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# 5.0 CONTAINMENT SYSTEM STRUCTURE

## 5.1 CONTAINMENT SYSTEM STRUCTURE

### 5.1.1 DESIGN BASIS

The reactor containment completely encloses the entire reactor and reactor coolant system and ensures that an acceptable upper limit for leakage of radioactive materials to the environment is not exceeded even if gross failure of the reactor coolant system occurs. The structure provides biological shielding for both normal and accident situations. The containment structures of Units 1 and 2 are designed to maintain leakage no greater than 0.2%/24 hours of containment air weight at a design pressure of 60 psig and 286°F.

#### 5.1.1.1 GENERAL DESIGN CRITERIA

General Design Criteria that apply to the Containment System Structure are delineated below.

Quality Standards

Criterion: Those systems and components of reactor facilities which are essential to the prevention, or the mitigation of the consequences, of nuclear accidents which could cause undue risk to the health and safety of the public shall be identified and then designed, fabricated, and erected to quality standards that reflect the importance of the safety function to be performed. Where generally recognized codes and standards pertaining to design, materials, fabrication, and inspection are used, they shall be identified. Where adherence to such codes or standards does not suffice to assure a quality product in keeping with the safety function, they shall be supplemented or modified as necessary. Quality assurance programs, test procedures, and inspection acceptance criteria to be used shall be identified. An indication of the applicability of codes, standards, quality assurance programs, test procedures, and inspection acceptance criteria used is required. Where such items are not covered by applicable codes and standards, a showing of adequacy is required. (GDC 1)

The Containment System structure is of primary importance with respect to its safety function in protecting the health and safety of the public. Quality standards of material selection, design, fabrication, and inspection governing the above features conform to the applicable provisions of recognized codes at the time of construction and good nuclear practice. The concrete structure of the reactor containment conforms to the applicable portions of ACI-318-63. Further elaboration on quality standards of the reactor containment is given in Section 5.1.2.5 and Section 5.6.

Performance Standards

Criterion: Those systems and components of reactor facilities which are essential to the prevention or to the mitigation of the consequences of nuclear accidents which could cause undue risk to the health and safety of the public shall be designed, fabricated, and erected to performance standards that enable such systems and components to withstand, without undue risk to the health and safety of the public, the forces that might reasonably be imposed by the occurrence of an extraordinary natural phenomenon such as earthquake, tornado, flooding condition, high wind, or heavy ice. The design bases so established shall reflect: (a) appropriate consideration of the most severe of these natural phenomena that have been officially recorded for the site and the surrounding area and (b) an appropriate margin for withstanding forces greater than those recorded to reflect uncertainties about the historical data and their suitability as a basis for design. (GDC 2)

All components and supporting structures of the reactor containment are designed so that there is no loss of function of such equipment in the event of maximum potential ground acceleration acting in the horizontal and vertical directions simultaneously, or other extraordinary natural phenomena referred to in the criterion above. The dynamic response of the structure to ground acceleration, based on the site characteristics and on the structural damping, is included in the design analysis.

The reactor containment is defined as a Class I structure for purposes of seismic design (see Section 5.1.2.3). Its structural members have sufficient capacity to accept, without exceeding specified stress limits, a combination of normal operating loads, functional loads due to a loss of coolant accident, and the loadings imposed by the safe shutdown earthquake (SSE).

Fire Protection

Refer to the Fire Protection Program Design Document (FPPDD) (Reference 14) at Point Beach Nuclear Plant.

Records Requirement

Criterion: The reactor licensee shall be responsible for assuring the maintenance throughout the life of the reactor of records of the design, fabrication, and construction of major components of the plant essential to avoid undue risk to the health and safety of the public. (GDC 5)

Records of the design, fabrication, construction, and testing of the reactor containment are maintained throughout the life of the reactor.

Reactor Containment

Criterion: The containment structure shall be designed (a) to sustain, without undue risk to the health and safety of the public, the initial effects of gross equipment failures, such as a large reactor coolant pipe break, without loss of required integrity, and (b) together with other engineered safety features as may be necessary, to retain for as long as the situation requires, the functional capability of the containment to the extent necessary to avoid undue risk to the health and safety of the public. (GDC 10)

The reactor containment structure is a horizontally and vertically prestressed post tensioned concrete cylinder on top of a reinforced concrete slab and covered by a prestressed post tensioned shallow concrete dome.

The design pressure of the containment exceeds the peak pressure occurring as the result of the complete blowdown of the reactor coolant through any rupture of the reactor coolant system up to and including the hypothetical double ended severance of a reactor coolant pipe.

The containment structure and all penetrations are designed to withstand, within design limits, the combined loadings of the design basis accident and safe shutdown earthquake.

All piping systems which penetrate the containment structure are anchored at the penetration. Penetrations for lines containing high pressure or high temperature fluids (steam, feedwater, and blowdown lines) are designed so that the containment is not breached by a hypothesized pipe rupture. All lines connected to the primary coolant system that penetrate the containment are also anchored in the secondary shield walls (i.e., walls surrounding the steam generators and reactor coolant pumps). These anchors are designed to withstand the thrust, moment, and torque resulting from a hypothesized rupture of the attached pipe.

All isolation valves are supported to withstand, without impairment of valve operability, the combined loadings of the design basis accident and safe shutdown earthquake.

The design pressure is not exceeded during any subsequent long term pressure transient determined by the combined effects of heat sources such as residual heat and metal water reaction with minimum operation of the emergency core cooling and the containment air recirculation and spray cooling systems.

Reactor Containment Design Basis

Criterion: The reactor containment structure, including openings and penetrations, and any necessary containment heat removal systems, shall be designed so that the leakage of radioactive materials from the containment structure under conditions of pressure and temperature resulting from the largest credible energy release following a loss-of-coolant-accident, including the calculated energy from metal-water or other chemical reactions that could occur as a consequence of failure of any single active component in the emergency core cooling system, will not result in undue risk to the health and safety of the public. (GDC 49)

The following general criteria are followed to assure conservatism in computing the required structural load capacity:

1. In calculating the containment pressure, rupture sizes up to and including a double ended severance of reactor coolant pipe are considered.

2. In considering post accident pressure effects, various malfunctions of the emergency systems are evaluated. Contingent mechanical or electrical failures are assumed to disable one of the diesel generators, two of the four fan cooler units, and one of the two containment spray units. Equipment which can be run from diesel power is described in Chapter 6, Chapter 8, Chapter 9, and Chapter 10.

3. The pressure and temperature loadings obtained by analyzing various loss-of-coolant accidents, when combined with operating loads and maximum wind or seismic forces, do not exceed the load carrying capacity of the structure, its access opening, or penetrations.

The most stringent case of these analyses is summarized below:

Discharge of reactor coolant through a double ended rupture of the main loop piping, followed by operation of only those engineered safety features which can run simultaneously with power from one emergency on site diesel generator (one high head safety injection pump, one residual heat removal pump, two fan cooler units, one spray pump), results in a sufficiently low radioactive materials leakage from the containment structure that there is no undue risk to the health and safety of the public.

NDT Requirement for Containment Material

Criterion: The selection and use of containment materials shall be in accordance with applicable engineering codes. (GDC 50)

The selection and use of containment materials comply with the applicable codes and standards tabulated in Section 5.1.1.5.

The concrete containment is not susceptible to a low temperature brittle fracture.

The containment liner is enclosed within the containment and thus is not exposed to the temperature extremes of the environs. The containment ambient temperature during operation is between 50 and 120°F.

Containment penetrations which can be exposed to the environment are also designed to the NDT + 30°F criterion in accordance with ASME Section III, Subsection B.

### 5.1.1.2 SUPPLEMENTARY ACCIDENT CRITERIA

Systems relied upon to operate under post accident conditions, which are located external to the containment and communicate directly with the containment, are considered to be extensions of the leakage limiting boundary.

The pressure retaining components of the containment structure are designed for the maximum potential earthquake ground motion of the site combined with the simultaneous loads of the design basis accident, and the normal operating loads.

### 5.1.1.3 ENERGY AND MATERIAL RELEASE

The principal design loads on the containment structure are created by the hypothetical large break loss-of-coolant accident and rupture of a steam pipe accident. The large break loss-of-coolant accident (LOCA) postulates three distinct locations for a double-ended break in the reactor coolant system piping: the reactor coolant pump suction (between the steam generator and pump), the hot-leg (between the vessel and steam generator), and the cold-leg (between the pump and reactor vessel). The steam pipe rupture accident assumes a double-ended rupture of a main steam line downstream of the integral flow restrictor in the outlet of the steam generator. The energy released in both accidents cause a rapid rise in containment pressure and temperature. The LOCA analysis is described in Section 14.3.2 and the steam pipe rupture analysis is described in Section 14.2.5.

The capability of the containment to withstand the loss-of-coolant and steam line rupture accidents energy release and other design loads imposed on it is discussed in Section 5.1.2.2.

### 5.1.1.4 ENGINEERED SAFETY FEATURES CONTRIBUTION

Engineered safety features are included in the design of this facility to assure containment integrity. These systems are discussed in Chapter 6 and their effectiveness analyzed in Chapter 14.

### 5.1.1.5 CODES AND CLASSIFICATIONS

Electrical penetrations are designed and demonstrated by test to withstand, without loss of leak tightness, the containment post accident pressure and to meet the following guides:

1. IEEE - Guide for Electrical Penetration Assemblies in Containment Structures for Stationary Nuclear Power Reactors (Eighth Revision)

2. Electrical requirements of IEEE 317 - IEEE Standard for Electrical Penetration Assemblies in Containment Structures for Nuclear Fueled Power Generating Stations (1971 or 1976 versions)

Containment design gives consideration to leakage testability, including necessary provisions to enable tests to comply with:

1. ANS 7.60 - Proposed Standard for Leakage Testing of Containment Structures (July 14, 1967)

2. AEC Technical Safety Guide 7.5.1, "Reactor Containment Leakage Testing and Surveillance Requirements", (December 15, 1966)

The design, materials, fabrication, inspection, and proof testing of the containment vessel complies with the applicable parts of the following:

ASHO M-73-49 Cotton Mats for Curing Concrete

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| ACI 214-57 | Recommended Practice for Evaluation of Compression Test Results of Field Concrete |
| ACI 301-66 | Specification for Structural Concrete for Buildings (proposed) |
| ACI 306-66 | Recommended Practice for Cold Weather Concreting |
| ACI 311-64 | Recommended Practice for Concrete Inspection |
| ACI 315-65 | Manual of Standard Practice for Detailing Reinforced Concrete Structures |
| ACI 318-63 | Building Code Requirements for Reinforced Concrete |
| ACI 347-63 | Recommended Practice for Concrete Form Work |
| ACI 605-59 | Recommended Practice for Hot Weather Concreting |

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| ACI 613-54 | Recommended Practice for Selecting Proportions for Concrete |
| ACI 614 | Recommended Practice for Measuring, Mixing, and Placing Concrete |
| ACI SP-2 | Manual of Concrete Inspection |
| AISC | Code of Standard Practice for Steel Buildings and Bridges, (February 1964) |
| AISC | Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings, (April 1963) |
| ASA N 6.2 | Safety Standard for Design, Fabrication, and Maintenance of Steel Containment Structures for Stationary Nuclear Power Reactors |
| ASME III | Nuclear Vessels (mostly 1965 Edition; 1968 Edition and all Addenda was used for the design, fabrication, inspection, and testing of the Class B containment penetration head fittings) |
| ASME III | Division 2, Subsection CC-3440, Concrete Temperatures |
| AMSE VIII | Unfired Pressure Vessels |
| ASME IX | Welding Qualifications |
| ASTM A15-64 | Specification for Billet Steel Bars for Concrete Reinforcement |
| ASTM A36-63T | Specification for Structural Steel |
| ASTM A148-65 | Specification for High Strength Steel Castings for Structural Purposes |
| ASTM A155-68 | Specification for Electric Fusion Welded Steel Pipe for High Temperature Service |
| ASTM A185-64 | Specification for Welded Steel Wire Fabric for Concrete Reinforcement |
| ASTM A193-66 | Specification for Alloy Steel Bolting Materials for High Temperature Service |
| ASTM A233-64T | Specification for Mild Steel Covered Arc Welding Electrodes |
| ASTM A300-63T | Specification for Steel Plates for Pressure Vessels for Service at Low Temperatures |
| ASTM A516-64 | Specification for Carbon Steel Plates of Intermediate Tensile Strength for Fusion Welded Pressure Vessels for Atmospheric and Lower Temperature Service |
| ASTM A559-65T | Specification for Mild Steel Electrodes for Gas Metal Arc Welding |
| ASTM A572-66 | Specification for High Strength Low Alloy Columbian Vanadium Steels of Structural Quality |

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| ASTM C31-66 | Making and Curing Concrete Compression and Flexure Test Specimens in the Field |
| ASTM C33-67 | Specification for Concrete Aggregates |
| ASTM C39-68 | Test for Compressive Strength of Molded Concrete Cylinders |
| ASTM C40-66 | Test for Organic Impurities in Sand for Concrete |
| ASTM C42-68 | Methods of Obtaining and Testing Drilled Cones and Sawed Beams of Concrete |
| ASTM C87-68 | Test for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar |
| ASTM C88-63 | Test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate |
| ASTM C94-68 | Specification for Ready Mixed Concrete |
| ASTM C117-67 | Test for Materials Finer Than No. 200 Sieve in Material Aggregates by Washing |
| ASTM C127-68 | Test for Specific Gravity and Absorption of Coarse Aggregate |
| ASTM C12-68 | Test for Specific Gravity and Absorption of Fine Aggregates |
| ASTM C131-66 | Test for Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Abrasion Machine |
| ASTM C136-67 | Test for Sieve or Screen Analysis of Fine and Coarse Aggregates |
| ASTM C138-63 | Test for Weight Per Cubic Foot Yield, and Air Content (Gravimetric) of Concrete |
| ASTM C142-67 | Test for Friable Particles in Aggregates |
| ASTM C143-58 | Test for Slump of Portland Cement Concrete |
| ASTM C150-65 | Specification for Portland Cement |
| ASTM C171-63 | Specification for Waterproof Paper for Curing Concrete |
| ASTM C172-68 | Method of Sampling Fresh Concrete |
| ASTM C173-68 | Test for Air Content of Freshly Mixed Concrete by the Volumetric Method |
| ASTM C177-63 | Test for Thermal Conductivity of Materials by Means of the Guarded Hot Plate |
| ASTM C192-68 | Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Laboratory |

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| ASTM C227-65 | Method of Test for Potential Alkali Reactivity of Cement Aggregate Combinations (Mortar Bar Method) |
| ASTM C231-68 | Method of Test for Air Content to Freshly Mixed Concrete by the Pressure Method |
| ASTM C232-58 | Method of Test for Bleeding of Concrete |
| ASTM C260-66T | Specification for Air Entraining Admixtures for Concrete |
| ASTM C289-66 | Test for Potential Reactivity of Aggregates (Chemical Method) |
| ASTM C309-58 | Specification for Liquid Membrane - Forming Compounds for Curing Concrete |
| ASTM C350-65T | Specification for Fly Ash for Use as an Admixture in Portland Cement Concrete |
| ASTM C494-62T | Specification for Chemical Admixtures for Concrete |
| ASTM D92-66 | Test for Flash and Fire Points by Cleveland Open Cup |
| ASTM D97-66 | Test for Pour Points |
| ASTM D127-63 | Test for Drop Melting Point of Petroleum Wax, Including Petrolatum |
| ASTM D287-64 | Method of Test API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method) |
| ASTM D512-62T | Tests for Chloride Ion in Industrial Water and Industrial Waste Water |
| ASTM D937-58 | Method of Test for Cone Penetration of Petrolatum |
| ASTM D992-52 | Test for Nitrate Ion in Industrial Water |
| ASTM D1190-64 | Specification for Concrete Joint Sealer, Hot Poured Elastic Type |
| ASTM D1255-65T | Test for Sulfides in Industrial Water and Industrial Waste Water |
| ASTM D1751-65 | Specification for Performed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types) |

## 5.1.2 CONTAINMENT SYSTEM STRUCTURE DESIGN

### 5.1.2.1 GENERAL DESCRIPTION

The general configuration and dimensions of the reactor containment structure for Point Beach Unit 1 are shown in Figure 5.1-1.

The structure is a right cylinder with a flat base slab and a shallow domed roof. A 1/4 in. thick welded ASTM A 442 steel liner is attached to the inside face of the concrete shell to insure a high degree of leak tightness. The base liner is installed on top of the structural slab and is covered with concrete. The structure provides biological shielding for both normal and accident situations.

The nominal 3 ft. 6 in. thick cylindrical wall and 3 ft. thick dome are prestressed and post tensioned. The nominal 9 ft. thick concrete base slab is reinforced with high strength reinforcing steel. The slab is supported on H piles driven to refusal in the underlying bedrock.

The reactor containment structure for Point Beach Unit 2 is essentially identical in design and construction to that of Unit 1 except that it is oriented to conform to the overall site plan as shown in Figure 5.1-1.

Numerous mechanical and electrical systems penetrate the containment wall through welded steel penetrations as shown in Figure 5.1-2 and Figure 5.1-3.

In the concept of post-tensioned containment, the internal pressure load is balanced by the application of an opposing external pressure type load on the structure. Sufficient post-tensioning is used on the cylinder and dome to more than balance the internal pressure so that a margin of external pressure exists beyond that required to resist the design accident pressure. Nominal, bonded reinforcing steel is also provided to distribute strains due to shrinkage and temperature. Additional bonded reinforcing steel is used at penetrations and discontinuities to resist local moments and shears.

The internal pressure loads on the base slab are resisted by both the piles and the strength of the reinforced concrete slab. Thus, post tensioning is not required to exert an external pressure for this portion of the structure.

The post tensioning system design consists of:

1. Three groups of 49 dome tendons oriented at 120° to each other, for a total of 147 tendons anchored at the vertical face of the dome ring girder;
2. 168 vertical tendons anchored at the top surface of the ring girder and at the bottom of the base slab;
3. A total of 367 hoop tendons anchored at the six vertical buttresses.

Each tendon design consists of ninety 1/4 in. diameter wires with button headed BBRV type anchorages, furnished by Inland-Ryerson Construction Products Company. Actual number of tendon wires vary as documented in tendon surveillance reports. The tendons are housed in spiral wrapped corrugated thin wall sheathing and capped at each anchorage by a sheathing filler cap. After fabrication, the tendon is shop dipped in a petrolatum corrosion protection material, bagged, and shipped. After installation, the tendon sheathing and caps are filled with a corrosion preventive grease. In addition to this corrosion protection system, that portion of the tendon system in the base slab and the reinforcing steel are connected into an impressed current cathodic protection system. The cathodic protection system provided utilizes close coupled anodes to protect the interconnected liner, reinforcing bars, and tendon steel casings. The system is conservatively designed for a 40 year life.

Permanent zinc reference electrodes are installed under the containment base slab in order to obtain potential gradient data throughout the foundation and thereby insure that the cathodic protection system is operating satisfactorily.

Ends of all tendons are covered with grease filled pressure tight caps for corrosion protection.

ASTM A-432 reinforcing steel is used throughout the base slab and around the large penetrations. A-15 steel is used for the bonded reinforcing throughout the cylinder and dome as crack control reinforcing. At areas of discontinuities where additional steel is used, such steel is generally A-432 to provide an additional margin of elastic strain capability.

The entire containment structure is housed in an unheated enclosure (facade) that provides protection from the weather.

The 1/4 in. thick liner plate is attached to the concrete by means of an angle grid system stitch welded to the liner plate and embedded in the concrete. The details of the anchoring system are provided in Figure 5.1-1. The frequent anchoring is designed to prevent significant distortion of the liner plate during accident conditions and to insure that the liner maintains its leaktight integrity. The design of the liner anchoring system also considers the various erection tolerances and their effect on its performance. The liner plate is coated on the inside with 1-1/2 mil zinc silicate primer. Top coat is an epoxy finish with thickness as required by location. There is no paint on the side in contact with concrete.

The liner plate is fabricated with a leak chase channel (LCC) system which covers all welded seams in the liner plate. In addition, some penetrations have leak chase channels installed over penetration assembly welds. The LCCs are welded on the inside of the liner plate, except for the dome LCCs, which are welded to the outside of the liner plate. The original purpose of the LCCs was to have the ability to pressure test the liner plate or penetration welds for leaks without pressurizing the full containment structure. They are not presently used, but are considered an integral part of the liner plate and therefore a part of the leak tight containment pressure boundary. See Section 5.1.2.9 for further discussion of the LCC system.

Personnel and equipment access to the structure is provided by a double door lock and by a 15 ft. clear diameter double gasketed single door as shown in Figure 5.1-4 and Figure 5.1-5. A double door emergency personnel escape lock is also provided. These locks and hatches are designed and fabricated of SA-516, Grade 70 firebox quality steel made to SA-300 specification, Charpy V notch impact tested to -45°F.

The structural brackets provided for the containment crane runway and for the dome liner erection trusses are fabricated of A-36 steel. Structural brackets and reinforcing plates were shop fabricated and then shipped to the job site for welding into the 1/4 in. liner plate similar to the penetration assemblies.

The containment structure is designed and constructed in accordance with the design criteria. These criteria are based upon ACI 318-63, ACI 301, and the ASME Pressure Vessel Code, Sections III, VIII, and IX. It is the intent of the criteria to provide a structure of unquestionable integrity that will meet the postulated design conditions with a low strain elastic response. The Point Beach containment structure meets these criteria because:

1. The design criteria are, in general, based on the proven stress, strain, and minimum proportioning requirements of the ACI or ASME Codes. Where departures or additions from these codes are made, they were done in the following manner:

    a. The environmental conditions of severity of load, load cycling, weather, corrosion conditions, maintenance, and inspection for this structure are compared and evaluated with those for code structures to determine the appropriateness of the modifications.

    b. During the design and construction phase, the consultants were retained to assist in the development of the criteria. In addition to assisting with the criteria submitted in the PSAR, they were involved in the updating of the criteria and the review of design methods and drawings to assure that the criteria were implemented as intended.

    c. Consultants were retained during the design and construction phase to assist in developing the proper approach to design criteria for combined shear bending and axially loaded structures.

    d. During the design and construction of the structure, all criteria, specifications, and details relating to liner plate and penetrations, cathodic protection, and corrosion protection were referred to Bechtel's Metallurgy and Quality Control Department. This department maintained a staff to advise and assist in problems of welding, quality control, metallurgy, cathodic protection, and corrosion protection.

    e. The design of the Point Beach containment structure was continuously reviewed as the improved criteria for subsequent license applications became available.

2. The primary membrane integrity of the structure is provided by the unbonded post-tensioning tendons, each one of which is stressed from 75% to 80% of ultimate strength during installation and performs at approximately 60%-65% during the life of the structure. The 75%-80% range is provided in order to recognize practical considerations in measuring the elongation of the tendons and in the accuracy of the jacking gages. Thus, the main strength elements were individually proof tested prior to operation of the plant.

3. Six hundred and eighty two such post-tensioning elements are provided, 147 in the dome, and 168 vertical and 367 hoop tendons in the cylinder. Any three adjacent tendons in any of these groups can be lost without significantly affecting the strength of the structure due to the load redistribution capabilities of the shell structure. The bonded reinforcing steel provided for crack control insures that this redistribution capability exists.

4. The unbonded tendons are continuous from anchorage to anchorage, being deflected around penetrations and isolated from secondary strains of the shell. Thus, the membrane integrity of the shell can be insured regardless of conditions of high local strains.

5. The unbonded tendons exist in the structure at a slightly ever decreasing stress due to relaxation of the tendon and creep of the concrete and, even during pressurization, are subject to a stress change of very small magnitude (2% to 3% of ultimate strength).

6. a. The prestressed concrete portion of the structure was subjected to the highest membrane compressive stresses after the post tensioning sequence was completed. Membrane compressive stress is defined in this case as the resultant normal force acting on the concrete cross sectional area.

   The local high compressive stress concentrations in the concrete are:

   (1) Behind the bearing plates of the tendon anchorages. These stresses reach their highest level at the time of the post tensioning operations, and then decrease because of prestressing losses.

   (2) At discontinuities, such as the inner edge of the penetrations through the containment wall. These stresses reach the highest level for load combination ($D + F + T_A$).

   b. Membrane tension, the tension force that is a result of the stresses throughout the concrete portion of the wall, is prevented by the post-tensioning forces for working stress design load combinations. The post-tensioning forces also prevent membrane tension for yield stress design load combinations if the self limiting thermal expansion of the liner plate is neglected.

   Tensile stresses are caused by uneven temperatures, discontinuities, and nonaxisymmetric loading, such as earthquake, wind, and pipe penetrations. In places and for load conditions where the tensile stresses exceed the values given, mild steel reinforcement is carrying the tensile forces.

7. The deformations of the structure during plant operation or due to accident conditions are relatively minor. The radial deflections in the shell at the time of initial post-tensioning and shortly thereafter were expected to be between 0.20 and 0.25 in. The design of the piping anchors to the shell takes into account the above mentioned shell deformations, thus eliminating the use of expansion bellow seals for containment barriers inside containment. (See Figure 5.1-2 for typical piping penetrations). The design of the piping restraint system is such as to accommodate shell deformations at all pipe penetration elevations without exceeding pipe and pipe restraint allowable stresses and without jeopardizing containment leak tightness integrity.

8. Virtually all of the exposed protective coatings and paints within the containment consist of (a) Dimetcote Steel Primer with Amercoat 66 epoxy top coat and modified phenolic coatings on carbon steel structures, equipment, and concrete, (b) galvanized steel on duct work, I&C conduit, and miscellaneous structural steel, and (c) polyvinyl chloride used for conduit sheathing and electrical insulation. For more information on committed standards relating to containment coatings, see Section 1.4.

### 5.1.2.2 MECHANICAL DESIGN BASES

Safety of the structure under extraordinary circumstances and proper performance of the containment structure at various loading stages were the main considerations in establishing the structural design criteria.

The two basic criteria are:

1. The integrity of the liner plate shall be guaranteed under all credible loading conditions.

2. The structure shall have a low strain elastic response such that its behavior will be predictable under all design loadings.

The strength of the containment structure at working stress and overall yielding is compared to various loading combinations to insure safety. The analysis and design of the containment structure is carried out with consideration for strength, the nature and the amount of cracking, the magnitude of deformation, and the extent of corrosion to insure proper performance. The structure is designed to meet the performance and strength requirements under the following conditions:

1. Prior to prestressing

2. At transfer of prestress

3. Under sustained prestress

4. At design loads

5. At yield loads

Deviations in allowable stresses for the design loading conditions in the working stress method are permitted if the yield capacity criteria are fully satisfied. All design is in accordance with the ACI Code 318-63 unless otherwise stated herein.

No special design bases are required for the design and checking of the base slab. It acts primarily in bending rather than membrane stress. This condition is covered by the ACI Code 318-63. The loads and stresses in the cylinder and dome are determined as described below.

<u>Design Method</u>

The structure is analyzed using a finite element computer program for individual and various combinations of loading cases of dead load, live load, prestress, temperature, and pressure. The computer output includes direct stresses, shear stresses, principal stresses, and displacements of each nodal point.

Stress plots which show the total stresses from appropriate combinations of loading cases are made and areas of high stress are identified. The modulus of elasticity is corrected to account for the nonlinear stress-strain relationship at high compression where necessary. Stresses are recomputed where there are sufficient areas which require attention.

In order to consider creep deformation, the modulus of elasticity of concrete under sustained loads such as dead and prestress load is differentiated from the modulus of elasticity of concrete under instantaneous loads such as internal pressure and earthquake loads.

The forces and shears are added over the cross section, and the total moment, axial force, and shear determined. From these values, the straight line elastic stresses are computed and compared to the allowable values. The ACI Code 318-63 design methods and allowable stresses are used for concrete and prestressed and nonprestressed reinforcing steel except as noted in these criteria.

Loads Prior To Prestressing

Under this condition the structure is designed as a conventionally reinforced concrete structure. It is designed for dead load, live loads (including construction loads), and a reduced wind load. Allowable stresses are according to ACI 318-63 Code requirements.

Loads At Transfer Of Prestress

The containment structure is checked for prestress loads and the stresses compared with those allowed by the ACI 318-63 Code with the following exceptions: ACI 318-63, Section 26 allows concrete stress of 0.60 $f'_{ci}$ at initial transfer. In order to limit creep deformations, the membrane compression stress is limited to 0.30 $f'_{ci}$, whereas, in combination with flexural compression, the maximum allowable stress is limited to 0.60 $f'_{ci}$ per the ACI 318-63 Code.

For local stress concentrations with nonlinear stress distribution as predicted by the finite element analysis, 0.75 $f'_{ci}$ is permitted when local reinforcing is included to distribute and control these localized strains. These high local stresses are present in every structure but they are seldom identified because of simplifications made in design analysis. These high stresses are allowed because they occur in a very small percentage of the cross section, are confined by material at lower stress, and would have to be considerably greater than the values allowed before significant local plastic yielding would result. Nonprestressed reinforcing is added to distribute and control these local strains.

Membrane tension and flexural tension are permitted provided they do not jeopardize the integrity of liner plate. Membrane tension is permitted to occur during post tensioning sequence but is limited to 1.0 $f'_{ci}$. When there is flexural tension but no membrane tension, the section is designed in accordance with Section 2605(a) of the ACI Code. The stress in the liner plate due to combined membrane tension and flexural tension is limited to 0.5 $f_y$.

Shear criteria are in accordance with the ACI 318-63 Code, Chapter 26, as modified by the equations shown elsewhere in this section using a load factor of 1.5 for shear loads.

Loads Under Sustained Prestress

The conditions for design and the allowable stresses for this case are the same as above except that the allowable tensile stress in nonpressurized reinforcing are limited to 0.5 $f_y$. The ACI limits the concrete compression to 0.45 $f'_c$ for sustained prestress load.

Values of 0.30 $f'_c$ and 0.60 $f'_c$ are used as described above, which bracket the ACI allowable value. However, with these same limits for concrete stress at transfer of prestress, the stresses under sustained load will be reduced due to creep.

<u>At Design Loads</u>

This loading case is the basic "working stress" design. The containment structure is designed for the following specific loading cases:

1. D + F + L + To

2. D + F + L + P + $T_A$ + W (or E)

3. D + F + L + P'

D = Dead Load
L = Appropriate Live Load
F = Appropriate Prestressing Load
P = Pressure Load (Varies with Time from Design Pressure to Zero Pressure)
$T_o$ = Thermal Loads Due to Operating Temperature
$T_A$ = Thermal Loads Based on a Temperature Corresponding to a Pressure P
E = Design Earthquake Load
P' = Test Pressure (1.15 P)
W = Wind Load

Sufficient prestressing is provided in the cylindrical and dome portions of the vessel to eliminate membrane tensile stress (tensile stress across the entire wall thickness) under design loads. Flexural tensile cracking of the concrete is permitted but is controlled by bonded unprestressed reinforcing steel.

According to the analysis of the containment, the working stress design limits for the loading condition, D + F + L + P + $T_A$ + E will be reached at values of ground acceleration as shown below:

1. Flexural Stresses

   The predicted critical section for flexural stresses is J-J (Table 5.1-1). The hoop reinforcement stress predicted there is 30,000 psi for a horizontal ground acceleration of 0.061 g. At Section K-K (Table 5.1-1) (taking an average of stresses obtained by using meshes #3 and #4), a 0.075 g ground acceleration is predicted to result in a 30,000 psi stress in the reinforcement.

2. Shear Stresses

   The critical section for shear stresses is L-L (Table 5.1-1). The limiting stresses will be reached there (using average shear stresses from mesh #3 and #4) at a horizontal ground acceleration of 0.094 g.

3. Membrane Stresses

   The design criteria require that the average stress across the concrete cross section should not be tensile. That design criterion is satisfied at section F-F (Table 5.1-1) for horizontal ground accelerations not in excess of 0.069 g. (Combination of membrane forces from axisymmetric loadings and seismic membrane shear.)

Under the design loads the same performance limits stated elsewhere in this section apply with the following exceptions:

1. If the net membrane compression is below 100 psi, it is neglected and a cracked section is assumed in the computation of flexural bonded reinforcing steel. The allowable tensile stresses in bonded reinforcing are 0.5 $f_y$.

2. When the maximum flexural stress does not exceed $6\sqrt{f'_c}$ and the extent of the tension zone is not more than 1/3 the depth of the section, bonded reinforcing steel is provided to carry the entire tension in the tension block. Otherwise, the bonded reinforcing steel is designed assuming a cracked section. When the bending moment tension is additive to the thermal tension, the allowable tensile stress in the bonded reinforcing steel is 0.5 $f_y$ minus the stress in reinforcing due to the thermal gradient as determined in accordance with the method of ACI 505.

3. The problem of shear and diagonal tension in a prestressed concrete structure is considered in two parts: membrane principal tension and flexural principal tension. Since sufficient prestressing was used to eliminate membrane tensile stress, membrane principal tension is not critical at design load. Membrane principal tension due to combined membrane tension and membrane shear is considered in the next section.

   Flexural principal tension is the tension associated with bending in planes perpendicular to the surface of the shell and shear stress normal to the shell (radial shear stress). The ACI 318-63 provisions of Chapter 26 for shear are adequate for design purposes with proper modifications as discussed using a load factor of 1.5 for shear loads.

Crack control in the concrete is accomplished by adhering to the ACI-ASCE Code Committee standards for the use of reinforcing steel. These criteria are based upon a recommendation of the Prestressed Concrete Institute and are as follows:

   0.25 percent reinforcing is provided at the tension face for small members

   0.20 percent for medium size members

   0.15 percent for large members

A minimum of 0.15 percent mild steel reinforcing is provided in two perpendicular directions on the exterior faces of the wall and dome for proper crack control.

The liner plate is attached on the inside faces of the wall and dome. Since, in general, there are no tensile stresses due to temperature on the inside faces, bonded reinforcing steel is provided at the inside face only where required to carry discontinuity moment tensile stresses.

The prestressing steel helps limit the amount of thermal cracking in concrete by virtue of the fact that it is close to the outside face and will be cooler compared to the inside face and thus causes compression in the elements of the structure. Additionally, any membrane cracking in the structure at factored load is resisted by tendons, mild steel reinforcing, and liner plate without exceeding the tensile yield strength of any of these resisting elements.

The containment structure is designed to withstand the thermal gradient shown in Figure 5.1-6. The increased temperature of the liner plate and concrete during an incident results in greater membrane forces and thus requires more tendons and external face reinforcing steel.

The accident temperature distribution through the wall sections is nonlinear. Since the finite element mesh, which uses the entire containment as a model, consists of 6 concrete element layers through the wall thickness with one additional layer for the liner plate, a nonlinearity in the temperature distribution gives rise to a nonlinear thermal stress distribution through the wall thickness.

This elastic thermal stress distribution is combined with the membrane stresses (uniformly distributed through the wall thickness) obtained from the live loads (D + F, P, and E) by the elastic finite element method for load combinations including (D + F and P) and by hand for (E), respectively. The stress reduction ($\Delta\sigma_c$) resulting from the cracking of the tensile zone of the concrete will reduce the compressive part of the nonlinear combined stress diagram by a constant value $\Delta s_c$, and will increase the stress in the reinforcing steel by $\Delta s_c$. The stress values obtained thus far are not based on any linearity in the considered stress diagram. Stress from loads, other than the thermal moment effect and seismic loads, are then superimposed on the above stresses. The steel and concrete stresses produced by these moments are assumed to be linear in accordance with the usual reinforced concrete design assumptions. The stresses are computed from moments resulting from the nonlinear stress distribution through the wall thickness.

The total stresses are obtained by adding the nonlinear stresses from the "relieved" thermal state of stress and linear stresses induced by the other moments.

These two computation methods were necessary for increased realism of stress predictions since the Point Beach containment was analyzed by a finite element program which required the idealized assumptions of the theory of elasticity.

Loads Necessary To Cause Structural Yielding

The structure is checked for the factored loads and load combinations given below and compared with the yield strength of the structure.

The load factors are the ratio by which loads are multiplied for design purposes to assure that the load/deformation behavior of the structure is one of elastic, low strain behavior. The load factor approach is used in this design as a means of making a rational evaluation of the isolated factors which are considered in assuring an adequate safety margin for the structure. This approach permits the designer to place the greatest conservatism on those loads most subject to variation and which most directly control the overall safety of the structure. It also places minimum emphasis on the fixed gravity loads and maximum emphasis on accident and earthquake or wind loads.

The final design of the containment structure satisfies the following loading combinations and factors:

1. $Y = 1/\Phi\ (1.05D + 1.5P + 1.0T_A + 1.0F)$

2. $Y = 1/\Phi\ (1.05D + 1.25P + 1.0T_A + 1.25H + 1.25E + 1.0F)$

3. $Y = 1/\Phi\ (1.05D + 1.25H + 1.0R + 1.0F + 1.25E + 1.0T_o)$

4. $Y = 1/\Phi\ (1.05D + 1.0F + 1.25H + 1.0W + 1.0T_o)$

5. $Y = 1/\Phi\ (1.0D + 1.0P + 1.0T_A + 1.0H + 1.0E' + 1.0F)$

6. $Y = 1/\Phi\ (1.0D + 1.0H + 1.0R + 1.0E' + 1.0F + 1.0T_o)$

Note: 0.95D is used instead of 1.05D where dead load subtracts from critical stress.

where

Y = Required yield strength of the structure as defined below

$\Phi$ = Yield capacity reduction factor

D = Dead loads of structures and equipment plus any other permanent loadings contributing stress, such as hydrostatic or soil. In addition, a portion of the live load is added when it includes items such as piping, cable, and trays suspended from floors. An allowance is made for future additional permanent loads.

P = Design accident pressure load

F = Effective prestress loads

R = Force or pressure on structure due to rupture of any one pipe

H = Force on structure due to thermal expansion of pipes due to design conditions

$T_o$ = Thermal loads due to the temperature gradient through wall during operating conditions (see Figure 5.1-6)

$T_A$ = Thermal loads due to the temperature gradient through the wall and expansion of the liner. It is based on a temperature corresponding to the factored design accident pressure.

E = Design earthquake or wind load (see Figure 5.1-14)

E′ = Hypothetical earthquake load (see Figure 5.1-14)

W = Tornado load

Equation 1 defines the containment's capacity to withstand pressure loadings at least 50% greater than those calculated for the postulated loss of coolant accident alone.

Equation 2 defines the containment's capacity to withstand loadings at least 25% greater than those calculated for the postulated loss of coolant accident with a coincident design earthquake or wind.

Equation 3 defines the containment's capacity to withstand loadings at least 25% greater than those calculated for the design earthquake coincident with rupture of any attached piping.

Equation 4 defines the containment's capacity to withstand tornado loadings equal to the design tornado.

Equations 5 and 6 assure that the containment has the capacity to withstand either the postulated loss of coolant accident or the rupture of any attached piping coincident with the maximum hypothetical earthquake.

With respect to the dynamic analysis for the containment, the following describes the procedures used to determine stresses at the various sections from the shear and moment envelopes. Figure 5.1-19 serves as a basis for the stress analysis. The following procedure was used to find the stresses at various sections in the containment.

1. Find the overturning $M_o$ at the bottom of the base slab

2. Find the triangular soil stress distribution as $P = \frac{M_0 C}{I}$

3. Assuming base slab fixed at edges and subjected to triangular soil pressure as determined above, find the following moments and forces:

   a. Radial Moment $M_r$

   b. Hoop Moment $M_\theta$

   c. Radial Shear Force $Q_r$

   d. Tangential Shear Force $Q_\theta$

   e. Twisting Moment $M_{r\theta}$

   (Reference 2, Chapter 9)

4. Find the percentage of fixity at the edge of the base slab. For this, apply 1 ksf uniform load at the base of the slab and find moment $M_1$ at a section near the edge of finite element computer analysis. The radial normal force $N_1$ of this calculation will be used in Step 6.

   Also, the same load is applied while assuming complete fixity around the base slab, obtaining a moment $M_2$ around the same section.

   The actual fixity is the ratio of $M_1$ and $M_2$: $f = \frac{M_1}{M_2}$

5. Make correction for the difference between the actual edge moment ($fM_r$) and moment ($M_r$) that would exist in case of complete fixity by applying a moment around the base slab varying as a cosine function (1-f) $M_r \cos\theta$. The resulting moments and forces are added to those obtained from Steps 3 and 4.

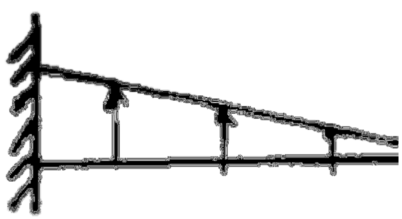
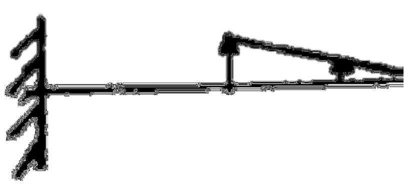
6. In addition, there are membrane forces N in the base slab due to the interaction with the cylinder. These membrane forces can be determined by the following edge loadings of the base slab.

$$N = \frac{fM_1N_1}{M_1}$$

7. In the cylindrical portion of the containment there are membraned forces in general and radial shear and moment at the base resulting from the edge moments around the base slab. These latter ones are obtained as a result of the analysis of the base slab.

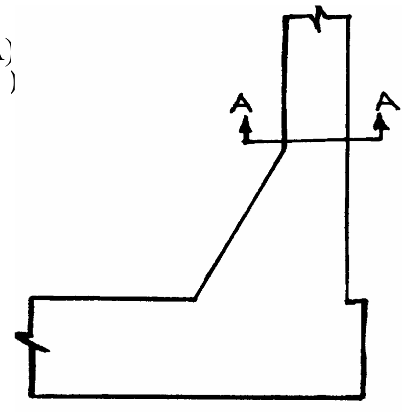
## SAMPLE CALCULATIONS FOR THE MOMENTS AND FORCES IN THE BASE SLAB CAUSED BY SEISMIC FORCES (E = 0.06g)

| 2.8' | | | 24.0' | | 41.5' | | 53.0' | |
|---|---|---|---|---|---|---|---|---|
| Load Case | Moment kips-ft | Force kips | Moment kips-ft | Force kips | Moment kips-ft | Force kips | Moment kips-ft | Force kips |
| Radial | | | | | | | | |
| I | +35.0 | | +188.0 | | +2.4 | | -396.0 | |
| II | +20.0 | | +90.0 | | -25.6 | | -80.0 | |
| III | -16.0 | | -19.0 | | +7.2 | | +17.7 | |
| IV | +2.0 | +0.8 | -8.0 | -0.8 | -16.8 | 0.0 | | |
| V | +8.0 | +1.0 | +64.0 | +9.0 | +110.4 | +16.0 | +141.0 | +20.0 |
| Total | +49.0 | +1.8 | +315.0 | +8.2 | +77.6 | +16.0 | -317.3 | +20.0 |
| Hoop | | | | | | | | |
| I | +15.7 | | +100.0 | | +57.8 | | -66.3 | |
| II | +9.6 | | +53.0 | | +12.4 | | -17.7 | |
| III | - 8.0 | | -13.8 | | -2.4 | | +5.7 | |
| IV | +1.0 | +0.9 | -2.4 | -1.4 | -11.7 | 0.0 | | |
| V | +3.2 | +3.2 | +28.4 | +27.0 | +47.6 | +47.0 | +67.5 | +60.0 |
| Total | +21.5 | +4.1 | +165.2 | +25.6 | +103.7 | +47.0 | -10.8 | +60.0 |

| | |
|---|---|
| I  | P-3.36 K, LATERAL EARTHQUAKE |
| | ECCENTRICITY OF INTERNALS |
| | EFFECT OF VERTICAL 'E' ON ECCENTRICITY |
| II  | VERTICAL EARTHQUAKE |
| | CORRECTION FOR PARTIAL FIXITY |

These moments and forces due to earthquake were then combined with the moments and forces due to other loading conditions and for various loading combination stresses were worked out. Table 5.1-1 shows the stress summaries.

Principal Stress Calculations Near Base Of Cylinder (Section A-A)




V = Shear from seismic calculations (at Section A-A) = 5478kips

$$\sigma_v = \frac{VQ}{It} = 127.5 \text{ psi}$$

Meridional Stresses ($\sigma_1$):

| | |
|---|---|
| Vertical Prestress | = +290.0 k/ft (+ denotes compression) |
| Force Due to Pressure | = -234.5 k/ft |
| Force Due to Dead Load | = +100.0 k/ft |
| Force in Liner Plate | = -100.0 k/ft |
| Net Vertical Force | = +55.5 k/ft |

$$\sigma_1 = \frac{55.5 \times 1000}{42 \times 12} = +110.1 \text{ psi}$$

Hoop Stresses ($\sigma_2$):

| | |
|---|---|
| Hoop Prestress | = +662.0 k/ft |
| Force Due to Pressure | = -469.9 k/ft |
| Force In Liner Plate | = -100.0 k/ft |
| Net Hoop Force | = +92.1 k/ft |

$$\sigma_2 = \frac{92.1 \times 1000}{42 \times 12} = +182.7 \text{ psi}$$

$$\text{Principal Stresses} = \frac{110.1 + 182.7}{2} \pm \sqrt{\left(\frac{182.7 - 110.1}{2}\right)^2 + (127.5)^2}$$

$$= +13.8 \text{ psi and } +279 \text{ psi}$$

For Class I equipment, sample dynamic analysis calculations are demonstrated by reference to the following typical application. The containment cavity cooling fan units, Items W4A and W4B, are carried, one above the other, on a structural steel frame located in containment on the 21' 0" elevation. The two level steel structure consists of platforms at the 26' 0" and 34' 0" levels fabricated from 8 in. and 10 in. WF beams connected by 8 in. WF columns and double angle bracing on all sides. The combined weight of the fans, motors, cooling coils, and plenum chamber casing is approximately 10,000 lbs. per platform. The configuration of the two fan units yields a two degrees of freedom system. The structure itself is analyzed as a rigid frame. The deflection of this frame, given a unit lateral loading, is used to generate a flexibility matrix. This matrix, when converted to a stiffness matrix, provides the stiffness factors for a simulated mathematical model. The weights of the two fan units and components are treated as lumped masses. The model is analyzed as a cantilever beam with a loading equivalent to the lumped masses to obtain the material frequency and mode shapes.

The acceleration values for these units obtained from the appropriate amplified response curves plus the natural frequencies and mode shapes are entered as input to a computer program (Bechtel CE641). This program generates a response of the structure to the seismic loads. Output is in terms of inertial forces and the shear, moment, acceleration, and displacement envelopes. The inertial forces are applied to the structure in this case by use of the STRESS structural analysis program, as additional stresses added algebraically to the normal dead load stresses. The final evaluation of the frame reflects the combined effects of each loading.

Sample Values

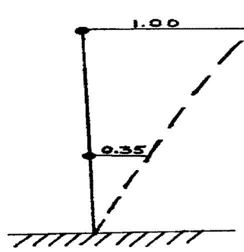
The flexibility matrix is:

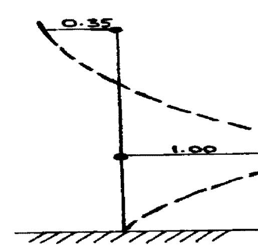
$$\begin{bmatrix} 0.6636 & -0.1919 \\ 0.1919 & 0.1806 \end{bmatrix} \times 10^{-5} \text{ in. - lb.}$$

The first and second frequencies respectively are:

16.4 cps 41.5 cps

The mode shapes are:



The inertia loads, due to accelerations from safe shutdown earthquake curves are:

| | Bottom Platform | Top Platform |
|---|---|---|
| 1st Mode | 273 lbs | 782 lbs |
| 2nd Mode | 377 lbs | -132 lbs |
| SBS Sum | 650 lbs | 914 lbs |

These loads, which are the absolute sum of the model inertia forces, are applied to the structure combined with dead load forces. By inspection, the most highly stressed member is the double angle cross bracing which, however, is well within allowable stresses.

The load combinations considering load factors given above are less than the yield strength of the structure. The yield strength of the structure is defined as the upper limit of elastic behavior of the effective load carrying structural materials. For steel (both prestress and nonprestress), this limit is taken to be the guaranteed minimum yield given in the appropriate ASTM specification. For concrete, it is the ultimate values of shear (as a measure of diagonal tension) and bond per ACI 318-63 and the 28 day ultimate compressive strength for concrete in flexure ($f'_c$). The ultimate strength assumptions of the ACI Code for concrete beams in flexure are not allowed; that is, the concrete stress is not allowed to go beyond yield and redistribute at a strain of 3 to 4 times that which causes yielding.

The maximum concrete strain due to secondary moments, membrane loads, and local loads exclusive of thermal loads is limited to that corresponding to the ultimate stress divided by the modulus of elasticity ($f'_c/E_c$) and a straight line distribution from there to the neutral axis assumed.

For the above loads combined with thermal loads, the peak strain is limited to 0.003 in./in. For concrete membrane compression, the yield strength is assumed to be 0.85 $f'_c$ to allow for local irregularities, in accordance with the ACI approach. The reinforcing steel forming part of the load carrying system is allowed to go to, but not to exceed, yield as is allowed for ACI ultimate strength design.

A further definition of yielding is the deformation of the structure which causes strains in the steel liner plate to exceed 0.005 in./in. The yielding on nonprestress reinforcing steel is allowed, either in tension or compression, if the above restrictions are not violated. Yielding of the prestress tendons is not allowed under any circumstances.

Principal concrete tension due to combined membrane tension and membrane shear, excluding flexural tension due to bending moments or thermal gradients, is limited to $3\sqrt{f'_c}$. Principal concrete tension due to combined membrane tension, membrane shear, and flexural tension due to bending moments or thermal gradients is limited to $6\sqrt{f'_c}$. When the principal concrete tension exceeds the limit of $6\sqrt{f'_c}$, bonded reinforcing steel is provided in the following manner:

1. Thermal Flexural Tension

   Bonded reinforcing steel is provided in accordance with the methods of ACI 505. The minimum area of steel provided is 0.15% in each direction.

2. Bending Moment Tension

Sufficient bonded reinforcing steel is provided to resist the moment on the basis of cracked section theory using the yield stresses stated above with the following exception: When the bending moment tension is additive to the thermal tension, the allowable tensile stress in the reinforcing steel is $f_y$ minus the stress in reinforcing due to thermal gradient as determined in accordance with the methods of ACI 505.

Shear stress limits and shear reinforcing for radial shear are in accordance with Chapter 26 of ACI 318-63 with the following exceptions:

Formula 26-12 of the Code shall be replaced by

$$V_{ci} = Kb'd\sqrt{f'_c} + M_{cr}\left(\frac{V}{M'}\right) + V_i \qquad (1)$$

where

$$K = \left[1.75 - \frac{0.036}{np'} + np'\right]$$

but not less than 0.6 for $p' \geq 0.003$. For $p' < 0.003$, the value of K shall be zero.

$$M_{cr} = \frac{I}{Y}[6\sqrt{f'_c} + f_{pe} + f_n + f_i]$$

where

$f_{pe}$ = Compressive stress in concrete due to prestress applied normal to the cross section after all losses (including the stress due to any secondary moment) at the extreme fiber of the section at which tension stresses are caused by live loads.

$f_n$ = Stress due to axial applied loads ($f_n$ shall be negative for tension stress and positive for compression stress).

$f_i$ = Stress due to initial loads at the extreme fiber of a section at which tension stresses are caused by applied loads (including the stress due to any secondary moment, $f_i$ shall be negative for tension stress and positive for compression stress).

$$n = \frac{505}{\sqrt{f'_c}}$$

$$p' = \frac{A's}{bd}$$

V = Shear at the section under consideration due to the applied loads.

M = Moment at a distance d/2 from the section under consideration, measured in the direction of decreasing moment, due to applied loads.

$V_i$ = Shear due to initial loads (positive when initial shear is in the same direction as the shear due to applied loads).

Lower limit placed by ACI 318-63 on $V_{ci}$ as $1.7b'd\sqrt{f'_c}$ is not applied. Formula 26-13 of the Code shall be replaced by:

$$V_{cw} = 3.5\ b'd\ \sqrt{f'_c}\left(\sqrt{1 + \frac{f_{pc} + f_n}{3.5\sqrt{f'_c}}}\right) \qquad (2)$$

The term $f_n$ is as defined above. All other notations are in accordance with Chapter 26, ACI 318-63.

Formula (1) is based on the tests and work done by Dr. A. H. Mattock of the University of Washington.

Formula (2) is based on the commentary for proposal redraft of Section 2610, ACI 318 by Dr. A. H. Mattock, dated December 1962.

When the above mentioned equations show that allowable shear in concrete is zero, radial horizontal shear ties are provided to resist all the calculated shear.

Yield Capacity Reduction Factors

The yield capacity of all load carrying structural elements is reduced by a yield capacity reduction factor Φ as given below. This factor provides for "the possibility that small adverse variations in material strengths, workmanship, dimensions, control, and degree of supervision while individually within required tolerance and limits of good practice, occasionally may combine to result in undercapacity" (refer to footnote on Page 66 of ACI 318-63 Code).

Yield Capacity Reduction Factors:

1. Φ = 0.90 for concrete in flexure
2. Φ = 0.85 for tension shear bond and anchorage in concrete
3. Φ = 0.75 for spirally reinforced concrete compression members
4. Φ = 0.70 for tied compression members
5. Φ = 0.90 for fabricated structural steel
6. Φ = 0.90 for mild reinforcing steel in direct tension
7. Φ = 0.90 for mild reinforcing steel with welded splices
8. Φ = 0.85 for mild reinforcing steel with lap splices
9. Φ = 0.95 for prestressed tendons in direct tension

The Capacity Reduction Factors 5 through 9 are in addition to those factors presented in ACI 318-63 Code and represent Bechtel's best judgement of how much under strength should be assigned to each material and condition not covered by the ACI Code.

The Φ factor is multiplied into the basic strength equation or into the basic permissible unit stress to obtain the dependable strength. The basic strength equation gives the "ideal" strength assuming materials are as strong as specified, sizes are as shown on the drawings, the workman- ship is excellent, and the strength equation itself is theoretically correct. The practical, dependable strength may be something less since all these factors vary.

Liner Plate Criteria

The design criteria which is applied to the containment liner to meet the specified leak rate under accident conditions are as follows:

1. That the liner is protected against damage by missiles coincident with the loss of coolant accident, excluding missiles generated by a rupture of the Reactor Coolant System piping (see Section 4.1 for additional details).
2. That the liner plate strains are limited to allowable values considerably below those that have been shown to result in leaktight vessels or pressure piping;
3. That the liner plate is prevented from developing significant distortion;
4. That all discontinuities and openings are well anchored to accommodate the forces exerted by the restrained liner plate, and that careful attention is paid to details of corners and con- nections to minimize the effects of discontinuities.

The leak tight criteria as applied to the liner plate Leak Chase Channels (LCCs) is discussed in Reference 1 and Reference 11.

The following sections of the ASME Boiler and Pressure Vessel Code, Section III, Nuclear Vessels, Article 4, are used as guides in establishing allowable strain limits:

1. Paragraph N-412(m)
2. Paragraph N-414.5
3. Table N-413
4. Figure N-414, N-415(A)
5. Paragraph N-412(n)
6. Paragraph N-415.1

Implementation of the ASME design criteria requires that the liner material be prevented from experiencing significant distortion due to thermal load and that the stresses be considered from a fatigue standpoint. [Paragraph N 412(m)(2)]

The following fatigue loads are considered in the design of the liner plate:

1. Thermal cycling due to annual outdoor temperature variations. The number of cycles for this loading is 60 cycles for the plant life of 60 years. (NRC SE dated 12/2005, NUREG-1839)

2. Thermal cycling due to containment interior temperature varying during the startup and shutdown of the reactor system. The number of cycles for this loading is assumed to be 500 cycles.

3. Thermal cycling due to the design basis accident is assumed to be one cycle. Thermal load cycles in the piping systems are somewhat isolated from the liner plate penetrations by the concentric sleeves between the pipe and the liner plate. The attachment sleeve is designed in accordance with ASME Section III fatigue considerations. All penetrations are reviewed for a conservative number of cycles to be expected during the plant life.

The thermal stresses in the liner plate fall into the categories considered in Article 4, Section III, Nuclear Vessels of the ASME Boiler and Pressure Vessel Code. The allowable stresses in Figure N-415(A) are for alternating stress intensity for carbon steel and temperatures not exceeding 700°F.

In accordance with ASME Code, Paragraph 412(m)(2), the liner plate is restrained against significant distortion by continuous angle anchors and never exceeds the temperature limitation of 700°F and also satisfies the criteria for limiting strains on the basis of fatigue consideration.

Paragraph 412(n), Figure N-415(A) of the ASME Code has been developed as a result of research, industry experience, and the proven performance of code vessels, and it is a part of a recognized design code. Figure N-415(A) and its appropriate limitations are used as a basis for establishing allowable liner plate strains. Since the graph in Figure N-415(A) does not extend below ten cycles, ten cycles are being used for a design basis accident instead of one cycle.

The maximum compressive strains are caused by accident pressure, thermal loading prestress, shrinkage, and creep. The maximum strains do not exceed 0.0025 in./in. and the liner plate always remains in a stable condition.

At all penetrations, the liner plate is thickened to reduce stress concentrations in accordance with the ASME Boiler and Pressure Vessel Code 1965, Section III, Nuclear Vessels.

Penetration Criteria

Penetrations conform to the applicable sections of ASA N6.2-1965, "Safety Standard for the Design, Fabrication, and Maintenance of Steel Containment Structures for Stationary Nuclear Power Reactors." All personnel locks and any portion of the equipment access door extending beyond the concrete shall conform in all respects to the requirements of ASME Section III, Nuclear Vessels Code.

The basis for limiting strains in the penetration steel is the ASME Boiler and Pressure Vessel Code for Nuclear Vessels, Section III, Article 4, 1965, and, therefore, the penetration structural and leak tightness integrity are maintained. Local heating of the concrete immediately around the penetration will develop compressive stress in the concrete adjacent to the penetration and a negligible amount of tensile stress over a large area. The mild steel reinforcing added around penetrations distributes local compressive stresses for overall structural integrity.

Missile Protection Criteria

High pressure reactor coolant system equipment which could be the source of missiles is suitably screened either by the concrete shield wall enclosing the reactor coolant loops, by the concrete operating floor, or by special missile shields to block any passage of missiles to the containment walls. Potential missile sources are oriented so that the potential missile is intercepted by the shields and structures provided. A structure is provided over the control rod drive mechanisms to block any missiles generated from fracture of the mechanisms.

