10A.7 CHEMICAL AND VOLUME CONTROL SYSTEM

The CVCS is designed to perform the following functions:

(a) Maintain reactor coolant activity at the desired level by removing corrosion and fission products.

(b) Inject chemicals into the Reactor Coolant System to control coolant chemistry and minimize corrosion.

(c) Control the reactor coolant volume by compensating for coolant contraction or expansion resulting from changes in reactor coolant temperature and other coolant losses or additions.

The above functions are accomplished by a continuous letdown and charging of the coolant loop at a normal letdown and purification flowrate of 40 gpm and charging flowrate of 44 gpm. FCR 87-0074 reduced the normal letdown and purification flowrate from 40 gpm to 38 gpm. The changes in this analysis as a result of FCR 87-0074 are insignificant.

The maximum letdown flowrate is 128 gpm. (As for the normal letdown and purification flowrate noted above, FCR 87-0074 reduced the maximum letdown flowrate to 126 gpm.) The maximum normal pressure and temperature in the letdown line at the coolant loop nozzle are 2250 psig and 550°F, respectively, occurring when the plant is in normal operation. The letdown CVs, which regulate the reactor coolant flow from the regenerative heat exchanger as required by the pressurizer level regulating system, will reduce the pressure to 460 psig. The letdown fluid temperature is reduced to 232°F after passing through the regenerative heat exchanger, and is further lowered to 120°F through the letdown heat exchanger.

An excess flow check valve has been added to the letdown line inside the Containment downstream of the regenerative heat exchanger. This valve is designed to shut in the event that the flow through the letdown line reaches 200 $\pm$ 20 gpm as would occur in the event of a double-ended guillotine or slot rupture, thus limiting the letdown flow in the Auxiliary Building.

The maximum charging flowrate is 132 gpm, supplied when all three positive displacement charging pumps are operating. Normally, only one pump is operating. The maximum normal pressure and temperature at the charging pump discharge are 2310 psig and 120°F. A short term discharge pressure of 3010 psig can be maintained. The charging fluid passes through the regenerative heat exchanger, which increases the temperature to 415°F. The fluid then enters the reactor coolant loop.

The high energy CVCS lines are shown in Figures 10A.7-1 and 10A.7-4.

10A.7.1 PIPE WHIP

Motor-operated valves and instrumentation on the Safety Injection System piping in the west piping Penetration Room at Elevation 27'0" will be protected against possible damage caused by pipe whip occurring at the high stress points of the letdown line because this is an ESFs System. Protection will also be provided for certain safety-related cable trays in the same piping Penetration Room in the vicinity of the letdown line.

Pipe whip protection measures for the letdown line are discussed in Section 10A.7.5.

10A.7.2 CRITERIA FOR PIPE BREAK LOCATIONS

The criteria used for determining the location of pipe breaks has been presented in Section 10A.1.2. The pipe break locations for the letdown line are shown in Figure 10A.7-5.

10A.7.3 CRITERIA FOR PIPE BREAK ORIENTATION

No restriction has been placed on pipe break orientation.

10A.7.4 SUMMARY OF DYNAMIC ANALYSIS

10A.7.4.1 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.1.2.

10A.7.4.2 The Postulated Rupture Orientation

The circumferential break is assumed to be perpendicular to the pipe axis. A further discussion of circumferential break area and the dynamic forces is provided in Section 10A.1.4.2.

10A.7.4.3 Description of the Forcing Function

The method used to compute the jet impingement forces and description of the forcing function used in the pipe whip analysis are discussed in Section 10A.2.4.3.

10A.7.4.4 Dynamic Analysis and Mathematical Model

The dynamic analysis method used for the CVCS lines is similar to the one used for the MS line and is described in Section 10A.1.4.4. The mathematical model is shown in Figure 10A.1-5.

10A.7.4.5 Unrestrained Motion of the Ruptured Line

There will not be any unrestrained motion of the CVCS line to damage structures, systems and components important to the plant safety.

