**Table C.2-1**
**DEFORMATION LIMIT**

| Either One of (Not Both) | | General Limit |
|---|---|---|
| a. $\left[\dfrac{\text{Permissible Deformation, DP}}{\text{Analyzed Deformation Causing Loss of Function, DL}}\right]$ | $\leq$ | $\dfrac{0.9}{SF_{min}}$ |
| b. $\left[\dfrac{\text{Permissible Deformation, DP}}{\text{Experimental Deformation Causing Loss of Function, DE}}\right]$ | $\leq$ | $\dfrac{1.0}{SF_{min}}$ |

where

DP = permissible deformation under stated conditions of normal, upset, emergency, or faulted

DL = analyzed deformation which would cause a system loss of function[(1)]

DE = experimentally determined formation which would cause a system loss of function[(1)]

(1) "Loss of Function" can only be defined quite generally until attention is focused on the component of interest. In cases of interest, where deformation limits can affect the function of equipment and components, they will be specifically delineated. From a practical viewpoint, it is convenient to interchange some deformation condition at which function is assured with the loss of function condition if the required safety margins from the functioning condition can be achieved. Therefore, it is often unnecessary to determine the actual loss of function condition because this interchange procedure produces conservative and safe designs. Examples where deformation limits apply are: control rod drive alignment and clearances for proper insertion, core support deformation causing fuel disarrangement, or excess leakage of any component.

**Table C.2-2**
**PRIMARY STRESS LIMIT**

| Any One of (No More than One Required) | | | General Limit |
|---|---|---|---|
| a. | $\left[\dfrac{\text{Elastic Evaluated Primary Stresses, PE}}{\text{Permissible Primary Stresses, PN}}\right]$ | $\leq$ | $\dfrac{2.25}{SF_{min}}$ |
| b. | $\left[\dfrac{\text{Permissible Load, LP}}{\text{Largest Lower Bound Limit Load, CL}}\right]$ | $\leq$ | $\dfrac{1.5}{SF_{min}}$ |
| c. | $\left[\dfrac{\text{Elastic Evaluated Primary Stress, PE}}{\text{Conventional ultimate strength at Temperature, US}}\right]$ | $\leq$ | $\dfrac{0.75}{SF_{min}}$ |
| d. | $\left[\dfrac{\text{Elastic – Plastic Evaluated Nominal Primary Stress, PE}}{\text{Conventional ultimate strength at Temperature, US}}\right]$ | $\leq$ | $\dfrac{0.9}{SF_{min}}$ |
| e. | $\left[\dfrac{\text{Permissible Load, LP}}{\text{Plastic Instability Load, PL}}\right]$ | $\leq$ | $\dfrac{0.9}{SF_{min}}$ |
| f. | $\left[\dfrac{\text{Permissible Load, LP}}{\text{Ultimate Load From Fracture Analysis, UF}}\right]$ | $\leq$ | $\dfrac{0.9}{SF_{min}}$ |
| g. | $\left[\dfrac{\text{Permissible Load, LP}}{\text{Ultimate Load or Loss of Function Load from Test, LE}}\right]$ | $\leq$ | $\dfrac{1.0}{SF_{min}}$ |

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**Table C.2-2 (continued)**
**PRIMARY STRESS LIMIT**

where

PE = Primary stresses evaluated on an elastic basis. The effective membrane stresses are to be averaged through the load carrying section of interest. The simplest average bending, shear or torsion stress distribution which will support the external loading will be added to membrane stresses at the section of interest.

PN = Permissible primary stress levels under normal or upset conditions under applicable industry code.

LP = Permissible load under stated conditions of emergency or faulted.

CL = Lower bound limit load with yield point equal to 1.5 $S_m$, where $S_m$ is the tabulated value of allowable stress at temperature of the ASME III code or its equivalent. The "lower bound limit load" is here defined as that produced from the analysis of an ideally plastic (nonstrain hardening) material where deformations increase with no further increase in applied load. The lower bound load is one in which the material everywhere satisfies equilibrium and nowhere exceeds the defined material yield strength using either a shear theory or a strain energy of distortion theory to relate multiaxial yielding to the uniaxial case.

US = Conventional ultimate strength at temperature or loading that would cause a system malfunction, whichever is more limiting.

EP = Elastic-plastic evaluated nominal primary stress. Strain hardening of the material may be used for the actual monotonic stress strain curve at the temperature of loading or any approximation to the actual stress strain curve which everywhere has a lower stress for the same strain as the actual monotonic curve may be used. Either the shear or strain energy of distortion flow rule may be used.

PL = Plastic instability load. The "plastic instability load" is defined here as the load at which any load bearing section begins to diminish its cross-sectional area at a faster rate than the strain hardening can accommodate the loss in area. This type analysis requires a true stress-true strain curve or a close approximation based on monotonic loading at the temperature of loading.

**Table C.2-2 (continued)**
**PRIMARY STRESS LIMIT**

UF = Ultimate load from fracture analyses. For components that involve sharp discontinuities (local theoretical stress concentration > 3) the use of a "fracture mechanics" analysis where applicable, utilizing measurements of plain strain fracture toughness may be applied to compute fracture loads. Correction for finite plastic zones and thickness effects as well as gross yielding may be necessary. The methods of linear elastic stress analysis may be used in the fracture analysis where its use is clearly conservative or supported by experimental evidence. Examples where "fracture mechanics" may be applied are for fillet welds or end of fatigue life crack propagation.

LE = Ultimate load or loss of function load as determined from experiment. In using this method account shall be taken of the dimensional tolerances which may exist between the actual part and the tested part or parts as well as differences which may exist in the ultimate tensile strength of the actual part and the tested parts. The guide to be used in each of these areas is that the experimentally determined load shall use adjusted values to account for material properties and dimension variations, each of which has no greater probability than 0.1 of being exceeded in the actual part.

**Table C.2-3**
**BUCKLING STABILITY LIMIT**

| Any One of (no more than one required) | | General Limit |
|---|---|---|
| a. $\left[\dfrac{\text{Permissible Load, LP}}{\text{Code Normal Event Permissible Load, PN}}\right]$ | $\leq$ | $\dfrac{2.25}{SF_{min}}$ |
| b. $\left[\dfrac{\text{Permissible Load, LP}}{\text{Stability Analysis Load, SL}}\right]$ | $\leq$ | $\dfrac{0.9}{SF_{min}}$ |
| c. $\left[\dfrac{\text{Permissible Load, LP}}{\text{Ultimate Buckling Collapse Load from Test, SE}}\right]$ | $\leq$ | $\dfrac{1.0}{SF_{min}}$ |

where:

LP = Permissible load under stated conditions of emergency or faulted.

PN = Applicable code normal event permissible load.

SL = Stability analysis load. The ideal buckling analysis is often sensitive to otherwise minor deviations from ideal geometry and boundary conditions. These effects shall be accounted for in the analysis of the buckling stability loads. Examples of this are ovality in externally pressurized shells or eccentricity of column members.

SE = Ultimate buckling collapse load as determined from experiment. In using this method, account shall be taken of the dimensional tolerances which may exist between the actual part and the tested part. The guide to be used in each of these areas is that the experimentally determined load shall be adjusted to account for material property and dimension variations, each of which has no greater probability than 0.1 of being exceeded in the actual part.

**Table C.2-4**
**FATIGUE LIMIT**

| | | General Limit |
|---|---|---|
| Summation of mean fatigue[(1)] usage including emergency or faulted events with design and operation loads following Miner hypotheses.... either one (not both) | a. Fatigue cycle usage from analysis | ≤ 0.05 |
| | b. Fatigue cycle usage from test | ≤ 0.33 |

(1) Fatigue failure is defined here as a 25% area reduction for a load carrying member which is required to function or excess leakage causing loss of function, whichever is more limiting. In the fatigue evaluation, the methods of linear elastic stress analysis may be used when the $3S_m$ range limit of ASME Code, Section III has been met. If $3S_m$ is not met, account will be taken of (a) increases in local strain concentration, (b) strain ratcheting, and (c) redistribution of strain due to elastic-plastic effects. The January 1969 draft of the USAS B31.7 Piping Code may be used where applicable, or detailed elastic-plastic methods may be used. With elastic-plastic methods, strain hardening may be used not to exceed in stress for the same strain the steady-state cyclic strain hardening measured in a smooth low cycle fatigue specimen at the average temperature of interest.

TABLE C.3-1A

LOAD COMBINATIONS AND ALLOWABLE STRESS CRITERIA FOR CLASS I PIPING AND TUBING

(PIPING OTHER THAN RRS, MS, FW AND CRDH SYSTEMS)[9]

| Plant Conditions Concurrent Loads | Moment Constituents[2] From Load Sources | Equations and Stress Limits | NC-3652[1] Eq. No. |
|---|---|---|---|
| **Design and Normal** | | | |
| Design Pressure + Sustained | $M_A = M(DW)$[10] | $\frac{P D_i^2}{D_o^2 - D_i^2} + \frac{0.75iM_A}{Z} \le S_h$ | (8) |
| **Upset** | | | |
| Max (Peak) Pressure + Sustained + OBE + Fluid Transient | $M_{BU} = M(E1,VT,WH)$[3,6] | $\frac{P_m D_i^2}{D_o^2 - D_i^2} + \frac{0.75i (M_A + M_{BU})}{Z} \le 1.2 S_h$ | (9U) |
| **Emergency** | | | |
| Max (Peak) Pressure + Sustained + Fluid Transient + (DBE or Jet Impingement) | $M_{BE} = M(E2,VT,WH,JI)$[5,6,8,11] | $\frac{P_m D_i^2}{D_o^2 - D_i^2} + \frac{0.75i (M_A + M_{BE})}{Z} \le 1.8 S_h$ | (9E) |

TABLE C.3-1A

LOAD COMBINATIONS AND ALLOWABLE STRESS CRITERIA FOR CLASS I PIPING AND TUBING

(PIPING OTHER THAN RRS, MS, FW AND CRDH SYSTEMS)[9]

| Plant Conditions Concurrent Loads | Moment Constituents[2] From Load Sources | Equations and Stress Limits | NC-3652[1] Eq. No. |
|---|---|---|---|
| **Faulted** | | | |
| (Max (Peak) Pressure + Sustained + DBE + Fluid Transient + Jet Impingement) | $M_{BF} = M(E2,VT,WH,JI)$[6,8] | $\frac{P_m D_i^2}{D_o^2 - D_i^2} + \frac{0.75i\left(M_A + M_{BF}\right)}{Z} \leq 2.4 S_h$ | (9F) |
| **Normal and Upset (Secondary)** | | | |
| Thermal Expansion + Thermal Anchor Movement + Seismic Anchor Movement | $M_C = M(T_i,SD,S1)$[3,4,7] | $\frac{iM_c}{Z} \leq S_A$ | (10) |
| OR | | | |
| Design Pressure + Sustained + Thermal Expansion + Thermal Anchor Movement + Seismic Anchor Movement | | $\frac{P D_i^2}{D_o^2 - D_i^2} + \frac{0.75iM_A}{Z} + \frac{iM_C}{Z} \leq S_A + S_h$ | (11) |
| **Differential Settlement** | | | |
| Differential Settlement | $M_D = M(BS)$ | $\frac{iM_D}{Z} \leq 3S_C$ | |

## TABLE C.3-1B

## LOAD COMBINATIONS AND ALLOWABLE STRESS CRITERIA OF CLASS I PIPING FOR REACTOR RECIRCULATION (RRS) MAIN STEAM (MS) AND FEEDWATER (FW) SYSTEMS[9]

| Plant Conditions Concurrent Loads | Moment Constituents[2] From Load Sources | Equations and Stress Limits | NC-3652[1] Eq. No. |
|---|---|---|---|
| **Design and Normal (Primary)** | | | |
| Design Pressure + Sustained | $M_A = M(DW)$[10] | $\frac{P D_i^2}{D_o^2 - D_i^2} + \frac{0.75iM_A}{Z} \leq S_h$ | (8) |
| **Upset (Primary)** | | | |
| Design Pressure + Sustained + Occasional | $M_{BU} = M(E1,VT,WH)$[3,6] | $\frac{P D_i^2}{D_o^2 - D_i^2} + \frac{0.75i (M_A + M_{BU})}{Z} \leq 1.2 S_h$ | (9U) |
| **Normal (Primary + Secondary)** | | | |
| Design Pressure + Sustained + Thermal Expansion + Thermal Anchor Movement | $M'_C = M(Ti,SD)$ | $\frac{P D_i^2}{D_o^2 - D_i^2} + \frac{0.75i M_A + iM'_C}{Z} \leq S_A + S_h$ | (11) |

