

Table C.2-1
DEFORMATION LIMIT

Either One of (Not Both)

General Limit

$$a. \left[\frac{\text{Permissible Deformation, DP}}{\text{Analyzed Deformation Causing Loss of Function, DL}} \right] \leq \frac{0.9}{SF_{\min}}$$

$$b. \left[\frac{\text{Permissible Deformation, DP}}{\text{Experimental Deformation Causing Loss of Function, DE}} \right] \leq \frac{1.0}{SF_{\min}}$$

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.	$\left[\frac{\text{Elastic Evaluated Primary Stresses, PE}}{\text{Permissible Primary Stresses, PN}} \right]$	$\leq \frac{2.25}{SF_{\min}}$
b.	$\left[\frac{\text{Permissible Load, LP}}{\text{Largest Lower Bound Limit Load, CL}} \right]$	$\leq \frac{1.5}{SF_{\min}}$
c.	$\left[\frac{\text{Elastic Evaluated Primary Stress, PE}}{\text{Conventional ultimate strength at Temperature, US}} \right]$	$\leq \frac{0.75}{SF_{\min}}$
d.	$\left[\frac{\text{Elastic - Plastic Evaluated Nominal Primary Stress, PE}}{\text{Conventional ultimate strength at Temperature, US}} \right]$	$\leq \frac{0.9}{SF_{\min}}$
e.	$\left[\frac{\text{Permissible Load, LP}}{\text{Plastic Instability Load, PL}} \right]$	$\leq \frac{0.9}{SF_{\min}}$
f.	$\left[\frac{\text{Permissible Load, LP}}{\text{Ultimate Load From Fracture Analysis, UF}} \right]$	$\leq \frac{0.9}{SF_{\min}}$
g.	$\left[\frac{\text{Permissible Load, LP}}{\text{Ultimate Load or Loss of Function Load from Test, LE}} \right]$	$\leq \frac{1.0}{SF_{\min}}$

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. $\left[\frac{\text{Permissible Load, LP}}{\text{Code Normal Event Permissible Load, PN}} \right]$	$\leq \frac{2.25}{SF_{\min}}$
b. $\left[\frac{\text{Permissible Load, LP}}{\text{Stability Analysis Load, SL}} \right]$	$\leq \frac{0.9}{SF_{\min}}$
c. $\left[\frac{\text{Permissible Load, LP}}{\text{Ultimate Buckling Collapse Load from Test, SE}} \right]$	$\leq \frac{1.0}{SF_{\min}}$

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

		<u>General Limit</u>
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

<u>Plant Conditions Concurrent Loads</u>	<u>Moment Constituents² From Load Sources</u>	<u>Equations and Stress Limits</u>	<u>NC-3652¹ Eq. No.</u>
<u>Design and Normal</u>			
Design Pressure + Sustained	$M_A = M(DW)^{10}$		
<u>Upset</u>		$\frac{P}{D_o^2 - D_i^2} + \frac{0.75iM_A}{Z} \leq S_h$	(8)
Max (Peak) Pressure + Sustained + OBE + Fluid Transient	$M_{BU} = M(E1, VT, WH)^{3,6}$	$\frac{P_m}{D_o^2 - D_i^2} + \frac{0.75i (M_A + M_{BU})}{Z} \leq 1.2 S_h$	(9U)
<u>Emergency</u>			
Max (Peak) Pressure + Sustained + Fluid Transient + (DBE or Jet Impingement)	$M_{BE} = M(E2, VT, WH, JI)^{5,6,8,11}$	$\frac{P_m}{D_o^2 - D_i^2} + \frac{0.75i (M_A + M_{BE})}{Z} \leq 1.8 S_h$	(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

<u>Plant Conditions Concurrent Loads</u>	<u>Moment Constituents² From Load Sources</u>	<u>Equations and Stress Limits</u>	<u>NC-3652¹ Eq. No.</u>
<u>Faulted</u>			
(Max (Peak) Pressure + Sustained + DBE + Fluid Transient + Jet Impingement)	$M_{BF} = M(E2, VT, WH, JI)^{6,8}$		(9F)
<u>Normal and Upset (Secondary)</u>		$\frac{P_m D_i^2}{D_o^2 - D_i^2} + \frac{0.75i (M_A + M_{BF})}{Z} \leq 2.4 S_h$	
Thermal Expansion + Thermal Anchor Movement + Seismic Anchor Movement	$M_C = M(T_i, SD, S1)^{3,4,7}$		(10)
<u>OR</u>		$\frac{iM_c}{Z} \leq S_A$	
Design Pressure + Sustained + Thermal Expansion + Thermal Anchor Movement + Seismic Anchor Movement			(11)
<u>Differential Settlement</u>		$\frac{P D_i^2}{D_o^2 - D_i^2} + \frac{0.75iM_A}{Z} + \frac{iM_c}{Z} \leq S_A + S_h$	
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) SYSTEMS⁹

<u>Plant Conditions Concurrent Loads</u>	<u>Moment Constituents² From Load Sources</u>	<u>Equations and Stress Limits</u>	NC-3652 ¹ <u>Eq. No.</u>
<u>Design and Normal (Primary)</u>			
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)
<u>Upset (Primary)</u>			
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)
<u>Normal (Primary + Secondary)</u>			
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) SYSTEMS⁹

Plant Conditions Concurrent Loads	Moment Constituents ² From Load Sources	Equations and Stress Limits	NC-3652 ¹ Eq. No.
<u>Upset (Primary + Secondary)</u>			
Design Pressure + Sustained + Thermal Expansion & Thermal Anchor Movement + OBE + SAM	$M_C = M(T_i, SD, S_1)^{3,4,7}$	$\frac{PD_i^2}{D_o^2 - D_i^2} + \frac{0.75i (M_A + M_{BU}) + iM_C}{Z} \leq 12(S_h + S_A)$	(9U+10)
<u>Emergency (Primary)</u>			
Design Pressure + Sustained + Fluid Transient + (DBE or Jet Impingement)	$M_{BE} = M(E2, VT, WH, JI)^{5,6,8,11}$	$\frac{PD_i^2}{D_o^2 - D_i^2} + \frac{0.75i (M_A + M_{BE})}{Z} \leq 18 S_h$	(9E)
Max. (Peak) Pressure + Sustained + OBE + Fluid Transient	$M_{BE}' = M(E1, VT, WH)^{6,8}$	$\frac{P_m D_i^2}{D_o^2 - D_i^2} + \frac{0.75i (M_A + M_{BE}')}{Z} \leq 15 S_h$	(9E)'
Max. (Peak) Pressure + Sustained + Fluid Transient + (DBE or Jet Impingement)		$\frac{P_m D_i^2}{D_o^2 - D_i^2} + \frac{0.75i (M_A + M_{BE})}{Z} \leq 2.0 S_h$	(9E)''
<u>Faulted Primary</u>			
Max (Peak) Pressure + Sustained + Fluid Transient + DBE + Jet Impingement	$M_{BF} = M(VT, E2, WH, JI)^{6,8}$	$\frac{P_m D_i^2}{D_o^2 - D_i^2} + \frac{0.75i (M_A + M_{BF})}{Z} \leq 2.4 S_h$	(9F)