Missile protection is provided to comply with the following criteria:

1. The containment and liner are protected from loss of function due to damage by such missiles as might be generated in a loss of coolant accident.

2. The engineered safeguards system and components required to maintain containment integrity are protected against loss of function due to damage by the missiles defined below.

During the detailed plant design, the missile protection necessary to meet the above criteria was developed and implemented using the following methods:

1. Components of the reactor coolant system were examined to identify and to classify missiles according to size, shape, and kinetic energy for purposes of analyzing their effects.

2. Missile velocities were calculated considering both fluid and mechanical driving forces which can act during missile generation.

3. The structural design of the missile shielding takes into account both static and impact loads and is based upon the state of the art of missile penetration protection.

The types of missiles for which missile protection is provided are:

1. Valve stems
2. Valve bonnets
3. Instrument thimbles
4. Various types and sizes of nuts and bolts
5. Complete control rod drive mechanisms or parts thereof
6. Reactor coolant pump flywheels

Certain types of postulated accidents resulting in generation of missiles are considered incredible because of the material characteristics, inspections, quality control during fabrication, and conservative design of the particular component. Included in this category are missiles caused by massive, rapid failure of the reactor vessel, steam generator, pressurizer, and main coolant pump casings and drives.

<u>Substructure Criteria</u>

The vertical piling loads include the dead weight of the structure, all the live loads acting upon this piling, the vertical seismic load, and the vertical load in the pile due to overturning forces from the horizontal seismic load. In addition, under seismic or wind lateral loading, the piling is subjected to a bending moment due to a slight deflection of the structures in passive pressure on the soil. A cathodic protection system is provided which utilizes close coupled anodes to protect the piles. The system is conservatively designed for a 40 year life, derating manufacturer's recommendations for inert anodes by approximately 50%.

The final Dames & Moore soils report (Reference 3) indicated that the containment structure could undergo settlements of up to 2 in. relative to adjacent structures if it were placed on a mat foundation. In addition, the report indicated an ultimate soil bearing value of 15,000 lb/sq ft and recommended a safety factor of 3 for dead and permanent live loads, and a factor of safety of 2 1/2 for dead, live, and seismic loads in combination; the recommended design values are, therefore, 5000 and 6000 lb/sq ft, respectively.

The soil bearing loads under a containment mat and the fuel pool could have exceeded the above recommendations with no opportunity to spread the foundation to reduce bearing loads to tolerable values. Therefore, the decision was made to put the containment structure and fuel pool on piles. The differential settlements are anticipated to be in the order of 1/4 in. with the fuel pool and containment structure on piles.

The type of pile chosen is a standard steel H pile (14BP117) having a 150 to 200 ton compression load capability. Pile material conforms to ASTM Standard A-572-66, Grade 55, Type 2. These piles are approximately 65 to 75 feet long under the containment structure and about 100 feet long under the fuel pool. The piling is designed according to the structural criteria for Class I structures.

The piles are driven to refusal in bedrock at approximately elevation 75 ft. with the criteria that there shall be not more than 1/4 in. movement of the piles under the last 8 blows with a hammer of approximately 32,000 ft.-lb. energy.

The H piles are distributed under the mat with added concentration of piles under the outer circumference of the mat where the foundation loadings are greatest due to seismic or wind overturning forces as shown in Table 5.1-1.

The piling is designed using working stress design methods with an allowable axial compressive stress of 12,000 psi for dead load plus live load in combination with wind or seismic loading, and an allowable axial plus bending stress of 33,000 psi from combined vertical and horizontal loads. In addition, the piling is checked using the formula:

$$Y = \frac{1}{\phi}[1.0D + 1.0T + 1.0P + 1.0E']$$

A $\phi$ of 0.90 is used as for fabricated structural steel.

The lateral loads allowed on the piling are determined from the method proposed by Reese and Matlock of the University of Texas entitled, “Nondimensional Solutions for Laterally Loaded Piles with Soil Modulus Assumed Proportional to Depth.” (See Reference 4) Curves are presented in the referenced article which relate the shearing force at the top of the pile to the maximum moment in the pile and to the maximum deflection at the top of the pile which is necessary to develop that force in the soil.

A model for analysis was used which includes the structures, the piling, the rock below the piling, and, for the lateral resistance, the soil around the piles and the mat (see Figure 5.1-14). A computer analysis was performed which yielded the maximum seismic response and the resulting vertical and horizontal loads and deformations for both the design and the maximum hypothetical earthquake.

The procedure used in the design of the pile foundation was as follows:

1. An initial probable pile foundation design was made using hand calculations and based on vertical loads and approximated (assumed) lateral loads.

2. A model for computer analysis was selected on the basis of lump masses and moments of inertia derived from this design. The lateral stiffness coefficient, $K_2$, was derived by considering piles bearing on an elastic foundation against lateral loads. Rotational stiffness coefficient, $K_1$, was derived using the stiffness property of

   the pile $\left(\frac{E\ I}{L}\right)$ .

3. A computer model analysis was performed to determine modes and frequencies for the design earthquake and maximum hypothetical earthquake.

4. The maximum seismic response and forces were obtained by hand solution using the results of the computer model analysis.

5. The pile formation design was rechecked based on lateral loads obtained above. The lateral loads allowed on the piling were determined from the method proposed by Reese and Matlock as noted above.

Spacing of piles under the containment vessel varies from approximately 4 feet to 9 feet. With a mat thickness approximately equal to maximum pile spacing, the design of the mat is not significantly different from one with uniform soil bearing under it. Bearing plates are welded to the piles to transfer the pile reaction to the concrete without exceeding the allowable concrete stresses.

The piles are embedded 3 feet into the mat, which is a sufficient distance to ensure that the pile end is fixed so that the maximum horizontal load can be developed in the soil surrounding the pile.

Design Loads

The following loadings are considered:

1. The loadings caused by the pressure and temperature transient of the maximum credible accident.

2. Structure dead load

3. Live loads

4. Internal test pressure loads

5. Earthquake load

6. Wind force and tornado loads

7. Uplift due to buoyant forces

8. External pressure load

The critical loading condition is that caused by the maximum credible accident resulting from severance of a reactor coolant pipe coincident with the maximum hypothetical earthquake.

Loss of Coolant Accident Load

The design pressure and temperature of the containment is in excess of the peak pressure and temperature occurring as the result of the complete blowdown of the reactor coolant through any rupture of the reactor coolant system up to and including the hypothetical severance of a reactor coolant pipe.

The supports for the reactor coolant system are designed to withstand the blowdown forces associated with the severance of the reactor coolant piping so that the coincidental rupture of the steam system is not considered credible. Transients resulting from the loss of coolant accident and other lesser accidents are presented in Chapter 14 and serve as the basis for a containment design pressure of 60 psig.

The design pressure is not exceeded during any subsequent long term pressure transient caused by the combined effects of such heat sources as residual heat and metal-water reactions. These effects are overcome by the combination of emergency powered engineered safeguards and structural heat sinks.

The temperature gradient through the wall during the loss of coolant accident is shown in Figure 5.1-6. The variation of temperature with time and the expansion of the liner plate are considered in designing for the thermal stresses associated with the loss of coolant accident load.

Structure Dead Load

Dead load consists of the weight of the concrete wall, dome, base slab, and any internal concrete. Weights used for dead load calculations are as follows:

| | | |
|---|---|---|
| 1. | Concrete | 143 $lb/ft^3$ |
| 2. | Steel Reinforcing & Prestressing Steel | 489 $lb/ft^3$ using nominal cross sectional areas of reinforcing as defined in ASTM for bar sizes and nominal cross sectional areas of prestressing tendons. |
| 3. | Steel Lining | 489 $lb/ft^3$ using nominal cross sectional area of lining. |

Live Loads

Live loads include snow loads on the roof of the enclosure over the containment dome, which is partially supported by columns to the dome. The roof load on the enclosure is 30 lbs. per horizontal square foot.

Equipment loads are those specified on the drawings supplied by the manufacturers of the various pieces of equipment.

Uniform live loads for the design of internal slabs are consistent with the intended use of the slabs. Most slabs are designed for 250 psf.

Internal Test Pressure Loads

At the end of construction, the containment was pressurized to prove the structural integrity of the vessel. The maximum test pressure is 69 psig, or 115% of the design pressure. This pressure was applied only as an initial test under controlled conditions.

Earthquake Loads

Earthquake loading is derived from an operating base earthquake (OBE) at the site having a horizontal ground acceleration of 0.06 g. In addition, a safe shutdown earthquake having a ground acceleration of 0.12 g is used to check the design to ensure no loss of function. A vertical component of ground acceleration of 2/3 of the magnitude of the horizontal component is applied in the load equations simultaneously.

Structures and equipment are analyzed and designed in compliance with the following criteria:

Class I

A dynamic analysis is used to determine loadings resulting from a postulated earthquake. Primary steady state stresses, when combined with seismic stresses calculated for the earthquake loading, are maintained within the allowable working stress limits accepted as good practice and set forth in appropriate design standards where applicable.

Values of damping coefficients used in the analysis are:

| | OBE | SSE |
|---|---|---|
| Ground Surface Acceleration | .06 g | .12 g |
| Type of Condition and Structure | Percentage of Critical Damping | |
| Welded Steel Plate Assemblies | 1% | 2% |
| Welded Steel Framed Structures | 2% | 2% |
| Bolted Steel Framed Structures | 2.5% | 5% |
| Interior Concrete Equipment Supports | 2% | 2% |
| Reinforced Concrete Structures on Soil | 5% | 7.5% |

| | | |
|---|---|---|
| Prestressed Concrete Containment Structure on Piles | 2% | 5% |
| Vital Piping Systems | 0.5% | 0.5% |

The calculation of modal damping is based on the relative strain energy of the individual materials. The damping is proportional to the displacement and strain energy as determined from the evaluation of the mode shapes.

Class II

A static analysis for a base shear is based on the .06g design earthquake.

Class III

A static analysis for a base shear is determined and distributed in accordance with the Uniform Building Code.

Figure 5.1-7 shows the acceleration response spectra to be used for the design earthquake and is based upon curves presented in TID 7024, "Nuclear Reactors and Earthquakes," August 1963.

Figure 5.1-8 shows the acceleration response spectra for the earthquake and is based upon curves presented in TID 7024.

Wind and Tornado Forces

Wind loading for the containment structure is based on Figure 1(b) of ASCE Paper 3269, "Wind Forces on Structures" (Reference 5), using the fastest wind speed for a 100 year recurrence period. This results in a 108 mph basic wind at 30 feet above grade.

ASCE Paper 3269 is also used to determine shape factors, gust factors, and variation of wind velocity with height.

The structure is analyzed for tornado loading (not coincident with accident or earthquake) on the following basis:

1. Differential pressure between the inside and outside of the containment structure is assumed to be 3 lbs. per sq. in. positive pressure.

2. Lateral forces on the containment structure is assumed as the force caused by a tornado funnel having a peripheral tangential velocity of 300 mph plus a forward progress of 60 mph. The applicable portions of wind design methods described in Reference 5 have been used, particularly for shape factors. The provision for gust factors and variation of wind velocity with height do not apply.

3. Tornado driven missiles equivalent to an airborne 4 in. by 12 in. by 12 ft. plank traveling end on at 300 mph (440 fps) or a 4000 lb. automobile flying through the air at 50 mph (74 fps) and at not more than 25 feet above the ground, are assumed.

There are few reliable measurements of the pressure drop associated with a tornado funnel. The greatest drop recorded was equivalent to a bursting pressure of approximately 3 psi. This measurement, however, is highly questionable and not regarded as authoritative. The greatest reliably measured pressure drops have been in the order of 1.5 psi or less.

Because of the complexity of the airflow in a tornado, it has not been possible to calculate the velocity or trajectory of missiles that would truly represent tornado conditions. For design purposes, it is assumed that objects of low cross sectional density, such as boards, metal siding, and similar items may be picked up and carried at the maximum wind velocity of 300 mph.

The behavior of heavier, oddly shaped objects such as an automobile, is less predictable. The design values of 50 mph for a 4000 lb. automobile lifted 25 feet in the air is felt to be representative of what would happen in a 300 mph wind as the automobile was lifted, tumbled along the ground, and ejected from the tornado funnel by centrifugal force. These missile velocities are consistent with reported behavior of such objects in previous tornadoes.

Uplift Due to Buoyant Forces

Uplift forces which are created by the displacement of ground water by the structure are accounted for in the design of the structure.

External Pressure Load

The containment is designed to withstand an internal design vacuum condition of 2 psi, which is equivalent to an external pressure loading with a differential of 2 lbs. per sq. in. from outside to inside. This condition will accommodate either a barometric pressure rise to 31 in. Hg after the containment is sealed at 29 in. Hg, or an interior containment cooldown from 120°F to 50°F. Therefore, operation of purge valves is not necessary due to barometric changes during normal operation or cooldown conditions, and vacuum breakers are not required.

### 5.1.2.3 SEISMIC DESIGN CLASSIFICATION

All equipment and structures are classified as Class I, Class II, or Class III as described in Appendix A.5.1.

These classifications are defined as follows:

1. Class I

   Those structures and components including instruments and control whose failure might cause or increase the severity of a loss of coolant accident or result in an uncontrolled release of excessive amounts of radioactivity. Also, those structures and components vital to safe shutdown and isolation of the reactor.

2. Class II

   Those structures and components which are important to reactor operation but not essential to safe shutdown and isolation of the reactor and whose failure could not result in the release of substantial amounts of radioactivity.

3. Class III

   Those structures and components which are not related to reactor operation or containment.

### 5.1.2.4 DETAILED DESIGN CRITERIA

General

The analysis for the containment structure falls into two general categories, axisymmetric analysis and nonaxisymmetric analysis. The axisymmetric analysis is performed through the use of the finite element computer program for the individual loading cases of dead load, live load, temperature, prestress, and pressure using the usual assumptions of the theory of elasticity as described in Section 5.1.2.2.

The finite element approximation of the containment structure does not consider the buttresses, and the lateral loads due to seismic or wind are considered in the nonaxisymmetric analysis described later in the section.

This section of the FSAR discusses analytical techniques, references, and design philosophy. The design criteria, analysis, and construction drawings were reviewed by Bechtel's consultants, T. Y. Lin, Kulka, Yang & Associate.

Axisymmetric Techniques

The finite element technique is a general method of structural analysis in which the continuous structure is replaced by a system of elements (members) connected at a finite number of nodal points (joints). Conventional analysis of frames and trusses can be considered to be examples of the finite element method. In the application of the method to an axisymmetric solid (e.g., a concrete containment structure), the continuous structure is replaced by a system of rings of triangular cross section which are interconnected along circumferential joints. Based on energy principles, work equilibrium equations are formed in which the radial and axial displacements at the circumferential joints are the unknowns of the system. The results of the solution of this set of equations is the deformation of the structure under the given loading conditions. For the output, the stresses are computed knowing the strain and stiffness of each element.

The finite element mesh used to describe the structure is shown in Figure 5.1-9. The upper portion and lower portion of the structure are analyzed independently to permit a greater number of elements to be used for those areas of the structure of major interest such as the ring girder area and the base of the cylinders. The finite element mesh of the structure base slab is extended down into the foundation material to take into consideration the elastic nature of the foundation material and its effect upon the behavior of the base slab.

The use of the finite element computer program permitted an accurate estimate of the stress pattern at various locations of the structure. The following material properties were used in the program for the various loading conditions:

| | Load Conditions $D, F, T_o, T_A$ | Load Condition P |
|---|---|---|
| $E_{concrete,\ foundation\ (psi)}$ | $2.7 \times 10^6$ | $5.0 \times 10^6$ |
| $E_{concrete,\ shell\ (psi)}$ | $2.5 \times 10^6$ | $5.0 \times 10^6$ |
| $\nu_{concrete(Poission's\ ratio)}$ | 0.17 | 0.17 |

| | | |
|---|---|---|
| $\alpha_{concrete\ (coeff\ of\ expansion)}$ | $0.5 \times 10^{-5}$ | |
| $E_{rock\ (psi)}$ | $0.13 \times 10^{8}$ | $0.13 \times 10^{8}$ |
| $E_{liner\ (psi)}$ | $30 \times 10^{6}$ | $30 \times 10^{6}$ |
| $E_{piles\ (psi)}$ | $30 \times 10^{6}$ | $30 \times 10^{6}$ |
| $fy_{liner\ (psi)}$ | 34,000 | |

For definition of Load Conditions, see Section 5.1.2.2.

The structure is analyzed assuming an uncracked homogeneous material.

The major benefit of the program is the capability to predict shears and moments due to internal restraint and the interaction of the foundation slab relative to the soil. The use of an uncracked section is conservative because the decreased relative stiffness of a cracked section would result in smaller secondary shears and moments.

In arriving at the above mentioned values of $E_c$, the effect of creep is included by using the following equation for long term loads such as thermal load, dead load, and prestress:

$$E_{cs} = E_{ci}\frac{\varepsilon_i}{\varepsilon_s + \varepsilon_i}$$

where

$E_{cs}$ = Sustained modulus of elasticity of concrete
$E_{ci}$ = Instantaneous modulus of elasticity of concrete
$\varepsilon_i$ = Instantaneous strain, in./in. per psi
$\varepsilon_s$ = Creep strain, in./in. per psi

The thermal gradients used for design are shown in Figure 5.1-6. The gradients for both the design accident condition and the factored load condition are based on the temperature associated with the factored pressure. The design pressure and temperature of 60 psig and 286°F become 90 psig and 310°F at factored conditions. For such a small increase in temperature, it was decided to use a single set of thermal gradients to simplify the analysis.

The thermal loads are a result of the temperature differential within the structure. The design temperature stresses for this finite element analysis were prepared so that when temperatures are given at every nodal point, stresses are calculated at the center of each element.

Thus, the liner plate is handled as an integral part of the structure but having different material properties, and not as a mechanism which would act as an outside source to produce loading on the concrete portion of the structure.

Under the design accident condition or factored load condition, cracking of the concrete at the outside face would be expected. The value of modulus of elasticity of concrete, $E_{cs}$ was used together with the method described in ACI Code 505-54 to find the stresses in concrete, reinforcing steel, and liner plate from the predicted design accident thermal loads and factored accident loads.

The isostress plots shown in Figure 5.1-10 and Figure 5.1-11 do not consider the concrete cracked. The thermal stresses are combined in the isostress output for the cases of D + F + T and D + F + 1.5P + T. The first case was critical for concrete stresses and occurs after depressurization of the containment; the second case is critical for the reinforcing stresses and it occurs when pressure and thermal loads are combined and cause cracking at the outside face.

The stresses shown in Table 5.1-1 consider cracking. The general approach of determining stresses in the concrete and reinforcement required the evaluation of the stress blocks of the cross section being analyzed.

The value of stresses was taken from the computer output in case of axisymmetric loading and from analytical solutions is case of nonaxisymmetric loading. Both computations are based on homogeneous materials, therefore, some adjustment is necessary to evaluate the true stress strain conditions when cracks develop in the tensile zone of the concrete.

The procedures used to determine the area of conventional reinforcing required and the stress in the concrete resulting from the loading condition, considering the effects of cracking where required, are presented.

Basic Assumption: The thermal stresses in the containment are comparable to those developed in a reinforced concrete slab which is restrained from rotation. The temperature varies linearly across the slab. The concrete will crack in tension and the neutral axis will be shifted toward the compressive extreme fiber. The cracking will reduce the compression at the extreme fiber and increase the tensile stress in reinforcing steel.

The following analysis is based on the equilibrium of normal forces, therefore, any normal force acting on the section must be added to the normal forces resulting from the stress diagram. The effects of Poisson's ratio are considered while the reinforcement is considered to be identical in both directions.

Stress-strain relationship in compressed region of concrete:

$$E_c\varepsilon_x = \sigma_x - v_c\sigma_y$$

$$E_c\varepsilon_y = -v_c\sigma_x + \sigma_y$$

$$\sigma_x = E_c\frac{\varepsilon_x + \varepsilon_y v}{1 - v_c^2}$$

$$\sigma_y = E_c \frac{\varepsilon_y + \varepsilon_x v}{1 - v_c^2}$$

assuming

$$\sigma_x = \sigma_y = \sigma_c \qquad \text{and} \qquad \varepsilon_x = \varepsilon_y = \varepsilon_c$$

$$\sigma_c = E_c \varepsilon_c \frac{1}{1 - v_c} = 1.205\ E_c \varepsilon_c [\text{if } v_c = 0.17]$$

The reinforcement is acting in one direction, independently from the reinforcement in the perpendicular direction.

Example:

If $E_c = 3 \text{ x } 10^6$ and $E_s = 30 \text{ x } 10^6$

$$n_r = \frac{30}{1.205 \times 3} = 8.3$$

The liner plate is acting in two directions, similar to the concrete except for the difference caused by the Poissons ratios:

$$\sigma_L = E_s \varepsilon_s \frac{1}{1 - v_L} = 1.35 E_s \varepsilon_s$$

If $v_L = 0.25$ and $v_c = 0.17$

$$n_L = \frac{1.35 \times 30}{1.205 \times 3} = 11.2$$

The following is an example of the use of the analytical method derived. Thermal stress in base slab:

$E_c = 3 \text{ x } 10^6$ psi

$E_s = 30 \text{ x } 10^6$ psi

$v_c = 0.17$

$v_L = 0.25$

$n_R = 8.3$

$n_L = 11.2$

Equilibrium of forces considering crack section:

$$4.42[293 + \Delta\sigma_c]8.3 - [65.0 + 105.7 + 24.0]$$
$$1000 + \Delta\sigma_c[12 \times 42 + 3 \times 11.2] = N = -95{,}000 \text{ lbs.}$$

$\Delta\sigma_c = 156.5$ psi

$\sigma_s = [293 + 156.5]8.3 = 3{,}731$ psi

The concrete and reinforcement stresses are calculated by conventional methods from the moment caused by loading other than thermal. The analyses assume homogeneous concrete sections. Those concrete and reinforcing steel stresses are then added to the thermal stresses as obtained by the method described.

Notation:

$E_c$ = Modulus of elasticity of concrete
$E_s$ = Modulus of elasticity of steel
$n_L$ = Modular ratio of liner plate/concrete
$n_R$ = Modular ratio of reinforcement/concrete
$\Delta\sigma_c$ = Reduction of concrete compressive stress considering cracking
$\varepsilon_c$ = Concrete strain
$\varepsilon_s$ = Steel strain
$\varepsilon_x$ = Concrete strain in X direction
$\varepsilon_y$ = Concrete strain in Y direction
$\nu_c$ = Poisson's ratio of concrete
$\nu_L$ = Poisson's ratio of liner plate
$\sigma_c$ = Stress in concrete
$\sigma_L$ = Stress in liner plate
$\sigma_R$ = Stress in reinforcement
$\sigma_x$ = Stress in concrete in direction X

An equilibrium equation can be written considering the tension force in the reinforcement, the compressive force in the concrete, and the axial force acting on the section. In this manner the neutral axis is shifted from the position defined by the computer analyses into a position which is the function of the amount of reinforcement, the modulus ratio, and the acting axial forces.

Large axial compressive force might prevent the existence of any tension stresses, as in the loading condition, D + F + T, therefore, no self relieving action is existing; the stresses are taken directly from the computer output.

In the case of D + F + 1.5P + T, the development of cracks in the concrete decreases the thermal moment and this effect is considered, but the self relieving properties of other loadings are not taken into account even in places where they do exist, such as at discontinuities, e.g., the cylinder base slab connection. This means that in analyzing the section, a reduced thermal moment is added to the moment caused by other loadings without any reduction.

Nonaxisymmetric Analysis

The nonaxisymmetric aspects of configuration of loading required various methods of analysis. The description of the methods used as applied to different parts of the containment are given in the sections below.

Buttresses

The buttresses are analyzed for two effects, nonaxisymmetry and anchorage zone stresses. Both effects are shown in the results of a two dimensional plane strain finite element analysis with loads acting in the plane of the coordinate system (Figure 5.1-12).

At each buttress, the hoop tendons are alternately either continuous or spliced by being mutually anchored on the opposite faces of the buttress. Between the opposite anchorages, the compressive force exerted by the spliced tendon is twice as much as elsewhere, therefore, this increased value added to the effects of the tendon which is not spliced will be 1.5 times larger than the prestressing force acting outside of the buttresses. The cross sectional area of the buttress is about 1.5 times that of the wall so the hoop stress as well as the hoop strains and radial displacements can be considered as being nearly constant all around the structure. Isostress plots of the plane strain analysis, Figure 5.1-13, confirm this. The vertical stresses and strains caused by the vertical post tensioning become constant at a short distance away from the anchorages because of the large stiffness of the cylindrical shell. Since, as stated above, the stresses and strains remain nearly axisymmetric despite the presence of the buttresses, their effect on the overall analysis is negligible when the structure is loaded with dead load or prestressing loads.

When an increasing internal pressure acts upon the structure, combined with a thermal gradient such as at the design accident condition, the resultant forces being axisymmetric, the stiffness variation caused by the buttresses will be decreased as the concrete develops cracks. The structure will then tend to shape itself to even more closely follow the direction of the acting axisymmetric at yield loads, which include factored pressure, than at design loads including pressure. This fact, combined with the redundancy of the pressure resisting structural elements, indicates that the buttresses will not reduce the margins of safety available in the structure.

Seismic or Wind Loading

Design requirements dictated by seismic loading of the structure are greater than that of tornado or wind loading. The seismic analysis is conducted in the following manner.

The loads on the containment structure caused by earthquake are determined by a dynamic analysis of the structure. The dynamic analysis is made on an idealized structure of lumped masses and weightless elastic columns acting as spring restraints.

The analysis is performed in two stages: the determination of the natural frequencies of the structure and its mode shapes, and the modal response of these modes to the earthquake by the spectrum response method.

The natural frequencies and mode shapes are computed from the equations of motion of the lumped masses established in a virtual displacement method solved by iteration techniques using a fully tested digital computer program. The form of the equation is:

$$(K) \times (\Delta) = \omega^2 \times (M) \times (\Delta)$$

(K) = Matrix of stiffness coefficient including the combined effects of shear, flexure, rotation, and horizontal translation

(M) = Matrix of concentrated masses

($\Delta$) = Matrix of mode shape

$\omega$ = Angular frequency of vibration

The results of this computation are the several values of $\omega_n$ and mode shapes $\Delta n$ for n = 1, 2, 3 -- m where m is the number of degrees of freedom (i.e., lumped masses) assumed in the idealized structure.

The response of each mode of vibration to the design earthquake is then computed by the response spectrum technique as follows:

1. The base shear contribution of the $n^{th}$ mode

$$V_n = W_n \times S_{an}(\omega_n;\delta)$$

where

$\omega_n$ = Angular frequency of the $n^{th}$ mode

$W_n$ = Effective weight of the structure in the $n^{th}$ mode

$$W_n = \frac{(\Sigma_x \Delta_{xn} W_x)^2}{\Sigma_x (\Delta_{xn})^2 W_x}$$

where the subscript x refers to levels throughout the height of the structure and Wx is the weight of the lumped mass at level x.

$S_{an}(\omega_n;\gamma)$ = Spectral acceleration of a single degree of freedom system with a damping coefficient of obtained from the response spectrum

2. The horizontal load distribution for the nth mode was then computed as:

$$F_x = V_n(\Delta_{xn}W_x)/(\Sigma_x\Delta_{xn}W_x)$$

The several mode contributions are then combined to give the final response of the structure to the design and hypothetical earthquake.

3. The number of modes to be considered in the analysis is determined to adequately represent the structure being analyzed. Since the spectral response technique yields the maximum value of response for each mode and these maxima do not occur at the same time, the response of the modes of vibration is combined by taking the square root of the sum of the squares of the modal values. The analytical model and results are shown in Figure 5.1-14.

Large Openings (Equipment Hatch and Personnel Lock Opening)

As stated in the design criteria, the primary loads considered in the design of the equipment hatch and personnel lock opening, as for any of the structure, are dead load, prestress, pressure, earthquake, and thermal loads. The secondary loads considered, caused by the above primary loads were:

1. The deflection of tendons around the opening
2. The curvature of the shell at the opening
3. The thickening around the opening

The loads described under primary loads are mainly membrane loads with the exception of the thermal loads. In addition to membrane loads, accident pressure also produces punching shear around the edge of the opening. The values of these loads for design purposes are the magnitudes of these loads at the center of the opening. These are fairly simple to establish, knowing the values of hoop and vertical prestress loads, accident pressure loads, and the geometry and location of the opening.

The hoop normal forces caused by either post tensioning or internal pressure have a very low value right at the base slab and gradually increase at higher elevations, accompanied by varying shear forces. The effects of the earthquake loading is also a function of the elevation.

The equipment hatch on the Point Beach containment is close to the base slab so that the forces are not constant in the vertical direction.

The analysis considers these forces and the values are obtained from calculations considering a continuous shell.

The shear stress near the edge of the opening, (E), for various components of loading is predicted to be as follows:

Prestress - 19 psi
Pressure - 36 psi
Earthquake - 3 psi

The contribution from temperature and dead load are very small. Under the D + F + P + TA + E case the shear stress is predicted to be 20 psi.

Secondary loads are predicted by the following methods:

1. The membrane stress concentration factors and effect of the deflection of the tendons around the equipment hatch are analyzed for a flat plate by the finite element method. The stresses predicted by conventional stress concentration factors, when compared with those values from the previously mentioned finite element computer program, demonstrated that the deflection of the tendons does not significantly affect the stress concentrations. This is a plane stress analysis and does not include the effect of the curvature of the shell. However, it gives an assurance of the correctness of the assumed stress pattern caused by the prestressing around the opening.

2. With the help of Reference 6, stress resultants around the large opening are found for various loading cases. Comparison of the results found from this reference with the results of a flat plate of uniform thickness with a circular hole show the effect of the cylindrical curvature on stress concentrations around the opening.

   Normal shear forces (relative to opening) are modified to account for the effect of twisting moments. These modified shear forces are called Kirschoff's shear forces. Horizontal wall ties are provided to resist a portion of these shear forces.

3. The effect of the thickening on the outside face around the large opening is considered using a separate axisymmetric finite element computer analysis for a flat plate with anticipated thickening on the outside face. This particular finite element computer program handles both axisymmetric and nonaxisymmetric loads. This finite element computer program is also used to predict the effect of concentration of hoop tendons (with respect to the containment) at the top and bottom of the opening.

Various conditions checked by the flat plate plane stress finite element analysis were as follows:

1. During prestressing with only the hoop tendons stressed

2. The local effects of hoop tendon curvature under the D + F + 1.5P design load condition

3. After total prestressing D + F

The membrane loads were applied at the flat plate boundary and the tendon loads from curvature in the plane of the model were applied at the tendon locations.

The analysis considered the effects of thickening by assigning increased E values for the elements representing the thickened portion of the shell, but it did not consider the shell curvature effects and the fact that the thickening is not symmetrical about the opening.

Reference 6 was used to determine the effects of shell curvature on the stress concentrations around the opening.

For the analysis of the thermal stresses around the opening, the same method is used as for the other loadings. At the edge of the opening, a uniformly distributed moment equal but opposite to the thermal moment existing on the rest of the shell is applied and evaluated using the methods of Reference 6. The effects are then superimposed on the stresses calculated for the other loads and effects.

In the case of accident temperature, after the accident pressure has already been decreased, very little or no tension develops on the outside, so thermal strains will exist without the relieving effect of the cracks. However, the liner plate will reach a high strain level, and so will the concrete at the inside corner of the penetration, thereby relieving once again the very high stresses, but still carrying a high moment in the state of redistribution stresses.

In the case of 1.5P (prestress fully neutralized) + 1.0T (accident temperature), the cracked concrete with highly strained tension reinforcement constitutes a shell with stiffness decreased but still essentially constant in all directions. In order to control the increased hoop moment around the opening, the hoop reinforcement is about twice that of the radial reinforcement (see Figure 5.1-15).

The equipment hatch opening is thickened for the following reasons:

1. To reduce the larger than acceptable predicted stresses around the opening;

2. To accommodate tendon placement;

3. To accommodate bonded steel reinforcing placement;

4. To compensate for the reduction in the overall shell stiffness due to the opening.

In order to minimize the effect of tensile stresses at the outside face and to distribute the concentration of radial forces exerted by hoop tendons in a more uniform manner, the inside row of vertical tendons is given a reverse curvature (they are deflected outward as they pass the opening) so as to reduce the inward acting radial forces (due to hoop tendons) at the top and bottom of the opening and to produce inward acting forces on the sides of the large opening.

The working stress method (elastic analysis) is applied to both the load combinations for design loads as well as for yield loads for the analytical procedures described above. The only difference is the higher allowable stresses under yield conditions. The various factored load combinations and capacity reduction factors are specified in Section 5.1.2.2 and are used for the yield load combinations using the working stress design method. The design assumption of straight line variation of stresses is maintained under yield conditions.

The governing design condition for the sides of the equipment hatch opening at the outside edge of the opening is the accident condition. Under this condition, approximately 60% of the total bonded reinforcing steel needed at the edge of the opening at the outside face is a result of the thermal load.

A breakdown of total loading follows:

| | | |
|---|---|---|
| 1. | Stress Breakdown From Thermal Gradient | (Plus 60%) |
| 2. | From Membrane Force Including The Thickening Effect | (Minus 14%) |
| 3. | From Moments Caused by Thickening | (Plus 60%) |
| 4. | From Membrane Forces and Moments Caused by the Effect of Cylindrical Curvature | (Minus 6%) |
| | Total | (100%) |

Excluding thermal load, the remaining stress (equivalent to approximately 40% of the total load, including thermal) at the edge of the outside face is the contribution of the following stress resultants:

1. Normal stresses resulting from membrane forces, including the effect of thickening, contribute approximately -35% (-14% of total).
2. Flexural stresses resulting from the moments caused by thickening on the outside face contribute approximately 150% (60% of total).
3. Normal and flexural stresses resulting from membrane forces and moments caused by the effect of cylindrical curvature contribute approximately -15% (-6% of total).

<u>Penetrations</u>

Analysis of the containment penetrations falls into three categories:

1. The concrete shell;
2. The liner plate reinforcement and closure to the pipe or electrical canister;
3. The thermal gradients and protection requirements at the high temperature penetrations.

The three categories will be discussed separately.

The basic computer analyses applied in the design of the containment shell are for axisymmetric solids subjected to axisymmetric loadings; therefore, areas where either the shape or the loading is nonaxisymmetric are analyzed by other methods. The nonaxisymmetric effects are not included in the axisymmetric analyses directly, but the results of two independent calculation methods are combined.

Small penetrations without appreciable accident pressure loads or pipe failure loads were analyzed as holes in a flat plate and the stress concentrations from the membrane loads were the main consideration in specifying the reinforcing steel. For penetrations which could be subjected to external forces and moments, additional reinforcement was added where necessary to resist moments and shear.

1. Concrete Shell

In general, special design consideration is given to all openings in the containment structure. Analysis of the various openings has, however, indicated that the degree of attention required depends upon the penetration size. Small penetrations are considered to be those with a diameter smaller than 1-1/2 times the shell thickness, i.e., approximately 8 ft. in diameter or less. Reference 6 indicates that for openings of 8 ft. diameter or less the curvature effect of the shell is negligible. In general, the existing concrete wall thickness is found to be capable of taking the imposed stresses using bonded reinforcement and the thickness is increased only as required to permit space requirements for tendon deflection. The induced stresses due to normal thermal gradients and postulated rupture conditions distribute rapidly and are of a minor nature compared to the numerous loading conditions for which the shell must be designed. The penetrations are analyzed as holes in a plane sheet. Applied piping restraint loads due to thermal expansion or accident forces are assumed to distribute in the cylinder as stated in Reference 6. Typical details associated with these openings are indicated in Figure 5.1-2 and Figure 5.1-3.

2. Liner Plate Closure

The stress concentrations around openings in the liner plate are calculated using the theory of elasticity. The stress concentrations are then reduced by the use of a reinforcing plate around the opening. In the case of a penetration with no appreciable external load, anchor bolts are used to maintain strain compatibility between the liner plate and the concrete. Inward displacement of the liner plate at the penetration is also controlled by the anchor bolts.

In the case of a pipe penetration in which large external operating loads are imposed upon the penetration, the stress level from the external loads is limited to the design stress intensity values, $S_{m,}$ given in the ASME Boiler and Pressure Vessel Code, Section III, Article 4. The stress level in the anchor bolts from external loads is in accordance with bearing values meeting ACI Code Requirements.

The combining of stresses from all effects is done by the methods outlined in the ASME Boiler and Pressure Vessel Code, Section III, Article 4, Figure 414. The maximum allowable stress intensity, $S_{a,}$ is the value from Figure N 415(A) of this code. Shown in Figure 5.1-16 is a typical penetration and the applied loads.

The stresses from the effects of pipe loads, pressure loads, dead load, and earthquake are calculated and the stress intensity kept below $S_m$.

The stresses from the remaining effects are combined with the above calculated stresses and the stress intensity kept below $S_a$.

3. Thermal Gradient

The only large lines penetrating the containment shell normally having high temperatures are the main steam and feedwater. The analytical steady state temperature gradients are determined for the case with no cooling with maximum insulation using the Generalized Heat Transfer Program (see Figure 5.1-17 for analytical results). In addition, temperatures have been measured in the concrete at the main steam penetrations. The results indicate that local heating of containment concrete is below the limit of 200°F (ASME Section III, Division 2, Subsection CC-3440, "Concrete Temperatures") and active cooling for these penetrations is not required (NUREG-1839"Safety Evaluation Report Related to the License Renewal of the Point Beach Nuclear Plant, Units 1 and 2").

Smaller lines penetrating the containment shell normally having high temperatures and normally in operation include the RCS hot leg sample line, steam generator blowdown sample lines and the steam generator blowdown lines. Temperature readings of the containment concrete in the vicinity of smaller lines have been measured during plant operation and found to be well below 200°F (Reference 10).

Liner Plate

There are no design conditions under which the liner plate is relied upon to assist the concrete in maintaining the integrity of the structure even though the liner will at times provide such assistance.

Loads are transmitted to the liner plate through the anchorage system and direct contact with the concrete and vice versa. Loads may be also transmitted by bond and/or friction with the concrete. These loads cause or are caused by liner strain. The liner is designed to withstand the predicted strains without leaking.

Possible cracking of concrete is considered and reinforcing steel is provided to control the width and spacing of the cracks. In addition, the design is made such that total structural deformation remains small during the loading conditions and that any cracking will be orders of magnitude less than that sustained in the repeated attempts to fail the prestressed concrete from overpressure tests of "Model 2" (both at General Atomic). (See "Prestressed Concrete Reactor Vessel, Model 1, #GA 7097, HTGR and Laboratory Staff" and "Concrete Reactor Vessel, Model 2, #GA 7150, Advance HTGR Staff.")

Under test condition, the cylinder wall and the dome will be under net membrane compressive stress. Therefore, there is only a slight possibility of cracking at the outside face of the wall and the dome from thermal gradient present during the test across the thickness of the wall and the dome.

The crack width is calculated using Reference 7.

Following is the equation as mentioned in the above reference to calculate the maximum size of the crack:

$$\text{W max.} = 0.115\sqrt[4]{A} \times f_s \times 10^{-6}\ \text{in.}$$

where

W max. = Maximum crack width

A = Area of concrete surrounding each bar, sq. in.

$f_s$ = Stress in the bar, psi

The maximum crack width is predicted to be 0.0055 in. The corresponding spacing of the crack is predicted to be 10 in.

It is expected that the crack pattern will be two dimensional. However, because of the higher circumferential prestressing compared to the vertical prestressing in the cylinder wall, the size of the vertical crack is predicted to be smaller than the horizontal crack. As described, the structural integrity consequences of concrete cracking are limited by the bonded reinforcing and unbonded tendons provided in accordance with the design criteria. The effect of concrete cracking on the liner plate is also considered. The anchor spacing and other design criteria are such that the liner will sustain, for example, orders of magnitude of strain less than did the liner of Model 1 at General Atomic without tensile failure.

Liner Plate Anchors

The liner plate anchors are designed to preclude failure when subjected to the worst possible loading combinations. The anchors are also designed such that, in the event of a missing or failed anchor, the total integrity of the anchorage system would not be jeopardized by the failure of adjacent anchors. The following loading conditions are considered in the design of the anchorage system:

1. Prestress;
2. Internal Pressure;
3. Shrinkage and Creep of Concrete;
4. Thermal Gradient (Normal and Design Basis Accident);
5. Dead Load;
6. Earthquake;
7. Vacuum.

The following factors are considered in the design of the anchorage system:

1. Initial inward curvature of the liner plate between anchors due to fabrication and erection accuracies;
2. Variation of anchor spacing;
3. Misalignment of liner plate seams;

4. Variation of plate thickness;

5. Variation of liner plate material yield stress;

6. Variation of Poisson's ratio for liner material;

7. Cracking of concrete in anchor zone;

8. Variation of the anchor stiffness.

The anchorage system satisfies the following conditions:

1. The anchor has sufficient strength and ductility so that its energy absorbing capability is sufficient to restrain the maximum force and displacement resulting from the condition where a panel with initial outward curvature is adjacent to a panel with initial inward curvature.

2. The anchor has sufficient flexural strength to resist the bending moment which would result from Condition 1.

3. The anchor has sufficient strength to resist radial pull out force.

When the liner plate moves inward radially as shown in Figure 5.1-18, the sections will develop membrane stress due to the fact that the anchors have moved closer together. Due to initial inward curvature, the section between 1 and 4 will deflect inward giving a longer length than adjacent sections and some relaxation of membrane strength will occur. It should be noted here that section 1-4 cannot reach an unstable condition due to the manner in which it is loaded.

The first part of the solution for the liner plate and anchorage system is to calculate the amount of relaxation that occurs in section 1-4, since this value is also the force across Anchor 1 if it is infinitely stiff. This solution is obtained by solving the general differential equation for beams, including the effect of relaxation or the lengthening of section 1-4. Figure 5.1-18, Sheet 1, shows the symbols for the forces that result from the first step in the solution.

Using the model shown in Figure 5.1-18, Sheet 2, and evaluating the necessary spring constants, the anchor is allowed to displace.

The solution yields a force and displacement at Anchor 1, but the force in Section 1-2 is $(N)\text{-}K_{R(Plate)}S_1$ and Anchor 2 is no longer in force equilibrium.

The model shown in Figure 5.1-18, Sheet 2, is used to allow Anchor 2 to displace and then to evaluate the effects on Anchor 1.

The displacement of Anchor 1 is $S_1 + S'_1$ and the force an Anchor 1 is $K_c(S_1 + S'_1)$. Then Anchor 3 is not in force equilibrium and the solution is continued to the next anchor.

After the solution is found for displacing Anchor 2 and Anchor 3, the pattern is established with respect to the effect on Anchor 1 and, by inspection, the solution considering an infinite amount of anchors is obtained in the form of a series solution.

The preceding solution yielded all necessary results. The most important results are the displacement and force on Anchor 1.

Various patterns of welds attaching the angle anchors to the liner plate were tested for ductility and strength when subject to a transverse shear load such as ΔN and are shown in Figure 5.1-19. Using the results from these tests together with the tests made for the Fort St. Vrain PSAR, Amendment No. 2, and Oldbury vessels, a range of possible spring constants were evaluated for the Point Beach liner. By using the solution previously obtained together with a chosen spring constant, the amount of energy required to be absorbed by the anchor was evaluated.

By dividing the amount of energy that the system will absorb by the most probable maximum energy, the result then yielded the factor of safety.

By considering the worst possible loading condition which resulted from the listed loading conditions and the conditions stated below, the following results are obtained:

Case I — Simulates a plate with a yield stress of 32 ksi and no variation in any other parameters.

Case II — Simulates a 1.25 increase in yield stress and no variation in any other parameters.

Case III — Simulates a 1.25 increase in yield stress, a 1.16 increase in plate thickness, and a 1.08 increase for all other parameters.

Case IV — Simulates a 1.88 increase in yield stress with no variation of any other parameters.

Case V — Is the same as Case III except the anchor spacing is doubled to simulate what happens if an anchor is missing or has failed.

LINER PLATE CALCULATIONS - RESULTS

| Case | Nominal Plate Thickness (In) | Initial Inward Displacement (In) | Anchor Spacing L (In) | Anchor Spacing $L_2$ (In) | Factor of Safety Against Failure |
|---|---|---|---|---|---|
| I | 0.25 | 0.125 | 15 | 15 | 37.0 |
| II | 0.25 | 0.125 | 15 | 15 | 19.4 |
| III | 0.25 | 0.125 | 15 | 15 | 9.9 |
| IV | 0.25 | 0.125 | 15 | 15 | 6.28 |
| V | 0.25 | 0.25 | 30 | 15 | 4.25 |

FSAR Section 5.1.2.9 provides additional information regarding structural analysis and testing associated with the containment liner plate leak chase channels (LCC).

Supports

In designing for structural bracket loads applied perpendicular to the plane of the liner plate or loads transferred through the thickness of the liner plate, the following criteria and methods are used:

a. The liner plate is thickened to reduce the predicted stress level in the plane of the liner plate. The thickened plate with the corresponding thicker weld attaching the bracket to the plate will also reduce the probability of the occurrence of a leak at this location.

b. Under the application of a real tensile load applied perpendicular to the plane of the liner plate, no yielding is to occur in the perpendicular direction. By limiting the predicted strain to 90% of the minimum guaranteed yield value, this criterion is satisfied.

c. The allowable stress in the perpendicular direction is calculated using the above allowable predicted strain in the perpendicular direction together with the predicted stresses in the plane of the liner plate.

d. In setting the above criteria, the reduced strength and strain ability of the material perpendicular to the direction of rolling (in plane of plate) is also considered if the bracket did not penetrate the liner reinforcing plate. In this case, the major stress is normal to the plane of the liner plate. The allowable stresses are reduced to 75% of the stress permitted in (c) above.

e. The necessary plate characteristics are assured by ultrasonic examination of the reinforcement plates for lamination defects.

Missiles

The containment structural design considered the following external missiles:

| Item | Weight (lb) | Velocity (fps) |
|---|---|---|
| 4 x 12 plank, 12 ft. long | 200 | 440 |
| Automobile | 4,000 | 74 |

The depth of penetration of these missiles was analyzed in Reference 8. None of the above missiles would penetrate the containment. The 200 lb. plank weight was used in the structural design of PBNP. However, the submittal of Bechtel Topical Report B-TOP-3, “Design Criteria for Nuclear power Plants Against Tornadoes,” to the AEC in early 1970 established the weight of the licensing basis plank missile as 108 lbs (Section 1.3.1).

Implementation of Criteria

This section documents the manner in which the design criteria are met by the designer. Various types of documentation are presented.

Figure 5.1-10, Figure 5.1-11, and Figure 5.1-13 illustrate isostress plots and tabulations of predicted stresses for the various materials. The isostress plots of the homogeneous uncracked concrete structure indicate the general stress pattern for the structure as a whole under various loading conditions. More specific documentation is made of the predicted stresses for all materials in the structure. In these tabulations, the predicted stress is compared with the allowable to permit an easy comparison and evaluation of the adequacy of the design.

Results of Analysis

The isostress plots, Figure 5.1-10, Figure 5.1-11, and Figure 5.1-13, show the three principal stresses and the direction of the principal stresses normal to the hoop direction. The principal stresses are the most significant information about the behavior of the structure under the various conditions and are a valuable aid for the final design.

The plots were prepared by a cathode ray tube plotter. The data for plotting were taken from the stress output of the finite element computer program of the following design load cases:

$D + F$

$D + F + 1.15P$

$D + F + 1.5P + T_A$

$D + F + T_A$

The above axisymmetric loading conditions are found to be governing in the design since they result in highest stresses at various locations of the structure.

The table of predicted stresses, Table 5.1-1, for various materials has been prepared for the presentation of the combined stresses of the axisymmetric and nonaxisymmetric loading cases. These stresses are computer analyzed considering cracked concrete sections where applicable, in the manner described previously. No stresses are shown for the tendons due to the almost constant stress level regardless of loading condition. The tabulated stresses may be considered the final results of the analysis and design.

The upper stress limit for a linear stress strain relationship was assumed to be 3000 psi (0.6 $f'_c$) for use with analyses made by the use of the axisymmetric finite element analytical method. (The analyses referred to considered the concrete as uncracked and the analytical model is the entire containment.) However, the maximum predicted compressive stress was about 2600 psi. The load combination considered was ($D + F + T_A$) and the location for the predicted stress was near the junction of the base slab and cylinder. Therefore, only the linear portion of the stress curve was used in the analyses that used the entire containment structure as a model.

The compressive stress and strain level is the highest (after the LOCA when temperature is still relatively high, 200°F, and pressure is dropping rapidly) at the inside face of the concrete at the edge of openings and also under the liner plate anchors. Neither concentration is a result of what may be considered a real load. In the case of an opening, the real stress is a result of prestress, reduced pressure, and dead load. Applying stress concentration factors to these loads still keeps the concrete in essentially the elastic range. When the strain and resulting stress from the thermal gradient are also multiplied by a stress concentration factor, the total strain and resulting stress will be above the linear stress range as determined by a uniaxial compression test. The relatively high stress level is not of real concern due to the following:

1. The concrete affected is completely surrounded by either other concrete or the penetration nozzle and liner reinforcing plate. This confinement puts the concrete in triaxial compression and gives it the ability to resist forces far in excess of that indicated by a uni-axial compression test.

2. The high state of stress and strain exist at a very local area and really have no effect on the overall containment integrity.

However, to be conservative, reinforcing steel was placed in these areas and, also, the penetration nozzle will function as compressive reinforcement.

The concrete under the liner plate anchors experiences some limited yielding in order to get the necessary stress distribution required to resist the liner plate self relieving loads.

Liner Plate Design Provisions

The liner plate is anchored as shown in Figure 5.1-1 with anchorage in both the longitudinal and hoop direction. The anchor spacing and welds are designed to preclude failure of an individual anchor. The load deformation tests, referred to above, indicate that the alternate stitch fillet weld used to secure the anchor to the liner plate would first fail in the weld and not jeopardize the liner plate leaktight integrity.

Erection and fabrication inaccuracies are controlled by specified tolerances given in Section 5.6.1.5.

Offsets at liner plate seams are controlled in accordance with ASME Section III Code which allows 1/16 in. misalignment for 1/4 in. plate. The flexural strains due to the moment resulting from the misalignment are added to calculate the total strain in the liner plate.

Penetration Details

Typical penetration details are shown in Figure 5.1-2 and Figure 5.1-3.

Horizontal and vertical bonded reinforcement is provided to help resist membrane and flexural loads at the penetrations. This reinforcement is located on both the inside and outside face of the concrete. Stirrups are also used to assist in resisting shear loads. Local crushing of the concrete due to deflection of the reinforcing or tendons is precluded by the following details.

1. The surface reinforcements either have a very large radius, such as the hoop bars, concentric with the penetration or are practically straight, having only standard hooks as anchorages where necessary.

2. The tendons are bent around penetrations at a minimum radius of approximately 20 feet. Maximum tendon force at initial prestress is 850 kips, which results in a bearing stress of about 880 psi on the concrete.

It is also important to note that the deflected tendons are continuous past the openings and are isolated from the local effects of stress concentrations by virtue of being unbonded.

In accordance with ASME Section III, all penetration reinforcing plates and the weldment of the pipe closure to it are shop stress relieved as a unit. This code requirement and the grouping of penetrations into large shop assemblies permits a minimum of field welding at penetrations.

Butt welds are used between the penetration sleeve and process piping. Both flued ends and drilled standard weight pipe caps are used for the closure piece between the sleeves and the pipes. The design, fabrication, inspection, and testing of the containment penetration head fittings are in accordance with ASME Boiler and Pressure Vessel Code, Section III, Class B, 1968 Edition and all addenda. Inspection procedures used for all closure welds consisted of liquid penetrant and local leak pressure testing at the containment design accident pressure. Open butt welds without backing rings were specified prior to June 1970. All of these welds were radiographed. Welds after June 1970 did not have the requirement for backing rings and radiographic inspection. Consequently, most of the Unit 1 penetration closure welds were radiographed and the majority of the Unit 2 closure welds were not.

Prestress Losses

The following categories and values of prestress losses are considered in the design:

| Type of Loss | Assumed Value |
|---|---|
| Seating of Anchorage | None |
| Elastic Shortening of Concrete | $\frac{f_{cpi}}{5. \times 10^6}$ In/In |
| Creep of Concrete | $0.27 \times 10^{-6}$ In/In/Psi |
| Shrinkage of Concrete | $100 \times 10^{-6}$ In/In/Psi |
| Relaxation of Prestressing Steel | 8% of $0.65 f_s$ = 12.5 Ksi |
| Frictional Loss | $K = 0.0003$, $\mu = 0.156$ |

There is no allowance for the seating of the BBRV anchor since no slippage occurs in the anchor during transfer of the tendon load into the structure. Sample lift off readings will be taken to confirm that any seating loss is negligible.

The loss of tendon stress due to elastic shortening is based on the strain change in the initial tendon relative to the last tendon stressed.

A concrete properties study using Point Beach samples was conducted at the University of California. (Reference 9) A similar study conducted on a nearly identical concrete mix has indicated a creep value of 0.125 x $10^{-6}$ In/In/Psi. Conversion of this unit creep data to hoop, vertical, and dome stress gives these values of stress loss in tendons:

Hoop - 5.5 Ksi
Vertical - 2.8 Ksi
Dome - 5.5 Ksi

A single creep loss figure of 400 x $10^{-6}$ in/in at 1500 psi ($f_{cpi}$) in the concrete is used throughout the structure. This results in a prestress loss of 11.8 ksi in the prestressing steel.

The value used for shrinkage loss represents only that shrinkage that could occur after stressing. Since the concrete is, in general, well aged at the time of stressing, little shrinkage is left to occur and add to prestress loss.

The value of relaxation loss is based on information furnished by the tendon system vendor, Inland-Ryerson Construction Products Company.

Frictional loss parameters for unintentional curvature (K) and intentional curvature ($\mu$) are based on full scale friction test data. This data indicate actual values of K = 0.0003 and $\mu$ = 0.125 versus the design values of K = 0.0003 and $\mu$ = 0.156.

Assuming that the jacking stress for the tendons is 0.8 $f'_s$ or 192,000 psi and using the assumed prestress loss parameters, the following tabulation shows the magnitude of the design losses and the final effective prestress at end of 60 years for a typical dome, hoop, and vertical tendon. (NRC SE dated 12/2005, NUREG-1839)

| | Dome (Ksi) | Hoop (Ksi) | Vertical (Ksi) |
|---|---|---|---|
| Jacking Stress | 192 | 192 | 192 |
| Friction Loss | 18.5 | 20.8(1) | 20.0 |
| Seating Loss | 0 | 0 | 0 |
| Seating Stress | 173.5 | 171.2 | 172.0 |

(1) Average of crossing tendons

| | Dome (Ksi) | Hoop (Ksi) | Vertical (Ksi) |
|---|---|---|---|
| Elastic Loss | 8.8 | 9.4 | 4.1 |
| Creep Loss | 11.8 | 11.8 | 11.8 |
| Shrinkage Loss | 3.0 | 3.0 | 3.0 |
| Relaxation Loss | 12.5 | 12.5 | 12.5 |
| Final Effective Stress(2) | 137.4 | 134.5 | 140.6 |

(2) This force does not include the effect of pressurization which increases the prestress force.

To provide assurance of achievement of the desired level of final effective prestress and that ACI 318-63 requirements are met, a written procedure was prepared for guidance of post tensioning work. The procedure provided nominal values for end anchor forces in terms of pressure gage readings for calibrated jack-gage combinations. Force measurements were made at the end anchor, of course, since that is the only practical location for such measurements.

The procedure required the measured temporary jacking force, for a single tendon, to approach but not exceed 850 kips ($0.8f'_s$). Thus, the limits set by ACI 318-63, Paragraph 2606(a)1, and of the prestressing system supplier, were observed. Additionally, benefits were obtained by in place testing of the tendon to provide final assurance that the force capability exceeded that required by design. During the increase in force, measurements were required of elongation changes and force changes in order to allow documentation of compliance with ACI 318-63, Paragraph 2621(e). The jacking force of $0.8f'_s$ further provided for a means of equalizing the force in individual wires of a tendon to establish compliance with ACI 318-63, Paragraph 2621(b). The procedures required compliance with ACI 318-63 such that if broken wires resulted from the post-tensioning sequence, compliance with Paragraph 2621(d) was documented. Each of the above procedures contributed to assurance that the desired level of final effective prestress would be achieved.

The requirements of ACI 318-63, Paragraph 2606(a)2 state that $f_s$ should not exceed $0.7f'_s$ for "post-tensioning tendons immediately after anchoring."

Paragraph 2606(a)2 of ACI 318-63 refers to "tendons" rather than to an individual tendon. Further, the paragraph does not refer to the location to be considered for the determination of fs in the manner, for example, of the "temporary jacking force" referred to in Paragraph 2606(a)1. Two interpretations were therefore required. Both interpretations had to consider the effect of the resultant actions on both the prestressing system and structure.

The first interpretation was that the location for measurement of the seating force used in calculating $f_s$ was at the end anchor and just subsequent to the measurement of the "temporary jacking force" referred to in Paragraph 2606(a)1. The advantages of this location are several. One is that it is a practical one and thus the possibility for achieving valid measurements could be made without the added complexity of additional measuring devices. Another advantage is that measurements at this location provide assurance that the calculated $f_s$ does not anywhere exceed the maximum fs ($0.8f'_s$) to which that tendon has been subjected.

One case considered was that of anchoring each tendon at a measured force of 850 kips ($0.8f'_s$). Although there was no apparent detrimental effect to the prestressing system or structure, insertion of shims would be almost impossible. Further, it was concluded that this case would not establish compliance with ACI 318-63.

The case adopted was to seat each tendon with a measured "pressure" reading for the jack, at "lift-off" of the end anchor, of 775 kips (between 0.72 and 0.73 $f'_s$). This procedure had several advantages.

One advantage was that the force on the containment and the tendon was within the bounds of those for which it had been tested and resulted in no known detrimental effects. The second advantage was that the stressing procedure was simplified since the stressing crews did not have to accommodate a large number of different anchoring force requirements. The third advantage was that, at the completion of stressing the last tendon, the expected losses were such that the average $f_s$ at the end anchors of the tendons would be less than $0.7f'_s$, thus establishing compliance with ACI 318-63, Paragraph 2606(a)1 and 2. The fourth advantage was that the percentage loss of prestressing force was less than would be the case if the tendons were anchored in such a manner that the calculated value of $f_s$ nowhere exceeded $0.7f'_s$.