10A.7.5 PROTECTION AGAINST PIPE WHIP, JET IMPINGEMENT, AND REACTIVE FORCES

10A.7.5.1 Pipe Whip Restraints and Sleeves

All high stress points of the CVCS letdown line (2" schedule 160) in the west piping Penetration Room are sleeved by a 6", schedule 160 pipe. The sleeve pipe is securely anchored to surrounding permanent structures and restrained to prevent its movement. This eliminates any danger from impact on structures, systems and components important to plant safety due to uncontrolled pipe whip resulting from a slot or double-ended rupture. Blowdown jet impingement or other reactive forces resulting from the break will also be effectively contained within the sleeve. Sleeves meet the criteria for the encapsulations referenced in Section 10A.1.5.

The jet impingement forces due to a critical size crack (0.204 in^2 crack area, 551 lbs forces) are not significant enough to damage any safety-related structure, systems or components. There will not be enough steam released from a critical crack to cause compartment pressurization.

10A.7.5.2 Excess Flow Check Valve

The excess flow check valve in the letdown line shuts immediately when the letdown flowrate reaches 210 gpm. This increased flow will occur in the event of a line rupture because of the reduced system pressure drop. Protection against the instantaneous pipe whip and jet impingement from a break will be provided for the time before the valve shuts, limiting the blowdown.

The spring-loaded excess flow check valve on the CVCS letdown line inside the Containment is supplied by Marotta Scientific Controls, Incorporated. It is 2" nominal size with a rating of 1500 lbs. It is designed for 2485 psig and 650°F. The valve body and internals will be constructed of Type 316 stainless steel. It closes automatically at a flowrate of 200 gpm ± 20 gpm. The operation of the check valve is tested periodically. A bypass orifice, designed to pass 10 gpm, permits resetting of the excess flow check valve from outside the Containment.

10A.7.5.3 Description of a Typical 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.

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

10A.7.6 EVALUATION OF SEISMIC CATEGORY I STRUCTURES

10A.7.6.1 Method of Evaluating Stresses

Category I structures were evaluated for structural adequacy following a postulated rupture using the design bases shown in Appendix 5A. Ultimate strength design method was used for structural evaluations. All Category I structures and structural components were found to be adequate against the loading due to the postulated break.

10A.7.6.2 Allowable Design Stresses

Design stresses are proportioned such that the combined stresses are within the limits established in Appendix 5A.

10A.7.6.3 Load Factors and Load Combinations

Load factors and load combinations used in the design are discussed in Appendix 5A.

10A.7.7 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.7.8 REVERSAL OF LOADS ON THE STRUCTURES

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

1. Jet Impingement Forces
2. Compartment Pressurization
3. Reactions from Pipe Whip Restraints

Since the CVCS letdown line is only 2" in diameter, the magnitude of the jet impingement forces resulting from a critical crack will not be greater than 6 kips. This force is smaller compared to a jet impingement force of 10 kips resulting from a critical crack in the MS line.

The excess flow check valve, located inside the Containment Structure, will close and limit the release of the high energy fluid following a postulated rupture. With the excess flow check valve closed, only 10 gpm can be released via the bypass orifice. This quantity is insignificant and will not overpressure the room in which the break occurs.

Table 10A-10 gives stresses in various structural components of the pipe Penetration Room in the vicinity of the letdown line. These stresses are due to a compartment pressurization of 4.85 psig. It can be seen from this table that the stresses in the structural components of the Penetration Room are well within the allowable stresses.

10A.7.9 EFFECTS OF NEW OPENINGS ON STRUCTURE

No openings are required to vent the compartment structure following a break in the letdown or charging lines.

10A.7.10 VERIFICATION THAT ANY STRUCTURAL FAILURE WILL NOT AFFECT OTHER STRUCTURES REQUIRED FOR SAFETY

No structures will fail (Section 10A.1.10).