TABLE C.3-1C
LOAD COMBINATIONS AND ALLOWABLE STRESS CRITERIA
FOR CONTROL ROD DRIVE HYDRAULIC PIPING

<u>Plant Conditions</u> <u>Concurrent Loads</u>	<u>Moment Constituents²</u> <u>From Load Sources</u>	<u>Equations and Stress Limits</u>	NC-3652 ¹ <u>Eg. No.</u>
<u>Design and Normal (Primary)</u>			
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)
<u>Upset (Primary)</u>			
Max Operating Pressure + Sustained + Occasional	$M_{BU} = M(E1, VT, WH)^{3,6}$ (9U)	$\frac{PD_i^2}{D_o^2 - D_i^2} + \frac{0.75i(M_A + M_{BU})}{Z} \leq 1.2S_h$	(9U)
<u>Upset (Primary + Secondary)</u>			
Max Operating Pressure + Sustained + Normal Scram Thermal Expansion and Anchor Movement + SAM (OBE)	$M_{C1} = M(Ti, SD, S1)^{3,7}$	OR $\frac{iM_{C1}}{Z} \leq S_A$	(10)
		$\frac{P_n D_i^2}{D_o^2 - D_i^2} + \frac{0.75i M_A + iM_{C1}}{Z} \leq S_A + S_h$	(11)

TABLE C.3-1CLOAD COMBINATIONS AND ALLOWABLE STRESS CRITERIAFOR CONTROL ROD DRIVE HYDRAULIC PIPING

<u>Plant Conditions Concurrent Loads</u>	<u>Moment Constituents² From Load Sources</u>	<u>Equations and Stress Limits</u>	<u>NC-3652¹ Eq. No.</u>
Max Operating Pressure + Sustained + Abnormal Scram Thermal Expansion and Anchor Movement	$M_{C2} = M(Ti, SD)^7$	$\frac{iM_{C2}}{Z} \leq S_A \quad \text{OR}$ $\frac{P_n D_i^2}{D_o^2 - D_i^2} + \frac{0.75i M_A + iM_{C2}}{Z} \leq S_A + S_h$	(10) (11)
<u>Emergency (Primary)</u> Max Operating Pressure + Sustained + Fluid Transient + (SSE or Jet Impingement) ⁵	$M_{DE} = M(E2, VT, WH, JI)^{6,8,11}$	$\frac{P_n D_i^2}{D_o^2 - D_i^2} + \frac{0.75i (M_A + M_{DE})}{Z} \leq 1.8S_h$	(9E)
<u>Faulted (Primary)</u> Max Operating Pressure + Sustained + Fluid Transient + SSE + Jet Impingement	$M_{DF} = M(E2, VT, WH, JI)^{6,8}$	$\frac{P_n D_i^2}{D_o^2 - D_i^2} + \frac{0.75i (M_A + M_{DF})}{Z} \leq 2.4S_h$	(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 T_i and corresponding SD are combined algebraically first, and then combined absolutely with S_1 .
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

<u>Support Category</u>	<u>Load Condition</u>	<u>Direction</u>	<u>Design Load Combinations^{1,2,9}</u>	<u>Allowable³ Stresses</u>
Linear Type Support	Normal	+	$DW + T_i^+$	1.0S AISC
		-	$DW + T_i^-$	
	Hydrotest		DW	1.0S AISC
	Upset	+	$DW + T_i^+ + \text{SRSS}[V_T^+, W_H^+, E1, S1]$	1.33S AISC ⁴
		-	$DW + T_i^- - \text{SRSS}[V_T^-, W_H^-, -E1, -S1]$	
	Emergency	+	$DW + T_i^+ + \text{SRSS}[V_T^+, W_H^+, E2, S2]$	1.5S AISC ⁴
			or	
			$DW + T_i^+ + \text{SRSS}[V_T^+, W_H^+] + PR^+$	
			or	
			$DW + T_i^+ \text{ (fire event)}$	
		-	$DW + T_i^- - \text{SRSS}[V_T^-, W_H^-, -E2, -S2]$	
			or	
			$DW + T_i^- - \text{SRSS}[V_T^-, W_H^-] + PR^-$	
			or	
			$DW + T_i^- \text{ (fire event)}$	
Faulted		+	$DW + T_i^+ + \text{SRSS}[V_T^+, W_H^+, E2, S2] + PR^+$	1.5S AISC ⁴
		-	$DW + T_i^- - \text{SRSS}[V_T^-, W_H^-, -E2, -S2] + PR^-$	

TABLE C.3-2 (CONTINUED)

<u>Support Category</u>	<u>Load Condition</u>	<u>Direction</u>	<u>Design Load Combinations^{1,2,9}</u>	<u>Allowable³ Stresses</u>
<u>Snubbers</u>				
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)

<u>Support Category</u>	<u>Load Condition</u>	<u>Direction</u>	<u>Design Load Combinations</u> ^{1,2,9}	<u>Allowable Stresses</u> ^{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.

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.