TABLE C.3-1B

LOAD COMBINATIONS AND ALLOWABLE STRESS CRITERIA OF CLASS I PIPING FOR REACTOR RECIRCULATION (RRS) MAIN STEAM (MS) AND FEEDWATER (FW) SYSTEMS[9]

| Plant Conditions Concurrent Loads | Moment Constituents[2] From Load Sources | Equations and Stress Limits | NC-3652[1] Eq. No. |
|---|---|---|---|
| **Upset (Primary + Secondary)** | | | |
| Design Pressure + Sustained + Thermal Expansion & Thermal Anchor Movement + OBE + SAM | $M_C = M(Ti,SD,S1)$[3,4,7] | $\frac{PD_i^2}{D_o^2 - D_i^2} + \frac{0.75i\left(M_A + M_{BU}\right) + iM_C}{Z} \le 1.2\left(S_h + S_A\right)$ | (9U+10) |
| **Emergency (Primary)** | | | |
| Design Pressure + Sustained + Fluid Transient + (DBE or Jet Impingement) | $M_{BE} = M(E2,VT,WH,JI)$[5,6,8,11] | $\frac{PD_i^2}{D_o^2 - D_i^2} + \frac{0.75i\left(M_A + M_{BE}\right)}{Z} \le 1.8\ S_h$ | (9E) |
| Max. (Peak) Pressure + Sustained + OBE + Fluid Transient | $M_{BE}' = M(E1,VT,WH)$[6,8] | $\frac{P_m D_i^2}{D_o^2 - D_i^2} + \frac{0.75i\left(M_A + M_{BE}'\right)}{Z} \le 1.5\ S_h$ | (9E)’ |
| Max. (Peak) Pressure + Sustained + Fluid Transient + (DBE or Jet Impingement) | | $\frac{P_m D_i^2}{D_o^2 - D_i^2} + \frac{0.75i\left(M_A + M_{BE}\right)}{Z} \le 2.0\ S_h$ | (9E)” |
| **Faulted Primary** | | | |
| Max (Peak) Pressure + Sustained + Fluid Transient + DBE + Jet Impingement | $M_{BF} = M(VT,E2,WH,JI)$[6,8] | $\frac{P_m D_i^2}{D_o^2 - D_i^2} + \frac{0.75i\left(M_A + M_{BF}\right)}{Z} \le 2.4\ S_h$ | (9F) |

## TABLE C.3-1C

## LOAD COMBINATIONS AND ALLOWABLE STRESS CRITERIA FOR CONTROL ROD DRIVE HYDRAULIC PIPING

| Plant Conditions Concurrent Loads | Moment Constituents[2] From Load Sources | Equations and Stress Limits | NC-3652[1] Eq. No. |
|---|---|---|---|
| **Design and Normal** (Primary) | | | |
| Design Pressure + Sustained | $M_A = M(DW)$[10] | $\frac{PD_i^2}{D_o^2 - D_i^2} + \frac{0.75i\ M_A}{Z} \leq S_h$ | (8) |
| **Upset** (Primary) | | | |
| Max Operating Pressure + Sustained + Occasional | $M_{BU} = M(E1,VT,WH)$[3,6] (9U) | $\frac{P_n D_i^2}{D_o^2 - D_i^2} + \frac{0.75i(M_A + M_{BU})}{Z} \leq 1.2S_h$ | (9U) |
| **Upset** (Primary + Secondary) | | | |
| Max Operating Pressure + Sustained + Normal Scram Thermal Expansion and Anchor Movement + SAM (OBE) | $M_{C1} = M(Ti,SD,S1)$[3,7] | $\frac{iM_{c1}}{Z} \leq S_A$ | (10) |
| | | OR | |
| | | $\frac{P_n\ D_i^2}{D_o^2 - D_i^2} + \frac{0.75i\ M_A + iM_{C1}}{Z} \leq S_A + S_h$ | (11) |

## TABLE C.3-1C

## LOAD COMBINATIONS AND ALLOWABLE STRESS CRITERIA FOR CONTROL ROD DRIVE HYDRAULIC PIPING

| Plant Conditions Concurrent Loads | Moment Constituents[2] From Load Sources | Equations and Stress Limits | NC-3652[1] Eq. No. |
|---|---|---|---|
| Max Operating Pressure + Sustained + Abnormal Scram Thermal Expansion and Anchor Movement | $M_{C2} = M(Ti,SD)$[7] | $\frac{iM_{C2}}{Z} \leq S_A$ OR | (10) |
| | | $\frac{P_n D_i^2}{D_o^2 - D_i^2} + \frac{0.75i\ M_A + iM_{C2}}{Z} \leq S_A + S_h$ | (11) |
| **Emergency** (Primary) | | | |
| Max Operating Pressure + Sustained + Fluid Transient + (SSE or Jet Impingement)[5] | $M_{DE} = M(E2,VT,WH,JI)$[6,8,11] | $\frac{P_n D_i^2}{D_o^2 - D_i^2} + \frac{0.75i\left(M_A + M_{DE}\right)}{Z} \leq 1.8S_h$ | (9E) |
| **Faulted** (Primary) | | | |
| Max Operating Pressure + Sustained + Fluid Transient + SSE + Jet Impingement | $M_{DF} = M(E2,VT,WH,JI)$[6,8] | $\frac{P_n D_i^2}{D_o^2 - D_i^2} + \frac{0.75i\left(M_A + M_{DF}\right)}{Z} \leq 2.4S_h$ | (9F) |

TABLE C.3-1A, 1B, 1C (Cont'd)

Nomenclature

| | | |
|---|---|---|
| P | = | Design Pressure, psi. |
| $P_m$ | = | Max (Peak) Pressure, psi. |
| $P_n$ | = | Maximum operational or scram pressure for the Hydraulic System Pump Pressure for CRDH System only. |
| $D_o$ | = | Outside Pipe Diameter, in. |
| $D_i$ | = | Nominal Inside Pipe Diameter, in. |
| i | = | Stress Intensification Factor from B31.1.0 - 1967. |
| $S_h$ | = | Basic material allowable stress at maximum operating temperature. |
| $S_c$ | = | Basic Material Allowable Stress at Ambient Temperature. |
| $S_A$ | = | Allowable expansion stress defined in B31.1.0 - 1967. |
| U,E,F | = | Added Suffixes for differentiation between Upset, Emergency, and Faulted. |
| Z | = | Pipe section modulus ($in^3$). |
| DW | = | Deadweight. |
| E1 | = | Operating Basis Earthquake (OBE) Inertia Effect. |
| E2 | = | Design Basis Earthquake (DBE) Inertia Effect. |
| WH | = | Steam/Water Hammer. |
| Ti | = | Thermal mode i (i = mode number). |
| SD | = | Thermal Anchor Movements. |
| S1 | = | OBE Seismic Anchor Movements. |
| BS | = | Differential movement between the soil and building structure for buried piping or relative differential building settlement for piping attached to two buildings. |
| VT | = | Valve Thrust (Main Steam Relief Valve Actuation). |
| JI | = | Jet Impingement. |

TABLE C.3-1A, 1B, 1C (Cont'd)

Notes

1. ASME Boiler and Pressure Vessel Code, Section III, Division 1, 1971 edition, through Summer 1973 Addenda and Code Case 1606-1. Material allowables and SIFs from USAS B31.1.0 - 1967

2. The sequence of events, consistent with the system operational requirements, is considered in establishing which load sources are taken as acting concurrently.

3. Seismic anchor movements are included in the evaluation of either equation (9) or equation (10), but need not be included in both.

4. All secondary load sources resulting from plant normal or upset conditions are identified and evaluated for the limiting operating modes of the system. The effects of these load sources are used in evaluating equipment loading, support loading, and type.

5. The largest loads from either DBE or Jet Impingement are used. Jet impingement loading requirements for piping inside and outside of containment are described in Appendix M.

6. If more than one dynamic load source is involved, such as earthquake, valve thrust, and water hammer, the SRSS method will be used to combine resultant moments from individual load sources. In the event that the dynamic load sources are determined to act nonconcurrently, then they can be considered independently.

7. For $M_c$, the effects of Ti and corresponding SD are combined algebraically first, and then combined absolutely with S1.

8. Only inertia term of earthquake effect to be considered.

9. Exceptions from the requirements in Table C.3-1A, -1B, and -1C may be allowed with proper justification and NRC concurrence.

10. Additional stresses caused by hydrostatic testing weight are evaluated when applicable.

11. Fire events are evaluated as separate emergency loading conditions. No dynamic loads are postulated to occur simultaneously with these events. Piping is evaluated for pressure plus deadweight effects of the events.

TABLE C.3-2 

LOAD COMBINATIONS AND ALLOWABLE STRESSES
FOR CLASS I PIPE AND TUBING SUPPORTS

| Support Category | Load Condition | Direction | Design Load Combinations[1,2,9] | Allowable[3] Stresses |
|---|---|---|---|---|
| Linear Type Support | Normal | + | $DW + Ti^{+}$ | 1.0S AISC |
| | | - | $DW + Ti^{-}$ | |
| | Hydrotest | | DW | 1.0S AISC |
| | Upset | + | $DW + Ti^{+}$ + SRSS[$VT^{+}$, $WH^{+}$, E1, S1] | 1.33S AISC[4] |
| | | - | $DW + Ti^{-}$ - SRSS [$VT^{-}$, $WH^{-}$, -E1, -S1] | |
| | Emergency | + | $DW + Ti^{+}$ + SRSS [$VT^{+}$, $WH^{+}$, E2, S2] | 1.5S AISC[4] |
| | | | or | |
| | | | $DW + Ti^{+}$ + SRSS [$VT^{+}$, $WH^{+}$] + $PR^{+}$ | |
| | | | or | |
| | | | $DW + Ti^{+}$ (fire event) | |
| | | - | $DW + Ti^{-}$ - SRSS [$VT^{-}$, $WH^{-}$, -E2, -S2] | |
| | | | or | |
| | | | $DW + Ti^{-}$ - SRSS [$VT^{-}$, $WH^{-}$] + $PR^{-}$ | |
| | | | or | |
| | | | $DW + Ti^{-}$ (fire event) | |
| Faulted | | + | $DW + Ti^{+}$ + SRSS [$VT^{+}$, $WH^{+}$, E2, S2] + $PR^{+}$ | 1.5S AISC[4] |
| | | - | $DW + Ti^{-}$ - SRSS [$VT^{-}$, $WH^{-}$, -E2, -S2] +$PR^{-}$ | |

TABLE C.3-2 (CONTINUED)



| Support Category | Load Condition | Direction | Design Load Combinations[1,2,9] | Allowable[3] Stresses |
|---|---|---|---|---|
| Snubbers | | | | |
| Hydraulic | | | | |
| | Upset | ± | Same as Linear | VLR |
| | Emergency | ± | Same as Linear | 1.2 VLR |
| | Faulted | ± | Same as Linear | 1.2 VLR |
| Mechanical | | | | |
| Pre-NF | Upset | ± | Same as Linear | VLR |
| | Emergency | ± | Same as Linear | The lesser of 1.33 VLR or LCD Level 'C' |
| | Faulted | ± | Same as Linear | The lesser of 1.33 VLR or LCD Level 'C' |
| Post-NF | Upset | ± | Same as Linear | LCD Level 'B' |
| | Emergency | ± | Same as Linear | LCD Level 'C' |
| | Faulted | ± | Same as Linear | LCD Level 'C' |

TABLE C.3-2 (CONTINUED)



| Support Category | Load Condition | Direction | Design Load Combinations[1,2,9] | Allowable Stresses[3,5,6] |
|---|---|---|---|---|
| Standard Support Components | Normal | ± | Same as Linear | $S_{58}$ |
| | Hydrotest | | Same as Linear | $2.0S_{58}$[8] |
| | Upset | ± | Same as Linear | $1.2S_{58}$ |
| | Emergency | ± | Same as Linear | (See Note 7) |
| | Faulted | ± | Same as Linear | (See Note 7) |

TABLE C.3-2 (CONTINUED) 

Notes:

1. Signs for Load Evaluation

   DW - Carries the actual analysis signs.

   Ti - Thermal load shall be evaluated for both hot and cold conditions.

2. Design value for (+) direction is the larger of zero and the value calculated; (-) direction is the smaller of zero and the value calculated.

3. S AISC = The basic allowable stresses defined in Part I of the AISC Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings, November 1978. (Excluding the 1.33 factor).

   $S_{58}$ = The basic allowable load as defined by the vendor in accordance with MSS SP-58, 1967 edition, Pipe Hangers and Supports.

   $F_y$ = The minimum yield stress of support member at elevated sustained temperature (i.e., normal operating temperature exceeds 150°F).

   VLR = The basic load rating supplied by the vendor.

   LCD = Load capacity data sheet as levels supplied by the vendor.

4. Linear Allowables shall not exceed $0.9F_y$ for tension or $0.9F_y/\sqrt{3} = 0.52F_y$ for shear.

5. Load rated allowables established according to ASME section III subsection NF are acceptable using the appropriate load level.

6. Linear support allowables may be used for detailed analysis of standard support components.

TABLE C.3-2 (CONTINUED) 

Notes:

7. Allowable stress shall not exceed the lesser of $2.05_{58}$ or the linear support allowance. However, the lesser shall not exceed available LCD Level 'D' limits.

