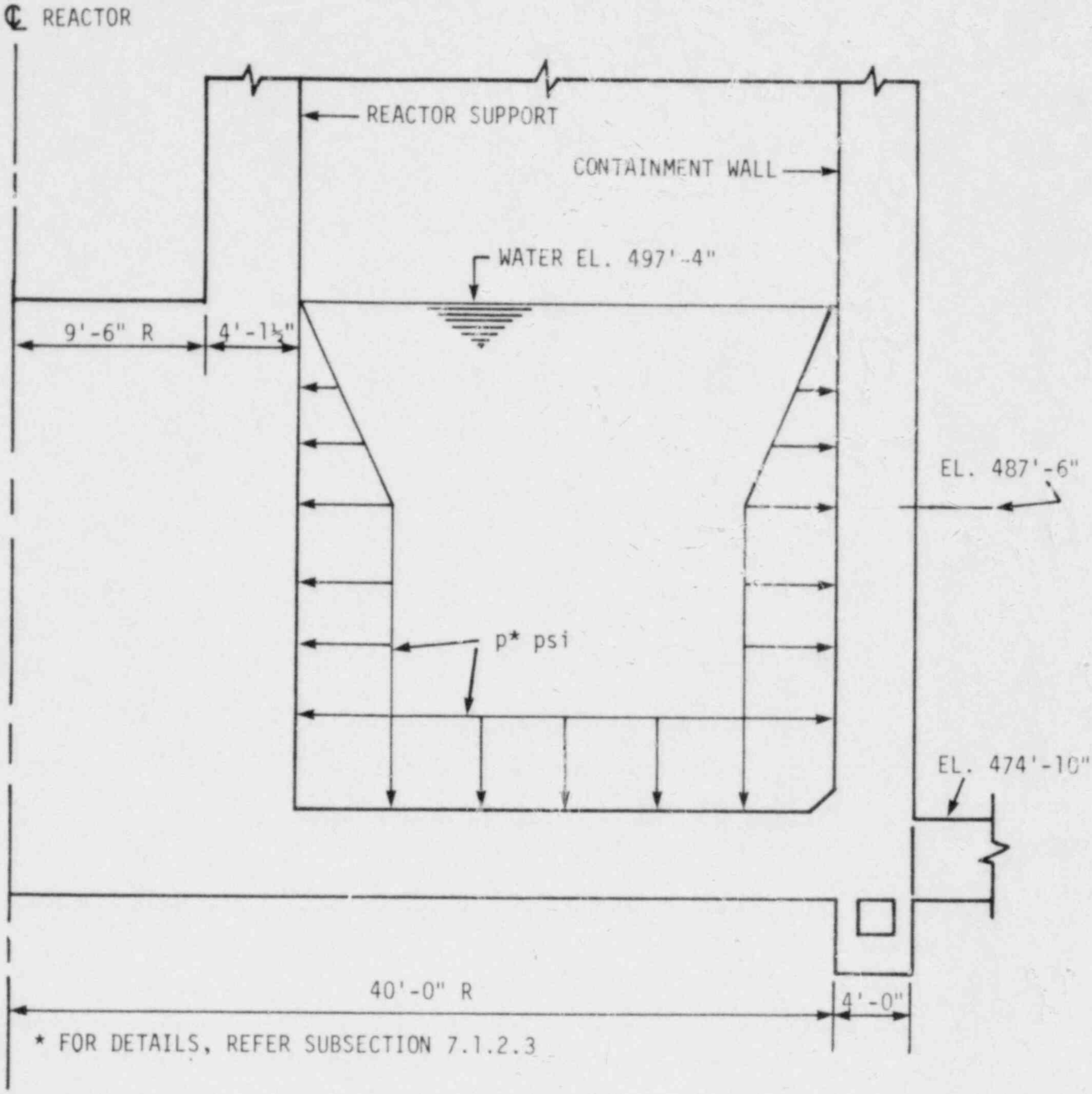
FIGURE 7.1-13

LOCA CYCLIC CONDENSATION PRESSURE LOAD ON BASE MAT CONTAINMENT AND REACTOR SUPPORT FOR RAMS HEAD



* FOR DETAILS, REFER SUBSECTION 7.1.2.3

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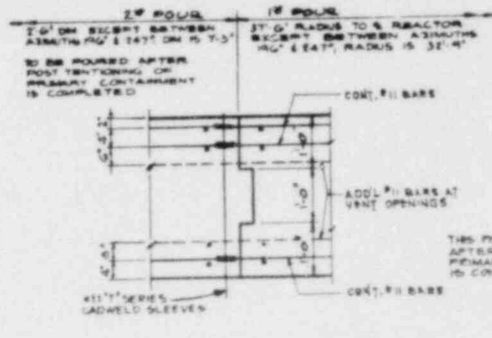
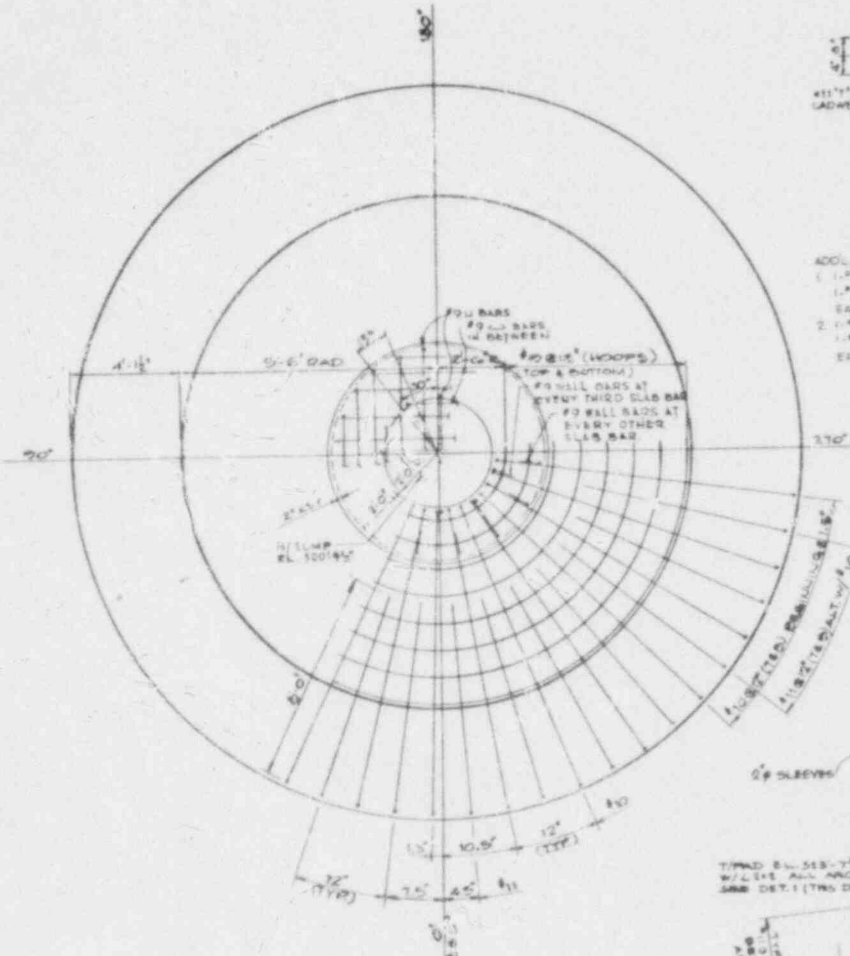
FIGURE 7.1-14