10A.7.11 VERIFICATION THAT PIPE RUPTURE WILL NOT AFFECT SAFETY

A break or crack in the letdown line will result in flashing a maximum of approximately 36% of the blowdown released into the West Piping Penetration Room or Letdown Heat Exchanger Room in the Auxiliary Building. The crack will cause compartment pressurization which will automatically close the letdown line isolation valves inside the Containment, upstream of the regenerative heat exchanger (Section 10A.7.17). This will terminate the letdown line blowdown before causing any adverse effects on plant safety.

Pressure relief for the letdown heat exchanger room is provided by an open block-out connecting to the west piping Penetration Room. Pressure in the Penetration Room will be allowed to gradually decay.

The interconnecting Penetration Room ventilation system will maintain negative pressure in these rooms. Backdraft dampers will prevent propagation of the steam environment into the electrical Penetration Rooms.

There will be no steam released from a charging line break because the system temperature is too low.

Shutting off the charging pumps by use of the remotely-located hand switches (one per pump) will serve to terminate blowdown from a rupture in the charging system lines. Accessibility to these hand switches will not be affected by a charging line rupture.

Discussion of specific emergency procedures to be followed in the event of a letdown or charging line rupture is in Section 10A.7.18.

10A.7.12 EFFECT ON CONTROL ROOM

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

10A.7.13 ENVIRONMENTAL QUALIFICATION OF AFFECTED REQUIRED EQUIPMENT

The release of high energy fluid as a result of circumferential or longitudinal break will be immediately limited to 10 gpm by the closure of the excess flow check valve. The 10 gpm released via the bypass orifice is not significant and can be easily handled by the ventilation system; therefore, no significant environmental change will occur.

Environmental conditions, leak detection and blowdown limitation from a crack in the letdown line are discussed in Sections 10A.7.17 and 10A.7.18. Equipment that must

function and equipment locations are shown in Tables 10A-5 and 10A-6. Equipment which must function in the steam environment has been qualified for that environment.

10A.7.14 DESIGN DRAWINGS

Figures 10A.7-2, 10A.7-3, and 10A.7-5 show the routing of the letdown and charging lines and the proposed break locations for the letdown line.

10A.7.15 FLOODING

No excessive amounts of water will be released from a slot or double ended rupture in the letdown line because the excess flow check valve will seat and terminate blowdown. However, a crack occurring at another point in the line in the piping Penetration Room may not cause enough blowdown to seat the excess flow check valve and terminate the flow. Water released from the crack will fall through the Penetration Room grating at Elevation 27'0" to the floor at Elevation 5'0". The room at Elevation 5'0" is equipped with floor drains which will carry the water off to the Waste Processing System. Similarly, should a break occur in the line in the Letdown Heat Exchanger Room, the floor drains in the room will be adequate to take the water to the Waste Processing System.

No appreciable amounts of water will be released from a break or crack in the charging line because of the rapid system pressure decay. Floor drains in the piping Penetration Room and Charging Pump Rooms are adequately sized to handle the resulting blowdown from the charging line without causing flooding.

10A.7.16 QUALITY CONTROL AND INSPECTION PROGRAMS

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

10A.7.17 LEAK DETECTION EQUIPMENT

Four pressure sensors are installed in the West Piping Penetration Room and Letdown Heat Exchanger Room to detect the rise in ambient pressure resulting from blowdown release in the event of a crack in the letdown line. Two-out-of-four trip logic (signal from two of the four pressure sensors) is used to close each of the two letdown line isolation valves (CV-515 and CV-516) located upstream of the regenerative heat exchanger. Each pressure sensor is set to send the actuation signal automatically when room pressure reaches 0.5 psig, which will occur in the Penetration Room at 0.75 seconds after the crack. The room vapor temperature will be 111°F at this time. The valve will close within 9 seconds after the signal. The pressure in the Penetration Room after this time period will be 4.85 psig with a room vapor temperature of 168°F.

These instruments are type tested to ensure they operate under the maximum environmental conditions experienced in the area they are located.