8. Maximum allowable stress for hydrotest condition shall not exceed $0.8F_y$.

9. SRSS combinations shall be consistent with the provisions of Section C.3.1.2.

Sheet 1

Table C.4-1

REACTOR VESSEL, REACTOR VESSEL INTERNALS AND SUPPORTS
CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES

| Criteria | Loading | Primary Stress Type | Allowable Stress (psi) |
|---|---|---|---|
| Stabilizer Bracket and Adjacent Shell | | | |
| Primary Stress Limit - ASME Boiler and Pressure Vessel Code, Sect. III defines primary membrane plus primary bending stress intensity limit for SA 302 - Gr. B | Normal and upset condition loads<br>1. Operating Basis Earthquake<br>2. Design pressure | Membrane and bending | 40,000 |
| For normal and upset condition<br>Stress limit = 1.5 X 26,700 = 40,000 psi | Emergency condition loads<br>1. Design Basis Earthquake<br>2. Design pressure | Membrane and bending | 60,000 |
| Faulted condition loads<br>For emergency condition<br>Stress limit = 1.5 X 40,000 = 60,000 psi | Membrane and bending<br>1. Design Basis Earthquake<br>2. Jet reaction forces<br>3. Design pressure | | 80,000 |
| For faulted condition<br>Stress limit = 2.0 X 40,000 = 80,000 psi | | | |
| Vessel Support Skirt | | | |
| Primary Stress Limit - ASME Boiler and Pressure Vessel Code, Sect. III defines stress limit for SA 302 Gr. B | Normal and upset condition loads<br>1. Dead weight<br>2. Operating Basis Earthquake | General membrane | 26,700 |
| For normal and upset condition<br>$S_M$ = 26,700 psi | Emergency condition loads<br>1. Dead weight<br>2. Design Basis Earthquake | General membrane | 40,000 |
| For emergency condition<br>$S_{limit}$ = 1.5 $S_M$ = 1.5 X 26,700 = 40,000 psi | Faulted condition loads<br>1. Dead weight<br>2. Design Basis Earthquake<br>3. Jet reaction forces | General membrane | 53,400 |
| For faulted condition<br>$S_{limit}$ = 2.0 $S_M$ = 20 X 26,700 = 53,400 psi | | | |

Table C.4-1 (Continued)

REACTOR VESSEL, REACTOR VESSEL INTERNALS AND SUPPORTS
CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES

| Criteria | Loading | Primary Stress Type | Allowable Stress (psi) |
|---|---|---|---|
| Shroud leg Support | | | |
| Primary Stress Limit - ASME Boiler and Pressure Vessel Code, Sect. III defines allowable primary membrane stress SB-168 material. | Normal and upset condition loads<br>1. Operating Basis Earthquake<br>2. Pressure drop across shroud (normal)<br>3. Subtract dead weight | Tensile | 23,300 |
| 1.<br>For normal and upset condition<br>$S_M$ = 23,300 psi<br><br>For emergency condition<br>$S_{limit} = 1.5\ S_M$<br>= 1.5 X 23,300 = 35,000 psi | Tensile Loads<br>Emergency condition loads<br>1. Design Basis Earthquake<br>2. Pressure drop across shroud (normal)<br>3. Subtract dead weight | Tensile | 35,000 |
| For faulted condition<br>$S_{limit} = 2.0\ S_M$<br>= 2.0 X 23,300 = 46,600 psi | Faulted condition loads<br>1. Design Basis Earthquake<br>2. Pressure drop across shroud during faulted condition<br>3. Subtract dead weight | Tensile | 46,600 |
| 2.<br>For normal and upset condition<br>$S_A = 0.4\ S_y$<br>= 0.4 X 35,000 = 14,000 psi | Compressive Loads<br>Normal and upset condition loads<br>1. Operating Basis Earthquake<br>2. Zero pressure drop across shroud<br>3. Dead weight | Compressive | 14,000 |
| For emergency condition<br>$S_{limit} = 0.6\ S_y$<br>= 0.6 X 35,000 = 21,000 psi | Emergency condition loads<br>1. Design Basis Earthquake<br>2. Subtract operating pressure drop across shroud<br>3. Dead weight | Compressive | 21,000 |
| For faulted condition<br>$S_{limit} = 0.8\ S_y$<br>= 0.8 X 35,000 = 28,000 psi | Faulted condition loads<br>1. Design Basis Earthquake<br>2. Zero pressure drop across shroud<br>3. Dead weight | Compressive | 28,000 |

Sheet 3

Table C.4-1 (Continued)

REACTOR VESSEL, REACTOR VESSEL INTERNALS AND SUPPORTS
CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES

| Criteria | Loading | Primary Stress Type | Allowable Stress (psi) |
|---|---|---|---|
| Top Guide Longest Beam | | | |
| Primary Stress Limit - The allowable primary membrane stress plus bending stress is based on ASME Boiler and Pressure Vessel Code, Sect. III for Type 304 stainless steel plate. | Normal and upset condition loads*<br>1. Operating Basis Earthquake<br>2. Weight of structure | General membrane plus bending | 25,388 |
| For normal and upset condition Stress Intensity<br>$S_A = 1.5\ S_m = 1.5 \times 16.925 = 25{,}388$ psi | Emergency condition loads*<br>1. Design Basis Earthquake<br>2. Weight of structure | General membrane plus bending | 38,081 |
| For emergency condition<br>$S_{limit} = 1.5\ S_A = 1.5 \times 25{,}388 = 38{,}081$ psi | Faulted condition loads*<br>(Same as emergency condition) | General membrane plus bending | 50,775 |
| For faulted condition<br>$S_{limit} = 2S_A = 2 \times 25{,}388 = 50{,}775$ psi | | | |
| Top Guide Beam End Connections | | | |
| Primary Stress Limit - ASME Boiler and Pressure Vessel Code, Sect. III defines material stress limit for Type 304 stainless steel | Normal and upset condition loads*<br>1. Operating Basis Earthquake<br>2. Weight of structure | Pure shear | 10,155 |
| For normal and upset condition Stress Intensity<br>$S_A = 06\ S_m = 0.6 \times 16{,}925 = 10{,}155$ psi | Emergency condition loads*<br>1. Design Basis Earthquake<br>2. Weight of structure | Pure shear | 15,232 |
| For emergency condition<br>$S_{limit} = 1.5\ S_A = 1.5 \times 10{,}155 = 15{,}232$ psi | Faulted condition loads*<br>(Same as emergency condition) | Pure shear | 20,310 |
| For faulted condition<br>$S_{limit} = 2S_A = 2 \times 10{,}155 = 20{,}310$ psi | | | |

*Note: Normal, upset, and accident top guide hydraulic loads are upward. These are not included in the stress analysis since they counteract the effect of the structure weight.

Sheet 4

Table C.4-1 (Continued)

REACTOR VESSEL, REACTOR VESSEL INTERNALS AND SUPPORTS
CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES

| Criteria | Loading | Primary Stress Type | Allowable Stress (psi) |
|---|---|---|---|
| Core support (pre-uprate) | | | |
| Primary Stress Limit - The allowable primary membrane stress plus bending stress is based on ASME Boiler and Pressure Vessel code, Sect. III for Type 304 stainless steel plate | Normal and Upset condition loads<br>1. Normal operation pressure drop<br>2. Operating Basis Earthquake | General membrane plus bending | 25,388 |
| For allowable stress see top guide longest beam above | Emergency condition loads<br>1. Normal operation pressure drop<br>2. Design Basis Earthquake | General membrane plus bending | 38,081 |
| | Faulted condition loads<br>1. Pressure drop after recirculation line rupture<br>2. Design Basis Earthquake | General membrane plus bending | 50,275 |
| Core support (uprate)*<br>For power uprate the allowable differential loading is based on the ratio of applied pressure to buckling pressure. | | | Allowable pressure differential (psid) |
| For normal and upset:<br>allowable ratio = 0.40 | Normal and Upset condition loads<br>1. Normal operation pressure drop<br>2. Operating Basis Earthquake | Buckling | 28.0 |
| For emergency:<br>allowable ratio = 0.60 | Emergency condition loads<br>1. Normal operation pressure drop<br>2. Design Basis Earthquake | Buckling | 42.0 |
| For faulted:<br>allowable ratio = 0.80 | Faulted condition loads<br>1. Pressure drop after main steam line rupture.<br>2. Design Basis Earthquake | Buckling | 56.0 |
| Core Support Aligners | | | Allowable Stress (psi) |
| Primary Stress Limit - ASME Boiler and Pressure Vessel Code, Sect. III defines material stress limit for Type 304 stainless steel | Normal and upset condition load<br>1. Operating Basis Earthquake | Pure shear | 10,155 |
| | Emergency condition load<br>1. Design Basis Earthquake | Pure shear | 15,232 |
| For allowable shear stresses, see top guide beam end connections above | Faulted condition load<br>1. Design Basis Earthquake | Pure shear | 20,310 |

*The component did not change as a result of increasing power but represents the parameters that were reevaluated as part of the power uprate analysis.

Table C.4-1 (Continued)

REACTOR VESSEL, REACTOR VESSEL INTERNALS AND SUPPORTS
CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES

| Criteria | Loading | Primary Stress Type | Moment Limit Accounting for Pressure Loads (in-lb) |
|---|---|---|---|
| Fuel Channels | | | |
| Primary Stress Limit - The allowable $S_m$ for Zircaloy determined according to methods recommended by ASME Boiler and Pressure Vessel Code, Sect. III. Allowable moment determined by calculating limit moment using Table C.2-2 equation (b), then applying $SF_{min}$ for applicable loading conditions. | Normal and Upset condition loads<br>1. Operating Basis Earthquake<br>2. Normal pressure load | Membrane and bending | 28,230 |
| | Emergency condition loads<br>1. Design Basis Earthquake<br>2. Normal pressure load | Membrane and bending | 42,350 |
| | Faulted condition loads<br>1. Design Basis Earthquake<br>2. Loss-of-coolant accident pressure | Membrane and bending | 56,500 |
| ($S_m$ = 9,270 psi, 1.5 $S_m$ = 13,900 psi) | | | |
| Emergency limit load = 1.5 X Normal limit load calculated using 1.5 $S_m$ = $\sigma$ yield | | | |

Table C.4-1 (Continued)

REACTOR VESSEL, REACTOR VESSEL INTERNALS AND SUPPORTS
CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES

| Criteria | Loading | Location | Allowable Stress (psi) |
|---|---|---|---|
| RPV Stabilizer | | | |
| Primary Stress Limit - AISC specification for the construction, fabrication and erection of structural steel for buildings | Upset condition<br>1. Spring preload<br>2. Operating Basis Earthquake | Rod<br>Bracket | 130,000<br>22,000<br>14,000 |
| For normal and upset conditions AISC allowable stresses, but without the usual increase for earthquake loads | Emergency condition<br>1. Spring preload<br>2. Design Basis Earthquake | Bracket | 33,000<br>21,000 |
| For emergency conditions 1.5 X AISC allowable stresses | Faulted condition<br>1. Spring preload<br>2. Design Basis Earthquake<br>3. Jet reaction load | Bracket | 36,000<br>21,500 |
| For faulted conditions Material yield strength | | | |
| RPV Support (Ring Girder) | | | |
| Primary Stress Limit - AISC specification for the design, fabrication and erection of structural steel for buildings | Normal and upset condition<br>1. Dead loads<br>2. Operating Basis Earthquake<br>3. Loads due to scram | Top flange<br><br>Bottom Flange<br>Vessel to girder bolts | 27,000<br><br>27,000<br>60,000<br>22,500 |
| For normal and upset conditions AISC allowable stresses, but without the usual increase for earthquake loads | | | |
| For faulted conditions 1.67 X AISC allowable stresses for structural steel members Yield strength for high strength bolts (vessel to ring girder) | Faulted condition<br>1. Dead loads<br>2. Design Basis Earthquake<br>3. Jet reaction load | Top flange<br>Bottom flange<br>Vessel to girder bolts | 45,000<br>45,000<br>125,000<br>75,000 |

Table C.4-1 (Continued)

REACTOR VESSEL, REACTOR VESSEL INTERNALS AND SUPPORTS
CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES

| Criteria | Loading | Location | Allowable Stress (psi) |
|---|---|---|---|
| CRD Housing Support "Shootout Steel" | | | |
| Primary Stress Limit - AISC specification for the design, fabrication and erection of structural steel for buildings | Faulted Condition loads<br>1. Dead weight<br>2. Impact force from failure of a CRD housing | Beams (top cord)<br><br>Beams (bottom cord) | 33,000<br>33,000<br>33,000<br>33,000 |
| For normal and upset condition<br>$F_a = 0.60\ F_y$ (tension)<br>$F_b = 0.60\ F_y$ (bending)<br>$F_v = 0.40\ F_y$ (shear) | (Dead weights and earthquake loads are very small as compared to jet force.) | Grid structure | 41,500<br>27,500 |
| For faulted conditions<br>$F_a$ limit = 1.5 $F_a$ (tension)<br>$F_b$ limit = 1.5 $F_b$ (bending)<br>$F_v$ limit = 1.5 $F_b$ (shear)<br>$F_y$ = Material yield strength | | | |
| Recirculating Pipe and Pump Pipe Rupture Restraints | | | |
| Primary Stress Limit - Structural Steel: AISC specification for the design, fabrication and erection of structural steel for buildings. | Faulted condition loads<br>1. Jet force from a complete circumferential failure (break) of recirculation line | Brackets on 28 in. pipe<br><br>Cable on pump restraints | 33,000<br><br>99,000 |
| For normal or upset conditions<br>$F_a = 0.60\ F_y$ (tension) | | | |
| For faulted conditions<br>$F_a$ limit = 1.5 $F_a$ (tension)<br>$F_y$ = yield strength<br>Cable (wire rope) | | | |
| For faulted conditions<br>$F_a = 0.80\ F_u$ (tension)<br>$F_u$ = ultimate strength | | | |