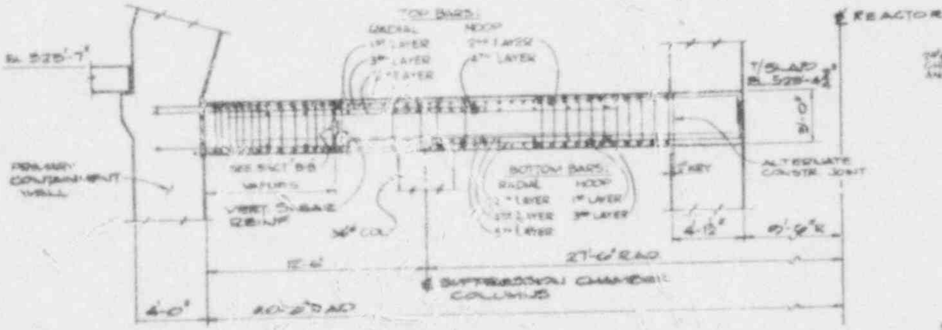
SPATIAL DISTRIBUTION OF LOCA CONDENSATION OSCILLATION LOAD FOR T-QUENCHER



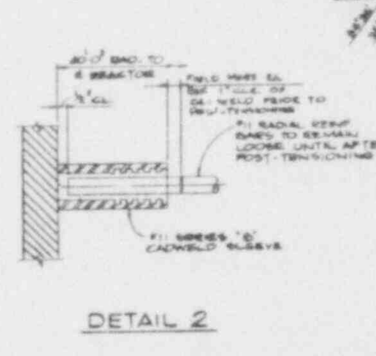
SECTION B-B



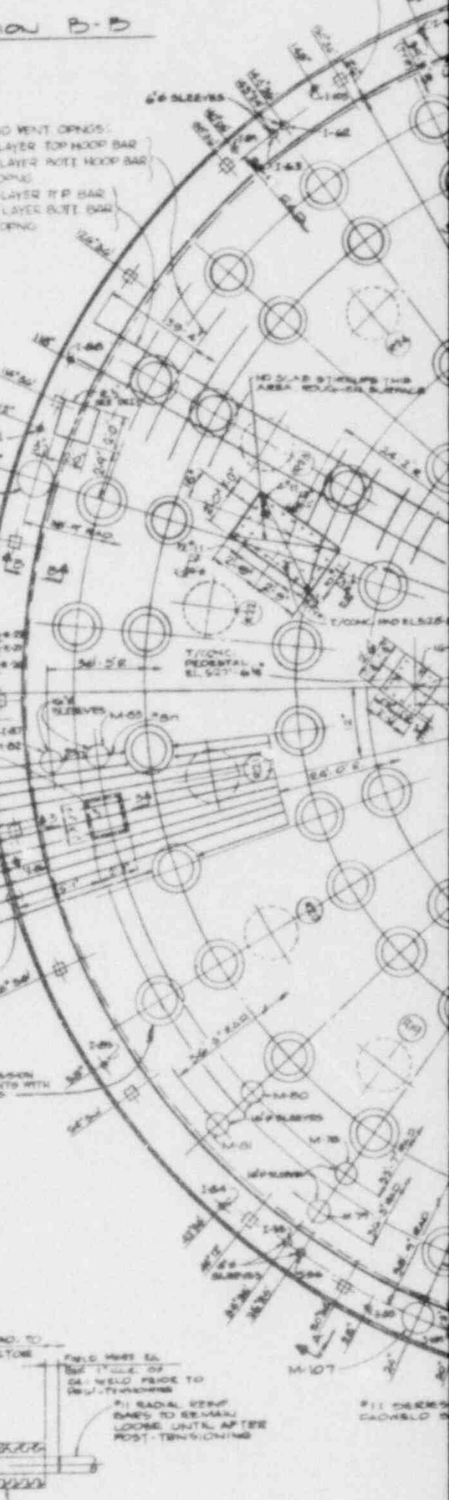
PLAN @ EL. 514'-9¾"



