10A.4.1 MAIN FEEDWATER SYSTEM (INSIDE AUXILIARY BUILDING)

The objective of the MFW System is to provide a dependable supply of feedwater to the steam generators. Two turbine-driven pumps supply the required feedwater flow rate to the steam generators to match the steam flow demand by the plant turbine generator and auxiliaries. The driving steam for high load operation is hot reheat, whereas for low load, an automatic changeover to MS takes place. Auxiliary steam from the auxiliary boiler is also readily available.

In the event of a postulated break in the Auxiliary Building, the blowdown from either steam generator into the Auxiliary Building is prevented due to a check valve provided on each MFW line inside the Containment Structure. The blowdown from the pump side into the Auxiliary and Turbine Buildings is handled by the drain systems (Section 10A.4.1.15).

The MFW line is completely sleeved with a 22" OD SCH 80 pipe below the floor Elevation 27'0" to retain jet impingement forces, reactive forces and pressurization due to a full break or a critical crack.

The feedwater pipe sleeve (Figure 10A.4-7) is also designed to accept thermal growth of the feedwater line and to withstand seismic loadings.

The pressure and temperature in the MFW lines at the discharge of the steam generator feedwater pumps will be 1150 psia and 345°F, respectively, at valves wide open.

10A.4.1.1 PIPE WHIP

The MFW System normally operates at a pressure above 275 psig and 200°F, and therefore, requires restraints to limit damage from a pipe whip following a longitudinal or circumferential break.

10A.4.1.2 CRITERIA FOR LOCATING PIPE BREAKS

The postulated break locations are chosen in accordance with the criteria stated in Section 10A.1.2. The circumferential or longitudinal stresses derived on an elastically-calculated basis, under the loadings associated with a seismic event and operational plant conditions did not exceed 0.8 (S_h + S_A); nor did the expansion stresses exceed 0.8 S_A. Therefore, pipe breaks were postulated to occur only at the terminal ends and the two highest intermediate stress locations (Table 10A-9).

10A.4.1.3 CRITERIA FOR PIPE BREAK ORIENTATION

Criteria for pipe break orientation is presented in Section 10A.1.3.

10A.4.1.4 SUMMARY OF DYNAMIC ANALYSIS

10A.4.1.4.1 Location and Number of Design Basis Breaks

The locations and number of design basis breaks are chosen in accordance with the criteria discussed in Section 10A.1.3. A further discussion is given in Section 10A.1.4.1.

10A.4.1.4.2 The Postulated Rupture Orientation

The longitudinal break is assumed to be parallel to the pipe axis and oriented at any point around the pipe circumference. The circumferential break is assumed to be perpendicular to the pipe axis. A further discussion of the break area and the dynamic forces is provided in Section 10A.1.4.2.

10A.4.1.4.3 Description of the Forcing Function

The jet impingement force, caused by the momentum change of fluid flowing through the break, is a function of the upstream fluid conditions, fluid enthalpy, source pressure, pipe flow restrictional friction and dimensions.

The method used to compute the jet forces acting upon the pipe are computed using a method outlined in Section 10A.1.4.3.

10A.4.1.4.4 Dynamic Analysis and Mathematical Model

The dynamic analysis method used for the MFW pipe whip restraint design is similar to the one used for the MS line pipe whip restraint design. This method is explained in Section 10A.1.4.4 and the mathematical model is shown in Figure 10A.1-5.

10A.4.1.4.5 Unrestrained Motion of the Ruptured Line

Since the MFW line is restrained at the postulated break location and additional restraints are provided to preclude axial movement within the sleeve, no damage can occur to structures, systems and components important to plant safety due to a MFW line break.

10A.4.1.5 PROTECTIVE MEASURES

10A.4.1.5.1 Pipe Whip Restraints

Pipe whip restraints are provided to prevent the pipe whip impact, due to a full instantaneous break, on structures, systems and components important to the plant safety. A further discussion of the pipe whip restraint is provided in Section 10A.1.5.1.

10A.4.1.5.2 Protective Measures - MFW Pipe Sleeve

The MFW line below floor Elevation 27'0" is sleeved completely in order to retain jet impingement forces and prevent pressurization of the Auxiliary Building below Elevation 27'0".

A detailed description of design criteria for sleeves is given in Section 10A.1.5.

The feedwater pipe sleeve is also designed to accept thermal growth of the feedwater line and to withstand seismic loadings. The sleeve is supported by hangers and anchors, as required, through the Auxiliary Building.

10A.4.1.5.3 Separation Provisions
10A.4.1.5.4

The MFW lines run parallel to each other approximately 8'0" apart. Separation of redundant features in the MFW lines is accomplished by a combination of sleeving and properly placed restraints.

10A.4.1.5.5 Description of the Pipe Whip Restraint

The pipe whipping restraints are provided at the postulated break locations and at other critical locations, such as elbows, to control the pipe whip impact and axial movement due to a full break at the postulated break locations.