Table C.4-1 (Continued)

REACTOR VESSEL, REACTOR VESSEL INTERNALS AND SUPPORTS
CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES

| Criteria | Loading | Location | Allowable Stress (psi) |
|---|---|---|---|
| Control Rod Drive Housing | | | |
| Primary Stress Limit - The allowable primary membrane stress is based on the ASME Boiler and Pressure Vessel Code Sect. III, for Class A vessels for Type 304 stainless steel<br><br>For normal and upset condition<br>$S_m$ = 16,925 psi at 575°F | Normal and upset condition loads<br>1. Design pressure<br>2. Stuck rod scram loads<br>3. Operating Basis Earthquake | Maximum membrane stress intensity occurs at the tube to tube weld near the center of the housing for normal upset and emergency conditions | 16,925 |
| For emergency conditions<br>$S_{limit} = 1.5\ S_m = 1.5 \times 16{,}925 = 25{,}400$ psi | Emergency condition loads<br>1. Design pressure<br>2. Stuck rod scram loads<br>3. Design Basis Earthquake | | 25,100 |
| Control Rod Drive | | | |
| Primary Stress Limit - The allowable primary membrane stress plus bending stress is based on ASME Boiler and Pressure Vessel Code Sect. III for SA-212 TP 316 tubing<br><br>For normal and upset condition<br>$S_A = 1.5\ S_m = 1.5 \times 17.375 = 26{,}060$ psi | Normal and upset condition loads<br>Maximum hydraulic pressure from the control rod drive Supply pump.<br>NOTE - Accident conditions do not increase this loading<br>Earthquake loads are negligible | Maximum stress intensity occurs at a point on the Y-Y axis of the indicator tube | 26,060 |

Table C.4-1 (Continued)

REACTOR VESSEL, REACTOR VESSEL INTERNALS AND SUPPORTS
CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES

| Criteria | Loading | Location | Allowable Stress (psi) | |
|---|---|---|---|---|
| Control Rod Guide Tube (pre-uprate) | | | | |
| Primary Stress Limit - The allowable primary membrane stress plus bending stress is based on the ASME Boiler and Pressure Vessel Code Sect III for Type 304 stainless steel tubing | Faulted condition loads<br>1. Dead weight<br>2. Pressure drop across guide tube due to failure of steam line<br>3. Design Basis Earthquake | The maximum bending stress under faulted loading conditions occurs at the center of the guide tube | 25,400 | |
| For normal and upset conditions<br>$S_m$ = 16,925 psi | | | | |
| For faulted condition<br>$S_{limit}$ = 1.5 $S_m$ = 1.5 X 16,925 - 25,400 | | | | |
| Control Rod Guide Tube (uprate)* | | | Allowable loads (lbs) (vertical) | Pressure differential (psi) |
| The allowable loading is based on the ratio of applied load to bucklling load | Faulted condition loads<br>1. Dead weight<br>2. Pressure drop across guide tube due to failure of steam line<br>3. Design Basis Earthquake | The maximum loading conditions occur at the center of the guide tube length | 35,200 | 84 |
| For normal and upset:<br>allowable ratio = 0.40 | | | | |
| For faulted:<br>allowable ratio = 0.80 | | | | |
| Incore Housing | | | Allowable Stress (psi) | |
| Primary Stress Limit - The allowable primary membrane stress is based on ASME Boiler and Pressure Vessel Code, Sect. III, for Class A vessels for Type 304 stainless steel | Emergency condition loads<br>1. Design pressure<br>2. Design Basis Earthquake | Maximum membrane stress intensity occurs at the outer surface of the vessel penetration | 25,400 | |
| For normal and upset conditions<br>$S_m$ = 16,925 psi at 575°F | | | | |
| For emergency condition (N + $A_M$)<br>$S_{limit}$ = 1.5 $S_m$ = 1.5 X 16,925 = 25,400 psi | | | | |

*The component did not change as a result of increasing power but represents the parameters that were reevaluated as part of the power uprate analysis.

**Table C.4-2**

**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**

**MAIN STEAM ISOLATION VALVES**

| Criteria | Method of Analysis | Minimum Dimension Required |
|---|---|---|
| **1. Body Minimum Wall Thickness**<br><br>Loads:<br><br>Design pressure and temperature<br><br>Primary Membrane Stress Limit:<br><br>S = 7,000 lb/in.$^2$ per ASA B16.5 | Minimum wall thicknesses in the cylindrical portions of the valve shall be calculated using the following formula:<br><br>$t = 1.5\left[\frac{Pd}{2S - 1.2P}\right] + C$<br><br>where:<br>S = allowable stress of 7000 psi<br>P = primary service pressure, 655 psi<br>d = Inside diameter of valve at section being considered, in.<br>C = corrosion allowance of 0.12 in. | Body wall thickness<br><br>t = 1.83 in. at 23-in. diameter |
| **2. Cover Minimum Thickness**<br><br>Loads:<br><br>Design pressure and temperature<br>Design bolting load<br>Gasket load<br><br>Primary Stress Limit:<br><br>Allowable working stress per ASME Section VIII | $t = d\left[\frac{CP}{S} + \frac{1.78 \; Wh_G}{Sd^3}\right]^{1/2} + C_1$<br><br>where:<br>t = minimum thickness, inches<br>d = diameter or short span, in.<br>C = attachment factor<br>S = allowable stress, psi<br>W = total, bolt load, lb<br>$h_G$ = gasket moment arm, in.<br>$C_i$ = corrosion allowance, in. | Valve cover thickness<br><br>t = 4.888 in. |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Main Steam Isolation Valves** (Continued)

| Criteria | Method of Analysis | Allowable Stress or Actual Dimension |
|---|---|---|
| **3. Cover Flange Bolt Area Loads**:<br><br>Loads:<br><br>Design pressure and temperature<br>Gasket load<br>Stem operational load<br>Seismic load-Design Basis Earthquake<br><br>Bolting Stress Limit:<br><br>Allowable working stress per ASME Nuclear Pump & Valve Code, Class I | Total, bolting loads and stresses shall be calculated in accordance with "Rules for Bolted Flange Connections" - ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II, except that the stem operational load and seismic loads shall be included in the total load carried by bolts. The horizontal and vertical seismic forces shall be applied at the mass center of the valve operator assuming that the valve body is rigid and anchored. | Flange Bolt Stress<br><br>S = 30,900 lb/in.$^2$ at 575°F |
| **4. Body Flange Thickness and Stress**<br><br>Loads:<br><br>Design pressure and temperature<br>Gasket load<br>Stem operational load<br>Seismic load - Design Basis Earthquake<br><br>Flange Stress Limits:<br><br>$S_H$, $S_R$, $S_T$<br><br>1.5 $S_m$ per ASME Nuclear Pump and Valve Code, Class I. | Flange thickness and stress shall be calculated in accordance with "Rules for Bolted Flange Connections" = ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II, except that the stem operational load and seismic loads shall be included in the total load carried by the flange. The horizontal and vertical seismic forces shall be applied at the mass center of the valve operator assuming that the valve body is rigid and anchored. | Body Flange Stress<br><br>$S_H$ = 26,700 lb/in.$^2$<br>$S_R$ = 26,700 lb/in.$^2$<br>$S_T$ = 26,700 lb/in.$^2$ |

**Table C.4-2** (Continued)

**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**

**Main Steam Isolation Valves**(Continued)

| **Criteria** | **Method of Analysis** | **Allowable Stress** |
|---|---|---|
| **5. Valve Disc Thickness** | $S_r = S_t = \frac{3(3 + v)PR^2}{8t^2}$ | |
| Loads:<br><br>Design pressure and temperature<br>Primary bending stress limit:<br><br>Allowable working stress per<br>ASME Section VIII | where:<br><br>$S_r$ = radial stress, psi<br>$S_t$ = tangential stress<br>v = Poisson's ratio<br>P = design pressure, psi<br>R = radius of disc, inches<br>t = thickness of disc, inches | S = 17,800 lb/in$^2$ |
| **6. Valve Operator Supports**<br><br>Loads:<br><br>Design pressure and temperature<br>Stem operational load<br>Equipment dead weight<br>Seismic load-Design Basis<br><br>Support Rod Stress Limit:<br><br>Allowable working stress per ASME<br>ASME Section VIII | The valve assembly shall be analyzed assuming that the rigid mass and that the valve body is an anchored, rigid mass and that the specified vertical and horizontal seismic forces are applied at the mass center of the operator assembly, simultaneously with operating pressure plus dead weight plus operational loads. Using these loads, stresses and deflections shall be determined for the operator support components. | S = 18,000 lb/in$^2$ |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Main Steam Safety Valves**

| Criteria | Method of Analysis | Allowable Stress | Minimum Dimension Required |
|---|---|---|---|
| **1. Inlet Nozzle Wall Thickness** | | | |
| Loads:<br>1.1 X Design pressure at 600°F<br>Primary Membrane Stress Limit:<br>Allowable stress intensity as defined by ASME Standard Code for Pumps and Valves for Nuclear Power | $t = \frac{PR}{SE - 0.6P} + C$<br>where:<br>T = min. required thickness, in.<br>S = allowable stress, lb/in.$^2$<br>P = 1.1 X design pressure, lb/in.$^2$<br>R = internal radius, in.<br>E = joint efficiency<br>C = corrosion allowable, in. | | t = 0.183 in. |
| **2. Valve Disc Thickness** | | | |
| Loads:<br>1.1 X Design pressure at 600°F<br>Diagonal Shear Stress Limit:<br>0.6 x allowable stress intensity as defined by ASME Standard Code for Pumps and Valves for Nuclear Power | $Ss = \frac{W}{A} = \frac{PA_1}{A}$<br>where:<br>W = shear load, lb<br>A = shear area, in.$^2$<br>P = 1.1 X design pressure, lb/in.$^2$<br>$A_1$ = disc area, in.2<br>and:<br>A = $\pi$S (R + R$^1$)<br>S = slope of frustrum of shear cone, in.<br>R$^1$ = radius at base of cone, in.<br>R = radius at top of cone, in. | $S_s$= 20,190 lb/in.$^2$ | |
| **3. Inlet Flange Bolt Area** | | | |
| Loads:<br>Design pressure and temperature<br>Gasket load<br>Operational load<br>Design Basis Earthquake<br>Bolting Stress Limit:<br>Allowable stress intensity, $S_m$, as defined by ASME Standard Code for Pumps and Valves for Nuclear Power | Total bolting loads and stresses shall be calculated in accordance with procedures of Para. 1-704.5.1 Flanged Joints, of B31.7 Nuclear Piping Code. | $S_b$ = 27,700 lb/in.$^2$ | |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Main Steam Safety Valves** (Continued)

| | Criteria | Method of Analysis | Allowable Stress |
|---|---|---|---|
| **4.** | **Inlet Flange Thickness**<br><br>Loads:<br><br>Design pressure and temperature<br>Gasket load<br>Operational load<br>Seismic load-Design Basis Earthquake<br><br>Flange Stress Limits:<br><br>$S_H$, $S_R$, $S_T$<br><br>1.5 $S_m$ per ASME Nuclear Pump and Valve Code | Flange thickness and stresses shall be calculated in accordance with procedures of Para. 1-704.5.1 Flanged Joints, of B31.7 Nuclear Piping Code. | $S_H$= 27,300 lb/in.$^2$<br>$S_R$= 27,300 lb/in.$^2$<br>$S_T$= 27,300 lb/in.$^2$ |
| **5.** | **Valve Spring-Torsional Stress**<br><br>Loads:<br><br>$W_1$ = Set point load<br>$W_2$ = Spring load at maximum lift, lb<br><br>Torsional Stress Limit<br><br>0.67 X torsional elastic limit when subjected to a load of $W_1$.<br><br>0.90 X torsional elastic limit when subjected to a load of $W_2$. | $S_{max} = \frac{8PD}{\pi d^3}\frac{4C-1}{4C-4} + \frac{0.615}{C}$<br><br>where:<br>$S_{max}$ = torsional stress, lb/in$^2$<br>P = $W_1$ or $W_2$ = spring load,<br>D = means diameter of coil, in.<br>d = diameter of wire, in.<br>$C = \frac{D}{d}$ = correction factor | Set Point<br><br>S = 82,500 lb/in$^2$<br><br>Maximum Lift<br><br>S = 112,500 lb/in.$^2$ |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Main Steam Safety Valves** (Continued)