SECTION A-A



DETAIL 2



DRYWEL

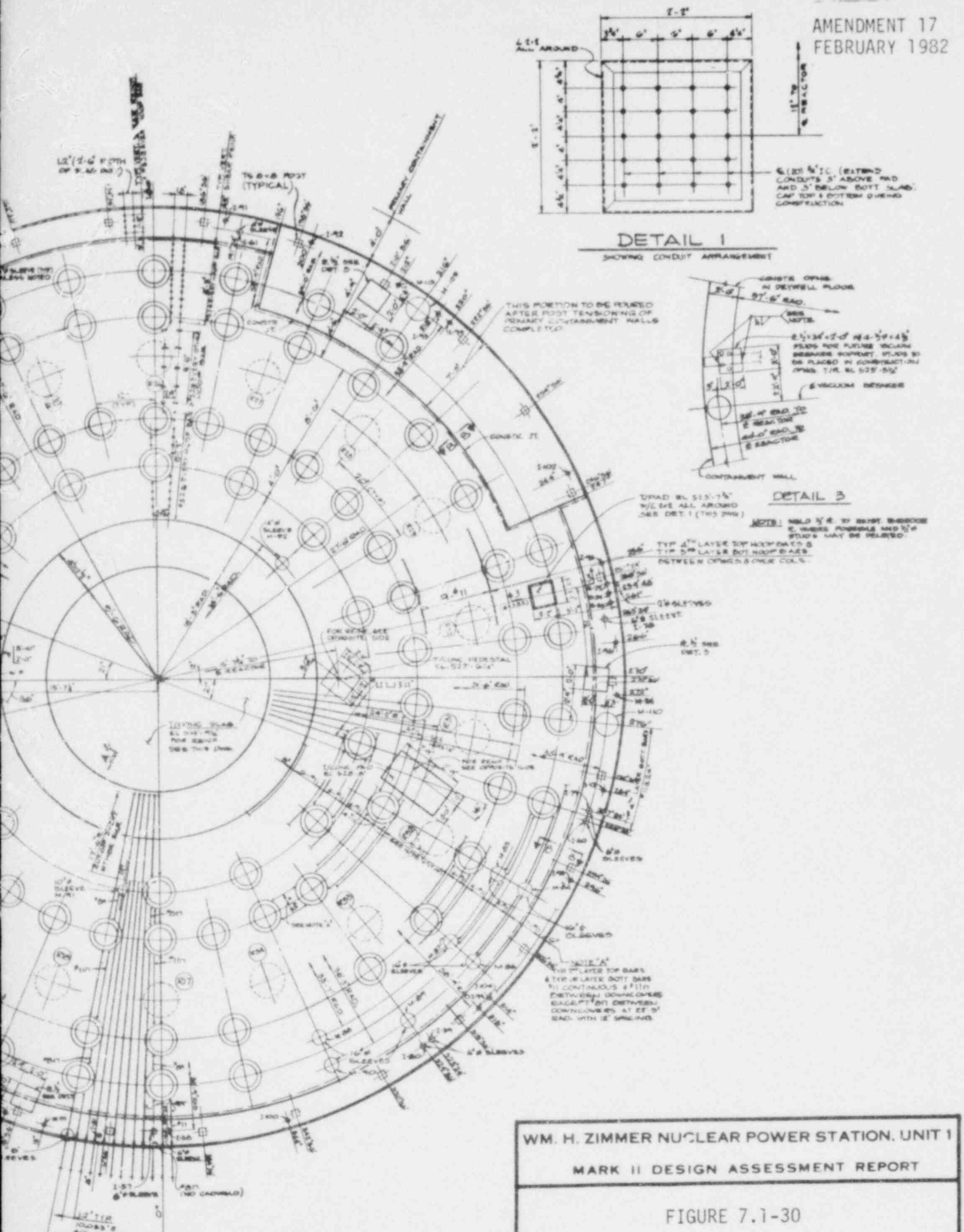


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FIGURE 7.1-30

DRYWELL FLOOR REINFORCING LAYOUT

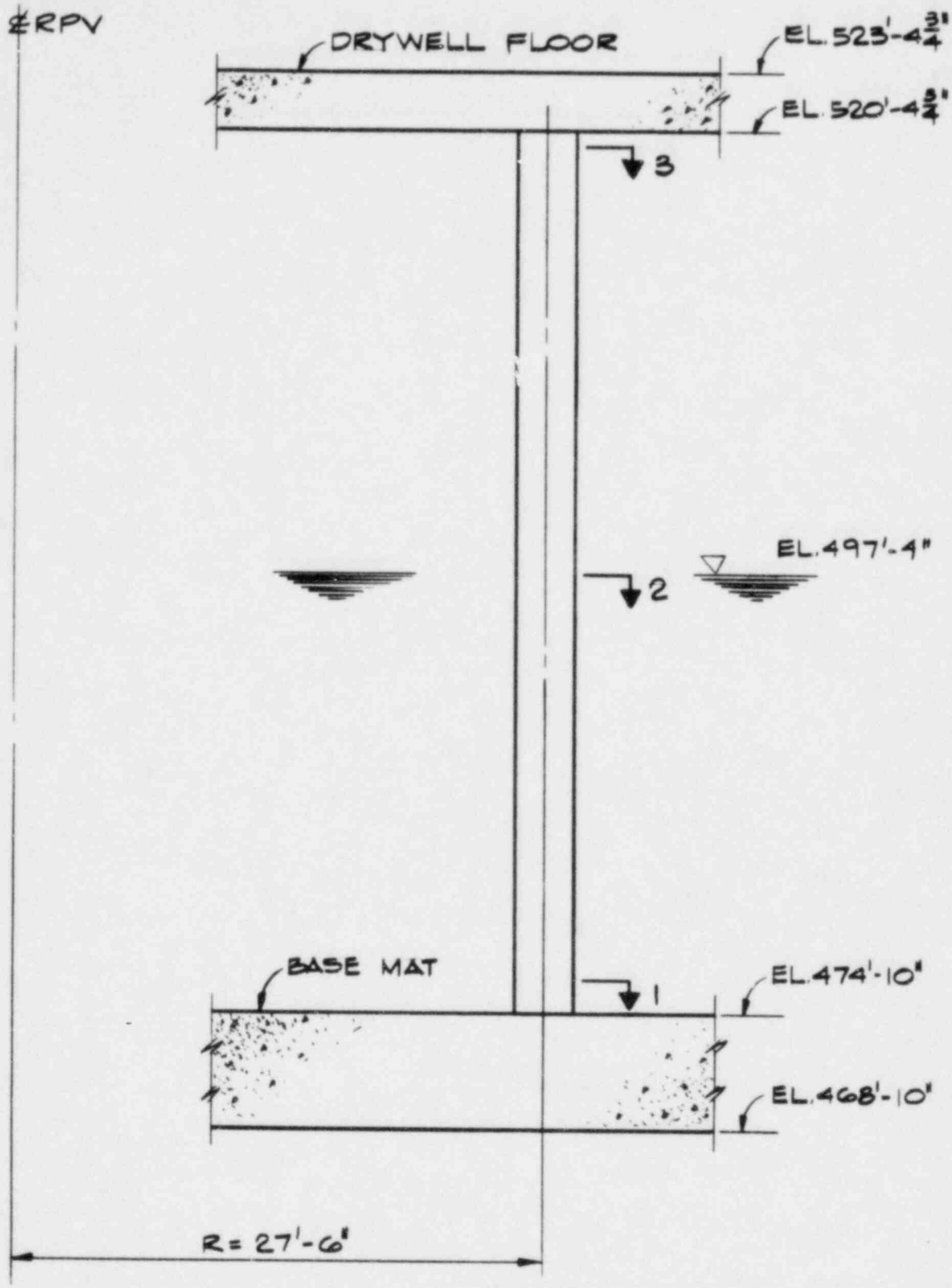

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FIGURE 7.1-34

DESIGN SECTIONS DRYWELL FLOOR COLUMN

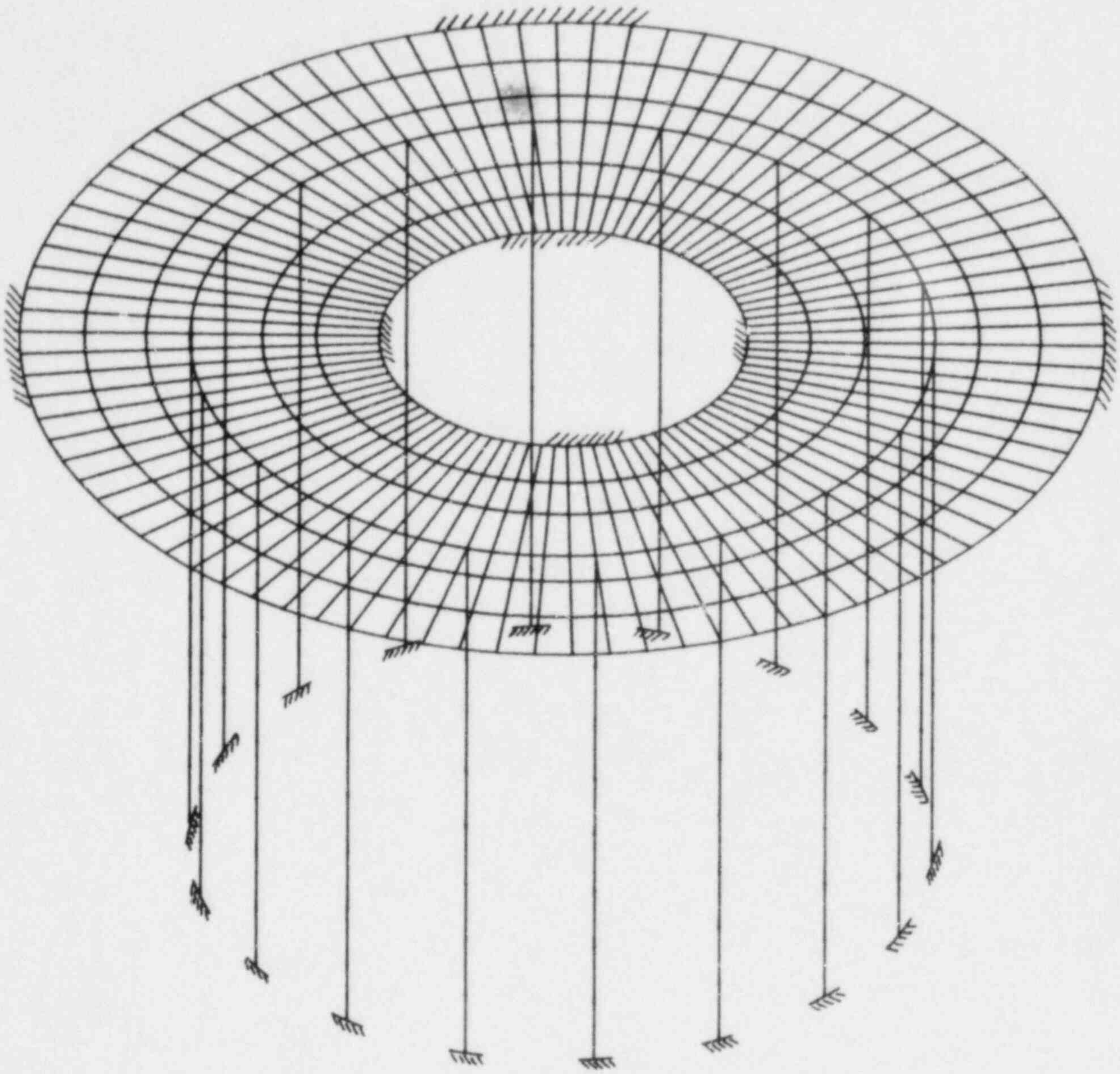

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FIGURE 7.1-37

DRYWELL FLOOR 3-D FINITE ELEMENT MODEL

III, Division I. Primary plus secondary membrane plus bending stresses are checked according to Subsection NE-3222.2 of the same code. Fatigue strength design stress is based on Subsection NE-3222.4 of Section III. Allowable design stress intensity values, design fatigue curves, and material properties used conform to Subsection NA Appendix I of the ASME B&PV Code, Section III, Division I. Subsection NB-3356 of the ASME B&PV Code, Section III, Division I is used to obtain a fatigue strength reduction factor of 4.0 for the fillet weld attachment of the containment wall liner plate and anchorage system.

7.2.1.5 Analysis

The hydrostatic pressure head on the basemat is 9.8 psi and the maximum uplift pressure load due to SRV alone is 9.2 psi. Since the negative load due to SRV discharge is more than balanced by the pressure head or water in the suppression chamber, the base liner plate does not experience any negative or uplift pressure load at any time during SRV actuation. Therefore, there are no flexural stresses induced in the basemat liner.

The maximum net uplift pressure that the basemat liner can withstand is 11.5 psi acting upward. Therefore, the basemat liner has the capability to carry an SRV negative pressure of 21.3 psi including the hydrostatic head, which is 232% of the design SRV pressure load.

7.2.2 Containment Wall Liner

7.2.2.1 Description of Liner

The suppression chamber wall liner consists of a 1/4-inch stainless steel plate of SA240, Type 304 up to elevation 500 feet 0 inch. Above elevation 500 feet 0 inch the liner is of carbon steel SA516, Grade 60 material. A 3 x 2 x 1/4-inch angles are welded to this plate intermittently with a 1/4-inch fillet weld at 4 inches every 12 inches center-to-center spacing. Refer to Figure 7.2-2 for the containment liner detail.

7.2.2.2 Loads for Analysis

The loads for analysis are described in Subsection 7.2.1.2.

7.2.2.3 Load Combinations

The load combinations are described in Subsection 7.2.1.3.

7.2.2.4 Acceptance Criteria

The acceptance criteria for the containment wall liner are described in Subsection 7.2.1.4.

7.2.2.5 Analysis

To study the response to the liner plate due to the SRV blowdown loads, a dynamic analysis using finite element idealization was performed. Since the liner plate experiences bending between anchor supports predominantly in one direction, a two-dimensional representation is used for the dynamic analysis. Several beam elements are used to represent the flexibility of the liner plate between two anchor locations. The ends of the model which represent the anchor supports are assumed to be fixed against both in-plane rotation and displacements. In addition, a non-linear stiffness matrix representation is used to simulate the stiffness of the concrete to resist compressive loads only, with no resistance towards tensile or negative SRV loads. The time-pressure history of the oscillating air bubble, which has approximately 10 negative pulses per actuation, is used as the input forcing function to the finite element model. The results of the dynamic analysis show that the dynamic load factor is approximately equal to 1.0. The liner plate can, therefore, be analyzed for SRV blowdown load by using a static solution procedure.

The suppression chamber wall liner has the capability to carry a SRV negative pressure of 16.5 psi (no credit for hydrostatic pressure), which is 180% of the design SRV pressure load.

The summary of stresses and strains in the containment wall liner plate and anchorage system are shown in Tables 7.2-1 through 7.2-4. It is apparent from the tables that the safety margin for each category of mechanical and self-limiting loads is greater than 1.0. Therefore, the suppression chamber wall liner and basemat liner plate and anchorage system are acceptable.