Figure 10A.4-2 shows the location of restraints for the MFW line.

A description of a pipe whip restraint is given in Section 10A.1.5.5.

10A.4.1.6 EVALUATION OF CATEGORY I STRUCTURES

10A.4.1.6.1 Method of Evaluating Stresses

The Auxiliary Building, a Category I reinforced concrete structure, was evaluated for a structural adequacy following a postulated rupture using ultimate strength design method as outlined in "Building Code Requirements for Reinforced Concrete" - American Concrete Institute (ACI) 318-63.

10A.4.1.6.2 Allowable Design Stresses

American Concrete Institute standard "Building Code Requirements for Reinforced Concrete" – ACI 318-63 was used for computing allowable stresses for concrete and reinforcing steel. Allowable stresses for concrete is taken at 85% of the ultimate strength and allowable stresses for the reinforcing steel is taken 85% of the yield strength.

10A.4.1.6.3 Load Factors and Load Combinations

Load factors and load combinations used in the evaluation of the Auxiliary Building are given in Section 10A.1.7.

10A.4.1.6.4 Stresses in the Category I Structure

The MFW line is completely sleeved with a 22" OD pipe below the floor Elevation 27'0" to retain jet impingement forces and pressurization resulting from postulated breaks in the MFW line below Elevation 27'0". The MFW line above floor Evaluation 27'0" is also sleeved at the postulated break locations.

The pressure inside the sleeve, above or below Elevation 27'0", will be released from the open ends of the sleeve and into the Turbine Building. A new vent stack has been provided to vent the MS Penetration Room. Thus, the pressure due to a postulated break in the MFW line inside the room will not be greater than 2.6 psi.

Table 10A-3 shows the concrete and steel stresses due to the pressurization of 2.6 psi resulting from a postulated pipe rupture.

Table 10A-2 shows the concrete and steel stresses due to a jet impingement force of 10 kips plus 1 psi compartment pressurization resulting from a critical crack in the MS line. These stresses are in various structural components in the MS Penetration Room.

The magnitude of jet impingement force and compartment pressurization, in the MS Penetration Room at Elevation 27'0", resulting from a critical crack in the MFW line will be less than 6 kips and 1 psi, respectively. Thus, the stresses in the MS Penetration Room due to a critical crack in the MFW line will be less than those listed in Table 10A-2.

It can be seen from Tables 10A-2 and 10A-4 that the stresses in the Category I structure resulting from a postulated break or critical crack in the MFW line will be well within the allowable stresses.

10A.4.1.6.5 Erosion of Concrete from Jet Impingement Forces

The MFW line is sleeved completely below Elevation 27'0". It is also sleeved above floor Elevation 27'0" at the postulated break location. Thus, the jet impingement forces resulting from a postulated break will be retained inside the sleeve. The jet impingement force resulting from a critical crack will be less than 6 kips. This force is considerably less than the jet impingement force resulting from a critical crack in the MS line to cause any concrete erosion.

A further discussion of concrete erosion due to a jet impingement force is given in Section 10A.1.6.5.

10A.4.1.7 STRUCTURAL DESIGN LOADS

The design loads used to evaluate the adequacy of Category I structures or structural components are discussed in the Section 10A.1.7.

10A.4.1.8 REVERSAL OF LOADS ON THE STRUCTURE

The forces causing reversal of loading due to the postulated accident on the Seismic Category I structures or structural components are:

A. Jet Impingement Force
B. Compartment Pressurization
C. Reaction from Pipe Whip Restraint

10A.4.1.8.1 Reversal of Loading Due to Jet Impingement Forces

The MFW line inside the Auxiliary Building and below Elevation 27'0" is sleeved completely. The postulated full break locations above Elevation 27'0" are also sleeved. The sleeve will resist jet impingement forces due to a pipe break or a critical size crack. The sleeve, therefore, will prevent Seismic Category I structures or structural components below floor Elevation 27'0" from being affected by the jet impingement forces.

The MFW line above Elevation 27'0" is also sleeved where full-break locations are postulated. The jet impingement forces due to a critical size crack break will not be significant enough to cause damage to Category I structure or structural components due to a reversal of loading.

10A.4.1.8.2 Reversal of Loading Due to Compartment Pressurization

The MFW line sleeve at Elevation 5'0" (below Elevation 27'0") will release the pressure due to a postulated break or critical crack at Elevation 27'0", so there will not be any reversal of loading on Category I structures or structural components at Elevation 5'0".

The pressure inside the sleeve, due to a postulated full break above or below Elevation 27'0", will be released above Elevation 27'0" in the area of the MS line compartment. A new vent stack has been provided to vent the MS line compartment. Thus, the pressure in the MS line compartment will be limited by the new vent to an acceptable level and

will not affect the integrity of the Category I structures or structural components.