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 1. Operating Basis Earthquake 2. Design pressure	Membrane and bending	40,000
For normal and upset condition Stress limit = $1.5 \times 26,700 = 40,000$ psi Faulted condition loads	Emergency condition loads 1. Design Basis Earthquake 2. Design pressure	Membrane and bending	60,000
For emergency condition Stress limit = $1.5 \times 40,000 = 60,000$ psi	Membrane and bending 1. Design Basis Earthquake 2. Jet reaction forces 3. Design pressure		80,000
For faulted condition Stress limit = $2.0 \times 40,000 = 80,000$ 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 1. Dead weight 2. Operating Basis Earthquake	General membrane	26,700
For normal and upset condition $S_M = 26,700$ psi	Emergency condition loads 1. Dead weight 2. Design Basis Earthquake	General membrane	40,000
For emergency condition $S_{limit} = 1.5 S_M = 1.5 \times 26,700 = 40,000$ psi	Faulted condition loads 1. Dead weight 2. Design Basis Earthquake 3. Jet reaction forces	General membrane	53,400
For faulted condition $S_{limit} = 2.0 S_M = 2.0 \times 26,700 = 53,400$ 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 1. Operating Basis Earthquake 2. Pressure drop across shroud (normal) 3. Subtract dead weight	Tensile	23,300
1. For normal and upset condition $S_M = 23,300$ psi For emergency condition $S_{limit} = 1.5 S_M$ $= 1.5 \times 23,300 = 35,000$ psi	Tensile Loads Emergency condition loads 1. Design Basis Earthquake 2. Pressure drop across shroud (normal) 3. Subtract dead weight	Tensile	35,000
For faulted condition $S_{limit} = 2.0 S_M$ $= 2.0 \times 23,300 = 46,600$ psi	Faulted condition loads 1. Design Basis Earthquake 2. Pressure drop across shroud during faulted condition 3. Subtract dead weight	Tensile	46,600
2. For normal and upset condition $S_A = 0.4 S_y$ $= 0.4 \times 35,000 = 14,000$ psi For emergency condition $S_{limit} = 0.6 S_y$ $= 0.6 \times 35,000 = 21,000$ psi	Compressive Loads Normal and upset condition loads 1. Operating Basis Earthquake 2. Zero pressure drop across shroud 3. Dead weight	Compressive	14,000
For faulted condition $S_{limit} = 0.8 S_y$ $= 0.8 \times 35,000 = 28,000$ psi	Emergency condition loads 1. Design Basis Earthquake 2. Subtract operating pressure drop across shroud 3. Dead weight	Compressive	21,000
	Faulted condition loads 1. Design Basis Earthquake 2. Zero pressure drop across shroud 3. Dead weight	Compressive	28,000

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* 1. Operating Basis Earthquake 2. Weight of structure	General membrane plus bending	25,388
For normal and upset condition Stress Intensity $S_A = 1.5 S_m = 1.5 \times 16,925 = 25,388$ psi	Emergency condition loads* 1. Design Basis Earthquake 2. Weight of structure	General membrane plus bending	38,081
For emergency condition $S_{limit} = 1.5 S_A = 1.5 \times 25,388 = 38,081$ psi	Faulted condition loads* (Same as emergency condition)	General membrane plus bending	50,775
For faulted condition $S_{limit} = 2S_A = 2 \times 25,388 = 50,775$ 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* 1. Operating Basis Earthquake 2. Weight of structure	Pure shear	10,155
For normal and upset condition Stress Intensity $S_A = 0.6 S_m = 0.6 \times 16,925 = 10,155$ psi	Emergency condition loads* 1. Design Basis Earthquake 2. Weight of structure	Pure shear	15,232
For emergency condition $S_{limit} = 1.5 S_A = 1.5 \times 10,155 = 15,232$ psi	Faulted condition loads* (Same as emergency condition)	Pure shear	20,310
For faulted condition $S_{limit} = 2S_A = 2 \times 10,155 = 20,310$ 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.

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 1. Normal operation pressure drop 2. Operating Basis Earthquake	General membrane plus bending	25,388
For allowable stress see top guide longest beam above	Emergency condition loads 1. Normal operation pressure drop 2. Design Basis Earthquake	General membrane plus bending	38,081
	Faulted condition loads 1. Pressure drop after recirculation line rupture 2. Design Basis Earthquake	General membrane plus bending	50,275
Core support (uprate)* 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: allowable ratio = 0.40	Normal and Upset condition loads 1. Normal operation pressure drop 2. Operating Basis Earthquake	Buckling	28.0
For emergency: allowable ratio = 0.60	Emergency condition loads 1. Normal operation pressure drop 2. Design Basis Earthquake	Buckling	42.0
For faulted: allowable ratio = 0.80	Faulted condition loads 1. Pressure drop after main steam line rupture. 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 1. Operating Basis Earthquake	Pure shear	10,155
	Emergency condition load 1. Design Basis Earthquake	Pure shear	15,232
For allowable shear stresses, see top guide beam end connections above	Faulted condition load 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 1. Operating Basis Earthquake 2. Normal pressure load	Membrane and bending	28,230
($S_m = 9,270$ psi, $1.5 S_m = 13,900$ psi)	Emergency condition loads 1. Design Basis Earthquake 2. Normal pressure load	Membrane and bending	42,350
Emergency limit load = $1.5 X$ Normal limit load calculated using $1.5 S_m = \sigma$ yield	Faulted condition loads 1. Design Basis Earthquake 2. Loss-of-coolant accident pressure	Membrane and bending	56,500

