4.2 OVERPRESSURE PROTECTION SYSTEM

4.2.1 HIGH TEMPERATURE OVERPRESSURE

4.2.1.1 Design Basis

The RCS is structurally designed for operation at 2500 psia and 650°F (pressurizer 700°F). Operation of the system at 2250 psia nominal and 600°F will result in material stresses 90% of design values. An evaluation of the effect of the RSGs on the structural analysis was performed by BWC and Framatome Technologies, Inc. Detailed structural analyses have been performed by the component vendors and reviewed independently by CE for all portions of the system. Welding materials used have physical properties superior to the materials which they join. Inspection procedures and tests specified and independently reviewed by CE were carried out to ensure that pressure-containing components have the maximum integrity obtainable with present code-approved inspection techniques.

The RCS is protected against overpressure by two ASME B&PV Code approved safety valves which limit system pressure to a maximum of 110% of design and by two solenoid-operated relief valves. These valves are described in Section 4.2.1.2.

Portions of the piping for the Code approved safety valves are ASME Class 1, and thus require a fatigue analysis of the applicable thermal shock transients and other operational cycles. In addition to design cyclic transients a, d, and e of Section 4.1.1, the relief valve system fatigue analysis considers 100 events where the relief valves are operated. See Reference 1 for further details.

4.2.1.2 System Description

Valves

Parameters for the actuator-operated pressurizer spray valves are given in Table 4-16. The actuator-operated relief valve isolation stop valve parameters are given in Table 4-17. The position of each valve on loss of actuating signal (failure position) is selected to ensure safe operation of the system and plant. System redundancy is considered when specifying the failure position of any given valve. Valve position indication is provided at the main control panel where considered necessary to ensure safe operation of the plant.

Manually operated valves in the RCS have backseats to limit stem leakage when in the open position. Globe valves are installed with flow entering the valve under the seat. This arrangement will reduce stem leakage during normal operation or when closed.

The two augmented quality PORVs relieve sufficient pressurizer steam during abnormal transients to prevent opening of the RCS safety valves. The relief valves are actuated by the high RCS pressure trip signal. Parameters for these valves are given in Table 4-18.

The valves are solenoid-operated power relief valves. The two half-capacity valves are located in parallel pipes which are connected to the two pressurizer safety and relief valve nozzles on the inlet side, and to the relief line piping to the quench tank on the outlet side. A motor-actuated isolation valve is provided upstream of each of the relief valves to permit isolating the valve for maintenance or in case of valve failure.

The PORVs, block valves, and associated control systems are classified as augmented quality. The main control board wiring for the isolation motor-operated valves is not required to meet the electrical separation criteria for safety related circuits. The wiring configuration is in accordance with the guidance issued in NRC Generic Letter 90-06.

The capacity of the PORVs is sufficient to pass the maximum steam surge associated with a continuous CEA withdrawal incident starting from low power. Assuming that a reactor trip is effected on a high-pressure signal, the capacity of the PORVs is sufficient so that the safety valves do not open. The relief valve capacity is also large enough so that the safety valves do not open during a loss-of-load incident from full power. This assumes normal operation of the pressurizer spray system, and reactor trip on high pressure.

Two safety valves located on the pressurizer provide overpressure protection for the RCS. They are totally enclosed, back pressure compensated, spring-loaded safety valves meeting ASME B&PV Code requirements. The stress analysis on these valves included the effects of sudden opening of these valves, and support and restraint location were selected on this basis. Parameters for these valves are given in Table 4-19.

The safety valves pass sufficient pressurizer steam to limit the primary system pressure to 110% of design (2,750 psia) following a complete loss of turbine generator load without simultaneous reactor trip while operating at 2737 MWt. The reactor is assumed to trip on a high RCS pressure signal. To determine the maximum steam flow, the only other pressure relieving system assumed operational is the steam system safety valves. Conservative values for all system parameters, delay times, and core moderator coefficient are assumed. A safety valve technical summary report is required by ASME B&PV Code, Section III, 1968 Edition (Summer 1969 Addendum). The effect of the RSGs on the ability of the safety valves to limit the pressure to 110% of design was evaluated. It was determined that this criterion is still met with the RSGs.

Forged and stainless steel valves for use within the Reactor Coolant Boundary have been supplied by Velan Engineering of Montreal, Quebec. Velan has supplied valves to numerous nuclear projects in the United States. Examples include Yankee Rowe, Connecticut Yankee, Palisades, Fort Calhoun and Maine Yankee. No other pressure boundary components were designed or fabricated outside of the United States.

The following steps are taken during fabrication to ensure foreign procured components are acceptable. ASTM materials are specified and mill tests report are submitted to verify material. Non-destructive tests, ultrasonic and liquid penetrant, are performed on the pressure containing parts. Hydrostatic shell pressure and leak tests are performed to MSS-SP-61. Manufacturing sequence plans, non-destructive test technique procedures and testing procedures are all submitted by the vendor to the purchaser for review and approval prior to use. All tests are witnessed by quality control representatives of the purchaser in addition to the vendor's own inspection force.

