10A.4.2 MAIN FEEDWATER AND HEATER DRAIN SYSTEM (INSIDE TURBINE BUILDING)

A general description of the feedwater system is given in Section 10A.4.1. In the Turbine Building, the feedwater line from the pumps to Feedwater Heaters 16A & B, and the drain line from Heater 16B to the condenser, are investigated for a full break.

The pressure and temperature in the feedwater line at the discharge of feedwater pumps are 1150 psig and 345°F at valves wide open, and in the drain line from Heater 16B to the condenser is 384 psia and 440°F, respectively.

Both of these high energy lines pass near the steam generator AFWP Room which is a Category I structure. Figure 10A.4-6 shows the routing of these high energy systems inside the Turbine Building.

10A.4.2.1 PIPE WHIP

The feedwater line and the heater drain line from Feedwater Heater 16B to the condenser normally operates at a pressure above 275 psig and 200°F, and therefore, requires protection from pipe whip following a longitudinal or circumferential break.

10A.4.2.2 CRITERIA FOR LOCATING PIPE BREAKS

Since the piping in the Turbine Building is not designed to seismic conditions, a break can occur anywhere in the Turbine Building.

10A.4.2.3 CRITERIA FOR PIPE BREAK ORIENTATION

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

10A.4.2.4 SUMMARY OF PIPE WHIP DYNAMIC ANALYSIS

10A.4.2.4.1 Location and Number of Breaks

Since the feedwater line inside the Turbine Building is not designed as a Category I (Seismic) system, a pipe break is postulated to occur anywhere along the line, either in the feedwater line from the feed pumps to Feedwater Heaters 16A & B, or in the drain line from Heater 16B to the condenser. Since a pipe break is postulated to occur anywhere along the line, the critical crack is not governing these lines. A large pipe break is assumed to be a one-time event, requiring a plant shutdown and necessary repairs.

10A.4.2.4.2 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 longitudinal break area is equal to the effective cross-sectional area upstream of the break location. The circumferential break is perpendicular to the pipe axis, and the break area is equivalent to the internal cross-sectional area of the ruptured pipe. Dynamic forces resulting from a circumferential break are assumed to separate the piping axially, and cause whipping in any direction normal to the pipe axis.

10A.4.2.4.3 Description of the Forcing Function and the Mathematical Model

10A.4.2.4.4

The jet thrust forces, 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 jet impingement forces acting upon the pipe are computed using the formula described in Section 10A.2.4.3. The jet forces are assumed to be instantaneous. The forcing function is assumed to be a straight line with changes so slow that the variation, up to the time of maximum response, is neglected.

The dynamic analysis method, used for the pipe whip restraint design, is similar to the maximum deflection of a structure subjected to a long duration loading relative to the natural period as presented on page 222 of Reference 1. The mathematical model is shown in Figure 10A.1-5.

10A.4.2.4.5 Unrestrained Motion of the Ruptured Line

The feedwater line from the feed pumps to Feedwater Heaters 16A & B, and the drain line from Heater 16B to the condenser, are sleeved along the length of the AFWP Room. The sleeve will retain jet impingement forces and a pressure due to a postulated break in these feedwater lines.

Restraints are provided along the length of these pipes and additional restraints are provided to preclude any axial movement within the sleeve; no damage can occur to the AFWP room walls and Category I equipment inside this room.

10A.4.2.5 PROTECTIVE MEASURES

10A.4.2.5.1 The Pipe Whip Restraint
10A.4.2.5.2

The feedwater line from the feed pumps to Feedwater Heaters 16A & B, and the drain line from Heater 16B to the condenser, are located inside the Turbine Building, a Seismic Category II structure. The steam-driven AFWP are located in the vicinity of these feedwater lines. These AFWPs are located inside the AFWP Room, a Category I (seismic) enclosure. The motor-driven AFW pumps are located in the SRW Heat Exchanger Room.

The Category I (seismic) enclosure is protected against the effects of jet impingement forces and pipe whip impact.

The pipe whip restraints are provided to protect the AFWP Room against a pipe whip impact due to a postulated beak in these lines. The pipe movement is restricted by limiting the distance between pipe restraints to some dimensions less than the critical plastic hinge length of the pipe.

A. Rupture at an Elbow (Circumferential Break)

When the postulated rupture is at a pipe elbow or fitting for a circumferential break, the critical plastic hinge length (L_1) is determined by the moment resisting capabilities of the pipe (M_p) and the magnitude of the jet thrust (F_j), assuming the pipe acts as a simple cantilever member. The critical plastic hinge length of this condition is determined as:

$$L_1 < \frac{M_p}{F_j}$$

B. Longitudinal rupture

The longitudinal break is considered in the straight pipe run. The most severe loading condition for this type of rupture is when it occurs midway between the restraints. The critical plastic hinge length (L_2) is analyzed if the pipe is considered as a continuous beam along a run of restraints.

$$L_2 < \frac{8M_p}{F_j}$$

Where, M_p is the plastic moment resisting capabilities of the pipe and the F_j is the jet thrust force.

10A.4.2.5.3 <u>Separation Criteria</u>
10A.4.2.5.4

Since the feedwater lines inside the Turbine Building are designed as a Category II system, no separation of redundant features are required.

10A.4.2.5.5 <u>Description of the Pipe Whip Restraint</u>

The pipe whip restraints are provided to prevent the pipe from the feedwater line from feed pump to the Feedwater Heaters 16A & B or the drain line from Heater 16B to the condenser to the AFWP Room. The pipe whip restraints are located using the criteria outlined in Section 10A.4.2.5.1&2.