10A.7.18 EMERGENCY PROCEDURES

Following rupture of the CVCS in the Auxiliary Building, the applicable emergency operating procedure(s) would be implemented. The excess flow check valve would shut if the leak exceeded 200 $\pm$ 20 gpm to limit the severity of the casualty.

10A.7.19 SEISMIC AND QUALITY CLASSIFICATION

The letdown and charging lines are designed to withstand a SSE in combination with normal design loads. The lines are constructed to ANSI B31.7, Class II standards in the Auxiliary Building to the letdown heat exchanger, and from the charging pump discharge.

10A.7.20 DESCRIPTION OF ASSUMPTIONS, METHODS, AND RESULTS OF ANALYSIS FOR PRESSURE AND TEMPERATURE TRANSIENTS IN COMPARTMENTS

The locations of the postulated circumferential or longitudinal breaks are shown on Figure 10A.7-5. The flow from these breaks will cause the excess flow check valve, which is located inside the Containment, to close and immediately limit the release of the high energy fluid to the bypass flow of 10 gpm, which is not significant. Thus, a pressurization problem from this type of break cannot occur.

Information on temperature and pressure in the piping Penetration Room and in the letdown cooling heat exchanger compartment due to a critical crack in the CVCS letdown line was developed with the aid of the Bechtel computer code COPATTA. This computer program is described in Section 14.20.

The piping Penetration Room and the letdown heat exchanger compartment are adjoining rooms connected by a large opening above a shield wall. Therefore, for the purpose of evaluating the environmental consequences of pipe cracks, the two rooms can be considered as one.

The parameters used with COPATTA for this analysis are as follows:

Initial Room Conditions

Temperature	-	120°F
Pressure	-	14.7 psia
Humidity	-	50%
Volume	-	29000 ft^3

Heat Sinks (west piping Penetration Room)

Walls	-	5600 ft^2 of painted concrete
Floors	-	100 ft^2 of concrete
Grating	-	100 ft^2 of galvanized steel

The mass flow rate was chosen to be just under the value that would close the excess flow check valve. The assumed blowdown conditions are:

Mass blowdown	=	24.6 lbm/sec
Enthalpy	=	545.3 Btu/lbm

The pressure exceeds 0.5 psig in 0.75 seconds at which time the temperature is 111°F. When the pressure-actuated isolation valve closes 9 seconds later, the pressure reaches a maximum of 4.85 psig and the temperature reaches a maximum of 168°F. Section 10A.7.17 for discussion on the operation and control logic for the isolation valve.

10A.7.21 INTEGRITY OF THE CONTAINMENT STRUCTURE AND A PIPE RUPTURE OUTSIDE THE CONTAINMENT

Since the CVCS letdown line is only 2" in diameter, any forces acting upon the Containment Structure (Section 10A.7.8 for magnitude of jet impingement forces) will not be significant enough to impair the integrity of the prestressed concrete Containment Structures.

TABLE 10A-10

STRESSES IN STRUCTURAL COMPONENTS IN THE PIPE PENETRATION ROOM DUE TO PRESSURIZATION FROM POSTULATED RUPTURE OF LETDOWN LINE

STRUCTURAL COMPONENT	THICKNESS	CALCULATED STRESSES DUE TO PRESSURIZATION OF 4.85 psig COMPREHENSIVE TENSILE		RATIO OF CALCULATED STRESSES VS. ALLOWABLE STRESSES[(a)]	
		STRESS IN CONCRETE (psi)	STRESS IN REBAR (psi)	CONCRETE	REBAR
North-South Walls	3'0"	970	22,000	0.285	0.45
East-West Walls	2'0"	880	33,000	0.258	0.312
Ceiling EL 45'0"	2'3"	30	3,025	0.0265	0.0577

(a) Allowable stresses for the concrete are taken at 85% of the ultimate strength. Allowable stresses for the rebar are taken at 90% of the ultimate strength.