CHAPTER 6 ENGINEERED SAFEGUARDS

6.1 DESIGN OBJECTIVES

The design, fabrication, inspection, and testing provisions of the various components and systems of this reactor plant are engineered with the prime objective of creating a facility that is completely reliable under all anticipated conditions of operation. In addition, several systems have been included in the overall design that serve as protection in the unlikely event of a major accident that might result in a potential release of radioactivity.

In a pressurized water reactor system, the accident that would present the largest potential for release of radioactivity is a loss of reactor coolant. However, should this happen, protection systems perform four types of functions: a) cool the core and thereby limit release of fission products from the reactor fuel into the containment, b) block potential leakage paths from the containment vessel, c) reduce the fission product concentration in the containment, and d) minimize the leakage from the containment by reducing the pressure driving force.

Routine periodic testing of the engineered safeguards components and all necessary support systems is intended. If such a test indicates a need for corrective maintenance, the redundancy of equipment in these systems permits maintenance to be performed in areas of most frequent anticipated need without shutting down or reducing load under prescribed conditions. These conditions would require that the component under repair be restored to service within a specified period of time, and that the remaining complement of equipment be demonstrated capable of functioning according to minimum system performance standards during the period.

The design objectives and the types of systems provided are presented herein to outline the philosophy used in the selection and design of engineered safeguards systems. The results of typical analyses are presented in Chapter 12.

6.2 GENERAL DESCRIPTION

The engineered safeguards systems incorporated in the design of this plant and the functions they serve are:

a) The safety injection system, which injects borated water into each reactor coolant loop. This system limits damage to the core and limits the energy and fission products released into the containment following a loss-of-coolant accident.

b) A steel-lined, concrete containment vessel consisting of a reinforced concrete cylindrical wall and reinforced concrete base and dome, with continuously pressurized, double penetrations and liner weld channels and an Isolation Valve Seal Water System. These form a virtually leak-tight barrier to the escape of fission products should a loss of coolant occur. Refer to Chapter 5 for detailed description of the containment system.

c) The air recirculation coolers and filters which reduce containment pressure and filter particulate matter following the loss-of-coolant accident.

d) The containment spray equipment which is used to reduce containment pressure and remove iodine from the containment atmosphere.

Diesel emergency power is provided for the engineered safeguards loads in the event of failure of station auxiliary power. Thus, even if commercial power to the station is lost concurrent with an accident, power is available for the engineered safeguards from redundant emergency power sources, which in their minimum operational status are capable of supplying the following engineered safeguards load which assure protection of the public health and safety for any loss-of-coolant accident.

a) Residual Heat Removal Pump

b) High Head Safety Injection Pumps (2)

c) Service Water Pumps (2)

d) Containment Air Recirculation Cooler Unit Fans (3)

e) Component Cooling Water Pump

f) Containment Spray Pump

g) Charging Pump

h) Primary Auxiliary Building Ventilation Fans ( )

i) Air Compressor

j) Auxiliary Feedwater Pump

All of the above units except the component cooling water pump, the charging pump and the primary auxiliary building fans and air compressor are automatically started in sequence after a loss-of-coolant accident. The service water pumps and the air recirculation fans are normally running during power operation and would be transferred in sequence to emergency power in the event of loss of outside power.

All components necessary for proper operation of the safeguards system are operable from the control room. In addition, sufficient local control is provided to maintain the plant in a safe condition if the control room is uninhabitable.

6.2.1 SAFETY INJECTION SYSTEM

6.2.1.1 Design Basis

The primary purpose of the safety injection system is to supply borated water to the reactor coolant system to limit fuel rod clad temperatures in the unlikely event of a loss of reactor coolant.

Operation of the safety injection system prevents melting of fuel cladding and limits the metal-water reaction to an insignificant amount for reactor coolant piping ruptures up to and including the double-ended severance of a reactor coolant loop. This ensures that the core will remain intact and in place, with its essential heat transfer geometry preserved.

6.2.1.2 Safety Injection Systems Reliability Criteria

To meet the systems design objectives, the following reliability criteria have been established:

a) Borated cooling water is to be supplied to the core through separated and redundant flow paths.

b) Loss of injection water through a severed reactor coolant loop or safety injection branch line will be considered. (For the double-ended severance of a reactor coolant loop, loss of all safety injection water delivered to that loop is assumed. For rupture of an injection branch line between the loop and check valve, an allowance for spilling of injection water, is determined according to the calculated back pressure on each injection line.)

c) Natural phenomena characteristic of the site will be considered. (All associated components, piping, structures, power supplied, etc. are designed to Class I seismic criteria.)

d) Layout and structural design will specifically protect the injection paths leading to unbroken reactor coolant loops against damage as a result of the maximum reactor coolant pipe rupture. (Single injection lines penetrate the missile barrier, with injection headers located in the missile-protected area. Individual injection lines are connected to the injection header, pass through the barrier and then connect to the loops. Separation of the individual injection lines is provided to the maximum extent practicable. Movement of the injection line associated with a rupture of a reactor coolant loop is accommodated by line flexibility and by the design of the pipe supports such that no damage beyond the missile barrier is possible.)

e) Response of the injection systems will be automatic, with appropriate allowances for delays in actuation of circuitry and active components. Operation of the accumulators is self-initiated upon loss of reactor coolant system pressure. The active portion of the injection system are automatically actuated by coincidence of low pressurizer water level and low pressurizer pressure signals. In addition, manual actuation of the entire injection system and individual components can be accomplished from the control room. In analysis of system performance, delays in reaching the programmed trip points and in actuation of components are conservatively established on the basis that only emergency plant power will be available.

f) Redundancy of instrumentation, components and systems will be incorporated, to assure that postulated malfunctions will not impair the ability of the sytems to meet the design objectives. The system will be effective in the event of loss of normal station auxiliary power coincident with the loss of coolant, and will be tolerant of failures of a single component or instrument channel to respond actively in each system.

g) In addition to manufacturer's performance tests and preoperational test results, provisions for periodic tests will be capable of demonstrating the state of readiness and functioning capability of the injection systems. (The systems, including their power supplies, are designed to permit complete demonstration of readiness and functioning capability when the reactor is operating at power or at a hot shutdown.)

6.2.1.3 System Design

The safety injection system arrangement is shown on Figure 6-1.

The principal components of the safety injection system which provide emergency core cooling following a loss of coolant are the four accumulator tanks, the three high head safety injection pumps, and the two low head residual heat removal pumps of the auxiliary coolant system. The safety injection pumps and the residual heat removal pumps are located in the auxiliary building and take suction directly from the refueling water storage tank located adjacent to the auxiliary building. The accumulator tanks are located in the containment structure, protected by a missile barrier from damage by the reactor coolant system piping and components.

The accumulator tanks and the residual heat removal pumps discharge into the cold legs of the reactor coolant piping, thus assuring core cooling by rapidly restoring the water level to a point above the top of the core.

The safety injection pumps deliver borated water to the reactor vessel by way of two cold legs and two hot legs. This injection flow augments the head and flow of the accumulator tanks and the residual heat removal pumps. The recirculation pumps are aligned to take suction from the containment sump after a sufficient volume of water has been transferred from the refueling water storage tank. The safety injection pumps and containment spray headers can be supplied from the containment sump in series with the recirculation pumps via bypass lines from the discharge of the residual heat exchangers.

The design capacity of the accumulator tanks is based on one of the four tanks spilling (i.e. that tank connected to the ruptured loop) with the remaining three containing sufficient water to fill the volume outside of the core barrel below the nozzles, the bottom plenum and one half the core.

The capacity of the refueling water storage tank is based on the requirement for filling the refueling canal and is approximately 350,000 gallons. This capacity provides a sufficient amount of borated water to assure:

a) A volume sufficient to refill the reactor vessel above the nozzles, plus

b) The volume of borated refueling water needed to increase the concentration of initially spilled water to a point that assures no return to criticality with the reactor at cold shutdown and all control rods, except the most reactive RCC assembly, inserted into the core.

The water in the tank is borated to a concentration which assures reactor shutdown by approximately 10% when all RCC assemblies are inserted and when the reactor is cooled down for refueling.

6.2.1.4 System Operation

The principal components of the accumulator subsystem are the tanks, one for each reactor coolant loop, located inside the reactor containment vessel. The tanks discharge into the cold leg of their respective loops through the same connections provided for the residual heat removal pump injection lines.

The tanks are initially charged with borated water at refueling water concentration, and pressurized by nitrogen gas at a pressure of about 650 psi. During normal plant operation the minimum allowed tank pressure is 600 psi, and each tank is isolated from the Reactor Coolant System by two check valves in series. Should the reactor coolant system pressure fall below the accumulator pressure, the check valves will open and the pressure difference between the tanks and the reactor will drive borated water into the reactor.

A remotely operated isolation valve is provided at the accumulator discharge. This valve is normally open, but would be closed when:

1. The reactor is purposely depressurized below accumulator pressure.
2. It is desired to test the seating effectiveness of the injection line check valve by depressurizing the pipe between that check valve and the accumulator and measuring water flow into the test line.
3. There is excessive leakage through the check valves. This is expected to be an unusual condition, not an intended normal mode of operation. The accumulator system is designed for plant operation with check valve leakage in excess of that which would be expected to occur in normal service.

During (2) or (3) the plant would be protected by redundant signals (SIS actuation) which would open any such valve should it be closed. Should closure for item (3) be required an orderly shutdown would be scheduled at the earliest convenient time for repair of the check valve.

Provisions are made for remotely adjusting level within the tanks without affecting normal plant operations. Samples of the solution in the tanks may be taken in order to check the boron concentration in the water.

Accidental release of the gas charge in the tanks would cause an increase in the containment pressure of less than 0.1 psi.

The remainder of the Safety Injection System is actuated by coincidence of low pressurizer pressure and low pressurizer water level. The safety injection signal opens the Safety Injection System isolation valves and starts the high head safety injection pumps and low head residual heat removal pumps. The items on Figure 6-1 marked with an "S" receive the safety injection signal. A volume control tank low level signal shifts the charging pump suction from the volume control tank to the refueling water storage tank. Suction for the high head safety injection pumps and residual heat removal pumps is always aligned to the refueling water storage tank when the reactor is in operation.

After the reactor coolant system has been cooled and depressurized through secondary steam dump and safety injection operation, coolant spilled from the break is cooled and returned to the reactor coolant system. In this mode of operation, the recirculation pumps take suction from the reactor containment sump, circulate the spilled coolant through the residual heat exchangers and return the coolant to the reactor or to the spray headers. This system is entirely located within the containment. Alternatively, the safety injection pumps can be supplied from the residual heat exchanger outlet if required.

Testing:

The operation of the remote stop valves in the accumulator tank discharge lines may be tested by opening the remote test valve just downstream of the stop valve. Flow through the test line can be observed on existing instruments and the opening and closing of the discharge line stop valve may be sensed on this instrumentation. Remote position indicators are provided in the control room and will alarm when the valve is off the full-open position. Test circuits are provided for periodic examination of the leakage back through the check valves and to ascertain that these valves seat whenever the reactor system pressure is raised.

The boron concentration may be sampled periodically using the sample tap provided.

The active components of the Safety Injection Systems can be actuated any time during plant operation when the reactor coolant pressure is higher than 1500 psig.

The main actuation relays are tripped manually in this test and all valves and pumps associated with the injection signal are actuated automatically. The starting of the high head safety injection and residual heat removal pumps can be checked in this manner. Operation of the system verifies the proper functioning of relays and circuit breakers between the main relays and pumps and valves in the system.

Pump operation is verified by observation of pump motor ammeters and discharge header pressure indication. Each pump will approach shutoff head on minimum flow recirculation. No flow will be delivered to the reactor coolant system to disturb normal plant operation since reactor coolant system operating pressure exceeds the shutoff head of the injection system pumps. All remote operated valves can be exercised and actuation circuits can be tested periodically during plant operation. Proper operation of valves is indicated with position indicating lights on the control panel..

The high-head safety injection pumps and residual heat removal pumps can also be tested individually during plant operation using minimum flow recirculation lines.

The injection piping up to the final isolation valve is maintained full of borated water at refueling concentration while the plant is in operation. This concentration will be checked periodically by sampling. The lines will be refilled with borated water as required by using the various system pumps to recirculate refueling water through the injection lines.

Component Redundancy:

a) Accumulator tanks:
One accumulator per loop is provided; system and containment evaluations are based on three accumulators delivering to the core and one spilling from the ruptured loop.

b) Pumps:
1) Safety Injection
Three pumps are provided;
System and containment evaluations are based on the operation of two.