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

10A.4.2.6 EVALUATION OF SEISMIC CATEGORY I STRUCTURES

Category I structures were evaluated for structural adequacy following a postulated pipe break, using the design bases shown in Appendix 5A. Ultimate strength design method for concrete was used as given in the above reference.

The design stresses were proportioned such that the combined stresses are within the limits established in Appendix 5A.

The load factors and load combination used in the evaluation of the existing structures or in the design of new structures or structural components are discussed in Appendix 5A.

10A.4.2.7 STRUCTURAL DESIGN LOADS

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

10A.4.2.8 REVERSAL OF LOADS ON THE STRUCTURE

The forces causing reversal of loadings due to the postulated break on the Category I structures or structural components are:

1. Jet Impingement Force
2. Compartment Pressurization
3. Reaction from Pipe Restraint

The feedwater line from the feed pump to Feedwater Heaters 16A & B, and the drain line from Heater 16B to the condenser are sleeved along the length of the AFWP Room wall. The sleeve will retain jet impingement forces and pressure resulting from a postulated break in these lines. Any jet forces escaping from the sleeve ends are distributed away from the AFWP Room walls. Thus, there will not be any jet impingement forces or pressurization of the AFWP Room walls due to a postulated rupture in these lines in the vicinity of the AFWP Room.

10A.4.2.9 STRUCTURAL EFFECTS OF OPENINGS

No new openings are provided that would affect the integrity of Category I structures or structural components.

10A.4.2.10 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.

The feedwater line from the feed pump to Heaters 16A & B, and the drain line from Heater 16B to the condenser, in the vicinity of the AFWP Room, are restrained due to a postulated break in these lines.

Any break in these lines beyond the boundary of the Auxiliary Building will have no adverse effects on the structural integrity of the Turbine Building.

10A.4.2.11 VERIFICATION THAT HIGH ENERGY PIPE RUPTURES WILL NOT AFFECT SAFETY

The Steam Generator AFWP room is considered with respect to damage from feedwater line breaks inside the Turbine Building. The AFWP Room is a Category I structure and is protected against jet impingement forces, reactive forces and pipe whipping.

The "Ram's Heads" of the Saltwater System are also located in the Turbine Building. Due to the size and location of the "Ram's Heads" with respect to the feedwater line in the Turbine Building, damage caused by rupture and whipping of these pipes and by jet impingement is not considered credible.

A portion of the feedwater piping is located near the K-line in the Turbine Building on the 12’ Elevation in the area of the safety-related main steam drains 5 and 6. If either of the two 16” feedwater lines in this area were to rupture, it could potentially break either or both of these small drain lines and require a unit shutdown to perform repairs. An evaluation of concurrent breaks in a feedwater line and both main steam drain lines were performed. This evaluation showed that this event would not impair the ability to achieve shutdown and would not increase the consequences beyond that of the ruptured feedwater line alone. Therefore, no barriers are required to protect these safety-related main steam drains from a rupture or jet impingement from the feedwater piping.

The other Auxiliary Building wall will not be impacted due to a postulated break in the feedwater line from the feed pump to Heaters 16A & B or a drain line from the Heater 16B to the condenser.

10A.4.2.12 EFFECT ON THE CONTROL ROOM

A high energy line rupture inside the Turbine Building will not affect the Control Room since there is no direct or indirect access from the affected area to the Control Room.

10A.4.2.13 ENVIRONMENTAL QUALIFICATION OF AFFECTED REQUIRED EQUIPMENT

Not applicable (Section 10A.4.2.20).

10A.4.2.14 DRAWINGS

Figure 10A.4-6 shows the routing of the feedwater line from the feed pumps to Feedwater Heaters 16A & B, and the drain line from Heater 16B to the condenser.

10A.4.2.15 FLOODING

In the event a feedwater line ruptures inside the Turbine Building, floor drains are provided to handle the resulting blowdown without causing flooding.

10A.4.2.16 QUALITY CONTROL AND INSPECTION

The quality control and inspection programs are presented in Section 10A.1.16.

10A.4.2.17 LEAK DETECTION

Leak detection is discussed in Section 10A.1.18.

10A.4.2.18 EMERGENCY PROCEDURES

Upon leak or rupture of piping in the MFW and heater drain system inside the Turbine Building, the applicable emergency operating procedure would be implemented.

10A.4.2.19 SEISMIC AND QUALITY CLASSIFICATION

The feedwater lines and the heater drain lines to the condenser are designed and constructed in accordance with ANSI B31.1.

10A.4.2.20 DESCRIPTION OF ASSUMPTIONS, METHODS, AND RESULTS OF ANALYSIS FOR PRESSURE AND TEMPERATURE TRANSIENT IN COMPARTMENTS

In the Turbine Building, a guillotine break at the MFW line is not as severe as a guillotine break of the MS line. Therefore, the MSLB as discussed in Section 10A.1.20, determines the maximum pressure in this region.

10A.4.2.21 DESCRIPTION OF ASSUMPTIONS, METHODS, AND RESULTS OF ANALYSIS FOR EFFECT ON PRIMARY OR SECONDARY CONTAINMENT STRUCTURE DUE TO PIPE RUPTURE OUTSIDE

Since the system is in the Turbine Building, a rupture in the feedwater system will not affect the Containment Structure.

10A.4.2.22 REFERENCES

1. "Introduction to Structural Dynamics" by professor John M. Biggs, 1964 edition, published by McGraw-Hill Book Company