TABLE 7.2-2

SUMMARY OF CONTAINMENT WALL LINER ANCHORAGE

LOAD/DISPLACEMENT FOR ALL SRV CASES (RAMS HEAD)

I MECHANICAL LOADS

(Suction Loads)

	STRESS CATEGORY	ACTUAL STRESS OR USAGE FACTOR	ALLOWABLE STRESS OR USAGE FACTOR	SAFETY MARGIN
Weld	Primary Membrane (P_m)	0.340 ksi	½ S_m = 10 ksi	29.41
	Peak (F)	0.04	1.0	25.0
Angle	Primary Membrane (P_m)	0.120 ksi	S_m = 13.9 ksi	115.83

II MECHANICAL LOADS

(Suction Loads)

	STRESS CATEGORY	ACTUAL LOAD OR STRESS	ALLOWABLE LOAD OR STRESS	SAFETY MARGIN
Concrete	Diagonal Tension Failure	30.0 lbs/in	860.0 lbs/in	28.67

III SELF-LIMITING LOADS

STRESS CATEGORY	ACTUAL DISPLACEMENT (in)	ALLOWABLE DISPLACEMENT (in)	SAFETY MARGIN
Anchorage System	.015	.045	3.0

TABLE 7.2-3

SUMMARY OF CONTAINMENT WALL LINER PLATE

STRESSES/STRAINS FOR ALL SRV CASES (T-QUENCHER)

I MECHANICAL LOADS

(Suction Loads)

STRESS CATEGORY	ACTUAL STRESS OR USAGE FACTOR	ALLOWABLE STRESS OR USAGE FACTOR	SAFETY MARGIN
Primary (P_b) Bending	4.752 ksi	1.5 S_m = 30 ksi	6.31
Secondary (Q)	44.403 ksi	3.0 S_m = 60 ksi	1.35
Peak (F)	.04	1.0	25.0

II SELF-LIMITING LOADS

STRAIN CATEGORY	ACTUAL STRAIN (in/in)	ALLOWABLE STRAIN (in/in)	SAFETY MARGIN
Self-limiting	.001	.002	2.0

TABLE 7.2-4

SUMMARY OF CONTAINMENT WALL LINER ANCHORAGE

LOAD/DISPLACEMENT FOR ALL SRV CASES (T-QUENCHER)

I MECHANICAL LOADS

(Suction Load)

	STRESS CATEGORY	ACTUAL STRESS OR USAGE FACTOR	ALLOWABLE STRESS OR USAGE FACTOR	SAFETY MARGIN
Weld	Primary Membrane (P_m)	0.332 ksi	$\frac{1}{2}S_m$ = 10 ksi	30.1
	Peak (F)	0.04	1.0	25.0
Angle	Primary Membrane (P_m)	0.117 ksi	S_m = 13.9 ksi	118.8

II MECHANICAL LOADS

(Suction Loads)

	STRESS CATEGORY	ACTUAL LOAD OR STRESS	ALLOWABLE LOAD OR STRESS	SAFETY MARGIN
Concrete	Diagonal Tension Failure	30.0 lb/in.	860.0 lbs/in	28.7

III SELF-LIMITING LOADS

STRESS CATEGORY	ACTUAL DISPLACEMENT (in)	ALLOWABLE DISPLACEMENT (in)	SAFETY MARGIN
Anchorage System	0.0144	0.040	2.78

c. weight per unit length - 72.42 lb/ft; and

d. material - A-106 Grade C.

7.3.1.1.3 Connection Properties

The following are the properties of the connections:

a. Connection of the bracing to the downcomer is accomplished through gusset plates and stiffened pipe sleeves.

b. The gusset plates are 3/4 inch thick, A-588 Grade A or B steel.

c. The stiffened pipe sleeves are composed of 3/4-inch thick, 27-inch OD pipe 3 feet long and two 1.5-inch thick, 39-inch OD stiffened rings, as shown in Figure 7.3-3.

7.3.1.2 Loads for Analysis

The individual loads affecting the downcomers and downcomer bracing are identified below:

a. Normal Load

This would include the dead load, temperature load, and the pressure differential effects which produce load on the design structure.

b. Operating-Basis Earthquake (OBE)

The OBE causes vibratory motions of the building structures which include dynamic forces on the downcomers. The OBE also causes water sloshing inside the suppression chamber. The drag and inertia forces of these oscillations will produce a dynamic loading on the submerged portion of the downcomer.

c. Safe Shutdown Earthquake (SSE)

The SSE causes the same type of dynamic loads on the downcomer as described for Operating-Basis Earthquake (OBE). However, the magnitude of the loads caused by SSE is greater than those caused by the OBE.

d. Loss-of-Coolant Accident (LOCA) Loads

The following two cases for LOCA loads were considered for analyses:

1. During the initial phases of a LOCA, high-steam flow rates through the downcomer produce condensation oscillation load on the downcomer.

   During the low-steam flow rates, there is a random dynamic chugging lateral load acting on the submerged portion of the downcomer.

2. Following the LOCA, the downcomer will experience a dynamic loading due to its response to:

   a) the vertical acceleration produced in the drywell floor by water jet impingement on the containment basemat during the downcomer clearing process, and

   b) the cyclic chugging load on the containment structure.

e. Safety/Relief Valve (SRV) Discharge Dynamic Load

   The following two cases of SRV discharges are considered for design purposes:

   1. resonant sequential symmetric discharge of all 13 valves, and

   2. subsequent actuation discharge of a single valve.

f. Hanger Load at Elevation 520 ft 0 in. on Downcomer

   The stresses due to the MSRV support framing on the downcomer wall at elevation 520 ft 0 in. are also taken into consideration.

   The downcomer will also experience dynamic loads due to its response to the base excitation produced in the building resulting from the forced vibration of the containment structure.

7.3.1.3 Design Load Combinations

The downcomer loads defined in Subsection 7.3.1.2 were combined for normal, upset, and emergency conditions as described below in accordance with Table 7.3-1 and Subsection NC-3600 of the ASME Boiler and Pressure Vessel Code, Section III. The resulting stresses were combined on an SRSS basis.

7.3.1.4 Acceptance Criteria

7.3.1.4.1 Acceptance Criteria for Downcomers

The stresses within the downcomer are considered acceptable if they satisfy the ASME Boiler and Pressure Vessel Code, Section III, Subsection NC-3600. The allowable stress S was obtained from Table 1.7-1, Section III, Appendix I for material SA-516, Grade 60 at a design temperature of not exceeding 400° F.

The primary stress intensity includes the primary membrane stresses plus the primary bending stresses. The limits of these stresses depend upon the loading conditions as follows:

a. The limit of stresses under normal condition: 1.0S.

b. The limit of stresses under upset condition: 1.2S.

c. The limit of stresses under emergency: 1.8S.

7.3.1.4.2 Acceptance Criteria for Downcomer Bracing

The stresses within the downcomer bracing are considered acceptable if they satisfy the ASME Boiler and Pressure Vessel Code, Section III, Subsection NF-3300. At design temperature, the allowable stresses in tension or bending depend upon the yield stress S_y as follows:

TABLE 7.3-1

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA FOR DOWNCOMER AND DOWNCOMER BRACING

LOAD CASE	NRC LOAD COMBINATION (NUREG-0487)	T-QUENCHER DESIGN-BASIS	ASME STRESS CRITERIA
1	$N+SRV_X$	$N+SRV$	B (UPSET)
2	$N+SRV_X+OBE$	$N+\sqrt{SRV^2+OBE^2}$	B (UPSET)
3	$N+SRV_X+SSE$	$N+\sqrt{SRV^2+SSE^2}$	C (EMERGENCY)
4	$N+SRV_{ADS}+IBA(SBA)$	$N+\sqrt{SRV^2+CHUG^2}$	C (EMERGENCY)
5	$N+SRV_{ADS}+OBE+IBA(SBA)$	$N+\sqrt{SRV^2+OBE^2+CHUG^2}$	C (EMERGENCY)
6	$N+SRV_{ADS}+SSE+IBA(SBA)$	$N+\sqrt{SRV^2+SSE^2+CHUG^2}$	C (EMERGENCY)
7	$N+SSE+DBA$	$N+\sqrt{SSE^2+CO^2}$	C (EMERGENCY)
8	N	N	A (NORMAL)
9	$N+OBE$	$N+OBE$	B (UPSET)
10	$N+SRV_X+SSE+DBA$	- CONTAINMENT STRUCTURE ONLY JUSTIFICATION PROVIDED BY GE.	