2) Residual Heat Removal
Two pumps are provided;
System and containment evaluations are based on operation of one.

c) Automatically operated valves:

1) High head safety injection line isolation at the loop
   Four lines with a valve in each line are provided;
   Three out of four are assumed to open and no other components in the high head trains fail.

2) Residual heat removal pump isolation
   Two lines with one valve are provided;
   One of the two is assumed to open.

3) Accumulator tank stop valves
   One valve per tank is provided to operate in the normal open position.

d) Valves operated from the control room for recirculation:

1) Containment sump internal recirculation isolation
   Two lines with valve in each are provided;
   One valve is required to open for recirculation.

2) Safety injection pump suction valves at residual heat exchanger discharge
   Two are provided in parallel;
   One is required to open.

3) Isolation valves on the miniflow line returning to refueling water storage tank
   Two valves are installed in series;
   One is required to close.

4) Isolation at suction header from refueling water storage tank
   One valve is provided and is closed;
   Redundancy is provided by the check valve.

Signal Redundancy:

The initiation of the safety injection system provided for loss-of-coolant accidents is accomplished from redundant signals derived from reactor coolant system instrumentation. Each of three pressurizer water level and three pressurizer pressure instruments sends a signal to a relay matrix which develops a safety injection and trip signal when either two-out-of-three low pressurizer pressure signals are received and two-out-of-three low pressurizer water level signals are received in coincidence. Channel independence is carried throughout the system from the sensors to the signal output relays including the power supplies for the channels. The redundancy of the circuit allows checking of the operability and calibration of each channel at any time. Removal or bypass of one signal channel places that circuit in the half-tripped mode.

Test Locations and Monitors:

The permanent test lines for the safety injection and residual heat removal loops are indicated on Figure 6-1. The test loops are located so that all components up to the isolation valve at the Reactor Coolant System may be tested. These isolation valves are checked separately. Flow in each of the loops is monitored by a local flow indicator in each of the test lines. Pressure and flow instrumentation is also provided for the main flow paths of the high head and residual heat removal pumps. Redundant level and pressure instrumentation are provided for each accumulator tank.

6.2.1.5 Components

The preliminary design parameters described below are subject to change based on subsequent detailed design analyses.

a) Accumulator Tanks

The tanks are carbon steel lined with a corrosion resistant material and designed to ASME Section III, Class C. The charging gas is nitrogen and the borated water is driven by the expansion of the contained gas charge. Connections for remotely venting or charging the gas space and for remotely draining or filling the fluid space, during normal plant operation, are provided.

The preliminary design parameters are given in Table 6-1.

TABLE 6-1

ACCUMULATOR TANKS PRELIMINARY DESIGN PARAMETERS

Number	4
Type	Stainless steel clad carbon steel
Design Pressure	700 psig
Design Temperature	300°F
Operating Temperature	100-150°F
Normal Pressure	660 psig
Total Volume	1100 ft^3
Normal Water Volume	774 ft^3

b) Safety Injection System Pumps

Three high-head safety injection pumps supply borated water to the Reactor Coolant System. The pumps are horizontal centrifugal type, driven by electric motors. Parts of the pump in contact with borated water are stainless steel or equivalent corrosion resistant material. A minimum flow bypass line is provided on each pump discharge to recirculate flow to the refueling water storage tank in the event the pumps are started with the normal flow paths blocked by closed valves. Table 6-2 presents the preliminary design parameters of these pumps.

TABLE 6-2

SAFETY INJECTION PUMP DESIGN PARAMETERS

Design Pressure	1750 psig
Design Temperature	300°F
Design Flow Rate	400 gpm
Design Head	2500 ft.
Min. Shutoff Head	3500 ft.

The two residual heat removal pumps, described in the section on Auxiliary Coolant System, are utilized as the low head subsystem. Table 6-3 presents the preliminary design parameters for these pumps.

TABLE 6-3

RESIDUAL HEAT REMOVAL PUMP DESIGN PARAMETERS

Design Pressure	600 psig
Design Temperature	400°F
Design Flow Rate	3000 gpm
Design Head	350 ft.

The high head safety injection and residual heat removal pumps will all be constructed of austenitic stainless steel or materials of equal corrosion resistance. The pressure containing parts of each pump will be static castings conforming to ASTM A-351 Grade CF8 or CF8M. Stainless steel forgings will be procured per ASTM A-182 Grade F304 or F316 or ASTM A-336, Class F8 or F8M, and stainless plate will be constructed to ASTM A-240, Type 304 or 316. All bolting material will conform to ASTM A-193. Materials such as weld-deposited Stellite or Colmonoy will be used at points of close running clearances in the pumps to prevent galling and to assure continued performance ability in high velocity areas subject to erosion.

All pressure containing parts of the pumps will be chemically and physically analyzed and the results will be checked to ensure conformance with the applicable ASTM specification. In addition, all pressure containing parts of the pump will be liquid penetrant inspected in accordance with Appendix VIII of Section VIII of the ASME Boiler and Pressure Vessel Code. The acceptance standard for the liquid penetrant test will be USA S.I. B31.1, Code for Pressure Piping, Case N-10.

The pump design is reviewed with special attention to the reliability and maintenance aspects of the working components. Specific areas include evaluation of the shaft seal and bearing design to determine that adequate allowances have been made for shaft deflection and clearances between stationary parts.

Should welding of one pressure containing part to another be necessary, a welding procedure including joint detail will be submitted for review and approval by Westinghouse. The procedure must include evidence of qualification necessary for compliance with Section IX of the ASME Boiler and Pressure Vessel Code Welding Qualifications. This requirement will also apply to any repair welding performed on pressure containing parts.

In addition to the above requirements, these welds must be radiographed in accordance with Paragraph UW-51 of Section VIII of the ASME Boiler and Pressure Vessel Code, and subsequently liquid penetrant inspected in accordance with Appendix VIII of Section VIII of the ASME Code. The acceptance standard for the liquid penetrant test will be USA S.I. B31.1, Case N-10.

The pressure-containing parts of the pump will be assembled and hydrostatically tested in accordance with Paragraph UG-99 of Section VIII of the ASME Code with the additional requirement that the test pressure shall be held for 30 minutes. This test will be witnessed by qualified Westinghouse personnel, and Consolidated Edison Company personnel or its agents, and any leakage is cause for rejection.

Each pump will be given a complete shop performance test in accordance with Hydraulic Institute Standards. The pumps will be run at design flow and head, shut-off head and three additional points to verify performance characteristics. When NPSH is critical, this value will be established at design flow by means of adjusting suction pressure.

c) Valves

All parts of the safety injection valves in contact with borated water are austenitic stainless steel or equivalent corrosion resistant material. The motor operators on the injection isolation valves are capable of rapid operation. All valves required for initiation of safety injection or isolation of the system have remote position indication in the control room.

All throttling control valves and remotely motor operated stop valves, regardless of size, are provided with double-packed stuffing boxes with stem leakoff connections. Leakoff connections are provided on the motor-operated isolation valves and control valves on lines which contain reactor coolant.

The check valves which isolate the Safety Injection System from the Reactor Coolant System are installed immediately adjacent to the reactor coolant piping to reduce the probability of a safety injection line rupture causing a loss-of-coolant accident.

A relief valve is installed on the safety injection pump discharge header discharging to the pressurizer relief tank to prevent overpressure in the lines which have a lower design pressure than the Reactor Coolant System. The relief valve is set at the design pressure of the Safety Injection System discharge piping.

The gas relief valve on the tanks protects the accumulators from pressures in excess of the design values.

Motor Operated Valves:

The pressure containing parts (Body, bonnet and discs) of the valves employed in the Safety Injection System are designed per criteria established by the ASA 16.5 or MSS SP66 specifications. The materials of construction for these parts are procured per

ASTM A182 F316 or A351 GR CF8M. All material in contact with the primary fluid, except the packing, will be austenitic stainless steel or equivalent corrosion resisting material. The pressure containing components are subject to radiographic inspection as outlined in ASTM E-71 Class 1 or Class 2. The body, bonnet and discs are subject to a liquid penetrant inspection conducted in accordance with ASME Boiler and Pressure Vessel Code Section VIII, Appendix VIII. The liquid penetrant acceptable standard is as outlined in USA S.I. B31.1 Case N-10.

The body-to-bonnet joint is designed per ASME Boiler and Pressure Vessel Code Section VIII or USA S.I. B16.5 with a fully trapped, controlled compression, spiral wound asbestos gasket with provisions for seal welding. The body-to-bonnet joint may also be of the pressure seal design with provisions for seal welding. The body-to-bonnet bolting and nut materials are procured per ASTM A193 and A194, respectively.

The entire assembled unit is subject to a hydrotest as outlined in MSS SP-61 with the exception that the test is maintained for a minimum period of 30 minutes per inch of wall thickness. Any leakage is cause for rejection. Special attention is paid to the seating surface design. The units are constructed principally with a venturi design. The venturi design reduces the seating area, hydraulic unbalance, and stroking distance. The seating design is of the Darling parallel disc design or the Crane flexible wedge design or equal. These designs have the feature of releasing the mechanical holding force during the first increment of travel. Thus, the motor operator has to work only against the frictional component of the hydraulic unbalance on the disc and the packing box friction. The discs are guided throughout the full disc travel to prevent chattering and provide easy gate hauling. The seating surfaces are hard faced (Stellite No. 6 or equivalent) to prevent galling and reduce wear.

The stem material is ASTM Type 316 condition B or precipitation hardened 17-4 pH stainless procured and heat treated to Westinghouse Specifications. These materials were selected because of their corrosion resistance, high tensile properties, and their resistance to surface scoring by the packing. The packing material is John Crane 187-I or equal. The valve stuffing box is designed with a lantern ring leak-off connection with a minimum of a full set of packing below the lantern ring and a maximum of one-half of a set of packing above the lantern ring; a full set of packing is defined as a depth of packing equal to 1-1/2 times the stem diameter. The experience with this stuffing box design and the selection of packing and stem materials has been very favorable in both conventional and nuclear power plants.

The motor operator, usually "Limitorque", is extremely rugged and is noted throughout the power industry for its reliability. The unit incorporates a "hammer blow" feature that allows the motor to impact the discs away from the fore or backseat upon opening or closing. This "hammer blow" feature assists the motor to attain its operational speed. During safety injection valve opening or closing, all limit switches and torque switches are removed from the control circuit and the operator strokes the valve without any protection against motor overload. The torque and limit switch control is reinserted at approximately 1/2 inch from the opposite position. The philosophy is that the valve will be stroked with no regard for the protection of the motor operator.

The valve is assembled, hydrotested, seat leakage tested (fore and back), operational tested, cleaned and packaged per specifications. All manufacturing procedures employed by the valve supplier such as hard facing, welding, repair welding and testing must be submitted for approval.

Manual Valves:

The stainless steel manual globe, gate and check valves are designed and built per the requirement outlined in the motor operated valve description above.

The carbon steel valves are built per USA S.I. B16.5 or MSS SP-66. The materials of construction of the body, bonnet and disc are procured per ASTM A105 Grade II, A181 Grade II or A216 Grade WCB or WCC. If the valves are required to pass radioactive fluids and have an USA S.I. rating above 150 psig, they shall follow the same quality control as outlined for the stainless steel valves. If the valves pass non-radioactive fluids, they will be subjected to hydrostatic tests as outlined in MSS SP-61 except that the test pressure shall be maintained for at least 30 minutes per inch of wall thickness.

The general design philosophy established for the design of the stainless steel valves is followed during the design of the carbon steel equipment. However, since the fluid controlled by the carbon steel valves is not radioactive, the double packing and seal weld provisions will not be provided.

d) Piping

All Safety Injection System piping in contact with borated water will be austenitic stainless steel. Piping joints are welded except for the flanged connections at the safety injection pumps.

The piping beyond the accumulator tank stop valves will be designed for reactor coolant system conditions (2485 psig, 650°F). All other piping connected to the accumulator tanks will be designed for 700 psig and 200°F.

The safety injection pump suction piping (300 psig at 300°F) from the refueling water storage will be is designed for low pressure losses to meet NPSH (net positive suction head) requirements of the pumps.

The high pressure injection branch lines (1500 psig at 300°F) will be designed for high pressure losses to limit the flow rate out of the branch line which may have ruptured at the connection to the reactor coolant loop. The branch lines are sized so that such a break will not result in a violation of the design criteria for the Safety Injection System.

The piping will be designed to meet the minimum requirements set forth in (1) the USA S.I. B31.1 Code for Pressure Piping, (2) Nuclear Code Case N-7, (3) USA S.I. Standards B36.10 and B36.19, (4) ASTM Standards, and (5) supplementary plus additional quality control measures delineated in Westinghouse specifications.