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 1. Spring preload 2. Operating Basis Earthquake	Rod Bracket	130,000 22,000 14,000
For normal and upset conditions AISC allowable stresses, but without the usual increase for earthquake loads	Emergency condition 1. Spring preload 2. Design Basis Earthquake	Bracket	33,000 21,000
For emergency conditions 1.5 X AISC allowable stresses	Faulted condition 1. Spring preload 2. Design Basis Earthquake 3. Jet reaction load	Bracket	36,000 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 1. Dead loads 2. Operating Basis Earthquake 3. Loads due to scram	Top flange Bottom Flange Vessel to girder bolts	27,000 27,000 60,000 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 1. Dead loads 2. Design Basis Earthquake 3. Jet reaction load	Top flange Bottom flange Vessel to girder bolts	45,000 45,000 125,000 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 1. Dead weight 2. Impact force from failure of a CRD housing	Beams (top cord) Beams (bottom cord)	33,000 33,000 33,000 33,000
For normal and upset condition $F_a = 0.60 F_y$ (tension) $F_b = 0.60 F_y$ (bending) $F_v = 0.40 F_y$ (shear)	(Dead weights and earthquake loads are very small as compared to jet force.)	Grid structure	41,500 27,500
For faulted conditions F_a limit = $1.5 F_a$ (tension) F_b limit = $1.5 F_b$ (bending) F_v limit = $1.5 F_b$ (shear) 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 1. Jet force from a complete circumferential failure (break) of recirculation line	Brackets on 28 in. pipe Cable on pump restraints	33,000 99,000
For normal or upset conditions $F_a = 0.60 F_y$ (tension)			
For faulted conditions F_a limit = $1.5 F_a$ (tension) F_y = yield strength Cable (wire rope)			
For faulted conditions $F_a = 0.80 F_u$ (tension) 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	Normal and upset condition loads 1. Design pressure 2. Stuck rod scram loads 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 normal and upset condition $S_m = 16,925$ psi at 575°F			
For emergency conditions $S_{limit} = 1.5 S_m = 1.5 \times 16,925 = 25,400$ psi	Emergency condition loads 1. Design pressure 2. Stuck rod scram loads 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	Normal and upset condition loads Maximum hydraulic pressure from the control rod drive supply pump. NOTE - Accident conditions do not increase this loading Earthquake loads are negligible	Maximum stress intensity occurs at a point on the Y-Y axis of the indicator tube	26,060
For normal and upset condition $S_A = 1.5 S_m = 1.5 \times 17,375 = 26,060$ psi			

Table C.4-1 (Continued)
 REACTOR VESSEL, REACTOR VESSEL INTERNALS AND SUPPORTS
 CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES

Criteria	Loading	Location	Allowable Stress (psi)	Allowable loads (lbs) (vertical)	Pressure differential (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 1. Dead weight 2. Pressure drop across guide tube due to failure of steam line 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 $S_m = 16,925$ psi					
For faulted condition $S_{limit} = 1.5 S_m = 1.5 \times 16,925 = 25,400$					
Control Rod Guide Tube (uprate)*					
The allowable loading is based on the ratio of applied load to buckling load	Faulted condition loads 1. Dead weight 2. Pressure drop across guide tube due to failure of steam line 3. Design Basis Earthquake	The maximum loading conditions occur at the center of the guide tube length		35,200	84
For normal and upset: allowable ratio = 0.40					
For faulted: allowable ratio = 0.80					
Incore Housing					
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 1. Design pressure 2. Design Basis Earthquake	Maximum membrane stress intensity occurs at the outer surface of the vessel penetration	25,400		
For normal and upset conditions $S_m = 16,925$ psi at 575°F					
For emergency condition ($N + A_m$) $S_{limit} = 1.5 S_m = 1.5 \times 16,925 = 25,400$ 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

Method of Analysis

Minimum wall thicknesses in the cylindrical portions of the valve shall be calculated using the following formula:

$$t = 15 \left[\frac{Pd}{2S - 12P} \right] + C$$

where:

- S = allowable stress of 7000 psi
- P = primary service pressure, 655 psi
- d = inside diameter of valve at section being considered, in.
- C = corrosion allowance of 0.12 in.

Minimum Dimension Required

Body wall thickness
t = 1.83 in. at 23-in. diameter

Criteria

1. Body Minimum Wall Thickness

Loads:

Design pressure and temperature

Primary Membrane Stress Limit:

S = 7,000 lb/in.² per ASA B16.5

2. Cover Minimum Thickness

Loads:

Design pressure and temperature

Design bolting load

Gasket load

Primary Stress Limit:

Allowable working stress per ASME Section VIII

Valve cover thickness

t = 4.888 in.

$$t = d \left[\frac{CP}{S} + \frac{178 \text{ } Wh_G}{Sd^3} \right]^{1/2} + C_1$$

where:

- t = minimum thickness, inches
- d = diameter or short span, in.
- C = attachment factor
- S = allowable stress, psi
- W = total, bolt load, lb
- h_G = gasket moment arm, in.
- C₁ = corrosion allowance, 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:		
Loads:	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 $S = 30,900 \text{ lb/in.}^2$ at 575°F
Design pressure and temperature Gasket load Stem operational load Seismic load-Design Basis Earthquake Bolting Stress Limit:		
Allowable working stress per ASME Nuclear Pump & Valve Code, Class I		
4. Body Flange Thickness and Stress		
Loads:	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 $S_H = 26,700 \text{ lb/in.}^2$ $S_R = 26,700 \text{ lb/in.}^2$ $S_T = 26,700 \text{ lb/in.}^2$
Design pressure and temperature Gasket load Stem operational load Seismic load - Design Basis Earthquake		
Flange Stress Limits: S_H, S_R, S_T 1.5 S_m per ASME Nuclear Pump and Valve Code, Class I.		

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	$S_r = S_t = \frac{3(3 + \nu)PR^2}{8t^2}$	
Loads:	where:	S = 17,800 lb/in ²
Design pressure and temperature Primary bending stress limit:	S _r = radial stress, psi S _t = tangential stress ν = Poisson's ratio	
Allowable working stress per ASME Section VIII	P = design pressure, psi R = radius of disc, inches t = thickness of disc, inches	
6. Valve Operator Supports	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
Loads:		
Design pressure and temperature Stem operational load Equipment dead weight Seismic load-Design Basis		
Support Rod Stress Limit:		
Allowable working stress per ASME ASME Section VIII		

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:			t = 0.183 in.
1.1 X Design pressure at 600°F	$t_{\text{where}} = \frac{SE}{\text{min. Required Thickness, in.}}$		
Primary Membrane Stress Limit:	$T = \text{allowable stress, lb/in.}^2$		
Allowable stress intensity as defined by ASME Standard Code for Pumps and Valves for Nuclear Power	$P = 1.1 \text{ X design pressure, lb/in.}^2$ $R = \text{internal radius, in.}$ $E = \text{joint efficiency}$ $C = \text{corrosion allowable, in.}$		
	$\frac{PR}{SE} - \frac{0.6P}{\text{Required Thickness, in.}} + C$		
2. Valve Disc Thickness			
Loads:		$S_s = 20,190 \text{ lb/in.}^2$	
1.1 X Design pressure at 600°F	where: $W = \frac{PA_1}{SS}$		
Diagonal Shear Stress Limit:	$W = \text{shear load, lb}$ $A = \text{shear area, in.}^2$ $P = 1.1 \text{ X design pressure, lb/in.}^2$ $A_1 = \text{disc area, in.}^2$ and: $A = \pi S (R + R^1)$		
0.6 x allowable stress intensity as defined by ASME Standard Code for Pumps and Valves for Nuclear Power	$S = \text{slope of frustum of shear cone, in.}$ $R^1 = \text{radius at base of cone, in.}$ $R = \text{radius at top of cone, in.}$		
3. Inlet Flange Bolt Area			
Loads:	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.	$S_b = 27,700 \text{ lb/in.}^2$	
Design pressure and temperature			
Gasket load			
Operational load			
Design Basis Earthquake			
Bolting Stress Limit:			
Allowable stress intensity, S_m , as defined by ASME Standard Code for Pumps and Valves for Nuclear Power			