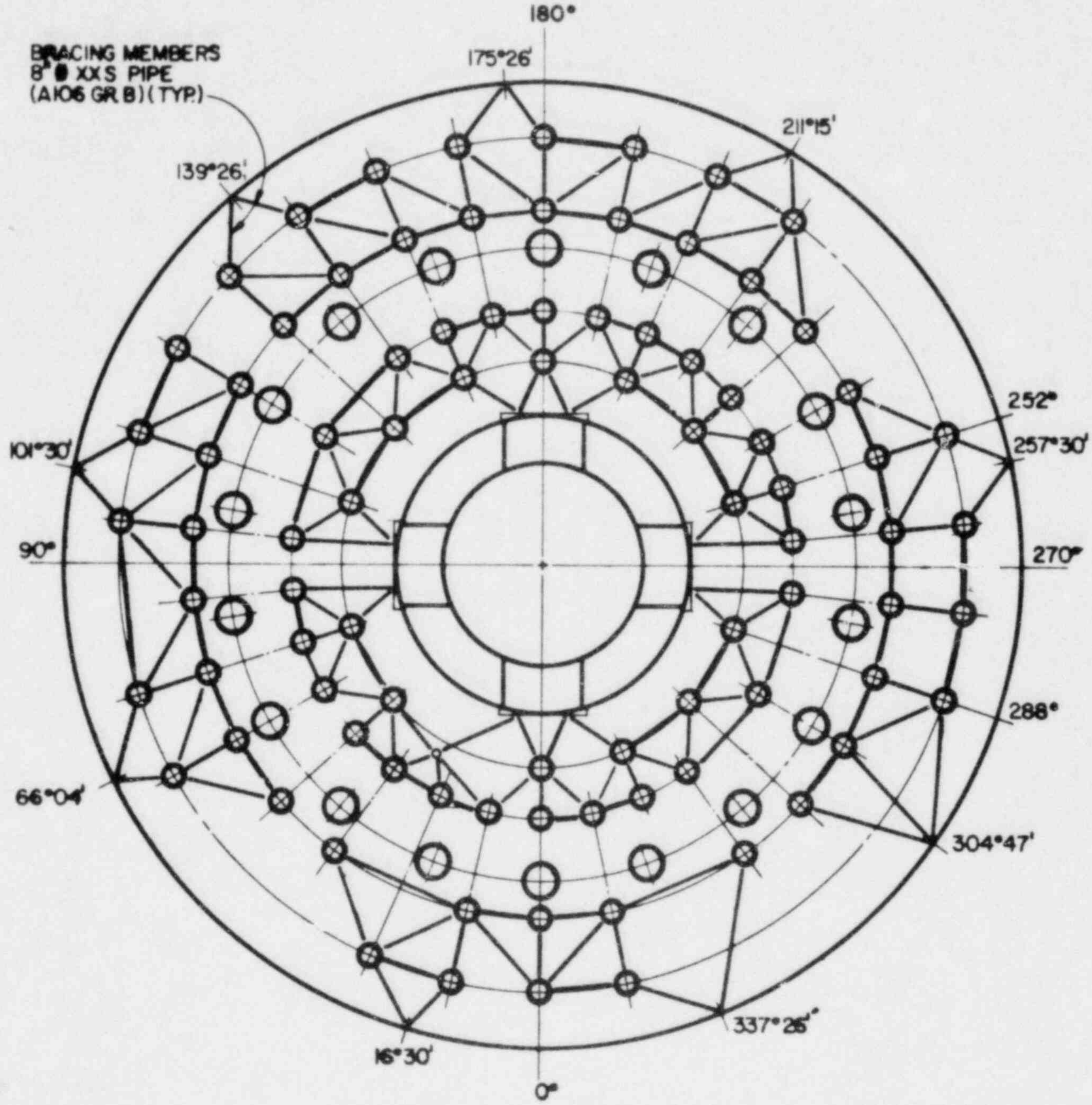

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FIGURE 7.3-2

DOWNCOMER BRACING LAYOUT

7.4 REACTOR PRESSURE VESSEL HOLDDOWN BOLTS

An assessment of the RPV holddown bolts for the forces acting at the RPV support skirt due to the Zimmer Empirical Loads by SRSS combinations has been made.

Table 7.4-1 gives the breakdown of the force components at the RPV skirt for various code conditions: upset, emergency, and faulted.

AISC Code allowable stresses defined in Table 3.8-9 of the ZPS-1 FSAR were used in calculating the margin factors.

Table 7.4-2 gives forces and margin factors for RPV holddown bolts for each of the three code conditions.

TABLE 7.4-1

RPV SUPPORT SKIRT - NEW LOADS (SRSS VALUE)

CODE CONDITION	VERTICAL (kips)	SHEAR (kips)	MOMENTS (in-lb x 10^{-6})
Upset	5938	403	78
Emergency	7367	403	78
Faulted	10836	2756	252

TABLE 7.4-2

FORCES AND MARGIN FACTOR FOR RPV HOLDDOWN BOLT

CODE CONDITION	TENSION (kip/bolt)	SHEAR (kip/bolt)	MARGIN FACTOR
Upset	61.15	6.7	1.9
Emergency	73.00	6.7	1.6
Faulted	128.00	45.9	1.3

b. The impact of the empirical limiting CO load had a localized effect on the piping and supports connected to the outer suppression pool wall.

c. No piping overstress was found for all loads and load combinations (including the empirical CO load) using the absolute sum method of combination. In all, 3,199 locations were evaluated.

7.5.1.1.4 Wetwell Piping

Due to the direct hydrodynamic loading from SRV discharge and LOCA, all wetwell piping was upgraded. Assessment of the rams head design basis was not performed. The design of the wetwall piping and piping supports is based on the bounding SRV T-quencher and LOCA loads outlined in Chapter 5.0 and the load combinations shown in Chapter 6.0.

7.5.1.2 Impact of Change to T-Quencher Discharge Device

The impact on piping systems of the change from a rams head to a T-quencher discharge device has been shown to be minimal. In general, only those piping subsystems whose fundamental mode frequency is less than 7 hertz were impacted. Those piping systems tended to be small-diameter (< 4-inch) piping whose loads were relatively small.

The increases in loads were still within the capacity of the restraints.

Piping overstress was shown to be almost negligible, and those locations where an overstress condition did exist could be qualified with a more refined analysis.

The detailed results of the T-quencher reevaluation report are included in Appendix H of this document.

7.5.1.3 Impact of SRV T-Quencher and LOCA on Rams Head Design Basis

In this section the assessment of the impact of the new suppression pool loads on the rams head design basis is summarized. The results of the assessment showed various degrees of impact on the rams head design for various load combinations. This assessment provided the basis for the use of the 1.33 factor for early release of hardware for procurement prior to completion of analysis for the Zimmer empirical load. The impact of three bounding load combinations were investigated. The three load combinations are:

a. N + SSE + CO (DFFR)

b. $N + SSE + CO$ (EMPIRICAL) $+ SRV_{ALL}TQ$ and

c. $N + SSE + CHUGGING + SRV_{ALL}\ TQ$

The purpose of this section is to determine how the above three load combinations affect the rams head design basis of

$$N + DBE^{*} + SRV_{ALL}RH$$

*DBE = 1.875 x OBE

for piping supports both inside and outside the drywell and to determine a bounding value for those supports loads which are not governed by the rams head design in order to release piping supports for early procurement and continue field construction.

From Subsection 6.4.2, the following bounding combinations were investigated:

a. $N + SSE + CO$ (DFFR)

b. $N + SSE + CO$ (EMPIRICAL) $+ SRV_{ALL/ASY}TQ$ and

c. $N + SSE + CHUGGING + SRV_{ALL/ASY}TQ$

The loads were combined using the absolute sum method.

The above load combinations were analyzed for 43 sample piping systems throughout the reactor building including subsystems both inside and outside the drywell. The support loads were tabulated and were compared with the corresponding support load for the rams head design basis.

The results are summarized in six histograms showing the percent change in support loads. The six histograms depict the load change for the following load combinations:

Figure 7.5-1 - CO (DFFR)	Inside Containment
Figure 7.5-2 - CO (EMPIRICAL)	Inside Containment
Figure 7.5-3 - Chugging	Inside Containment
Figure 7.5-4 - CO (DFFR)	Outside Containment
Figure 7.5-5 - CO (EMPIRICAL)	Outside Containment
Figure 7.5-6 - Chugging	Outside Containment

The results are also shown in Table 7.5-2, "Impact on Piping Support - ABSUM." Table 7.5-3 summarizes numerically for the three load combinations the quantity of restraint increases and the percentage change.

CHAPTER 8.0 - SUPPRESSION POOL WATER TEMPERATURE MONITORING SYSTEM

8.1 SYSTEM DESIGN

8.1.1 Safety Design Basis

The safety design basis for setting the temperature limits for the suppression pool temperature monitoring system are based on providing the operator with adequate time to take the necessary action required to ensure that the suppression pool temperature will always remain below the pool temperature limit established by the NRC. An analysis of suppression pool temperature transients can be found in Section 8.2. The system design also provides the operator with necessary information regarding localized heatup of the pool water while the reactor vessel is being depressurized. If SRV's are selected for actuation, they may be chosen to ensure mixing and uniformity of heat energy injection to the pool.