The latter advantage deserves special mention since it plays a strong role in assuring that the final effective prestress equaled or exceeded the desired value. For example, if the $f_s$ at anchorage of the tendons were $0.1f'_s$, the final effective prestress, neglecting relaxation for the moment, would be about 86% of the initial prestress. Clearly, the assurance (that the concrete creep and shrinkage losses have been properly accounted for) increases as the $f_s$ for the anchored tendons and tendon increases. However, this design was committed to meeting the ACI 318-63 requirement and the anchorage force for the tendons was kept at or below $0.7f'_s$ in accordance with the interpretation described.

Miscellaneous Considerations

In various cases, it is the designer's decision to provide structural adequacy in excess of design criteria submitted in the PSAR. Those cases are as follows:

1. Section 5.1.2.2 requires a minimum of 0.15% bonded reinforcing steel in two perpendicular directions on the exterior faces of the wall and dome for proper crack control. Due to the cold weather exposure, a minimum of approximately 0.25% is provided.

2. Section 5.1.2.2 requires a minimum of 0.15% at cross section area bonded steel reinforcing (as stated above) for any location. At the base of the cylinder, the controlling design case requires 0.25% vertical reinforcing. As a result of pursuing the recommendation of the NRC Staff to further investigate current research on shear in concrete, several steps were taken:

    a. The work of Dr. Alan H. Mattock was reviewed and he was retained as a consultant on the implementation of the research being conducted under his direction. The criteria was updated in accordance with his recommendation.

    b. In addition to reviewing Dr. Mattock's work, the firm of T. Y. Lin, Kulka, Yang and Associate was consulted to review the detailed design of the cylinder to slab connection. Pursuant to their recommendation, approximately 0.5% reinforcing was used rather than the 0.25% reinforcing indicated by the detailed design analysis for the vertical wall dowels. This increase insures that there was sufficient flexural steel to place the section within the lower limits of Mattock's test data (approximately 0.3%) to prevent flexural cracking from adversely affecting the shear capability of the section.

### 5.1.2.5 QUALITY CONTROL

Quality Control of materials and construction during the construction phase is considered historical information, and is described in FFDSAR Section 5.1.2.5.

### 5.1.2.6 PENETRATIONS

Penetrations conform to the applicable sections of ASA N6.2-1965, "Safety Standard for the Design, Fabrication, and Maintenance of Steel Containment Structures for Stationary Nuclear Power Reactors." All personnel locks and the equipment access door conform in all respects to the requirements of ASME Section III Nuclear Vessels Code.

The basis for limiting strains in the penetration steel is the ASME Boiler and Pressure Vessel Code for Nuclear Vessels, Section III, Article 4, 1965, and, therefore, the penetration structural and leak tightness integrity is maintained. Local heating of the concrete immediately around the penetration will develop compressive stress in the concrete adjacent to the penetration and a negligible amount of tensile stress over a large area. The mild steel reinforcing added around penetrations distributes local compressive stresses for overall structural integrity.

Spare penetrations without process piping are not considered penetrations that require double barriers. The containment side weld provides the single ASME Section XI Class MC boundary.

Double barriers may consist of double gasketed or sealed joints as defined in the specific examples in the remainder of this section.

<u>Equipment Hatch</u>

An equipment hatch 15 ft. in diameter is provided as shown in Figure 5.1-5. The hatch is fabricated from steel and furnished with a double gasketed flange and bolted dished door. Equipment up to and including the size of the reactor vessel O ring seal can be transferred into or out of containment through this hatch.

Provision is made to allow test pressurization of the spaces between the double gaskets of the door flanges and the weld seam channels at the liner joint, hatch flanges, and dished door.

<u>Personnel Locks</u>

Two personnel locks are provided as shown on Figure 5.1-4 and Figure 5.1-5. One of these is for convenience access and penetrates the dished door of the equipment hatch. Each personnel lock is a double door, welded steel assembly. The locks are designed to withstand all containment design conditions with either or both doors closed and locked. Doors open toward the center of the containment and are thus sealed under containment pressure. The lock barrel may be pressurized to demonstrate its leak tightness without pressurizing the containment. The personnel lock was pneumatically shop tested for pressure and leakage. Quick acting type equalizing valves connect the personnel lock with the interior and exterior of the containment vessel for the purposes of equalizing pressure in the two systems when entering or leaving the containment. Each air lock door is provided with double gaskets to permit pressurization between the gaskets for leakage testing.

The two doors in each personnel lock are interlocked to prevent both being opened simultaneously and to ensure that one door is completely closed before the opposite door can be opened. Provision is made to permit by-passing the door interlocking system to allow doors to be left open during the plant cold shutdown. Each door lock hinge is designed to be capable of independent, three-dimensional adjustment to assist proper seating.

Operation of the lock is manual, that is, without power assist. Normal procedure requires personnel using the lock to close the door behind them. If a door is inadvertently left open, a person approaching the lock in the same direction may remotely close the open (far) door, thus permitting him to open the near door and travel through the lock in the normal manner.

Containment personnel airlock inner and outer doors are provided with alarms to remotely monitor the position of the containment airlock doors. The door alarms may be used to provide indication of personnel entry or to monitor the status of airlock door position for containment integrity.

Fuel Transfer Penetration

A fuel transfer penetration is provided in each containment structure for fuel movement between the refueling transfer canal and the spent fuel pool. The penetration consists of a 20 in. stainless steel pipe installed inside a 24 in. pipe. The inner pipe acts as the transfer tube and is fitted with a double gasketed Transfer Tube Closure assembly in the refueling canal and a standard gate valve in the spent fuel pool. This arrangement prevents leakage through the transfer tube in the event of an accident. The outer pipe is welded to the containment liner and provision is made by use of continuous leakchase channels for test pressurizing all welds essential to the integrity of the penetration during plant operation. Bellows expansion joints are provided on the pipes to compensate for any differential movement between the two pipes or other structures. Figure 5.1-20 shows a sketch of the fuel transfer tube.

Piping and Ventilation Penetrations

All piping and ventilation penetrations are of the rigid welded type and are solidly anchored to the containment wall, thus eliminating the need to use expansion bellows for containment barriers inside containment. All penetrations and anchorages are designed for the forces and moments resulting from operating condition or postulated pipe rupture. External guides and stops or increased pipe wall thickness are provided as required to limit motions, bending, and torsional moments to prevent rupture of the penetrations and the adjacent liner plate. Each penetration flued head or pipe cap inside containment and its connection to the piping are designed to withstand containment design basis accident pressure and temperature. Most mechanical penetration assemblies include test connections and pipe caps with or without expansion bellows outside containment for leak testing purposes. Penetration bellows and pipe caps outside containment are not considered part of the containment pressure boundary.

For typical details of piping penetrations, see Figure 5.1-2.

Electrical Penetrations

There are two general areas for electrical containment penetrations located approximately 38 ft. apart. Each one of the two areas contains one of the trains for engineered safeguards service and two of the four channels of instrumentation (for reactor protection and safeguards). Within each area, penetrations for safeguards or protection are located below the penetrations for nonessential services. In one of the general areas, the vertical clearance between penetrations for safeguards or protection and penetrations for nonessential services is 5 ft., except for one of the protection channels which has approximately 2 ft. clearance to the nonessential penetrations above. In the other area, vertical clearance is 14 ft. Outside the containment, safeguards or protection service penetrations load into two pipe tunnels where nonessential penetrations are located above the concrete tunnel ceilings.

The 38 ft. separation between the two areas will preclude propagation of fire from one to the other of the two general areas described above. Therefore, fire separation is provided between the penetrations for the two safeguards trains. Likewise, a 38 ft. separation is provided between the two pairs of penetrations serving reactor protection circuits. Separation between the two penetrations for one pair is by 3 ft. vertical clearance and for the other pair by 1 ft.

Electrical penetrations consist of carbon steel pipe canisters with stainless steel header plates welded to each end. Identical hermetically ceramic sealed multipin connectors are welded into both headers for all conductors rated less than 600 volts. High voltage conductors utilize single conductor hermetically sealed ceramic busings welded to both header plates. Thus, each canister affords a double barrier against leakage. A flange on each canister is welded to the penetration sleeve. Thermal conduction and radiation paths are sufficient to prevent damage to seals or conductors during field welding of the canisters to the containment liner.

The canister with two welded headers permits pressure and leakage tests to be performed simply and reliably both at the shop and after installation. A tap, convenient to the exterior of the containment, is provided for pressurizing the canister. The terminations of the conductors to the connectors inside the canisters are potted to protect against moisture.

Typical details are shown in Figure 5.1-3.

### 5.1.2.7 MISSILE PROTECTION

High pressure equipment, which is a potential source of missiles, is surrounded by barriers to prevent credible missiles from reaching the primary system, the containment liner, the secondary steam and feedwater piping, or the engineered safeguards system. Principal barriers against missiles are the reinforced concrete in biological shield and secondary shield walls surrounding the primary coolant loops. Supplementary barriers are provided to protect the liner plate from missiles which might be projected through openings in the secondary shield walls.

In addition, a missile shield located above the reactor vessel head is designed to block any missiles that could be generated by the control rod drive mechanisms. A reinforced concrete roof is provided above the pressurizer to prevent missiles from the pressurizer piping valves from reaching the containment liner plate or other metal structures and systems.

### 5.1.2.8 CONTAINMENT ACCESSIBILITY CRITERIA

The normal mode of operation is to have the containment completely closed whenever the reactor is not cold shutdown (at least 1% $\Delta k/k$ subcritical and the reactor coolant system temperature is less than or equal to 200°F) with nuclear fuel in place in accordance with Technical Specifications. Also, a containment carbon filter cleanup system consisting of roughing, high efficiency and carbon filters, and fans is designed to keep the radioactivity levels safe for personnel. During the emergency repair or inspection under hot shutdown or power conditions, radioactivity levels are continuously monitored to assure personnel safety and compartment access is limited accordingly.

For cooldown and shutdown entry, the containment vessel may be purged to reduce the concentration of radioactive gases and airborne particulates. This purge system is designed to reduce the radioactivity level to doses defined by 10 CFR 20 for a 40 hour occupational work week, within 2 to 6 hours after plant shutdown. However, this objective may not be achievable until containment purge is available after inboard blind flanges are removed. Since minimal fuel defects are expected for this particular reactor configuration, much less than the 1% fuel rod defects used for design, purging of the containment is normally accomplished in less than 2 hours. If necessary to ensure removal of particulate matter, the purged air can be passed through a high efficiency filter before being released to the atmosphere through the purge vent. The containment carbon filter system, as described above, is utilized as standby for cleanup purposes.

The primary reactor shield is designed so that access to the primary equipment would be limited by the activity of the primary system equipment and not the reactor. Specific conditions under which the containment equipment hatch or both doors of the personnel locks may be open are outlined in Technical Specifications.

#### 5.1.2.9 Leak Chase Channels (LCC)

The leak chase channels which cover the containment liner welds are welded to the liner plate. These channels were not specifically addressed in the original liner plate analysis, were not intended to be vented to the containment, and were not vented during the early containment integrated leakage rate tests (CILRT). It was subsequently recognized that the requirement of 10 CFR Part 50 Appendix J to test the qualified leakage barrier may not have been strictly met during periodic Type A testing with the LCCs not vented. Additional analyses, tests and comparison to more recent ASME design codes were performed to demonstrate both structural and leaktight integrity of the LCC system. This additional information, as described below, formed the basis for the NRC's approval to continue Type A testing with the LCCs not vented (Reference 11).

Structural Analysis

Structural analyses of typical containment liner plate sections were performed to evaluate the severity of loading on leak chase channels (Reference 12). These analyses included investigation of internal forces, stresses, strains and displacements of the leak chase channels in the liner plate system and the assessment of the effect of the presence of the leak chase channels on the structural behavior of the liner plate system. The results of these analyses indicate that some of the leak chase channel sections in the cylindrical portion of the containment could sustain minor inelastic deformations when subjected to maximum design load conditions. The dome area leak chase channels, which are embedded in concrete, would also sustain some nonlinear deformation with a high factor of safety.

For analytical purposes, each leak chase channel section may be placed in one of two categories. In the first category, which is typical of the dome sections, the leak chase channel projects outward and interacts with the containment structure concrete when relative displacement occurs between the liner plate and the concrete. In the second category, all leak chase channel sections project inward and do not directly interact with the concrete.

The general approach for the first category, i.e., embedded channels, included definition of loads in terms of induced strains, load-deformation characteristics in both linear and nonlinear response ranges, development of a mathematical model and a parametric analysis of the system. Conventional structural analysis techniques are utilized with evaluations based on lower bound physical material properties. Because the loads in the liner plate leak chase channel system are predominantly a direct function of the relative strain between the liner plate and the containment structure concrete, the loads were redefined in terms of relative strain. The load combination includes dead load, differential pressure, accident pressure, seismic prestress, shrinkage, creep, operating thermal, and accident thermal loads.

Analytical results for embedded leak chase channels in concrete show that the lowest calculated safety factor is 11.3. The presence of the leak chase channels increases safety margins for other critical elements of the liner plate system.

In the analyses of the second category, the interior leak chase channel sections receive direct containment internal pressure load in addition to forced displacements due to the strain in the structural elements to which the leak chase channel members are attached. The axial stresses and strains of the leak chase channels are comparable to those of the support element in the axial direction of the channels. The forced lateral displacements induce internal forces and moments into the leak chase channel member cross section which responds to these displacements and to direct pressure loading essentially as a rigid frame with flexural continuity at corners and support points. Conventional structural analysis procedures were utilized in solving the frame models. Most leak chase channels were found to remain elastic. In cases where inelastic response was predicted, ductility ratios based on strain levels and plastic section strengths were calculated. The resulting maximum ductility ratio was found to be 1.94 which is well within acceptable range and is comparable to a safety factor based on displacement of about 22.

Load Deformation and Leak Tests

Testing was conducted to obtain the load-deformation characteristics of leak chase channels interacting with the liner plate and containment concrete and to verify the leak tight integrity of the leak chase channels under the severe load and deformation conditions imposed during testing (Reference 13).

The LCCs were pressurized to 70 psig internal pressure during the load tests. The tests demonstrated that the leak chase channels and the 3/16-inch double pass fillet welds retained their leaktight integrity throughout the test loading which produced lateral deformations in the 2-inch channel sections in excess of 0.149 inch.

For the composite tests (channels embedded in concrete), the shear resistance capacity was controlled by compressive failure of the concrete engaged by the leak chase channels. For the liner plate leak chase channel (steel only) tests, the capacity was limited by the flexural resistance of the 1/4-inch-thick liner plate. Although the sections sustained inelastic displacement in excess of 0.10 inch, no failures were observed in the channels or welds to the liner plate.

Code Comparison

While acknowledging that Point Beach was constructed prior to the implementation of the ASME Section III, Division 1, Subsection MC, the NRC staff required that the LCCs, as built, meet the intent of the Code. A comparison of the ASME code to the original design and construction codes was included in a summary report provided to the NRC (Reference 1). The summary report supports the conclusions that: 1) the channel welds are qualitatively equivalent to those for the primary containment liner welds as demonstrated by construction records, quality control measures, leak tests and inspection reports, and 2) the analyses and tests demonstrate that the leak chase channels, external or internal, are rugged components which will function as integral parts of the liner plate system, are capable of withstanding the loading conditions of both normal operation and design basis accidents, and will maintain their structural integrity at all times.

## 5.1.3 REFERENCES

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9. Bechtel Letter PBB-W-2476, Transmittal of "Progress Report No. 2, Studies of Concrete for Two Rivers Nuclear Containment Vessels," October 7, 1969

10. CAP01125324, "High Temperature Containment Penetrations," April 10, 2008.

11. NRC Safety Evaluation, AC Nos. 63152 and 63153, "Containment Liner Leak Chase Channel Venting," September 18, 1989.

12. "Evaluation of Containment Liner Plate Leak Chase System for Point Beach Nuclear Plant, Units 1 and 2," by Bechtel Associates Professional Corporation, dated June, 1986.

13. "Test Report on Static Load Tests on Liner Plate Leak Chase Channel Assemblies," by University of Michigan Department of Civil Engineering, dated December 1985.

14. NFPA 805 Fire Protection Program Design Document (FPPDD)

Table 5.1-1 CONTAINMENT STRUCTURE SUMMARY OF CONCRETE AND REINFORCING STEEL STRESSES

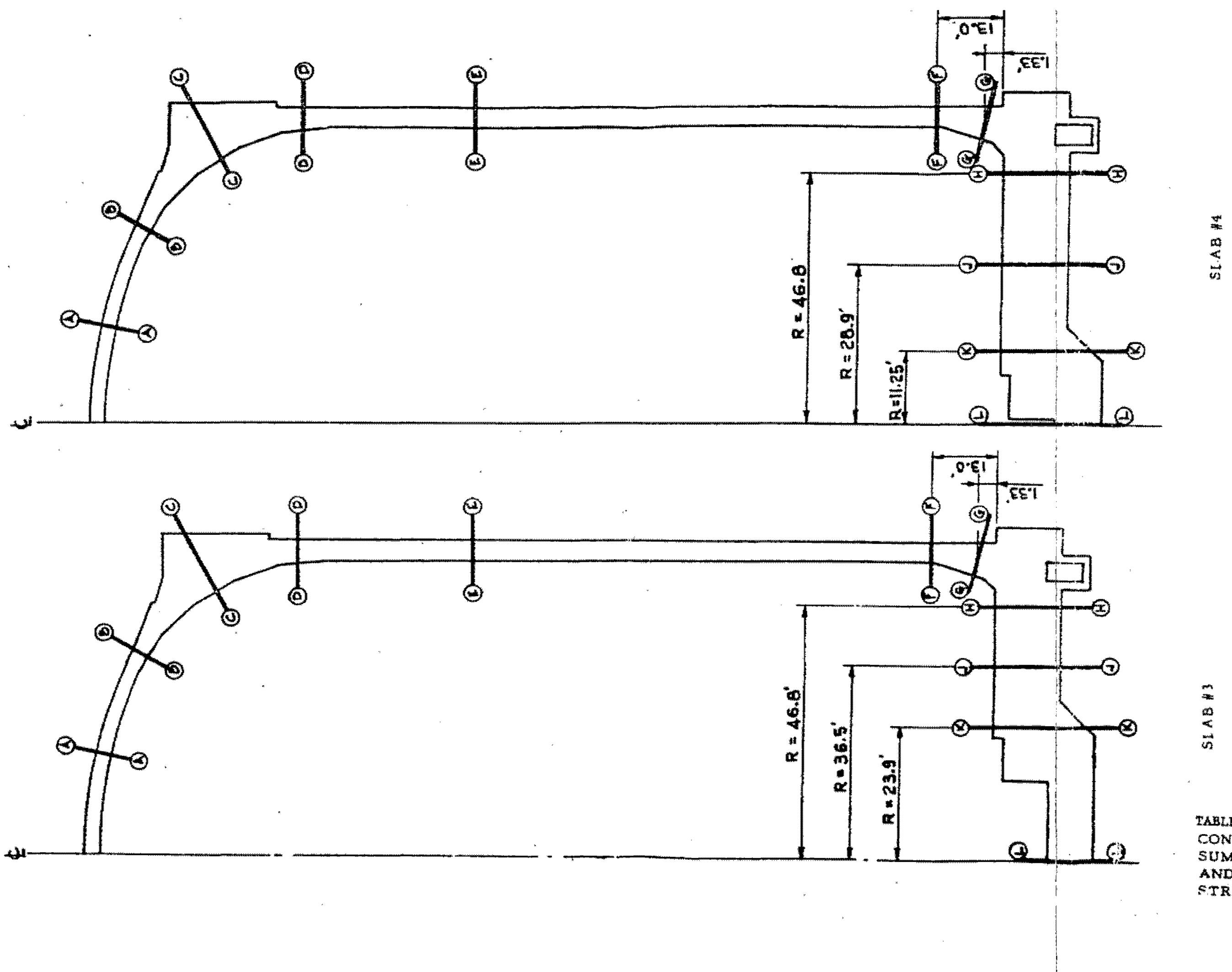



TABLE 5.1-1
CONTAINMENT STRUCTURE
SUMMARY OF CONCRETE
AND REINFORCING STEEL
STRESSES.

SHEET 1

Table 5.1-1(2A) CONTAINMENT STRUCTURE SUMMARY OF CONCRETE AND REINFORCING STEEL STRESSES

Structural Data

| | | Concrete | | Reinforcing Steel | |
|---|---|---|---|---|---|
| Location | $p'_c$-psi | t-in. | Type | $P_m$-% | $P_h$-% |
| A-A | 5000 | 36 | A-15 | 0.07 | 0.07 |
| A-A | 5000 | 36 | A-15 | 0.23 | 0.23 |
| B-B | 5000 | 60 | A-15 | 0.09 | 0.09 |
| B-B | 5000 | 60 | A-15 | 0.24 | 0.22 |
| C-C | 5000 | 148 | A-432 | - | - |
| C-C | 5000 | 148 | A-432 | 0.09 | 0.09 |
| D-D | 5000 | 50 | A-432 | 0.11 | - |
| D-D | 5000 | 50 | A-432 | 0.73 | 0.28 |
| E-E | 5000 | 42 | A-15 | - | - |
| E-E | 5000 | 42 | A-15 | 0.25 | 0.25 |
| F-F | 5000 | 42 | A-15 | 0.25 | 0.25 |
| F-F | 5000 | 42 | A-15 | 0.31 | - |
| G-G | 4000 | 78 | A-432 | 0.29 | 0.20 |
| G-G | 4000 | 78 | A-432 | 0.57 | 0.25 |
| H-H | 4000 | 110 | A-432 | 0.22 | 0.12 |
| H-H | 4000 | 110 | A-432 | 0.42 | 0.32 |
| J-J | 4000 | 138 | A-432 | 0.17 | 0.10 |
| J-J | 4000 | 138 | A-432 | 0.28 | 0.25 |
| K-K | 4000 | 150 | A-432 | 0.17 | 0.09 |
| K-K | 4000 | 150 | A-432 | 0.28 | 0.19 |
| L-L | 4000 | 84 | A-432 | 0.19 | 0.19 |
| L-L | 4000 | 84 | A-432 | 0.37 | 0.37 |

First line for each section refers to interior face containment structure, second line refers to exterior face.

Table 5.1-1(2B) CONTAINMENT STRUCTURE SUMMARY OF CONCRETE AND REINFORCING STEEL STRESSES

Notes

1. Loading Cases I, II, and IV are for Working Stress Analysis. Case III has been included for additional information. Cases V, VI, and VII are for Yield Stress Analysis.
2. The stresses shown are based on cracked section analysis unless noted by *.
3. Deviation in allowable stresses are in accordance with 5.1.2-2.
4. All concrete extreme fiber stresses ( ) are shown for the inside surface. Outside surface stresses are indicated by ( ). The stresses listed are the controlling stresses for that section.
5. Computed vs. allowable ratios for Cases V, VI, and VII include appropriate factors.
6. Allowable shear stresses include stirrups wherever applicable.

Notation

| | |
|---|---|
| D | Dead Load |
| F | Prestress |
| P | Internal Pressure |
| E | Earthquake |
| E′ | Earthquake |
| $T_A$ | Accident Temperature |
| $f_c$ | Ultimate Concrete Stress |
| $f_y$ | Steel Rebar Yield Stress |
| $f_a$ | Allowable Concrete Axial Stress |
| $f_{ce}$ | Allowable Concrete Axial and Flexure Stress |
| $\nu$ | Allowable Concrete Shear Stress Including Stirrups if Applicable |
| $f_s$ | Allowable Steel Stress |
| $\sigma_a$ | Average Axial Stress, Thermal Effects Excluded |
| $\sigma_e$ | Flexural Stress |
| $\sigma$ Total | Sum of Membrane and Flexural Stresses |
| h | Subscript Indicating Hoop Direction |
| m | Subscript Indicating Meridional Direction |
| $P_h$ | Hoop Steel Percentage |
| $P_m$ | Meridional Steel Percentage |
| + | Tensile Stresses |
| - | Compressive Stresses |
| $\tau$ | Nominal Shear Stress: $\tau = \frac{V}{bd}$ |

## Table 5.1-1(2C) CONTAINMENT STRUCTURE SUMMARY OF CONCRETE AND REINFORCING STEEL STRESSES

Allowable Stresses

Working Stress Design

| | |
|---|---|
| Shell Concrete | $f_a$ = 1500 psi |
| | $f_{ce}$ = 3000 psi |
| Base Concrete | $f_{ce}$ = 1800 psi |
| Steel A-15 | $f_s$ = 20,000 psi |
| Steel A-432 | $f_s$ = 30,000 psi |

Yield Stress Design

| | |
|---|---|
| Shell Concrete | $f_a = \phi_a f_c = (0.85)(5000) = 4,250$ psi |
| | $f_{cd} = \phi_{ce} f_c = (0.90)(5000) = 4,500$ psi |
| Base Concrete | $f_a = \phi_a f_c = (0.85)(4000) = 3,400$ psi |
| | $f_{ce} = \phi_{ce} f_c = (0.90)(4000) = 3,600$ psi |
| Steel | $f_s = \phi f_y = (0.90)(40,000) = 36,000$ psi |
| | $f_s = \phi f_y = (0.90)(60,000) = 54,000$ psi |

Table 5.1-1(3) CONTAINMENT STRUCTURE SUMMARY OF CONCRETE AND REINFORCING STEEL STRESSES D & F INITIAL (STRESSES IN PSI) CASE I MESH #3 AND #4

| | Meridional | | | Inside | | | Shear | | |
|---|---|---|---|---|---|---|---|---|---|
| | σ Outside (psi) | σ Inside (psi) | σ Axial (psi) | σ Outside (psi) | σ Inside (psi) | σ Axial (psi) | τ (psi) | $\nu_{ci}$ (psi) | $\nu_{cw}$ (psi) |
| Section | | | | | | | | | |
| Shell | -802 | -950 | -840 | -770 | -833 | -775 | -96 | 1,140 | 619 |
| F-F | -135 | -1,123 | -478 | -77 | -365 | -237 | -212 | 424 | 541 |
| G-G | | | | | | | | | |
| Slab #4 | | | | | | | | $\nu_c$ (psi) | |
| H-H | +206 | -440 | -111 | 0 | -198 | -103 | +96 | 214 | |
| J-J | -60 | -80 | -71 | -67 | -56 | -62 | +21 | 162 | |
| K-K | -72 | -93 | -76 | -61 | -67 | -64 | -35 | 169 | |
| L-L | -29 | -60 | -49 | -37 | -69 | -56 | +2 | 122 | |
| Slab #3 | | | | | | | | | |
| J-J | -8 | -135 | -77 | -31 | -129 | -84 | 23 | 132 | |
| K-K | -31 | -250 | -69 | -35 | -159 | -101 | 38 | 133 | |
| L-L | +34 | -79 | -20 | +27 | -63 | -16 | 5 | 122 | |

Allowable Concrete Stresses

Shell: $f_a$ = 1500 psi, $f_{ce}$ = 3000 psi Base: $f_a$ = 1200 psi, $f_{ce}$ = 1800 psi

# Table 5.1-1(4A) CONTAINMENT STRUCTURE SUMMARY OF CONCRETE AND REINFORCING STEEL STRESSES MESH #4

| | Concrete | | | | | | | | | | Reinforcing Steel | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Computed | | | | | | | Computed vs Allowable | | | Computed | | Computed vs Allowable | | Liner Plate | |
| Load Case | $\sigma_{em}$ | $\sigma_{eh}$ | $\sigma_{am}$ | $\sigma_{ah}$ | Total $\sigma_m$ | Total $\sigma_h$ | $\tau$ | Total $\frac{\sigma}{f_{ce}}$ | $\frac{\sigma_a}{f_a}$ | $\frac{\tau}{v}$ | $\sigma_m$ | $\sigma_h$ | $\frac{\sigma_m}{f_s}$ | $\frac{\sigma_h}{f_s}$ | $\sigma_m$ | $\sigma_h$ |
| **Section F-F** | | | | | | | | | | | | | | | | |
| I D+F+1.15P | -88* | -11* | -297 | -348 | -385 | -359 | +8 | 0.128* | 0.232 | 0.039 | | | | | -2,720 | -4,780 |
| II D+F+$T_A$ | -1,721 | -1,251 | -720 | -665 | -2,441 | -1,916 | -120 | 0.814 | 0.480 | 0.219 | 12,085 | 10,530 | 0.403 | 0.351 | -49,910 | -43,450 |
| III D+F+P+$T_A$ | -1,064 | -883 | -334 | -332 | -1,398 | -1,215 | -24 | 0.470 | 0.223 | 0.119 | 9,220 | 13,450 | 0.461 | 0.673 | -33,940 | -36,150 |
| IV D+F+P+$T_A$+E | -1,130 | -793 | -397 | -309 | -1,527 | -1,102 | -27 | 0.509 | 0.166 | 0.130 | 13,285 | 15,060 | 0.443 | 0.502 | -35,550 | -33,390 |
| V 1.05+F+1.5P+$T_A$ | -303 | -282 | -138 | -186 | -441 | -468 | +20 | 0.104 | 0.044 | 0.086 | 10,800 | 17,840 | 0.300 | 0.495 | -22,950 | -27,525 |
| VI 1.05D+F+1.25P+1.25E+$T_A$ | -1,066 | -792 | -315 | -229 | -1,381 | -1,021 | -5 | 0.308 | 0.074 | 0.023 | 12,060 | 14,180 | 0.335 | 0.393 | -33,820 | -33,750 |
| VII 1.05D+F+P+E′+$T_A$ | -1,195 | -703 | -460 | -285 | -1,655 | -988 | -30 | 0.368 | 0.108 | 0.140 | 17,350 | 6,670 | 0.482 | 0.463 | -37,160 | -30,630 |
| **Section G-G** | | | | | | | | | | | | | | | | |
| I D+F+1.15P | +37* | -13* | -183 | -155 | (-146) | -168 | -40 | 0.093* | 0.122 | 0.1.54 | - | - | - | - | -500 | -2,850 |
| II D+F+$T_A$ | -1,294 | -954 | -410 | -203 | -1,704 | -1,157 | -216 | 0.950 | 0.274 | 0.532 | 25,420 | 26,930 | 0.847 | 0.898 | -40,730 | -36,690 |
| III D+F+P+$T_A$ | -698 | -423 | -213 | -161 | -911 | -584 | -95 | 0.507 | 0.142 | 0.300 | 8,100 | 21,400 | 0.270 | 0.713 | -28,230 | -29,820 |
| IV D+F+P+$T_A$+E | -787 | -339 | -255 | -118 | -1,042 | -457 | -108 | 0.580 | 0.106 | 0.295 | 9,105 | 26,675 | 0.303 | 0.889 | -30,472 | -28,595 |
| V 1.05D+F+1.5P+$T_A$ | -65 | -328 | -115 | -140 | -180 | -468 | -34 | 0.130 | 0.027 | 0.103 | 2,030 | 17,700 | 0.037 | 0.328 | -19,280 | -28,560 |
| VI 1.05D+F+1.25P+1.25E+$T_A$ | -628 | -231 | -242 | -96 | -870 | -327 | -85 | 0.242 | 0.057 | 0.223 | 5,600 | 26,000 | 0.104 | 0.480 | -25,835 | -27,100 |
| VII 1.05D+F+E′+P+$T_A$ | -876 | -254 | -296 | -74 | -1,172 | -328 | -120 | 0.326 | 0.070 | 0.289 | 10,110 | 31,950 | 0.174 | 0.591 | -32,715 | -27,370 |
| **Section H-H** | | | | | | | | | | | | | | | | |
| I D+F+1.15P | 0 | -72 | +52 | -31 | +52 | -103 | -68 | 0.057 | LIMIT | 0.326 | 3,200 | 3,000 | 0.107 | 0.100 | +600 | -1,460 |
| II D+F+$T_A$ | -799 | -424 | -95 | -88 | -894 | -512 | +77 | 0.498 | fa | 0.486 | 18,050 | 9,350 | 0.602 | 0.312 | -14,060 | -8,750 |
| III D+F+P+$T_A$ | -372 | -397 | -60 | -68 | -432 | -465 | -53 | 0.258 | DOES | 0.337 | 7,800 | 11,000 | 0.260 | 0.367 | -7,560 | -7,990 |
| IV D+F+P+$T_A$+E | -447 | -242 | -40 | -9 | -487 | -251 | -127 | 0.271 | NOT | 0.816 | 11,850 | 20,900 | 0.395 | 0.697 | -8,410 | -5,950 |
| V 1.05D+F+1.5P+$T_A$ | -120 | -368 | -12 | -43 | -132 | -411 | -118 | 0.114 | APPLY | 0.437 | 3,100 | 12,000 | 0.057 | 0.222 | -3,900 | -7,490 |
| VI 1.05D+F+1.25P+1.25E+$T_A$ | -295 | -380 | -11 | +24 | -306 | -356 | -178 | 0.099 | HERE | 0.690 | 11,500 | 25,500 | 0.213 | 0.472 | -6,320 | -7,340 |
| VII 1.05D+F+E′+P+$T_A$ | -521 | -87 | -20 | +51 | -541 | -36 | -201 | 0.150 | | 0.779 | 15,900 | 30,800 | 0.294 | 0.570 | -9,260 | -3,910 |

# Table 5.1-1(4B) CONTAINMENT STRUCTURE SUMMARY OF CONCRETE AND REINFORCING STEEL STRESSES MESH #4

| | Concrete | | | | | | | | | | Reinforcing Steel | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Computed | | | | | | | Computed vs Allowable | | | Computed | | Computed vs Allowable | | Liner Plate | |
| Load Case | $\sigma_{em}$ | $\sigma_{eh}$ | $\sigma_{am}$ | $\sigma_{ah}$ | Total $\sigma_m$ | Total $\sigma_h$ | $\tau$ | Total $\frac{\sigma}{f_{ce}}$ | $\frac{\sigma_a}{f_a}$ | $\frac{\tau}{v}$ | $\sigma_m$ | $\sigma_h$ | $\frac{\sigma_m}{f_s}$ | $\frac{\sigma_h}{f_s}$ | $\sigma_m$ | $\sigma_h$ |
| Section J-J | | | | | | | | | | | | | | | | |
| I D+F+1.15P | -338 | -411 | -2 | -8 | -340 | -419 | -23 | 0.232 | | 0.212 | 14,100 | 20,400 | 0.470 | 0.680 | -4,500 | -5,400 |
| II D+F+$T_A$ | -409 | -181 | -61 | -53 | -470 | -242 | +11 | 0.261 | | 0.104 | 3,640 | 3,326 | 0.121 | 0.111 | -6,900 | -5,370 |
| III D+F+P+$T_A$ | -535 | -475 | -62 | -24 | -597 | -499 | -25 | 0.332 | | 0.234 | 11,800 | 15,000 | 0.393 | 0.500 | -9,380 | -8,870 |
| IV D+F+P+$T_A$+E | -781 | -366 | -43 | +6 | -823 | -360 | -32 | 0.457 | | 0.303 | 20,900 | 23,650 | 0.697 | 0.788 | -12,400 | -7,585 |
| V 1.05+F+1.5P+$T_A$ | -641 | -617 | -37 | -4 | -678 | -621 | -43 | 0.189 | | 0.244 | 19,200 | 23,800 | 0.355 | 0.440 | -10,550 | -10,510 |
| VI 1.05D+F+1.25P+1.25E+$T_A$ | -917 | -427 | -40 | +6 | -957 | -421 | -43 | 0.266 | | 0.249 | 26,300 | 31,300 | 0.486 | 0.580 | -14,200 | -8,600 |
| VII 1.05D+F+P+E′+$T_A$ | -1,027 | -257 | -23 | +35 | -1,050 | -222 | -39 | 0.293 | | 0.255 | 30,000 | 32,300 | 0.555 | 0.598 | -15,420 | -6,300 |
| Section K-K | | | | | | | | | | | | | | | | |
| I D+F+1.15P | -397 | -242 | -18 | -3 | -415 | -245 | -25 | 0.230 | LIMIT | 0.231 | 15,400 | 11,000 | 0.513 | 0.367 | -5,300 | -3,300 |
| II D+F+$T_A$ | -541 | -117 | -65 | -55 | -606 | -172 | -19 | 0.344 | DOES | 0.179 | 2,340 | 4,658 | 0.095 | 0.155 | -10,320 | -3,140 |
| III D+F+P+$T_A$ | -1,143 | -388 | -176 | +87 | -1,319 | -301 | -15 | 0.734 | NOT | 0.141 | 15,930 | 22,600 | 0.531 | 0.753 | -17,890 | -5,170 |
| IV D+F+P+$T_A$+E | -1,318 | -449 | -170 | +100 | -1,488 | -349 | -37 | 0.926 | APPLY | 0.350 | 20,155 | 25,540 | 0.672 | 0.851 | -20,245 | -6,015 |
| V 1.05D+F+1.5P+$T_A$ | -1,412 | -571 | -155 | +110 | -1,567 | -461 | -13 | 0.436 | HERE | 0.075 | 25,750 | 29,400 | 0.477 | 0.544 | -21,430 | -7,650 |
| VI 1.05D+F+1.25P+1.25E+$T_A$ | -1,622 | -567 | -157 | +114 | -1,779 | -453 | -42 | 0.495 | | 0.242 | 25,130 | 30,100 | 0.465 | 0.557 | -24,330 | -7,600 |
| VII 1.05D+F+E′+P+$T_A$ | -1,493 | -510 | -165 | +114 | -1,658 | -396 | -59 | 0.460 | | 0.341 | 24,380 | 28,480 | 0.451 | 0.527 | -22,600 | -6,860 |
| Section L-L | | | | | | | | | | | | | | | | |
| I D+F+1.15P | -179 | -172 | +99 | +82 | -80 | -90 | -18 | 0.050 | | 0.017 | 4,900 | 4,600 | 0.060 | 0.053 | -1,400 | -1,600 |
| II D+F+$T_A$ | -378 | -448 | -42 | -48 | -420 | -496 | -11 | 0.276 | | 0.104 | 5,767 | 5,965 | 0.192 | 0.199 | -4,770 | -12,300 |
| III D+F+P+$T_A$ | -465 | -534 | +13 | -35 | -452 | -569 | -29 | 0.311 | | 0.270 | 6,600 | 6,500 | 0.220 | 0.216 | -5,150 | -12,770 |
| IV D+F+P+$T_A$+E | -509 | -566 | +17 | -33 | -492 | -599 | -73 | 0.332 | | 0.69 | 8,700 | 7,150 | 0.290 | 0.238 | -6,085 | -13,250 |
| V 1.05D+F+1.5P+$T_A$ | -410 | -517 | +75 | +22 | -335 | -495 | -38 | 0.138 | | 0.220 | 9,400 | 9,200 | 0.174 | 0.171 | -4,180 | 12,360 |
| VI 1.05D+F+1.25P+1.25E+$T_A$ | -575 | -574 | +49 | -4 | -526 | -578 | -89 | 0.161 | | 0.515 | 10,200 | 9,000 | 0.189 | 0.166 | -6,900 | 13,290 |
| VII 1.05D+F+E′+P+$T_A$ | -553 | -597 | +21 | -30 | -532 | -627 | -117 | 0.174 | | 0.675 | 10,800 | 7,800 | 0.200 | 0.144 | -7,020 | 13,730 |

# Table 5.1-1(5) CONTAINMENT STRUCTURE SUMMARY OF CONCRETE AND REINFORCING STEEL STRESSES MESH #3

| | Concrete | | | | | | | | | | Reinforcing Steel | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Computed | | | | | | | Computed vs Allowable | | | Computed | | Computed vs Allowable | | Liner Plate | |
| Load Case | $\sigma_{em}$ | $\sigma_{eh}$ | $\sigma_{am}$ | $\sigma_{ah}$ | Total $\sigma_m$ | Total $\sigma_h$ | $\tau$ | Total $\frac{\sigma}{f_{ce}}$ | $\frac{\sigma_a}{f_a}$ | $\frac{\tau}{\nu}$ | $\sigma_m$ | $\sigma_h$ | $\frac{\sigma_m}{f_s}$ | $\frac{\sigma_h}{f_s}$ | $\sigma_m$ | $\sigma_h$ |
| **Section J-J** | | | | | | | | | | | | | | | | |
| I D+F+1.15P | -240 | -432 | +13 | -14 | -227 | -446 | -53 | 0.250 | LIMIT | 0.500 | 8,760 | 22,640 | 0.292 | 0.755 | -3,000 | -5,900 |
| II D+F+$T_A$ | -430 | -253 | -61 | -66 | -491 | -319 | +8 | 0.273 | fa | 0.075 | 5,920 | 8,510 | 0.197 | 0.284 | -8,400 | -6,500 |
| III D+F+P+$T_A$ | -533 | -522 | -64 | +1 | -597 | -521 | -54 | 0.332 | DOES | 0.508 | 8,700 | 19,000 | 0.290 | 0.633 | -9,150 | -9,240 |
| IV D+F+P+$T_A$+E | -749 | -648 | -39 | +38 | -788 | -610 | -61 | 0.437 | NOT | 0.577 | 14,000 | 29,850 | 0.467 | 0.995 | -11,680 | -9,720 |
| V 1.05+F+1.5P+$T_A$ | -565 | -460 | -32 | +25 | -597 | -435 | -86 | 0.166 | APPLY | 0.492 | 11,300 | 27,900 | 0.209 | 0.516 | -9,260 | -9,200 |
| VI 1.05D+F+1.25P+1.25E+$T_A$ | -825 | -818 | -31 | +37 | -856 | -781 | -79 | 0.238 | HERE | 0.456 | 17,000 | 40,400 | 0.315 | 0.747 | -12,670 | -10,500 |
| VII 1.05D+F+P+E′+$T_A$ | -965 | -773 | -15 | +76 | -980 | -697 | -68 | 0.272 | | 0.393 | 19,300 | 40,700 | 0.357 | 0.754 | -14,210 | -10,200 |
| **Section K-K** | | | | | | | | | | | | | | | | |
| I D+F+1.15P | -559 | -481 | +6 | -12 | -553 | -493 | -78 | 0.307 | | 0.74 | 27,100 | 18,170 | 0.903 | 0.602 | -7,300 | -6,300 |
| II D+F+$T_A$ | -682 | -31 | -56 | -82 | -738 | -113 | -49 | 0.410 | | 0.460 | | | | | -12,770 | -4,650 |
| III D+F+P+$T_A$ | -1,276 | -731 | -112 | +75 | -1,388 | -656 | -80 | 0.770 | | 0.757 | 26,560 | 25,700 | 0.885 | 0.856 | -20,190 | -9,250 |
| IV D+F+P+$T_A$+E | -1,535 | -732 | -105 | +123 | -1,640 | -609 | -102 | 0.910 | | 0.965 | 34,665 | 32,150 | 1.155 | 1.071 | -23,605 | -10,075 |
| V 1.05D+F+1.5P+$T_A$ | -1,568 | -973 | -85 | +106 | -1,653 | -867 | -100 | 0.460 | | 0.578 | 36,590 | 40,300 | 0.678 | 0.746 | -23,960 | -13,000 |
| VI 1.05D+F+1.25P+1.25E+$T_A$ | -1,782 | -853 | -89 | +123 | -1,871 | -730 | -117 | 0.520 | | 0.675 | 42,700 | 40,300 | 0.791 | 0.746 | -26,900 | -11,600 |
| VII 1.05D+F+E′+P+$T_A$ | -1,793 | -732 | -98 | +171 | -1,891 | -561 | -124 | 0.525 | | 0.715 | 42,770 | 38,600 | 0.792 | 0.715 | -27,020 | -10,900 |
| **Section L-L** | | | | | | | | | | | | | | | | |
| I D+F+1.15P | -430 | -418 | +211 | +144 | -219 | -274 | -44 | 0.152 | | 0.414 | 11,800 | 11,600 | 0.393 | 0.387 | -3,300 | -3,600 |
| II D+F+$T_A$ | -49 | -207 | -17 | -37 | -66 | -244 | -12 | 0.136 | | 0.114 | 8,690 | 3,710 | 0.290 | 0.290 | -3,700 | -6,800 |
| III D+F+P+$T_A$ | -192 | -262 | +226 | +146 | +34 | -166 | -46 | 0.065 | | 0.433 | 29,000 | 22,000 | 0.967 | 0.733 | -4,000 | -4,900 |
| IV D+F+P+$T_A$+E | -283 | -295 | +230 | +149 | -53 | -146 | -90 | 0.081 | | 0.85 | 31,350 | 22,750 | 1.045 | 0.758 | -5,550 | -5,450 |
| V 1.05D+F+1.5P+$T_A$ | -219 | -322 | +325 | +225 | +106 | -97 | -63 | 0.029 | | 0.369 | 42,600 | 32,000 | 0.789 | 0.592 | -5,000 | -6,260 |
| VI 1.05D+F+1.25P+1.25E+$T_A$ | -338 | -347 | +298 | +188 | -40 | -159 | -110 | 0.042 | | 0.635 | 38,700 | 29,200 | 0.716 | 0.540 | -6,800 | -6,450 |
| VII 1.05D+F+E′+P+$T_A$ | -347 | -327 | +234 | +151 | -140 | -176 | -134 | 0.049 | | 0.774 | 33,700 | 23,500 | 0.624 | 0.435 | -7,100 | -6,000 |

## Table 5.1-1(5) CONTAINMENT STRUCTURE SUMMARY OF CONCRETE AND REINFORCING STEEL STRESSES

| | | Concrete | | | | | | | | | | Reinforcing Steel | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Computed | | | | | | | Computed vs Allowable | | | Computed | | Computed vs Allowable | | Liner Plate | |
| | Load Case | $\sigma_{em}$ | $\sigma_{eh}$ | $\sigma_{am}$ | $\sigma_{ah}$ | Total $\sigma_m$ | Total $\sigma_h$ | $\tau$ | Total $\sigma / f_{ce}$ | $\sigma_a / f_a$ | $\tau / \nu$ | $\sigma_m$ | $\sigma_h$ | $\sigma_m / f_s$ | $\sigma_h / f_s$ | $\sigma_m$ | $\sigma_h$ |
| Section Mesh #4 | | | | | | | | | | | | | | | | | |
| F-F | E | -66 | +90 | -63 | +23 | -129 | +113 | -3 | 0.043 | 0.042 | n/a | 4,065 | 1,610 | 0.135 | 0.053 | -1,610 | +2,760 |
| G-G | E | -89 | +84 | -42 | +43 | -131 | +127 | -13 | 0.073 | 0.023 | n/a | 1,005 | 5,275 | 0.035 | 0.176 | -2,242 | +1,225 |
| H-H | E | -75 | +155 | -20 | +59 | -95 | +214 | -74 | 0.013 | n/a | n/a | 4,050 | 9,900 | 0.135 | 0.330 | -850 | +2,040 |
| J-J | E | -246 | +109 | +19 | +30 | -227 | +139 | -7 | 0.125 | n/a | n/a | 9,100 | 8,650 | 0.303 | 0.289 | -3,020 | +1,285 |
| K-K | E | -175 | -61 | +6 | +13 | -169 | -48 | -48 | 0.092 | n/a | n/a | 4,225 | 2,960 | 0.141 | 0.099 | -2,355 | -845 |
| L-L | E | -44 | -32 | +4 | +2 | -40 | -30 | -30 | 0.022 | n/a | n/a | 2,100 | 650 | 0.070 | 0.022 | -935 | -480 |
| Mesh #3 | | | | | | | | | | | | | | | | | |
| J-J | E | -216 | -126 | +25 | +37 | -191 | -89 | -7 | 0.106 | n/a | n/a | 5,300 | 10,850 | 0.177 | 0.362 | -2,530 | -500 |
| K-K | E | -259 | -1 | +7 | +48 | -252 | +47 | -22 | 0.140 | n/a | n/a | 8,105 | 6,450 | 0.270 | 0.215 | -3,415 | -825 |
| L-L | E | -91 | -33 | +4 | +3 | -87 | -30 | -44 | 0.048 | n/a | n/a | 2,350 | 750 | 0.078 | 0.003 | -1,550 | -550 |

Table 5.1-2 TABLE OF LOADING CONDITIONS

| | |
|---|---|
| Figure 5.1-11 Sheet 1 | D + F initial - Mesh #3 |
| Figure 5.1-11 Sheet 2 | D + F + $T_{A\ eq}$ - Mesh #3 |
| Figure 5.1-11 Sheet 3 | D + F + $T_A$ + 1.5P - Mesh #3 |
| Figure 5.1-11 Sheet 4 | D + F + 1.15P - Mesh #3 |
| Figure 5.1-11 Sheet 5 | D + F initial - Mesh #4 |
| Figure 5.1-11 Sheet 6 | D + F + $T_A$ - Mesh #4 |
| Figure 5.1-11 Sheet 7 | D + F + 1.5P + $T_A$ - Mesh #4 |
| Figure 5.1-11 Sheet 8 | D + F + 1.15P - Mesh #4 |

Figure 5.1-1 CONTAINMENT STRUCTURE - GENERAL ARRANGEMENT
Sheet 1

[redacted]

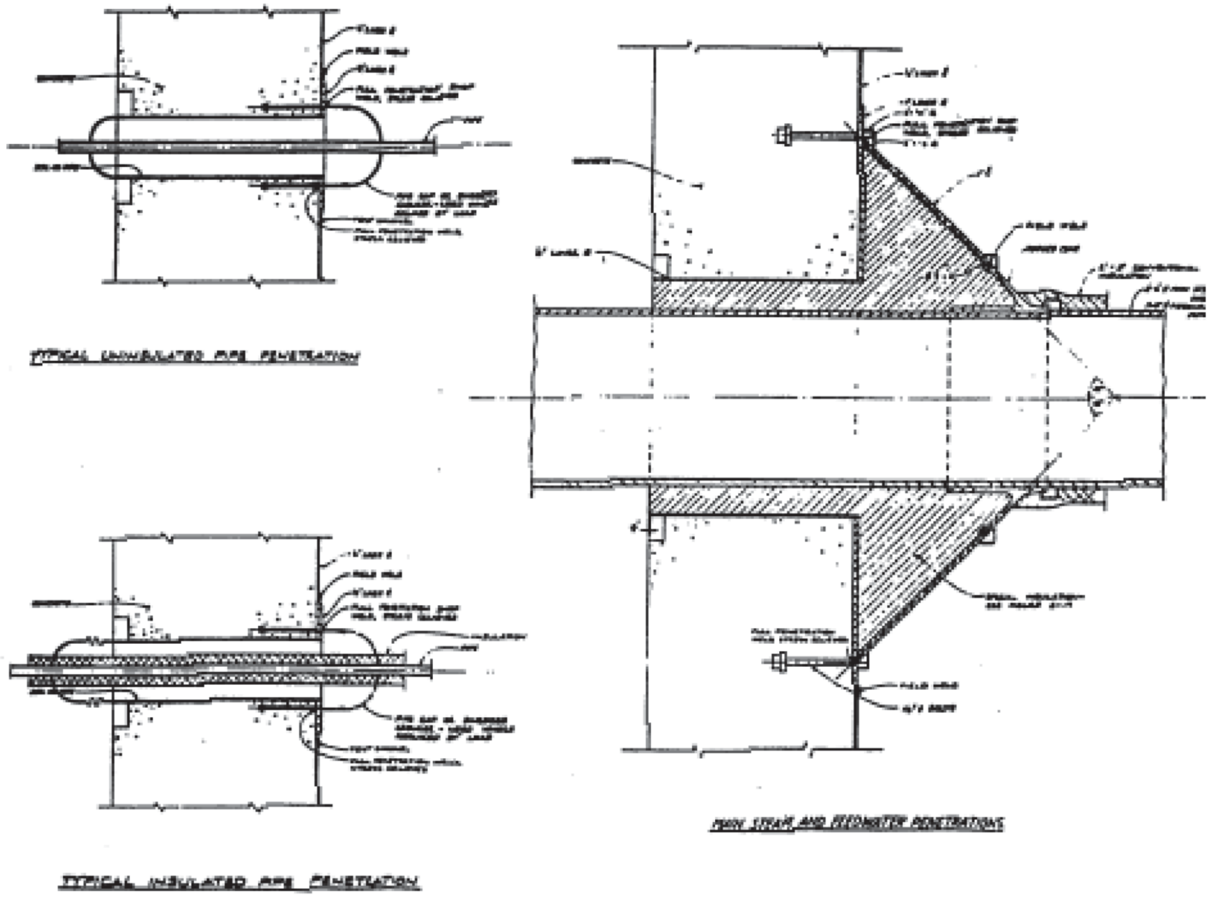
Figure 5.1-1 CONTAINMENT STRUCTURE - GENERAL ARRANGEMENT
Sheet 2

[redacted]

Figure 5.1-1 CONTAINMENT STRUCTURE - GENERAL ARRANGEMENT
Sheet 3

[redacted]

Figure 5.1-2 CONTAINMENT STRUCTURE - TYPICAL PIPING PENETRATIONS




CONTAINMENT STRUCTURE - TYPI

Figure 5.1-3 CONTAINMENT STRUCTURE - TYPICAL ELECTRICAL PENETRATIONS

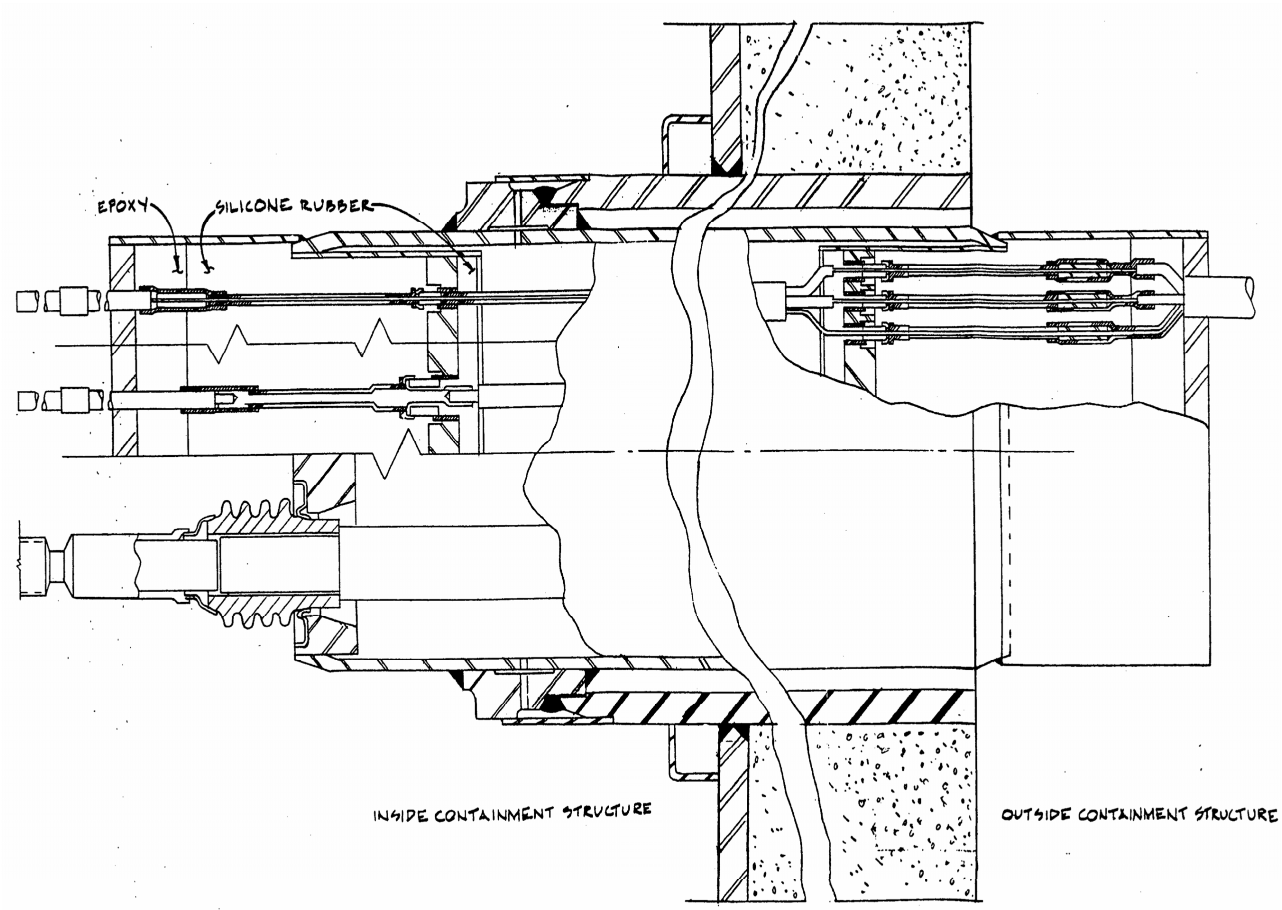


Figure 5.1-4 CONTAINMENT STRUCTURE - PERSONNEL LOCK

[redacted]

Figure 5.1-5 CONTAINMENT STRUCTURE - EQUIPMENT HATCH

[redacted]