Minimum wall thicknesses are determined by the USA S.I. Code formula found in the power piping Section 1 of the USA S.I. Code for Pressure Piping. This minimum thickness is increased to account for (1) the manufacturer's permissible tolerance of minus 12-1/2 per cent on the nominal wall, and (2) a 10 per cent allowance for wall thinning on the external radius during any pipe bending operations in the shop fabrication of the subassemblies. Purchased pipe and fittings will have a specified nominal wall thickness that is no less than the sum of that required for pressure containment, mechanical strength, manufacturing tolerance, and an allowance for wall thinning associated with shop bending.

Thermal and/or seismic piping flexibility analyses will be performed as required. The necessity and extent of such analyses will be determined as a result of a thorough review of the final piping layout. Special attention will be directed to the piping configuration at the pumps with the objective of minimizing pipe imposed loads at the suction and discharge nozzles.

Pipe and fitting materials will be procured in conformance with all requirements of the latest ASTM and USA S.I. specifications or standards. All materials will be verified for conformance to specification and documented by certification of compliance to ASTM material requirements. Specifications will impose additional quality control upon the suppliers of pipes and fittings as listed below.

1. Check analyses will be performed on both the purchased pipe and fittings. Supplementary requirement S1 will be performed on pipe purchased to ASTM A312 and ASTM A376 and supplementary requirement S1 will be performed on fittings purchased to ASTM A403.

2. Pipe branch lines between the reactor coolant pipes and the isolation stop valves will be purchased to ASTM A376 and the supplementary requirements S2 and S6 covering transverse tension tests and ultrasonic tests, respectively.

3. Fittings will be purchased to the specified requirements of ASTM A403 plus the performance of tension tests as defined by supplementary requirement S2.

Shop fabrication of piping subassemblies will be performed by reputable suppliers in accordance with specifications which define and govern material procurement, detailed design, shop fabrication, cleaning, inspection, identification, packaging and shipment.

All welds in run sizes 2-1/2" and larger will be of full penetration design. Reducing tees will be used where the branch size exceeds 1/2 of the header size. Branch connections of sizes that are equal to or less than 1/2 of the header size will be of a design that complies to the USA S.I. rules for reinforcement set forth in the USA S.I. B31.1 Code for Pressure Piping. Bosses for branch connections will be attached to the header by means of full penetration welds.

All welding will be performed by welders and welding procedures qualified in accordance with the ASME Boiler and Pressure Vessel Code Section IX, Welding Qualifications. The Shop Fabricator will be required to submit all welding procedures and evidence of qualifications for review and approval prior to release for fabrication. All welding materials used by the Shop Fabricator must have prior approval.

Butt welds will be radiographically examined in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, paragraph UW-51. In addition, butt welds will be liquid penetrant examined in accordance with the procedure of ASME B&PV Code, Section VIII, Appendix VIII and the acceptance standard as defined in the USA S.I. Nuclear Code Case N-10. Finished branch welds will be liquid penetrant examined on the outside and where size permits, on the inside root surfaces.

A post-bending solution anneal heat treatment will be performed on cold and hot-formed stainless steel pipe bends. Completed bends will then be completely cleaned of oxidation from all effected surfaces. The Shop Fabricator will be required to submit the bending, heat treatment and clean-up procedures for review and approval prior to release for fabrication. Cleaning by acid pickling is not permitted.

General cleaning of completed piping subassemblies (inside and outside surfaces) will be governed by basic ground rules set forth in the specifications. For example, these specifications prohibit the use of hydrochloric acid and limit the chloride content of service water and demineralized water.

Packaging of the piping subassemblies for shipment will be done so as to preclude damage during transit and storage. Openings will be closed and sealed with tight-fitting covers to prevent entry of moisture and foreign material. Flange facings and weld end preparations will be protected from damage by means of wooden cover plates and securely bolted and/or fastened in position. The packing arrangement proposed by the shop fabricator is subject to approval.

e) Component Supports

For the hypothetical double-ended severance of a reactor coolant pipe, the functional integrity of the Safety Injection System connections to the remaining reactor coolant loops will not be impaired. This integrity will be established and maintained by the application of the following design criteria:

(1) The reactor vessel, steam generators and pumps will be supported and restrained to limit their movement under pipe break conditions (including a double-ended main pipe rupture) to a maximum amount which will ensure the integrity of the steam and feedwater piping. The safety injection piping in the intact loops will be designed to accommodate the limited movement of the loop components without failure. The coolant loop supports are designed to restrict the motion to about one-tenth of an inch, whereas the attached safety injection piping can sustain a 3-inch displacement without exceeding the working stress range.

(2) The safety injection piping serving each loop will be anchored at the missile barrier in each loop area to restrict potential accident damage to the portion of piping beyond this point. The anchorage will be designed to withstand without failure, the thrust force on the safety injection branch line severed from the reactor coolant pipe and discharging safety injection fluid to atmosphere, and to withstand a bending moment equivalent to that which produces failure of the safety injection piping under the action of free end discharge to atmosphere or motion of the broken reactor coolant pipe to which the safety injection piping is connected. This will prevent possible failure upstream from the support point where the branch line ties into the safety injection piping header.

All hangers, stops and anchors will be designed in accordance with USA S.I. B31.1 Code for Pressure Piping and ACI 318 Building Code Requirements for Reinforced Concrete which provide minimum requirements on materials, design and fabrication with ample safety margins for both dead and dynamic loads over the life of the equipment. Specifically, these standards require the following:

(1) All materials used will be in accordance with ASTM specifications which establish quality levels for the manufacturing process, minimum strength properties, and for test requirements which ensure compliance with the specifications.

(2) Qualification of welding processes and welders for each class of material welded and for types and positions of welds.

(3) Maximum allowable stress values are established which provide an ample safety margin on both yield strength and ultimate strength.

f) Heat Exchangers

The Residual Heat Exchanger and the Component Cooling Heat Exchangers will meet all the requirements of the ASME Boiler and Pressure Vessel Code, Section III, "Nuclear Vessels. The residual heat exchanger is a Class A vessel on the tube side and Class C on the shell side. The component cooling heat exchanger is a Class C vessel. The Code has strict rules regarding the wall thicknesses of all pressure containing parts, material quality assurance provisions, weld joint design, radiographic and liquid penetrant examination of materials and joints, and hydrostatic testing of the unit as well as requiring final inspection and stamping of the vessel by a Code inspector.

The designs of the heat exchangers will also conform to the requirements of TEMA (Tubular Exchanger Manufacturers Association) for Class R heat exchangers. Class R is the most rugged class of TEMA heat exchangers and is intended for units where safety and durability is required under severe service conditions. Items such as: tube spacing, flange design, nozzle location , baffle thickness and spacing, and impingement plate requirements are set forth by TEMA Standards.

In addition to the above, additional design and inspection requirements will be imposed to ensure rugged, high quality heat exchangers such as: confined-type gaskets, main flange studs with two nuts on each end instead of one to insure permanent leak tightness, nozzles designed to withstand any load adjacent piping may impose on them, general construction and mounting brackets suitable for the plant seismic design requirements, tubes and tube sheet(s) capable of withstanding full secondary side pressure and temperature with atmospheric pressure on the primary side, ultrasonic inspection in accordance with Paragraph N-324.3 of Section III of the ASME Code of all tubes before bending, penetrant inspection in accordance with Paragraph N-627 of Section III of the ASME Code of all welds and all hot or cold formed parts, a hydrostatic test duration of not less than thirty minutes, the witnessing of all hydro and penetrant tests by a qualified inspector, a thorough final inspection of the unit for good workmanship and the absence of any gouge marks or other scars that could act as stress concentration points, a review of the radiographs and of the certified chemical and physical test reports for all materials used in the unit.

The Residual Heat Exchanger will be a conventional shell and U-tube type unit having one shell and two tube passes. Tubes will be seal welded to the tube sheet. The channel connections will be flanged to facilitate tube bundle removal for inspection and cleaning. It has a SA-106 Grade A or B carbon steel shell, a SA-234 carbon steel shell end cap, SA-213 TP-304 stainless steel tubes, SA-376 TP-304 stainless steel channel, SA-240 Type 304 stainless steel channel cover and a SA-240 Type 304 stainless steel tube sheet.

Each Component Cooling Exchanger will be a fixed tube sheet type heat exchanger with removable flanged channel covers which permit rodding of the tubes. All piping connections are welded. The heat exchanger consist of SA-285 Grade B welded carbon steel shell and channels, and SA-285 Grade B carbon steel channel covers. Wetted surfaces of the channel will be coated with epoxy to prevent corrosion. Admiralty metal or Cu Ni tubes will be used with a Cu-Ni or Muntz metal tube sheet..

g) Motors

Motors Located Outside of the Containment:

Motor electrical insulation systems will be supplied in accordance with USA S.I., IEEE and NEMA standards and will be tested as required by such standards. Temperature rise design selection will be such that normal long life will be achieved even under accident loading conditions. Periodic electrical insulation tests made during the lifetime of the plant will detect deterioration, if any, on the insulation system.

The application criteria for motors to be used in the safety injection systems will include performance lifetime equal to or greater than other major motors in the plant which are designed for continuous service throughout the plant lifetime. Pump design and test criteria will insure that motor loading does not exceed the application criteria.

Motors Located Inside of the Containment:

Insulation systems which can safely and continuously operate at temperatures well in excess of those calculated to occur under the postulated accident condition have been developed and are routinely used in industry. Internal heat rise limitations will specify that when the rise is added to the postulated accident ambient conditions, motor insulation hot spot temperatures will be well within the systems capability. Periodic electrical insulation tests during the life of the plant will detect deterioration, if any, of the system.

Bearings will be anti-friction, ball type, grease lubricated on which high temperature experience has been accumulated. Bearing loading and high temperature tests have been performed and expected life will be equal to or exceed those specified by AFBMA. Pump or fan motors which have a routine function in addition to a safety injection system function will have bearing vibration detectors to continuously monitor for abnormal bearing conditions. Motor housing design will be such that no air or vapor pressure differential will occur across the bearings during or after the containment pressure rise associated with the postulated loss-of-coolant accident.

Motor housing designs which prevent the moisture in the containment from entering the motors will be completely enclosed fan self-cooled or fan heat exchanger cooled. Slight modifications of these designs will be specified such that no interchange other than heat between the motor internal ambient cavity and the containment accident ambient can occur.

Motors which operate only during or after the postulated accident will be designed for standby service incorporating space heaters and non-corrosive hardware. Periodic operation of the motors and tests of the insulation will ensure that the motors remain in a reliable operating condition.

Although these motors are normally run only for test, the design loading and temperature rise limits shall be based on accident ambient conditions. Normal design margins will be specified for these motors to make sure the expected lifetime is well in excess of the required operating time for the accident.

6.2.1.6 Inspection And Installation of Equipment in the Field

Equipment and materials will be delivered to the site by either railroad, barge or motor vehicle. As material is received, it is checked for cleanliness, damage and checked against the bill of material specification for completeness. If trouble is found, an immediate request is made for rectification. Special inspection procedures and specifications for proper repairs are prepared in the event of damage.

After the receiving check, the materials and equipment will be placed in storage if erection cannot proceed immediately. Small items will be placed in a warehouse and segregated according to material classification or designated ultimate use. The very large items will be stored outdoors, off the ground, and covered. All openings shall remain sealed until erection except when further inspection or pre-erection work may be required; afterwards they are resealed until installation.

Components and materials destined for use in the nuclear and engineered safeguards systems will receive special consideration during storage and installation to assure the assembled systems do not contain foreign material that will create operating problems.

Special attention is given to maintaining the equipment in a clean and uncontaminated condition during erection. Requirements for the highest grade commercial cleanliness are specified. Specifications will be prepared which dictate special handling instruction and precautions to be observed when opening and inspecting any internal workings where foreign material could cause damage or impair the proper operation of the equipment.

Dirt and debris which could contaminate the atmosphere and the equipment in the immediate area of the building will be continuosuly removed. All equipment will be protected from physical harm, and kept sealed when not open for inspection.

Should it be necessary to open up a piece of equipment in an area where the atmosphere is contaminated as a result of grinding or concrete finishing, for example, the cause of the air pollution will be terminated and/or a protective tent will be erected to minimize chances of contamination.

Dessicants will be used and periodically monitored in components which are susceptible to damage by moisture. Heaters installed in equipment for moisture control will be kept energized when required. Special precautions will be taken to assure that the dessicant has been removed prior to system operation.

As part of the final cleaning procedures, a visual inspection of each system will be performed following a solvent wash. All systems will be flushed using demineralized water during which time temporary screens are installed in the pump suction lines as required.