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	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.	$S_H = 27,300 \text{ lb/in.}^2$ $S_R = 27,300 \text{ lb/in.}^2$ $S_T = 27,300 \text{ lb/in.}^2$
Loads: Design pressure and temperature Gasket load Operational load Seismic load-Design Basis Earthquake		
Flange Stress Limits: S_H, S_R, S_T		
1.5 S_m per ASME Nuclear Pump and Valve Code		
5. Valve Spring-Torsional Stress	$S_{\max} = \frac{8PD}{\pi d^3} \frac{4C - 1}{4C - 4} + \frac{0.615}{C}$	Set Point
Loads: $W_1 =$ Set point load $W_2 =$ Spring load at maximum lift, lb	where: S_{\max} = torsional stress, lb/in ² P = W_1 or W_2 = spring load, D = means diameter of coil, in. d = diameter of wire, in. $C = \frac{D}{d}$ = correction factor	$S = 82,500 \text{ lb/in.}^2$ Maximum Lift
Torsional Stress Limit		$S = 112,500 \text{ lb/in.}^2$
0.67 X torsional elastic limit when subjected to a load of W_1 .		
0.90 X torsional elastic limit when subjected to a load of W_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			
Loads:	$A = \frac{F}{2S_m}$		
Spring load at maximum lift	where: A = required area per rod, in. ²		A = 0.852 in. ²
Primary Stress Limit:	F = total spring load, lb 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 S _s = shear stress, lb/in. ²		
Bending and Shear Stress Limits:	M = bending moment, in.-lb 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 A = shear area, in. ²		
8. Body Minimum Wall Thickness			
Loads:	$t = 15 \left[\frac{Pd}{2S - 12P} \right] + C$ where: t = required thickness, in. S = allowable stress, 7,000 lb/in. ² P = primary service pressure, 150 lb/in. ² d = inside diameter of valve at section being considered, in.		Body Bowl t = 0.3312 in. Inlet Nozzle t = 0.231 in. Outlet Nozzle t = 0.2823 in.
Primary service pressure			
Primary Stress Limit:			
Allowable stress, 7,000 lb/in. ² , in accordance with USAS B16.5.			

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 Loads: Spring load at maximum lift Operational load Seismic load-Design Basis Earthquake Combined Stress Limit: 1.5 X allowable stress intensity, 1.5 S _m , per ASME Code for Pumps and Valves for Nuclear Power.	$S = \frac{F_1 + F_2}{A} + \frac{M_1 + M_2}{Z}$ <p>where: S = combined bending and tensile stress, lb/in.² F₁ = maximum spring load, lb F₂ = thrust, lb A = cross section area of nozzle, in.² M₁ = moment resulting from horizontal component of reaction, lb-in. M₂ = moment resulting from horizontal seismic force, in.-lb</p>	S = 27,300 lb/in. ² vertical component of reaction	
10. Spindle Diameter	$F_c = \frac{\pi^2 EI}{L^2}$ <p>where: F_c = critical buckling load, lb E = modulus of elasticity, lb/in.² I = moment of inertia, in.⁴ L = length of spindle in compression, in.</p>		Load limit (0.2F _c) F = 30,210 lb
11. Spring Washer Shear Area Loads: Spring load at maximum lift Spindle Column Load Limit: 0.2 X critical buckling load	$S_s = \frac{F}{A}$ <p>where: S_s = shear stress, lb/in.² F = spring load, lb A = shear area, in.²</p>	S _s = 15,960 lb/in. ²	
Shear Stress Limit: 0.6 X allowable stress intensity, 0.6S _m , per ASME Nuclear Pump and Valve Code.			

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	$t = 1.5 \left[\frac{PD}{2S - 1.2P} \right] + C$ <p>where:</p> <p>t = minimum required thickness, in. S = allowable stress, 7,000 lb/in.² P = primary service pressure, 655 d = inside diameter of valve at section being considered, in. C = corrosion allowance, 0.12 in.</p>	Main Body: t = 0.625 in. Bonnet: t = 0.287 in.
2. Bonnet Cap and Pilot Base	$t = d \left[\frac{CP}{S_m} + \frac{1.78 WhG}{S_m d^3} \right]^{1/2} + C_1$ <p>where:</p> <p>t = minimum required thickness, in. d = diameter or short span, in. C = attachment factor, ASME Section VIII P = design pressure, lb/in.² S_m = allowable stress, lb/in.² W = total bolt load, lb h_g = gasket moment arm, in. C₁ = corrosion allowance, 0.12 in.</p>	Bonnet Cap: t = 0.612 in. Pilot Base: t = 2.117 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	$A_b = 10.26 \text{ in.}^2$	Body to Base: $A_b = 2.854 \text{ in.}^2$
Loads: Design pressure and temperature Gasket load Operational load Design Basis Earthquake		$A_b = 1.452 \text{ in.}^2$	Bonnet to Cap: $A_b = 0.995 \text{ in.}^2$
Bolting Stress Limit: Allowable stress intensity, S_m as defined by ASME Standard Code for Pumps and Valves for Nuclear Power.		$A_b = 13.9 \text{ in.}^2$	Inlet Flange $A_b = 6.25 \text{ in.}^2$
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	$A_b = 12.2 \text{ in.}^2$	Outlet Flange: $A_b = 5.5 \text{ in.}^2$
Loads: Design pressure and temperature Gasket load Operational load Design Basis Earthquake		$S_H = 26,250 \text{ lb/in.}^2$ $S_R = 26,250 \text{ lb/in.}^2$ $S_T = 26,250 \text{ lb/in.}^2$	
Flange Stress Limits: S_H, S_R, S_T 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		
Loads: Design pressure and temperature	$S_r = S_t = \frac{3(3 + v) PR^2}{8t^2}$ <p>where: S_r = radial stress, lb/in² S_t = tangential stress, lb/in² v = Poisson's ratio P = design pressure, lb/in² R = radius of disc, in. t = thickness of disc, in.</p>	Disc Stress: $S_m = 15,800 \text{ lb/in}^2$
Primary Stress Limit: Allowable stress intensity, S_m as defined by ASME Standard Code for Pumps and Valve for Nuclear Power.		
Inlet Nozzle Diameter Thickness and Stress	$S = \frac{F_1 + F_2}{A} + \frac{M_1 + M_2}{Z}$	Inlet Nozzle Stress: $S = 26,250 \text{ lb/in}^2$
Loads: Design pressure and temperature Operational load Design Basis Earthquake Primary Stress Limit: 1.5 X allowable stress intensity, 1.5 S_m as defined by ASME Standard Code for Pumps and Valves for Nuclear Power.	where: S = combined bending and tensile stress, lb/in ² F_1 = vertical load due to design pressure, lb F_2 = vertical component of reaction thrust, lb A = cross section area of nozzle, in ² M_1 = moment resulting from horizontal reaction, in.-lb 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 (Continued)