Figure 5.1-6 DESIGN THERMAL GRADIENT ACROSS CONTAINMENT WALL
POINT BEACH NUCLEAR PLANT

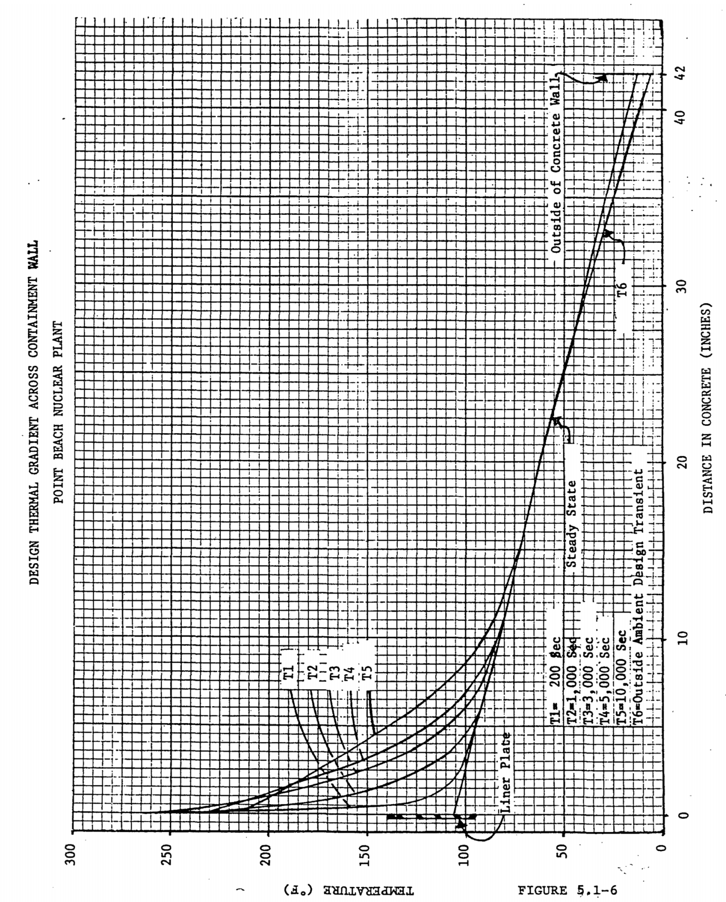


Figure 5.1-7 EARTHQUAKE RESPONSE SPECTRUM - 0.06g

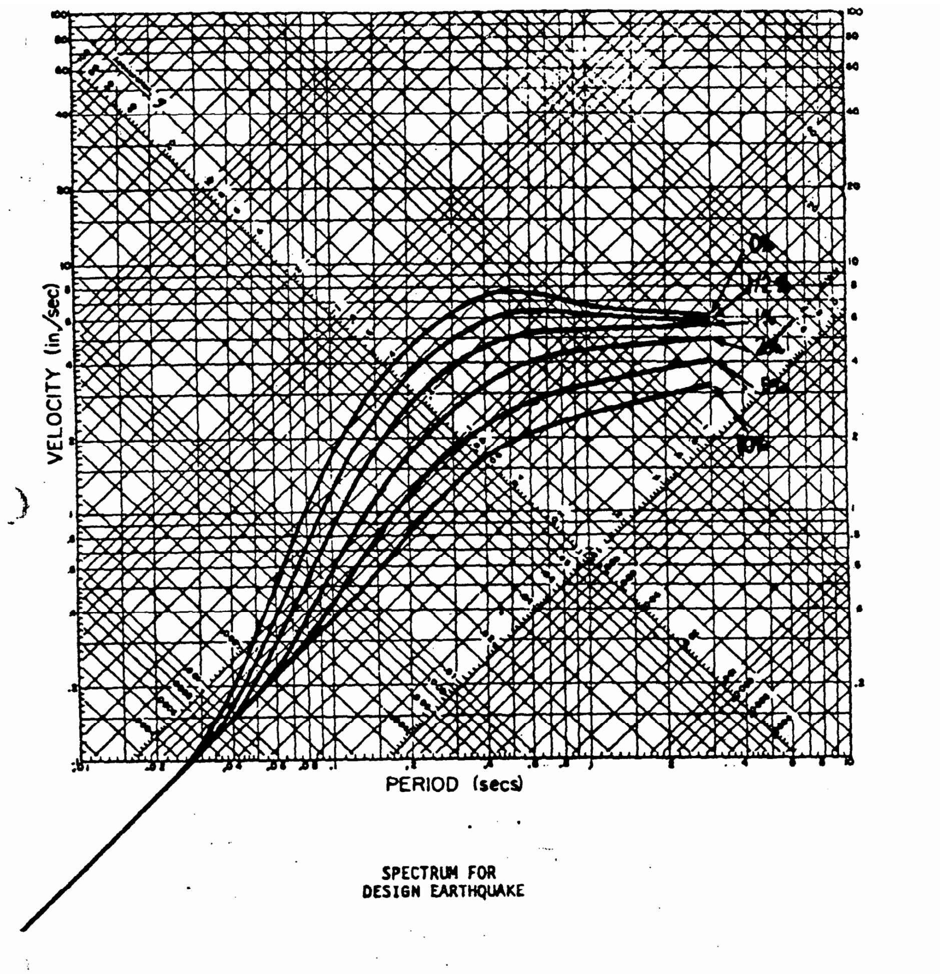


Figure 5.1-8 EARTHQUAKE RESPONSE SPECTRUM - 0.12g

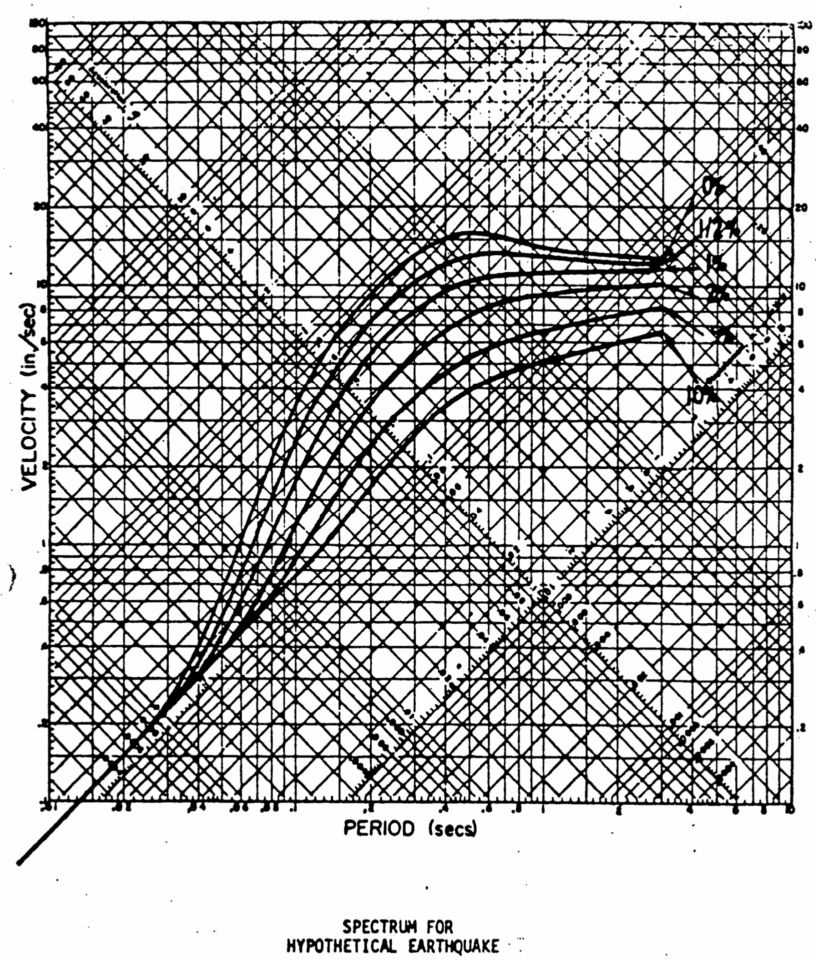
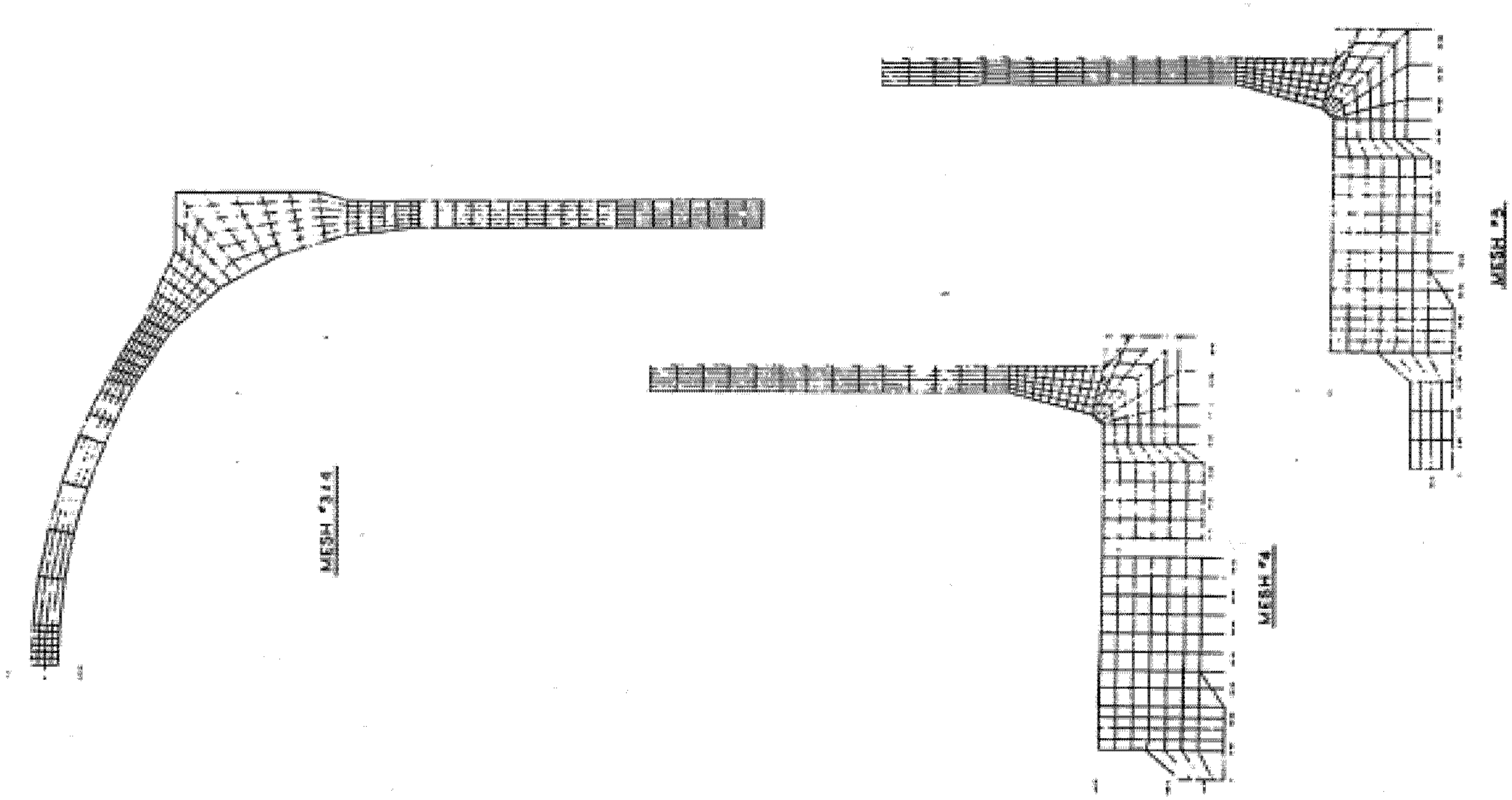
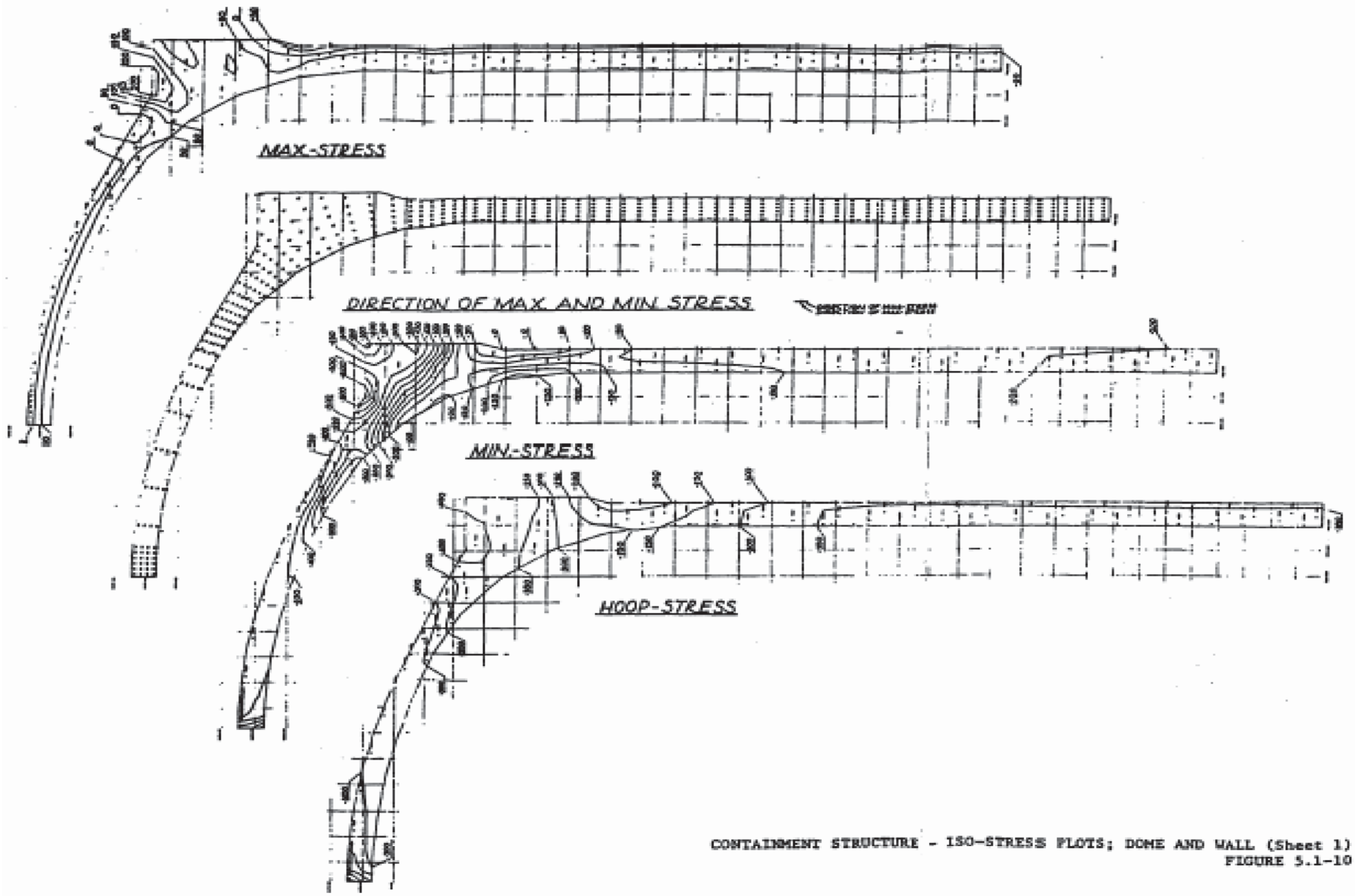


Figure 5.1-9 CONTAINMENT STRUCTURE - FINITE ELEMENT MESH



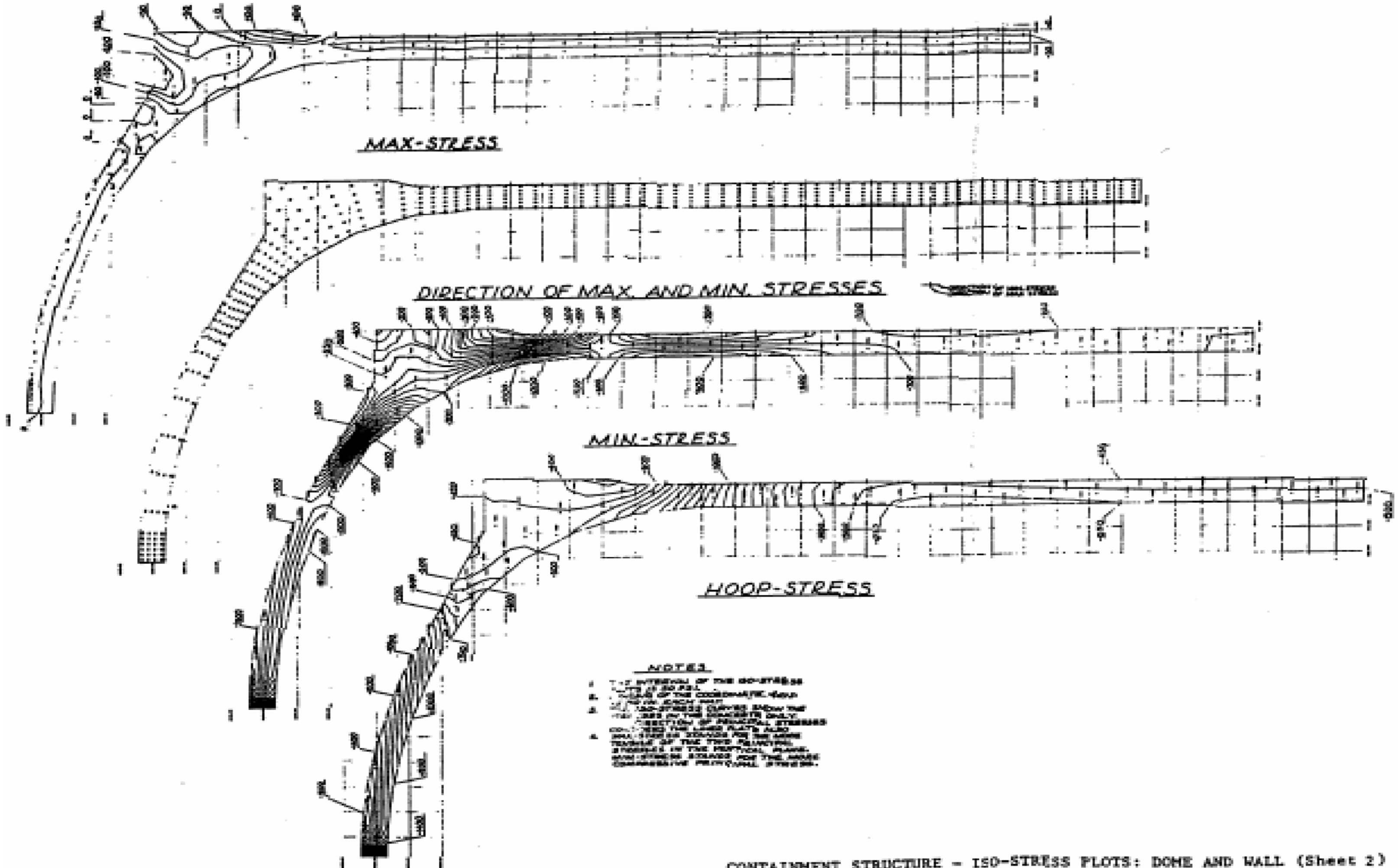

CONTAINMENT STRUCTURE - FINITE ELEMENT MESH
FIGURE 5.1-9

Figure 5.1-10 CONTAINMENT STRUCTURE - ISO-STRESS PLOTS: DOME AND WALL
Sheet 1



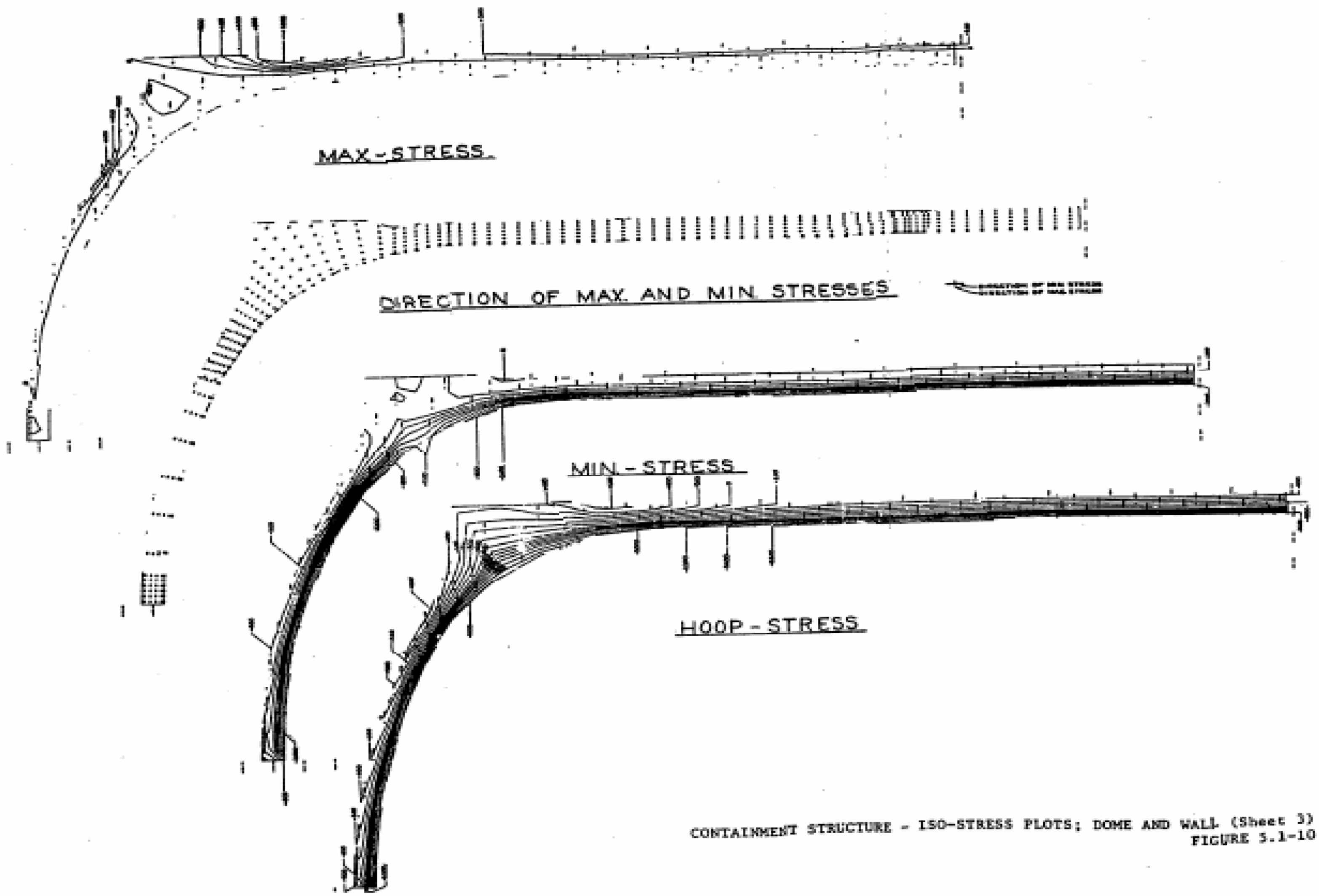

CONTAINMENT STRUCTURE - ISO-STRESS PLOTS; DOME AND WALL (Sheet 1)
FIGURE 5.1-10

Figure 5.1-10 CONTAINMENT STRUCTURE - ISO-STRESS PLOTS: DOME AND WALL
Sheet 2



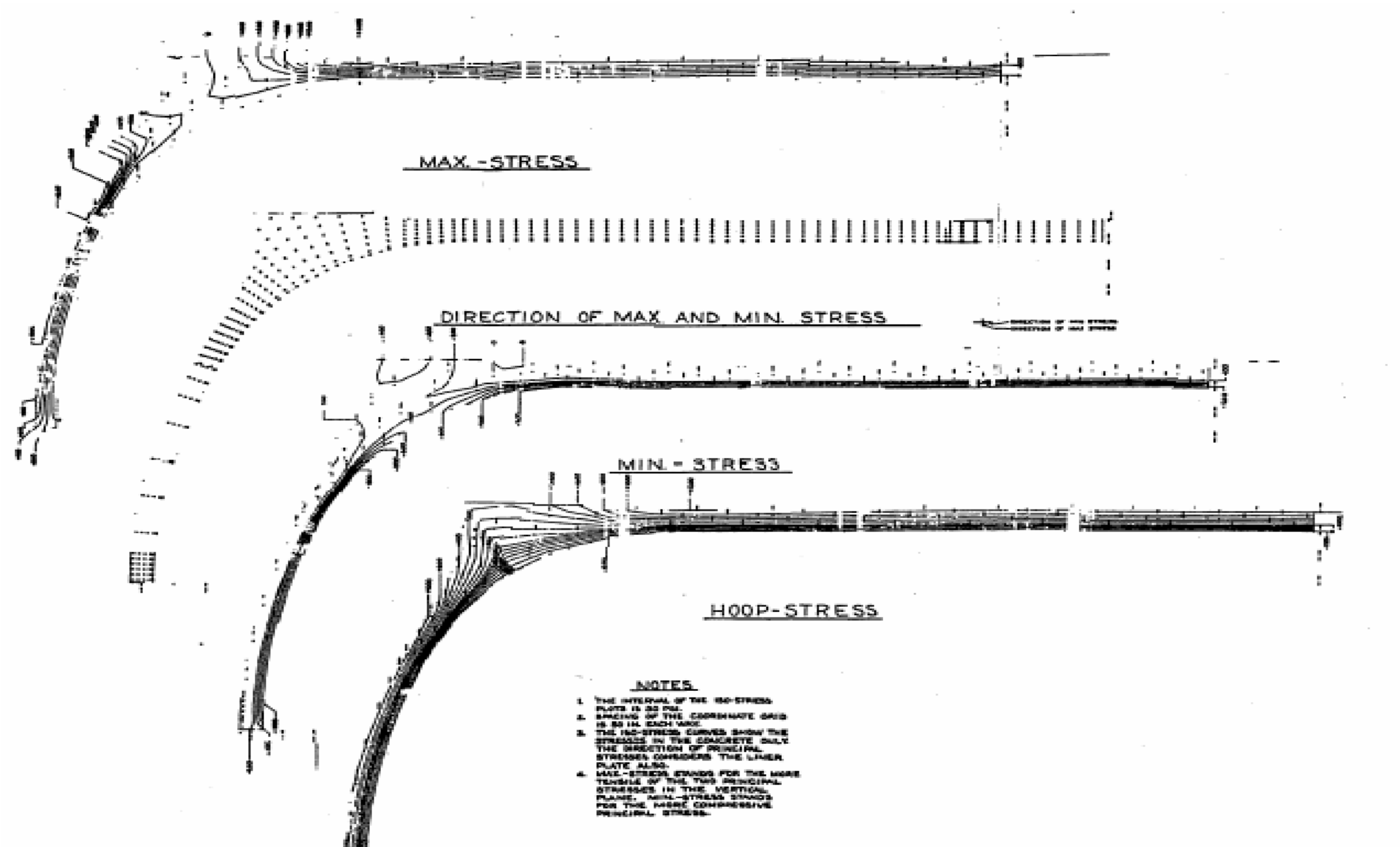

CONTAINMENT STRUCTURE - ISO-STRESS PLOTS: DOME AND WALL (Sheet 2)
FIGURE 5.1-10

Figure 5.1-10 CONTAINMENT STRUCTURE - ISO-STRESS PLOTS: DOME AND WALL
Sheet 3




CONTAINMENT STRUCTURE - ISO-STRESS PLOTS; DOME AND WALL (Sheet 3)
FIGURE 5.1-10

Figure 5.1-10 CONTAINMENT STRUCTURE - ISO-STRESS PLOTS: DOME AND WALL
Sheet 4



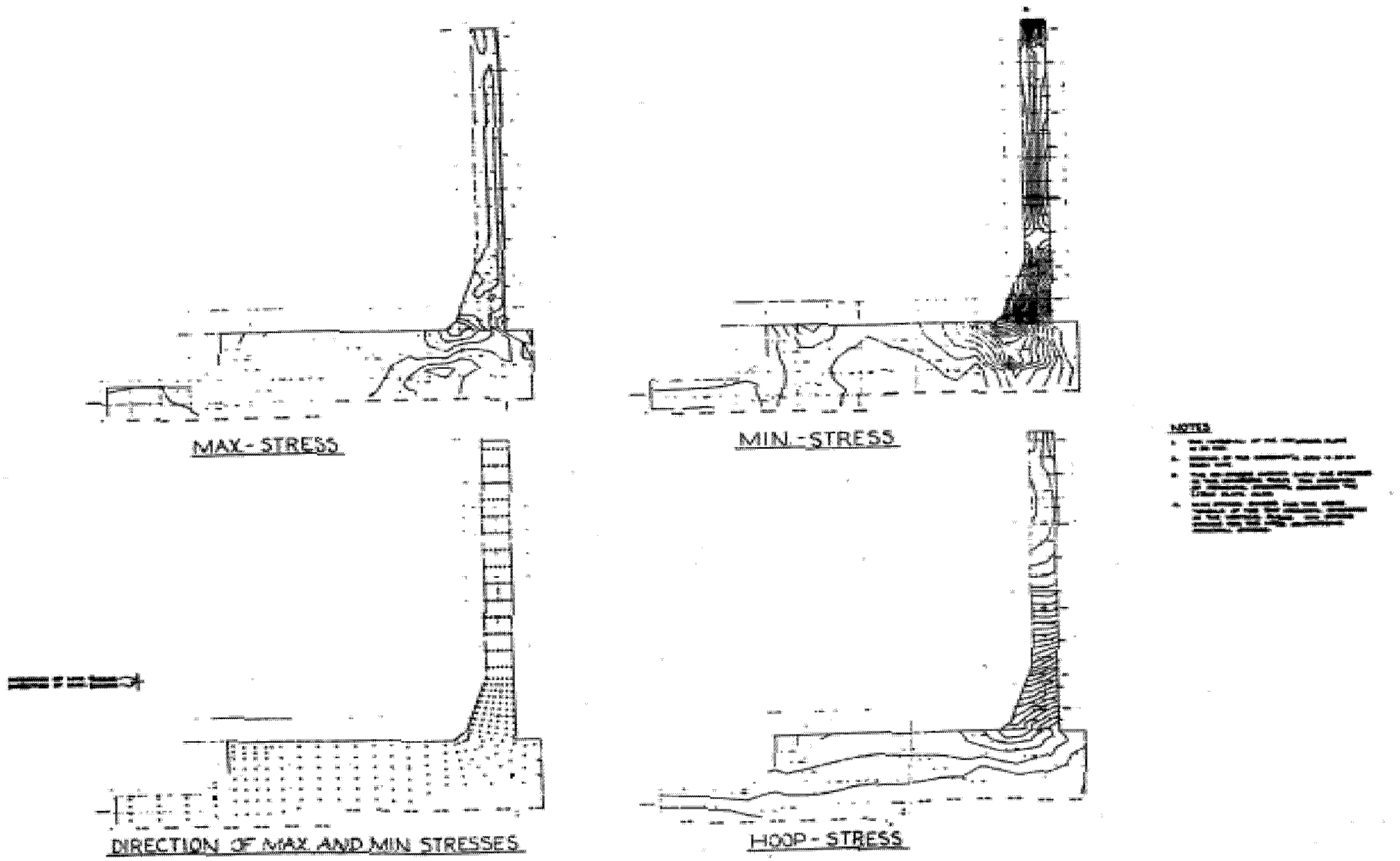

CONTAINMENT STRUCTURE - ISO-STRESS PLOTS; DOME AND WALL (Sheet 4)
FIGURE 5.1-10

Figure 5.1-10 CONTAINMENT STRUCTURE - ISO-STRESS PLOTS: DOME AND WALL
Sheet 5

Table Of Loading Conditions

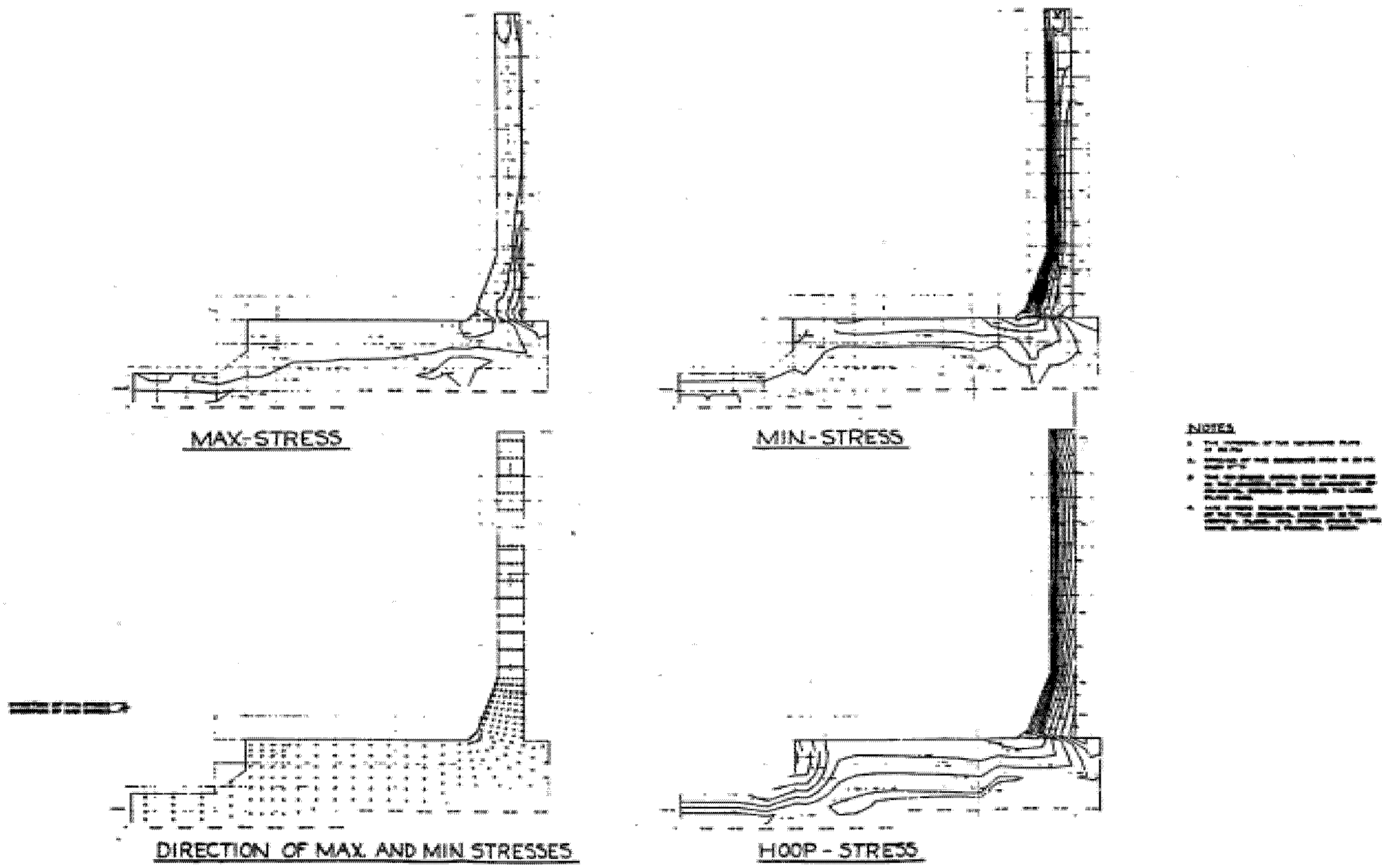
| Figure | Loading |
|---|---|
| Figure 5.1-10 Sheet 1 | D + F + 1.15P |
| Figure 5.1-10 Sheet 2 | D + F initial |
| Figure 5.1-10 Sheet 3 | D + F+ $T_A$ |
| Figure 5.1-10 Sheet 4 | D + F + $T_A$ + 1.5P |