<u>Quench Tank</u>

The quench tank is designed to prevent the discharge of the pressurizer relief or safety valves from being discharged to the containment. The steam discharged into the quench tank from the pressurizer is discharged under water by a sparger to enhance condensation. The normal quench tank water volume of 135 ft^3 is sufficient to condense the steam released from the pressurizer safety and relief valves. The steam released as a result of the uncontrolled rod withdrawal is based on no coolant letdown or pressurizer spray.

The water temperature rise in the quench tank is limited to 160°F, assuming a maximum initial water temperature of 120°F. The gas volume in the tank is sufficient to limit the tank pressure after the above steam release to approximately 85 psia. The quench tank is equipped with a demineralized water supply to cool the tank after a steam discharge into it.

The quench tank can condense the steam discharged during a loss-of-load incident as described in Section 14.5 without exceeding the rupture disc setpoint of 100 psig, assuming normal closing of the safety valves at the end of the incident. It is not designed to accept a continuous uncontrolled safety or relief valve discharge. The rupture disc vents to the containment atmosphere. The quench tank parameters are given in Table 4-21.

The tank normally contains demineralized water under a nitrogen overpressure. The sparger, spray header, nozzles and rupture disc fittings are stainless steel. The tank is designed and fabricated in accordance with ASME B&PV Code, Section III, Class C.

4.2.2 LOW TEMPERATURE OVERPRESSURE PROTECTION

Low temperature overpressure protection is provided at Calvert Cliffs by a combination of administrative controls and hardware provisions. The hardware provisions include the incorporation of a multiple setpoint capability in the PORV control circuitry and enabling the low temperature pressure setpoint of PORVs during low temperature operations. A microprocessor-based control unit provides either a variable setpoint that varies as a function of RCS temperature or a fixed setpoint, depending on plant conditions. Although the PORVs are the primary means of protection, it is desirable to avoid challenging them. Therefore, maintenance of administrative controls is integral to overpressure protection. Disabling components when unnecessary for plant operation will prevent their inadvertent actuation and therefore minimize their potential for causing overpressurization.

Operator action is also used to mitigate LTOP events. However, because operator action cannot always be assumed, and because possible equipment malfunctions must be considered, additional controls have been put in place to ensure adequate protection exists for all postulated events. Analyses have been performed which demonstrate that a combination of administrative controls and hardware modifications provide this protection. In general, this protection includes the following:

- Procedural precautions and controls;
- Disabling of non-essential components whenever LTOP is required [below Minimum Pressurization Temperature (MPT) enable temperature and RCS not vented];
- Maintenance of a non-solid system whenever practical; and
- Use of the variable or fixed setpoint in the PORV control logic.

Design Criteria

The basic criteria to be satisfied in determining the adequacy of overpressure protection is that no single equipment failure or operator error shall result in violation of the pressure-temperature (P-T) limits.

Design Events

Overpressurization analyses were performed as follows:

- The worst-case overpressurization scenarios were identified for both mass and energy addition events; and
- The effectiveness of the PORV to terminate an overpressurization event was evaluated.

RCS Mass Addition Analysis

The following mass addition events were postulated:

- Inadvertent high pressure safety injection (HPSI) pump start;
- Inadvertent HPSI and charging pump start; and
- Inadvertent mismatch of charging and letdown flow.

RCS Energy Addition Analysis

The following energy addition events were postulated:

- RCS expansion following loss of shutdown cooling, including SG heat addition;
- Inadvertent pressurizer heater actuation; and
- Energy addition from the SG secondary side to the RCS due to a start of an RCP when the SGs are at a higher temperature than the reactor vessel inventory.

Energy additions which are constant with time include inadvertent pressurizer heater actuation and decay heat addition. Also, all letdown flow paths which could mitigate or terminate a particular overpressurization event were assumed isolated. Hand calculations were sufficient to model the resulting transients.

The design events are:

- An RCP start with hot SGs; and
- An inadvertent HPSI actuation with concurrent charging.

Any measures which will prevent or mitigate the design events are sufficient for any of the less severe incidents.

A single PORV and the administrative controls will provide satisfactory control of all transients. Overpressurization due to the spurious actuation of full flow from a HPSI pump will be precluded at and below the MPT enable temperature by disabling two HPSI pumps, placing the third in pull-to-lock, and by throttling the third pump when used to add mass to the RCS. Lifting of the PORV on an RCP start will be precluded by placing administrative limitations on initial pressurizer pressure, secondary-to-primary temperature ΔT, and pressurizer level.

Operator Action

In each of the transient analyses, operator action was not credited for the first 10 minutes. The pressure alarms, in addition to other plant condition indications, will make the operator aware of the transient.

Single Failure

A single failure is considered in the overpressure mitigation system response to an initiating event.

The sensing/actuating/relieving system consists of two redundant and independent trains.

For the operational energy addition transient following an RCP start with a hot SG, the PORV setpoint will not be challenged for at least 10 minutes if specified initial conditions for the pump start are satisfied. In this case, failure of a PORV cannot result in overpressurization since the valve setpoint is not challenged. Failure to satisfy one of the initial conditions may result in opening one or both PORVs. In the case with a water solid system, pressure could exceed the Appendix G limits following an RCP start.