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

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:	
Flood weight	
Design Basis Earthquake	
Combined Stress Limit:	
Yield Stress	
	summing the equipment and fluid weights and vertical seismic forces. Bracket horizontal loads shall be determined by applying the specified seismic force at mass center of pump-motor assembly (flooded). Horizontal and vertical loads shall be applied simultaneously to determine tensile, shear and bending stresses in the brackets. Tensile shear, and bending stress shall be combined to determine maximum combined stresses.
	Pump Lug 17,280 psi
	Motor Lug 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		
Loads:	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: 11,200 psi
Operating pressure and temperature		Pump Cover Bolt Tensile Stress: 32,000 psi
Design Basis Earthquake		Motor Support Barrel Combined Stress: 22,400 psi
Combined Stress Limit:		
Yield stress		

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 1. Dead loads 2. Full fuel load in rack 3. Design Basis Earthquake	At column to base welds At base hold down lug (casting)	11,000 psi ⁽¹⁾ 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 Conditions
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.	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.	Pump Design Pressure 450 psig Maximum Design Temperature 350°F 2. Stress in the pump casing shall be calculated at the point of maximum internal pump diameter by the formula	14,000 psi

$$S_c = \frac{P(D + 0.2t)}{2t}$$

where

- S_c = calculated stress, psi
 P = pump design pressure, psi
 D = maximum pump internal diameter
 t = actual minimum metal thickness less corrosion allowance, 0.080 in.

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

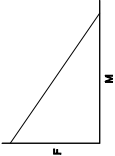
Criteria	Method of Analysis and Allowable Nozzle Loads	
3. Application of forces and moments by attaching pipe on pump nozzles under combined maximum thermal expansion and Operating Basis Earthquake loading reaction plus load due to internal pressure shall not produce an equivalent bending and torsional 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.	
	Suction $F_{Intercept}$	OBE 88,000 lb
		DBE 146,000 lb
		(M=0)
	$M_{Intercept}$	1,200,000 in.-lb
	(F=0)	1,800,000 in.-lb
	Discharge $F_{Intercept}$	68,000 lb
		126,000 lb
		(M=0)
	$M_{Intercept}$	760,000 in.-lb
	(F=0)	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. Pump Design Pressure 500 psig 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.	2. Stress in the pump casing shall be calculated at the point of maximum internal pump diameter by the formula	14,000 psi

$$S_c = \frac{P(D + 0.2t)}{2t}$$

where

- S_c = calculated stress, psi
 P = pump design pressure, psi
 D = maximum pump internal diameter
 t = actual minimum metal thickness less corrosion allowance, 0.080 in.

17,500 psi allowable for 216 WCB X
0.8 (quality factor) = 14,000 psi

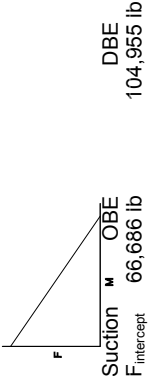
Table C.4-2 (Continued)
PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES
Core Spray Pumps (Continued)

Method of Analysis and Allowable Nozzle Loads

Criteria

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.



(M=0)

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

M_{Intercept} 564,193 in.-lb 880,105 in.-lb

(F=0)

Discharge

F_{Intercept} 35,105 lb 65,982 lb

(M=0)

M_{Intercept} 266,479 in.-lb 463,492 in.-lb

(F=0)

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. Main Pump Design Pressure 1500 psig Boost Pump Design Pressure 450 psig	Main Pump 20,000 psi Boost Pump 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 $S_h = \frac{P(D + 0.2t)}{2ET}$ Volute stress shall be calculated by the following formula $S_v = \frac{P_b}{2t} \left[\frac{R + a}{R} \right]$ and $R = a - 0.5b$	Main Pump 14,000 psi Boost Pump 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.		Roark p. 307 Case 26

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

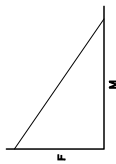
Criteria	Method of Analysis and Allowable Nozzle Loads																																									
3. Application of forces and moments by attaching pipe on pump nozzles under combined maximum thermal expansion and Operating Basis Earthquake loading reaction plus load due to internal pressure shall not 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.	<div>3. Stresses will not be excessive if the maximum resultant force when taken with the maximum resultant moment falls below the line.</div> <div></div> <table><tr><td>Suction</td><td>OBE</td><td>DBE</td></tr><tr><td>$F_{intercept}$</td><td>33,000 lb</td><td>43,000 lb</td></tr><tr><td>$(M=0)$</td><td></td><td></td></tr><tr><td>$M_{intercept}$</td><td>500,000 in.-lb</td><td>700,000 in.-lb</td></tr><tr><td>$(F=0)$</td><td></td><td></td></tr><tr><td colspan="3">Discharge</td></tr><tr><td>$F_{intercept}$</td><td>32,000 lb</td><td>47,000 lb</td></tr><tr><td>$(M=0)$</td><td></td><td></td></tr><tr><td>$M_{intercept}$</td><td>250,000 in.-lb</td><td>460,000 in.-lb</td></tr><tr><td>$(F=0)$</td><td></td><td></td></tr><tr><td colspan="3">Pipe Design Pressure</td></tr><tr><td>Suction</td><td colspan="2">= 150 psig</td></tr><tr><td>Discharge</td><td colspan="2">= 1500 psig</td></tr></table>			Suction	OBE	DBE	$F_{intercept}$	33,000 lb	43,000 lb	$(M=0)$			$M_{intercept}$	500,000 in.-lb	700,000 in.-lb	$(F=0)$			Discharge			$F_{intercept}$	32,000 lb	47,000 lb	$(M=0)$			$M_{intercept}$	250,000 in.-lb	460,000 in.-lb	$(F=0)$			Pipe Design Pressure			Suction	= 150 psig		Discharge	= 1500 psig	
Suction	OBE	DBE																																								
$F_{intercept}$	33,000 lb	43,000 lb																																								
$(M=0)$																																										
$M_{intercept}$	500,000 in.-lb	700,000 in.-lb																																								
$(F=0)$																																										
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Discharge	= 1500 psig																																									
For Design Basis Earthquake stress shall be less than 1.5 of allowable stress.																																										