Figure 5.1-11 CONTAINMENT STRUCTURE - ISO-STRESS PLOTS: BASE AND WALL
Sheet 1



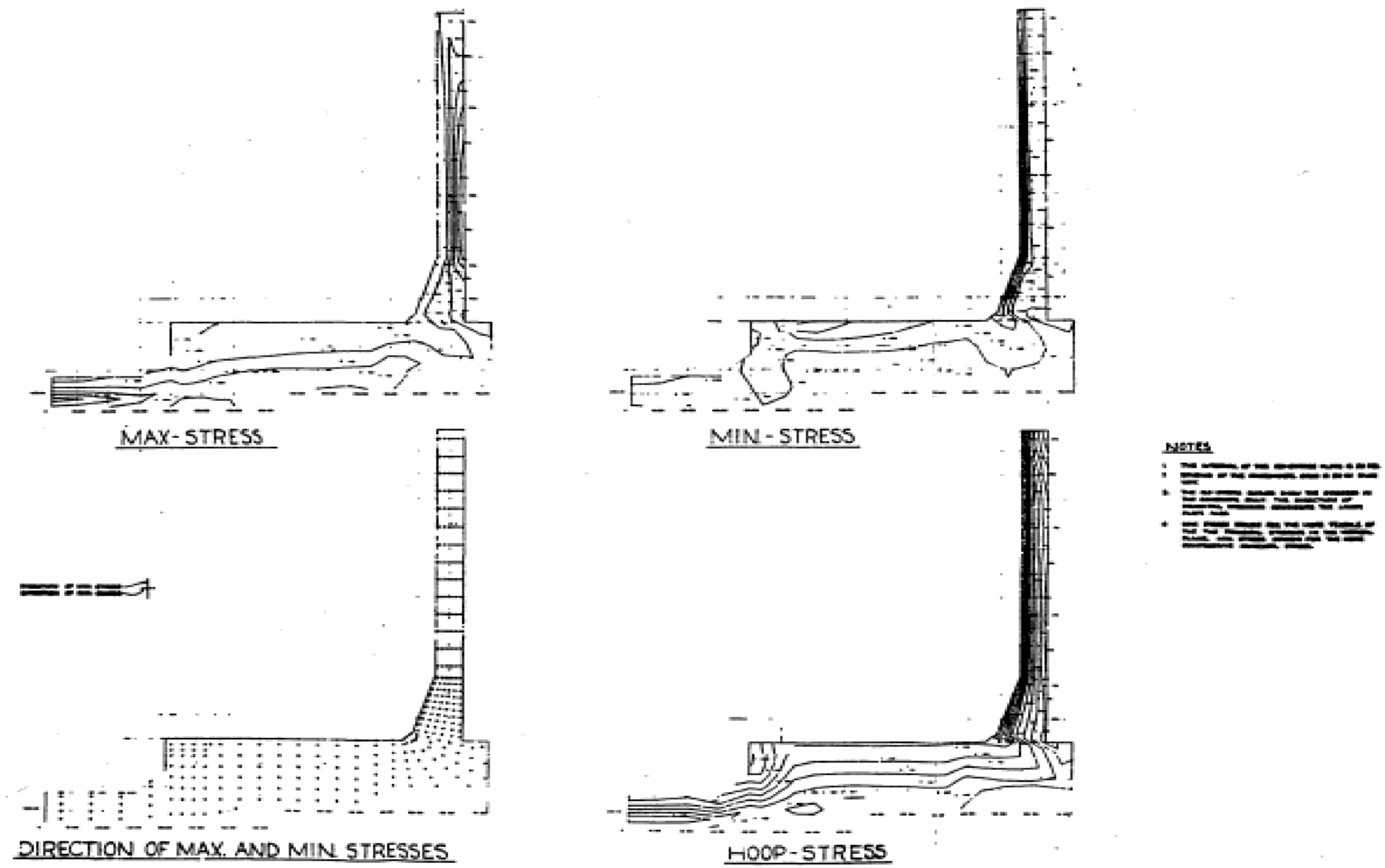

CONTAINMENT STRUCTURE - ISO-STRESS PLOTS; BASE AND WALL (Sheet 1)
FIGURE 5.1-11

Figure 5.1-11 CONTAINMENT STRUCTURE - ISO-STRESS PLOTS: BASE AND WALL
Sheet 2



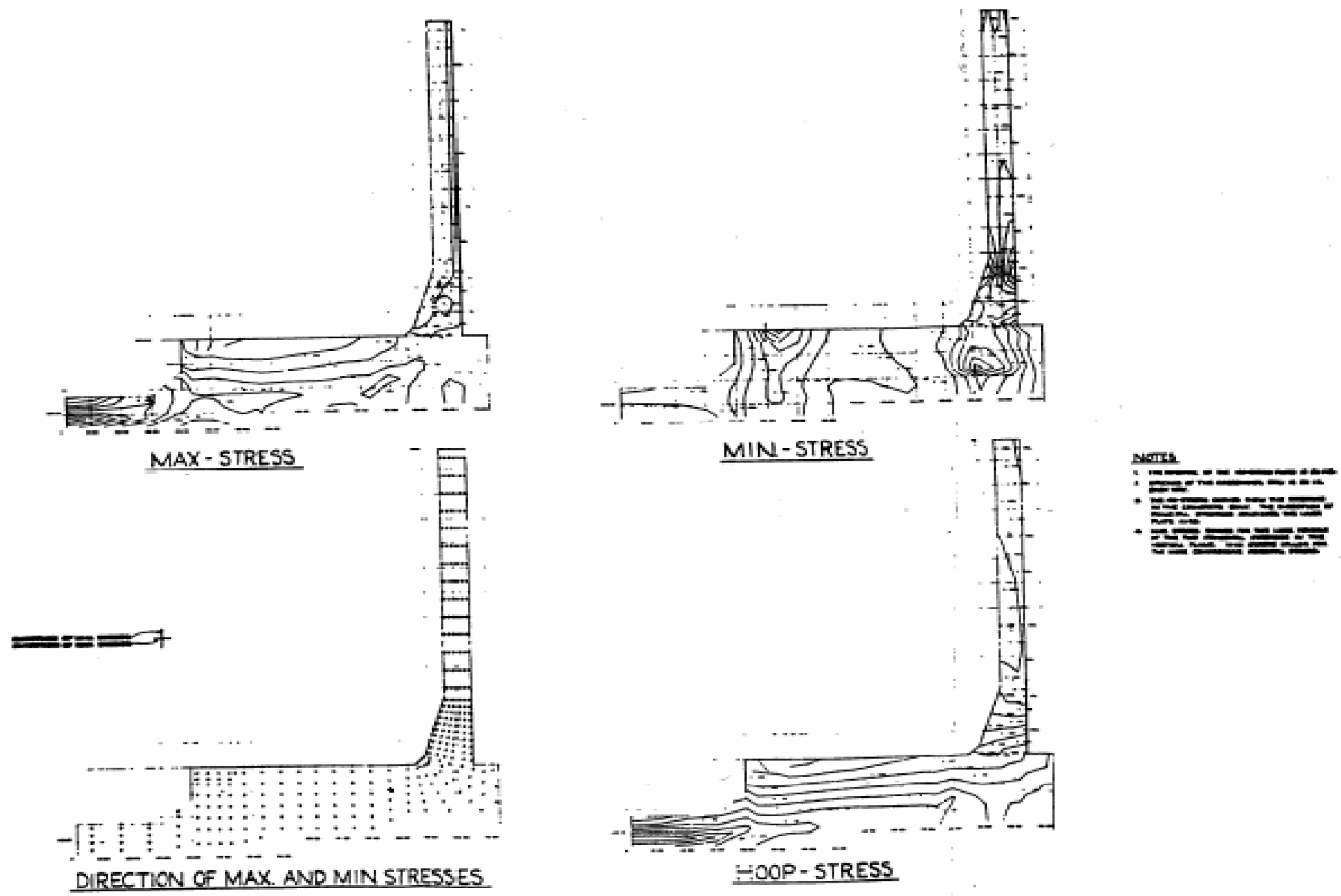

CONTAINMENT STRUCTURE - ISO-STRESS PLOTS; BASE AND WALL (Sheet 2)
FIGURE 5.1-11

Figure 5.1-11 CONTAINMENT STRUCTURE - ISO-STRESS PLOTS: BASE AND WALL
Sheet 3



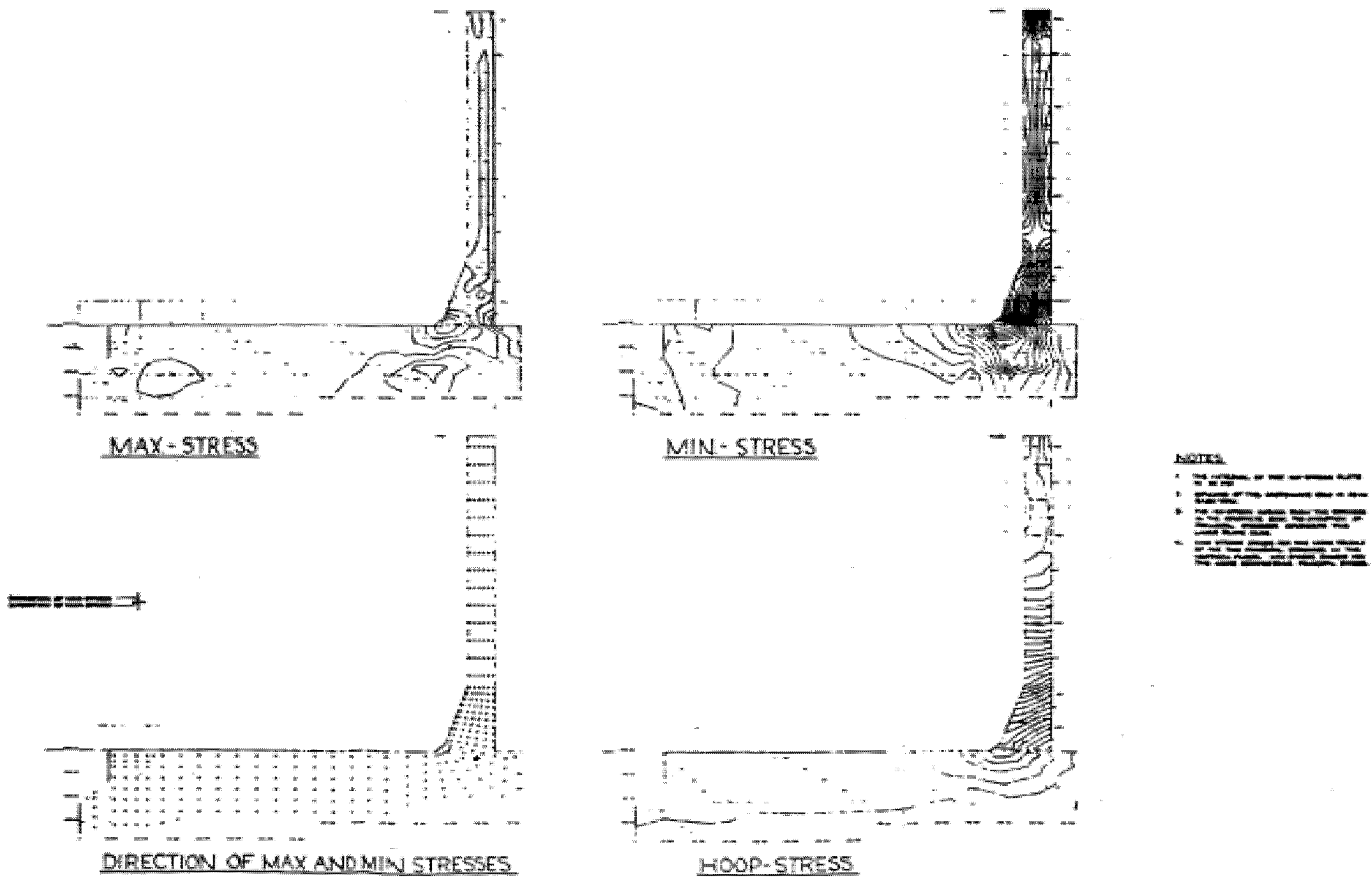

CONTAINMENT STRUCTURE - ISO-STRESS PLOTS; BASE AND WALL (Sheet 3)
FIGURE 5.1-11

Figure 5.1-11 CONTAINMENT STRUCTURE - ISO-STRESS PLOTS: BASE AND WALL
Sheet 4



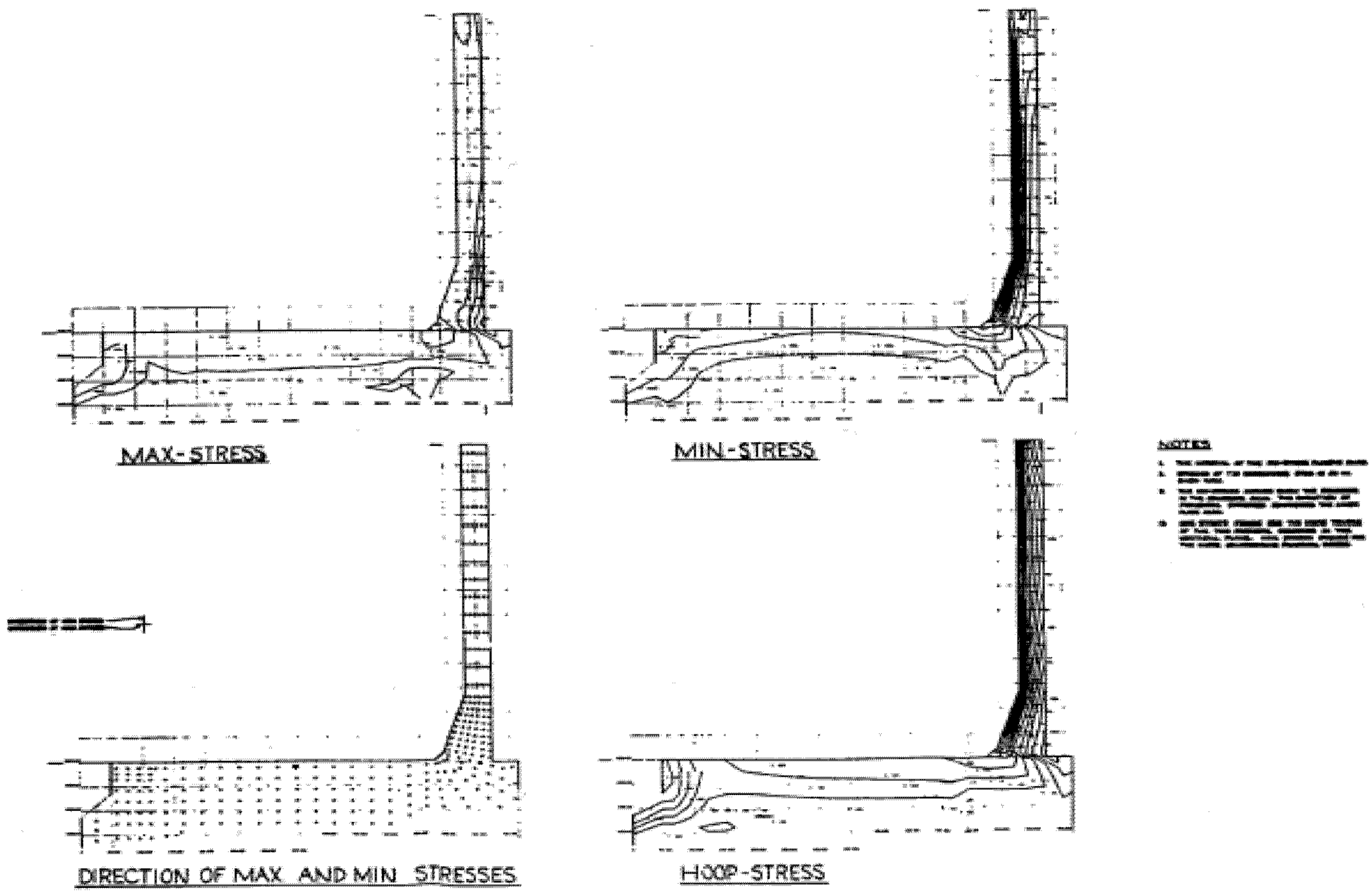

CONTAINMENT STRUCTURE - ISO-STRESS PLOTS; BASE AND WALL (Sheet 4)
FIGURE 5.1-11

Figure 5.1-11 CONTAINMENT STRUCTURE - ISO-STRESS PLOTS: BASE AND WALL
Sheet 5



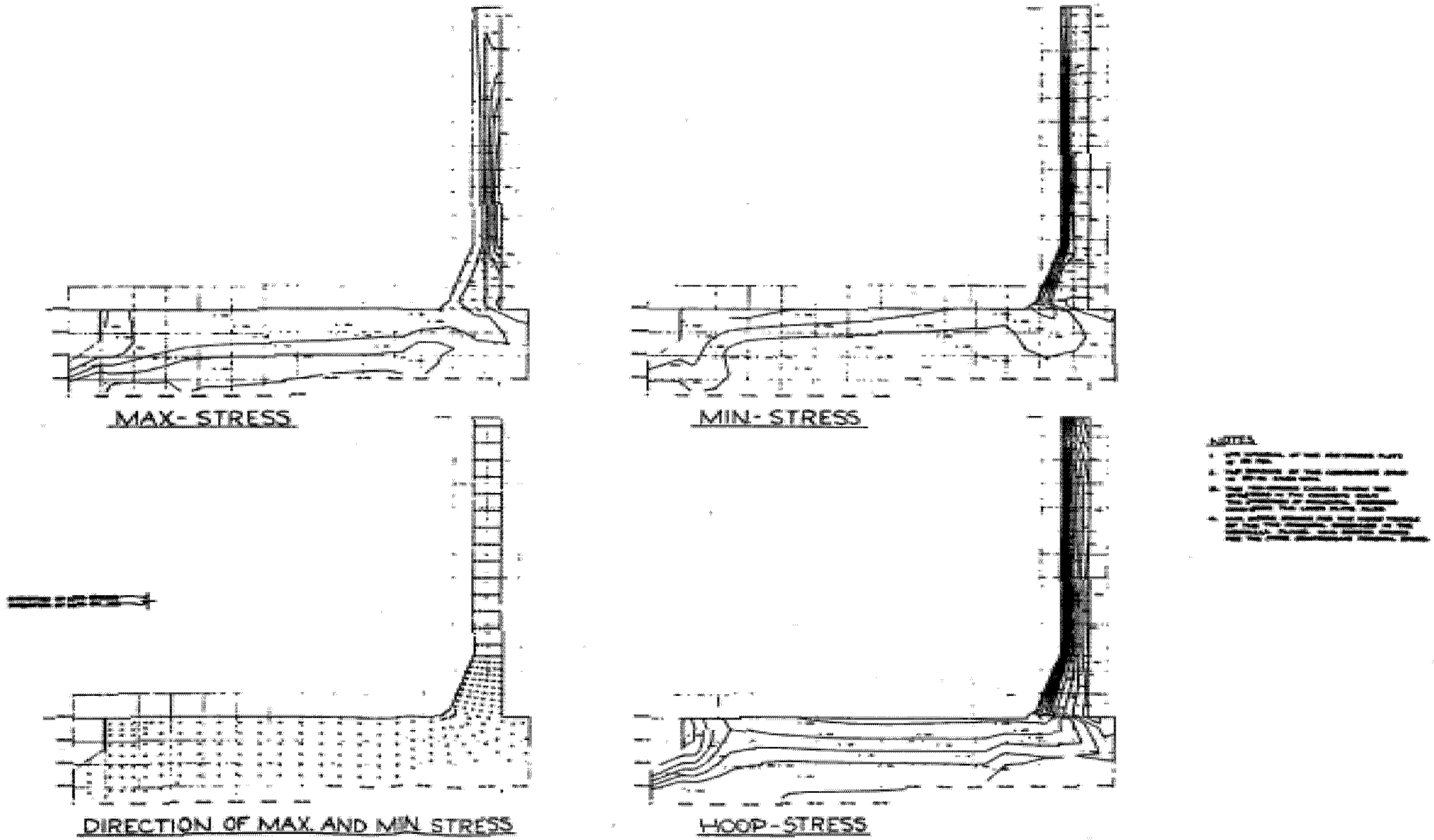

CONTAINMENT STRUCTURE - ISO-STRESS PLOTS; BASE AND WALL (Sheet 5)
FIGURE 5.1-11

Figure 5.1-11 CONTAINMENT STRUCTURE - ISO-STRESS PLOTS: BASE AND WALL
Sheet 6




CONTAINMENT STRUCTURE - ISO-STRESS PLOTS; BASE AND WALL (Sheet 6)
FIGURE 5.1-11

Figure 5.1-11 CONTAINMENT STRUCTURE - ISO-STRESS PLOTS: BASE AND WALL
Sheet 7




CONTAINMENT STRUCTURE - ISO-STRESS PLOTS; BASE AND WALL (Sheet 7)
FIGURE 5.1-11

Figure 5.1-11 CONTAINMENT STRUCTURE - ISO-STRESS PLOTS: BASE AND WALL
Sheet 8

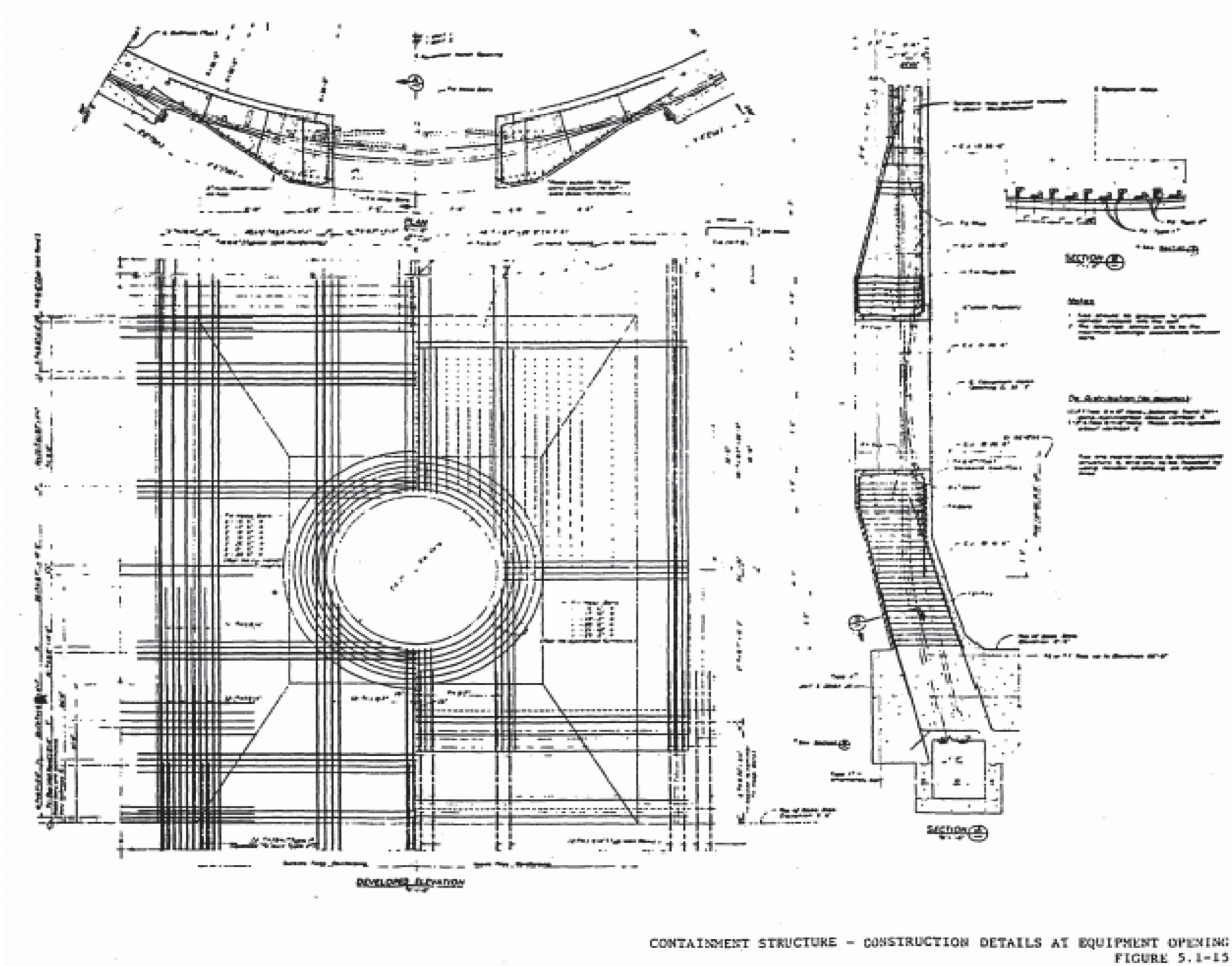


Figure 5.1-12 CONTAINMENT STRUCTURE - FINITE ELEMENT MESH FOR BUTTRESS

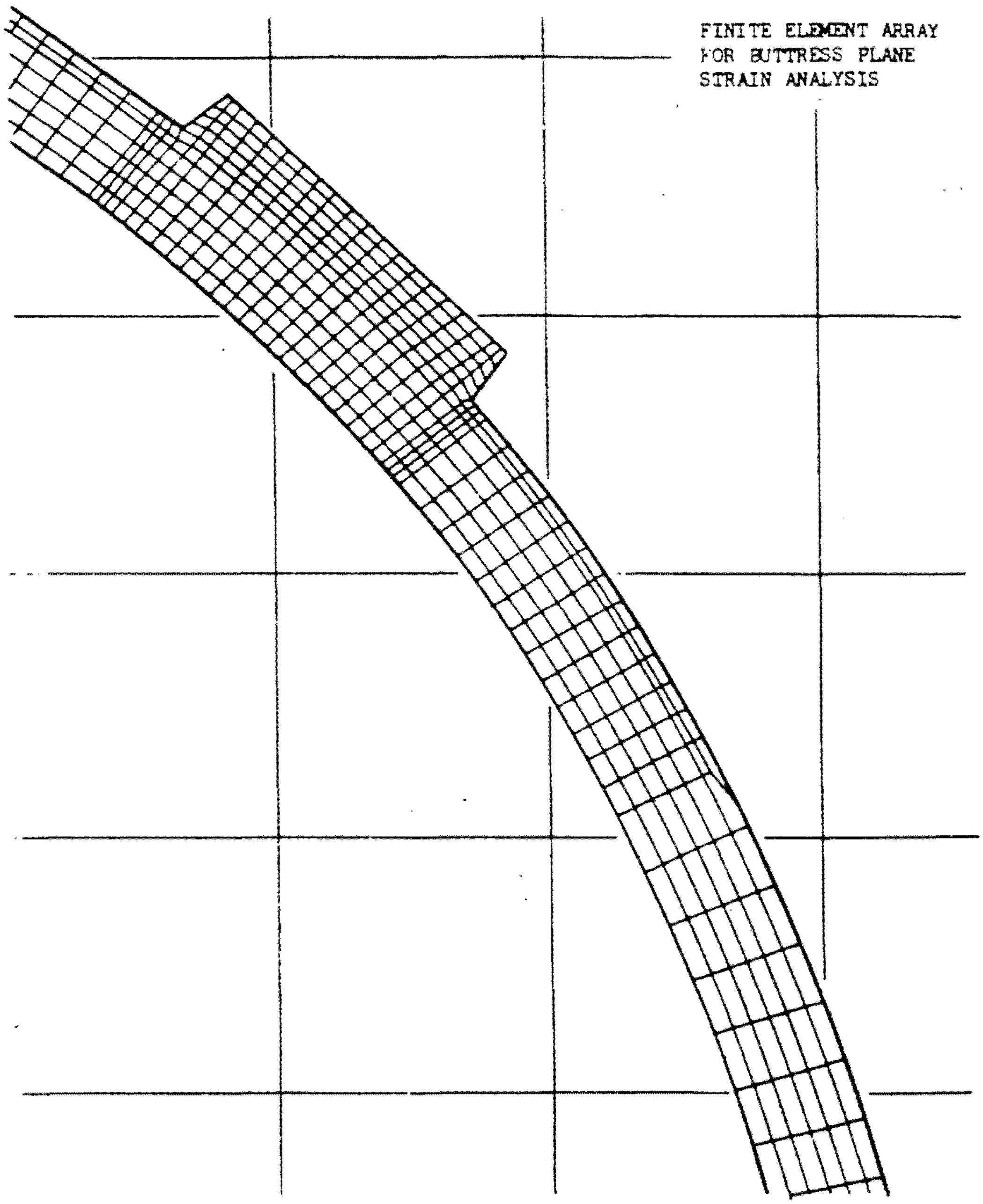



FIGURE 5.1-12
CONTAINMENT STRUCTURE -
FINITE ELEMENT MESH FOR
BUTTRESS

Figure 5.1-13 ISO-STRESS PLOTS - CONTAINMENT STRUCTURE BUTTRESS
Sheet 1

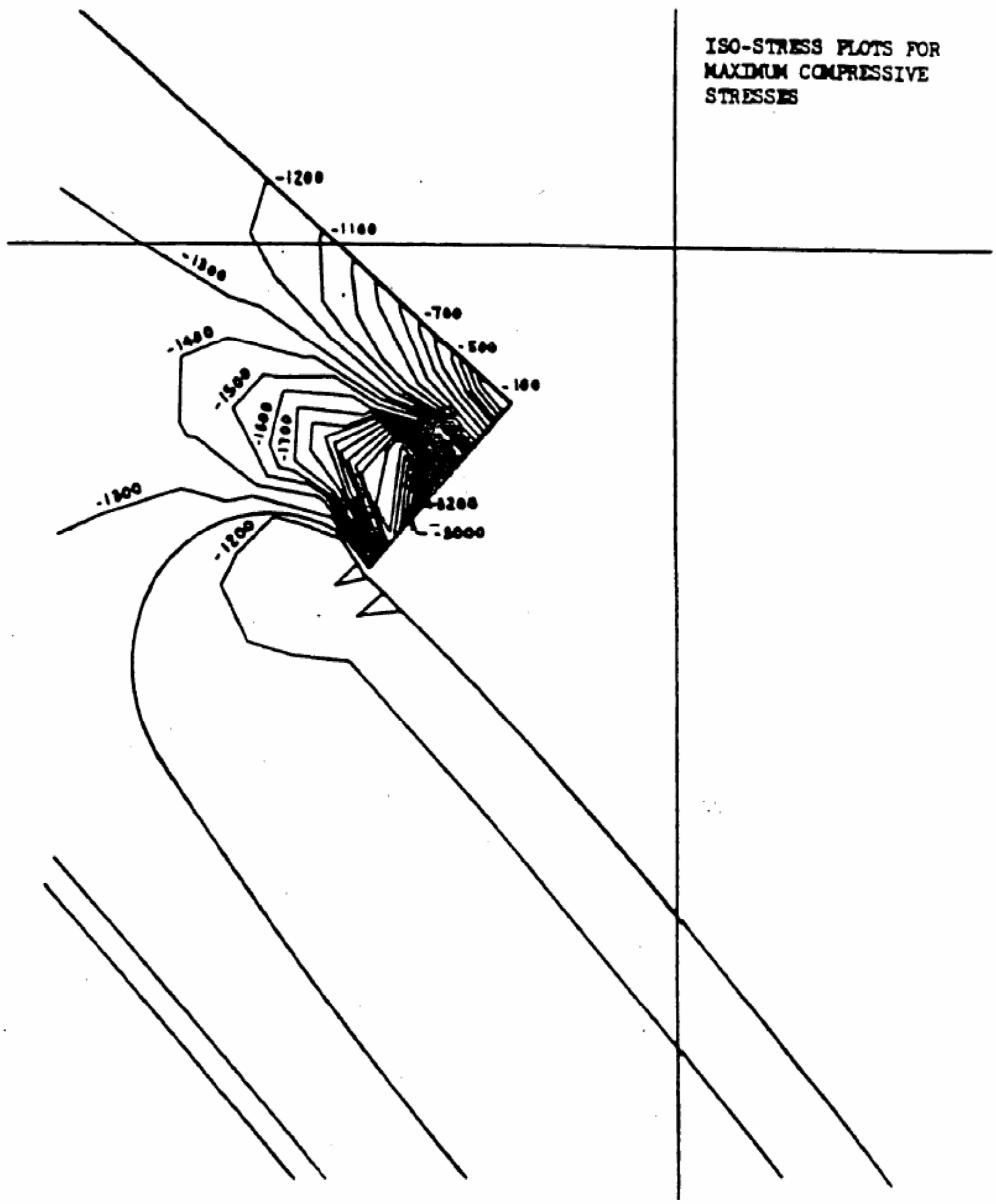



FIGURE 5.1-13 SHEET 1
ISO-STRESS PLOTS -
CONTAINMENT STRUCTURE
BUTTRESS

Figure 5.1-13 ISO-STRESS PLOTS - CONTAINMENT STRUCTURE BUTTRESS
Sheet 2

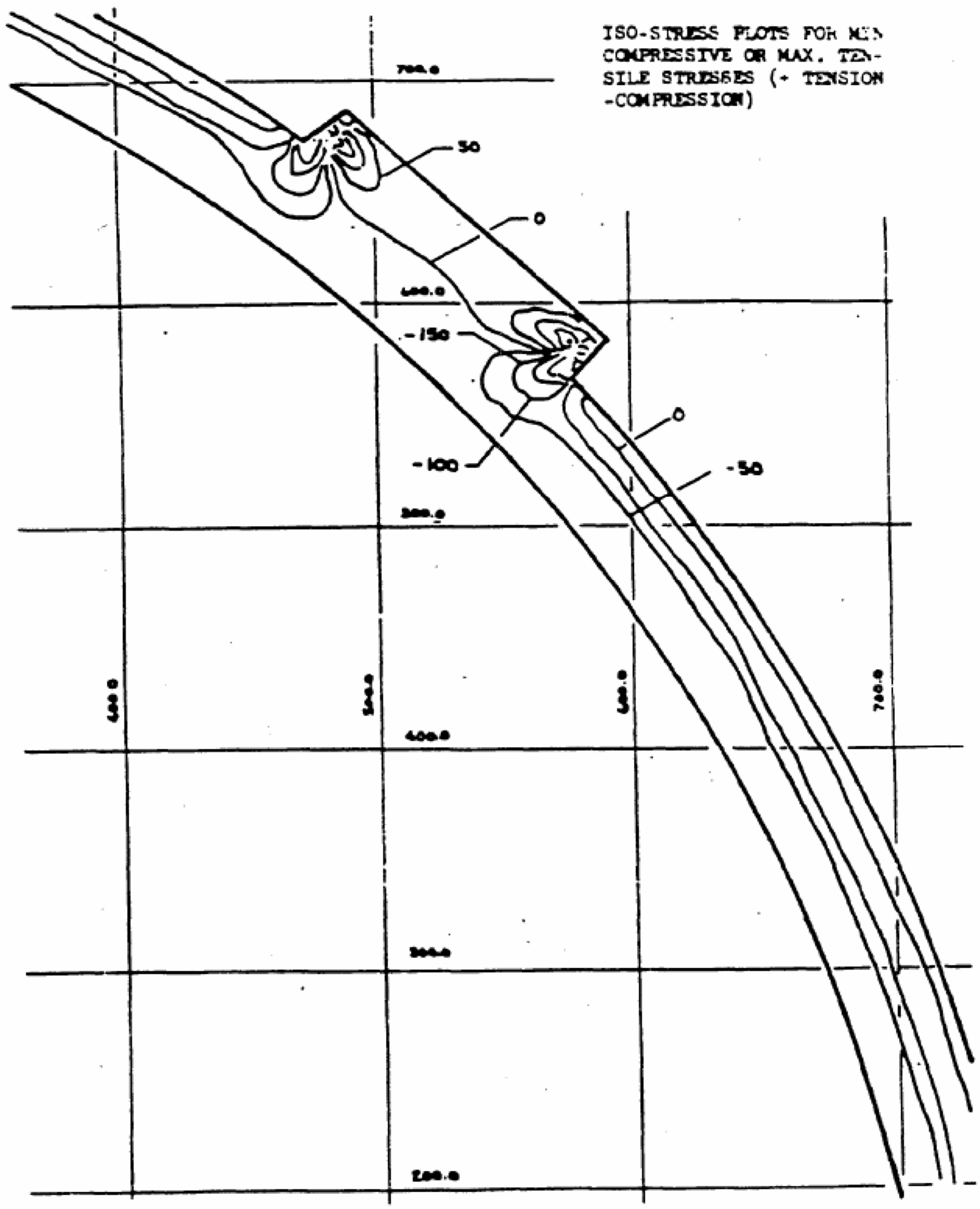



FIGURE 5.1-13 SHEET 2
ISO-STRESS PLOTS -
CONTAINMENT STRUCTURE
BUTTRESS

Figure 5.1-14 CONTAINMENT STRUCTURE - EARTHQUAKE RESPONSE DATA

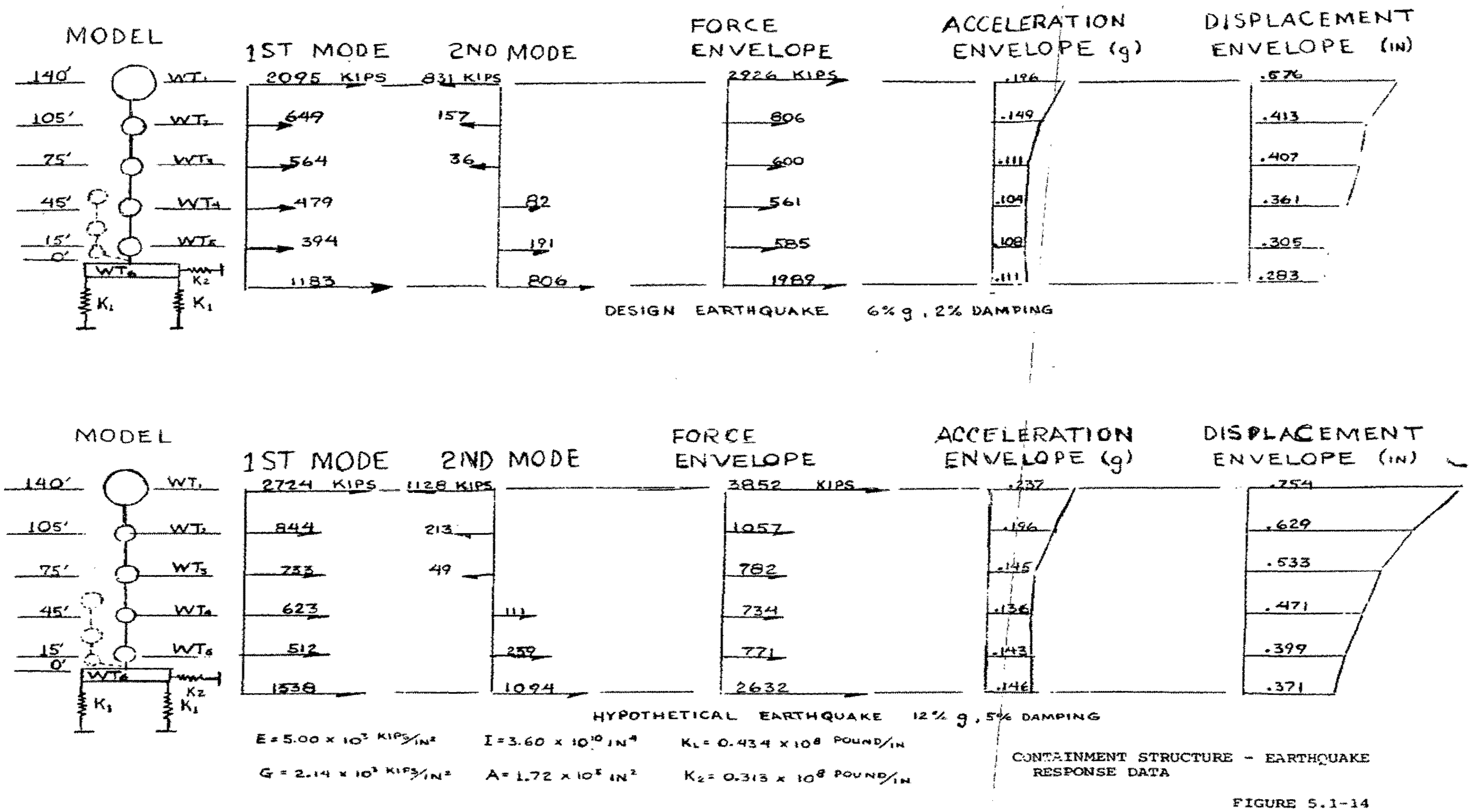


Figure 5.1-15 CONTAINMENT STRUCTURE - CONSTRUCTION DETAILS AT EQUIPMENT OPENING

[redacted]

Figure 5.1-16 CONTAINMENT STRUCTURE - PENETRATION LOADS

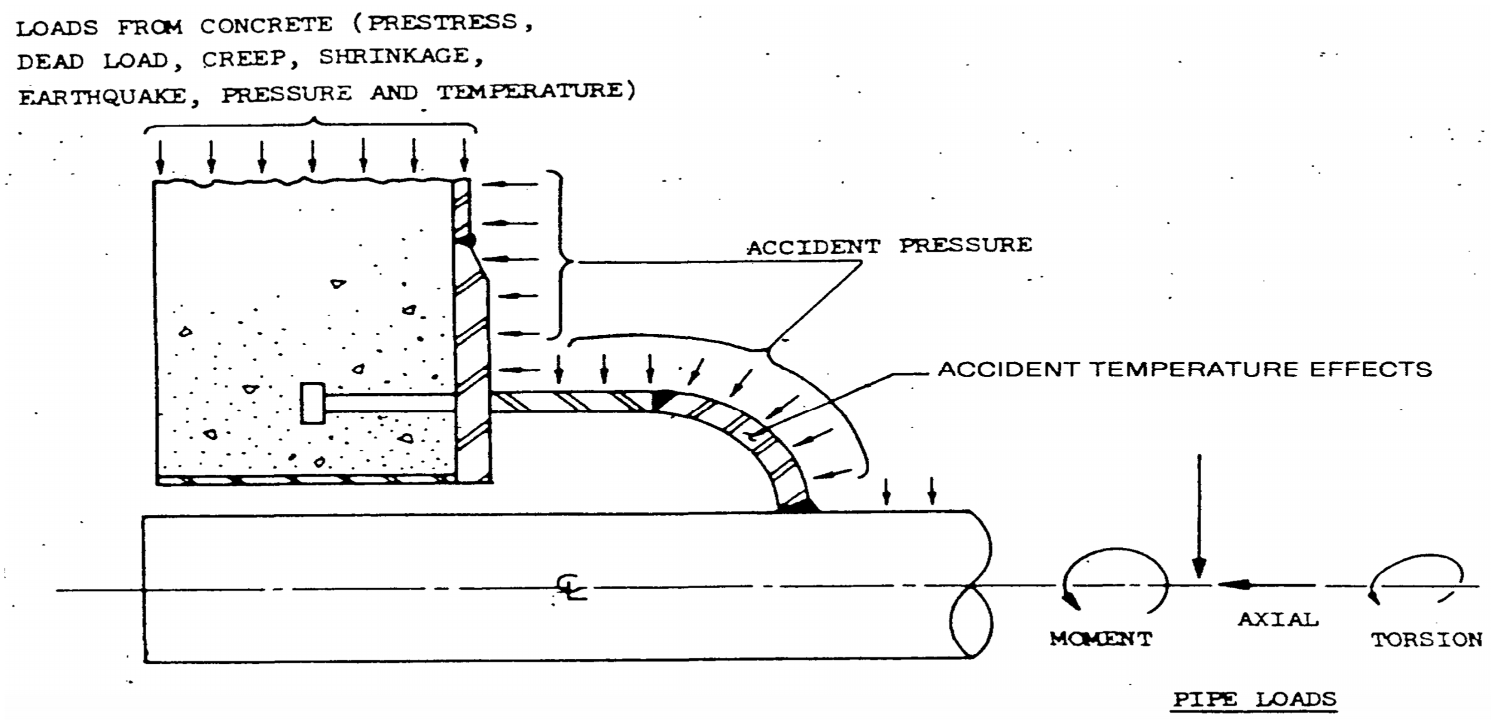
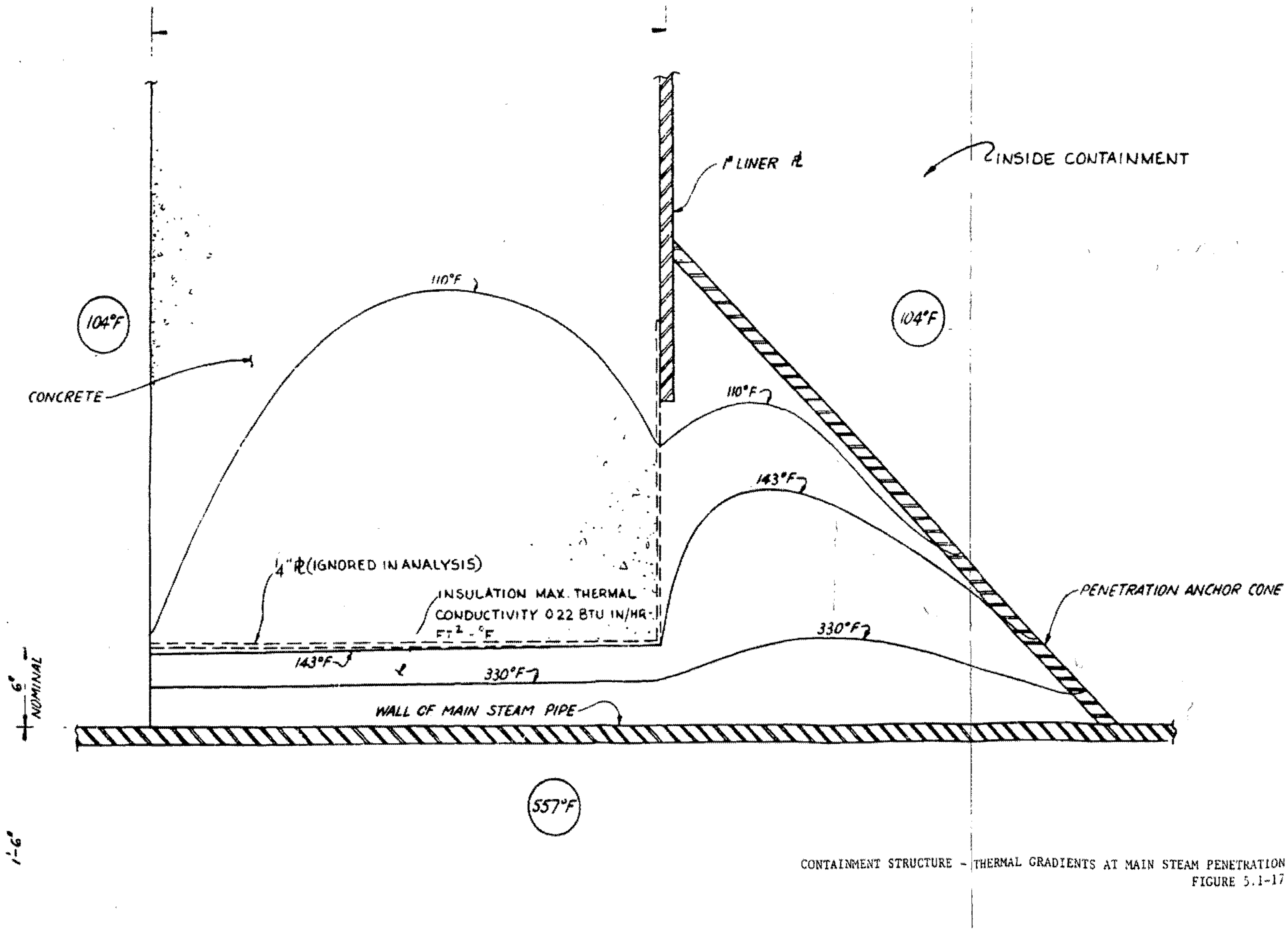
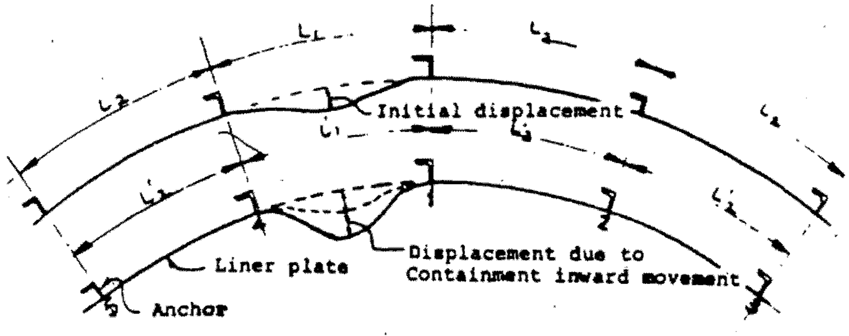


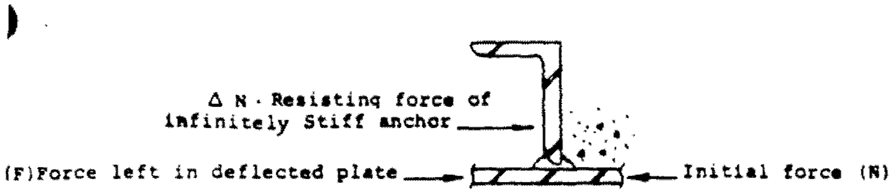
Figure 5.1-17 CONTAINMENT STRUCTURE - THERMAL GRADIENTS AT MAIN STEAM PENETRATION




CONTAINMENT STRUCTURE - THERMAL GRADIENTS AT MAIN STEAM PENETRATION
FIGURE 5.1-17

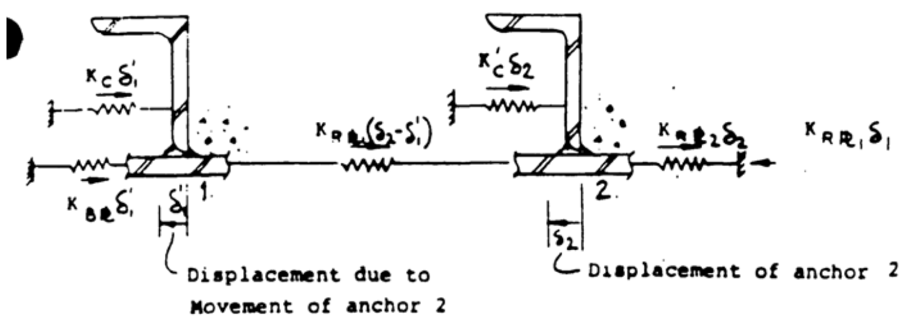
Figure 5.1-18 CONTAINMENT STRUCTURE - MODEL FOR LINER PLATE ANALYSIS
Sheet 1 of 2

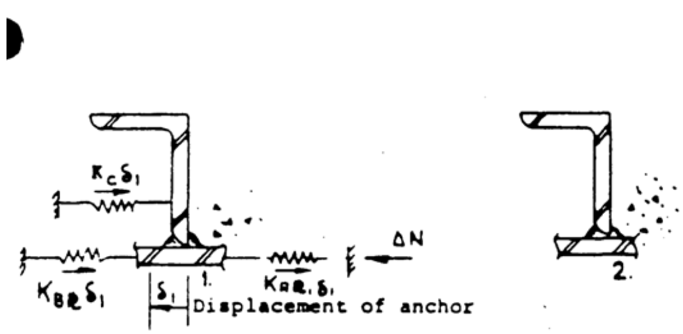



CONTAINMENT STRUCTURE
MODEL FOR LINER
PLATE ANALYSIS

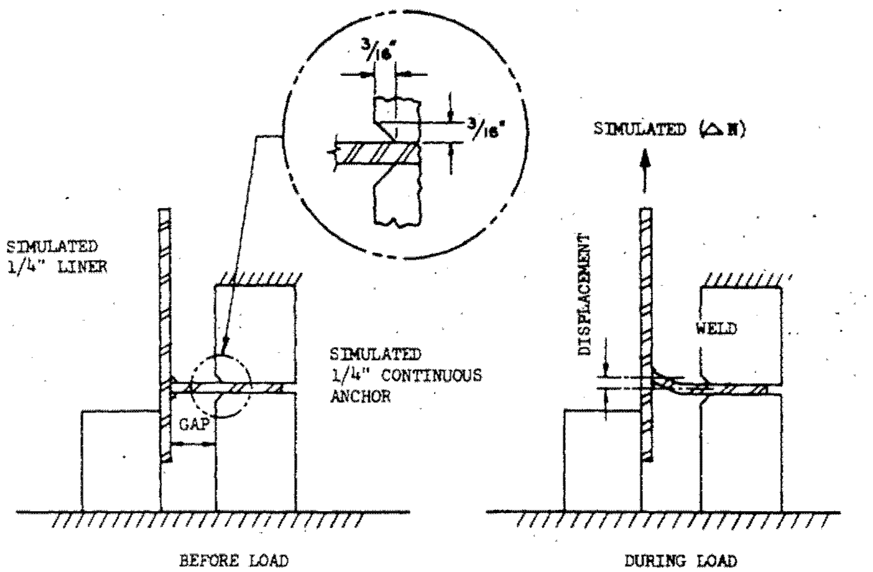
Figure 5.1-18 CONTAINMENT STRUCTURE - MODEL FOR LINER PLATE ANALYSIS
Sheet 2 of 2



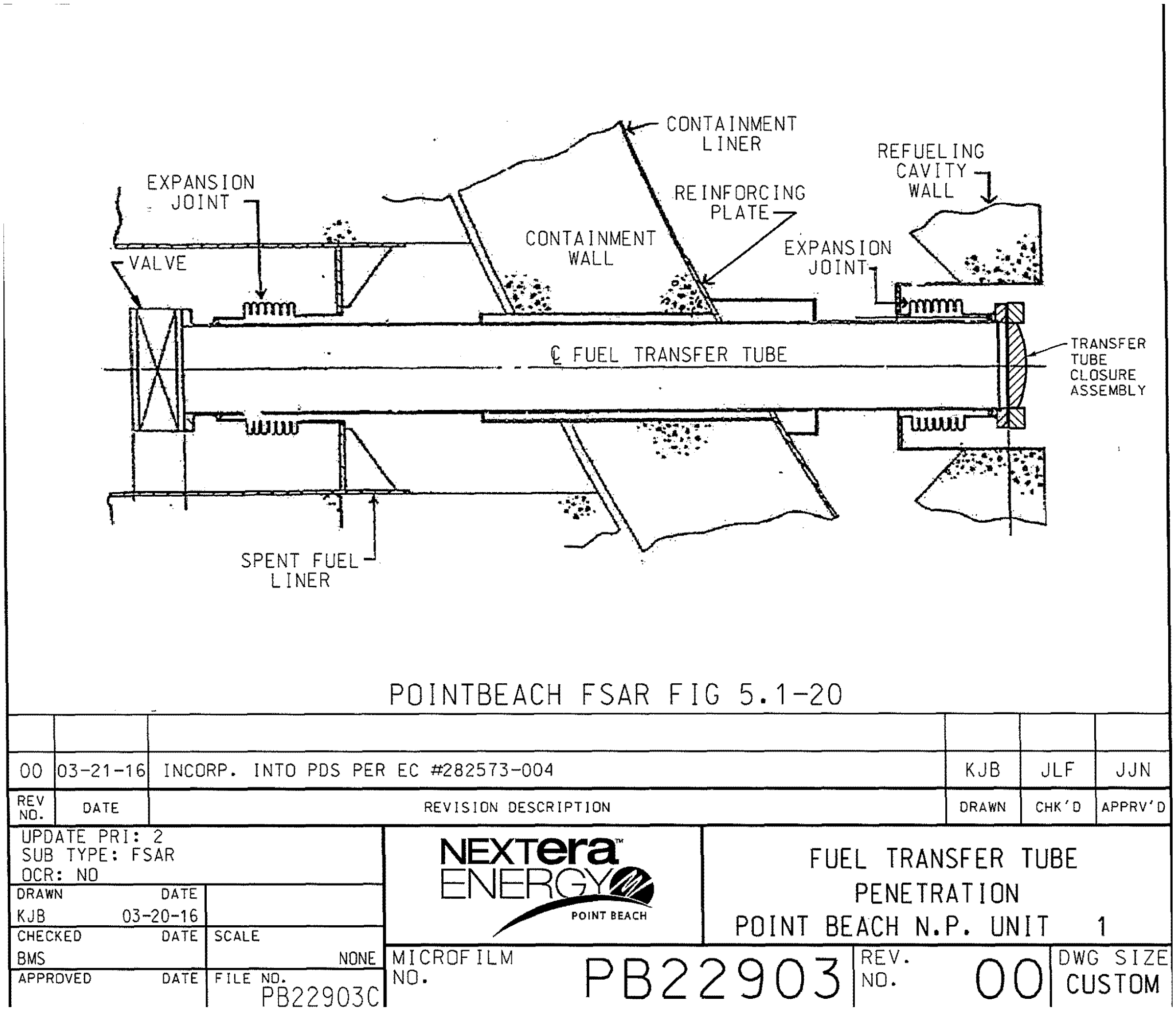

CONTAINMENT STRUCTURE
MODEL FOR LINER PLATE
ANALYSIS

Figure 5.1-19 CONTAINMENT STRUCTURE - RESULTS FROM TESTS ON LINER PLATE ANCHORS




| WELD CONFIGURATION | GAP (IN) | ULTIMATE LOAD (K/IN) | ULTIMATE DISPLACEMENT (IN) | LOCATION OF FAILURE |
|---|---|---|---|---|
| 3/16 | 0 | 14.95 | .14 | LINER PLATE |
| 3/16 | 5/8 | 5.56 | .68 | ANCHOR WELD |
| 3/16 6-12 | 0 | 7.65 | .18 | ANCHOR WELD |
| 3/16 6-12 | 5/8 | 2.93 | .60 | ANCHOR WELD |
| 3/16 4-12 | 0 | 6.67 | .18 | ANCHOR WELD |
| 3/16 4-12 | 5/8 | 2.46 | .30 | ANCHOR WELD |

Figure 5.1-20 FUEL TRANSFER TUBE PENETRATION



# 5.2 CONTAINMENT ISOLATION SYSTEM

## 5.2.1 DESIGN BASES

Each system whose piping penetrates the containment leakage limiting boundary is designed to maintain or establish isolation of the containment from the outside environment under the following postulated conditions:

1. Any accident for which isolation is required (severely faulted conditions)

2. A coincident independent single failure or malfunction (expected fault condition) occurring in any active system component within the isolated bounds

Piping penetrating the containment is designed for pressures at least equal to the containment design pressure. Containment isolation valves are provided as necessary in lines penetrating the containment to assure that no unrestricted release of radioactivity can occur. Such releases might be due to rupture of a line within the containment concurrent with a loss-of-coolant accident or due to rupture of a line outside the containment which connects to a source of radioactive fluid within the containment.

In general, isolation of a line outside the containment protects against rupture of the line inside concurrent with a loss-of-coolant accident or closes off a line which communicates with the containment atmosphere in the event of a loss-of-coolant accident.

Isolation of a line inside the containment prevents flow from the reactor coolant system or any other large source of radioactive fluid in the event that a piping rupture outside the containment occurs. A piping rupture outside the containment at the same time as a loss-of-coolant accident is not considered credible, as the penetrating lines are seismic Class I design at least up to and including the second isolation barrier and are assumed to be an extension of the containment. The isolation valve arrangement provides barriers between the reactor coolant system or containment atmosphere and the environment.

System design is such that no manual operation is required for immediate isolation. In addition, containment isolation can be accomplished if one valve fails to close. Closure of automatic isolation valves is initiated by a containment isolation signal, Chapter 7, derived either from any automatic safety injection signal or manually.

The containment isolation valves have been examined to assure that they are capable of withstanding the maximum potential seismic loads. To assure their adequacy in this respect:

1. Valves are located in a manner to reduce the accelerations on the valves. Valves suspended on piping spans are reviewed for adequacy for the loads to which the span would be subjected. Valves are mounted in the position recommended by the manufacturer.

2. Valve yokes have been reviewed for adequacy and strengthened as required for the response of the valve operator to seismic loads.

3. Where valves are required to operate during seismic loading, the operator forces have been reviewed to assure that system function is preserved. Seismic forces on the operating parts of the valve are small compared to the other forces present.

4. Control wires and piping to the valve operators have been designed and installed to assure that the flexure of the line does not endanger the control system. Appendages to the valve, such as position indicators and operators, have been checked for structural adequacy.

Containment Isolation Valves

Criterion: Penetrations that require closure for the containment function shall be protected by redundant valving and associated apparatus. (GDC 53)

Isolation valves are provided as necessary for all fluid system lines penetrating the containment to assure at least two barriers for redundance against leakage of radioactive fluids to the environment in the event of a loss-of-coolant accident. These barriers, in the form of isolation valves or closed systems, are defined on an individual line basis. In addition to satisfying containment isolation criteria, the valving is designed to facilitate normal operation and maintenance of the systems and to ensure reliable operation of other engineered safeguards systems.

With respect to numbers and locations of isolation valves, the criteria applied are generally those outlined by the five classes described below.

## 5.2.2 SYSTEM DESIGN

The five classes listed below are general categories into which lines penetrating the containment may be classified. The following notes apply to those classifications.

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 accident.[1]

2. In order to qualify for containment isolation, valves inside the containment must be protected against loss of function following an accident. They must, therefore, either be located outside the missile barrier, or be afforded protection against missiles (including jet forces and pipe whip) by physical barriers, restraints, or design configuration.[1]

3. Manual and remotely operated 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 qualifies as an automatic trip valve in certain incoming lines.

5. The double disk type of gate valve is used to isolate certain lines.

6. Isolation lines between the containment and the second outside isolation barrier (valve or closed system) are designed to the same seismic criteria as the containment vessel and are assumed to be an extension of containment.

---

1. Missiles may be generated as the result of various Loss-of-Coolant Accidents (LOCAs), though not from reactor coolant pipe ruptures. See Section 5.1 for further details.

7. The first outside isolation valve is located as close to the containment as possible unless a more remote location is dictated by equipment isolation requirements.

Class 1 (Outgoing Lines, Reactor Coolant System)

Normally operating outgoing lines connected to the reactor coolant system are provided with two automatic trip valves in series, one located inside containment and one located outside containment.

Class 2 (Outgoing Lines)

Normally operating outgoing lines not connected to the reactor coolant system and not protected from missiles throughout their length are provided with either (1) two automatic trip valves in series or (2) a closed system outside containment and either a remotely operated stop valve or an automatic trip valve in series.

Class 3 (Incoming Lines)

Incoming lines connected to open systems outside containment are provided with two automatic trip valves in series, one of which may be located inside containment. Incoming lines connected to closed systems outside containment are provided with one automatic trip valve located inside containment.

Class 4 (Missile Protected)

Normally operating incoming and outgoing lines which penetrate the containment and are connected to closed systems inside the containment and protected from missiles throughout their length are provided with at least one containment isolation valve located outside the containment. See Section 5.1 for details of design missiles.

Class 5 (Normally Closed Lines Open to 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 blank flange. One valve or flange is located inside and the second valve or flange located outside the containment.

Special Classed Penetrations

In the detailed design of the nuclear plant systems, certain lines required minor modification to the arrangements defined by the above classes in order to implement the basic redundant barrier criterion.

The designation "Special" indicates that the line cannot be classified in accordance with the five general classifications. In these lines, special arrangements of isolation features provide the redundant barriers and are described in the note associated with each figure.

The equipment access closure is bolted, gasketed, and sealed during reactor operation. The personnel air lock consists 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 for leakage testing.

Closed Systems Inside Containment

PBNP is committed to 10CFR50 Appendix J. Appendix J refers to Regulatory Guide 1.163 as the specific guidance concerning a performance based leakage program, acceptable leakage-rate test methods, procedures, and analysis that may be used to implement these requirements. Regulatory Guide 1.163 refers to the use of NEI 94-01 which sets the requirements and explains performance-based testing programs. NEI 94-01 states the following is exempt from leak testing under the Appendix J program: "primary containment boundaries that do not constitute potential primary containment atmospheric pathways during and following a Design Basis Accident (DBA)." PBNP recognizes these boundaries that do not constitute potential primary containment atmospheric pathways as Closed Systems. This applies to the designated CIVs listed in the FSAR Figures 5.2 as Closed Systems.

Some lines which penetrate the containment are not open to the containment atmosphere. When these lines meet the following criteria, they are considered as closed systems, not subject to rupture following a LOCA. The main steam lines, feedwater lines, and service water lines are examples of closed systems within containment.

1. Class 1 seismic,
2. Design pressure greater than containment design pressure,
3. Penetrations conform to the applicable sections of ASA N6.2-1965, "Safety Standard for the Design, Fabrication, and Maintenance of Steel Containment Structures for Stationary Nuclear Power Reactors."

Where closed system lines penetrate the missile shield they also must be protected against the dynamic effects of a break of the RCS pressure boundary, for those parts of the pressure boundary that have not been demonstrated to have an extremely low probably of rupture ("Leak-Before-Break"). This protection includes missiles, jet impingement, and pipe whip.

By meeting these criteria closed systems inside containment are considered missile protected throughout their length.

### 5.2.2.1 ISOLATION VALVES AND INSTRUMENTATION DIAGRAMS

Figure 5.2-1 through Figure 5.2-X2 show all containment isolation valves in lines leading to the atmosphere or to closed systems on both sides of the containment barrier, valve actuation and preferential failure modes, the application of "trip" (containment isolation) signals, and relative location of the valves with respect to missile barriers. Containment penetrations that previously had process lines through them but were modified so they no longer are in use, do not have isolation valves or other barriers that require periodic testing (other than Type A), are now considered spares, and have been removed from the figures shown in this section. Figure 5.2-72 shows a fuel transfer tube penetration. Figure 5.2-73-1 shows the containment structure and spent fuel pool pile foundation layout.

All trip isolation valves are provided with position indication in the main control room. Air operated valves which are designed as automatic trip isolation valves are designed to fail to the closed position upon loss of control air or electric services. The trip valves will be closed automatically upon receipt of the containment isolation signal. Circuits which control redundant automatic valves shall be redundant in the sense that no single failure shall preclude isolation of the penetration. Table 5.2-1 is an index of figures showing the physical configuration of each penetration and their isolation features. The applicable piping and instrumentation drawing is listed for each figure.

Certain penetrations for engineered safeguards systems lines are exceptions to the above categories. The operation of valves in these systems is governed by the functional requirements of the systems as outlined in this section.

Supplementary criteria noted below, which pertain to certain lines penetrating containment, have also been applied in the selection of isolation features incorporated in these lines. These criteria are identified in the containment penetration drawings.

1. Lines which penetrate containment and are open to the external atmosphere or to systems designed for less than containment design pressure shall be protected by redundant, automatic[1] isolation valves if they fulfill either of the following conditions:

    a. They are connected to the primary system
    b. They are normally open to containment atmosphere

    Exception: Lines which must remain open subsequent to loss-of-coolant accident shall be protected by redundant valves, one or both of which shall be remote-manual.

2. Ventilation lines shall be isolated upon receipt of "Safety Injection" signals.

3. Lines which have a low probability of rupture during Design Basis Accident, DBA (e.g., certain secondary system lines) shall be protected by at least one automatic valve external to containment.

    Exception: Lines which must remain open subsequent to DBA shall be protected by one automatic valve or one remote manual valve external to containment.

1. Check valves are considered to be automatic valves.

## EXPLANATORY NOTES
## FOR CONTAINMENT PENETRATION FIGURES

General Note: The purpose of these figures is to illustrate the general configuration of the containment isolation provisions for each penetration. It is not the intent of these figures to illustrate piping and instrumentation details, and particularly those details outside a penetration's pressure boundary. Refer to the associated P&ID for piping and instrumentation details.

General Note: Valves are depicted in their normal at-power position, which should coincide with the normal position depicted in the P&ID. Refer to the P&ID for these details.

Note A: Relief valves are not considered as leakage paths if set pressure is such that the relief valve will not lift with 60 psig containment design pressure present.

Note B: The designation "CS" in the figures applies to penetrating lines connected to a closed system either inside or outside containment. These systems are also protected against missiles and are designed in accordance with Class I seismic criteria. Their design pressure is higher than the containment design pressure.

Note C: The term "in use" indicates that the line will be in service following a loss-of-coolant accident.

Table 5.2-1 INDEX OF CONTAINMENT PENETRATION FIGURES
(1 of 4)

| PENETRATION | FIGURE | DESCRIPTION | P & I D No. Unit 1 | P & I D No. Unit 2 |
|---|---|---|---|---|
| 1 | 5.2-1 | MAIN STEAM LOOP A | M-201 | M-2201 |
| 2 | 5.2-2 | MAIN STEAM LOOP B | M-201 | M-2201 |
| 3 | 5.2-3 | MAIN FEEDWATER LINE TO STEAM GENERATOR | M-202 | M-2202 |
| 4 | 5.2-4 | MAIN FEEDWATER LINE TO STEAM GENERATOR | M-202 | M-2202 |
| 5-1 | 5.2-5-1 | AUXILIARY FEEDWATER LINES (UNIT 1) | M-217 | |
| 5-2 | 5.2-5-2 | AUXILIARY FEEDWATER LINES (UNIT 2) | | M-217 |
| 6-1 | 5.2-6-1 | AUXILIARY FEEDWATER LINES (UNIT 1) | M-217 | |
| 6-2 | 5.2-6-2 | AUXILIARY FEEDWATER LINES (UNIT 2) | | M-217 |
| 7 | 5.2-7 | RESIDUAL HEAT REMOVAL SUCTION | W110E018 | W110E029 |
| 8 | 5.2-8 | RESIDUAL HEAT REMOVAL LOOP INTO CONTAINMENT | W684J741<br>W54lF091<br>W110E017<br>W110E018 | W685J175<br>W541F445<br>W110E035<br>W110E029 |
| 9 | 5.2-9 | REACTOR COOLANT DRAIN TANK DISCHARGE | W684J971 | W684J971 |
| 10 | 5.2-10 | LETDOWN LINE | W684J741<br>W541F091 | W685J175<br>W541F445 |
| 11 | 5.2-11 | EXCESS LETDOWN AND REACTOR COOLANT PUMP SEAL WATER RETURN LINE | W684J741 | W685J175 |
| 12a | 5.2-12a | CONTAINMENT DE-IONIZED WATER SUPPLY | PBM-231 | PBM-231 |
| 12c | 5.2-12c | CONTAINMENT VENT HEADER | W684J971<br>W541F091<br>W684J972 | |
| 13 | 5.2-13 | SAFETY INJECTION SYSTEM | W110E017 | W110E035 |
| 14a | 5.2-14a | PRESSURIZER RELIEF TANK NITROGEN SUPPLY LINE | W541F091 | W541F445 |
| 14b | 5.2-14b | CONTAINMENT PRESSURE TRANSMITTERS/INDICATORS | M-224 | M-224 |
| 14c | 5.2-14c | ACCUMULATOR NITROGEN SUPPLY | W110E017 | W110E035 |
| 15 | 5.2-15 | COMPONENT COOLING WATER SUPPLY TO REACTOR COOLANT PUMP | W110E018 | W110E029 |
| 16 | 5.2-16 | COMPONENT COOLING WATER SUPPLY TO REACTOR COOLANT PUMP | W110E018 | W110E029 |
| 17 | 5.2-17 | COMPONENT COOLING WATER FROM REACTOR COOLANT PUMP | W110E018 | W110E029 |
| 18 | 5.2-18 | COMPONENT COOLING WATER FROM REACTOR COOLANT PUMP | W110E018 | W110E029 |
| 19 | 5.2-19 | COMPONENT COOLING WATER SUPPLY TO EXCESS LETDOWN HEAT EXCHANGER | W110E018 | W110E029 |

Table 5.2-1 INDEX OF CONTAINMENT PENETRATION FIGURES
(2 of 4)

| PENETRATION | FIGURE | DESCRIPTION | P & I D No. Unit 1 | Unit 2 |
|---|---|---|---|---|
| 20 | 5.2-20 | COMPONENT COOLING WATER FROM EXCESS LETDOWN HEAT EXCHANGER | W110E018 | W110E029 |
| 22 | 5.2-22 | SAFETY INJECTION SYSTEM | W110E017<br>W110E018 | W110E035<br>W110E029 |
| 25c | 5.2-25c | POST-ACCIDENT CONTAINMENT VENTILATION SYSTEM (UNIT 1 ONLY) | M-224 | |
| 26 | 5.2-26 | CHARGING LINE | W684J741 | W685J175 |
| 27 | 5.2-27 | SAFETY INJECTION SYSTEM | W110E017 | W110E035 |
| 28a | 5.2-28a | REACTOR COOLANT SYSTEM SAMPLE LINES (HOT LEG SAMPLE) | W541F092 | W541F448 |
| 28b | 5.2-28b | REACTOR COOLANT SYSTEM SAMPLE LINES (PZR LIQUID SAMPLE) | W541F092 | W541F448 |
| 28c | 5.2-28c | REACTOR COOLANT SYSTEM SAMPLE LINES (PZR STEAM SPACE SAMPLE) | W541F092 | W541F448 |
| 29a | 5.2-29a | REACTOR COOLANT PUMP SEAL WATER SUPPLY LINE (PUMP A) | W684J741 | W685J175 |
| 29b | 5.2-29b | REACTOR COOLANT PUMP SEAL WATER SUPPLY LINE (PUMP B) | W684J741 | W685J175 |
| 30c | 5.2-30c | PRESSURIZER RELIEF TANK MAKEUP | W541F091 | W541F445 |
| 31a | 5.2-31a | CONTAINMENT PRESSURE TRANSMITTERS | M-224 | M-224 |
| 31b | 5.2-31b | POST-ACCIDENT CONTAINMENT VENTILATION SYSTEM SAMPLE | M-224 | M-224 |
| 31c | 5.2-31c | POST-ACCIDENT CONTAINMENT VENTILATION SYSTEM | M-224 | M-224 |
| 32a | 5.2-32a | CONTAINMENT PRESSURE TRANSMITTERS | M-224 | M-224 |
| 32b | 5.2-32b | SAFETY INJECTION TEST LINE | W110E017 | W110E035 |
| 32c | 5.2-32c | AUXILIARY CHARGING LINE | W684J741 | W685J175 |
| 33a-1 | 5.2-33ab1 | INSTRUMENT AIR HEADERS (UNIT 1) | M-209 | |
| 33a-2 | 5.2-33ab2 | INSTRUMENT AIR HEADERS (UNIT 2) | | M-209 |
| 33b-1 | 5.2-33ab1 | INSTRUMENT AIR HEADERS (UNIT 1) | M-209 | |
| 33b-2 | 5.2-33ab2 | INSTRUMENT AIR HEADERS (UNIT 2) | | M-209 |
| 33c | 5.2-33c | SERVICE AIR HEADER | M-209 | M-209 |
| 34a | 5.2-34a | PRESSURIZER RELIEF TANK GAS ANALYZER LINE | W541F091 | W541F445 |
| 34b | 5.2-34b | STEAM GENERATOR BLOWDOWN SAMPLE LINE | M-201 | M-2201 |
| 34c | 5.2-34c | STEAM GENERATOR BLOWDOWN SAMPLE LINE | M-201 | M-2201 |

Table 5.2-1 INDEX OF CONTAINMENT PENETRATION FIGURES
(3 of 4)

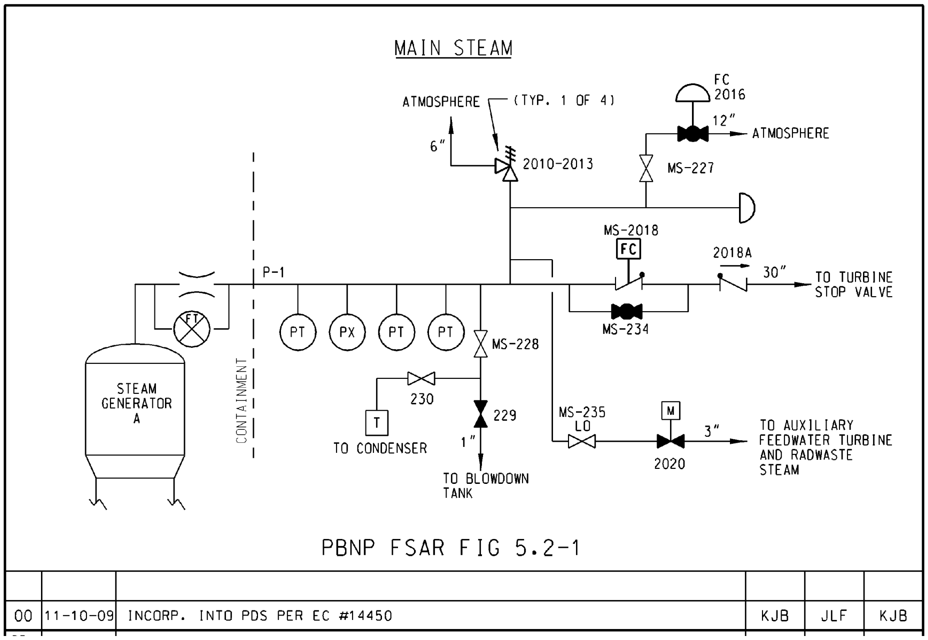
| PENETRATION | FIGURE | DESCRIPTION | P & I D No. Unit 1 | P & I D No. Unit 2 |
|---|---|---|---|---|
| 34d | 5.2-34d | REACTOR COOLANT DRAIN TANK SAMPLE TO GAS ANALYZER | W684J971<br>W684J972 | W684J971<br>W684J972 |
| 35-1 | 5.2-35-1 | SERVICE WATER SUPPLY TO CONTAINMENT FAN COOLER UNIT (UNIT 1) | M-207 | |
| 35-2 | 5.2-35-2 | SERVICE WATER SUPPLY TO CONTAINMENT FAN COOLER UNIT (UNIT 2) | | M-2207 |
| 36-1 | 5.2-36-1 | SERVICE WATER SUPPLY TO CONTAINMENT FAN COOLER UNIT (UNIT 1) | M-207 | |
| 36-2 | 5.2-36-2 | SERVICE WATER SUPPLY TO CONTAINMENT FAN COOLER UNIT (UNIT 2) | | M-2207 |
| 37-1 | 5.2-37-1 | SPARE LINE (UNIT 1) | M-207 | |
| 37-2 | 5.2-37-2 | SPARE LINE (UNIT 2) | | M-2207 |
| 38-1 | 5.2-38-1 | SPARE LINE (UNIT 1) | M-207 | |
| 38-2 | 5.2-38-2 | SPARE LINE (UNIT 2) | | M-2207 |
| 39-1 | 5.2-39-1 | SERVICE WATER SUPPLY TO CONTAINMENT FAN COOLER UNIT (UNIT 1) | M-207 | |
| 39-2 | 5.2-39-2 | SERVICE WATER SUPPLY TO CONTAINMENT FAN COOLER UNIT (UNIT 2) | | M-2207 |
| 40-1 | 5.2-40-1 | SERVICE WATER SUPPLY TO CONTAINMENT FAN COOLER UNIT (UNIT 1) | M-207 | |
| 40-2 | 5.2-40-2 | SERVICE WATER SUPPLY TO CONTAINMENT FAN COOLER UNIT (UNIT 2) | | M-2207 |
| 42c-2 | 5.2-42c-2 | POST-ACCIDENT CONTAINMENT VENTILATION SYSTEM (UNIT 2) | M-224 | |
| 43-1 | 5.2-43-1 | SERVICE WATER RETURN LINE FROM CONTAINMENT FAN COOLER UNITS (UNIT 1) | M-207 | |
| 43-2 | 5.2-43-2 | SERVICE WATER RETURN LINE FROM CONTAINMENT FAN COOLER UNIT (UNIT 2) | | M-2207 |
| 44-1 | 5.2-44-1 | SERVICE WATER RETURN LINE FROM CONTAINMENT FAN COOLER UNIT (UNIT 1) | M-207 | |
| 44-2 | 5.2-44-2 | SERVICE WATER RETURN LINE FROM CONTAINMENT FAN COOLER UNIT (UNIT 2) | | M-2207 |

Table 5.2-1 INDEX OF CONTAINMENT PENETRATION FIGURES
(4 of 4)

| PENETRATION | FIGURE | DESCRIPTION | P & I D No. Unit 1 | P & I D No. Unit 2 |
|---|---|---|---|---|
| 45-1 | 5.2-45-1 | SPARE LINE (UNIT 1) | M-207 | |
| 45-2 | 5.2-45-2 | SPARE LINE (UNIT 2) | | M-2207 |
| 46-1 | 5.2-46-1 | SPARE LINE (UNIT 1) | M-207 | |
| 46-2 | 5.2-46-2 | SPARE LINE (UNIT 2) | | M-2207 |
| 47-1 | 5.2-47-1 | SERVICE WATER RETURN LINE FROM CONTAINMENT FAN COOLER UNIT (UNIT 1) | M-207 | |
| 47-2 | 5.2-47-2 | SERVICE WATER RETURN LINE FROM CONTAINMENT FAN COOLER UNIT (UNIT 2) | | M-2207 |
| 48-1 | 5.2-48-1 | SERVICE WATER RETURN LINE FROM CONTAINMENT FAN COOLER UNIT (UNIT 1) | M-207 | |
| 48-2 | 5.2-48-2 | SERVICE WATER RETURN LINE FROM CONTAINMENT FAN COOLER UNIT (UNIT 2) | | M-2207 |
| 50-1 | 5.2-50-1 | STEAM GENERATOR BLOWDOWN LINE (UNIT 1) | M-201 | |
| 50-2 | 5.2-50-2 | STEAM GENERATOR BLOWDOWN LINE (UNIT 2) | | M-2201 |
| 51-1 | 5.2-51-1 | STEAM GENERATOR BLOWDOWN LINE (UNIT 1) | M-201 | |
| 51-2 | 5.2-51-2 | STEAM GENERATOR BLOWDOWN LINE (UNIT 2) | | M-2201 |
| 54 | 5.2-54 | CONTAINMENT SPRAY HEADERS | W110E017 | W110E035 |
| 55 | 5.2-55 | CONTAINMENT SPRAY HEADERS | W110E017 | W110E035 |
| 56 | 5.2-56 | SPARE PENETRATION | | |
| 57 | 5.2-57 | MAIN STEAM GENERATOR VENTS | M-201 | M-2201 |
| 58 | 5.2-58 | MAIN STEAM GENERATOR VENTS | M-201 | M-2201 |
| 67-2 | 5.2-67-2 | SPARE PENETRATION | | |
| 69 | 5.2-69 | CONTAINMENT SUMP RECIRCULATION LINES | W110E017<br>W110E018 | W110E035<br>W110E029 |
| 70 | 5.2-70 | CONTAINMENT SUMP RECIRCULATION LINES | W110E017<br>W110E018 | W110E035<br>W110E029 |
| 71 | 5.2-71 | CONTAINMENT SUMP DISCHARGE | W684J971 | W684J971 |
| Vl | 5.2-V1 | CONTAINMENT PURGE EXHAUST DUCT | M-215 | M-2215 |
| V2 | 5.2-V2 | CONTAINMENT PURGE SUPPLY DUCT | M-215 | M-2215 |
| X1 | 5.2-X1 | CONTAINMENT AIR SAMPLE OUT | M-215 | M-2215 |
| X2 | 5.2-X2 | CONTAINMENT AIR SAMPLE IN | M-215 | M-2215 |

NOTE: Standard equipment data base designations are used for valve numbers. See Bechtel drawing M-200 P&ID “Legend” for symbol descriptions used in the figures.