Erection procedures will be issued to ensure that the equipment and materials are installed correctly and according to design. These procedures include such items as sequence of installation, when necessary, and specifications for welding. Particular attention is paid to methods which are not standard to the construction industry. Included in the welding specs will be non-destructive tests required such as dye penetrant, radiography, and ultrasonic.

Qualified resident supervisory service engineers with training in electrical, civil, mechanical, instrumentation, and welding categories, experienced in installation and checkout of piping and equipment at other nuclear sites, will review the specifications and procedures. Special attention will be given to systems incorporated in the engineered safeguards, These supervisory engineers will continually monitor the installation and checkout of the equipment for conformance to the procedures and specifications. During critical phases of the work, they will provide personal guidance and record data for future reference. Specified tests will be witnessed and accepted or rejected according to the results. If repairs are required, the work will be supervised and the subsequent retesting witnessed.

An example of the above service engineers is the Welding Engineer assigned to the site. This man arrives at the site early in the construction program to instruct and train welders in the art of welding to code specifications. Coupons will be fabricated and tested and when all requirements are met, work may proceed. Welders will be given the necessary qualifying tests as required in the Boiler, Unfired Pressure Vessel and Piping Codes.

As assemblies of the systems are made, the engineer will inspect each fit-up for alignment and symmetry. He will supervise the weld fusion pass and monitor the work as it proceeds until the final weld pass.

When welds are completed, the Welding Engineer will examine the conditioning of the weld for final non-destructive testing as required by specification. The Welding Engineer approves the interpretation of the radiographs and monitors the welds during hydrostatic testing. He is also responsible for keeping records, inspection reports, and a file of radiographs throughout the job. When work is complete, he prepares a final report.

6.2.1.7 Systems Initial Checkout and Testing

The initial tests of individual components and the initial functional test of the systems as a whole complement each other to assure performance of the systems and to prove proper operation of the actuation circuitry.

Shop testing of pumps will establish the ability of each pump to meet its full range of design requirements. For example, the residual heat removal pumps will be submitted to a shop test program including the following:

a) Establishment of flow-head characteristics and NPSH requirements over the range of flows possible during injection or recirculation conditions.

b) A test demonstrating the function of the pump and its associated sump suction piping under the suction pressure, water temperature and maximum flow expected during the recirculation phase of operation.

The above tests are in addition to quality control procedures such as the hydrostatic test and liquid penetrant examination of the pump casing.

The remote operated valves in the safety injection systems will be motor-operated gate valves. Shop tests for each valve will include a hydrostatic pressure test, leakage tests, a check of opening and closing time, and verification of torque switch and limit switch settings. The ability of the motor operator to move the valve with the design differential pressure across the gate will be demonstrated by opening the valve with an appropriate hydrostatic pressure on one side of the valve.

An initial functional test of the core cooling portion of the safety injection systems will be conducted before plant power operation. The purpose of the initial systems test will be to demonstrate the proper functioning of the instrumentation and actuation circuits and to evaluate the dynamics of placing the system in operation. This test will be performed following the flushing and hydrostatic testing of the system.

The functional test will be performed with the water level below the safety injection set point in the pressurizer and with the Reactor Coolant System initially cold and at low pressure. The safety injection system valving is set to initially simulate the system alignment for plant power operation.

To initiate the test, the safety injection block switch will be moved to the unblock position to provide control power allowing the automatic actuation of the safety injection relays from the pressurizer low water level and low pressure signals. Simultaneously, the breakers supplying outside power to the 480 volt buses will be tripped manually and operation of the emergency power system will commence automatically. The high-head safety injection pumps and the residual heat removal pumps will be started automatically following the prescribed loading sequence. The valves will be operated automatically to align the flow path for injection into the reactor coolant system.

The functioning of the accumulator tanks can be checked separately using the test lines with the reactor coolant system pressurized or by closing the stop valve, raising the pressure in the tank and then opening the stop valve and observing the rising pressurizer level.

The rising water level in the pressurizer will provide indication of systems delivery. Flow into the reactor coolant system will be terminated prior to filling of the pressurizer, and the operation of the safety injection systems will be terminated manually in the main control room.

This functional test will provide information to confirm valve operating times, pump motor starting times, the proper automatic sequencing of load addition to the emergency generators, and delivery rates of injection water to the reactor coolant system.

The functional test will be repeated for the various modes of operation needed to demonstrate performance at partial effectiveness, i.e., to demonstrate the proper loading sequence with loss of one of the emergency power sources and to demonstrate the correct automatic starting of a second pump should the first pump fail to respond. These latter cases will be performed without delivery of water to the reactor coolant system, but will include starting of all pumping equipment involved in each test.

The systems will be accepted only after demonstration of proper actuation and after demonstration of flow delivery and shutoff head within design requirements.

6.2.1.8 Recirculation Loop Leakage Protection

When most of the contents of the refueling water storage tank are transferred into the containment following a loss-of-coolant accident, the spilled coolant and injection water is recirculated inside the reactor containment. The external recirculation loop is isolated from the internal loop by remotely operated isolation valves. These valves are opened only if high head recirculation is required. In this event, the external loop becomes an extension of the containment.

The penetrations and all the piping in the external recirculation loop will be designed for pressures at least equal to the containment design pressure. Independent and redundant isolation features will be provided to isolate the penetrations to the external recirculation loop. Table 6-4 presents a summary of the penetrations and isolation features of the external recirculation loop.

In addition, all components of the external recirculation loop are totally enclosed in the primary auxiliary building. The primary auxiliary building is adjacent to the containment so the recirculation path is never outside the control zones of the plant buildings.

The external recirculation loop as an extension of the containment is therefore adequately isolated from the atmosphere. The only leakage possible is that associated with the leakage through components and system joints. These leak sources are:

a) Recirculation loop boundaries

b) Pump seals

c) Flanges

d) Valves - stem leakoffs

e) Valves - bonnet to body flanges

f) Valves - flanged body, packed stems

Design criteria applied to the design of this loop to ensure a high degree of leak tightness under operating conditions are:

TABLE 6-4

CONNECTION TO THE RECIRCULATION LOOP

	PENETRATION	NORMAL USE	ISOLATION
1.	Pump suction header at refueling water storage tank	Suction from refueling water storage tank to the safeguards pumps	One motor operated valve and one check valve in series.
2.	Safety injection test line	Used during periodic test and then under administrative control. Line discharges into RWST.	Same as 1 Two air operated valves, fail closed.
3.	Sample and waste disposal connection at the safety injection test line	Sample line opened to sample S. I. line concentration. Path to waste disposal opened if sample shows back leakage from RCS. Lines only opened under administrative control for testing.	Locked closed valve in test line backed up by normally closed valves.
4.	Containment Spray lines downstream of spray pumps	Used prior to initiation of recirculation. These lines are isolated and residual heat removal pump feeds spray headers.	Check valve backed by two remotely operated stop valves in parallel.

a) Small, normally open valves will have backseats which limit leakage to less than one cubic centimeter per hour per inch of stem diameter assuming no credit for packing in the valve.

b) Normally closed globe valves will be installed with recirculation flow under the seat to prevent stem leakage from the more radioactive fluid side of the seat.

c) Instrumentation valves will be of the packless diaphragm type. Modulating valves, and other valves 2 1/2" or greater and carrying radioactive material are supplied with double packing and intermediate leakoff connections to the waste disposal facilities.

d) Water leakage across the valve disc will be specified and acceptance tested for the following valves:
   1) Conventional Globe - 3 cc/hr/in. of nominal pipe size
   2) Gate Valves - 3 cc/hr/in. of nominal pipe size
   3) Motor Operated Gate Valves - 3 cc/hr/in. of nominal pipe size
   4) Check Valves - 3 cc/hr/in. of nominal pipe size
      - Accumulators, 2 cc/hr/in.

e) Relief valves will be totally enclosed.

f) The residual heat removal and safety injection pump shaft seals will be designed for low leakage and the liquid leaking from the seal will be collected and piped to the waste disposal facilities.

g) Valve body to bonnet flanges will have provisions for seal welds.

The recirculation piping will be initially hydrostatically tested at 125% of design pressure of each loop. The entire loop can also be pressurized and leak tested during periodic testing.

Since the external recirculation system is operated at a pressure in excess of the containment pressure, it can be hydrotested during periodic tests at the recirculation operating pressures. This can be accomplished by running each pump (safety injection, and residual heat removal pumps) in turn at near shutoff head conditions and checking the discharge, test and miniflow lines. The suction lines can be tested by running the residual heat removal pumps and opening the flow path to containment spray and safety injection pumps in the same manner as the actual operation of the recirculation loop, thus pressurizing the entire suction header.

During the above tests, all system joints, valve packings, pump seals, leakoff connection, or other potential points of leakage can be visually examined. Valve gland packing, pump seals, and flanges will be adjusted or replaced as required to reduce the leakage to acceptable proportions. For power-operated valves, final packing adjustments will be made, and the valve will be put through an operating cycle before a final leakage examination will be made.

Estimated Leakage During External Recirculation:

Table 6-5 summarizes the potential leakage from external recirculation loop leak sources. In the analysis, a maximum leakage is assumed from each leak source. For conservatism, three times the maximum expected leak rate from the pump seals was assumed; while a leakage of 10 drops per minute was assumed from each flange where each flange would be adjusted to zero leakage.

Leakage from the mechanical seals of the residual heat removal pumps and the valve stem leakoffs will be piped to the sump tank in the primary auxiliary building. This sump tank will be maintained at a slight negative pressure.

The total leakage resulting from all sources is estimated at 930 cc/hr to the primary auxiliary building atmosphere and 65 cc/hr to the drain tank.

TABLE 6-5

EXTERNAL RECIRCULATION LOOP LEAKAGE

	Items	No. of Units	Type of Leakage Control and Unit Leakage Rate Used in the Analysis	Leakage to Atmosphere cc/hr	Leakage to Drain Tank cc/hr
1.	Residual Heat Removal Pumps (Low Head Safety Injection)	2	Mechanical seal with leakoff - 3 drop/min	0	18
2.	High Head Safety Injection Pumps	3	Same as residual heat removal	0	27
3.	Flanges:		Gasket - adjusted to zero leakage following any test - 10 drops/min/flange used in analysis		
	a. Pump	10		300	0
	b. Valves Bonnet to Body (larger than 2")	20		600	0
4.	Valves - Stem Leakoffs	20	Backseated, double packing with leakoff - 1 cc/hr/in. stem diameter	0	20
5.	Misc. Small Valves	10	Flanged body packed stems - 1 drop/min used	30	0
			TOTALS	930	65

6.2.2 CONTAINMENT SPRAY

6.2.2.1 Design Bases

The containment spray system, shown in Figure 6-2, will be designed to reduce containment pressure and to remove iodine from the containment atmosphere. The heat removal capacity of the spray, with both pumps operating, is at least equivalent to the heat removal capability of all five fan-coolers. The system will be also designed to deliver, with only one pump running, enough thiosulfate solution to the containment prior to emptying the refueling water storage tank to form a 1 weight per cent solution of thiosulfate in the refueling water and spilled reactor coolant in the containment.

6.2.2.2 System Design

Two separate pumps, automatically actuated by a combination of high containment pressure and safety injection signals are provided for containment spray. These pumps are located in the primary auxiliary building and take their suction directly from the refueling water storage tank.

Sodium thiosulfate ($Na_2S_2O_3$) is mixed with the borated spray to provide a means of cleaning the containment atmosphere of iodine. The thiosulfate will react chemically with the iodine, either in the dispersed spray droplets or on surfaces, reducing it as a leakage source. A portion of the water discharged by each spray pump is used to sweep the contents of the thiosulfate solution tank into the spray pump suction header. The thiosulfate solution mixes with the borated refueling water and is discharged into the spray header.

Each spray header is located outside the reactor coolant system missile shielding where it is protected from missiles. Spray nozzles are oriented to provide effective coverage of the containment free volume and to wash down surfaces where iodine may be deposited. Spray nozzles are of an open throat design, not subject to clogging, and will be designed to produce the total surface of spray drops per unit volume of containment necessary for iodine removal.

The thiosulfate solution tank is isolated from the refueling water line and spray header during normal plant operation. Thiosulfate injection is initiated automatically following initiation of spray flow by opening of the two valves at the thiosulfate solution tank inlet and the two valves at the tank outlet.

Enough thiosulfate solution will be delivered even though only one inlet valve, one outlet valve and either containment spray pump operates. The thiosulfate solution tank contains sufficient solution to yield approximately one per cent solution when mixed with the contents of the refueling water storage tank and the spilled reactor coolant. This assures the continued iodine removal effectiveness of the containment spray during the recirculation phase of operation after the supply of borated water in the refueling water storage tank has been exhausted.