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. 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 $S_c = \frac{P(D+0.2t)}{2tE}$ $S_c = 0.8S_a$	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: $S_b = \beta \frac{P_b^2}{t^2}$ <p>β = factor from Roark a = volute length b = volute width</p> Roark p. 225 Case No. 36	14,000 psi

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

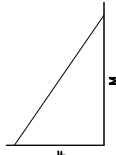
Criteria		Method of Analysis and Allowable Nozzle Loads	
3. Application of forces and moments by attaching pipe on pump nozzles under combined maximum thermal expansion and Operating Basis Earthquake loading reaction plus load due to internal pressure shall not produce an equivalent bending and torsional 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.		
			
	Suction	OBE	DBE
	$F_{\text{intercept}}$	9,000 lb	13,500 lb
For Design Basis Earthquake stress shall be less than 1.5 of allowable stress.	$(M=0)$		
	$M_{\text{intercept}}$	54,000 in.-lb	69,000 in.-lb
	$(F=0)$		
	Discharge		
	$F_{\text{intercept}}$	9,000 lb	13,500 lb
	$(M=0)$		
	$M_{\text{intercept}}$	54,000 in.-lb	69,000 in.-lb
	$(F=0)$		
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 25,000 psi Cylinder Head Bolts 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. 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 16,500 psi Shear 10,000 psi

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

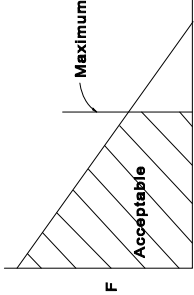
Method of Analysis and Allowable Nozzle Loads

Criteria

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.

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:



OBE
Discharge $M = 2.3 (342\text{-F})$
not to exceed 283 ft-lb

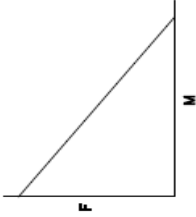
Suction $M = 4.59 (711\text{-F})$
not to exceed 1385 ft-lb
DBE
Discharge $M = 2.3 (684\text{-F})$
not to exceed 444 ft-lb
Suction $M = 4.59 (1422\text{-F})$
not to exceed 2060 ft-lb

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		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 b BFN-50-C-7106 Table 3.1-1 for Active Pumps.	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(Lateral)
		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.			
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.				
		Suction		
		Pump is a vertically mounted deep-well type with submerged suction.		
		Discharge	OBE	DBE
		$F_{\text{intercept}} (M=0)$	45,200 lb	73,000 ob
		$M_{\text{intercept}} (F=0)$	336,000 in.-lb	536,500 in.-lb
		Pipe Design Pressure		
		Discharge = 185 psig		

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

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, Inlet $F = (2620-M)/3.0$ 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 Earthquake. Inlet $F = (3000-M)/2.5$ Exhaust $F = 3.0 (6000-M)$, but not to exceed 8,370 lb
	For the combination of dead weight, maximum thermal expansion, and Design Basis Earthquake Inlet $F = (4500-M)/2.5$ Exhaust $F = 3.0 (9000-M)$, but not to exceed 12,555 lb

Where "F" is the resultant force in lb and "M" is the resultant moment in ft-lb

Typical acceptable area on the force-moment diagram is indicated below:

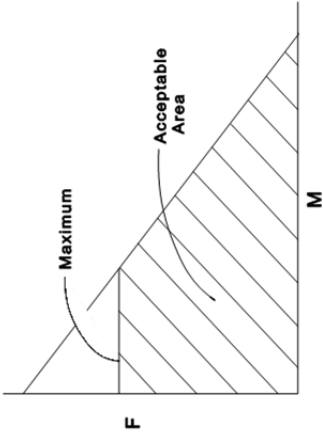


Table C-4-2 (Continued)
PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES
RCIC Turbine (Continued)

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: a. Weight of the turbine assembly times the vertical component of acceleration, b. The vertical pipe force reactions, c. The pipe moment reactions tending to tip the turbine and subject the bolting to tension. Horizontal forces on the anchor bolts, subjecting them to shear, shall be the sum of the following: a. Weight of the turbine assembly times the horizontal component of acceleration, b. The horizontal pipe force reactions, c. The effect of pipe moment reactions causing horizontal loading at the anchor bolts 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

3. The forces and moments imposed by the attached piping on the turbine inlet and exhaust connections shall satisfy the following conditions:
- 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.
 - 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

Method of Analysis and Allowable Nozzle Loads

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:

For the combination of dead weight and maximum thermal expansion,

Inlet	$F = (7570-M)/3.0$
Exhaust	$F = (9930-M)/3.0$

For the combination of dead weight, maximum thermal expansion, and Operating Basis Earthquake

Inlet	$F = (20,000-M)/2.5$ but not to exceed 5000 lb
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,

Inlet	$F = (30,000-M)/2.5$, but not to exceed 17,250 lb
Exhaust	$F = (30,000-M)/0.8$, but not to exceed 17,250 lb

Where "F" is the resultant force in lb and "M" is the resultant moment in ft-lb

Typical acceptable area on the force-moment diagram is indicated below:

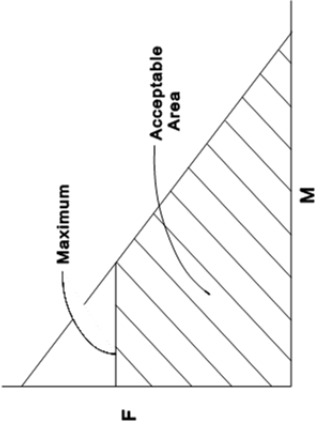


Table C.4-2 (Continued)
PRIMARY SYSTEM COMPONENTS - CRITICAL LOAD COMBINATIONS, LOCATIONS, AND ALLOWABLES
HPCI Turbine (Continued)

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: <ul style="list-style-type: none">a. Weight of the turbine assembly times the vertical component of acceleration,b. The vertical pipe force reactions,c. The pipe moment reactions tending to tip the turbine and subject the bolting to tension. Horizontal forces on the anchor bolts, subjecting them to shear, shall be the sum of the following: <ul style="list-style-type: none">a. Weight of the turbine assembly times the horizontal component of acceleration,b. The horizontal pipe force reactions,c. The effect of pipe moment reactions causing horizontal loading at the anchor bolts
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.	NOTE: Friction shall not be considered to be restrictive 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	Codes and Standards 1. USAS B31.1-1.0 1967		2 in. (Equalizer Bypass Valve) t = 0.253 in.
2 in. Equalizer Bypass Valve 4 in. Discharge Bypass Valve 22 in. Equalizer Valve 28 in. Suction Valve 28 in. Discharge Valve	2. Manufacturers Standards Society MSS-SP.66		4 in. (Discharge Bypass Valve) t = 0.405 in.
Loads:	$t = \frac{15P_d}{\text{where: } 2S - 2P(1 - y)} + 0.1$		22 in. (Equalizer Valve) t = 1.520 in.
Design Pressure Design Temperature	t = minimum wall thickness, in. P = design pressure, psig d = minimum diameter of flow passage, but not less than 90% of inside diameter at welding end, in. S = allowable working stress, psi y = plastic stress distribution factor, 0.4		28 in. (Suction Valve) t = 1.938 in.
Primary Membrane Wall Thickness			28 in (Discharge Valve) t = 1.938 in.
2. Body-to-Bonnet Bolt Area Loads	ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II, 1968 Edition.	2 in. (Equalizer Bypass Valve) $S_{\text{allow}} = 29,000 \text{ lb/in.}^2$	
2 in. Equalizer Bypass Valve 4 in. Discharge Bypass Valve			
Loads:	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.	4 in. (Discharge Bypass Valve) $S_{\text{allow}} = 29,000 \text{ lb/in.}^2$	
Design pressure and temperature Gasket load Stem operational load Design Basis Earthquake			

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	ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II, 1968 Edition.	2 in. (Equalizer Bypass)		
2 in. Equalizer Bypass Valve		S _H	S _R	S _T
4 in. Discharge Bypass Valve		20,100	3,426	13,426
Loads:	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.	4 in. (Discharge Bypass)		
Design pressure and temperature		20,100	13,426	13,426
Gasket load				
Stem operational load				
Seismic load -				
Design Basis				
Earthquake				
4. (A) Body and Bonnet Flange Stress	ASME Boiler and Pressure Vessel Code, Section III, Article 4	Primary Stresses		
(B) Body Neck Wall Stress	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	Membrane Stress Allowable = 15,800 psi		
22 in. Equalizer Valves		Local Membrane Stress Allowable = 23,700 psi		
28 in. Suction Valves		Primary Plus Secondary Stresses		
28 in. Discharge Valves		Code Allowable - 3S _m =		
Loads:		47,400 psi		
Design pressure and				
Design temperature				

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		
Loads:		Under operating conditions 67,000 psi
Design Pressure		Maximum conditions 100,500 psi
Design Temperature		S_b allowable = 20,000 lb/in. ²
6. Valve Operator Support Bolting		
2 in. Equalizer Bypass Valve	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.	
4 in. Discharge Bypass Valve		
22 in. Equalizer Valve		
28 in. Suction Valve		
28 in. Discharge Valve		
Loads:		
Design Pressure and Temperature		
Stem operational load		
Equipment dead weight		
Seismic load		
Design Basis Earthquake		

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. 4 in. Valve - t = 0.405 in.
Design pressure and temperature	where:		2 in. Valve - t = 0.253 in.
Primary Membrane Stress Limit:	t = minimum wall thickness, in.		28 X 24 X 28 in. Valve - t = 1.677 in. (Suction)
Allowable working stress per ASME Section 1	P = design pressure, psig d = minimum diameter of flow passage but not less than 90% of inside diameter at welding end, in. S = allowable working stress, psi y = plastic stress distribution factor, 0.4		28 X 24 X 28 in. Valve - t = 1.938 in. (Discharge)
2. Body-to-Bonnet Bolt Area		Flanged Bolt Stress	
Loads:	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.	$S_{allow} = 29,000 \text{ lb/in.}^2$	
Design pressure and temperature			
Gasket load			
Stem operational load			
Seismic load -			
Design Basis Earthquake			
Bolting Stress Limit:			
Allowable working stress per ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II, 1968 Edition.			

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		
Loads:	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	S_H : 20,100 lb/in. ² (Hub Stress) S_R : 13,426 lb/in. ² (Radial Stress) S_T : 13,426 lb/in. ² (Tangential Stress)
Design pressure and temperature	that the stem operational load and seismic loads shall be included in the total load carried by the flange.	
Gasket load	The horizontal and vertical seismic forces shall be applied at the mass center of the valve operator assuming that the valve body is rigid.	
Stem operational load		
Seismic Loads -		
Design Basis		
Earthquake		
Flange Stress Limits;		
S_H, S_R, S_T :		
S_m per ASME Boiler and Pressure Vessel Code, Section VIII, Appendix II, 1968 Edition.		
4. Valve Operator Support Bolts		
Loads:	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_t allowable = 20,000 lb/in. ²
Design pressure and temperature		
Stem operational load		
Equipment dead weight		
Seismic load -		
Design Basis		
Earthquake		
Yoke and Yoke Bolt Stress Limits:		
Allowable working stress per ASME Section VIII.		

TABLE C.5-1

DRYWELL-LOADING CONDITIONS AND ALLOWABLE STRESSES

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

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.