8.1.2 General System Description

The suppression pool temperature monitoring system monitors the pool water temperature in order to prevent the local pool water temperature from exceeding the pool temperature limit during SRV discharge and provides the operator with the information necessary to prevent excessive pool temperatures during a transient or accident. Temperatures in the pool are recorded and alarmed in the main control room. The instrumentation arrangement in the suppression pool consists of 18 local temperature sensors in individual guide tubes mounted off the pool walls.

The local temperature sensors consist of 18 dual-element, copper constantan thermocouples located 1 foot below the low water level.

Twelve of the sensors are located off the outer suppression pool wall at azimuths 28°, 45°, 86°, 117°, 147°, 183°, 217°, 240° 263°, 277°, 325°, and 344°. The other six are located off the pedestal at azimuths 55°, 142°, 202°, 246°, 298°, and 344°.

The sensors and readout devices are assigned to ESS-1 and ESS-2 divisions and local discharge areas are monitored by two sensors, one from each division. This represents a conservative measurement of local pool water heatup. All instrumentation will be qualified Seismic Category I. The time constant of the thermocouple installation will be no greater than 15 seconds. The difference between measurement reading and actual temperature will be within ± 2° F.

The display techniques for monitoring the pool temperature are:

a. to continuously input to the computer system the measurement made by Element 1 of each of the nine thermocouples in ESS-1 which can be displayed individually or averaged by the computer to display the bulk temperature;

b. to sequentially record on a multipoint recorder the measurement made by Element 1 of each of the nine thermocouples in ESS-2 at a rate of 5 sec/point when all nine are below the alarm level, and at a rate of 1 sec/point when any of the nine are above the alarm level;

c. to continously record on a strip-chart recorder the bulk temperature obtained by averaging the nine Element 2 thermocouples of ESS-1; and

d. to continuously input to the computer system and display on a hardwired indicator the bulk temperature as obtained by averaging the nine Element 2 thermocouples of ESS-2.

Each instrumentation division has the capability of alarming both local and bulk high temperature. The computer system provides temperature readout via CRT/data logger on demand. The above configuration provides the maximum flexibility for providing redundant pool temperature information to the operator.

The quenching of the steam at the quencher discharge forms jets that heat the water and generate convection currents in the suppression pool. These currents eventually rise and displace cooler water near the pool surface.

During an extended blowdown, a large temperature gradient is expected initially near the quencher. After a short time the pool gradients will stabilize with a bulk to local temperature difference of about 10° F. The adequacy of the temperature monitoring system will be confirmed by the in-plant SRV testing, described in Subsection 3.2.

8.1.3 Normal Plant Operation

The temperature monitoring system is utilized during normal plant operation to ensure that the pool temperature will remain low enough to condense all quantities of steam that may be released in any anticipated transient or postulated accident. When rams head devices were specified for design, there was an NRC concern that high pool temperature might result in high pool dynamic loads during SRV discharge because of unstable steam condensation. Installation of T-quenchers has eliminated this concern. During normal plant operation, the system is in continuous operation recording the suppression pool water temperature with a readout in the main control room. If the pool temperature rises above normal operating temperatures, an alarm

CHAPTER 9.0 - PLANT MODIFICATIONS AND RESULTANT IMPROVEMENTS

9.1 STRUCTURAL MODIFICATIONS

In general, the impact of the addition of the pool dynamic loads on a majority of the structures was minimal. The primary reasons are as follows:

a. Fixed-base seismic loads were used in the original design.

b. Except in local areas, the design of the containment structure is generally governed by load combinations involving safe shutdown earthquake and design-basis accident. Pool dynamic loads are relatively small compared to these governing loads.

The following is a summary of the structural modifications necessitated by the addition of pool dynamic loads:

a. The inner core of the reactor support was filled with concrete up to elevation 497 feet 6 inches to reduce the bending stresses induced by the pool dynamic loads. Structural integrity of this core fill was ensured by providing reinforcing bars and concrete stud anchors welded to the reactor support liner.

   Figure 7.1-28 of the DAR gives the details of this modification.

b. The gallery platform in the suppression pool at elevation 510 feet 6 inches has been removed.

   Additional steel framing has been installed in the suppression pool at elevation 520 feet ¼-inch to support MSRV and non-MSRV piping. New embedments (anchored plates) and ring girders have been installed in the suppression pool for MSRV and non-MSRV piping.

c. The flange at the end of the downcomer vent has been removed.

d. Horizontal bracing of the downcomer at elevation 496 feet.

e. Embedments and pedestal anchor installed for downcomer bracing and for supporting MSRV and non-MSRV guides in the wetwell.

f. Removed vacuum breakers from downcomers.

g. The steel framing in the drywell requires additional stiffening cover plates or replacement with stiffer members.

h. Distribution of drywell framing loads to other support locations is required to reduce loads on heavily loaded embedments.

i. Some of the cable tray hangers in the reactor building wall are to be stiffened.

j. Block wall fixes.

k. HVAC duct support fixes.

l. Conduit support fixes.

m. Cable tray support fixes.

c. upgrading piping wall thickness and shear lug sizes where required,

d. adding approximately 226 piping supports,

e. replacing the elbow and stancion arrangement at the top of the MSRV line riser with a special fabricated tee and strut arrangement, and

f. installing new suction strainers for the ECCS and RCIC pump intakes.

9.2.1.3 BOP Piping

The BOP piping which was designed for the rams head design basis was found to be impacted locally due to the chugging and empirical CO load. The local impact affected only those piping systems attached to the outer suppression pool wall (at approximately elevation 497 feet).

It was found that a factor of 1.33 x rams head design-basis emergency loads would be adequate to accommodate the chugging and CO loads for the piping supports.

As a result, all the support loads on piping systems connected to or supported on the outer suppression pool wall at mid-center (elevation 497 feet) were increased by 33%.

9.2.2 Equipment

The reactor building closed cooling water (RBCCW) expansion tank, the residual heat removal (RHR) heat exchanger support bolts, and the RBCCW heat exchanger support bolts have been modified to accommodate the additional pool dynamic loads. This design modification consisted of strengthening the saddle supports and replacing or adding additional support bolts. As a result of the design assessment performed for assessing the impact of changing the quencher device to the T-quencher, it is anticipated that design modifications may be required for the following equipment:

a. core spray cooling system - RHR equipment room cooling coil;

b. core spray cooling system - LPCS/RHR equipment room cooling coil;

c. core spray cooling system - HPCS equipment room cooling coil;

d. reactor building closed cooling water heat exchanger 1B;

e. HVAC control panel 1PL69JA; and

f. HVAC control panel 1PL69JB.

9.2.3 Final Piping and Equipment Assessment

Subsections 9.2.1 and 9.2.2 described the status of piping and equipment assessment for the Zimmer Empirical Loads and SRV T-quencher device made up to December 5, 1979 and presented to the NRC. The assessment and documentation has continued since the December 5, 1979 status and has now been completed. Table 9.2-1 summarizes the BOP equipment scope of supply which have had design modifications issued to accommodate the final hydrodynamic loads.

Based on the final reanalysis of the Zimmer BOP scope of piping and equipment for the Zimmer Empirical Loads and SRV T-quencher load, the Zimmer plant meets or exceeds the load definitions summarized in the NRC Mark II Lead Plant Acceptance Criteria, NUREG-0487.

TABLE 9.2-1

SUMMARY OF EQUIPMENT MODIFICATIONS

EQUIPMENT NUMBER	DESCRIPTION	MODIFICATION DESCRIPTION
1VG02CA	Standby Gas Treatment System Fan 1A	Vibration Isolators and Mounting Bolts Strengthened
1VG02CB	Standby Gas Treatment System Fan 1B	Vibration Isolators and Mounting Bolts Strengthened
1VG03CA	Standby Gas Treatment System Cooling Fan 1A	Vibration Isolators Strengthened
1VG03CB	Standby Gas Treatment System Cooling Fan 1B	Vibration Isolators Strengthened
1VG04AA	Standby Gas Treatment System Heating Coil 1A	Reinforcement of Coil Support
1VG04AB	Standby Gas Treatment System Heating Coil 1B	Reinforcement of Coil Support
1VC11XA	Control Room HVAC Return Fan Silencer 1A	Providing Anchorage to Foundation
1VC11XB	Control Room HVAC Return Fan Silencer 1B	Providing Anchorage to Foundation
1VY01C	CSCS-RHR Equipment Room Cooling Fan	Vibration Isolators Strengthened
1VY02C	CSCS-LPCS/RHR Equipment Room Cooling Fan	Vibration Isolators Strengthened

TABLE 9.2-1 (Cont'd)