The thiosulfate solution tank valves can be opened periodically for testing. The contents of the tank will be periodically sampled to determine that the proper thiosulfate solution is present.

Component Redundancy:

a) Pumps:
   1) Containment Spray - Two are provided - System and containment evaluations based on one.

b) Automatically operated valves operated on containment spray actuation signal:
   1) Isolation valves at discharge of each pump - Two are provided - One is required to operate.
   2) Isolation valves at thiosulfate addition tank, two inlet and two outlet - One at inlet and one at outlet are required to operate.

c) Valves operated from control room for recirculation:

1) Containment spray valves at residual heat exchanger discharge - Two are provided in parallel - One is required to operate.

Test Locations and Monitors:

The permanent test lines for the containment spray loops are indicated on Figure 6-2. The air test location for checking that spray nozzles are clear is also indicated. The test loops are located so that all components up to the isolation valve at the spray nozzles may be tested. These isolation valves are checked separately. Air flow through the nozzles is monitored by tell-tale devices attached to each nozzle or by use of a smoke generator.

6.2.2.3 Components

a) Containment Spray Pumps

The two containment spray pumps are of the horizontal centrifugal type driven by electric motors.

The design head on the pumps shall be sufficient to continue at rated capacity with a minimum level in the refueling water storage tank against a head equivalent to the sum of the design pressure of the containment, the head to the uppermost nozzles, and the line and the nozzle pressure losses. Pump motors shall be direct-coupled and non-overloading to the end of the pump curve. The materials of construction shall be suitable for use in mild boric acid solutions, such as stainless steel or equivalent corrosion resistant material.

TABLE 6-6

PRELIMINARY
CONTAINMENT SPRAY PUMP DESIGN PARAMETERS

Design Pressure	300 psig
Design Temperature	300°F
Design Flow Rate	2600 gpm
Design Head	400 ft.

b) Thiosulfate Solution Tank

The capacity of the tank shall be sufficient to contain enough 30 w/o $Na_2S_2O_3$ solution which upon mixing with the refueling water and primary coolant will bring the concentration in the containment to 1 w/o. The design pressure of the tank shall be the sum of the refueling water storage tank head and the total developed head of the containment spray pumps at shutoff. Nozzles shall be provided so that incoming refueling water thoroughly sweeps the contained solution toward the discharge.

c) Spray Nozzles

The spray nozzles shall be of the open-throat design not subject to clogging and shall be capable of producing a mean drop size of at least as small as 700 microns diameter with the spray pump operating at design conditions and the containment at design pressure.

d) Instrumentation and Control

All pump and tank block valves are provided with automatic remote operators which will open upon initiation by a combination of high containment pressure and safety injection system signals. Tank block valves are provided in duplicate. Position indication is provided in the control room for all remotely operated valves. A flow indicating alarm is provided in the control room if there is no flow through the Thiosulfate Solution Tank when the pumps have started. A level indicating alarm is provided in the control room if, at any time, the solution tank contains less then the required amount of sodium thiosulfate solution.

6.2.3 CONTAINMENT VENTILATION SYSTEM

6.2.3.1 General

The reactor containment ventilation system is a closed self-contained air recirculation system that does not introduce any outside air to the containment during reactor operation. Except for infrequent cases which may require air release due to unexpected leaks from the Penetration Pressurization System, the system does not exhaust any containment air to the atmosphere during reactor operation. Following a loss-of-coolant accident, the recirculation system, which is equipped with cooling equipment, and absolute filters is used to control the containment atmosphere temperature and pressure and to remove particulate activity.

A separate small internal recirculation system utilizing charcoal filters is provided for removal of iodine as necessary prior to routine access to the containment.

A purging system is provided to reduce the total containment activity as required for prolonged access for refueling or maintenance. Filters in the system reduce the airborne particulate activity remaining, if any. Prior to activating the purge system, the particulate and gas monitor will indicate the system activity levels inside the containment and be utilized as a guide for routine release from the building.

The purging system would also be used to purge the containment after a loss-of-coolant accident once the activity in the containment has reached a level low enough to allow its exhaust to the atmosphere.

6.2.3.2 Design Basis

The reactor containment ventilation recirculation system is designed to maintain a temperature of 120°F inside the containment with four out of five fans operating during normal plant operation. The system is designed to maintain a normal containment air temperature of 120°F or less during normal operation by recirculating a total of 260,000 cfm, or 65,000 cfm per unit. The unit is capable of removing 85.0 $\times 10^6$ Btu/hr from the containment atmosphere under accident conditions with the containment atmosphere of saturated air and steam at a temperature of 271°F. About 2000 gpm of service water is supplied to each unit.

The purging system is designed to exhaust the containment air to the atmosphere. The purge ducts will be closed during operation. A smaller separate line is used to maintain containment air pressure below about 0.3 psig.

Unit heaters are provided to maintain a minimum temperature of 50°F inside the containment in the winter during periods of prolonged shutdown.

6.2.3.3 Recirculation System

The reactor containment ventilation system consists of five air handling units located in the space between the containment wall and the secondary shielding (crane support wall). Each unit draws air from the containment atmosphere and discharges to a common header from where is it distributed through ductwork to the individual areas. Air will never be drawn directly into the unit from inside the shield wall. Each air handling unit consists of water cooling coils, demisters, roughing filter, absolute filters, and a motor driven centrifugal non-overloading fan in series. The filtration system reduces the airborne particulates by constant recirculation of the containment atmosphere.

The location of the distribution ductwork outlets, with reference to the location of the ventilating unit return inlets, ensures that the air will be directed to areas requiring ventilation before returning to the units.

In addition to ventilating areas inside the periphery of the shield wall, the distribution system also includes two branch ducts located at opposite extremes of the containment wall for ventilating the dome portion of the containment. These ducts will be provided with nozzles and will extend upward along the containment wall as required to permit air from the nozzles to reach the highest point in the containment and assure that the discharge air will mix with the atmosphere.

The air discharge inside the periphery of the shield wall will circulate and rise above the operating floor through openings around the steam generators where it will mix with air displaced from the dome area. This mixture will return to the ventilating units through the floor grating located at the operating floor directly above each ventilating unit inlet. The temperature of this air will be essentially the ambient existing in the containment vessel.

The steam-air mixture from the containment entering the demister will be at approximately 271°F and have a density of 0.175 pounds per cubic foot. The demister will remove all entrained moisture or fog but not vapor. The fluid will, therefore, leave the demister and enter the cooling coil at approximately 271°F and saturated (110% R.H.) condition. Part of the water vapor will condense in the cooling coil, and the air leaving the unit will be saturated at a temperature somewhat below 271°F.

The fluid will remain in this condition as it flows through the roughing filter, absolute filter and into the fan. At this point, it will acquire some sensible heat from the fan and fan motor before flowing into the distribution header. This sensible heat will increase the dry-bulb temperature slightly above 271°F and will decrease the relative humidity slightly below 100 per cent.

6.2.3.4 Design Criteria

The containment ventilation system is designed to be capable of operating after a loss-of-coolant accident which results in a 47 psig containment pressure. In addition, every component of these systems is capable of withstanding without impairing operability, a pressure of 1.5 times the design pressure and the associated temperature of the air-vapor mixture (298°F) for a period of 1 hour.

The following design criteria are common and applicable to filter assemblies, moisture eliminators, cooling coils and ductwork for each of the five air handling assemblies.

1. Minimum design flow rate per assembly - 65,000 cfm
2. Number of units required to operate - three out of five
3. Fluid description; saturated steam and air mixture, 271°F at 47 psig, density 0.175 lb/cu. ft.
4. All components and their supports shall meet the requirement for Class I (Seismic) structures.
5. All components shall be capable of withstanding or shall be protected from differential pressures which may occur during the rapid pressure rise to 47 psig in ten (10) seconds.
6. Each component shall be mounted to isolate it from fan vibration.

In addition to the design criteria common to the components stated above, additional design criteria applicable to specific components are as follows:

Absolute and Roughing Filter Units

1. Minimum efficiency with particles 0.3 microns and larger shall be 99.97%.
2. Filter media shall be of the self-extinguishing type.
3. Filter cells shall be installed in stainless steel frames securely sealed against a gasket.
4. The gasket shall be capable of withstanding a temperature of 300°F.
5. Filter units shall be designed to Class I (seismic) standards.

Moisture Eliminators (Demister)

With an entrained moisture content of 0.35 lb/1000 cu. ft., the leaving fluid shall have essentially zero moisture content.

Cooling Coils

1. Cooling duty, 85.0×10^6 Btu/hr per air handling assembly at saturation conditions (47 psig, 271°F).

2. Design pressure of coil, 150 psig.
3. Coils shall be provided with adequate drain pans and drain piping to prevent flooding. Water will be directed to the reactor cavity sump.
4. The cooling coils and their water supply shall be designed to Class I (seismic) standards.

<u>Fans</u>

1. Characteristic curve for fan shall provide a minimum flow rate of 65,000 cfm when operating against the system resistance existing during the accident condition.
2. Fan shall be centrifugal, non-overloading, direct drive type.
3. Shaft bearings and motor coupling shall be suitable for operation in the temperature and pressure environment existing during accident.
4. Fan assembly and support shall be designed as a Class I (Seismic) structure.
5. Fan shall be capable of withstanding or shall be protected from differential pressures which may occur during a rapid pressure rise to 47 psig in 10 seconds.
6. Fan rotating assembly shall be statically and dynamically balanced.
7. All parts in contact with containment fluid shall be suitably protected against corrosion.
8. The fan assembly shall be supported by vibration isolators.

<u>Motors</u>

1. Rating of motor shall be suitable to match the power requirements of the fan during the accident condition described below.
2. Electrical insulation and bearings shall be suitable for the temperature and humidity conditions during the accident as described below.
3. Enclosure of motor shall be of a special design which will withstand the pressure and temperature condition during the accident without impairing operation.

4. Motors shall be statically and dynamically balanced.
5. Accident conditions will be described in the specification for the motor as follows:
   a. Motor shall run for 48 hours at the load required by the fan in an atmosphere consisting of an air-water vapor mixture at 47 psig and 271°F.
   b. The load on the motor will gradually decrease from the peak condition of (a.) during the first two hours to a lower load equivalent to operation of the fan in an atmosphere with 5 to 10 psi water vapor pressure.
6. The motor shall operate indefinitely in the atmosphere with 5 to 10 psi water vapor pressure.

Ducts

1. Ducts shall be capable of withstanding the differential pressure developed during the hypothetical loss-of-coolant accident, or shall be provided with pressure devices to prevent an excessive differential pressure.
2. Ducts shall be constructed of corrosion resistant material.
3. Ducts shall be capable of withstanding the maximum temperature and shall be supported to accommodate expansion due to temperature changes occurring during an accident.
4. Where flanged joints are used, joints shall be provided with gaskets suitable for temperatures to 300°F.

Instrumentation and Control

1. Local flow and temperature indication, outside containment, for service water to each cooling unit shall be provided. Abnormal flow and temperature alarms shall be provided in the control room.
2. The service water discharge from the containment shall be monitored for radioactivity and the monitor shall function during the loss-of-coolant accident.

6.2.3.5 Purging System

The reactor containment purge system is an integral part of the main exhaust system. The purging system consists of supply and exhaust ductwork penetrations which incorporate butterfly valves to insure tight shutoff. A filtering system that includes prefilters and absolute filters is located in the exhaust ductwork. The exhaust ductwork is connected to the suction side of the main exhaust fan located in the auxiliary building. The main exhaust fan normally operates as part of the ventilation system and its capacity is based upon exhausting the entire ventilation system. The auxiliary building exhaust branch is connected to the main exhaust duct to bypass the filters in the exhaust branch from the reactor containment. In addition, a connection is provided to draw outside air into the main exhaust ductwork. This outside air connection is provided with motor operated dampers which are open during normal operation and closed when the purge system is activated. The outside air connection balances the purge system air quantity so that a constant quantity of air is exhausted by the fan through the vent. A roughing type filter is included in the supply duct to the containment. During the purging operation, fresh filtered air is supplied to the containment.

The purging system exhaust and air supply connections through the containment are provided with tight seating 125 psig butterfly valves both inside and outside the containment. These valves are closed during plant operation and the space between them pressurized by the Penetration Pressurization System. The containment pressure relief line is provided with one such butterfly valve inside the containment and two outside with provisions for pressurizing with air between them. Any automatic signals which actuates an engineered safeguard system will automatically close the butterfly valves if they are open.

All actuators can be remotely controlled from the control room by the operator except where automatic interlocks are involved. All actuators are designed to fail in the position required for post accident operation upon loss of electric or pneumatic power. Instruments will be located in the control room to provide information to allow proper remote operation of the system.