# Figure 5.2-1 MAIN STEAM LOOP A



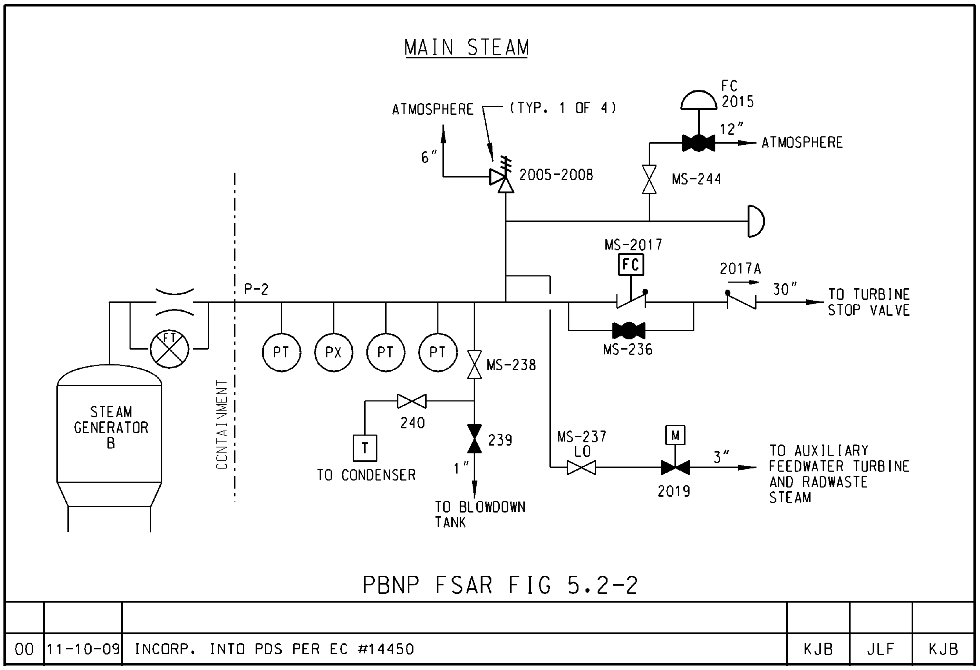

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 1 | CLOSED SYSTEM | MS-227 | ATMOSPHERIC STEAM DUMP/MS | 6’ | G | HOT | 4 |
| | CLOSED SYSTEM | MS-2018 | STEAM TO TURBINE/ MS | 30’ | G | HOT | 4 |
| | CLOSED SYSTEM | MS-234 | MSIV BYPASS/MS | 3’ | G | HOT | 4 |
| | CLOSED SYSTEM | MS-228 | STEAM LINE DRAIN TO BLOWDOWN TANK AND CONDENSER/MS | 2’ | G | HOT | 4 |
| | CLOSED SYSTEM | MS-235 | AUXILIARY FEED PUMP AND RADWASTE STEAM/ MS | 3’ | G | HOT | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIGURE 10.2-1 SHT. 1

NOTE:

1. ATMOSPHERIC STEAM DUMP - THIS IS AN OUTGOING LINE CONNECTED TO A CLOSED SYSTEM INSIDE CONTAINMENT. THE MANUAL ISOLATION REQUIREMENT IS MET BY MS-227.
2. STEAM TO TURBINE - THIS IS AN OUTGOING LINE CONNECTED TO A CLOSED SYSTEM INSIDE CONTAINMENT. IT THEREFORE SATISFIES CLASS 4 PENETRATION CRITERIA BECAUSE REMOTE STOP VALVE MS-2018 PROVIDES A DEGREE OF ISOLATION WHICH EXCEEDS THAT OF A MANUAL VALVE SINCE IT CAN BE REMOTELY OPERATED.
3. MSIV BYPASS - THIS IS AN OUTGOING LINE CONNECTED TO A CLOSED SYSTEM INSIDE CONTAINMENT. THE MANUAL ISOLATION REQUIREMENT IS SATISFIED BY MS-234.
4. STEAMLINE DRAIN TO STEAM GENERATOR BLOWDOWN TAND AND CONDENSER - THIS IS AN OUTGOING LINE CONNECTED TO A CLOSED SYSTEM INSIDE CONTAINMENT. THE MANUAL ISOLATION REQUIREMENT IS SATISFIED BY MS-228.
5. AUXILIARY FEED PUMP AND RADWASTE STEAM SUPPLY - THIS IS AN OUTGOING LINE CONNECTED TO A CLOSED SYSTEM INSIDE CONTAINMENT. THE MANUAL ISOLATION VALVE IS SATISFIED BY MS-235.

# Figure 5.2-2 MAIN STEAM LOOP B




| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 2 | CLOSED SYSTEM | MS-244 | ATMOSPHERIC STEAM DUMP/MS | 6’ | G | HOT | 4 |
| | CLOSED SYSTEM | MS-2017 | STEAM TO TURBINE/ MS | 30’ | G | HOT | 4 |
| | CLOSED SYSTEM | MS-236 | MSIV BYPASS/MS | 3’ | G | HOT | 4 |
| | CLOSED SYSTEM | MS-238 | STEAM LINE DRAIN TO BLOWDOWN TANK AND CONDENSER/MS | 2’ | G | HOT | 4 |
| | CLOSED SYSTEM | MS-237 | AUXILIARY FEED PUMP AND RADWASTE STEAM/ MS | 3’ | G | HOT | 4 |

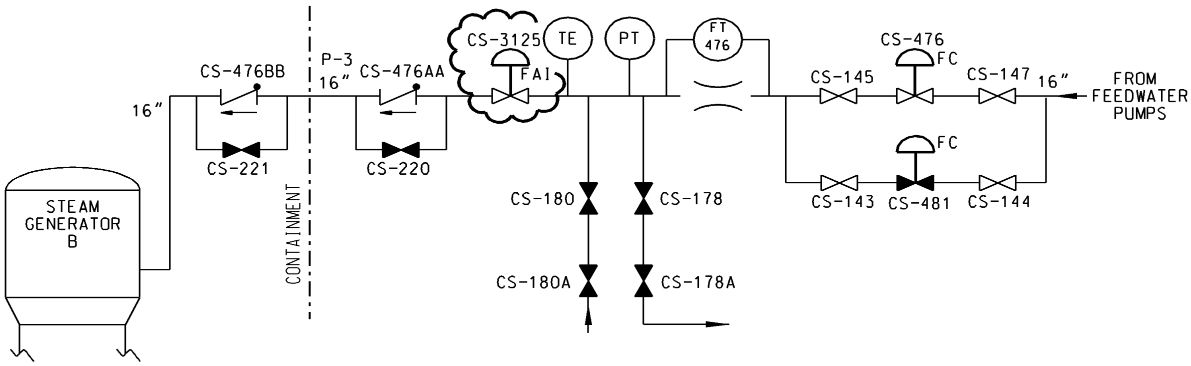
FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIG 10.2-1 SHT. 1

NOTE:

1. ATMOSPHERIC STEAM DUMP - THIS IS AN OUTGOING LINE CONNECTED TO A CLOSED SYSTEM INSIDE CONTAINMENT. THE MANUAL ISOLATION REQUIREMENTS IS MET BY MS-244.
2. STEAM TO TURBINE - THIS IS AN OUTGOING LINE CONNECTED TO A CLOSED SYSTEM INSIDE CONTAINMENT. IT THEREFORE SATISFIES CLASS 4 PENETRATION CRITERIA BECAUSE REMOTE STOP VALVE MS-2017 PROVIDES A DEGREE OF ISOLATION WHICH EXCEEDS THAT OF A MANUAL VALVE SINCE IT CAN BE REMOTELY OPERATED.
3. MSIV BYPASS - THIS IS AN OUTGOING LINE CONNECTED TO A CLOSED SYSTEM INSIDE CONTAINMENT. THE MANUAL ISOLATION REQUIREMENT IS SATISFIED BY MS-236.
4. STEAMLINE DRAIN TO STEAM GENERATOR BLOWDOWN TAND AND CONDENSER - THIS IS AN OUTGOING LINE CONNECTED TO A CLOSED SYSTEM INSIDE CONTAINMENT. THE MANUAL ISOLATION REQUIREMENT IS SATISFIED BY MS-238.
5. AUXILIARY FEED PUMP AND RADWASTE STEAM SUPPLY - THIS IS AN OUTGOING LINE CONNECTED TO A CLOSED SYSTEM INSIDE CONTAINMENT. THE MANUAL ISOLATION VALVE IS SATISFIED BY MS-237.

# Figure 5.2-3 MAIN FEEDWATER LINE TO STEAM GENERATOR

MAIN FEEDWATER LINE TO STEAM GENERATOR




UPDATE PRI: 2
CBD: NO

POINTBEACH FSAR FIG 5.2-3

| REV NO. | DATE | REVISION DESCRIPTION | DRAWN | CHK'D | APPRV'D |
|---|---|---|---|---|---|
| | | | | | |
| 02 | 03-30-13 | REVISED PER EC #278618 | KJB | JLF | KJB |

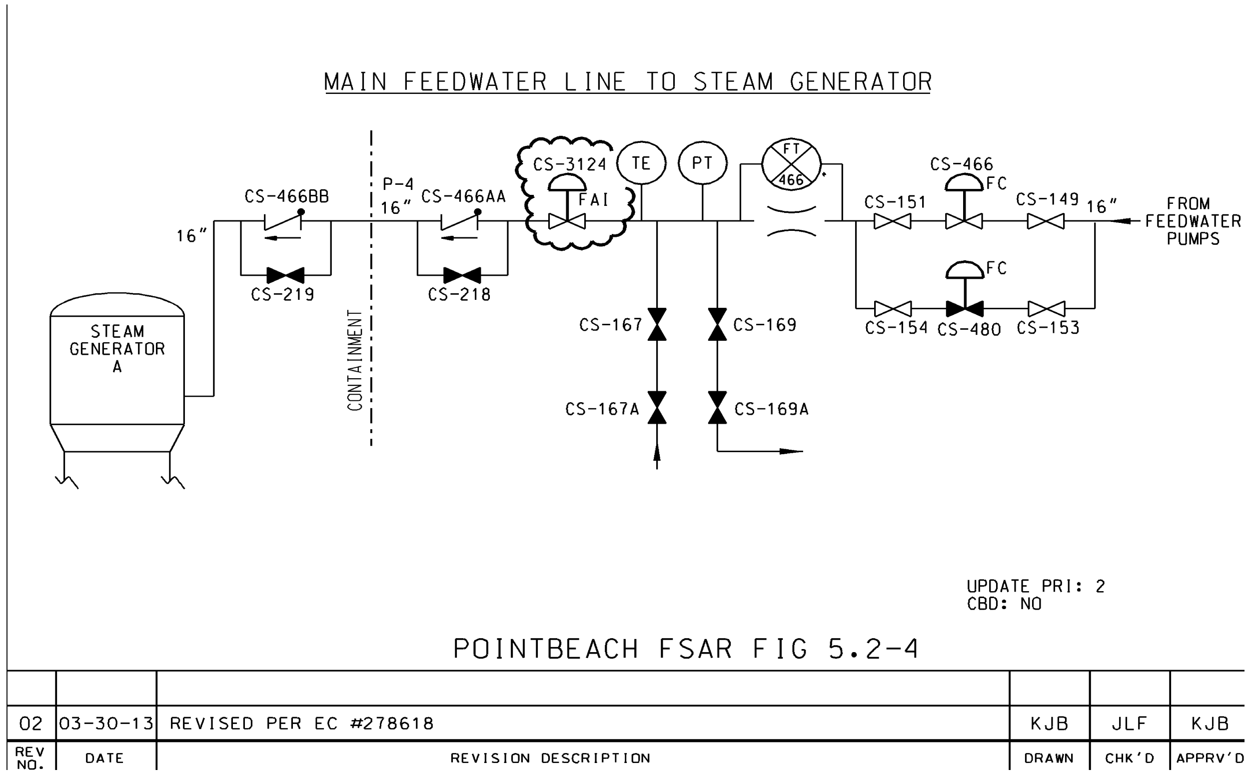
| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 3 | CLOSED SYSTEM | CS-476AA | MAIN FEED TO STEAM GENERATOR/CS | 16" | W | HOT | 4 |
| 3 | CLOSED SYSTEM | CS-220 | MAIN FEED TO STEAM GENERATOR TEST LINE/CS | 2" | W | HOT | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10, FIGURE 10.1.2 SHEET 2, AND FIGURE 10.1-2A Sheet 2

NOTE:

MAIN FEED TO STEAM GENERATOR - THIS IS AN INCOMING LINE CONNECTED TO A CLOSED SYSTEM INSIDE CONTAINMENT. IT DOES NOT PRECISELY SATISFY THE CLASS 4 CRITERIA BECAUSE THERE IS A CHECK VALVE RATHER THAN A MANUAL ISOLATION VALVE OUTSIDE CONTAINMENT. IT ALSO SATISFIES SUPPLEMENTAL CRITERION #3 IN THAT IT IS A LINE WITH LOW PROBABILITY OF RUPTURE AND THEREFORE MAY HAVE AN AUTOMATIC VALVE EXTERNAL TO CONTAINMENT AS EXPLAINED IN FSAR Section 5.2 "A CHECK VALVE QUALIFIES AS AN AUTOMATIC TRIP VALVE..." OUTSIDE OF CONTAINMENT CHECK VALVE CS-476AA FULFILLS THIS REQUIREMENT.

# Figure 5.2-4 MAIN FEEDWATER LINE TO STEAM GENERATOR



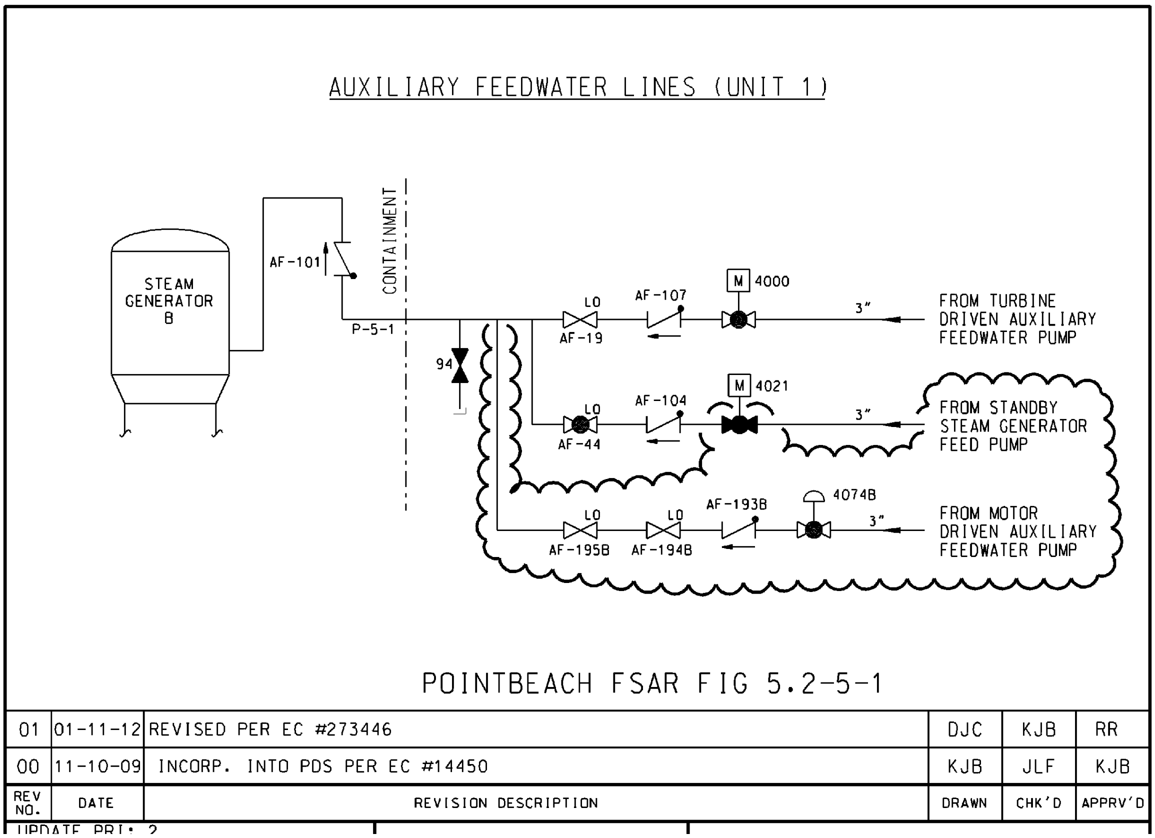

| PENETRATION | CONTAINMENT ISOLATION VALVES<br>INSIDE | <br>OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP.<br>HOT>200<br>COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 4 | CLOSED SYSTEM | CS-466AA | MAIN FEED TO STEAM GENERATOR/CS | 16" | W | HOT | 4 |
| 4 | CLOSED SYSTEM | CS-218 | MAIN FEED TO STEAM GENERATOR TEST LINE/CS | 2" | W | HOT | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10, FIGURE 10.1.2 SHEET 2, AND FIGURE 10.1-2A SHEET. 2

NOTE:

MAIN FEED TO STEAM GENERATOR - THIS IS AN INCOMING LINE CONNECTED TO A CLOSED SYSTEM INSIDE CONTAINMENT. IT DOES NOT PRECISELY SATISFY THE CLASS 4 CRITERIA BECAUSE THERE IS A CHECK VALVE RATHER THAN A MANUAL ISOLATION VALVE OUTSIDE CONTAINMENT. IT ALSO SATISFIES SUPPLEMENTAL CRITERION #3 IN THAT IT IS A LINE WITH LOW PROBABILITY OF RUPTURE AND THEREFORE MAY HAVE AN AUTOMATIC VALVE EXTERNAL TO CONTAINMENT AS EXPLAINED IN FSAR Section 5.2 "A CHECK VALVE QUALIFIES AS AN AUTOMATIC TRIP VALVE..." OUTSIDE OF CONTAINMENT CHECK VALVE CS-466AA FULFILLS THIS REQUIREMENT.

# Figure 5.2-5-1 AUXILIARY FEEDWATER LINES (UNIT 1)



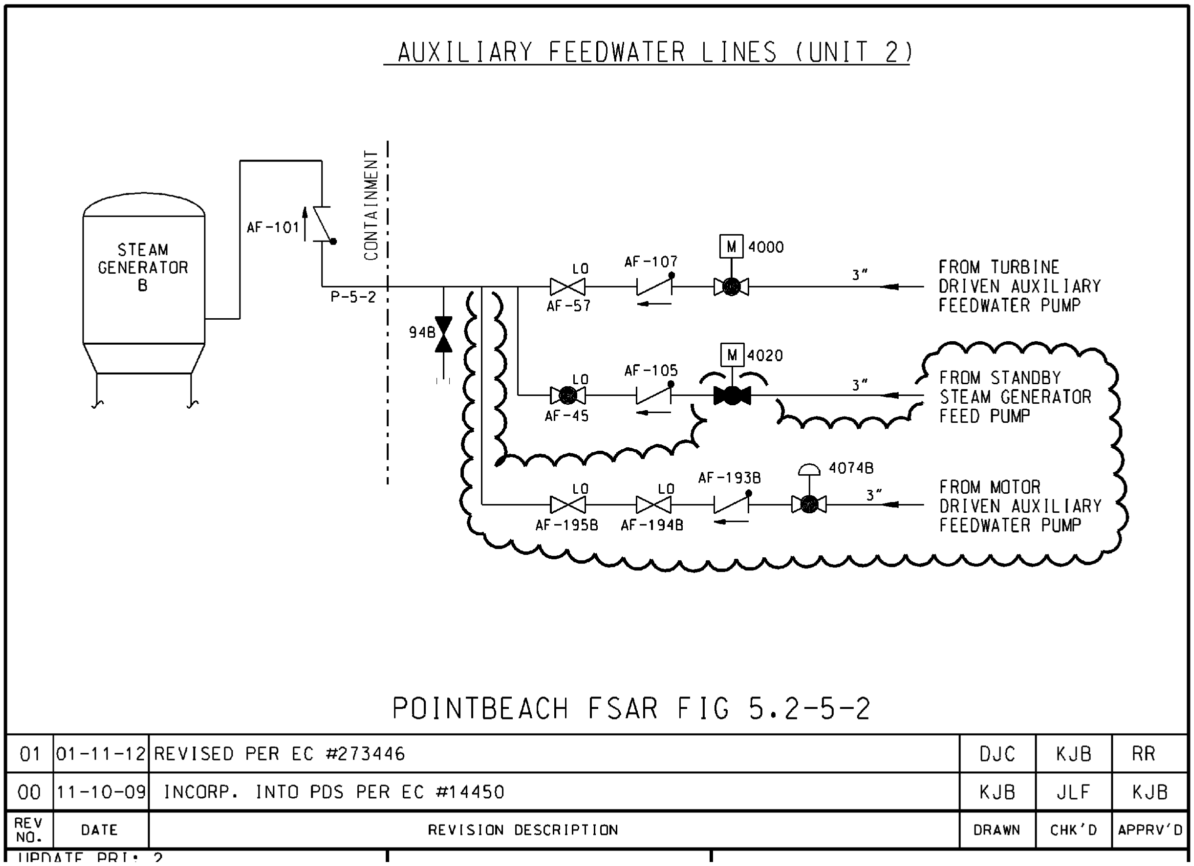

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 5-1 | CLOSED SYSTEM | AF-19 | TURBINE DRIVEN AUXILIARY FEED TO STEAM GENERATOR/ AF | 3" | W | HOT | 4 |
| | CLOSED SYSTEM | AF-44 | STANDBY STESM GENERATOR FEED TO STEAM GENERATOR/ AF | 3" | W | HOT | 4 |
| | CLOSED SYSTEM | AF-195B | MOTOR DRIVEN AUXILIARY FEED TO STEAM GENERATOR/ AF | 3" | W | HOT | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIG. 10.2-1 SHEETS 1 AND 2

NOTE:

AUXILIARY FEEDWATER LINES - THESE ARE INCOMING LINES NORMALLY OPERATING AFTER A DBA. THE MANUAL ISOLATION VALVE REQUIREMENT FOR A CLASS 4 PENETRATION IS MET BY VALVES AF-19, AF-44, AND AF-195B

# Figure 5.2-5-2 AUXILIARY FEEDWATER LINES (UNIT 2)

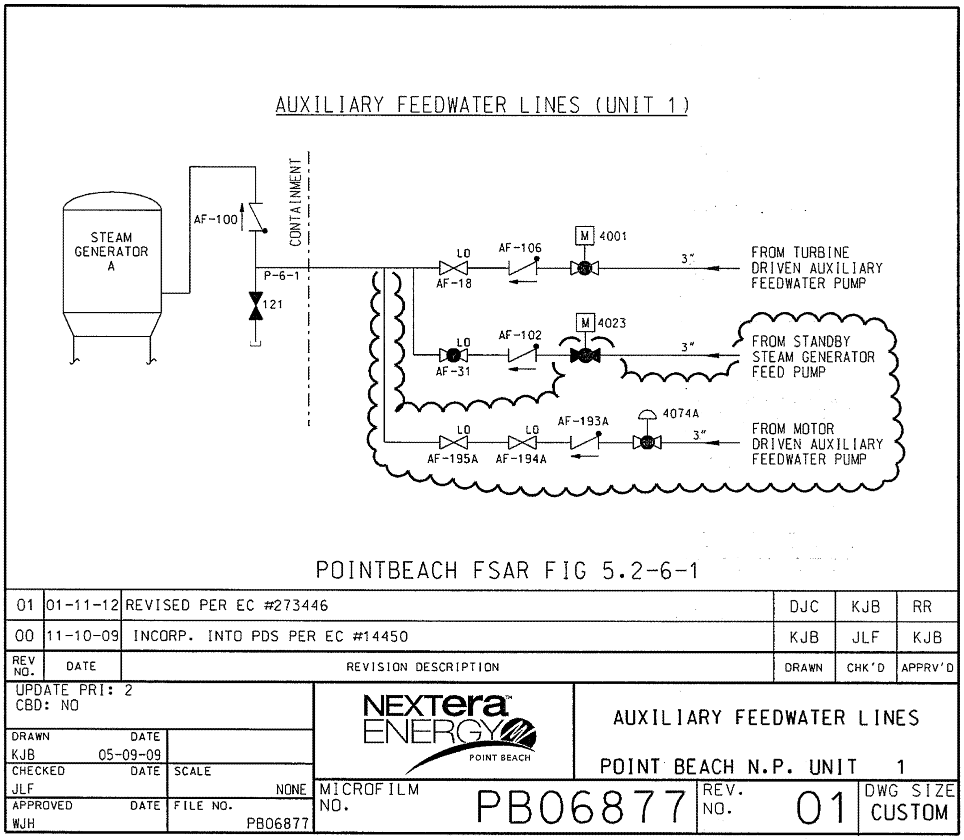



| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 5-2 | CLOSED SYSTEM | AF-57 | TURBINE DRIVEN AUXILIARY FEED TO STEAM GENERATOR/ AF | 3" | W | HOT | 4 |
| | CLOSED SYSTEM | AF-45 | STANDBY STEAM GENERATOR FEED TO STEAM GENERATOR/ AF | 3" | W | HOT | 4 |
| | CLOSED SYSTEM | AF-195B | MOTOR DRIVEN AUXILIARY FEED TO STEAM GENERATOR/ AF | 3" | W | HOT | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIG. 10.2-1 SHEETS 1 AND 2

NOTE: AUXILIARY FEEDWATER LINES - THESE ARE INCOMING LINES NORMALLY OPERATING AFTER A DBA. THE MANUAL ISOLATION VALVE REQUIREMENT FOR A CLASS 4 PENETRATION IS MET BY VALVES AF-57, AF-44, AND AF-195B.

# Figure 5.2-6-1 AUXILIARY FEEDWATER LINES (UNIT 1)



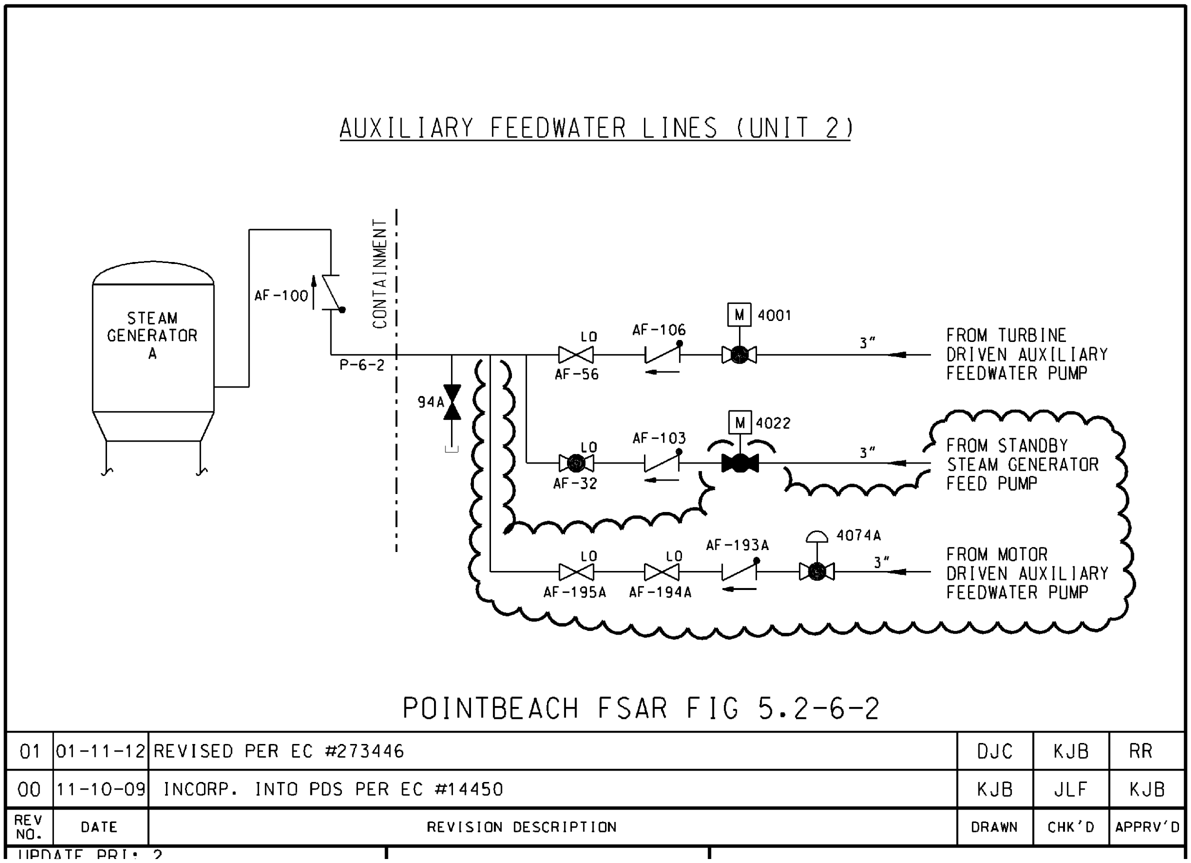

| PENETRATION | CONTAINMENT ISOLATION VALVES: INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 6-1 | CLOSED SYSTEM | AF-18 | TURBINE DRIVEN AUXILIARY FEED TO STEAM GENERATOR/ AF | 3" | W | HOT | 4 |
| | CLOSED SYSTEM | AF-31 | STANDBY STEAM GENERATOR FEED TO STEAM GENERATOR/ AF | 3" | W | HOT | 4 |
| | CLOSED SYSTEM | AF-195A | MOTOR DRIVEN AUXILIARY FEED TO STEAM GENERATOR/ AF | 3" | W | HOT | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIG. 10.2-1 SHEETS 1 AND 2

NOTE:

AUXILIARY FEEDWATER LINES - THESE ARE INCOMING LINES NORMALLY OPERATING AFTER A DBA. THE MANUAL ISOLATION VALVE REQUIREMENT FOR A CLASS 4 PENETRATION IS MET BY VALVES AF-31, AF-18, AND AF-195A.

# Figure 5.2-6-2 AUXILIARY FEEDWATER LINES (UNIT 2)

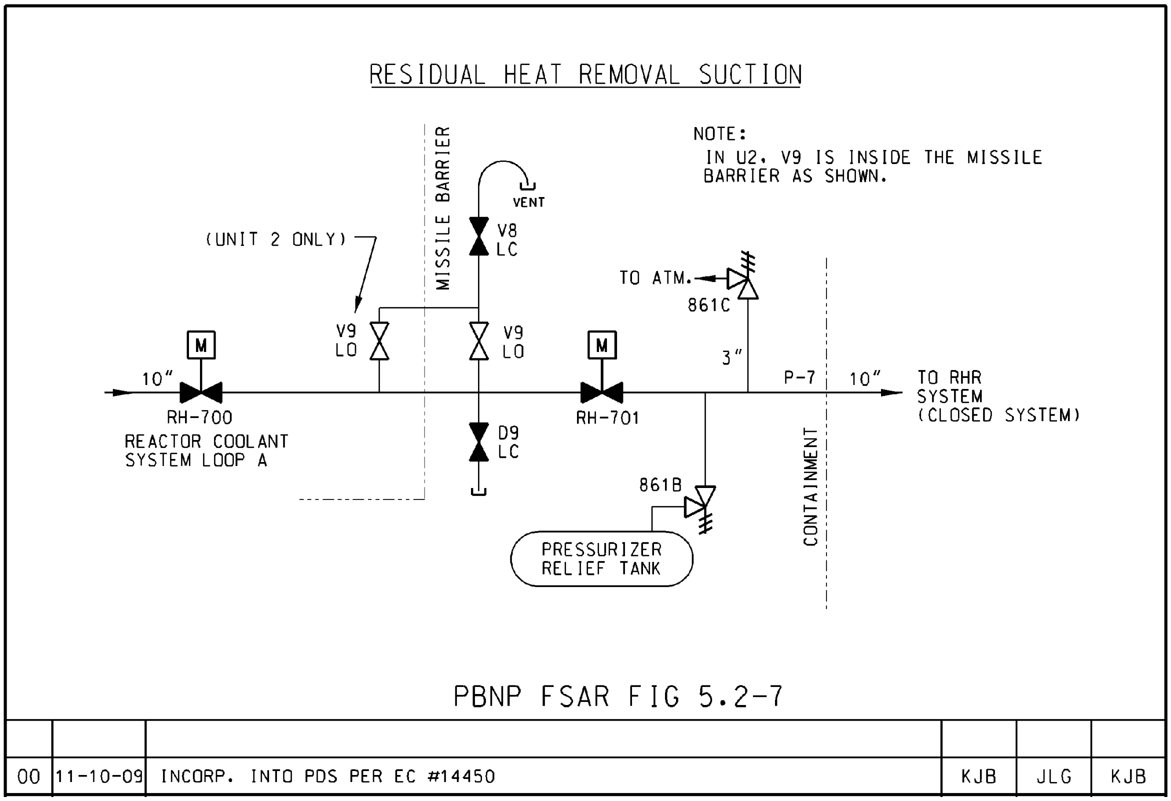



| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 6-2 | CLOSED SYSTEM | AF-56 | TURBINE DRIVEN AUXILIARY FEED TO STEAM GENERATOR/ AF | 3" | W | HOT | 4 |
| | CLOSED SYSTEM | AF-32 | STANDBY STEAM GENERATOR FEED TO STEAM GENERATOR/ AF | 3" | W | HOT | 4 |
| | CLOSED SYETEM | AF-195A | MOTOR DRIVEN AUXILIARY FEED TO STEAM GENERATOR/ AF | 3" | W | HOT | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIG. 10.2-1 SHEETS 1 AND 2

NOTE: AUXILIARY FEEDWATER LINES - THESE ARE INCOMING LINES NORMALLY OPERATING AFTER A DBA. THE MANUAL ISOLATION VALVE REQUIREMENT FOR A CLASS 4 PENETRATION IS MET BY VALVES AF-56, AF-32, AND AF-195A.

Figure 5.2-7 RESIDUAL HEAT REMOVAL SUCTION



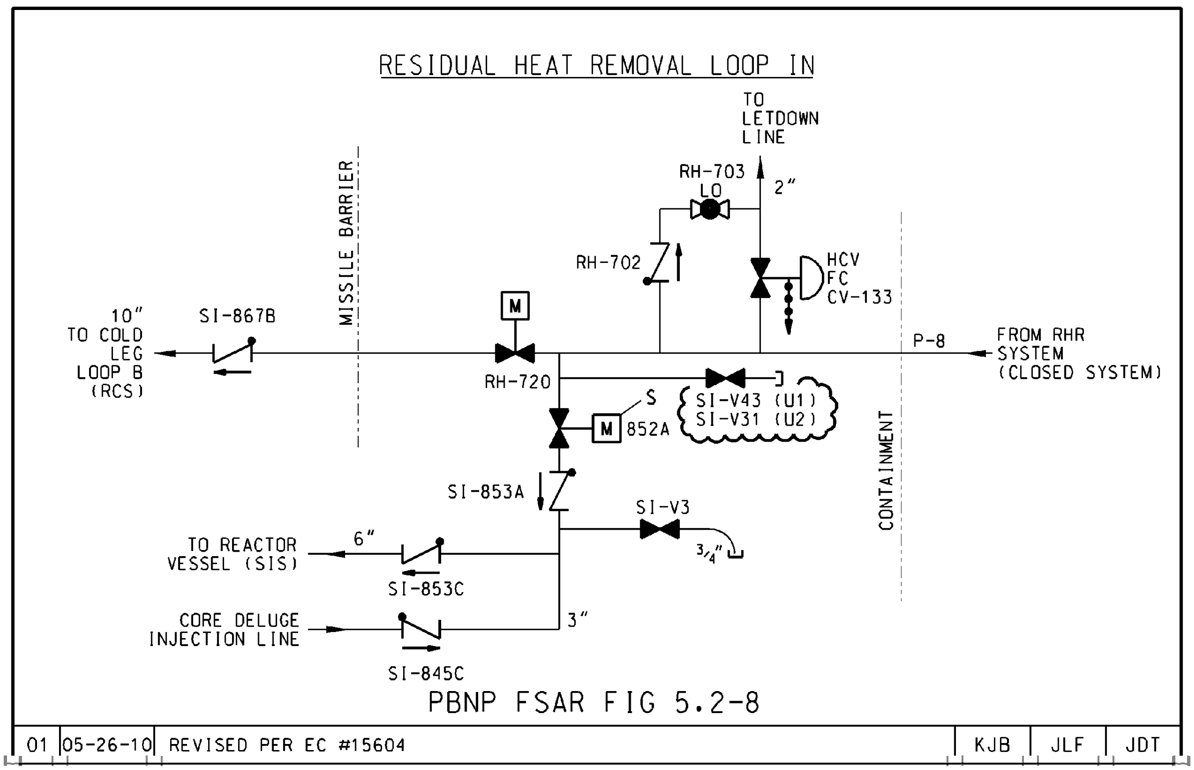

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 7 | RH-701 | CLOSED SYSTEM | RHR | 10" | W | HOT | SPECIAL |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.2-1

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IN USE POST DBA. THE CLOSED SYSTEM OUTSIDE CONTAINMENT PROVIDES THE CONTAINMENT ISLOATION BOUNDARY POST DBA.

Figure 5.2-8 RESIDUAL HEAT REMOVAL LOOP IN



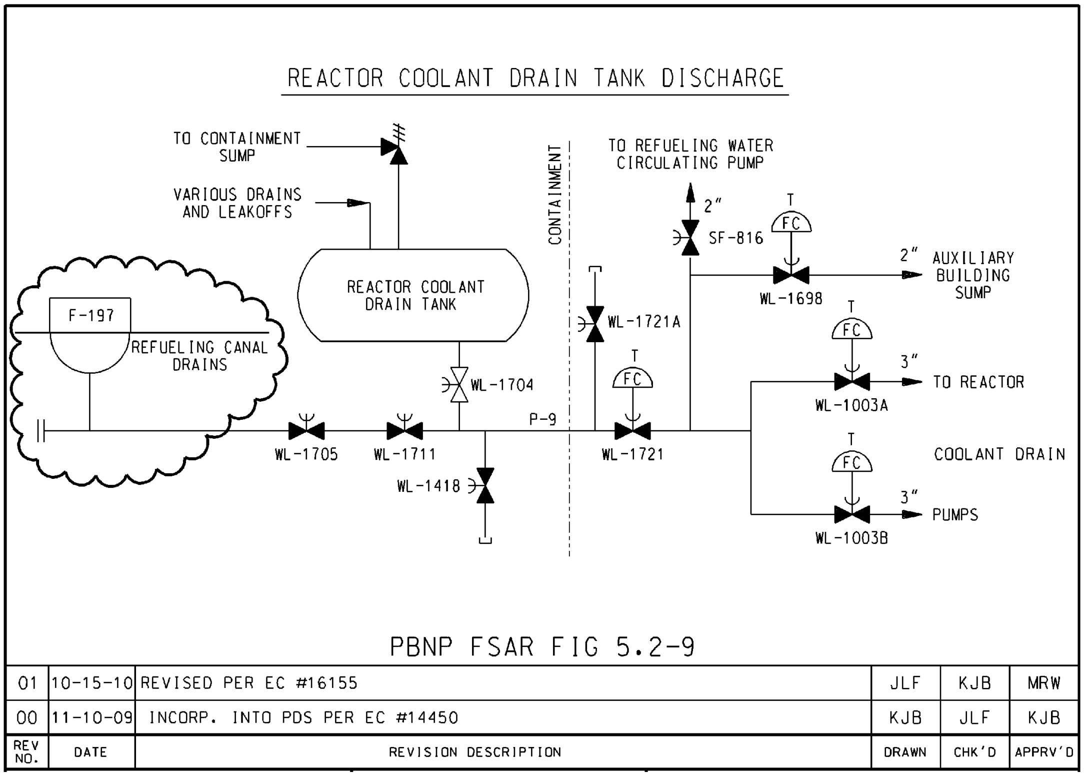

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 8 | SI-853A<br>RH-720<br>RH-702<br>CV-133 | CLOSED SYSTEM | RHR INJECTION TO LOOP B COLD LEG/ RHR | 10" | W | HOT | SPECIAL |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.3-1, FIGURE 9.4-1

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IN USE POST DBA. THE CLOSED SYSTEM OUTSIDE CONTAINMENT PROVIDES THE CONTAINMENT ISOLATION BOUNDARY POST DBA.

# Figure 5.2-9 REACTOR COOLANT DRAIN TANK DISCHARGE




| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 9 | | WL-1721<br>WL-1003A<br>WL-1003B | REACTOR COOLANT DRAIN PUMP SUCTION/WDS | 3" | W | COLD | 2 |
| | | WL-1721<br>SF-816 | REFUELING WATER CIRCULATION PUMP/ WDS | 2" | W | COLD | 2 |
| | | WL--1721<br>WL-1698 | AUXILIARY BUILDING SUMP/WDS | 2" | W | COLD | 2 |

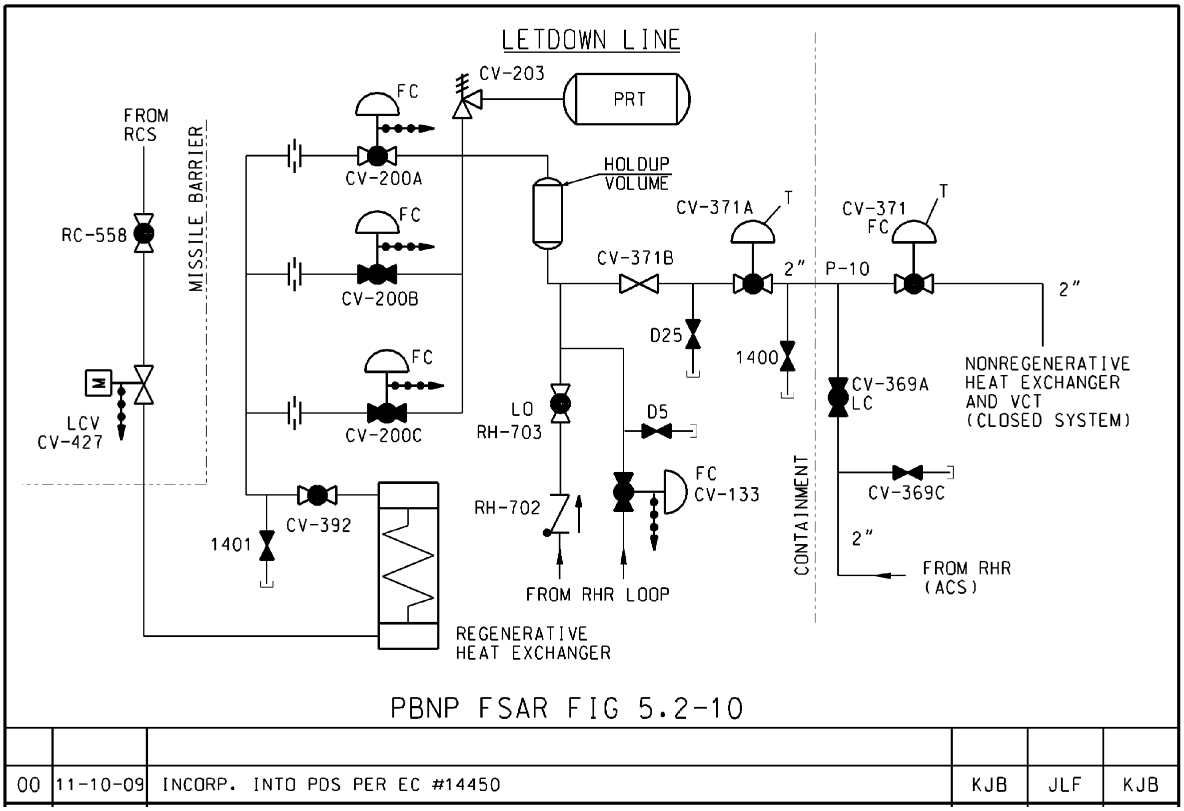
FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 11 & FIGURE 11.1-1

NOTE:

THIS PENETRATION MEETS CLASS 2 CONTAINMENT ISOLATION CRITERIA.

1. REACTOR COOLANT DRAIN PUMP SUCTION BRANCH - AUTOMATIC TRIP VALVE WL-1721 IN SERIES WITH AUTOMATIC TRIP VALVES WL-1003A AND WL-1003B OUTSIDE CONTAINMENT MEET CLASS 2 CRITERIA.
2. REFUELING WATER CIRCULATION PUMP BRANCH - AUTOMATIC TRIP VALVE WL-1721 IN SERIES WITH LOCKED CLOSED MANUAL VALVE SF-816 SERVING THE PURPOSE OF AN AUTOMATIC TRIP VALVE OUTSIDE CONTAINMENT MEET CLASS 2 CRITERIA.
3. AUXILIARY BUILDING SUMP BRANCH - AUTOMATIC TRIP VALVE WL-1721 IN SERIES WITH AUTOMATIC TRIP VALVE WL-1698 OUTSIDE CONTAINMENT MEET CLASS 2 CRITERIA.

Figure 5.2-10 LETDOWN LINE




| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200<br>COLD<200 | CLASS |
| 10 | CV-371A | CV-371 | LETDOWN LINE/RCS | 2” | W | HOT | 1 |
| | CV-371A | CV-369A | RHR PUMP DISCHARGE TO LETDOWN LINE/RHR | 2” | W | HOT | 1 |

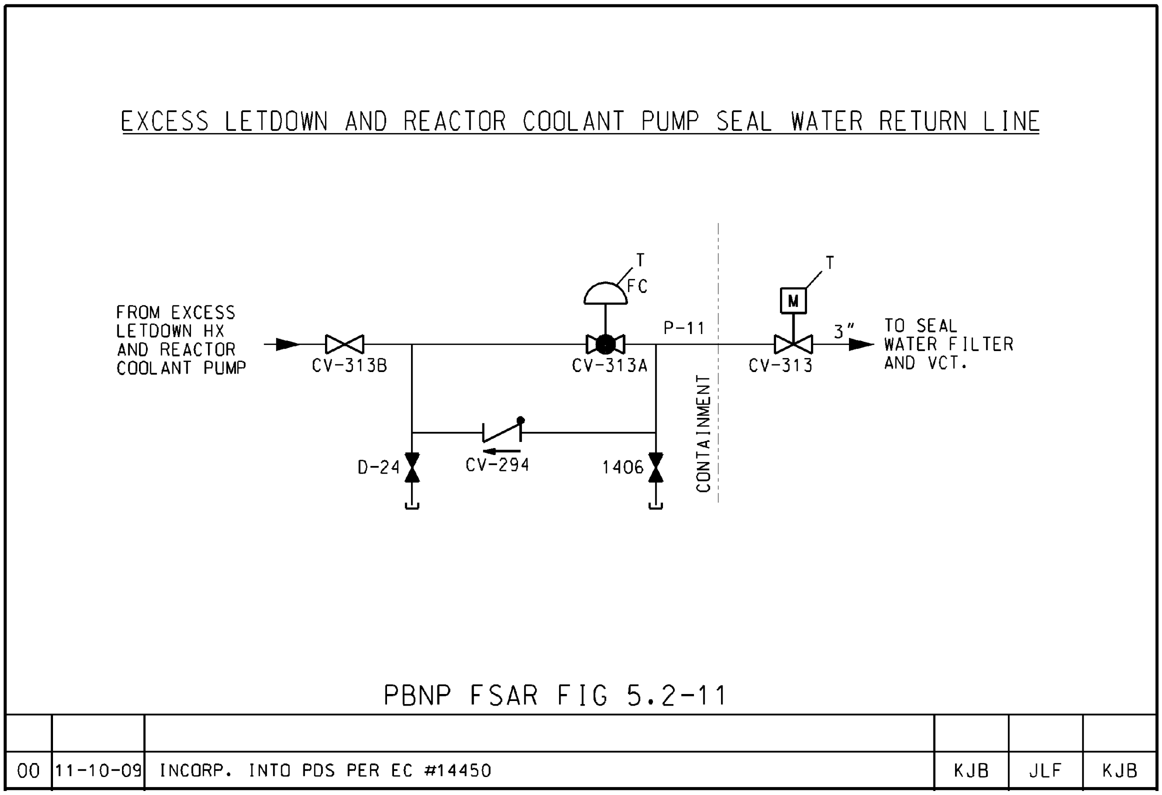
FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.2-1, 9.2-2

NOTE:

THIS PENETRATION MEETS CLASS 1 CONTAINMENT ISOLATION CRITERIA.

1. LETDOWN LINE BRANCH - AUTOMATIC TRIP VALVES CV-371A INSIDE CONTAINMENT AND CV-371 OUTSIDE CONTAINMENT MEET CLASS 1 CRITERIA.
2. RHR PUMP DISCHARGE TO LETDOWN LINE BRANCH - AUTOMATIC TRIP VALVE CV-371A INSIDE CONTAINMENT AND LOCKED SHUT MANUAL VALVE CV-369A OUTSIDE CONTAINMENT SERVING THE PURPOSE OF AN AUTOMATIC TRIP VALVE MEET CLASS 1 CRITERIA.

Figure 5.2-11 EXCESS LETDOWN AND REACTOR COOLANT PUMP SEAL WATER RETURN LINE



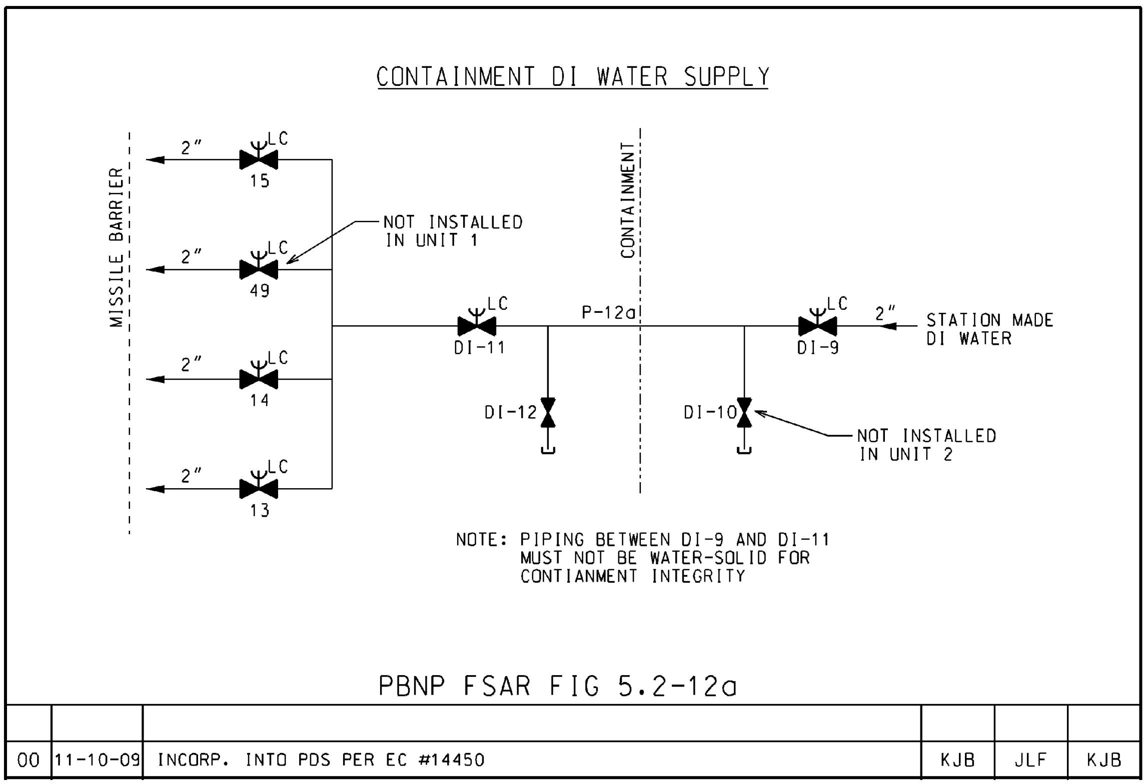

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200<br>COLD<200 | CLASS |
| 11 | CV-313A<br>CV-294 | CV-313 | EXCESS LETDOWN AND REACTOR COOLANT PUMP SEAL WATER RETURN/CV | 3" | W | HOT | 1 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9

NOTE:

THIS PENETRATION MEETS CLASS 1 CONTAINMENT ISOLATION CRITERIA WITH AUTOMATIC TRIP VALVES CV-313A INSIDE CONTAINMENT AND CV-313 OUTSIDE CONTAINMENT.

# Figure 5.2-12a CONTAINMENT DI WATER SUPPLY

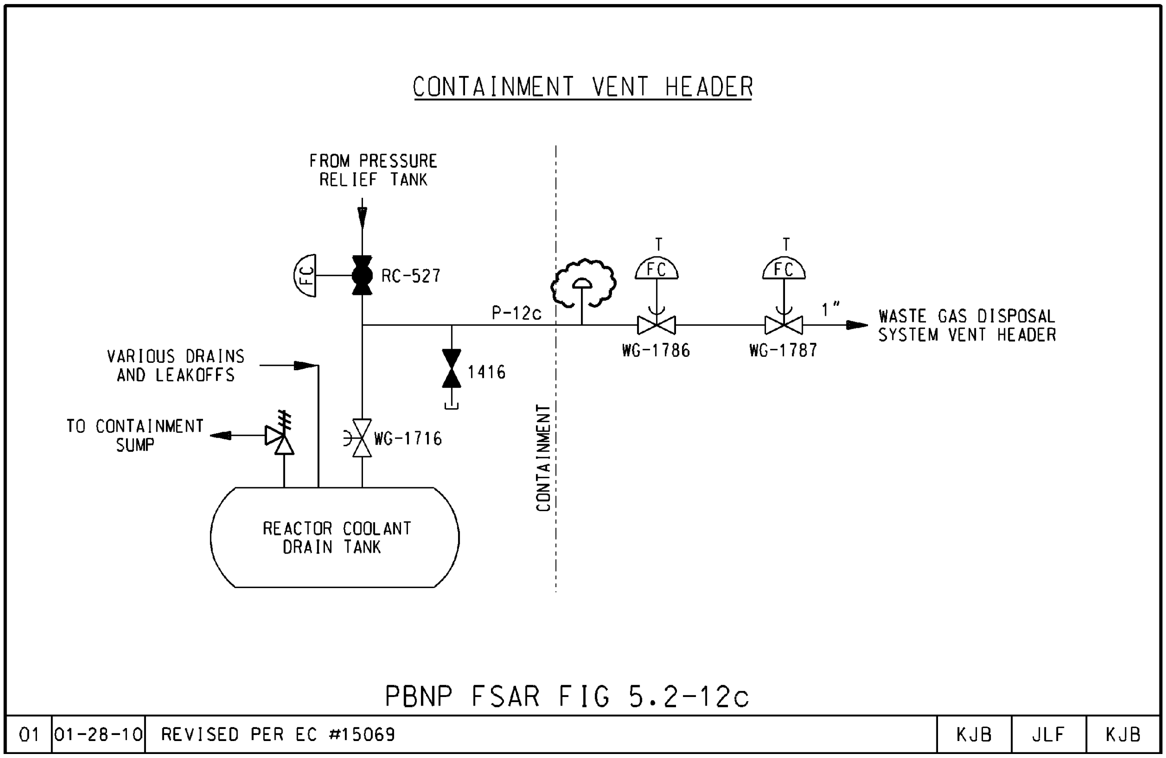



| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 12a | DI-11 | DI-9 | CONTAINMENT SECTION DI WATER CONNECTIONS | 2" | W | COLD | 5 |

NOTE:

THIS PENETRATION MEETS CLASS 5 CONTAINMENT ISOLATION CRITERIA WITH LOCKED CLOSED MANUAL VALVE DI-11 INSIDE CONTAINMENT AND LOCKED CLOSED MANUAL VALVE DI-9 OUTSIDE CONTAINMENT.

Figure 5.2-12c CONTAINMENT VENT HEADER



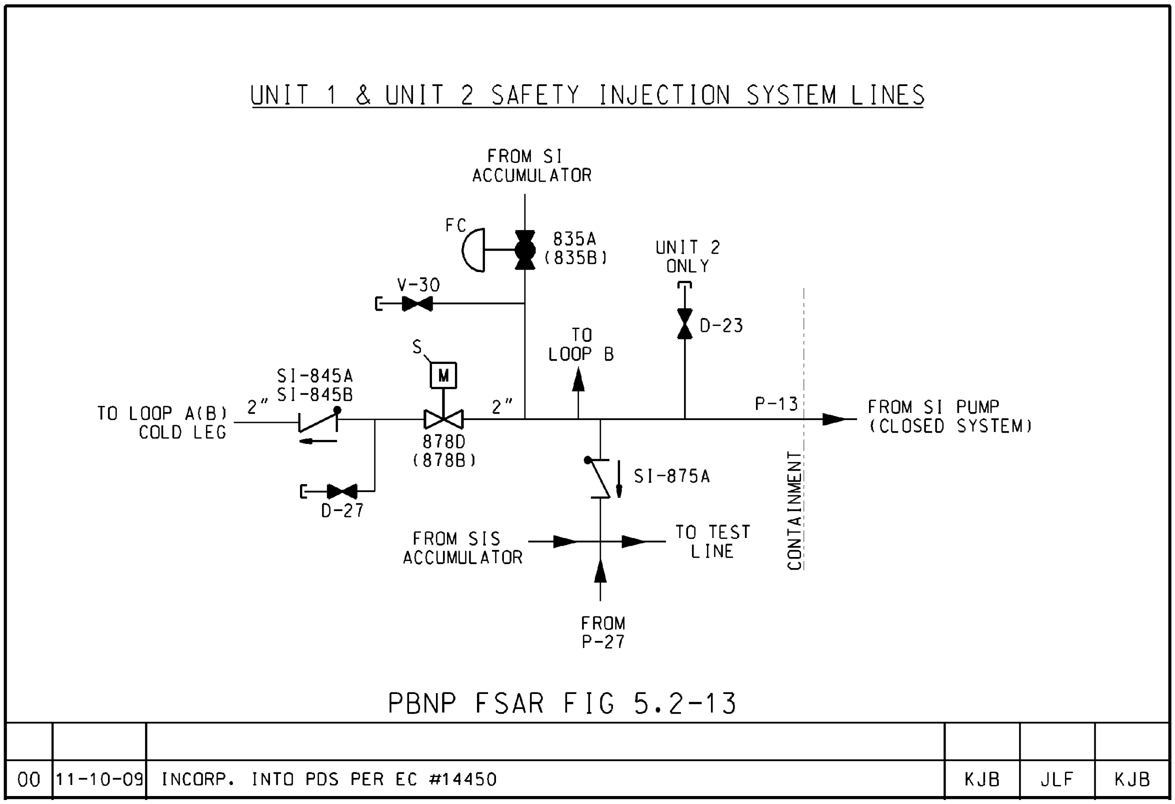

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 12c | | WG-1786<br>WG-1787 | REACTOR COOLANT DRAIN TANK TO VENT HEADER/WDS | 1" | G | COLD | 2 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 11 & FIGURE 11.1-1

NOTE:

THIS PENETRATION MEETS CLASS 2 CONTAINMENT ISOLATION CRITERIA WITH AUTOMATIC TRIP VALVES WG-1786 AND WG-1787 IN SERIES OUTSIDE CONTAINMENT.