10A.4.1.8.3 Pipe Whip Restraints

Pipe whip restraints are provided in accordance with the criteria stated in Section 10A.1.5.5. They are supported by the existing structural components. When the restraint loads cannot be sustained by the existing structure or structural components, these loads are transferred to the foundation level using additional supports.

The restraints for the MFW line above floor Elevation 27'0" required additional supports to transfer restraint loads from Elevation 27'0" to the floor Elevation 5'0", a foundation level.

10A.4.1.9 STRUCTURAL EFFECTS OF OPENINGS

A vent stack has been provided to vent the MS line Penetration Room to a compartment pressure below the acceptable level, and is described in Section 10A.1.9.

10A.4.1.10 EFFECTS OF STRUCTURAL FAILURE

There will not be a failure of any structure, including Category II (non-seismic Category I) structures, due to the accident, that could cause failure of any other structure in a manner to adversely affect:

A. Mitigation of the consequences of the accident; and

B. Capability to bring the unit(s) to a cold shutdown condition.

10A.4.1.11 VERIFICATION THAT HIGH ENERGY PIPE RUPTURES WILL NOT AFFECT SAFETY

Since the MFW is completely sleeved below floor Elevation 27'0" in the Auxiliary Building, a rupture of the pipe below this elevation will not affect any safety equipment. In the event a crack break occurs in the feedwater line portion which is not sleeved above Elevation 27'0" in the Auxiliary Building, the only region affected is the MS Penetration Room which is designed so there will be no effect on plant safety. Section 10A.1.11 describes the high energy pipe rupture in this room.

10A.4.1.12 EFFECT ON CONTROL ROOM

A feedwater line rupture will not affect the Control Room since there is no direct or indirect access from the affected area to the Control Room.

10A.4.1.13 ENVIRONMENTAL QUALIFICATION OF AFFECTED REQUIRED EQUIPMENT

A detailed description of environmental qualification of affected equipment above Elevation 27'0" in the Auxiliary Building is given in Section 10A.1.13.

The MFW check valves on the MFW lines inside the Containment are supplied by Rockwell Manufacturing Company. They are 16" nominal size with a rating of 900 lbs. Each valve is cast carbon steel A-216 Gr. WCB or WCC, butt-welded, pressure seal cap or bolted-body joint, welded or integral stellited seat ring, and stellited tilting disc with standard trim for steam or water service at 400°F.

The check valve closure can be verified when the plant is shut down by upstream pressure indicators.

10A.4.1.14 DRAWINGS

Figures 10A.4-2, 10A.4-3, 10A.4-4 and 10A.4-5 show the routing of the MFW piping from the containment penetration through the Auxiliary Building. The complete condensate and feedwater system is shown in Figure 10-4. (Figure 10A.4-1 shows that portion of the system diagram affected by the high energy system criteria.)

10A.4.1.15 FLOODING

In the event a feedwater line ruptures at Elevation 27'0" or within the sleeved area below, approximately three-fourths of the mass released would be a source of flooding.

Flooding of the MS Valve Room will be controlled by means of a lightly constructed (gypsum) wall located at the turbine room end of the steam line tunnel. The gypsum wall design and construction will be based on the collapse of the wall when subjected to a hydraulic pressure of 3' of water.

Minor flooding of the MS valve room at Elevation 27'0" resulting from a crack in the feedwater line will be handled by two 6" diameter drain lines penetrating the tunnel gypsum wall at floor level and gravity draining to the turbine room floor drain system at Elevation 12'0".

Pressure retaining walls and doors enclosing the MS valve room prevent communication of steam or water resulting from a pipe break to other areas of the Auxiliary Building.

10A.4.1.16 QUALITY CONTROL AND INSPECTION

A full description of the quality control and inspection requirements is given in Section 10A.1.16.

10A.4.1.17 LEAK DETECTION

A. Crack break above Elevation 27'0":

   A temperature switch is located in the room to give an indication in the Control Room if a crack break should occur in the MFW line.

B. Crack break within Sleeve:

   Vents and drains are provided for leak detection.

10A.4.1.18 EMERGENCY PROCEDURE

Following rupture of the MFW system in the Auxiliary Building or Turbine Building, the applicable emergency operating procedure(s) would be implemented.

10A.4.1.19 SEISMIC AND QUALITY CLASSIFICATION

The MFW lines in the Auxiliary Building to the isolation valve outside the Containment are designed and constructed in accordance with ANSI B31.1 and between the stop valve and the Containment in accordance with ANSI B31.7, Class II requirements. The feedwater line in the Auxiliary Building is designed to withstand a SSE in combination with normal design loads.