EQUIPMENT NUMBER	DESCRIPTION	MODIFICATION DESCRIPTION
1VY03C	CSCS-RCIC Equipment Room Cooling Fan	Vibration Isolators Strengthened
1VY04C	CSCS-HPCS Equipment Room Cooling Fan	Vibration Isolators Strengthened
1VY05A	CSCS-RHR Equipment Room Heat Exchanger	Additional Cabinet Anchorage and Coil Reinforcement
1VY06S	CSCS-LPCS/RHR Equipment Room Coil Cabinet (1VY07AA, 1VY07AB)	Additional Cabinet Anchorage and Coil Reinforcement
1VY08A	CSCS-RCIC Equipment Room Heat Exchanger	Additional Cabinet Anchorage and Coil Reinforcement
1VY09A	CSCS-HPCS Equipment Room Heat Exchanger	Additional Cabinet Anchorage and Coil Reinforcement
1WR02AA	Reactor Building Closed Cooling Water Heat Exchanger 1A	Saddle Supports Modified and Additional Anchorage Provided
1WR02AB	Reactor Building Closed Cooling Water Heat Exchanger 1B	Saddle Supports Modified and Additional Anchorage Provided
1WR02AC	Reactor Building Closed Cooling Water Heat Exchanger 1C	Saddle Supports Modified and Additional Anchorage Provided
1PX56J	Rack for Locally-mounted Instruments	Additional Anchorage Provided
1PX57J	Rack for Locally-mounted Instruments	Additional Anchorage Provided

TABLE 9.2-1 (Cont'd)

EQUIPMENT NUMBER	DESCRIPTION	MODIFICATION DESCRIPTION
1PX58J	Rack for Locally-mounted Instruments	Additional Anchorage Provided
1PX71J	Rack for Locally-mounted Instruments	Additional Anchorage Provided
1PX72J	Rack for Locally-mounted Instruments	Additional Anchorage Provided
1FC02AA	Fuel Pool Heat Exchanger 1A	Additional Bracing Provided; Reinforcing Saddle Supports and Additional Anchorage Provided
1FC02AB	Fuel Pool Heat Exchanger 1B	Additional Bracing Provided; Reinforcing Saddle Supports and Additional Anchorage Provided
1VC08SA	Control Room HVAC Air Handling Unit 1A	Additional Anchorage Provided
1VC08SB	Control Room HVAC Air Handling Unit 1B	Additional Anchorage Provided
1AP05E	480-V ESS Substation 1A-1	Additional Anchorage Provided
1AP06E	480-V ESS Substation 1A-2	Additional Anchorage Provided
1AP09E	480-V ESS Substation 1B-1	Additional Anchorage Provided
1AP10E	480-V ESS Substation 1B-2	Additional Anchorage Provided
1AP13E	480-V ESS Substation 1C-1	Additional Anchorage Provided

TABLE 9.2-1 (Cont'd)

EQUIPMENT NUMBER	DESCRIPTION	MODIFICATION DESCRIPTION
1VG01YB	Essential Recirculation Fan Isolation Damper	Modification of Operator Mounting and/or Hangers
1C41F001A	3 in. Motor-operated Globe Valve	Reinforce Yoke
1C41F001B	3 in. Motor-operated Globe Valve	Reinforce Yoke
1WS076A	3 in. Motor-operated Globe Valve	Reinforce Yoke
1WS076B	3 in. Motor-operated Globe Valve	Reinforce Yoke
1IN061	3 in. Motor-operated Globe Valve	Reinforce Yoke
1B21F019	3 in. Motor-operated Gate Valve	Reinforce Yoke
1C11F0[illegible]	3 in. Motor-operated Gate Valve	Reinforce Yoke
1B21F016	3 in. Motor-operated Gate Valve	Reinforce
1WR055	6 in. Motor-operated Gate Valve	Upgrade Bolt Material
1E51F010	6 in. Motor-operated Gate Valve	Upgrade Bolt Material
1E51F031	6 in. Motor-operated Gate Valve	Upgrade Bolt Material

9.4 SRV DISCHARGE QUENCHER

The discharge lines from the 13 safety/relief valves (SRV) are routed from the drywell down into the suppression pool. Each discharge line terminates with a T-quencher discharge device as shown in Figure 9.4-1. Each T-quencher is attached to a base plate in the containment floor. The centerline of the T-quencher arms is 3 feet 6 inches above the top of the suppression pool basemat. This elevation is equivalent to a submergence of 18 feet 6 inches below the pool low water level.

The plan location of the T-quencher is shown in Figure 9.4-2. The location and orientation of the quenchers was based on several considerations which included the following:

a. physical separation from structures to minimize submerged structure loads (a minimum separation of approximately 5 feet has been provided),

b. physical separation from suction strainers to prevent an air or two-phase mixture from entering the ECCS or RCIC pumps, and

c. thermal mixing and utilization.

d. The plan location of the quencher incorporates SRV symmetry by setpoint group as follows:

   1. Low setpoint group, two valves at lowest setpoint.

   2. Multiple valve groups, five valves which are from the two lowest setpoint groups.

   3. ADS valves.

The T-quencher discharge device is substantially different from the original rams head device. The primary reasons for switching from the rams head to the T-quencher were as follows:

a. The T-quencher provides wider dispersal of the air inventory in the vent line with lower air clearing loads.

b. The T-quencher provides wider dispersal of steam and enhances the condensation of steam

c. The T-quencher discharges steam without steam condensation instability at higher pool temperatures than the rams head device.

The changes to systems and structures are described in Sections 9.1 through 9.3. In most areas of the plant these changes were minimal, since for most frequencies the rams head response

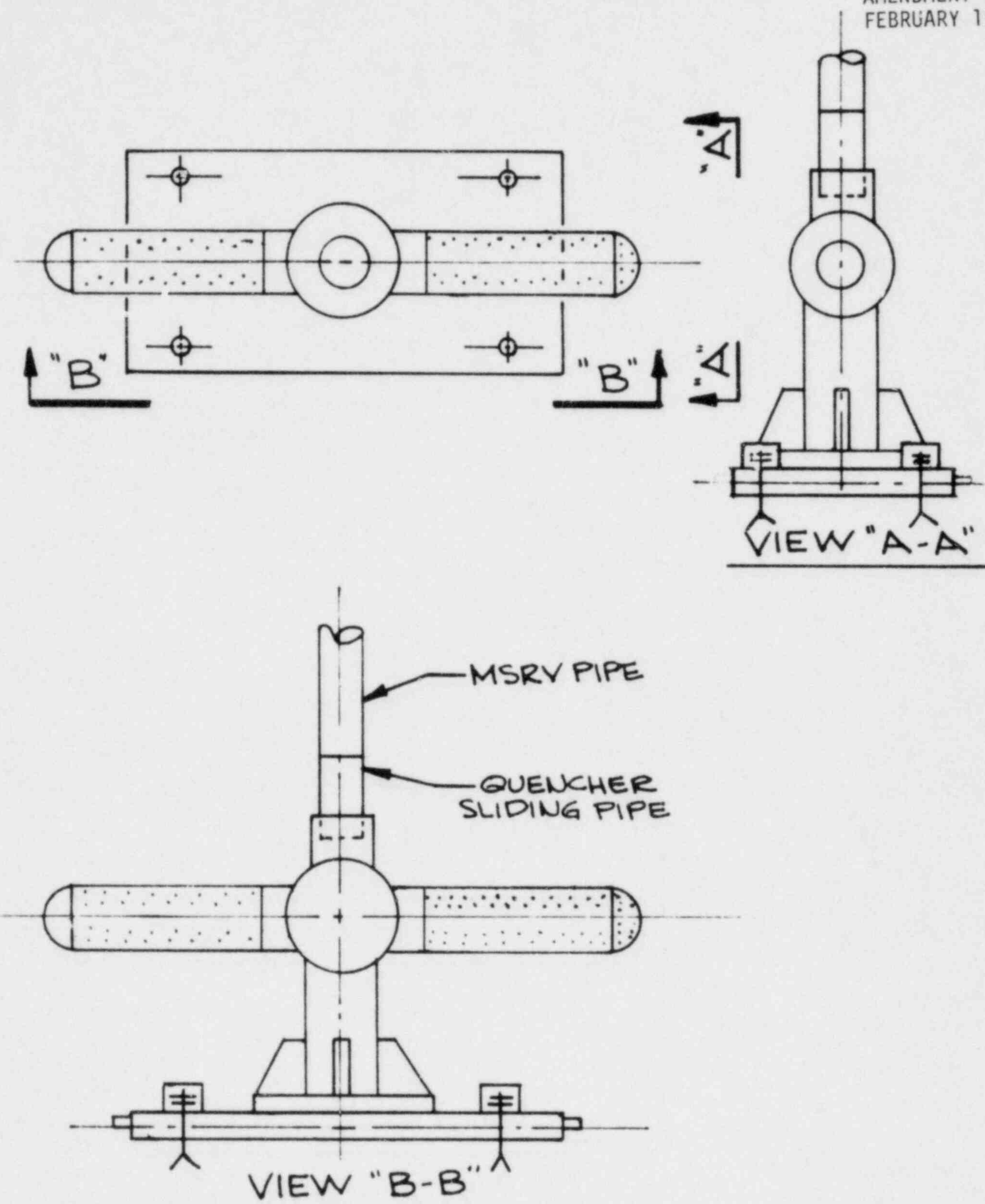

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FIGURE 9.4-1

T-QUENCHER DISCHARGE DEVICE

10.1.2 Structural Conservatism

The margin factors listed in Section 7.0 are conservative for the following reasons:

a. The fact that the instantaneous peak responses induced by loads such as earthquake, SRV discharge, LOCA, etc., do not occur simultaneously at all points along the circumference of the structure was conservatively neglected in the design.