Figure 5.2-13 UNIT 1 AND UNIT 2 SAFETY INJECTION SYSTEM LINES



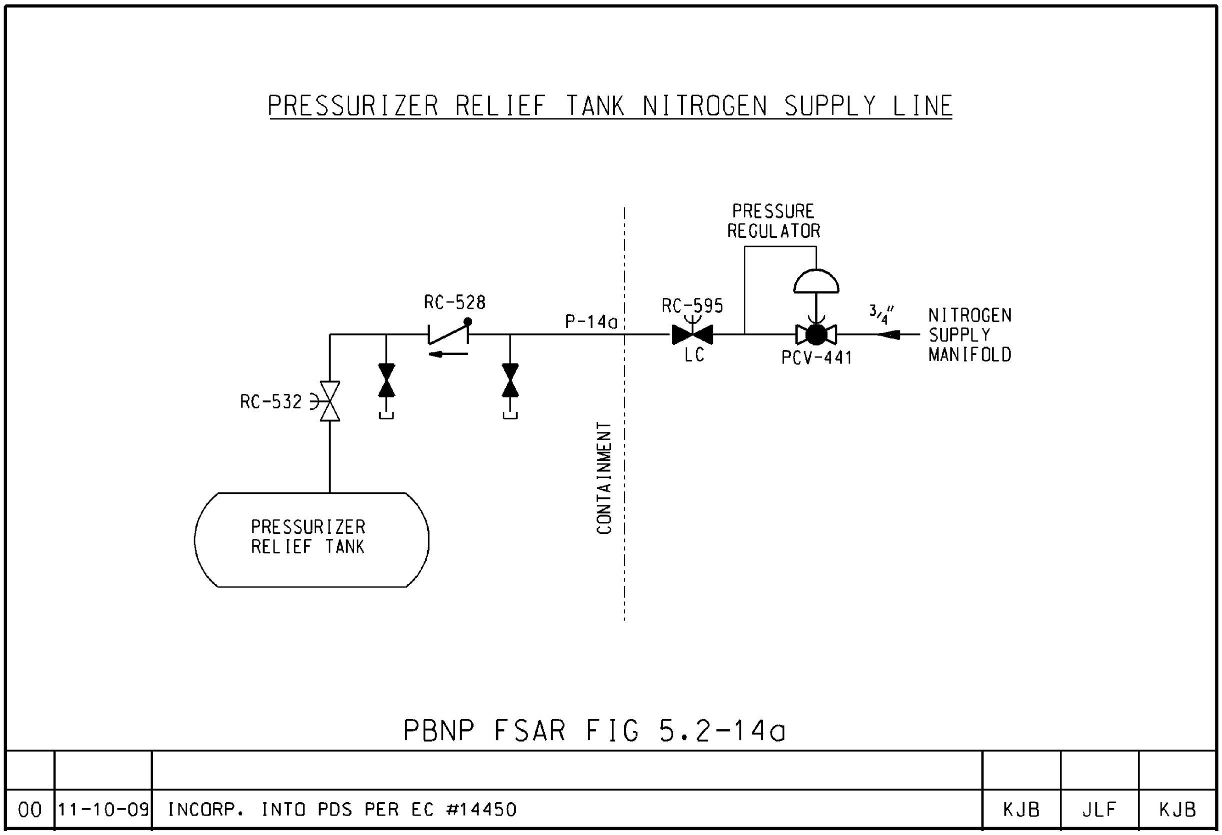

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200<br>COLD<200 | CLASS |
| 13 | SI-845A,B<br>SI-875B<br>SI-835A,B | CLOSED<br>SYS | SAFETY INJECTION<br>SYS<br>COLD LEG/SIS | 4" | W | COLD | SPECIAL |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 6

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IN USE POST DBA. THE CLOSED SYSTEM OUTSIDE CONTAINMENT PROVIDES THE CONTAINMENT ISOLATION BOUNDARY POST DBA.

Figure 5.2-14a PRESSURIZER RELIEF TANK NITROGEN SUPPLY LINE



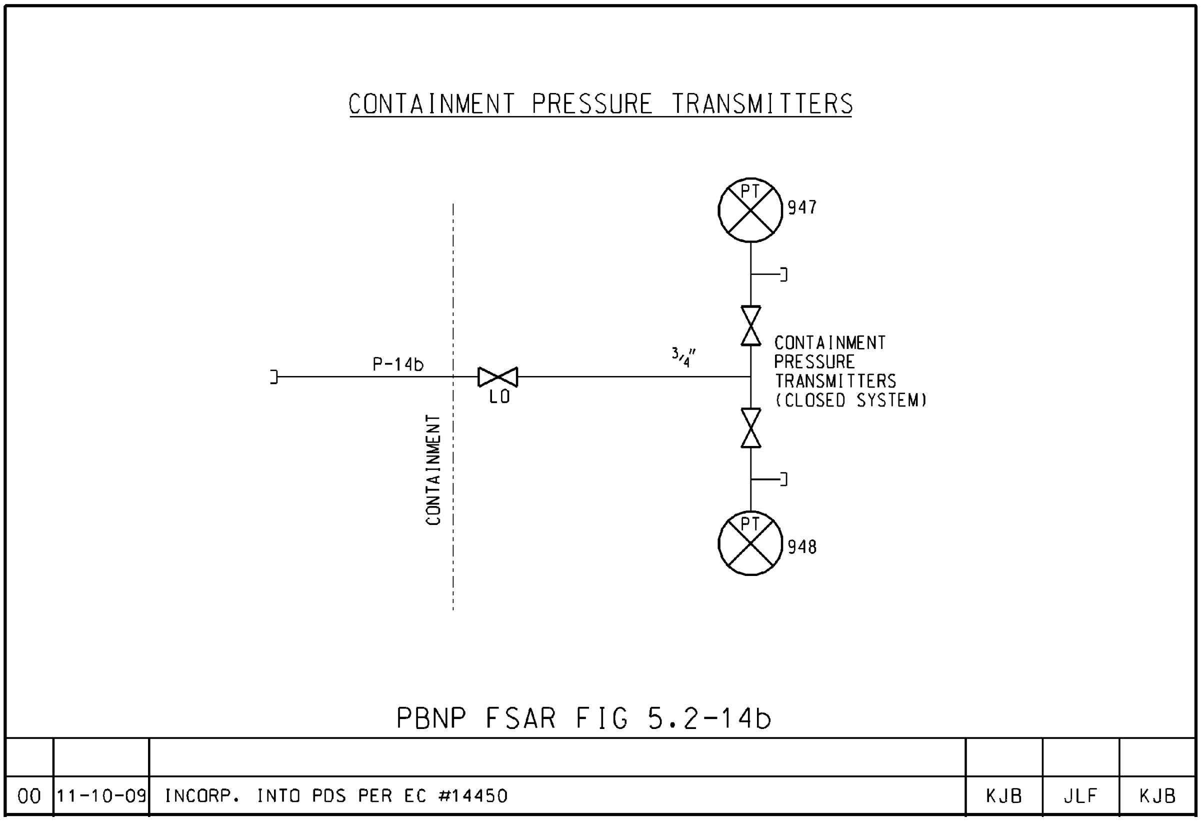

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 14a | RC-528 | RC-595 | NITROGEN SUPPLY TO PRESSURE RELIEF TANK /REACTOR COOLANT SYS. | 3/4” | G | COLD | 3 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 4 & FIGURE 4.2-1 SHT. 2

NOTE:

THIS PENETRATION MEETS CLASS 3 CONTAINMENT ISOLATION CRITERIA WITH CHECK VALVE RC-528 INSIDE CONTAINMENT SERVING THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND LOCKED CLOSED MANUAL VALVE RC-595 OUTSIDE CONTAINMENT SERVING THE PURPOSE OF AN AUTOMATIC TRIP VALVE.

# Figure 5.2-14b CONTAINMENT PRESSURE TRANSMITTERS

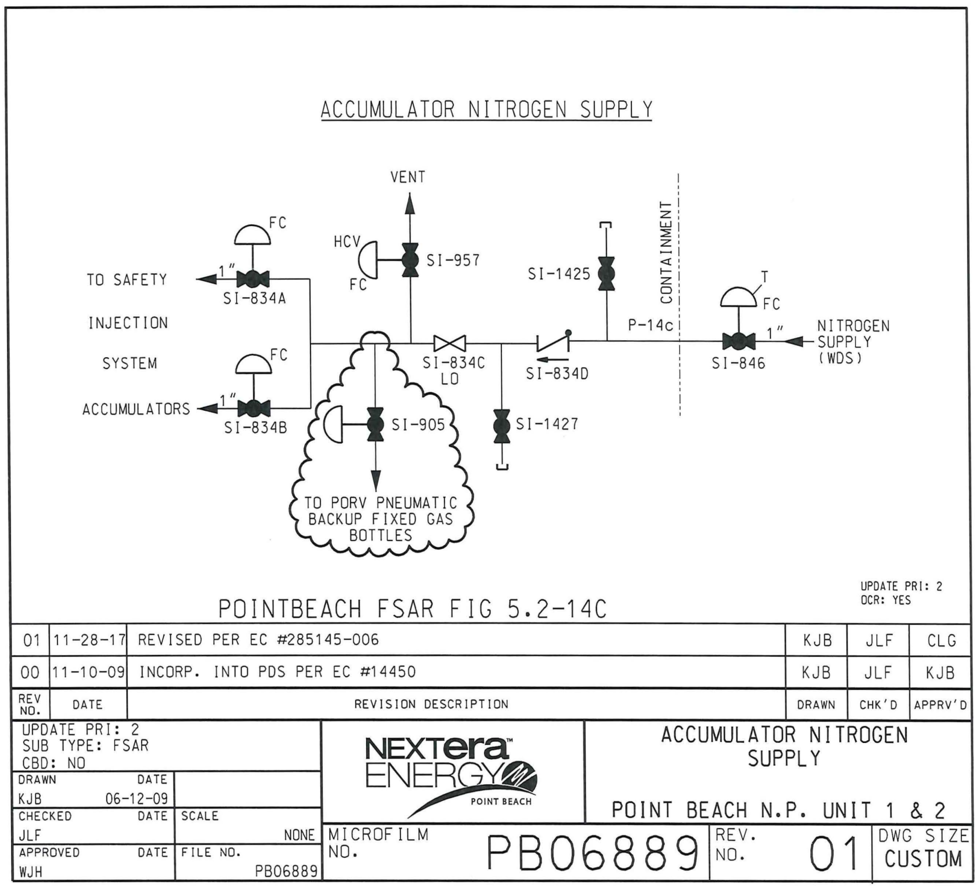



| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | CONTAINMENT ISOLATION VALVES OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 14b | | MANUAL VALVE CLOSED SYS. | CONTAINMENT PRESSURE TRANSMITTER. | 3/4” | G | COLD | SPECIAL |

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IN USE POST DBA. THE CLOSED SYSTEM OUTSIDE CONTAINMENT PROVIDES THE CONTAINMENT ISOLATION BOUNDARY POST DBA.

Figure 5.2-14c ACCUMULATOR NITROGEN SUPPLY



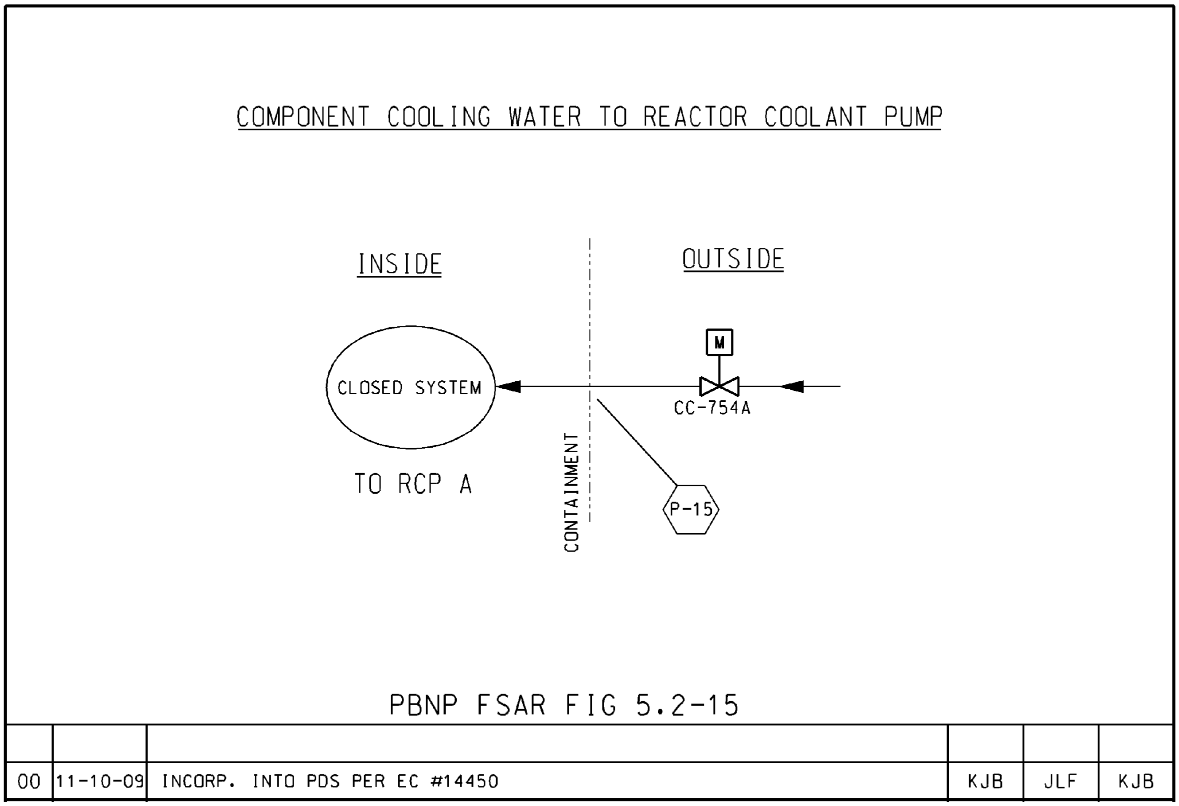

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 14c | SI-834D | SI-846 | NITROGEN SUPPLY TO ACCUMULATOR/ SAFETY INJECTION SYSTEM. | 1" | G | COLD | 3 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 6 & FIGURE 6.2-1 SHEET 1

NOTE:

THIS MEETS CLASS 3 CRITERIA. SI-846 MEETS THE REQUIREMENT TO HAVE AN AUTOMATIC TRIP VALVE OUTSIDE CONTAINMENT. CHECK VALVE SI-834D MEETS THE REQUIREMENT TO HAVE AN AUTOMATIC TRIP VALVE INSIDE CONTAINMENT.

# Figure 5.2-15 COMPONENT COOLING WATER TO REACTOR COOLANT PUMP

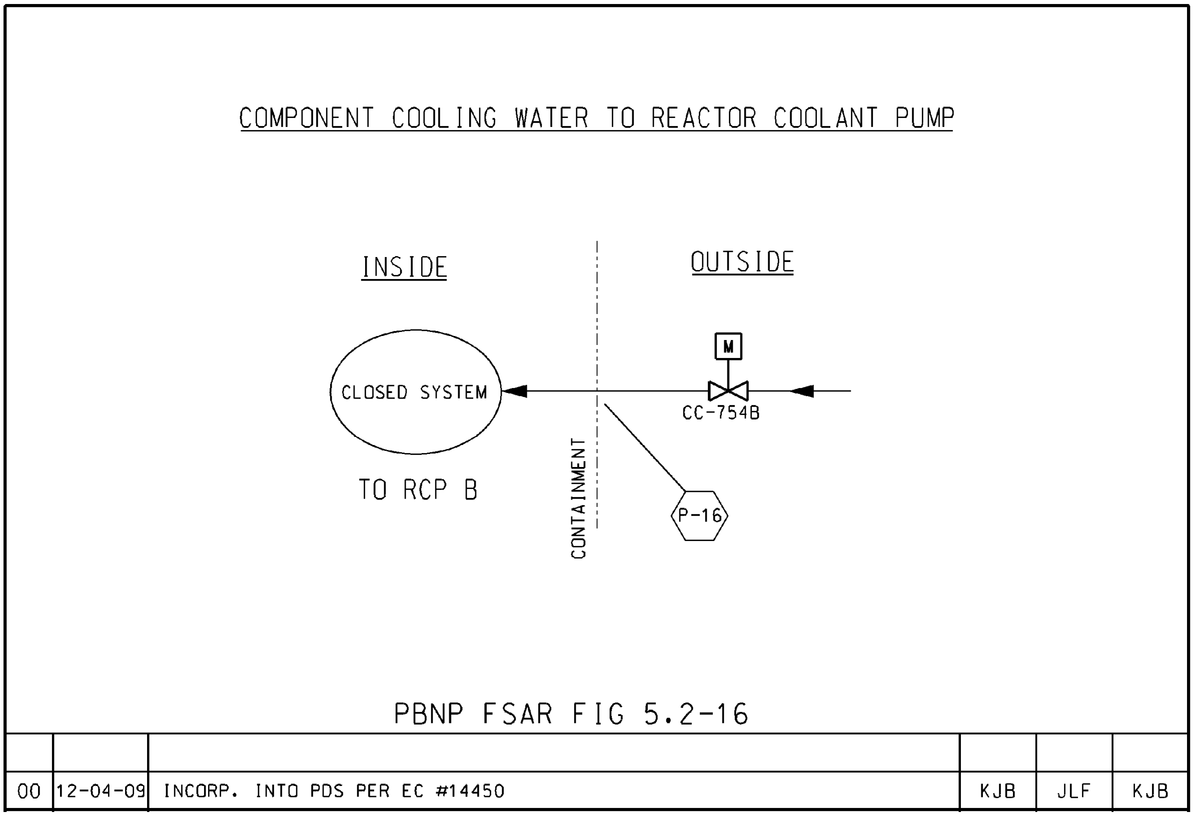



| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 15 | CLOSED SYSTEM | CC-754A | CC WATER SUPPLY TO RCP A. | 4” | W | COLD | 4 |

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH CLOSED SYSTEM INSIDE CONTAINMENT AND REMOTELY OPERATED VALVE CC-754A OUTSIDE CONTAINMENT.

Figure 5.2-16 COMPONENT COOLING WATER TO REACTOR COOLANT PUMP

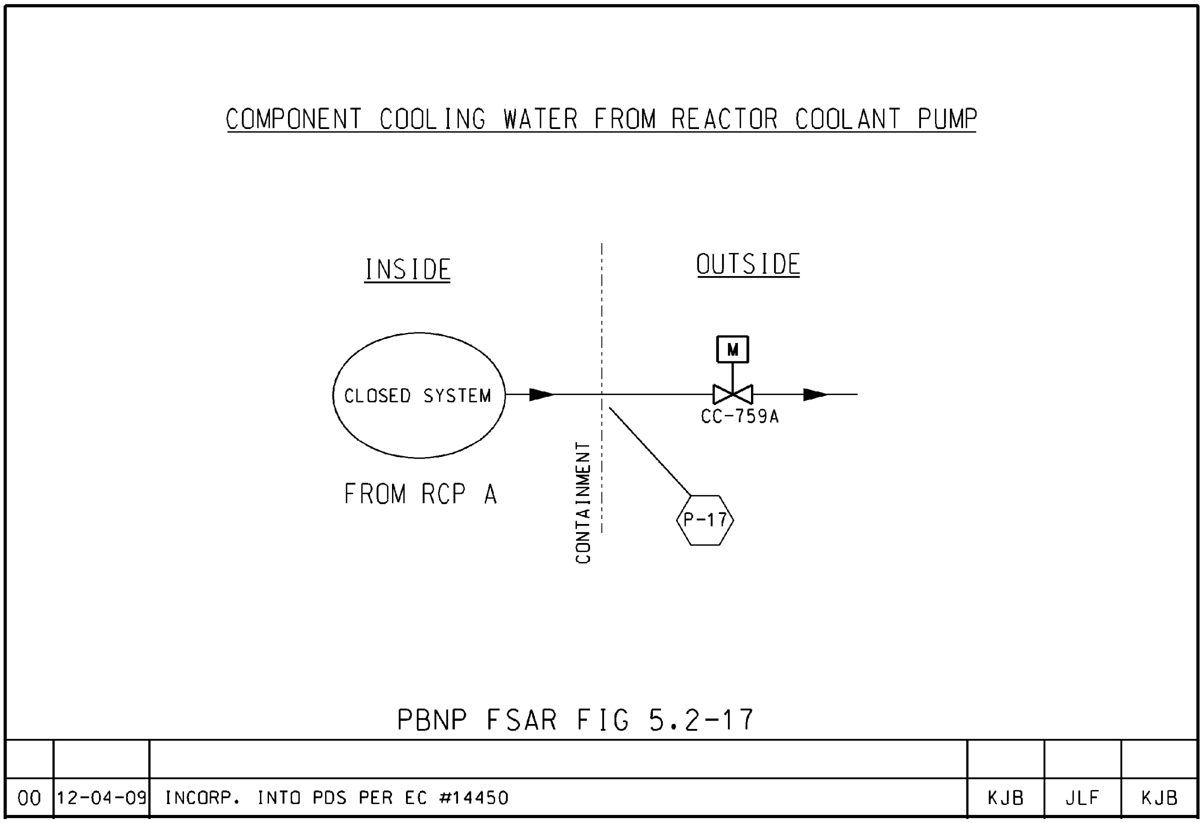



| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 16 | CLOSED SYSTEM | CC-754B | CC WATER SUPPLY TO RCP B. | 4” | W | COLD | 4 |

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH CLOSED SYSTEM INSIDE CONTAINMENT AND REMOTELY OPERATED VALVE CC-754B OUTSIDE CONTAINMENT.

Figure 5.2-17 COMPONENT COOLING WATER FROM REACTOR COOLANT PUMP

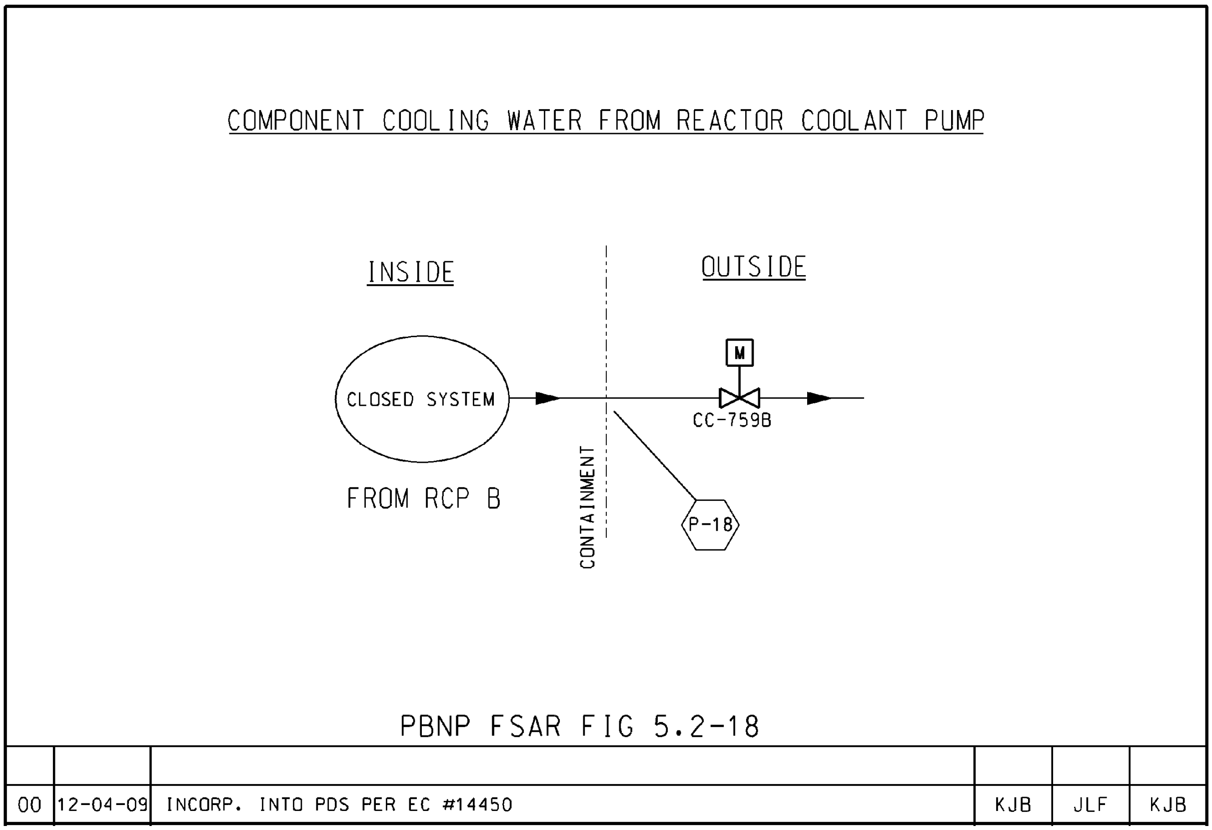



| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | CONTAINMENT ISOLATION VALVES OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 17 | CLOSED SYSTEM | CC-759A | CC WATER RETURN FROM RCP A. | 4” | W | COLD | 4 |

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH CLOSED SYSTEM INSIDE CONTAINMENT AND REMOTELY OPERATED VALVE CC-759A OUTSIDE CONTAINMENT.

# Figure 5.2-18 COMPONENT COOLING WATER FROM REACTOR COOLANT PUMP

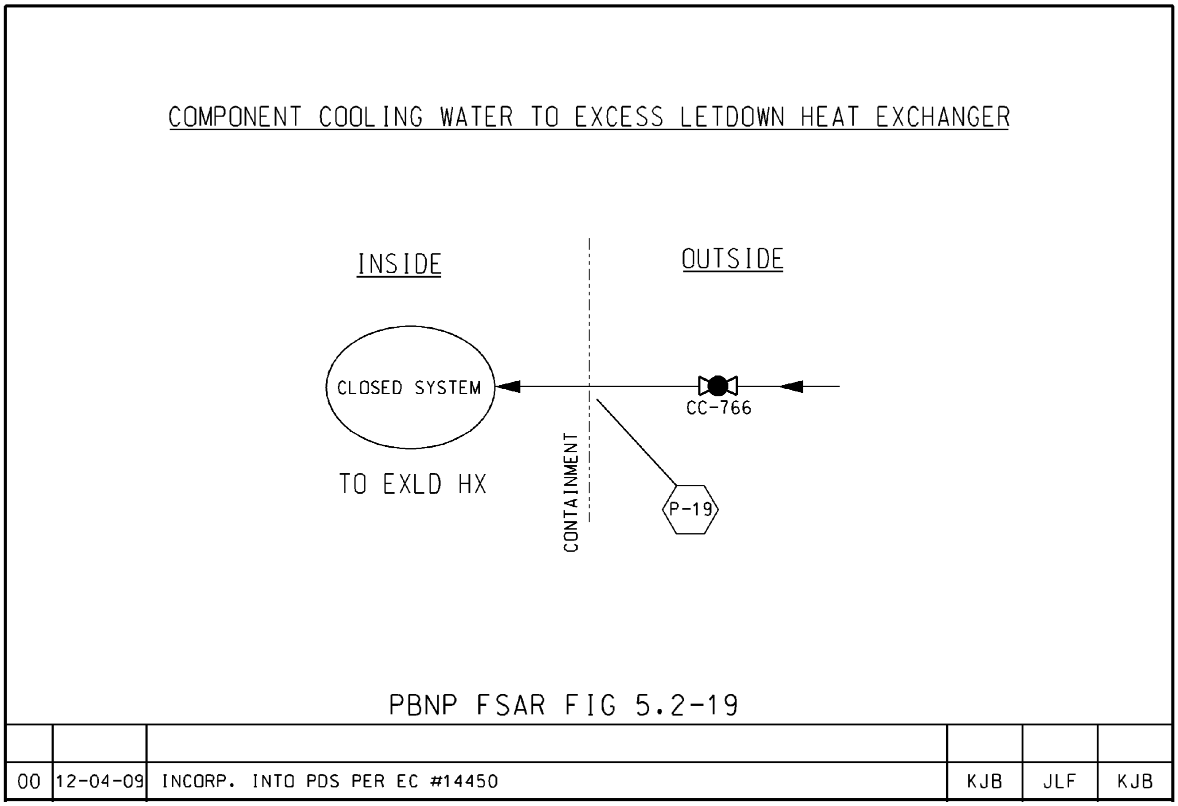



| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | CONTAINMENT ISOLATION VALVES OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 18 | CLOSED SYSTEM | CC-759B | CC WATER RETURN FROM RCP B. | 4” | W | COLD | 4 |

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH CLOSED SYSTEM INSIDE CONTAINMENT AND REMOTELY OPERATED VALVE CC-759B OUTSIDE CONTAINMENT.

# Figure 5.2-19 COMPONENT COOLING WATER TO EXCESS LETDOWN HEAT EXCHANGER

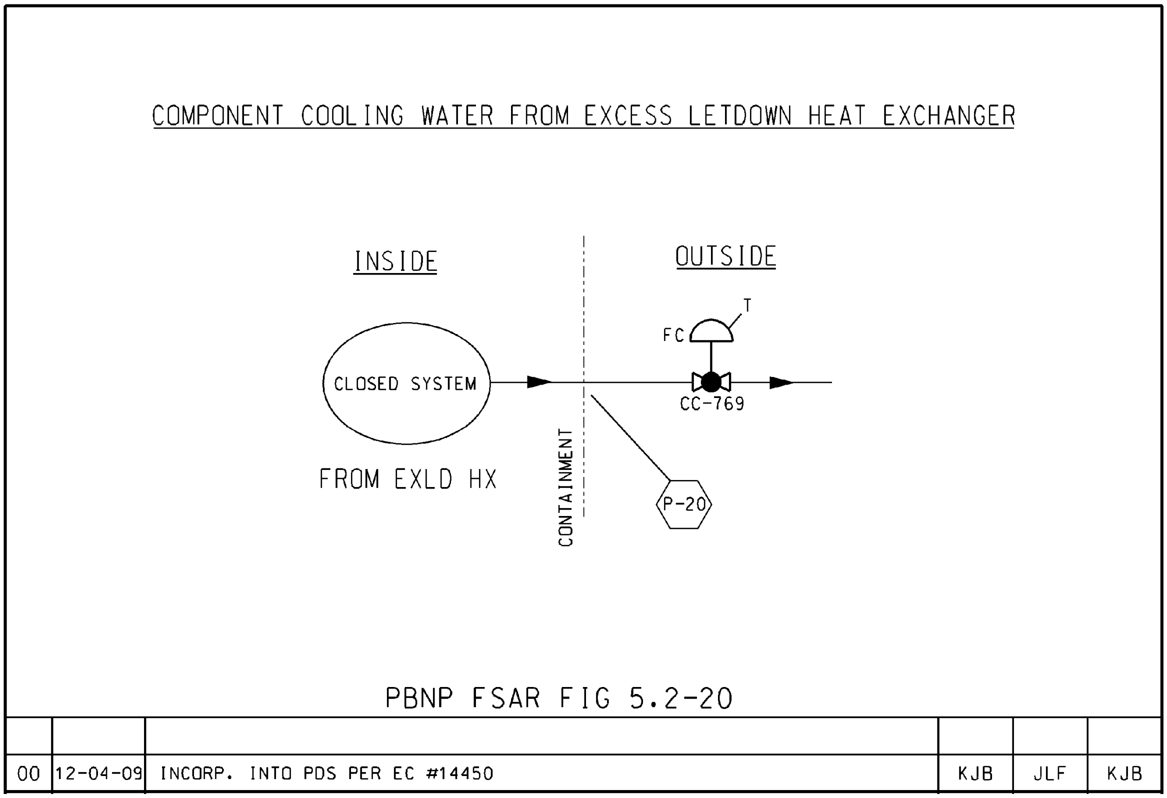



| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | CONTAINMENT ISOLATION VALVES OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 19 | CLOSED SYSTEM | CC-766 | CC WATER SUPPLY TO EXCESS LETDOWN HEAT EXCHANGER. | 2” | W | COLD | 4 |

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH CLOSED SYSTEM INSIDE CONTAINMENT AND MANUALLY OPERATED VALVE CC-766 OUTSIDE CONTAINMENT.

# Figure 5.2-20 COMPONENT COOLING WATER FROM EXCESS LETDOWN HEAT EXCHANGER

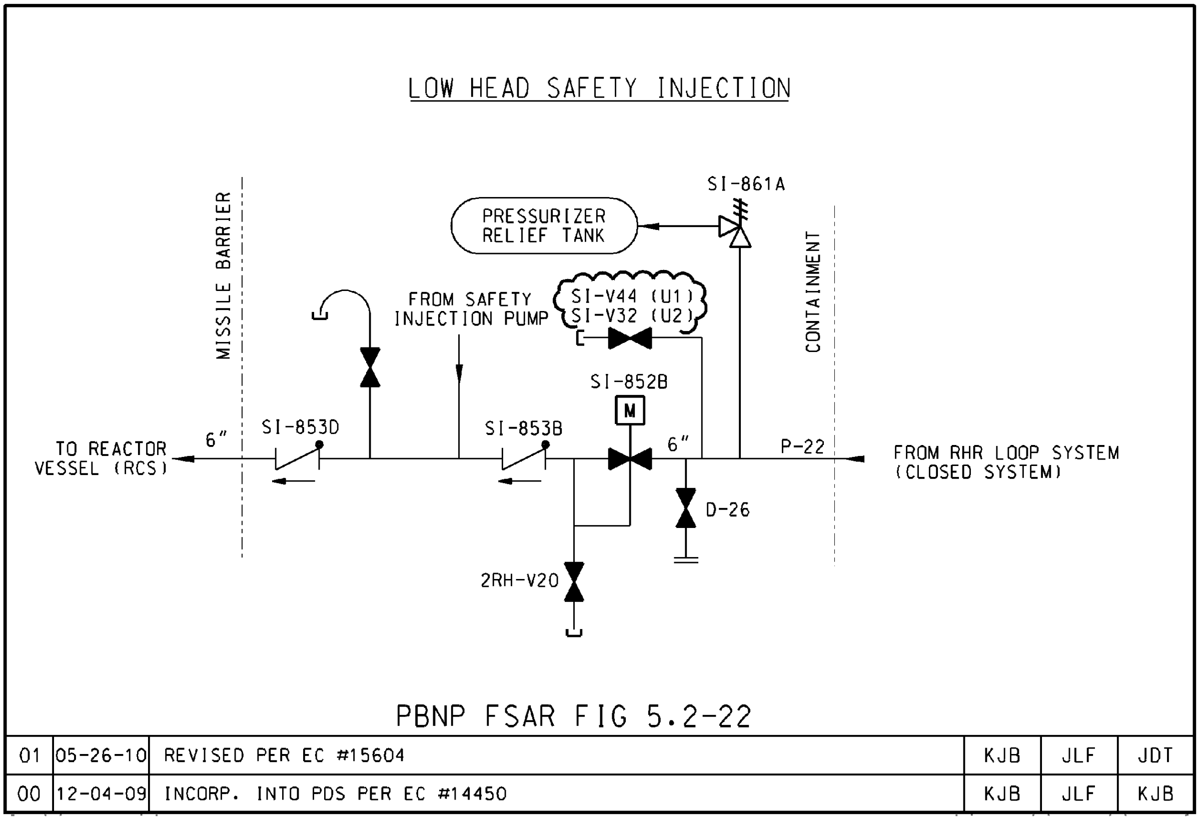



| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 20 | CLOSED SYSTEM | CC-769 | CC WATER RETURN FROM EXCESS LETDOWN HEAT EXCHANGER. | 2” | W | COLD | 4 |

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH CLOSED SYSTEM INSIDE CONTAINMENT AND AUTOMATIC TRIP VALVE CC-769 OUTSIDE CONTAINMENT.

# Figure 5.2-22 LOW HEAD SAFETY INJECTION



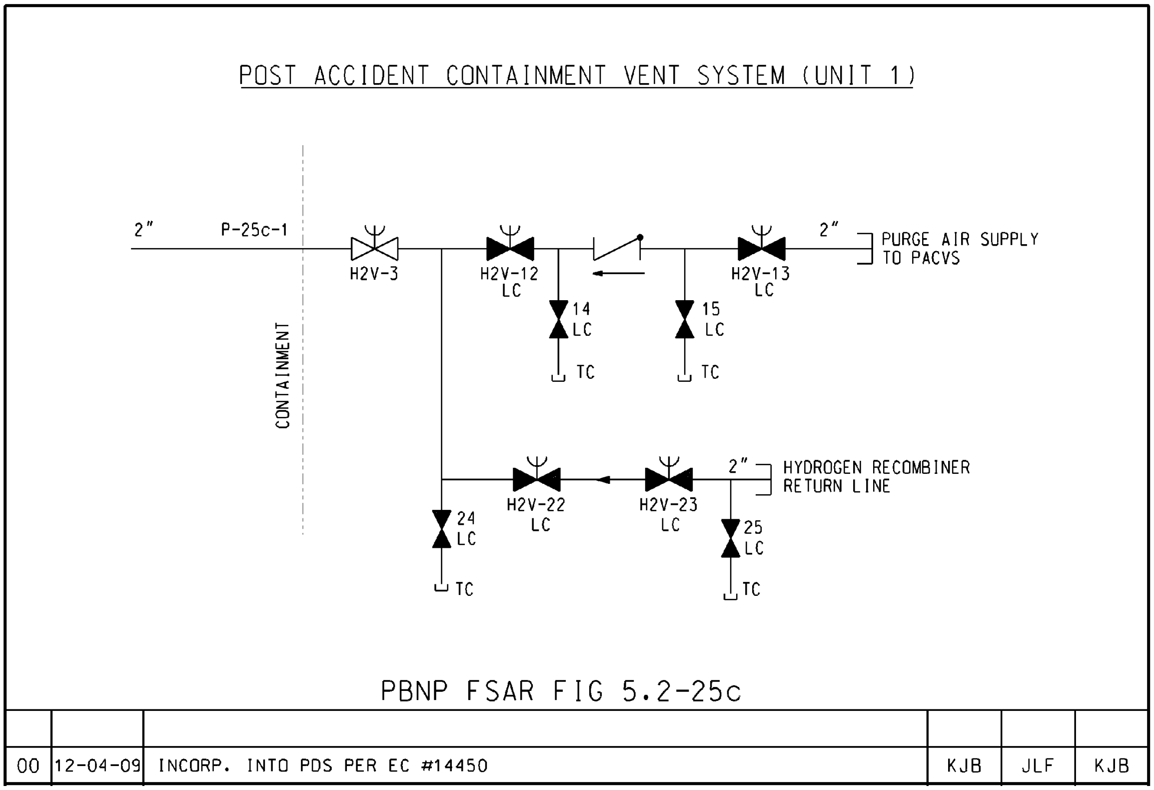

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 22 | SI-853B | CLOSED SYSTEM. | REACTOR VESSEL INJECTION LINE/ SAFETY INJECTION SYSTEM. | 6” | W | HOT | SPECIAL |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 6 & FIGURE 6.2-1 SHT. 1

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IN USE POST DBA. THE CLOSED SYSTEM OUTSIDE CONTAINMENT PROVIDES THE CONTAINMENT ISOLATION BOUNDARY POST DBA.

Figure 5.2-25c POST-ACCIDENT CONTAINMENT VENT SYSTEM (UNIT 1)




| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 25c-1 | | H2V-12<br>H2V-13 | PURGE AIR TO POST ACCIDENT CONTAINMENT VENT SYS./PACVS | 2” | G | COLD | SPECIAL |
| | | H2V-22<br>H2V-23 | $H_2$ RECOMBINER RETURN LINE/PACVS | 2” | G | COLD | SPECIAL |

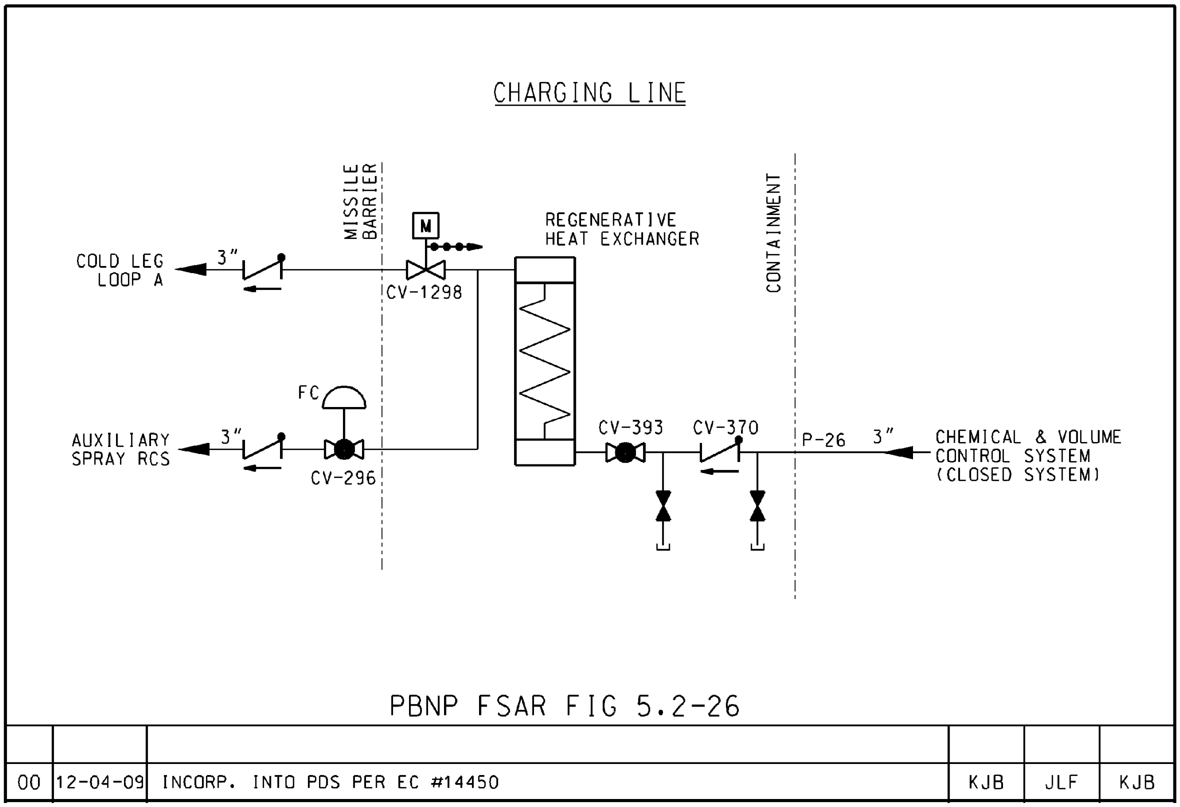
FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 5 & FIGURE 5.3-1 SHEET 2 & FIGURE 5.3-1 SHEET 3

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IDENTIFIED AS AN INTERMITTENT USE SYSTEM POST DBA.

1. PURGE AIR SUPPLY BRANCH - LOCKED CLOSED MANUAL VALVES H2V-12 AND H2V-13 OUTSIDE CONTAINMENT MEET CONTAINMENT ISOLATION CRITERIA.
2. HYDROGEN RECOMBINER BRANCH - LOCKED CLOSED MANUAL VALVES HSV-22 AND H2V-23 OUTSIDE CONTAINMENT MEET CONTAINMENT ISOLATION CRITERIA.

# Figure 5.2-26 CHARGING LINE



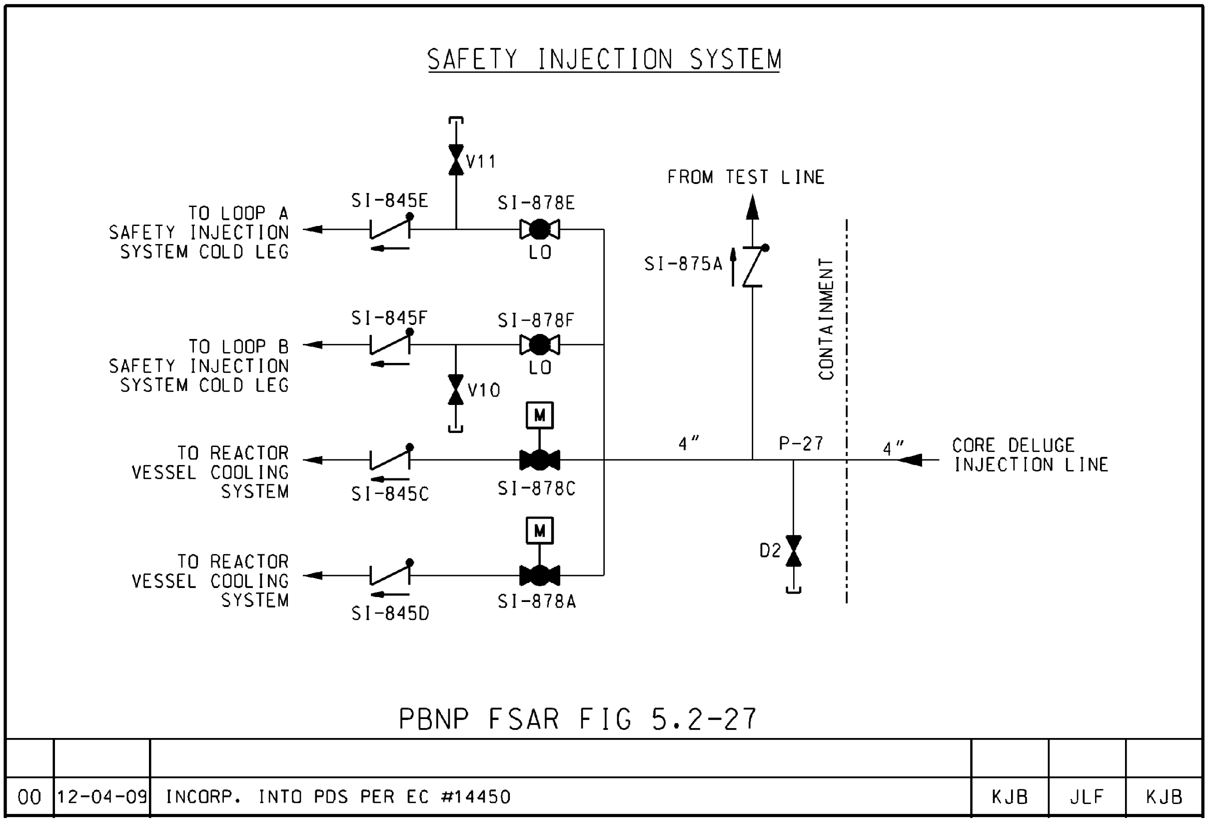

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 26 | CV-370 | CLOSED SYSTEM | CHARGING LINE/ CHEMICAL & VOLUME CONTROL SYS. | 3" | W | HOT | 3 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.2-1, 9.2-2

NOTE:

THIS PENETRATION MEETS CLASS 3 CONTAINMENT ISOLATION CRITERIA WITH CHECK VALVE CV-370 INSIDE CONTAINMENT SERVING THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND CVCS A CLOSED SYSTEM OUTSIDE CONTAINMENT.

# Figure 5.2-27 SAFETY INJECTION SYSTEM



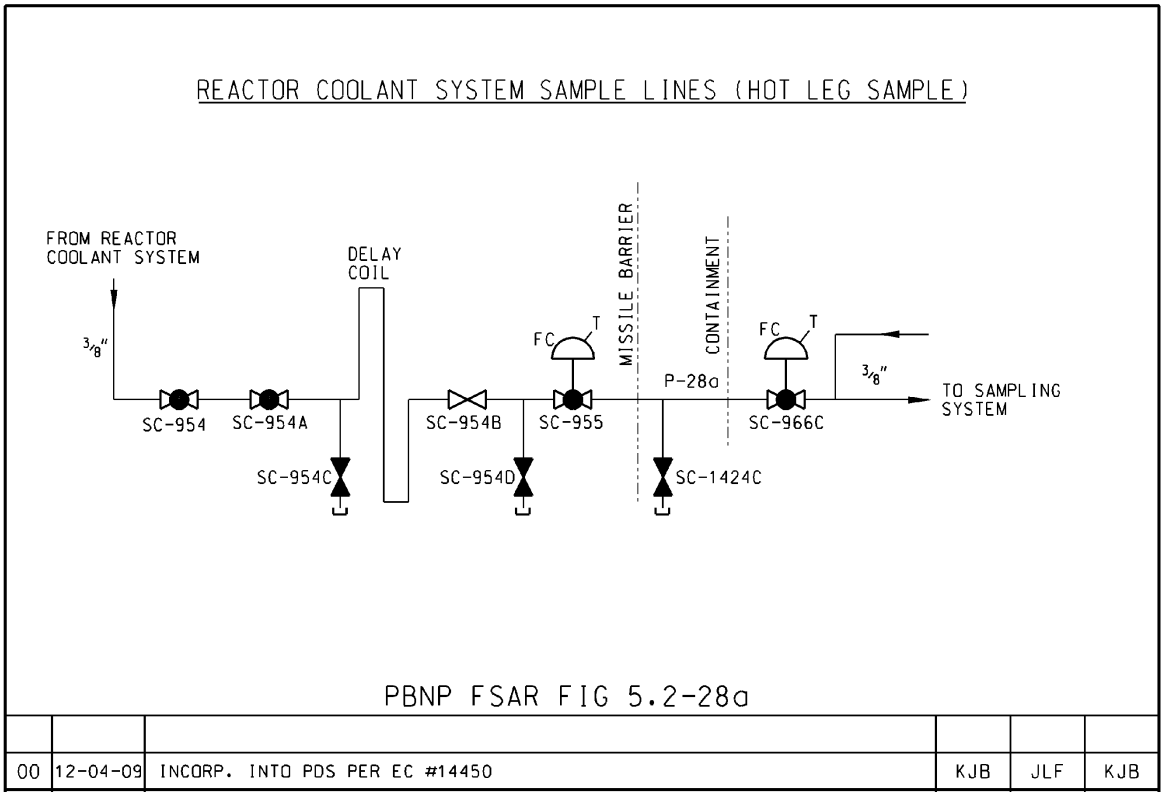

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200<br>COLD<200 | CLASS |
| 27 | SI-845C & D<br>SI-845E & F<br>SI-875A | CLOSED SYSTEM. | SAFETY INJECTION SYSTEM. | 4" | W | COLD | SPECIAL |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 6 & FIGURE 6.2-1 SHEET 1

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IN USE POST DBA. THE CLOSED SYSTEM OUTSIDE CONTAINMENT PROVIDES THE CONTAINMENT ISOLATION BOUNDARY POST DBA.

Figure 5.2-28a REACTOR COOLANT SYSTEM SAMPLE LINES (HOT LEG SAMPLE)



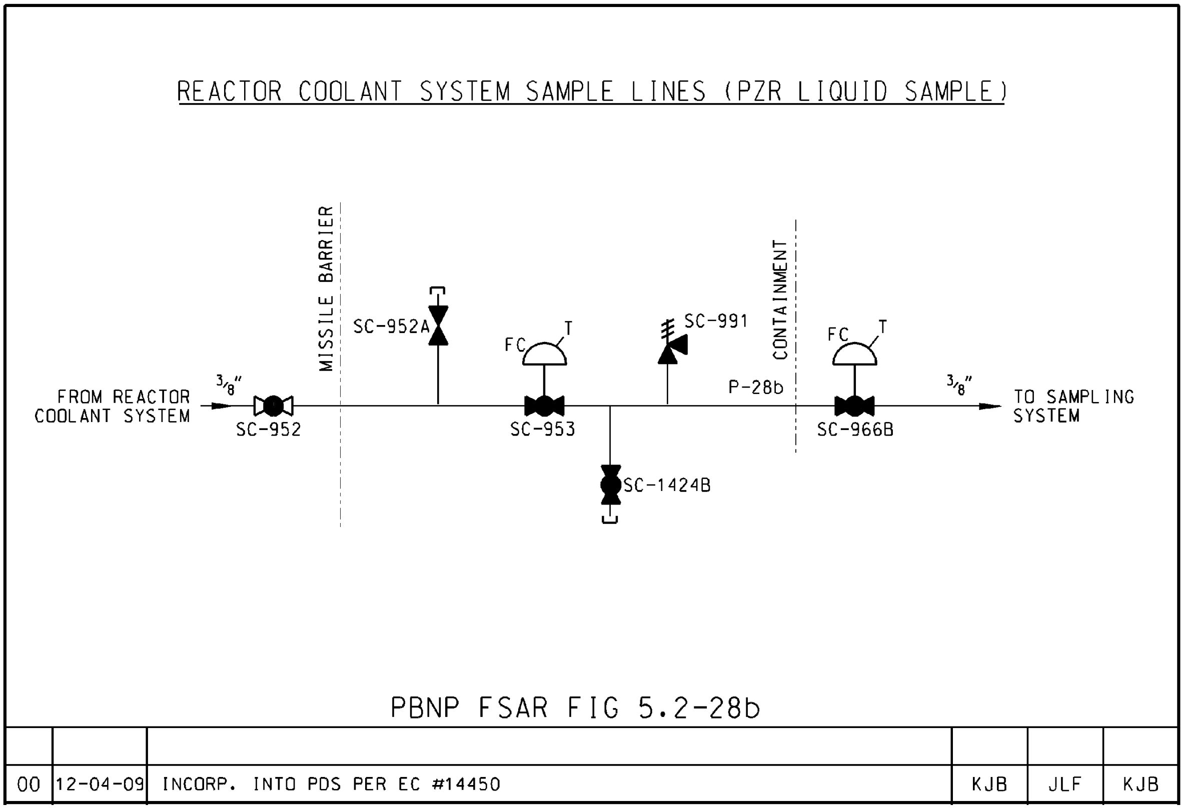

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | CONTAINMENT ISOLATION VALVES OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 28a | SC-955 | SC-966C | HOT LEG SAMPLE /SAMPLING SYSTEM | 3/8” | G | HOT | 1 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.4-1

NOTE:

1. THIS PENETRATION MEETS CLASS 1 CONTAINMENT ISOLATION CRITERIA WITH AUTOMATIC TRIP VALVES SC-955 INSIDE CONTAINMENT AND SC-966C OUTSIDE CONTAINMENT.
2. ALTHOUGH LOCATED INSIDE THE MISSLE BARRIER, THERE ARE NO CREDIBLE MISSILES THAT COULD IMPACT VALVES 1&2 SC-955 (REFERENCE SCR 2007-0181.)

# Figure 5.2-28b REACTOR COOLANT SYSTEM SAMPLE LINES (PZR LIQUID SAMPLE)



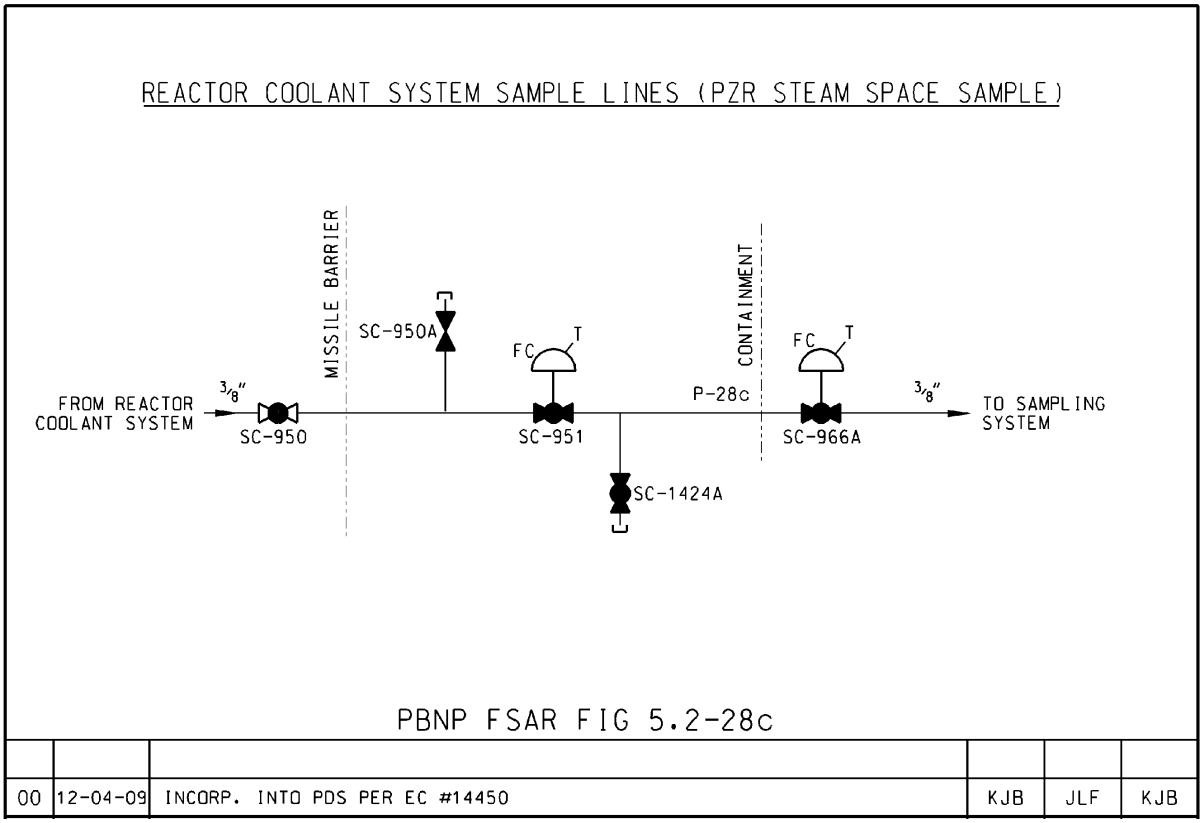

| PENETRATION | CONTAINMENT ISOLATION VALVES<br>INSIDE | <br>OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP.<br>HOT>200<br>COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 28b | SC-953<br>SC-991 | SC-966B | PRESSURIZER LIQ SAMPLE /SAMPLING SYSTEM | 3/8” | W | HOT | 1 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9

NOTE:

THIS PENETRATION MEETS CLASS 1 CONTAINMENT ISOLATION CRITERIA WITH AUTOMATIC TRIP VALVES SC-953 INSIDE CONTAINMENT AND SC-966B OUTSIDE CONTAINMENT.