6.2.4 CONTAINMENT ISOLATION SYSTEM

6.2.4.1 Design Basis

Piping penetrating the containment is designed for pressure at least equal to the containment design pressure. Containment isolation valves are provided as necessary in these lines to prevent release of radioactivity. The six classes listed below are general categories into which lines penetrating containment may be classified. Also described are the basic isolation valve arrangements used to provide two barriers between the Reactor Coolant System or containment atmosphere, and the environment. System design is such that failure of one valve to close will not prevent isolation, and no manual operation is required for immediate isolation. Automatic isolation is initiated by a containment isolation signal, derived from high containment pressure signals.

6.2.4.2 Penetration Classifications

The following notes are applicable to the classification described below.

1. The "not missile protected" designation refers to lines that are not protected throughout their length inside containment against missiles generated as the result of a loss of coolant accident. These lines, therefore, are not assumed invulnerable to rupture as a result of a loss of coolant.

2. In order to qualify for containment isolation, valves inside the containment must be located behind the missile barrier for protection against loss of function following an accident.

3. Manual isolation valves that are locked closed or otherwise closed and under administrative control during power operation qualify as automatic trip valves.

4. A check valve qualifier as an automatic trip valve in certain incoming lines not requiring seal water injection.

5. The double disk type of gate valve is used to isolate certain lines. When sealed by water injection, this valve provides both barriers against leakage of radioactive liquids or containment atmosphere.

6. In lines isolated by globe valves and provided with seal water injection, the valves are installed so that the seal water wets the stem packing.

7. Excessive loss of seal water through an isolation valve that fails to close on signal, is prevented by the high resistance of the seal water injection line. A water seal at the failed valve is assured by proper slope of the protected line, or a loop seal, or by additional valves on the side of the isolation valves away from the containment.

8. Isolated lines between the containment and the first outside isolation valve are designed to the same seismic criteria as the containment vessel, and are assumed to be an extension of containment.

Class 1 (Outgoing Lines, Reactor Coolant System)

Normally operating outgoing lines connected to the Reactor Coolant System are provided with at least two automatic trip valves in series located outside the containment. Automatic seal water injection is provided for lines in this classification.

An exception to the general classification is the residual heat removal loop outlet line, which has two barriers established by normally closed valves.

Class 2 (Outgoing Lines)

Normally operating outgoing lines not connected to the Reactor Coolant System, and not missile protected or which can otherwise communicate with the containment atmosphere following an accident, are provided at a minimum with two automatic trip valves in series outside containment. Automatic seal water injection is provided for lines in this classification. Most of these lines are not vital to plant operation following an accident.

An exception is the residual heat exchanger cooling water return line, which is valved in accordance with safeguards operation.

Class 3 (Incoming Lines)

Incoming lines connected to open systems outside containment, and not missile protected or which can otherwise communicate with the containment atmosphere following an accident are provided with one of the following arrangements outside containment:

1. Two automatic trip valves in series, with automatic seal water injection. This arrangement is provided for lines which are not necessary to plant operation after an accident.

2. Two manual isolation valves in series, with manual seal water injection. This arrangement is provided for lines which remain in service for a time, or are used periodically, subsequent to an accident.

Incoming lines connected to closed systems outside containment, and not missile protected or which can otherwise communicate with the containment atmosphere are provided, at a minimum, with one check valve or normally closed isolation valve located either inside or outside containment. The closed piping system outside containment provides the necessary isolation redundancy. Most lines in this category are provided with additional isolation valves which satisfy particular systems or safeguards requirements. Seal water injection is provided for certain lines in this category.

Exceptions are the containment spray headers and residual heat exchanger cooling water supply line, for which valving is based on safeguards requirements.

Class 4 (Missile Protected)

Normally operated incoming and outgoing lines which penetrate the containment and are connected to closed systems inside the containment and protected from missiles throughout their length and are provided with at least one manual isolation valve located outside the containment. Seal water injection is not required for the class of penetration.

Class 5 (Normally Closed Lines Penetrating the Containment)

Lines which penetrate the containment and which can be opened to the containment atmosphere but which are normally closed during reactor operation are provided with two isolation valves in series or one isolation valve and one blind flange. One valve or flange is located inside and the second valve or flange located outside the containment.

Class 6 (Special Service)

The ventilation purge duct penetrations and containment access openings at the fuel transfer tube are special cases.

Each ventilation purge duct penetration is provided with two tight-closing butterfly valves which are closed automatically upon a containment isolation or a containment high radiation signal. One valve is located inside and one valve is located outside the containment at each penetration. The space between valves is pressurized by the Penetration Pressurization System whenever they are closed during plant operation.

The equipment access closure is a bolted, gasketed closure which is sealed during reactor operation. The personnel air locks consist of two doors in series with mechanical interlocks to assure that one door is closed at all times. Each air lock door and the equipment closure are provided with double gaskets to permit pressurization between the gaskets by the Penetration Pressurization System.

The fuel transfer tube penetration inside the containment is designed to present a missile protected and pressurized double barrier between the containment atmosphere and the atmosphere outside the containment. The penetration closure is treated in a manner similar to the equipment access hatch. A positive pressure is maintained between these gaskets to complete the double barrier between the containment atmosphere and the inside of the fuel transfer tube. The interior of the fuel transfer tube is not pressurized. Seal water injection is not required for this penetration.

6.2.5 ISOLATION VALVE SEAL WATER SYSTEM

6.2.5.1 Design Bases

The Isolation Valve Seal Water System assures the effectiveness of certain containment isolation valves, during any condition which requires containment isolation, by providing a water seal at the valves. These valves are located in lines that could be exposed to the containment atmosphere in the event of a loss of coolant accident. The system provides a simple and reliable means for injecting seal water between the seats and stem packing of the globe and double disc types of isolation valves, and into the piping between closed diaphragm type isolation valves.

6.2.5.2 System Design

The system includes one seal water tank capable of supplying the total requirements of the system. The tank is pressurized from the nitrogen gas bottle header of the Penetration Pressurization System through pressure control valves. Design pressure of the tank and injection piping *is 150 psig, and relief valves are provided to prevent overpressurization of the system if a pressure control valve fails, or if a seal water injection line communicates with a high pressure line due to a valve failure in the seal water line. Two separate sources of makeup water are provided to ensure that an adequate supply of seal water is available at all times.

System operation (i.e. automatic seal water injection) is initiated by the containment isolation signal. When actuated, the Isolation Valve Seal Water System interposes water inside the penetrating line between two isolation points located outside the containment. The water is introduced at a pressure slightly higher than the containment design pressure. The high pressure nitrogen supply used to maintain pressure in the seal water tank does not require any external power source to maintain the required driving pressure. The possibility of leakage from the containment or Reactor Coolant System past the first isolation point is thus prevented by assuring that if leakage does exist, it will be from the seal water system into the containment.

Isolation and seal water injection are accomplished automatically for certain penetrating lines requiring early isolation, and manually for others, depending on the status of the system being isolated and the

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* The injection piping runs and nitrogen supply piping are fabricated using 3/8 inch O.D. tubing, which is capable of 2500 psig service.

potential for leakage in each case. Generally, the following criteria determine whether the isolation and seal water injection shall be atuomatic or manual.

Automatic isolation and automatic seal water injection are required for lines that could communicate with the containment atmosphere and be void of water immediately following a loss of coolant accident. These lines include:

1. Reactor coolant pump cooling water supply and return lines
2. Reactor coolant pump seal water return line
3. Excess letdown heat exchanger cooling water supply and return lines
4. Letdown line
5. Reactor Coolant System sample lines
6. Containment vent header
7. Containment air sample inlet and outlet lines
8. Reactor coolant drain tank gas analyzer line
9. Auxiliary steam supply and condensate return lines
10. Service air and service water lines

Automatic isolation and automatic seal water injection are also provided for the following lines, which are not connected directly to the Reactor Coolant System, but terminate inside the containment at certain components. These components can be exposed to the reactor coolant or containment atmosphere as the result of leakage or failure of a related line or component. The isolated lines are not required for post-accident service.

1. Pressurizer relief tank gas analyzer line
2. Pressurizer relief tank makeup line
3. Safety Injection System test line
4. Reactor coolant drain tank pump discharge line
5. Steam generator blowdown lines
6. Accumulator sample line

Manual isolation and manual seal water injection are provided for lines that are normally filled with water and will remain filled following a loss of coolant accident, and for lines that must remain in service for a time following the accident. The manual seal water injection assures a long term seal. These lines include:

1. Reactor coolant pump seal water supply lines.
2. Charging line

Seal water injection is not necessary to insure the integrity of isolated lines in the following categories:

1. Lines that are connected to non-radioactive systems outside the containment and in which a pressure gradient exists which opposes leakage from the containment. These include nitrogen supply lines to the pressurizer relief tank, accumulators, and reactor coolant drain tank, the instrument air header, and the weld channel pressurization air lines.

2. Lines that do not communicate with the containment or Reactor Coolant System and are missile protected throughout their length inside containment. These lines are not postulated to be severed or otherwise opened to the containment atmosphere as a result of a loss of coolant accident. These include the steam and feedwater headers and the containment ventilation system cooling water supply and return lines.

3. Lines that are designed for post-accident service as part of the engineered safeguards. These include the safety injection line, containment spray headers, residual heat exchanger cooling water lines, residual heat removal pump suction and discharge lines, and the containment sump recirculation line. These lines are connected to closed systems outside containment.

4. Special lines-fuel transfer tube and containment purge ducts. The zone between the two gaskets sealing the blind flange to the inner end of the fuel transfer tube is pressurized to prevent leakage from the containment in the event of an accident. The zone between the two butterfly valves in each containment purge duct is pressurized above incident pressure while the valves are closed during power operation.

Reliable operation is assured by periodic testing of containment isolation valves and the Isolation Valve Seal Water System. Each automatic isolation valve can be tested for operability at times when the line is not required for normal service. Lines supplying automatic seal water injection can be similarly tested. The capacity of the system to deliver water at the required rate will be verified during the pre-operational test period of plant construction and startup.

6.2.5.3 Penetration List

Table 6-7 is a preliminary list of lines penetrating containment and the isolation methods employed, classification per Section 6.2.4. and the type of seal water injection.

6.2.6 CONTAINMENT PENETRATION AND WELD CHANNEL PRESSURIZATION SYSTEM

6.2.6.1 Design Basis

The function of the containment penetration and weld channel pressurization system is to prevent leakage of containment air through penetrations and liner welds under all conditions by supplying air above the containment postincident design pressure to the positive pressure zones incorporated in the penetration and weld channel design.

This system also provides a means of continuously monitoring the leakage status of the containment. This is much more sensitive and accurate than the conventional integrated leak rate tests.

6.2.6.2 System Operation

The containment penetration and weld channel pressurization system is shown on Figure 6-4. The system utilizes a regulated supply of clean and dry compressed air from the instrument air system which is backed up by the plant air system to maintain pressure in all penetrations and weld channels whenever plant operating conditions require the containment to be closed. The penetration and weld channels are grouped in four independent zones, each supplied by its own air receiver.

Nitrogen cylinders provide a standby source of gas pressure for each zone. The regulators on the nitrogen supply are set to deliver at a slightly lower pressure than the normal regulated air supply pressure. Thus, in the event of failure of the normal air supply pressure the penetration pressure requirements will automatically be maintained by the nitrogen supply.

Each penetration or weld channel section air supply line can be isolated for leak testing. A capped tubing connection is provided in each supply line to allow injection of the leak-test gas.

Leakage from the system (and potential leakage from penetrations) is checked by continuous measurement of the integrated makeup air flow.

The system is supplied continuously with dried and filtered air from the 100 psig instrument air supply, and is operated at approximately 50 psig. The instrument air system is manually backed up by the plant air system. With loss of both of these sources, each of the four pressurization system zones will continue to be supplied with air from its respective minimum 360 ft^3 air receiver. Each air receiver is sized to provide make up air to its respective pressurized zone for a period of four hours, based on a leakage rate of 0.2% of the containment free volume per day based upon 0.1% leakage into the containment and 0.1% leakage to the environment. Should the receivers become exhausted before air service is restored, nitrogen will be supplied to each of the four pressurization zones by a bank of five nitrogen cylinders. Each of these banks is sized to supply nitrogen to its zone for 24 hours, based on a total leakage rate from the entire pressurization system of 0.2% of the containment free volume in 24 hours. Since the penetrations are pressurized at a pressure higher than containment post-incident design pressure there is no outleakage from the containment.