For the mass addition design basis event [one HPSI pump actuation], a single PORV and a pressurizer steam volume provides protection provided that two of the three HPSI pumps are disabled and the remaining pump's flow is throttled. If the single failure is a failure to throttle the HPSI pump while adding mass through one HPSI loop motor-operated valve, then two PORVs are capable to maintain the pressurization below Appendix G limits.

Pressure-Temperature Limits

The technical specification P-T limits, from which the heatup and cooldown curves were derived, were calculated per the requirements of 10 CFR Part 50, Appendix G as supplemented by ASME B&PV Code, 1986 Edition, Section III, Appendix G. Pressure-Temperature limits were calculated using adjusted reference temperatures (ARTs) developed from the guidance of RG 1.99, Revision 2. In addition, these P-T limits were corrected for pressure drops and for pressure and temperature instrument uncertainties.

The low temperature PORV pressure lift setpoint is based on protecting the most restrictive pressure of both the heatup and cooldown curves.

The LTOP enable temperature (MPT enable) has been developed using the guidance found in Nuclear Regulatory Commission Standard Review Plan (SRP) 5.2.2, Revision 2. This SRP defines MPT enable as "the water temperature corresponding to a metal temperature of at least RT_{NDT} + 90°F at the beltline location (1/4 T or 3/4 T) that is controlling the Appendix G limit calculations." MPT enable temperature was calculated accordingly by using specific heatup transients with changing thermal rates to accurately determine stress distributions.

Seismic and IEEE-279 Design Criteria

The PORV installation meets seismic criteria consistent with the basic objective of preventing a LOCA pathway. In addition, LTOP mitigating system equipment is designed such that their failure will not degrade the performance of other safety-related equipment.

In addition, the intent of IEEE-279 criteria is met for the reliability and effectiveness of the mitigating system in that a single failure which initiates an overpressurization event does not disable the mitigating system.

Power is supplied to the PORVs from vital supplies. Cable raceways for this equipment are supported to withstand a seismic event.

The low temperature overpressure protection (LTOP) controls are also used to prevent and mitigate overpressure events in the shutdown cooling system (Section 9.2.6).

Testability

The LTOP system is designed to be tested with a frequency that will ensure the system is operable when needed.

4.2.3 REFERENCE

1. Bechtel Specification 6750-M-0310E, "Design Specification for Piping, Valves, and Associated Equipment of the Pressurizer Relief System"

TABLE 4-16

ACTUATOR-OPERATED THROTTLING VALVE PARAMETERS

Service - Pressurizer Spray Valves	
Design Temperature, °F	650
Design Pressure, psia	2,500
Flow, gpm	375
Pressure Drop, psi	8.5 - 40
Failure Position	Fail Closed

TABLE 4-17

ACTUATOR-OPERATED STOP VALVE PARAMETERS

Service - Pressurizer Power-Operated Relief Isolation

Design Temperature, °F	675
Design Pressure, psia	2,500
Actuator	Electric Motor
Failure Position	As Is
ANSI Class	1,703 lb

TABLE 4-18

PRESSURIZER POWER-OPERATED RELIEF VALVE PARAMETERS

Design Pressure, psia	2,500
Design Temperature, °F	700
Fluid	Saturated Steam, 0.1% (wt) Boric Acid
Number	2
Capacity, lb/hr min. Each	153,000
Type	Solenoid Operated
Set Pressure, psig	2,385
Failure Position	Fail Closed

TABLE 4-19

PRESSURIZER SAFETY VALVE PARAMETERS

Design Pressure, psia	2,500
Design Temperature °F	700
Fluid	Saturated Steam, 0.1% (wt) Boric Acid
Set Pressure	
RC-200, psig	2,485
RC-201, psig	2,510
Capacity, lb/hr, at set pressure	
RC-200	296,068[a]
RC-201	299,065
Type	Spring loaded-balanced bellows, enclosed bonnet
Accumulation, %	3
Back Pressure Compensation	Yes

[a] Rated capacity is based on valve area at accumulation pressure (set pressure plus 3%).

TABLE 4-21

QUENCH TANK PARAMETERS

Design Pressure, psig	100
Design Temperature, °F	350
Normal Operating Pressure, psig	3
Normal Operating Temperature, °F	120
Internal Volume, ft^3	217
Normal Water Volume, ft^3	135
Normal Gas Volume, ft^3	82
Blanket Gas	Nitrogen
Manway (1 ea.) in.	16
Nozzles	
Pressurizer discharge (1 ea) nominal, in.	10
Demineralized water (1 ea) in.	2
Rupture Disc (1 ea) in.	18
Drain (1 ea) in.	2
Temp. Instrument (1 ea) in.	1
Level Instrument (2 ea) in.	1/2
Vent (1 ea) in.	1 ½
Vessel Material	ASTM A240, TP 304
Dimensions	
Overall Length, in.	144 3/8
Outside Diameter, in.	60
Dry Weight, lb	4600
Flooded Weight, lb	18,120