b. The amplified building response spectra for pool dynamic loads were widened by a factor of ± 20% on either side of a peak rather than the conventional ± 15% as per Regulatory Guide 1.22.

c. In load combinations, the effects of individual loads are magnified by a load factor to account for probable overloads.

d. Current ASME Code for the design of concrete containment structures (ACI-359) treats thermal stresses as self-limiting secondary stresses and permits yielding of the reinforcing steel when thermal loads occur in a load combination. However, the structural design criteria for the ZPS-1 containment are very conservative and more stringent than the current practice and do not permit yielding of the reinforcing steel even under thermal loads.

e. Material understrength factors (ϕ-factors) built into the allowable stress criteria will lead to actual safety margins larger than those computed.

10.1.3 Mechanical Conservatisms

10.1.3.1 Conservatisms in BOP Piping Analysis

Conservatisms incorporated in the BOP piping analysis are outlined in the following:

a. The envelope of the $SRV_{ALL}TQ$ and $SRV_{ASY}TQ$ was used for all SRV loads in the load combinations where the $SRV_{ALL}TQ$ load was required.

b. The $SRV_{ALL}TQ$ (all valve discharge) load was used in lieu of the $SRV_{ADS}TQ$ (ADS valve discharge).

c. The condensation oscillation (CO) load used the envelope of both the high mass flux and medium mass flux Zimmer empirical limiting CO load as defined in Chapter 1.0.

d. The CO load combination which included the envelope of both the high mass and medium mass flux Zimmer empirical limiting CO load also included the envelope of $SRV_{ALL}TQ$ and $SRV_{[illegible]}TQ$ and the SSE loads. The Zimmer empirical limiting CO load is defined in Chapter 1.0.

e. The piping stresses and support loads were added by the absolute sum method. Exceptions are noted in the piping stress reports; however, annulus pressurization (AP) and safe-shutdown earthquake (SSE) loads were combined by the square root of the sum of the squares (SRSS) method.

f. The piping subsystem analyses were performed using the enveloped response spectra method.

g. The analyses used the maximum (or design) operating pressure and temperature for all load combinations. The actual pressures and temperatures would be lower if actual plant conditions during a shutdown period were used (e.g., actual RPV pressure and temperatures following an SRV discharge).

h. The minimum valve closure time was used in calculating transient loads.

i. All reactor building restraint loads and piping attached to the outer suppression pool wall near mid-center (excluding instrumentation lines) were increased by a factor of 1.33 or higher times the rams head design load to account for the uncertainties in T-quencher and LOCA loads that had been completely analyzed at the time of reassessment. The majority of restraint loads actually decreased from the rams head load, thus providing a factor greater than 1.33 for those restraints. This is conservative procedure that allows continuation of redesign and reassessment without delaying the project schedule.

j. All instrumentation lines and small-bore piping using a simplified method of dynamic analysis were designed to the envelope of the rams head and T-quencher loads for all response spectra in a particular area.

For example, all response spectra inside the drywell, including the spectra for the RPV, drywell floor, biological shield wall, and containment wall, were

CHAPTER 11.0 - CONCLUSIONS

All suppression pool hydrodynamic loads which have been considered in the final assessment of the Wm. H. Zimmer Nuclear Power Station are identified in this report. The report includes summary descriptions and references appropriate documents for more detailed descriptions of the very conservative forcing functions applied for this final loading assessment. The forcing functions used in the loading assessment include the Mark II containment lead plant information and other information which has been used in response to comments from the NRC staff and consultants. With the information included in or referenced by this report, the NRC staff will have adequate information to determine that suppression pool hydrodynamic loads have been satisfactorily identified, described, and used for the final ZPS-1 assessment.

The forcing functions utilized for loss-of-coolant-accident (LOCA) loads are based primarily on the results of full-scale tests which simulate Mark II containment conditions. In our judgment, the LOCA forcing functions described in this report and used in ZPS-1 design/assessment are conservative and consistent with NRC acceptance requirements.

The forcing functions utilized for loads associated with the operation of the safety/relief valve (SRV) in ZPS-1 design/assessment were those developed for a T-quencher discharge device. The load definition is supported by full-scale, single-cell tests of an actual Mark II quencher and was shown to be conservative. On the basis of these assessments, it is our judgment that ZPS-1 will satisfactorily withstand the loads and load combinations resulting from the T-quencher forcing functions described in this report.

Both sets of forcing functions, LOCA and SRV, included within the Zimmer Empirical Loads, not only meet or exceed DFFR and NUREG-0487 (Lead Plant Acceptance Criteria), but are also conservative in certain areas.

The final ZPS-1 assessment, including suppression pool hydrodynamic loads, has been completed. The assessment was performed, as described in this report, using conservative load combinations, acceptance criteria, and load methodology. Some items have been treated in a more conservative manner for ZPS-1 than established in the dynamic forcing functions report (NEDO-21061) of the Mark II Owners Group or as required by the Lead Plant Acceptance Criteria (NUREG-0487) and its two supplements. Based on the information included in or referenced by this report, the NRC staff will have adequate information to determine that suppression pool hydrodynamic loads have been adequately included in the final design assessment for ZPS-1.

APPENDIX G

SUBMERGED STRUCTURE METHODOLOGY

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loading on the structure. Therefore, only the $SRV_{ALL}TQ$ load was selected. For the governing horizontal loads, the $SRV_{ASY}TQ$ generated bounding spectra over the $SRV_{ALL}TQ$ load. Thus, only the governing $SRV_{ASY}TQ$ was used for the comparative study as the governing horizontal SRV load.

The load combinations considered for the T-quencher loads can be illustrated as follows:

LOAD COMBINATION	ACCEPTANCE CRITERIA
$N+OBE+SRV_{ALL}TQ$	Service Level B
$N+OBE+SRV_{ASY}TQ$	Service Level B

The $SRV_{ALL}TQ$ and $SRV_{ASY}TQ$ loads were evaluated using a 1% damping coefficient.

The SRV T-quencher loads were combined with the seismic (OBE) load by both the absolute sum (ABSUM) and the square root of the sum of the squares (SRSS) method. The results were compared to the SRV rams head load, which used the absolute sum method of combination.

1.2 LEAD PLANT CONDENSATION OSCILLATION (CO) AND CHUGGING LOAD DEFINITIONS BASED ON 4TCO

In order to confirm the adequacy of the Zimmer design basis in light of the results of the Mark II Owners' Group 4TCO test and the Japanese Atomic Energy Resarch Institute (JAERI) Full-Scale Multivent LOCA test, load definitions developed from the 4TCO data and verified as conservative with the available JAERI data were compared to the design basis. These load definitions were generated to permit this assessment and do not alter the Zimmer Design Basis.

1.2.1 Lead Plant (4TCO) Condensation Oscillation Load Definition

The CO load definition developed from the 4TCO data for Lead Plant assessment is fully described in Reference 1. The load definition is a set of pressure time histories which bound all the applicable 4TCO Condensation Oscillation data.

There are two parts of the CO load definition. The first is a load definition which bounds all the 4TCO data taken under blowdown conditions which could be conservatively predicted to occur during a LOCA in the Zimmer station. This load was defined using all the 4TCO Condensation Oscillation data except for a small amount of data taken with a pool temperature well above that which could occur during the CO regime of a LOCA in the Zimmer station.

The maximum applicable temperature for Zimmer under the most conservative conditions is predicted to be less than 135° F during CO. All of the CO data recorded with pool temperatures not exceeding 140° F was used in the definition of the Lead Plant CO Load.

Predictions of the Zimmer LOCA transients were examined to determine the conditions which might exist during the actuation of the Automatic Depressurization System (ADS). This indicated that ADS discharge will not occur coincident with CO loading. However, to ensure conservatism and to be consistent with the Zimmer Empirical Load the predicted conditions corresponding to ADS were expanded and a CO load was defined from the corresponding 4TCO data. This second CO load was used to assess the impact of load combinations including both ADS and CO.

I.2.2 Lead Plant (4TCO) Chugging Load Definition

The lead plant chugging load definition based on the 4TCO chugging data is fully described in Reference 2. The load definition is a set of averaged time histories which conservatively represent the most severe loads anticipated in the Zimmer station.