| | Criteria | Method of Analysis | Allowable Stress | Minimum Dimension Required |
|---|---|---|---|---|
| **6.** | **Yoke Rod Area** | $A = \frac{F}{2S_m}$ | | |
| | Loads: | where: | | |
| | Spring load at maximum lift | A = required area per rod, in$^2$ | | A = 0.852 in.$^2$ |
| | Primary Stress Limit: | F = total spring load, lb<br>$S_m$ = allowable stress, lb/in.$^2$ | | |
| | Allowable stress intensity, $S_m$, as defined by ASME Standard Code for Pumps and Valves for Nuclear Power. | | | |
| **7.** | **Yoke Bending and Shear Stresses** | $S_b = \frac{M}{Z}, \; S_s = \frac{V}{A}$ | $S_b$ = 18,200 lb/in.$^2$ | |
| | Loads: | where: | $S_s$ = 10,900 lb/in.$^2$ | |
| | Spring load at maximum lift | $S_b$ = bending stress, lb/in.$^2$<br>$S_s$ = shear stress, lb/in.$^2$ | | |
| | Bending and Shear Stress Limits: | M = bending moment, in.-lb<br>Z = section modulus, in.$^3$ | | |
| | Bending-allowable stress intensity, $S_m$, per ASME Nuclear Pump and Valve Code Shear - 0.6 X allowable stress intensity, 0.6 $S_m$, per ASME Nuclear Pump and Valve Code. | V = vertical shear, lb<br>A = shear area, in.$^2$ | | |
| **8.** | **Body Minimum Wall Thickness** | $t = 1.5\left[\frac{Pd}{2S - 1.2P}\right] + C$ | | |
| | Loads: | where:<br>t = required thickness, in | | Body Bowl<br>t = 0.3312 in |
| | Primary service pressure | S = allowable stress, 7,000 lb/in.$^2$<br>P = primary service pressure, 150 lb/in$^2$ | | Inlet Nozzle<br>t = 0.231 in. |
| | Primary Stress Limit: | d = inside diameter of valve at section being considered, in. | | |
| | Allowable stress, 7,000 lb/in$^2$, in accordance with USAS B16.5. | | | Outlet Nozzle<br>t = 0.2823 in. |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Main Steam Safety Valves**

| Criteria | Method of Analysis | Allowable Stress | Load Limit |
|---|---|---|---|
| **9. Inlet Nozzle Combined Stress** | $S = \frac{F_1 + F_2}{A} + \frac{M_1 + M_2}{Z}$ | $S = 27{,}300$ lb/in.$^2$ | |
| Loads:<br>Spring load at maximum lift<br>Operational load<br>Seismic load-Design Basis Earthquake<br><br>Combined Stress Limit:<br><br>1.5 X allowable stress intensity, 1.5 $S_m$, per ASME Code for Pumps and Valves for Nuclear Power. | where:<br>$S$ = combined bending and tensile stress, lb/in.$^2$<br>$F_1$ = maximum spring load, lb<br>$F_2$ = thrust, lb<br><br>$A$ = cross section area of nozzle, in.$^2$<br>$M_1$ = moment resulting from horizontal component of reaction, lb-in.<br>$M_2$ = moment resulting from horizontal seismic force, in.-lb | vertical component of reaction | |
| **10. Spindle Diameter** | $F_c = \frac{\pi^2 EI}{L^2}$ | | Load limit ($0.2F_c$) |
| Loads:<br>Spring load at Maximum lift<br><br>Spindle Column Load Limit:<br><br>0.2 X critical buckling load | where:<br>$F_c$ = critical buckling load, lb<br>$E$ = modulus of elasticity, lb/in.$^2$<br>$I$ = moment of inertia, in.$^4$<br>$L$ = length of spindle in compression, in. | | F = 30,210 lb |
| **11. Spring Washer Shear Area** | $S_s = \frac{F}{A}$ | $S_s = 15{,}960$ lb/in.$^2$ | |
| Loads<br><br>Spring load at maximum lift<br><br>Shear Stress Limit:<br>0.6 X allowable stress intensity, 0.6$S_m$, per ASME Nuclear Pump and Valve Code. | where:<br><br>$S_s$ = shear stress, lb/in.$^2$<br>$F$ = spring load, lb<br>$A$ = shear area, in.$^2$ | | |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Main Steam Relief Valves**

| Criteria | Method of Analysis | Minimum Dimension Required |
|---|---|---|
| **1. Body Minimum Wall Thickness** | $$t = 1.5\left[\frac{PD}{2S - 1\ 2P}\right] + C$$ | Main Body: |
| Loads: | where: | t = 0.625 in. |
| Design pressure and temperature | t = minimum required thickness, in.<br>S = allowable stress, 7,000 lb/in.$^2$ | Bonnet: |
| Primary Membrane Stress Limit: | P = primary service pressure, 655<br>d = inside diameter of valve at section being considered, in. | t = 0.287 in. |
| Allowable working stress as defined by USAS B16.5 (7,000 psi at primary service pressure). | C = corrosion allowance, 0.12 in. | |
| **2. Bonnet Cap and Pilot Base** | | Bonnet Cap: |
| **Minimum Thickness** | $$t = d\left[\frac{CP}{S_m} + \frac{1.78\,WhG}{S_m d^3}\right]^{1/2} + C_1$$ | t = 0.612 in. |
| Loads: | where:<br>t = minimum required thickness, in. | Pilot Base: |
| Design pressure and temperature<br>Gasket load | d = diameter or short span, in.<br>C = attachment factor, ASME Section VIII | t = 2.117 in. |
| Primary Stress Limit: | P = design pressure, lb/in.$^2$<br>$S_m$ = allowable stress, lb/in.$^2$ | |
| Allowable stress intensity, Sm, as defined by ASME Standard Code for Pumps and Valves for Nuclear Power. | W = total bolt load, lb<br>$h_g$ = gasket moment arm, in.<br>$C_1$ = corrosion allowance, 0.12 in. | |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Main Steam Relief Valves** (Continued)

| | Criteria | Method of Analysis | Allowable Stress | Minimum Dimension Required |
|---|---|---|---|---|
| **3.** | **Flange Bolt Area - Inlet Flange, Outlet Flange, Body to Bonnet, Bonnet to Base** | Total bolting loads and stresses shall be calculated in accordance with procedures of Para. 1-704.5.1 Flanged Joints, of B31.7 Nuclear Piping Code | $A_b$ = 10.26 in$^2$ | Body to Base: $A_b$ = 2.854 in.$^2$ |
| | Loads: | | | Bonnet to Cap: |
| | Design pressure and temperature<br>Gasket load<br>Operational load<br>Design Basis Earthquake | | $A_b$ = 1.452 in.$^2$ | $A_b$ = 0.995 in.$^2$ |
| | | | $A_b$ = 13.9 in.$^2$ | Inlet Flange<br>$A_b$ = 6.25 in.$^2$ |
| | Bolting Stress Limit:<br>Allowable stress intensity, $S_m$ as defined by ASME Standard Code for Pumps and Valves for Nuclear Power. | | $A_b$ = 12.2 in$^2$ | Outlet Flange:<br>$A_b$ = 5.5 in.$^2$ |
| **4.** | **Flange Thickness - Inlet, Outlet, Bonnet Flanges** | Flange thickness and stresses shall be calculated in accordance with procedures of Para. 1-704.5.1 Flanged Joints, of B31.7 Nuclear Piping Code | $S_H$ = 26,250 lb/in.$^2$<br>$S_R$ = 26,250 lb/in.$^2$<br>$S_T$ = 26,250 lb/in.$^2$ | |
| | Loads:<br>Design pressure and temperature<br>Gasket load<br>Operational load<br>Design Basis Earthquake | | | |
| | Flange Stress Limits:<br>$S_H$, $S_R$, $S_T$<br>1.5 $S_m$ per ASME Nuclear Pumps and Valve Code. | | | |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Main Steam Relief Valves** (Continued)

| | Criteria | Method of Analysis | Allowable Stress |
|---|---|---|---|
| **5.** | **Valve Disc. Thickness and Stress** | $S_r = S_t = \frac{3(3 + v)\ PR^2}{8t^2}$ | Disc Stress: |
| | Loads:<br>Design pressure and temperature | where:<br>$S_r$ = radial stress, $lb/in^2$<br>$S_t$ = tangential stress, $lb/in^2$ | $S_m$ = 15,800 $lb/in^2$ |
| | Primary Stress Limit: | v = Poisson's ratio<br>P = design pressure, $lb/in^2$ | |
| | Allowable stress intensity, $S_m$ as defined by ASME Standard Code for Pumps and Valve for Nuclear Power. | R = radius of disc, in.<br>t = thickness of disc, in. | |
| | **Inlet Nozzle Diameter Thickness and Stress** | $S = \frac{F_1 + F_2}{A} + \frac{M_1 + M_2}{Z}$ | Inlet Nozzle Stress: |
| | Loads: | where: | S = 26,250 $lb/in^2$ |
| | Design pressure and temperature<br>Operational load<br>Design Basis Earthquake | S = combined bending and tensile stress, $lb/in^2$<br>$F_1$ = vertical load due to design pressure, lb<br>$F_2$ = vertical component of reaction thrust, lb | |
| | Primary Stress Limit: | A = cross section area of nozzle, $in^2$<br>$M_1$ = moment resulting from horizontal reaction, in.-lb | |
| | 1.5 X allowable stress intensity, 1.5 $S_m$ as defined by ASME Standard Code for Pumps and Valves for Nuclear Power. | $M_2$ = moment resulting from horizontal seismic force at mass center of valve, in.-lb | |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Recirculation Pumps**

| | Criteria | Method of Analysis | Allowable Stress | Minimum Dimension Required |
|---|---|---|---|---|
| **1.** | **Casing Minimum Wall Thickness** | | | t = 2.68 in. |
| | Loads: Normal and Upset Condition<br><br>Design pressure and temperature<br><br>Primary Membrane Stress Limit:<br><br>Allowable working stress per ASME Section III, Class C | $t = \frac{PR}{SE-06P} + C$<br>where:<br>t = minimum required thickness, in.<br>P = design pressure, psig<br>R = maximum internal radius, in.<br>S = allowable working stress, psi<br>E = joint efficiency<br>C = corrosion allowance, in. | | |
| **2.** | **Casing Cover Minimum Thickness**<br>Loads: Normal and Upset Condition<br><br>Design pressure and temperature | $S_r = \frac{3W}{4t^2}\left[a^2 - 2b^2 + \frac{b^4(m-1) - 4b^4(m+1)\ln a/b + a^2b^2(m+1)}{a^2(m-1) + b^2(m+1)}\right]$<br>$+ \frac{3W}{2pt^2}\left[1 - \frac{2mb^2 - 2b^2(m+1)\ln a/b}{a^2(m-1) + b^2(m+1)}\right]$ | $S_r$ = 15,075 psi | |
| | Primary Bending Stress Limit:<br><br>1.5 $S_m$ per ASME code for Pumps and Valves for Nuclear Power Class I | $S_t = \frac{3W(m^2-1)}{4mt^2}\left[\frac{a^4 - b^4 - 4a^2b^2\ln a/b}{a^2(m-1) + b^2(m+1)}\right] +$<br>$\frac{3W}{2pmt^2}\left[1 + \frac{ma^2(m-1) - mb^2(m+1) - 2(m^2-1)a^2\ln a/b}{a^2(m-1) + b^2(m+1)}\right]$<br>where:<br>$S_r$ = radial stress at outer edge, psi<br>$S_t$ = tangential stress at inner edge, psi<br>w = pressure load, psi<br>W = uniform load along inner edge, lb<br>t = disc thickness, in.<br>m = reciprocal of Poisson's ratio<br>a = radius of disc, in.<br>b = radius of disc hole, in. | $S_t$ = 15,075 psi | |

Sheet 12

**Table C.4-2 (Continued)**
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Recirculation Pumps** (Continued)

| | Criteria | Method of Analysis | Allowable Stress | Minimum Dimension Required |
|---|---|---|---|---|
| **3.** | **Cover and Seal Flange Bolt Areas** | Bolting loads, areas and stresses shall be calculated in accordance with "Rules for Bolted Flange Connections" - ASME Section VIII, Appendix II | | |
| | Loads: Normal and upset conditions | | 20,000 psi | |
| | Design pressure and temperature<br>Design gasket load | | | |
| | Bolting Stress Limit: | | 20,000 psi | |
| | Allowable working stress per ASME Section III, Class C | | | |
| **4.** | **Cover Clamp Flange Thickness** | Flange thickness and stress shall be calculated in accordance with "Rules for Bolted Flange Connections" -ASME Section VIII, Appendix II | | Flange Thickness 8.9 in. |
| | Loads: Normal and upset condition | | | |
| | Design pressure and temperature<br>Design gasket load<br>Design bolting load | | | |
| | Tangential Flange Stress Limit: | | | |
| | Allowable working stress per ASME Section III, Class C | | | |
| **5.** | **Pump Nozzle Stress** | Pipe Stress is compared to allowable of 0.9 (Yield stress of pump nozzle) | 21,708 psi | |
| | Loads: Normal, Upset and Faulted Condition | | | |