10A.4.1.20 DESCRIPTION OF ASSUMPTIONS, METHODS, AND RESULTS OF ANALYSIS FOR PRESSURE AND TEMPERATURE TRANSIENTS IN COMPARTMENTS

In the Auxiliary Building, the MFW line is protected by a sleeve at all locations below the floor at Elevation 27'0" (Figure 10A.4-2). This ensures that no high energy fluid can be released in these areas.

The MFW lines above floor Elevation 27'0" in the Auxiliary Building pass through the MS Penetration Room. This portion of the MFW line is partially sleeved to provide jet impingement protection. Any circumferential break in the sleeved portion would vent into the MS Penetration Room or into the Turbine Building. In the MS Penetration Room, the open end of the sleeve is partially restricted to limit the rate of feedwater release into this room.

The flow restriction is a closure plate similar to the ones used on the MS encapsulation (Figure 10A.1-3). The construction tolerances imposed on the design will limit the escape area to a maximum of 56.2 in^2.

To determine the pressure transient in the Penetration Room, the Bechtel computer code COPDA (Reference 1) was utilized. The parameters were as follows:

Initial conditions:		
Temperature	-	160°F
Pressure	-	14.7 psia
Humidity	-	70%
Penetration Room:		
Volume	=	24,000 ft^3
Vent to atmosphere	=	44.1 ft^2
Vent coefficient	=	0.71

The mass and energy release rates are determined by the methods presented in Section 10A.1.20.2. The feedwater pressure is reduced to near saturation as the fluid expands into the sleeve. The feedwater temperature is assumed to be 436°F. The discharge rate from the sleeve is conservatively determined to be a maximum of 4500 lbm/sec-ft^2. This is based on a frictionless Moody two-phase flow model. For an escape area of 56.2 in^2 this is equivalent to 1755 lbm/sec. The enthalpy is assumed to be 416 Btu/lbm. The results of the COPDA analysis show that the maximum compartment pressure is 2.4 psig.

The pressure effects of a full feedwater line circumferential break in the Turbine Building will be less than that of a MS line circumferential break, which is discussed in Section 10A.1.20.1.

10A.4.1.21 INTEGRITY OF THE CONTAINMENT STRUCTURE WITH A PIPE RUPTURE OUTSIDE THE CONTAINMENT

The MFW line is sleeved completely below Elevation 27'0", and is also sleeved at the postulated break locations above Elevation 27'0", to retain jet impingement forces and compartment pressurization resulting from a postulated break.

The pressure inside the sleeve due to a postulated break will be released from the open ends of the sleeve into the MS Penetration Room and the Turbine Building. A new vent stack inside the MS Penetration Room will reduce the compartment pressure below 2.6 psi. The partial pressurization of the Containment walls will not affect the integrity of the prestressed concrete Containment Structure.

The magnitude of jet impingement forces resulting from a critical crack will not be greater than 6 kips, in addition to a compartment pressurization of 1 psi. These forces are not large enough to affect the 3'9"-thick prestressed concrete walls of the Containment Structure.

Thus, the integrity of the prestressed concrete Containment Structure will not be impaired due to a postulated full break of the MFW line.

10A.4.1.22 REFERENCE

1. BN-TOP-4, Revision 1, "Subcompartment Pressure and Temperature Transient Analysis," October, 1977

TABLE 10A-9

MAIN FEEDWATER STRESS VALUES

Following is a stress summary of the two intermediate points considered between the terminal ends. The postulated full break locations are shown on Figures 10A.4-2 and 10A.4-3.

PRIMARY STRESS psi

POINT NUMBER	SECONDARY STRESS ($<0.8\ S_A$) psi[(a)]	LONGITUDINAL PRESSURE STRESS	LONGITUDINAL WEIGHT STRESS	SEISMIC OBE	PRIMARY STRESS TOTAL S_{PR}[(d)] TOTAL $0.8\ S_h$[(a,b)]	TOTAL STRESS [$<0.8\ (S_A + S_h)$] psi[(c)]
2	12,354	5,204	432	572	6,208	18,562
3	10,862	5,204	663	352	6,219	17,081
6	15,320	5,204	458	378	6,040	21,360
7	15,998	5,204	379	405	5,988	21,986

(a) S_A = The larger of f [$1.25\ S_c + 0.25\ S_h + (S_h - S_{PR})$] or f ($1.25\ S_c + 0.25\ S_h$) as per paragraph 102.3.2(c) and (d) of the USAS Code for pressure piping, USAS B 31.1.0-1967 and as per NC-3600 of Section III (Nuclear Power Plant Components), ASME B&PV Code. 0.8 S_A taken as 21,000 psi.

(b) S_c and S_h are the allowable stresses at cold and hot conditions, respectively, for Class 2 and Class 3 components as per ASME B&PV Code, Section III (Nuclear Power Plant Components).

(c) 0.8 ($S_A + S_h$) taken as 35,000 psi.

(d) S_{PR} is the total of columns 3 through 5.