During normal reactor operation, the total leakage from the penetration will be a maximum of 0.2% of the free volume of the Containment Building per day, as stated above. This will be indicated by the sum of the recorded flows in the four pressurization sub-systems. Before a leak causes the total flow to exceed the 0.2% value, it is expected to build up slowly and therefore would be noted through one of the flow recorders. Thus, remedial action can be taken before the total potential leakage passes the 0.2% point.

A pressure relief valve protects the system from failure of the pressure reducing valve in the line from each of the groups of nitrogen storage cylinders. Each zone of piping will also be protected by a rupture disc. Should an air receiver fail, the pressurization gas load will be automatically picked up by the bank of nitrogen bottles in that particular piping zone. Pressure control valves, shut off valves and check valves will be located outside the containment for ease of inspection and maintenance. Failure of any of these components, except the lock-open manual shut-off valves at each penetration, will not lead to loss of pressurizing gas, since another source will automatically take over on loss of pressure in the supply source.

In order to insure that all penetrations are pressurized, a flow recorder, a pressure recorder and a low pressure alarm are provided in the control room for each of the four independent pressurized zones. Final piping layouts will also provide branch pressurization lines from three of the four independent zones to the following:

a) The double-gasketed space on each hatch of the personnel air lock.
b) The double-gasketed space on the equipment door flange.
c) The pressurized zones in the spent fuel transfer tube.
d) The spaces between butterfly valves in the purge ducts and containment pressure relief line.

The pressurization line to each pressurized zone is equipped with a restricting orifice to assure that air consumption will be within the capacity of the pressurization system, and will not result in loss of pressure in other zones connected to the same pressurization header.

With a continuous leakage into the containment from the penetration of 0.1% of the containment volume per day, the containment pressure will rise to 0.3 psig over a number of days, but is not considered to be an operating or safety problem. From the standpoint of allowable pressure, a much greater inleakage would be permitted. Containment overpressure can be relieved through the purge air fan, passing through the absolute filter and up the discharge duct along with the exhaust air from the Primary Auxiliary Building. The containment pressure during normal operation will be limited to maximum of 0.3 psig.

TABLE 6-7

CONTAINMENT PIPING PENETRATION LIST

PENETRATION	SYSTEM	LINE SIZE INCHES	CONTAINMENT ISOLATION – INSIDE: ISOLATION METHODS	INSIDE: VALVE TYPE	INSIDE: VALVE POSITION	CONTAINMENT ISOLATION – OUTSIDE: ISOLATION METHODS	OUTSIDE: VALVE TYPE	OUTSIDE: VALVE POSITION	SEAL WATER INJECTION	FLUID G-GAS W-Water	>200°F-HOT <200°F-COLD	C.I.S.	PENET. CLASS
Main Steam Headers	Sec.	28	Miss. Prot.	–	–	Non-Return+ Throttle Stop	–	Open	–	G	Hot	–	4
Feedwater Headers	Sec.	18	Miss. Prot.	–	–	Check + MV	–	Open	–	W	Hot	–	4
Residual Heat Removal Loop In	ACS/SIS	12	Check		Closed	Closed Systems	–	–	–	W	Cold	–	3
Residual Heat Removal Loop Out	ACS/SIS	12	RSV	Gate	NC, FAI	MV	Gate	LC	–	W	Hot	–	Special
Ventilation Coolers-Water In	SWS	10	Miss. Prot.	Closed System	–	MV	Gate	NO	–	W	Cold	–	4
(+Drain Lines)		?	"	"	–	MV	Globe	NC	–	W	Cold	–	–
Ventilation Coolers-Water Out	SWS	10	Miss. Prot.	Closed System	–	MV	Gate	NO	–	W	Cold	–	4
(+Drain Lines)		?	"	"	–	MV	Globe	NC	–	W	Cold	–	–
(+RIA Lines)		?	"	"	–	MV	Globe	NO	–	W	Cold	–	–
R. C. Pumps Cooling Water In	ACS	6	Check		Open	RSV+RSV	DDV, Gate	NO, FAI	A	W	Cold	2	3
R. C. Pumps Cooling Water Out	ACS	6	–	–	–	RSV+RSV	DDV, Gate	NO, FAI	A	W	Cold	2	2
R. C. Pumps Cooling Water Out	ACS	3	–	–	–	RSV+RSV	DDV, Gate	NO, FAI	A	W	Cold	2	2
Containment Spray Header	SIS	8	Miss. Prot.	–	–	Closed System	–	–	–	W	Cold	–	Special
Safety Injection Line	SIS	6	RSV	Gate	NC, FAI	Closed System	–	–	–	W	Cold	–	3
R. C. Pump Seal Water Return	CVCS	4	–	–	–	RSV+RSV	Dia.	NO, FC	A	W	Cold	2	2
Excess Letdown H. X. Cooling Water Out	ACS	3	–	–	–	RSV+RSV	Globe, Dia.	NO, FC	A	W	Cold	2	2
Charging Line	CVCS	2	–	–	–	MV+MV	Globe	NO	M	W	Cold	–	3
Auxiliary Steam Supply	Sec.	3	–	–	–	MV	DDV	LC	A	G	Hot	–	3
Auxiliary Steam Condensate Return	Sec.	3	–	–	–	MV	DDV	LC	A	W	Cold	–	2
Excess Letdown H. X. Cooling Water In	ACS	3	–	–	–	RSV+RSV	Dia.	NC, FC	A	W	Cold	2	3
Containment Vent Header	WDS	1	–	–	–	RSV+RSV	Dia.	NO, FC	A	G	Cold	2	2
Pressurizer Relief Tank Gas Anal. Line	WDS	3/8	–	–	–	RSV+RSV	Globe	NO, FC	A	G	Cold	2	2
R.C.S. Sample Lines	SS	3/8	–	–	–	RSV+RSV	Globe	NO, FC	A	W	Hot	2 Ea.	1
Letdown Line	CVCS	2	RSV (3)*	Globe	2-NC, FC 1-NO, FC	RSV+RSV	Globe	NO, FC	A	W	Hot	5	1
Containment Air Sample In	Rad. Mon.	1	–	–	–	RSV+RSV	Dia.	NO, Fc	A	G	Cold	2	3
Containment Air Sample Out	Rad. Mon.	1	–	–	–	RSV+RSV	Dia.	NO, FC	A	G	Cold	2	2
Safety Injection System Test Line	SIS	3/4	–	–	–	MV+MV	Globe	LC	A	W	Cold	–	2
Pressurizer Relief Tank N_2 Supply	RCS	3/4	Check	–	–	MV+PRV	Dia. PRV	NO Closed	–	G	Cold	–	3
Pressurizer Relief Tank Makeup	RCS	3	Check	–	–	RSV+RSV	Dia.	NO, NC	A	W	Cold	2	3
Service Air	Sec.	1 1/2	–	–	–	MV+MV	Dia.	LC	A	G	Cold	–	3
City Water	Sec.	2	–	–	–	MV+MV	Dia.	LC	A	W	Cold	–	3
Weld Channel Pressurization Air	Pene. Pres.	1 1/2	Miss. Prot.	–	–	MV+Closed Sys.	Dia.	NO	–	G	Cold	–	4
R. C. Drain Tank N_2 Supply	WDS	3/4	Check	–	–	MV+PRV	Dia., PRV	NO Closed	–	G	Cold	–	3
Instrument Air	Sec.	1 1/2	–	–	–	Check+RSV	Dia.	NO, FC	–	G	Cold	1	3
R. C. Drain Tank Pump Discharge	WDS	3	RSV	Dia.	NC, FC	RSV+RSV	Dia.	NO, FC	A	W	Cold	2	2
R. C. Drain Tank Gas Analyzer Line	WDS	3/8	–	–	–	RSV+RSV	Globe	NO, FC	A	G	Cold	2	2
R. C. Pump Seal Water Supply	CVCS	2	–	–	–	MV+MV	Globe	NO	M	W	Cold	–	3
Steam Generator Blowdown	Sec.	2	–	–	–	RSV+RSV	Globe	NO, FC	A	W	Hot	2 ea.	2
Containment Purge Air In	Vent.	36	RSV	Butterfly	NC, FC	RSV	Butterfly	NC, FC	–	G	Cold	2	6
Containment Purge Air Out	Vent.	36	RSV	Butterfly	NC, FC	RSV	Butterfly	NC, FC	–	G	Cold	2	6
Residual H. X. Cooling Water Out	ACS	12	RSV	Gate	NC, FAI	MV	Gate	NO	–	W	Cold	–	Special
Residual H. X. Cooling Water In	ACS	12	MV	Gate	NO	Closed System	–	–	–	W	Cold	–	Special
Residual H. X. to S. I. Pumps	SIS	6	Miss. Prot.	Closed System	–	RSV	Gate	NC, FAI	–	W	Cold	–	4
Containment Sump Recirculation Line	SIS	18	Miss. Prot.	–	–	RSV+RSV	Gate	NC, FAI	–	W	Cold	–	4
Containment Pressure Relief	Vent.	10	RSV	Butterfly	NC, FC	RSV	Butterfly	NC, FC	–	G	Cold	2	6
Fuel Transfer Tube	FH	20	Double Gasketed	Blind	Flange	MV	Gate	NC	–	W	Cold	–	6
Accumulator N_2 Supply	SIS	1	Miss. Prot.	–	–	RSV+PRV	Globe, PRV	NO, FC	–	G	Cold	–	3
Accumulator Sample Line	SS	3/8	RSV	Globe	NO, FC	RSV+RSV	Globe	NO, FC	A	W	Cold	2	2

Valves: RSV - Remote Stop Valve
MV - Manual Valve
PRV - Pressure Regulating Valve

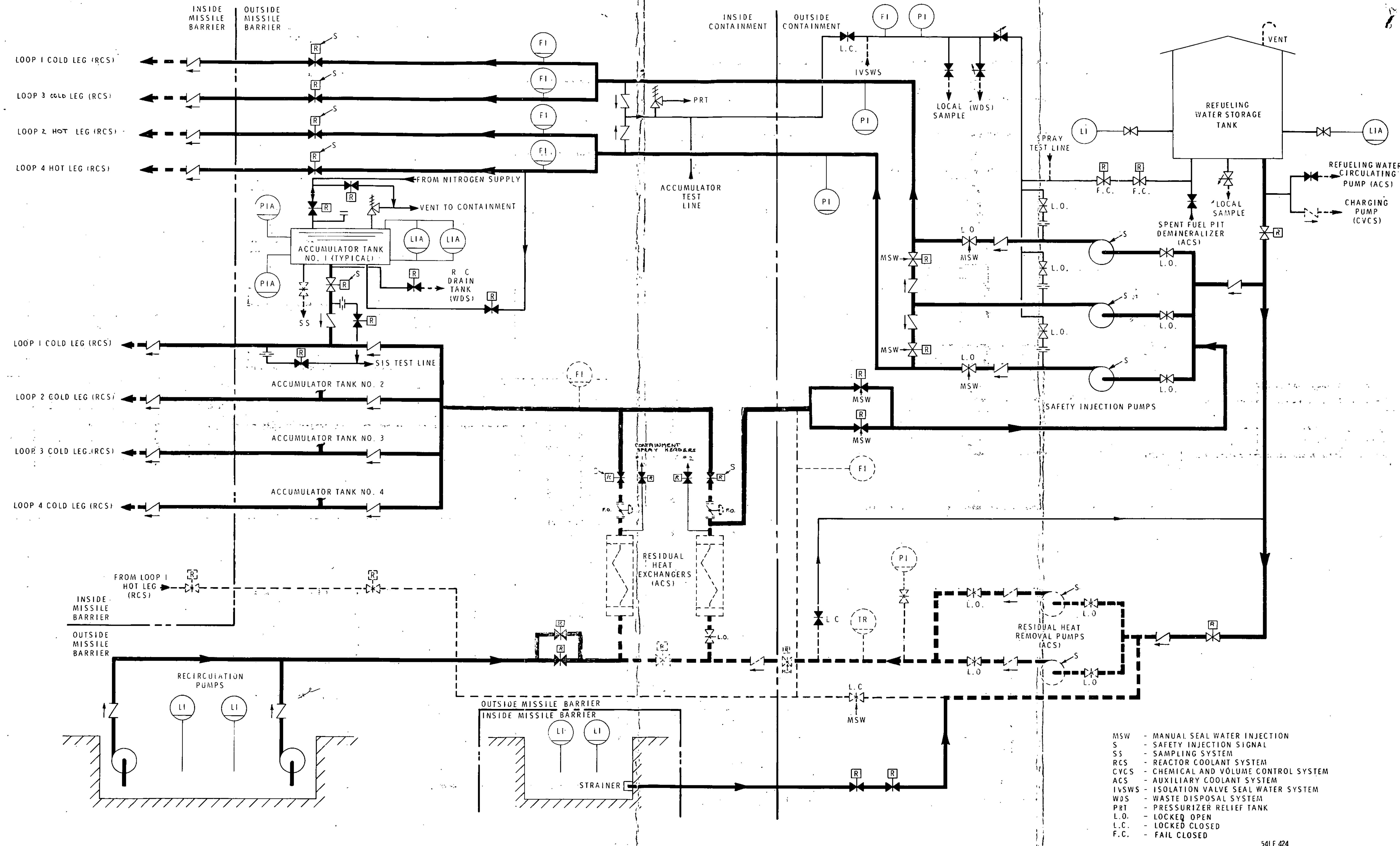
Valve Types: Dia. - Diaphragm
DDV - Double disc gate