Sheet 13

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Recirculation Pumps** (Continued)

| | Criteria | Method of Analysis | Allowable Stress |
|---|---|---|---|
| **6.** | **Mounting Bracket Combined Stress** | Bracket vertical loads shall be determined | |

| | | |
|---|---|---|
| Loads: | summing the equipment and fluid weights and vertical seismic forces. | Pump Lug |
| Flood weight<br>Design Basis Earthquake | Bracket horizontal loads shall be determined by applying the specified seismic force at mass center of pump-motor assembly (flooded). | 17,280 psi |
| Combined Stress Limit: | Horizontal and vertical loads shall be applied simultaneously to determine | |
| Yield Stress | tensile, shear and bending stresses in the brackets. Tensile shear, and bending stress shall be combined to determine maximum combined stresses. | Motor Lug<br><br>21,000 psi |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Recirculation Pumps** (Continued)

| | Criteria | Method of Analysis | Allowable Stress |
|---|---|---|---|
| **7.** | **Stresses Due to Seismic Loads**<br><br>Loads:<br><br>Operating pressure and temperature<br>Design Basis Earthquake<br><br>Combined Stress Limit:<br><br>Yield stress | The flooded pump-motor assembly shall be analyzed as a free body supported by constant support hangers from the pump brackets. Horizontal and vertical seismic forces shall be applied at mass center of assembly and equilibrium reactions shall be determined for the motor and pump brackets. Load, shear, and moment diagrams shall be constructed using live loads, dead loads, and calculated snubber reactions. Combined bending, tension and shear stresses shall be determined for each major component of the assembly including motor, motor support barrel, bolting and pump casing. The maximum combined tensile stress in the cover bolting shall be calculated using tensile stresses determined from loading diagram plus tensile stress from operating pressure. | Motor Bolt Tensile Stress:<br><br>11,200 psi<br><br>Pump Cover Bolt Tensile Stress:<br><br>32,000 psi<br><br>Motor Support Barrel Combined Stress:<br><br>22,400 psi |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Fuel Storage Racks**

| Criteria | Loading | Location | Allowable Stress |
|---|---|---|---|
| Stresses due to normal, upset, or emergency loading shall not cause the racks to fail so as to result in a critical fuel array | Emergency condition "A" loads<br>1. Dead loads<br>2. Full fuel load in rack<br>3. Design Basis Earthquake | At column to base welds | 11,000 psi(1) |
| | | At base hold down lug (casting) | 20,000 psi(2) |
| Primary Stress Limit-Paper numbers 3341 and 3342, Proceedings of the ASCE, Journal of the Structural Division, December 1962 (task committee on lightweight alloys) (Aluminum) | Emergency condition "B" loads (see below) | | |
| Emergency Conditions<br>Stress limit = yield strength at 0.2% offset. | | | |

(1) Load testing shows that the structure will not yield when subjected to simulated emergency condition "A" loads. Strain gages mounted on the welds show that calculated stresses are conservative.
(2) Calculated stresses compare very well with test results.

Emergency Condition "B"

Loading

In addition to the loading conditions given above, the racks are tested and analyzed to determine their capability to safely withstand the accidental, uncontrolled drop of the fuel grapple from its full retracted position into the weakest portion of the rack.

Method of Analysis

The displacement of the vertical columns at the ends of the racks is determined by considering the effect of the grapple kinetic energy on the upper structure. The energy absorbed shearing the rack longitudinal structural member welds is determined.

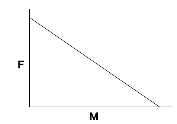
The effect of the remaining energy on the vertical columns is analyzed. Equivalent static load tests are made on the structure to assure that the criteria are met.

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**RHR Pumps**

| Criteria | Method of Analysis | Allowable Stress |
|---|---|---|
| 1. Closure bolting shall be designed to contain the internal design pressure of the pump casing without exceeding the allowable stress of the bolting material. Allowable stresses at design temperature shall be in accordance with ASME Boiler and pressure Vessel Code, Section VIII. | 1. Bolting loads and stresses shall be calculated in accordance with the "Rules for Bolted Flange Connections," ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II.<br><br>Pump Design Pressure 450 psig<br>Maximum Design Temperature 350°F | 25,000 psi |
| 2. The minimum wall thickness of the pump shall limit stress to the allowable stress when subjected to design pressure and temperature. Allowable stresses shall be in accordance with ASME Boiler and Pressure Vessel Code, Section VIII. | 2. Stress in the pump casing shall be calculated at the point of maximum internal pump diameter by the formula<br><br>$S_c = \frac{P(D + 0.2t)}{2t}$<br><br>where<br><br>$S_c$ = calculated stress, psi<br>P = pump design pressure, psi<br>D = maximum pump internal diameter<br>t = actual minimum metal thickness less corrosion allowance, 0.080 in. | 14,000 psi |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**RHR Pumps** (Continued)

| **Criteria** | **Method of Analysis and Allowable Nozzle Loads** |
|---|---|
| 3. Application of forces and moments by attaching pipe on pump nozzles under combined maximum thermal expansion and Operating Basis Earthquake loading reaction plus load due to internal pressure shall not produce an equivalent bending and torsional stress in the nozzles in excess of the allowable stress as defined by the ASME Boiler and Pressure Vessel Code, Section VIII. | 3. Stresses will not be excessive if the maximum resultant force when taken with the maximum resultant moment falls below the line. |
| For Design Basis Earthquake stress shall be less than 1.5 of allowable stress. | |




| Suction | OBE | DBE |
|---|---|---|
| $F_{intercept}$ (M=0) | 88,000 lb | 146,000 lb |
| $M_{intercept}$ (F=0) | 1,200,000 in.-lb | 1,800,000 in.-lb |
| **Discharge** | | |
| $F_{intercept}$ (M=0) | 68,000 lb | 126,000 lb |
| $M_{intercept}$ (F=0) | 760,000 in.-lb | 1,300,000 in.-lb |

Pipe Design Pressure

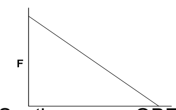
Suction = 150 psig
Discharge = 450 psig

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Core Spray Pumps**

| Criteria | Method of Analysis | Allowable Stress |
|---|---|---|
| 1. Closure bolting shall be designed to contain the internal design pressure of the pump casing without exceeding the allowable stress of the bolting material. Allowable stresses at design temperature shall be in accordance with ASME Boiler and Pressure Vessel Code, Section VIII. | 1. Bolting loads and stresses shall be calculated in accordance with the "Rules for Bolted Flange Connections," ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II.<br><br>Pump Design Pressure 500 psig<br>Maximum Design Temperature 210°F | 20,000 psi |
| 2. The minimum wall thickness of the pump shall limit stress to the allowable stress when subjected to design pressure and temperature. Allowable stresses shall be in accordance with ASME Boiler and Pressure Vessel Code, Section VIII.<br><br>17,500 psi allowable for 216 WCB X 0.8 (quality factor) = 14,000 psi | 2. Stress in the pump casing shall be calculated at the point of maximum internal pump diameter by the formula<br><br>$S_C = \frac{P(D + 0.2t)}{2t}$<br><br>where<br>$S_c$ = calculated stress, psi<br>P = pump design pressure, psi<br>D = maximum pump internal diameter<br>t = actual minimum metal thickness less corrosion allowance, 0.080 in. | 14,000 psi |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Core Spray Pumps** (Continued)

| Criteria | Method of Analysis and Allowable Nozzle Loads | Representative Results |
|---|---|---|
| 3. Application of forces and moments by attaching pipe on pump nozzles under combined maximum thermal expansion Operating Basis Earthquake loading reaction plus load due to internal pressure shall not produce an equivalent bending and torsional stress in the nozzles in excess of the allowable stress as defined by the ASME Boiler and Pressure Vessel Code, Section VIII. | 3. Stresses will not be excessive if the maximum resultant force when taken with the maximum resultant moment falls below the line. | |




| | OBE | DBE |
|---|---|---|
| Suction | | |
| $F_{intercept}$ (M=0) | 66,686 lb | 104,955 lb |
| $M_{intercept}$ (F=0) | 564,193 in.-lb | 880,105 in.-lb |
| Discharge | | |
| $F_{intercept}$ (M=0) | 35,105 lb | 65,982 lb |
| $M_{intercept}$ (F=0) | 266,479 in.-lb | 463,492 in.-lb |

For Design Basis Earthquake stress shall be less than 1.5 of allowable stress.

Pipe Design Pressure

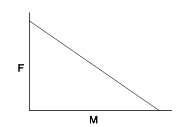
Suction = 125 psig
Discharge = 500 psig

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**HPCI Pumps**

| Criteria | Method of Analysis | Allowable Stress |
|---|---|---|
| 1. Closure bolting shall be designed to contain the internal design pressure of the pump casing without exceeding the allowable stress of the bolting material. Allowable stresses at design temperature shall be in accordance with ASME Boiler and Pressure Vessel Code, Section VIII. | 1. Bolting loads and stresses shall be calculated in accordance with the "Rules for Bolted Flange Connections," ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II.<br><br>Main Pump Design Pressure 1500 psig<br>Boost Pump Design Pressure 450 psig | Main Pump<br>20,000 psi<br>Boost Pump<br>20,000 psi |
| 2. The minimum wall thickness of the pump shall limit stress to the allowable stress when subjected to design pressure and temperature. Allowable stresses shall be in accordance with ASME Boiler and Pressure Vessel Code, Section VIII. | 2. Stress in the pump casing shall be calculated at the point of maximum internal pump diameter by the formula<br><br>$S_h = \frac{P(D + 0.2t)}{2ET}$ | Main Pump<br>14,000 psi |
| The maximum stress in the pump casing when subjected to design pressure shall not exceed the allowable working stress of the material. The allowable stress shall be in accordance with ASME Boiler and Pressure Vessel Code, Section III. | Volute stress shall be calculated by the following formula<br><br>$S_v = \frac{Pb}{2_t}\left[\frac{R + a}{R}\right]$   Roark p. 307 Case 26<br>and R = a - 0.5b | Boost Pump<br>14,000 psi |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**HPCI Pumps** (Continued)

| **Criteria** | **Method of Analysis and Allowable Nozzle Loads** |
|---|---|
| 3. Application of forces and moments by attaching pipe on pump nozzles under combined maximum thermal expansion and Operating Basis Earthquake loading reaction plus load due to internal pressure shall not produce an equivalent bending and torsional stress in the nozzles in excess of the allowable stress as defined by the ASME Boiler and Pressure Vessel Code, Section VIII. | 3. Stresses will not be excessive if the maximum resultant force when taken with the maximum resultant moment falls below the line. |
| For Design Basis Earthquake stress shall be less than 1.5 of allowable stress. | |




| Suction | OBE | DBE |
|---|---|---|
| $F_{intercept}$ (M=0) | 33,000 lb | 43,000 lb |
| $M_{intercept}$ (F=0) | 500,000 in.-lb | 700,000 in.-lb |

| Discharge | OBE | DBE |
|---|---|---|
| $F_{intercept}$ (M=0) | 32,000 lb | 47,000 lb |
| $M_{intercept}$ (F=0) | 250,000 in.-lb | 460,000 in.-lb |

Pipe Design Pressure

Suction = 150 psig

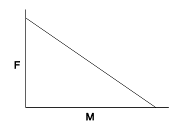
Discharge = 1500 psig

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**RCIC Pump**

| Criteria | Method of Analysis | Allowable Stress |
|---|---|---|
| 1. Closure bolting shall be designed to contain the internal design pressure of the pump casing without exceeding the allowable stress of the bolting material. Allowable stresses at design temperature shall be in accordance with ASME Boiler and Pressure Vessel Code, Section VIII. | 1. Bolting loads and stresses shall be calculated in accordance with the "Rules for Bolted Flange Connections," ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II.<br><br>Pump Design Pressure 1500 psig | 20,000 psi |
| 2. The minimum wall thickness of the pump shall limit stress to the allowable stress when subjected to design pressure and temperature. Allowable stresses shall be in accordance with ASME Boiler and Pressure Vessel Code, Section VIII. | 2. Stress in the pump casing shall be calculated at the point of maximum internal pump diameter by the formula<br><br>$S_c = \frac{P(D+.02t)}{2tE}$<br>$S_c = 0.8Sa$ | 14,000 psi |
| The maximum stress in the pump casing when subjected to design pressure shall not exceed the allowable working stress of the material. The allowable stress shall be in accordance with ASME Boiler and Pressure Vessel Code, Section III. | Volute stress shall be computed by the following formula:<br><br>Roark p. 225 Case No. 36<br><br>$S_b = \beta \frac{P_b^2}{t^2}$<br>$\beta$ = factor from Roark<br>a = volute length<br>b = volute width | 14,000 psi |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**RCIC Pump** (Continued)

| Criteria | Method of Analysis and Allowable Nozzle Loads |
|---|---|
| 3. Application of forces and moments by attaching pipe on pump nozzles under combined maximum thermal expansion and Operating Basis Earthquake loading reaction plus load due to internal pressure shall not produce an equivalent bending and torsional stress in the nozzles in excess of the allowable stress as defined by the ASME Boiler and Pressure Vessel Code, Section VIII. | 3. Stresses will not be excessive if the maximum resultant force when taken with the maximum resultant moment falls below the line. |
| For Design Basis Earthquake stress shall be less than 1.5 of allowable stress. | |




| Suction | OBE | DBE |
|---|---|---|
| $F_{intercept}$ (M=0) | 9,000 lb | 13,500 lb |
| $M_{intercept}$ (F=0) | 54,000 in.-lb | 69,000 in.-lb |

| Discharge | | |
|---|---|---|
| $F_{intercept}$ (M=0) | 9,000 lb | 13,500 lb |
| $M_{intercept}$ (F=0) | 54,000 in.-lb | 69,000 in.-lb |

Pipe Design Pressure

Suction = 150 psig
Discharge = 1500 psig

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Standby Liquid Control Pumps**

| Criteria | Method of Analysis | Allowable Stress |
|---|---|---|
| 1. Closure bolting shall be designed to contain the internal design pressure of the pump without exceeding the allowable working stress of the bolting material. Allowable stresses shall be in accordance with ASME Boiler and Pressure Vessel Code. | 1. Bolting loads and stresses shall be calculated in accordance with the "Rules for Bolted Flange Connections," ACME Boiler and Pressure Vessel Code, Section VIII, Appendix II. | Stuffing Box Bolts<br>25,000 psi<br>Cylinder Head Bolts<br>25,000 psi |
| 2. The maximum stress in the pump fluid cylinder when subjected to design pressure shall not exceed the allowable working stress of the material. The allowable stress shall be in accordance with ASME Boiler and Pressure Vessel Code, Section VIII. | 2. Stress in the pump fluid cylinder shall be calculated at the point of maximum stress by the pressure area method.<br>Pump Design Pressure 1400 psig | 16,500 psi |
| 3. The stresses in the motor mounting bolts when the motor is subjected to the Design Basis Earthquake shall not exceed 0.9 of yield stress and twice the allowable shear stress for bolting material in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII. | 3. The seismic forces acting on the motor to subject the bolting to shear or tension are considered. The motor is isolated from the pump and nozzle forces by the flexible coupling. | Tension<br>16,500 psi<br>Shear<br>10,000 psi |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Standby Liquid Control Pumps** (Continued)

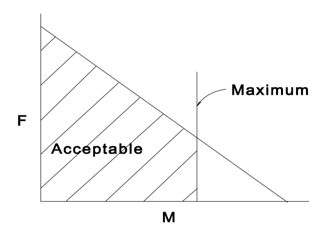
| Criteria | Method of Analysis and Allowable Nozzle Loads |
|---|---|
| 4. The stresses in the pump mounting bolts due to the combination of Operating Basis Earthquake acting on the flooded pump plus the attaching pipe reactions under combined maximum thermal expansion plus Operating Basis Earthquake shall not exceed the allowable shear and tensile stresses for the bolting material in accordance with the ASME Boiler and Pressure Vessel code, Section VIII. The attaching pipe reaction plus the load due to internal pressure shall not produce an equivalent bending and torsional stress in nozzles in excess of the allowable stress.<br><br>The stresses in the pump mounting bolts due to the combination of the Design Basis Earthquake acting on the flooded pump plus the attaching pipe reactions under combined maximum thermal expansion plus Design Basis Earthquake shall not exceed 0.9 times the yield stress in tension and twice the allowable shear stress for the bolting material in accordance with the ASME Boiler and Pressure vessel Code, Section VIII. The attaching pipe reaction plus the load due to internal pressure shall not produce an equivalent bending and torsional stress in nozzles in excess of 1.5 times allowable stress. | 4. The maximum force taken with the maximum resultant moment shall fall below the line on the force-moment diagram:<br><br><br>OBE<br>Discharge M = 2.3 (342-F) not to exceed 283 ft-lb<br>Suction M = 4.59 (711-F) not to exceed 1385 ft-lb<br>DBE<br>Discharge M = 2.3 (684-F) not to exceed 444 ft-lb<br>Suction M = 4.59 (1422-F) not to exceed 2060 ft.lb<br><br>Where M is maximum moment (ft-lb) in any direction and F is maximum force (lb) in any direction. |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**RHR Service Water Pumps A2, A3, B2, B3, C1, C2, C3**

**Criteria**

1. Application of forces and moments by attaching pipe on pump nozzles under combined maximum thermal expansion and Operating Basis Earthquake loading reaction plus load due to internal pressure shall not produce an equivalent bending and torsional stress in the nozzles in excess of the allowable stress as defined b BFN-50-C-7106 Table 3.1-1 for Active Pumps.

**Method of Analysis and Allowable Nozzle Loads**

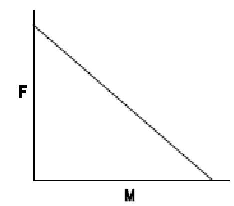
1. Stresses will not be excessive if the loads on the pump nozzles do not exceed the following values:

| Condition | F(Axial) | F(Vertical) | F(Lateral) | M(Torsion) | M(Vertical) | M(Laterial) |
|---|---|---|---|---|---|---|
| Normal | 6,211 lb | 6,888 lb | 3,882 lb | 5,552 ft-lb | 17,499 ft-lb | 10,419 ft-lb |
| Upset | 9,110 lb | 8,970 lb | 5,103lb | 8,790 ft-lb | 19,218 ft-lb | 13,006 ft-lb |
| Emergency | 12,010 lb | 11,052 lb | 6,984 lb | 12,047 ft-lb | 30,527 ft-lb | 15,593 ft-lb |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**RHR Service Water Pumps A1, B1, D1, D2, D3**

| Criteria | Method of Analysis and Allowable Nozzle Loads |
|---|---|
| 1. Application of forces and moments by attaching pipe on pump nozzles under combined maximum thermal expansion and Operating Basis Earthquake loading reaction plus load due to internal pressure shall not produce an equivalent bending and torsional stress in the nozzles in excess of the allowable stress as defined by the ASME Boiler and Pressure Vessel Code, Section VIII. | 1. Stresses will not be excessive if the maximum resultant force when taken with the maximum resultant moment falls below the line. |

Suction




Pump is a vertically mounted deep-well type with submerged suction.

| Discharge | OBE | DBE |
|---|---|---|
| $F_{intercept}$ (M=0) | 45,200 lb | 73,000 ob |
| $M_{intercept}$ (F=0) | 336,000 in.-lb | 536,500 in.-lb |

For Design Basis Earthquake stress shall be less than 1.5 of allowable stress..

Pipe Design Pressure

Discharge = 185 psig

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**RCIC Turbine**

| Criteria | Method of Analysis | Allowable Stress |
|---|---|---|
| 1. Closure bolting shall be designed to contain the internal design pressure of the turbine casing without exceeding the allowable working stress of the bolting material. Allowable stresses shall be in accordance with ASME Boiler and Pressure Vessel Code, Section VIII. | 1. Bolting loads and stresses shall be calculated in accordance with the "Rules for Bolted Flange Connections," ACME Boiler and Pressure Vessel Code, Section VIII, Appendix II. | 20,000 psi |
| 2. The maximum wall thickness of the turbine casing shall be based on that to limit stress to the allowable working stress when subjected to design pressure plus corrosion allowance. Allowable stresses shall be in accordance with ASME Boiler and Pressure Vessel Code, Section VIII. | 2. Stresses in the various pressure containing portions of the turbine casing shall be calculated according to the rules of Part UG, Section VIII, of the ASME Boiler and Pressure Vessel Code. | 17,500 psi |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**RCIC Turbine** (Continued)

| Criteria | Method of Analysis and Allowable Nozzle Loads |
|---|---|
| 3. The forces and moments imposed by the attached piping on the turbine inlet and exhaust connections shall satisfy the following conditions: | 3. The total resultant of the forces and the total resultant of the moments on both the inlet and the exhaust connections of the turbine shall satisfy the following equations: |
| a. The resultant force and moment from the combination of dead weight, and thermal expansion shall be less than that stipulated by the equipment vendor. | For the combination of dead weight and maximum thermal expansion,<br>Inlet F = (2620-M)/3.0<br>Exhaust F = (6000-M)/3.0 |
| b. The resultant force and moment from the combination of dead weight, thermal expansion, and Operating (or Design) Basis Earthquake shall be less than that demonstrated acceptable by detailed seismic analysis of the equipment. | For the combination of dead weight, maximum thermal expansion, and Operating Basis Earth-quake.<br>Inlet F = (3000-M)/2.5<br>Exhaust F = 3.0 (6000-M), but not to exceed 8,370 lb<br><br>For the combination of dead weight, maximum thermal expansion, and Design Basis Earthquake<br>Inlet F = (4500-M)/2.5<br>Exhaust F = 3.0 (9000-M), but not to exceed 12,555 lb<br><br>Where "F" is the resultant force in lb and "M" is the resultant moment in ft-lb<br><br>Typical acceptable area on the force-moment diagram is indicated below: |

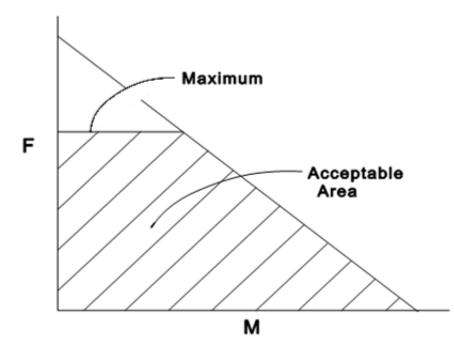


**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**RCIC Turbine** (Continued)

| **Criteria** | **Method of Analysis** |
|---|---|
| 4. The stresses in the turbine anchor bolts (turbine to baseplate) due to the combination of the Operating Basis Earthquake acting on the turbine while running plus the total piping loads (weight, thermal & OBE) shall not exceed the allowable tensile stress nor the allowable shear stress for the bolting materials as specified in the ASME Boiler and Pressure Vessel Code, Section VIII. | 4. Vertical forces on the anchor bolts shall be the sum of the following:<br><br>a. Weight of the turbine assembly times the vertical component of acceleration,<br>b. The vertical pipe force reactions,<br>c. The pipe moment reactions tending to tip the turbine and subject the bolting to tension.<br><br>Horizontal forces on the anchor bolts, subjecting them to shear, shall be the sum of the following:<br><br>a. Weight of the turbine assembly times the horizontal component of acceleration,<br>b. The horizontal pipe force reactions,<br>c. The effect of pipe moment reactions causing horizontal loading at the anchor bolts<br><br>NOTE: Friction shall not be considered to be restrictive |
| 5. The stresses in the turbine anchor bolts (turbine to baseplate) due to the combination of Design Basis Earthquake acting on the turbine in standby plus the total piping loads (weight, thermal, and DBE) shall not exceed 0.9 times the yield stress in tension, nor twice the allowable shear stress for the bolting materials as specified in the ASME Boiler and Pressure Vessel Code, Section VIII. | 5. Same as analysis under 4, above. |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**HPCI Turbine**

| | Criteria | Method of Analysis | Allowable Stress |
|---|---|---|---|
| 1. | Closure bolting shall be designed to contain the internal design pressure of the turbine casing without exceeding the allowable working stress of the bolting material. Allowable stresses shall be in accordance with ASME Boiler and Pressure Vessel code, Section VIII. | 1. Bolting loads and stresses shall be calculated in accordance with the "Rules for Bolted Flange Connections," ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II. | 20,000 psi |
| 2. | The minimum wall thickness of the turbine casing shall be based on that to limit stress to the allowable working stress when subjected to design pressure plus corrosion allowance. Allowable stresses shall be in accordance with ASME Boiler and Pressure Vessel Code, Section VIII. | 2. Stresses in the various pressure containing portions of the turbine casing shall be calculated according to the rules of Part UG, Section VIII, of the ASME Boiler and Pressure Vessel Code. | 17,500 psi |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**HPCI Turbine** (Continued)

| Criteria | Method of Analysis and Allowable Nozzle Loads |
|---|---|
| 3. The forces and moments imposed by the attached piping on the turbine inlet and exhaust connections shall satisfy the the following conditions: | 3. The total resultant of the forces and the total of the moments on both the inlet and connections of the turbine shall satisfy the following equations: |
| a. The resultant force and moment from the combination of dead weight and thermal expansion shall be less than that stipulated by the equipment vendor. | For the combination of dead weight and maximum thermal expansion,<br>Inlet F = (7570-M)/3.0<br>Exhaust F = (9930-M)/3.0 |
| b. The resultant force and moment from the combination of dead weight, thermal expansion, and Operating (or Design) Basis Earthquake shall be less than that demonstrated acceptable by detailed seismic analysis of the equipment | For the combination of dead weight, maximum thermal expansion, and Operating Basis Earthquake<br>Inlet F = (20,000-M)/2.5 but not to exceed 5000 lb<br>Exhaust F = (20,000-M)/0.8, but not to exceed 11,500 lb |
| | For the combination of dead weight, maximum thermal expansion, and Design Basis Earthquake,<br>Inlet F = (30,000-M)/2.5, but not to exceed 17,250 lb<br>Exhaust F = (30,000-M)/0.8, but not to exceed 17,250 lb<br><br>Where "F" is the resultant force in lb and "M" is the resultant moment in ft-lb<br><br>Typical acceptable area on the force-moment diagram is indicated below: |