Seal Water Injection: A - Automatic
M - Manual

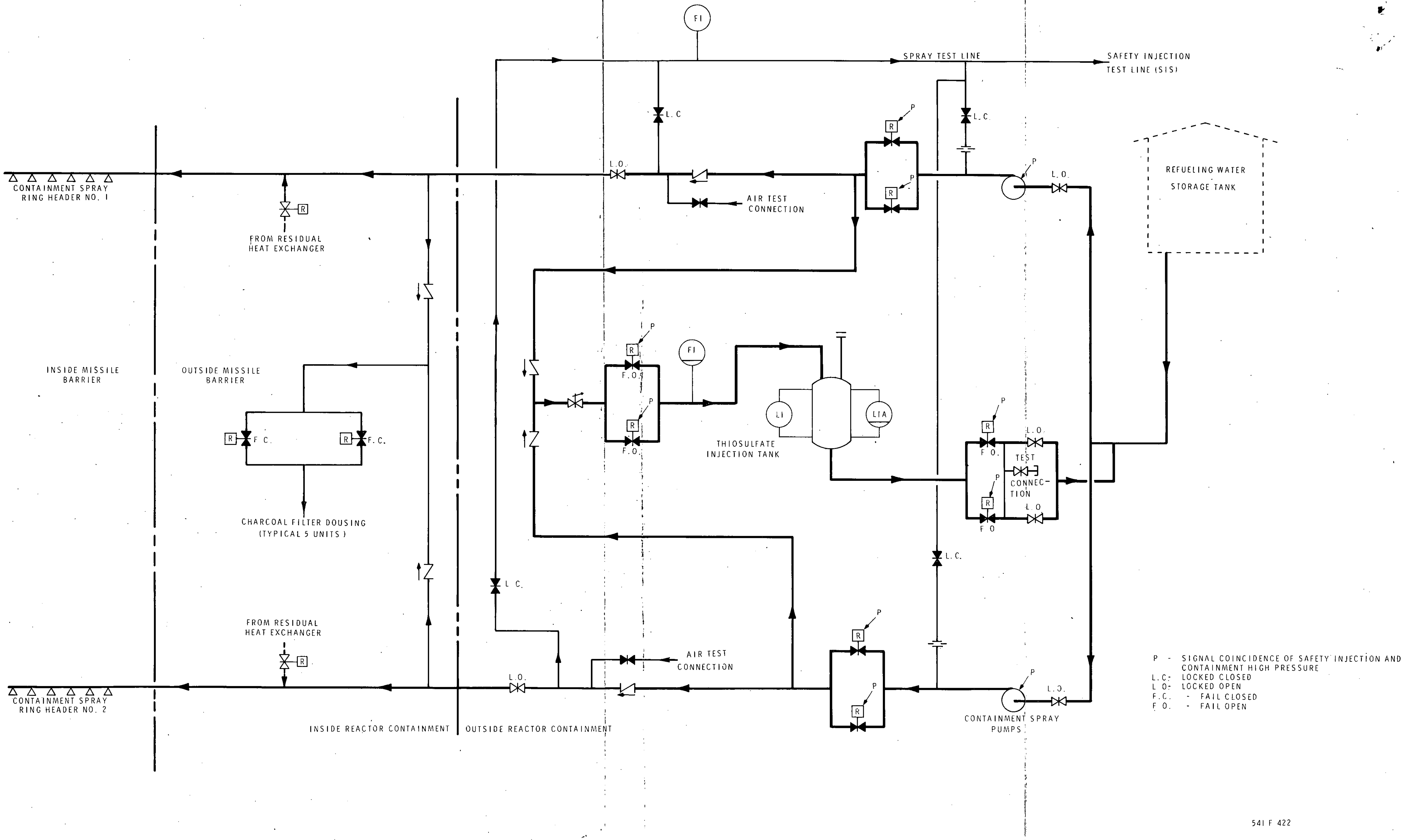
Valve Positions: NO - Normally Open
NC - Normally Closed
FC - Fail Closed
FAI - Fail As Is
LC - Locked Closed

C.I.S. - Containment Isolation Signal

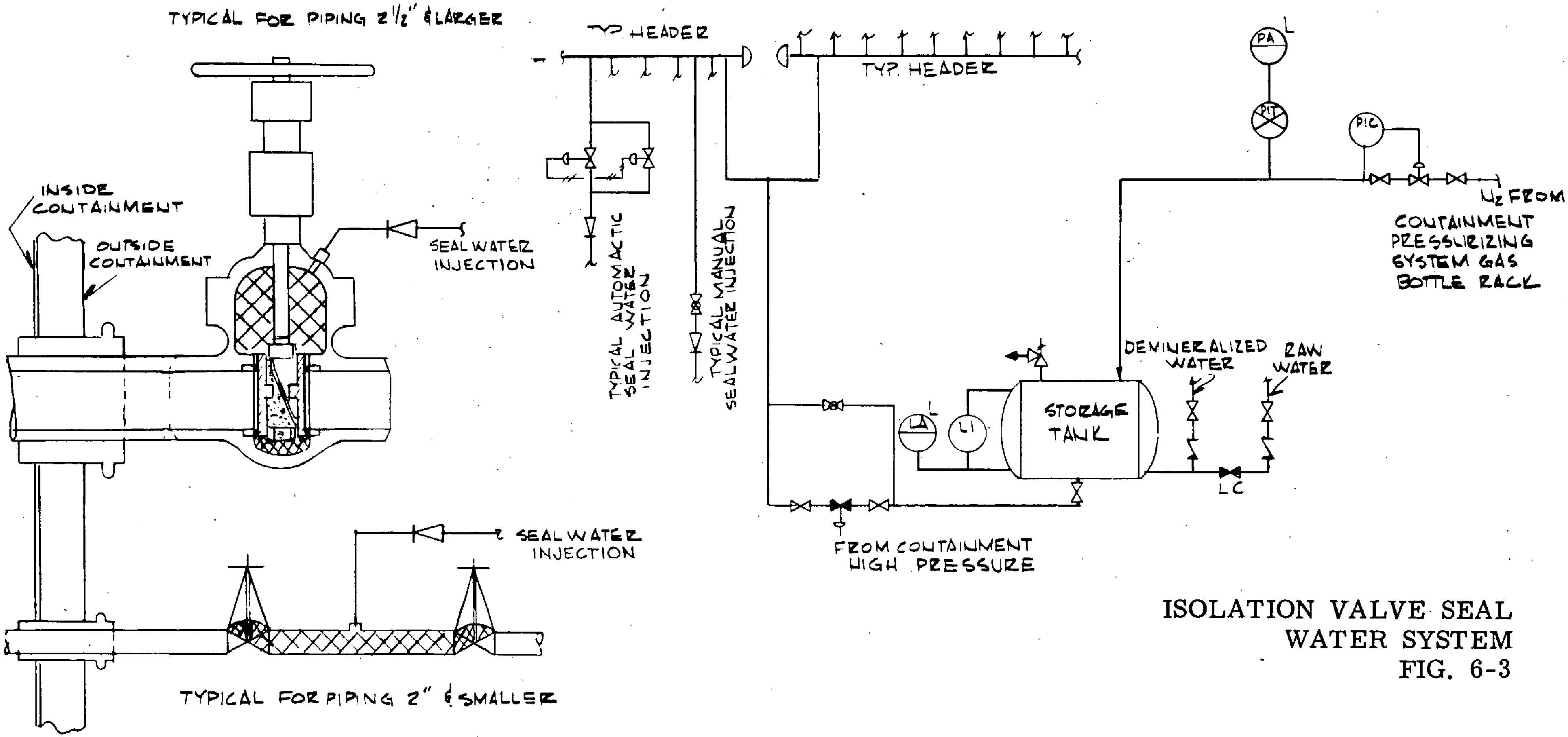
* - The 3 RSV's are the letdown orifice isolation valves



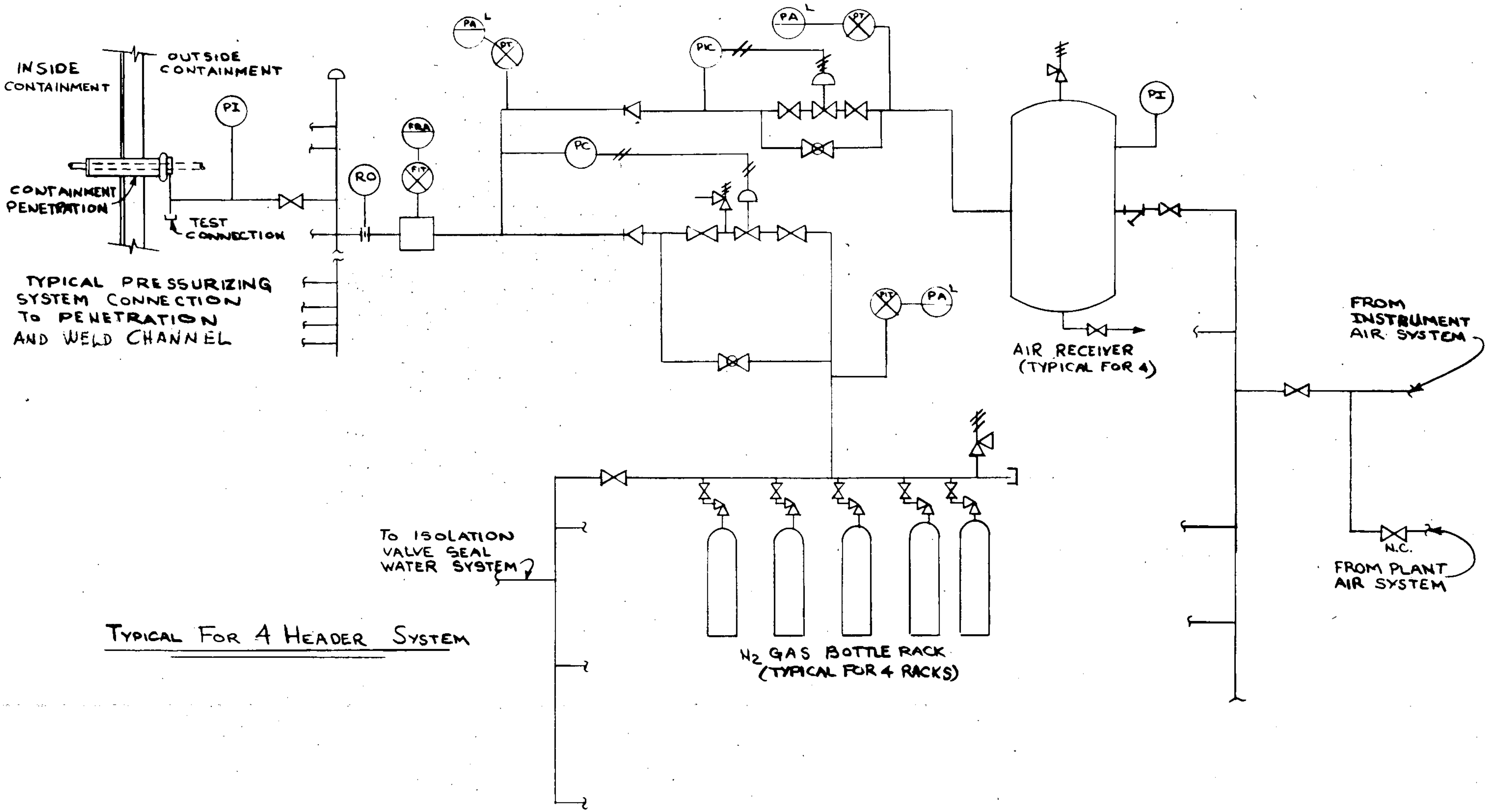
SAFETY INJECTION SYSTEM
FIG. 6-1



CONTAINMENT SPRAY SYSTEM
FIG. 6-2



ISOLATION VALVE SEAL
WATER SYSTEM
FIG. 6-3



PENETRATION PRESSURIZATION SYSTEM
FIG. 6-4