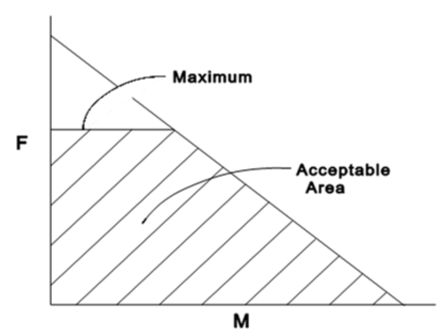


**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**HPCI Turbine** (Continued)

| **Criteria** | **Method of Analysis** |
|---|---|
| 4. The stresses in the turbine anchor bolts (turbine to baseplate) due to the combination of the Operating Basis Earthquake acting on the turbine while running plus the total piping loads (weight, thermal and OBE) shall not exceed the allowable tensile stress nor the allowable shear stress for the bolting materials as specified in the ASME Boiler and Pressure Vessel Code, Section VIII. | 4. Vertical forces on the anchor bolts shall be the sum of the following:<br>a. Weight of the turbine assembly times the vertical component of acceleration,<br>b. The vertical pipe force reactions,<br>c. The pipe moment reactions tending to tip the turbine and subject the bolting to tension.<br><br>Horizontal forces on the anchor bolts, subjecting them to shear, shall be the sum of the following:<br>a. Weight of the turbine assembly times the horizontal component of acceleration,<br>b. The horizontal pipe force reactions,<br>c. The effect of pipe moment reactions causing horizontal loading at the anchor bolts<br><br>NOTE: Friction shall not be considered to be restrictive |
| 5. The stresses in the turbine anchor bolts (turbine to baseplate) due to the combination of Design Basis Earthquake acting on the turbine in standby plus the total piping loads (weight, thermal and OBE) shall not exceed 0.9 times the yield stress in tension, nor twice the allowable shear stress for the bolting materials as specified in the ASME Boiler and Pressure Vessel Code, Section VIII. | 5. Same as analysis under 4, above. |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Recirculation Valves - Units 1 and 2**

| Criteria | Method of Analysis | Allowable Stress | Minimum Dimension Required |
|---|---|---|---|
| 1. Body Minimum Wall In Pipe Run<br><br>2 in. Equalizer Bypass Valve<br>4 in. Discharge Bypass Valve<br>22 in. Equalizer Valve<br>28 in. Suction Valve<br>28 in. Discharge Valve<br><br>Loads:<br><br>Design Pressure<br>Design Temperature<br><br>Primary Membrane Wall Thickness | Codes and Standards<br>1. USAS B31.1.0 1967<br><br>2. Manufacturers Standards Society MSS-SP.66<br><br>$t = \frac{1.5Pd}{2S - 2P(1 - y)} + 0.1$<br>where:<br><br>t = minimum wall thickness, in.<br>P = design pressure, psig<br>d = minimum diameter of flow passage, but not less than 90% of inside diameter at welding end, in.<br>S = allowable working stress, psi<br>y = plastic stress distribution factor, 0.4 | | 2 in. (Equalizer Bypass Valve)<br>t = 0.253 in.<br><br>4 in. (Discharge Bypass Valve)<br>t = 0.405 in.<br><br>22 in. (Equalizer Valve)<br>t = 1.520 in.<br><br>28 in. (Suction Valve)<br>t = 1.938 in.<br><br>28 in (Discharge Valve)<br>t = 1.938 in. |
| 2. Body-to-Bonnet Bolt Area Loads<br><br>2 in. Equalizer Bypass Valve<br>4 in. Discharge Bypass Valve<br><br>Loads:<br><br>Design pressure and temperature<br>Gasket load<br>Stem operational load<br>Design Basis<br>Earthquake | ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II, 1968 Edition.<br><br>Total bolting loads and stresses shall be calculated in accordance with "Rules for Bolted Flange Connections," ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II, except that the stem operational load and seismic loads shall be included in the total load carried by bolts. The horizontal and vertical seismic forces shall be applied at the mass center of the valve operator assuming that the valve body is rigid and anchored. | 2 in. (Equalizer Bypass Valve)<br><br>$S_{allow}$ = 29,000 lb/in.$^2$<br><br>4 in. (Discharge Bypass Valve)<br><br>$S_{allow}$ = 29,000 lb/in.$^2$ | |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Recirculation Valves - Units 1 and 2** (Continued)

| Criteria | Method of Analysis | Allowable Stress |
|---|---|---|
| 3. Flange Stress<br><br>2 in. Equalizer Bypass Valve<br><br>4 in. Discharge Bypass Valve<br><br>Loads:<br><br>Design pressure and temperature<br>Gasket load<br>Stem operational load<br>Seismic load -<br>Design Basis<br>Earthquake | ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II, 1968 Edition.<br><br>Flange thickness and stress shall be calculated in accordance with "Rules for Bolted Flange Connections," ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II, except that the stem operational load and seismic loads shall be included in the total load carried by the flange. The horizontal and vertical seismic forces shall be applied at the mass center of the valve operator assuming that the valve body is rigid. | 2 in. (Equalizer Bypass)<br><br>$S_H$ $S_R$ $S_T$<br><br>20,100 3,426 13,426<br><br>4 in. (Discharge Bypass)<br><br>20,100 13,426 13,426 |
| 4. (A) Body and Bonnet Flange Stress<br><br>(B) Body Neck Wall Stress<br><br>22 in. Equalizer Valves<br>28 in. Suction Valves<br>28 in. Discharge Valves<br><br>Loads:<br><br>Design pressure and<br>Design temperature | ASME Boiler and Pressure Vessel Code, Section III, Article 4<br><br>Primary, secondary, and peak stresses were analyzed in accordance with ASME Section III using finite element computer analysis. The model was verified by strain gage tests | Primary Stresses<br><br>Membrane Stress Allowable = 15,800 psi<br><br>Local Membrane Stress Allowable = 23,700 psi<br>Primary Plus Secondary Stresses<br><br>Code Allowable - $3S_m$ =<br><br>47,400 psi |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Recirculation Valves - Units 1 and 2**

| Criteria | Method of Analysis | Allowable Stress |
|---|---|---|
| 5. Body to Bonnet Bolting<br><br>Loads:<br><br>Design Pressure<br>Design Temperature | | Under operating conditions<br><br>67,000 psi<br><br>Maximum conditions<br>100,500 psi |
| 6. Valve Operator Support Bolting<br><br>2 in Equalizer Bypass Valve<br>4 in. Discharge Bypass Valve<br>22 in. Equalizer Valve<br>28 in. Suction Valve<br>28 in. Discharge Valve<br><br>Loads:<br><br>Design Pressure and Temperature<br>Stem operational load<br>Equipment dead weight<br>Seismic load<br>Design Basis Earthquake | The valve assembly is analyzed assuming that the valve body is an anchored, rigid mass and that the specified vertical and horizontal seismic forces are applied at the mass center of the operator assembly, simultaneously with operating pressure plus dead weight plus operational loads. Using these loads, stresses and deflections are determined for the operator support components. | $S_b$ allowable = 20,000 lb/in.$^2$ |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Recirculation Valves - Unit 3**

| Criteria | Method of Analysis | Allowable Stress | Minimum Required Dimension |
|---|---|---|---|
| **1. Body Minimum Wall In Pipe Run** | | | |
| Loads: | $t = \frac{1.5\ Pd}{2S - 2P(1 - y) + 0.1}$ | | 22 in. Valve - t = 1.52 in.<br>4 in. Valve - t = 0.405 in. |
| Design pressure and temperature<br><br>Primary Membrane Stress Limit:<br><br>Allowable working stress per ASME Section 1 | where:<br>t = minimum wall thickness, in.<br>P = design pressure, psig<br>d = minimum diameter of flow passage but not less than 90% of inside diameter at welding end, in.<br>S = allowable working stress, psi<br>y = plastic stress distribution factor, 0.4 | | 2 in. Valve - t = 0.253 in.<br><br>28 X 24 X 28 in. Valve - t = 1.677 in. (Suction)<br><br>28 X 24 X 28 in. Valve - t = 1.938 in. (Discharge) |
| **2. Body-to-Bonnet Bolt Area** | Total bolting loads and stresses shall be calculated in accordance | Flanged Bolt Stress | |
| Loads:<br><br>Design pressure and temperature<br>Gasket load<br>Stem operational load<br>Seismic load -<br>Design Basis Earthquake<br><br>Bolting Stress Limit:<br><br>Allowable working stress per ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II, 1968 Edition. | with "Rules for Bolted Flange Connections," ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II, except that the stem operational load and seismic loads shall be included in the total load carried by bolts. The horizontal and vertical seismic forces shall be applied at the mass center of the valve operator assuming that the valve body is rigid and anchored. | $S_{allow}$ = 29,000 $lb/in.^2$ | |

**Table C.4-2** (Continued)
**PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES**
**Recirculation Valves - Unit 3** (Continued)

| Criteria | Method of Analysis | Allowable Stress |
|---|---|---|
| **3. Flange Stress**<br><br>Loads:<br><br>Design pressure and temperature<br>Gasket load<br>Stem operational load<br>Seismic Loads -<br>Design Basis<br>Earthquake<br><br>Flange Stress Limits;<br>$S_H, S_R, S_T$:<br>$S_m$ per ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II, 1968 Edition. | Flange thickness, and stress shall be calculated in accordance with "Rules for Bolted Flange Connections"-ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II, except that the stem operational load and seismic loads shall be included in the total load carried by the flange. The horizontal and vertical seismic forces shall be applied at the mass center of the valve operator assuming that the valve body is rigid. | $S_H$: 20,100 lb/in.$^2$ (Hub Stress)<br>$S_R$: 13,426 lb/in.$^2$ (Radial Stress)<br>$S_T$: 13,426 lb/in.$^2$ (Tangential Stress) |
| **4. Valve Operator Support Bolts**<br><br>Loads:<br><br>Design pressure and temperature<br>Stem operational load<br>Equipment dead weight<br>Seismic load -<br>Design Basis<br>Earthquake<br><br>Yoke and Yoke Bolt Stress Limits:<br>Allowable working stress per ASME Section VIII. | The valve assembly is analyzed assuming that the valve body is an anchored, rigid mass and that the specified vertical and horizontal seismic forces are applied at the mass center of the operator assembly, simultaneously with operating pressure plus dead weight plus operational loads. Using these loads, stresses and deflections are determined for the operator support components. | $S_b$ allowable = 20,000 lb/in.$^2$ |

TABLE C.5-1

DRYWELL-LOADING CONDITIONS AND ALLOWABLE STRESSES

| Loading Condition | Loading Components | Allowable Stress Intensity (ksi) (Notes 1 and 2) |
|---|---|---|
| Initial and Final Test Condition | Dead Loads<br>Test Pressure<br>Vent Thrusts<br>OBE | $P_m < S_m = 17.5$<br>$P_L < 1.5\ S_m = 26.3$<br>$P_L + P_b < 1.5\ S_m = 26.3$<br>$P_L + P_b + Q < 3.0\ S_m = 52.5$ |
| Normal and Upset Operating Condition | Dead Loads<br>Vent Thrusts<br>OBE<br>Accident Temperature<br>Accident Pressure | $P_m < S_m = 17.5$<br>$P_L < 1.5\ S_m = 26.3$<br>$P_L + P_b < 1.5\ S_m = 26.3$<br>$P_L + P_b + Q < 3.0\ S_m = 52.5$ |
| Emergency Condition (Note 3) | Dead Loads<br>Accident Pressure<br>Accident Temperature<br>Vent Thrusts<br>OBE<br>Jet Loads | Region not Backed by Concrete<br>$P_m < 0.9\ S_y = 30.3$<br>$P_L < 0.9\ S_y = 30.3$<br><br>Region Backed by Concrete<br>$P_m < S_y = 33.7$<br>$P_L < 1.5S_y = 50.6$ |
| Flooded Condition | Dead Loads<br>Hydrostatic Pressure<br>From Flooded DryWell<br>DBE | $P_m < S_y = 38.0$<br>$P_L < S_y = 38.0$<br>$P_L + P_b < S_u = 70.0$<br>$P_L + P_b + Q < S_u = 70.0$ |

NOTE:

1. Stress intensities are based on ASME Boiler and Pressure Vessel Code, Section III, Subsection B of Reference 17.

2. Definition of symbols are as follows:
   $P_m$ = Primary membrane stress,
   $P_L$ = Primary local membrane stress,
   $P_b$ = Primary bending stress, Q = secondary stress.

3. The 1965 ASME Code does not address accident conditions. Therefore, this design criteria utilizes the 1968 ASME Code with addenda through the summer of 1969 to establish design allowables for the accident condition for that portion of the vessel backed by concrete.