Figure 5.2-28c REACTOR COOLANT SYSTEM SAMPLE LINES (PZR STEAM SPACE SAMPLE)



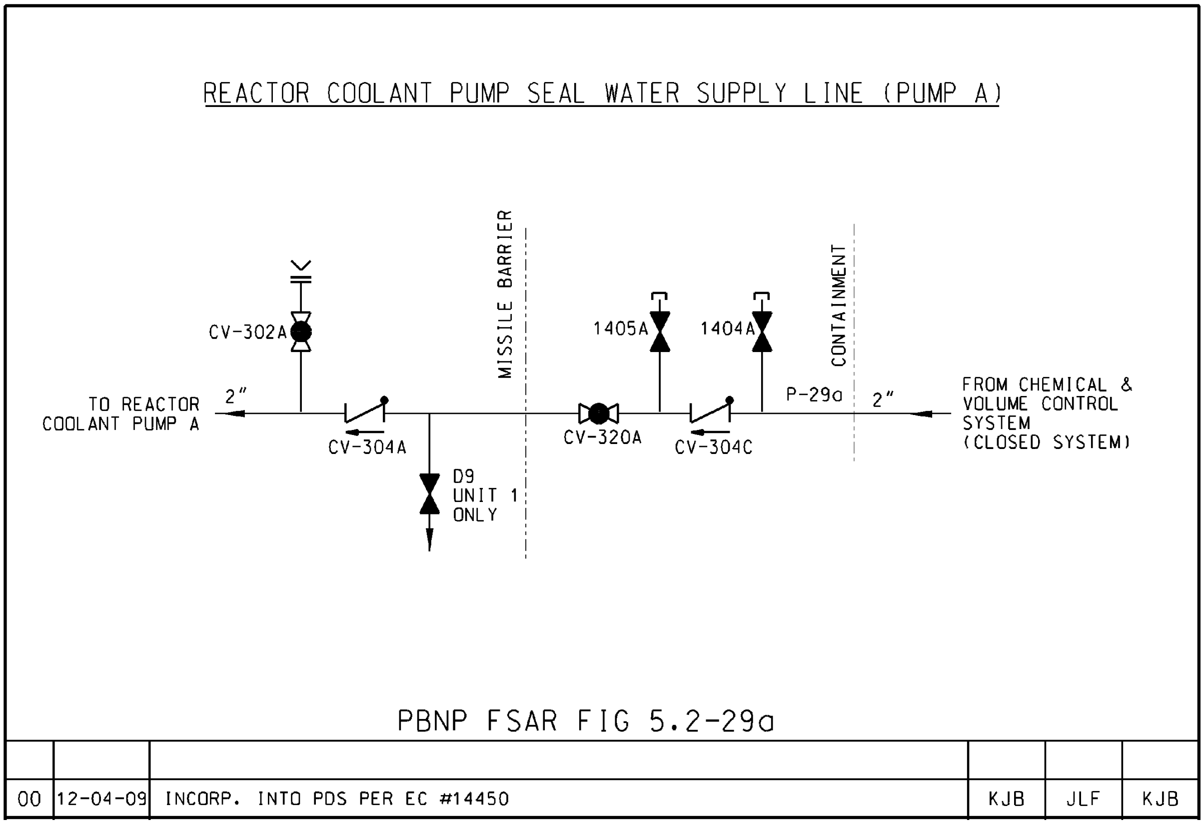

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 28c | SC-951 | SC-966A | PRESSURIZER STEAM SPACE SAMPLE /SAMPLING SYSTEM | 3/8" | G | HOT | 1 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.4-1

NOTE:

THIS PENETRATION MEETS CLASS 1 CONTAINMENT ISOLATION CRITERIA WITH AUTOMATIC TRIP VALVES SC-951 INSIDE CONTAINMENT AND SC-966A OUTSIDE CONTAINMENT.

Figure 5.2-29a REACTOR COOLANT PUMP SEAL WATER SUPPLY LINE (PUMP A)



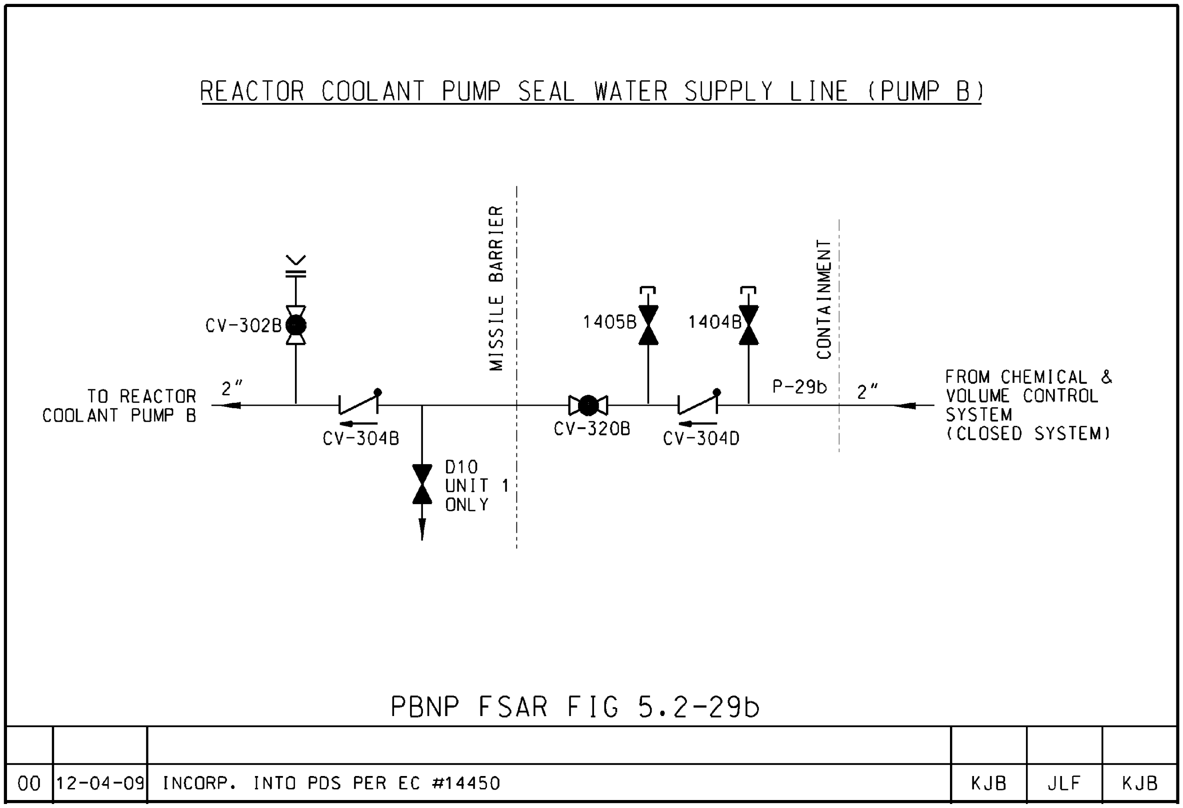

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 29a | CV-304C | CLOSED SYSTEM | SEAL WATER INTO PUMP “A”/CHEMICAL & VOLUME CONTROL SYS. | 2” | W | COLD | 3 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.2-1, 9.2-2

NOTE:

THIS PENETRATION MEETS CLASS 3 CONTAINMENT ISOLATION CRITERIA WITH CHECK VALVE CV-304C INSIDE CONTAIMENT SERVING THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND CVCS A CLOSED SYSTEM OUTSIDE CONTAINMENT.

Figure 5.2-29b REACTOR COOLANT PUMP SEAL WATER SUPPLY LINE (PUMP B)



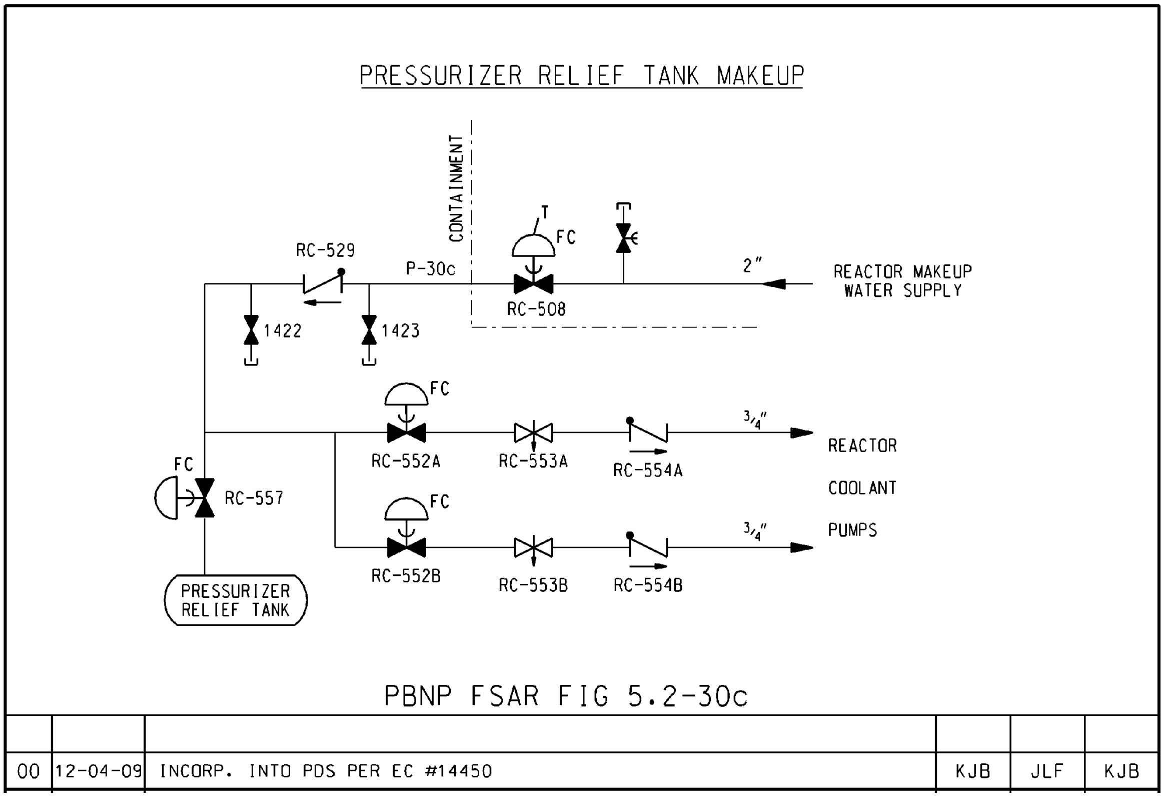

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 29b | CV-304D | CLOSED SYSTEM | SEAL WATER INTO PUMP “B”/CHEMICAL & VOLUME CONTROL SYS. | 2” | W | COLD | 3 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.2-1, 9.2-2

NOTE:

THIS PENETRATION MEETS CLASS 3 CONTAINMENT ISOLATION CRITERIA WITH CHECK VALVE CV-304D INSIDE CONTAIMENT SERVING THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND CVCS A CLOSED SYSTEM OUTSIDE CONTAINMENT.

Figure 5.2-30c PRESSURIZER RELIEF TANK MAKEUP



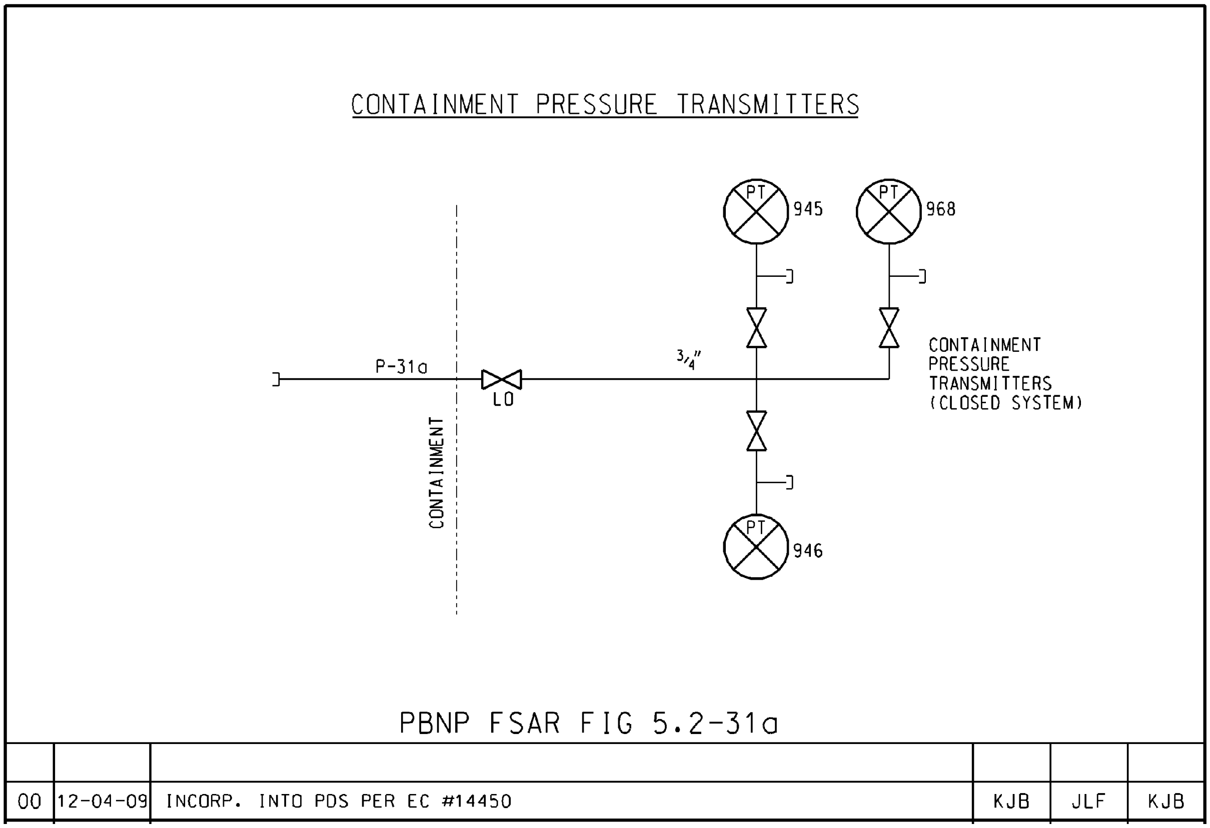

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | CONTAINMENT ISOLATION VALVES OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 30c | RC-529 | RC-508 | REACTOR MAKEUP WATER TO PRESSURIZER RELIEF TANK/REACTOR COOLANT SYS. | 2” | W | COLD | 3 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 4, FIGURE 4.2-1 SHT. 2, & FIGURE 4.2-1A SHT.2

NOTE:

THIS PENETRATION MEETS CLASS 3 CONTAINMENT ISOLATION CRITERIA WITH CHECK VALVE RC-529 INSIDE CONTAIMENT SERVING THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND AUTOMATIC TRIP VALVE RC-508 OUTSIDE CONTAINMENT.

# Figure 5.2-31a CONTAINMENT PRESSURE TRANSMITTERS

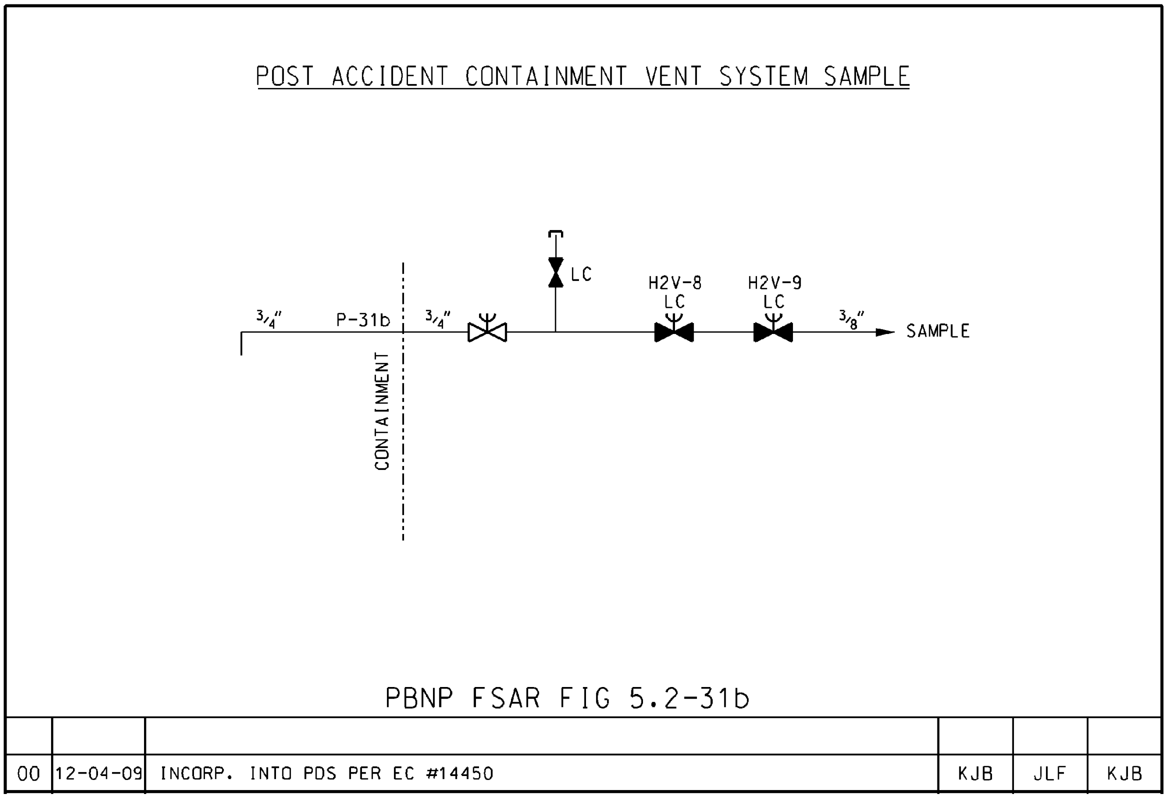



| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 31a | | MANUAL VALVE CLOSED SYSTEM | CONTAINMENT PRESSURE TRANSMITTER. | 3/4” | G | COLD | SPECIAL |

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IN USE POST DBA. THE CLOSED SYSTEM OUTSIDE CONTAINMENT PROVIDES THE CONTAINMENT ISOLATION BOUNDARY POST DBA.

# Figure 5.2-31b POST-ACCIDENT CONTAINMENT VENT SYSTEM SAMPLE



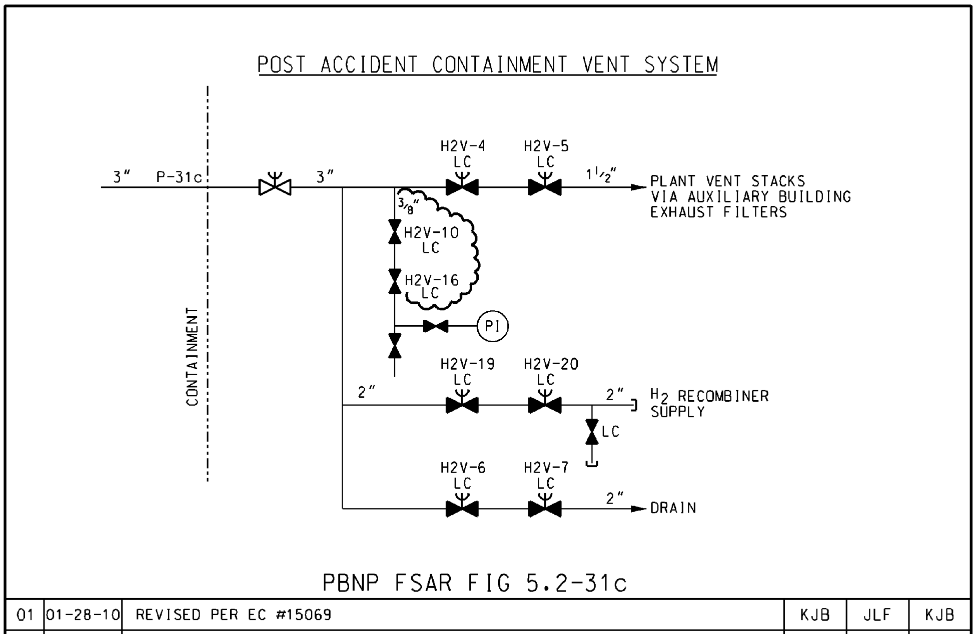

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 31b | | H2V-8<br>H2V-9 | POST ACCIDENT CONTAINMENT VENT SYS. $H_2$ SAMPLE/ PACVS. | 3/4" | G | COLD | SPECIAL |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 5 & FIGURE 5.3-1 SHT. 2 & FIGURE 5.3-1 SHT. 3

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IDENTIFIED AS AN INTERMITTENT USE SYSTEM POST DBA. LOCKED CLOSED MANUAL VALVES H2V-8 AND H2V-9 OUTSIDE CONTAINMENT MEET CONTAINMENT ISOLATION CRITERIA.

# Figure 5.2-31c POST-ACCIDENT CONTAINMENT VENT SYSTEM




| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 31c | | H2V-6<br>H2V-7 | POST ACCIDENT CONTAINMENT VENT SYS. DRAIN/PACVS. | 2" | G | COLD | SPECIAL |
| | | H2V-4<br>H2V-5 | POST ACCIDENT CONTAINMENT VENT SYS TO VENT DUCT / PACVS. | 1-1/2" | G | COLD | SPECIAL |
| | | H2V-20<br>H2V-19 | POST ACCIDENT CONTAINMENT VENT SYS. $H_2$ RECOMBINER SUPPLY/PACVS. | 2" | G | COLD | SPECIAL |

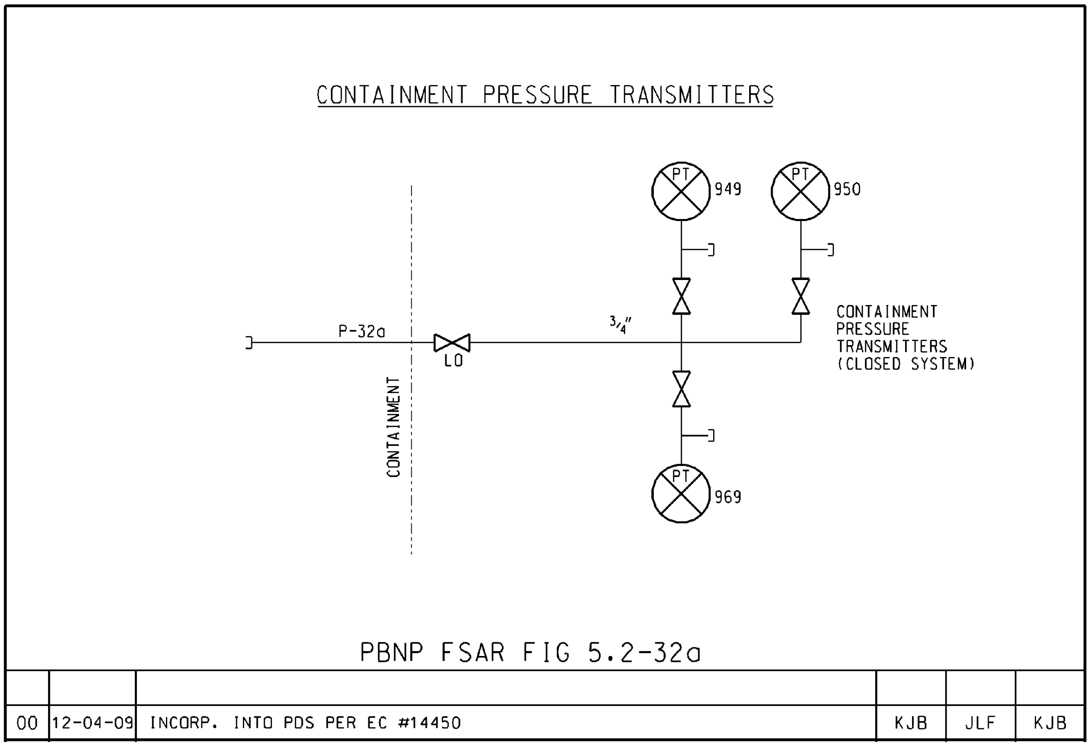
FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 5 & FIGURE 5.3-1 SHT. 2 & FIGURE 5.3-1 SHT. 3

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IDENTIFIED AS AN INTERMITTENT USE SYSTEM POST DBA.

1. VENT STACK BRANCH - LOCKED CLOSED MANUAL VALVES H2V-4 AND H2V-5 OUTSIDE CONTAINMENT MEET CONTAINMENT ISOLATION CRITERIA.
2. HYDROGEN RECOMBINER BRANCH - LOCKED CLOSED MANUAL VALVES H2V-19 AND H2V-20 OUTSIDE CONTAINMENT MEET CONTAINMENT ISOLATION CRITERIA
3. DRAIN BRANCH - LOCKED CLOSED MANUAL VALVES H2V-6 AND H2V-7 OUTSIDE CONTAINMENT MEET CONTAINMENT ISOLATION CRITERIA.

Figure 5.2-32a CONTAINMENT PRESSURE TRANSMITTERS

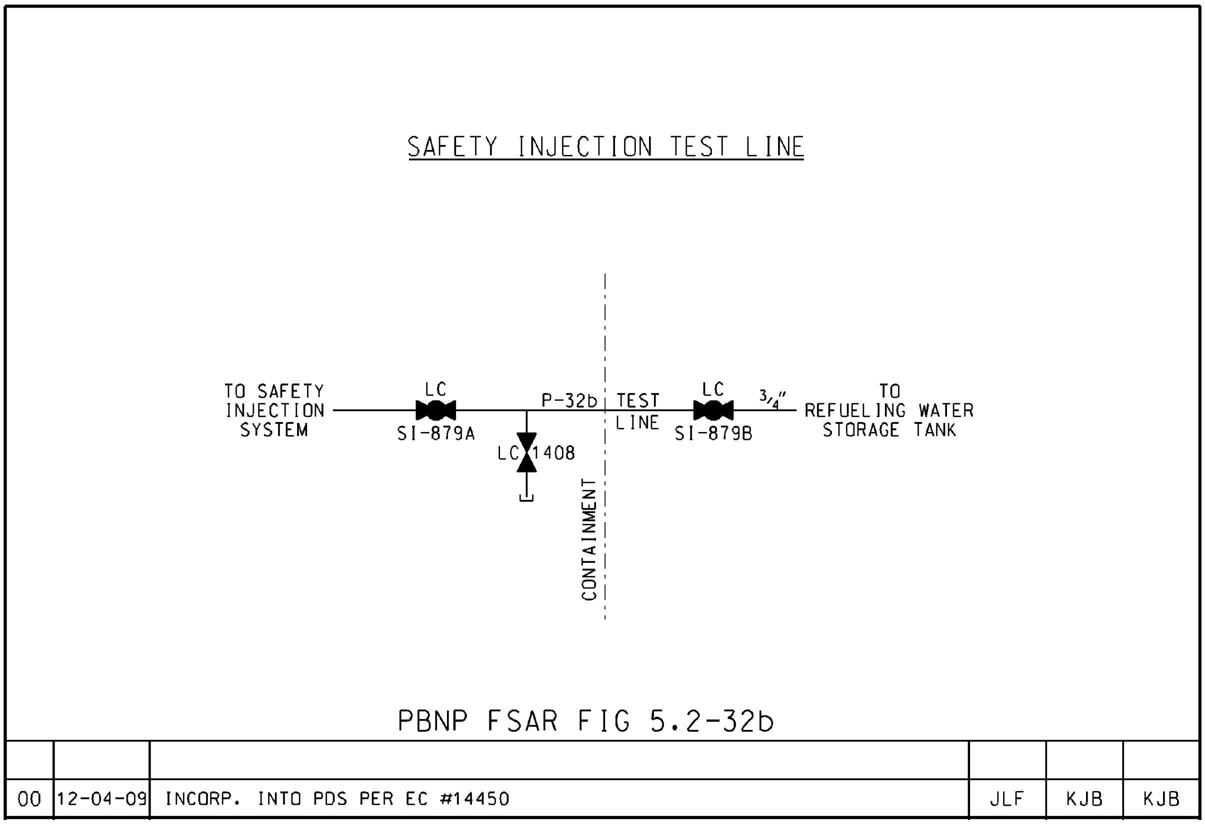



| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 32a | | MANUAL VALVE CLOSED SYSTEM | CONTAINMENT PRESSURE TRANSMITTER. | 3/4" | G | COLD | SPECIAL |

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IN USE POST DBA. THE CLOSED SYSTEM OUTSIDE CONTAINMENT PROVIDES THE CONTAINMENT ISOLATION BOUNDARY.

Figure 5.2-32b SAFETY INJECTION TEST LINE



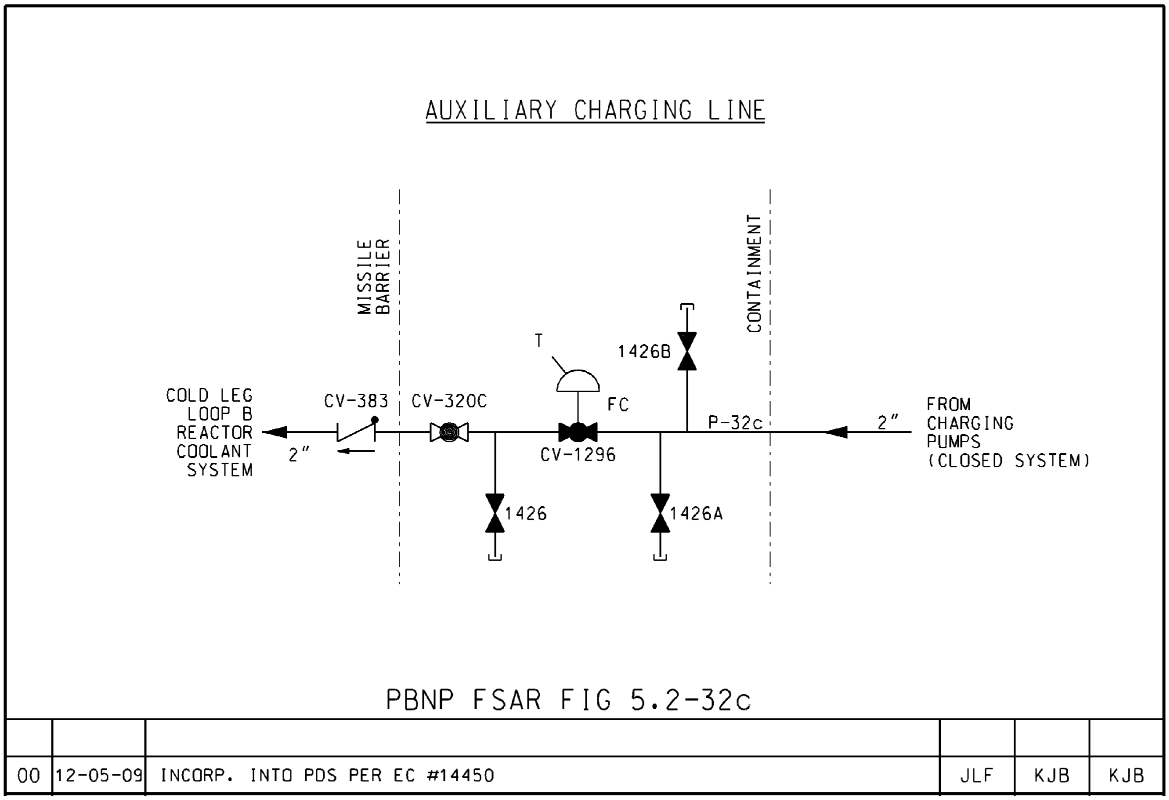

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 32b | SI-879A | SI-879B | SAFETY INJECTION SYS. TEST LINE/SAFETY INJECTION SYSTEM | 3/4” | W | COLD | SPECIAL |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 6

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND MEETS CONTAINMENT ISOLATION CRITERIA WITH LOCKED CLOSED MANUAL VALVES SI-879A AND SI-879B SERVING THE PURPOSE OF AUTOMATIC TRIP VALVES.

Figure 5.2-32c AUXILIARY CHARGING LINE



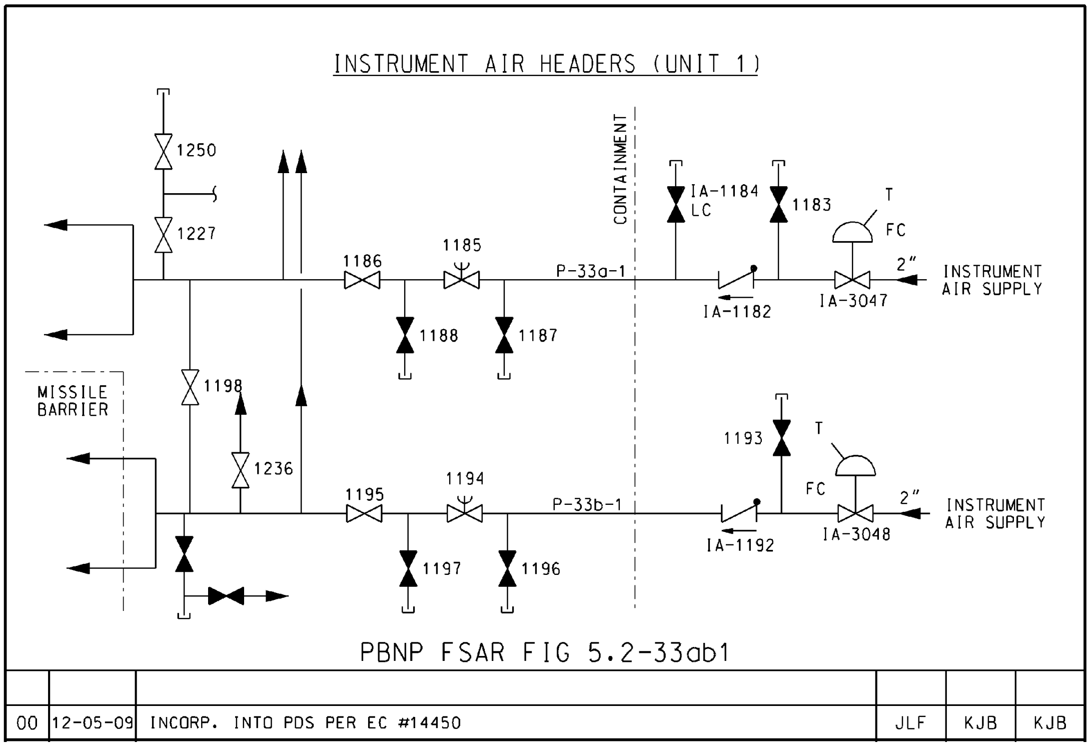

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 32c | CV-1296 | CLOSED SYSTEM | AUXILIARY CHARGING LINE/CVCS | 2" | W | COLD | 3 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.2-1, 9.2-2

NOTE:

THIS PENETRATION MEETS CLASS 3 CONTAINMENT ISOLATION CRITERIA WITH AUTOMATIC TRIP VALVE CV-1296 INSIDE CONTAIMENT AND CVCS A CLOSED SYSTEM OUTSIDE CONTAINMENT.

Figure 5.2-33ab1 INSTRUMENT AIR HEADERS (UNIT 1)



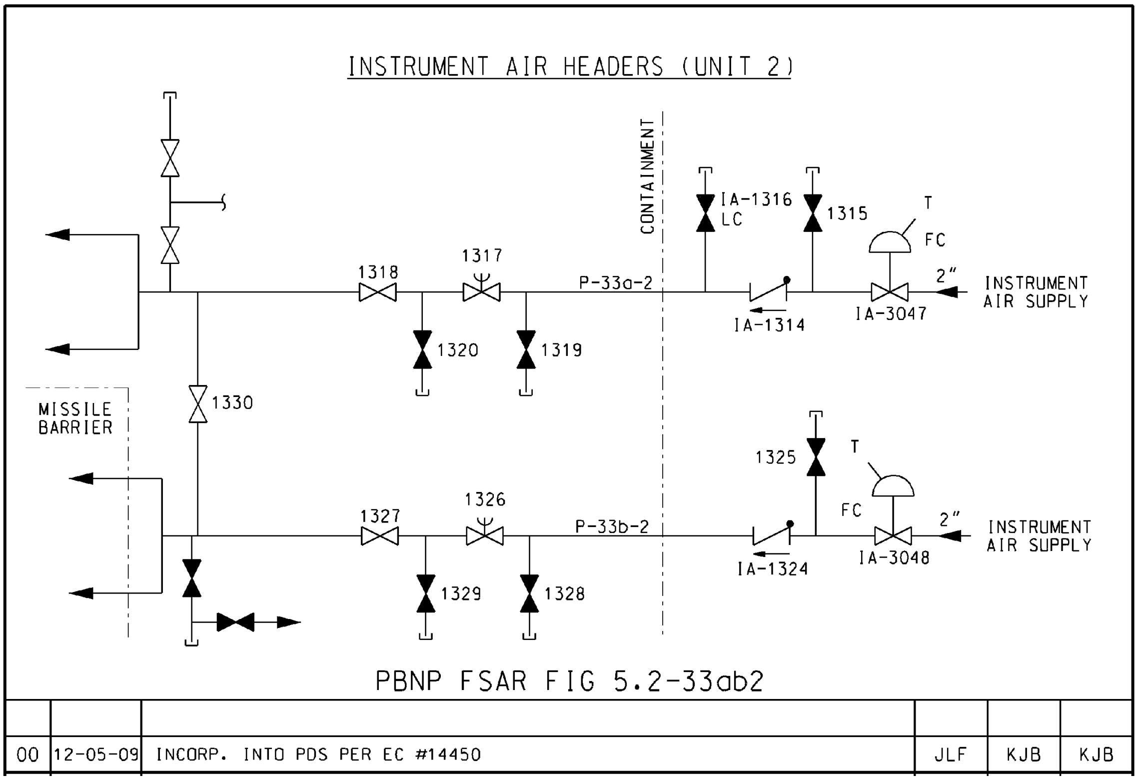

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 33a-1 | | IA-3047<br>IA-1182 | INSTRUMENT AIR SUPPLY/SECONDARY SYSTEM. | 2” | G | COLD | 3 |
| 33b-1 | | IA-3048<br>IA-1192 | INSTRUMENT AIR SUPPLY/SECONDARY SYSTEM. | 2” | G | COLD | 3 |

NOTE:

33a-1 THIS PENETRATION MEETS CLASS 3 CONTAINMENT ISOLATION CRITERIA WITH CHECK VALVE IA-1182 SERVING THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND AUTOMATIC TRIP VALVE IA-3047 OUTSIDE CONTAINMENT.

33b-1 THIS PENETRATION MEETS CLASS 3 CONTAINMENT ISOLATION CRITERIA WITH CHECK VALVE IA-1192 SERVING THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND AUTOMATIC TRIP VALVE IA-3048 OUTSIDE CONTAINMENT.

Figure 5.2-33ab2 INSTRUMENT AIR HEADERS (UNIT 2)



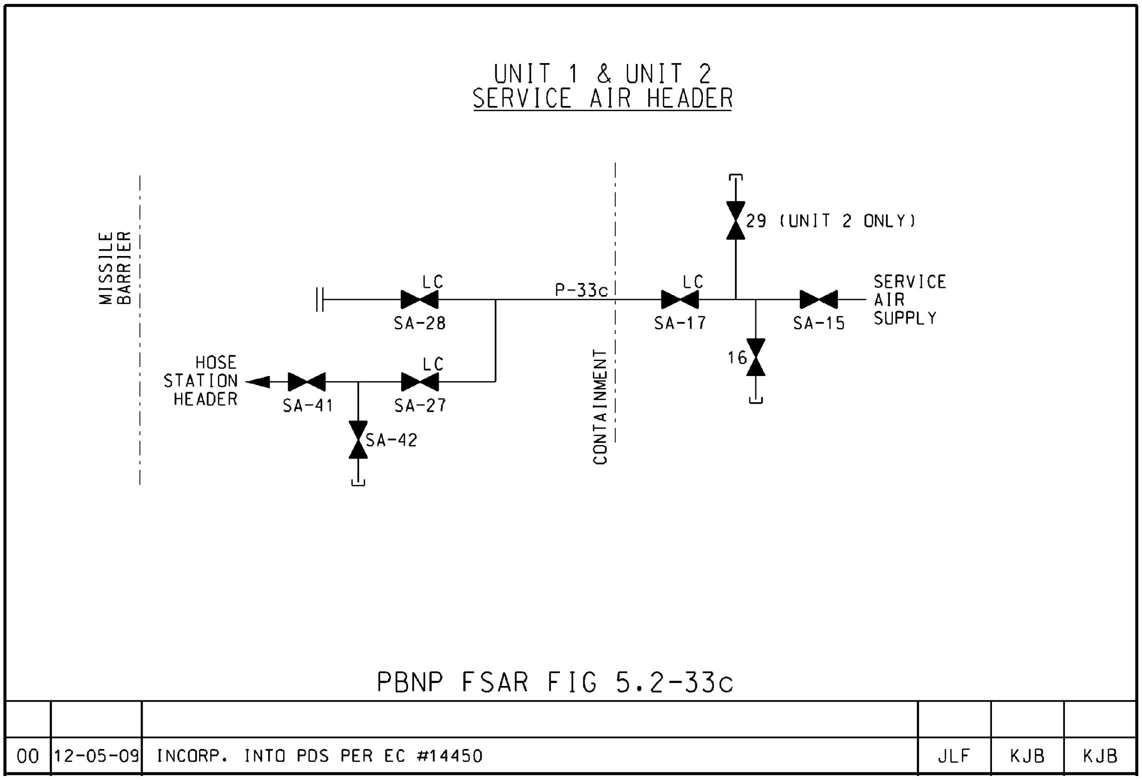

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 33a-2 | | IA-3047<br>IA-1314 | INSTRUMENT AIR SUPPLY/SECONDARY SYSTEM. | 2" | G | COLD | 3 |
| 33b-2 | | IA-3048<br>IA-1324 | INSTRUMENT AIR SUPPLY/SECONDARY SYSTEM. | 2" | G | COLD | 3 |

NOTE:

33a-2 THIS PENETRATION MEETS CLASS 3 CONTAINMENT ISOLATION CRITERIA WITH CHECK VALVE IA-1314 SERVING THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND AUTOMATIC TRIP VALVE IA-3047 OUTSIDE CONTAINMENT.

33b-2 THIS PENETRATION MEETS CLASS 3 CONTAINMENT ISOLATION CRITERIA WITH CHECK VALVE IA-1324 SERVING THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND AUTOMATIC TRIP VALVE IA-3048 OUTSIDE CONTAINMENT.

Figure 5.2-33c UNIT 1 AND UNIT 2 SERVICE AIR HEADER

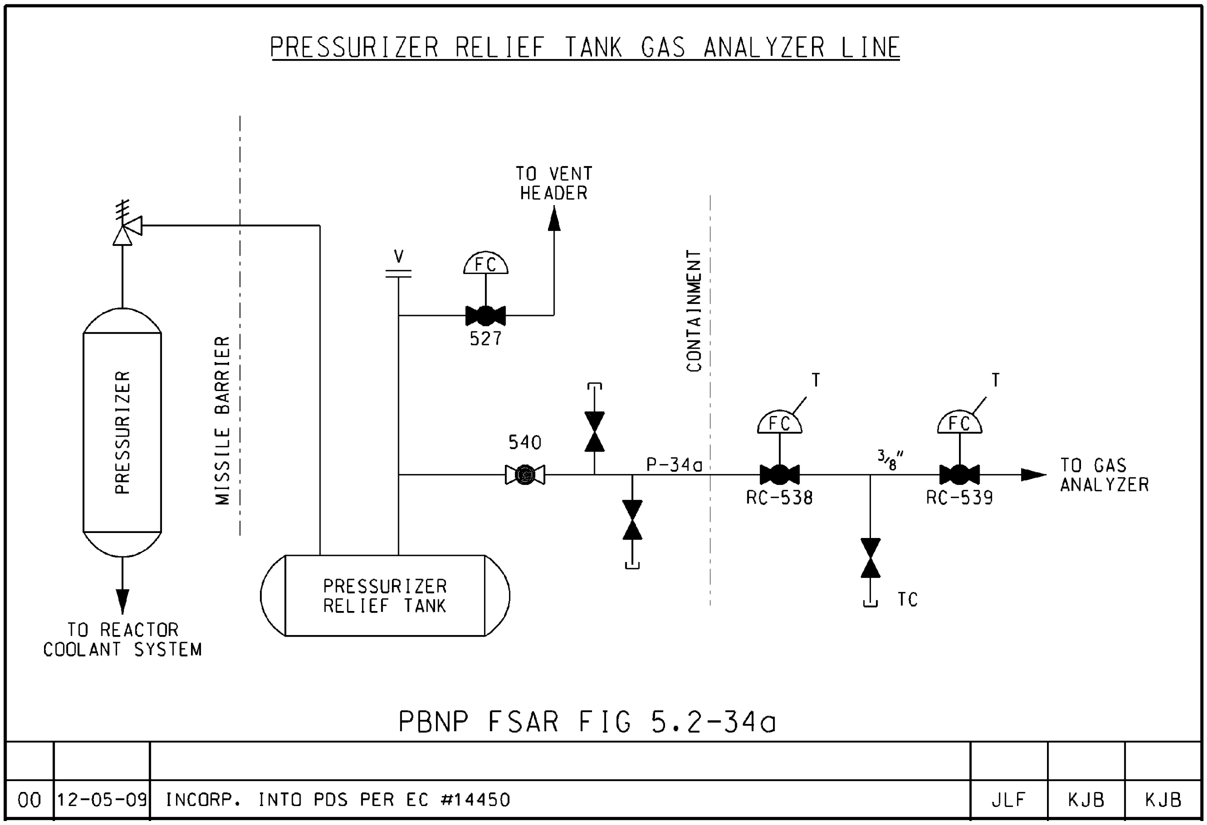



| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 33c | SA-27 BLANK FLANGE | SA-17 | SERVICE AIR SUPPLY/ SECONDARY SYSTEM. | 4” | G | COLD | 5 |

NOTE:

THIS PENETRATION MEETS CLASS 5 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY A LOCKED CLOSED MANUAL VALVE SA-17 OUTSIDE CONTAINMENT AND A LOCKED CLOSED MANUAL VALVE SA-27 AND THE BLANK FLANG AT SA-28 INSIDE CONTAINMENT.

Figure 5.2-34a PRESSURIZER RELIEF TANK GAS ANALYZER LINE



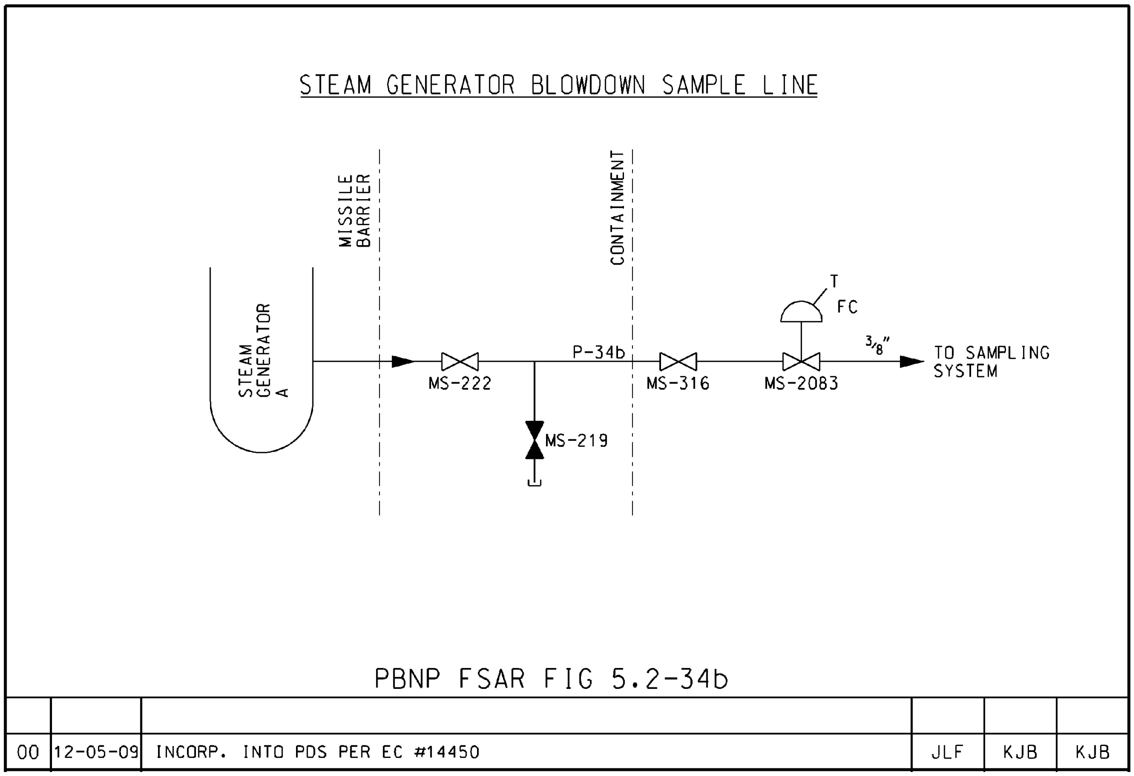

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | CONTAINMENT ISOLATION VALVES OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 34a | | RC-538<br>RC-539 | PRESSURIZER RELIEF TANK SAMPLE TO GAS ANALYZER/REACTOR COOLANT SYSTEM | 3/8" | G | COLD | 2 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 4 & FIGURE 4.2-1 SHT. 2

NOTE:

THIS PENETRATION MEETS CLASS 2 CONTAINMENT ISOLATION CRITERIA WITH AUTOMATICALLY OPERATED TRIP VALVES (RC-538 AND RC-539) IN SERIES LOCATED OUTSIDE OF CONTAINMENT.

# Figure 5.2-34b STEAM GENERATOR BLOWDOWN SAMPLE LINE



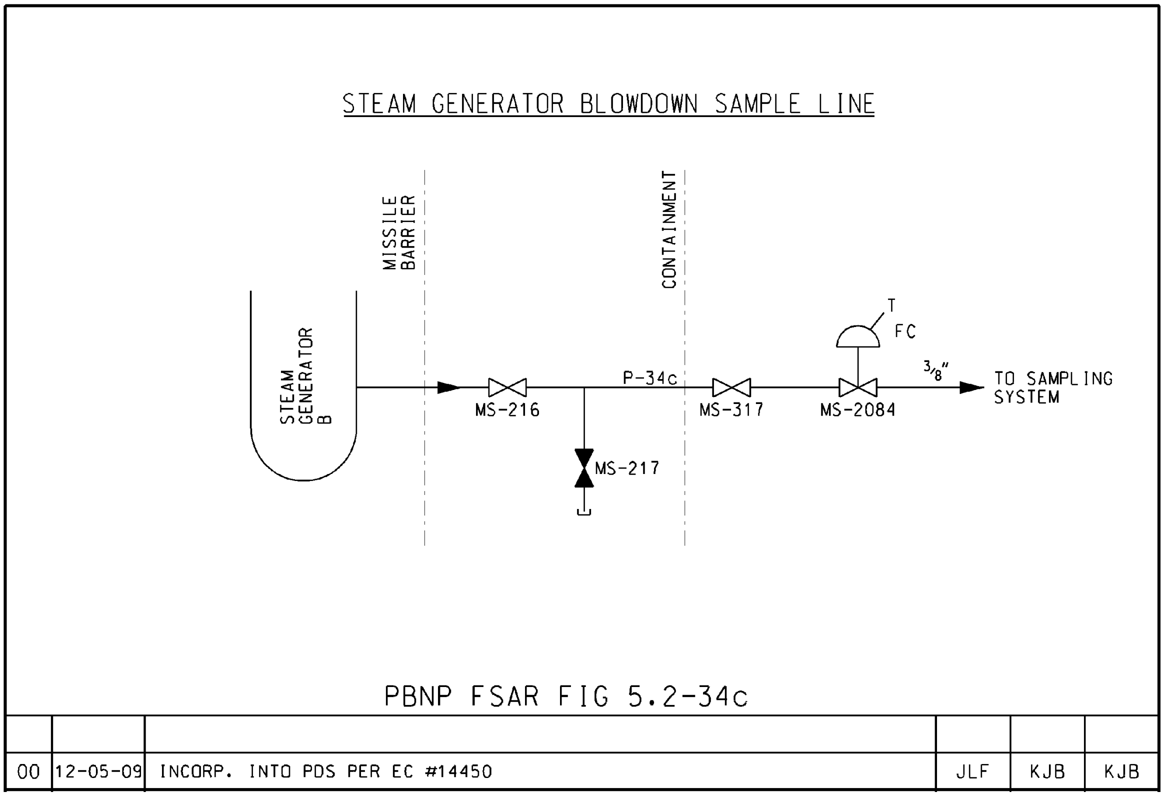

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 34b | CLOSED SYS. | MS-2083 | STEAM GENERATOR BLOWDOWN SAMPLE LINE/SECONDARY SYSTEM | 3/8" | W | HOT | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIGURE 10.2-1 SHT. 1

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH AUTOMATIC TRIP VALVE (MS-2083) LOCATED OUTSIDE OF CONTAINMENT. THE SYSTEM INSIDE CONTAINMENT IS A CLOSED SYSTEM. MS-2083 IS USED AS THE CONTAINMENT ISOLATION VALVE OUTSIDE CONTAINMENT BECAUSE IT WAS ADDED AS AN NRC COMMITMENT.

# Figure 5.2-34c STEAM GENERATOR BLOWDOWN SAMPLE LINE



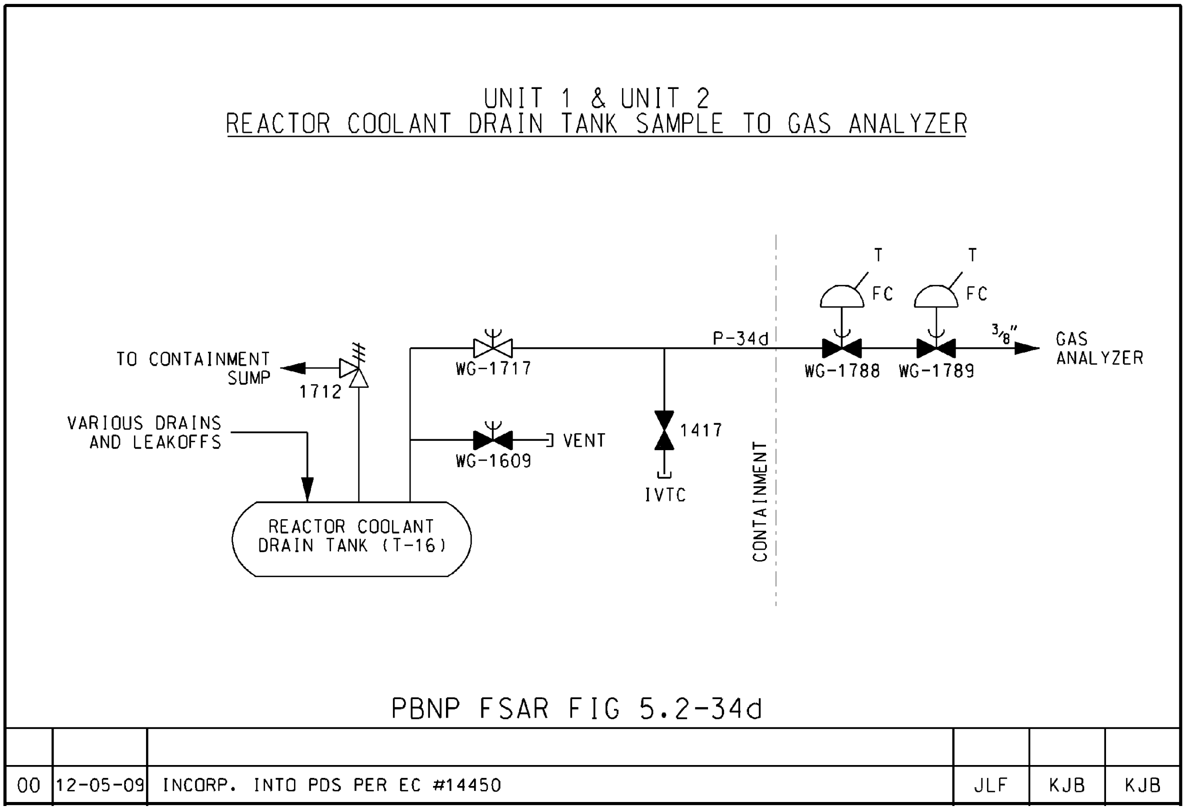

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 34c | CLOSED SYS. | MS-2084 | STEAM GENERATOR BLOWDOWN SAMPLE LINE/SECONDARY SYSTEM | 3/8" | W | HOT | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIGURE 10.2-1 SHT. 1

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH AUTOMATIC TRIP VALVE (MS-2084) LOCATED OUTSIDE OF CONTAINMENT. THE SYSTEM INSIDE CONTAINMENT IS A CLOSED SYSTEM. MS-2084 IS USED AS THE CONTAINMENT ISOLATION VALVE OUTSIDE CONTAINMENT BECAUSE IT WAS ADDED AS AN NRC COMMITMENT.

# Figure 5.2-34d UNIT 1 & UNIT 2 REACTOR COOLANT DRAIN TANK SAMPLE TO GAS ANALYZER



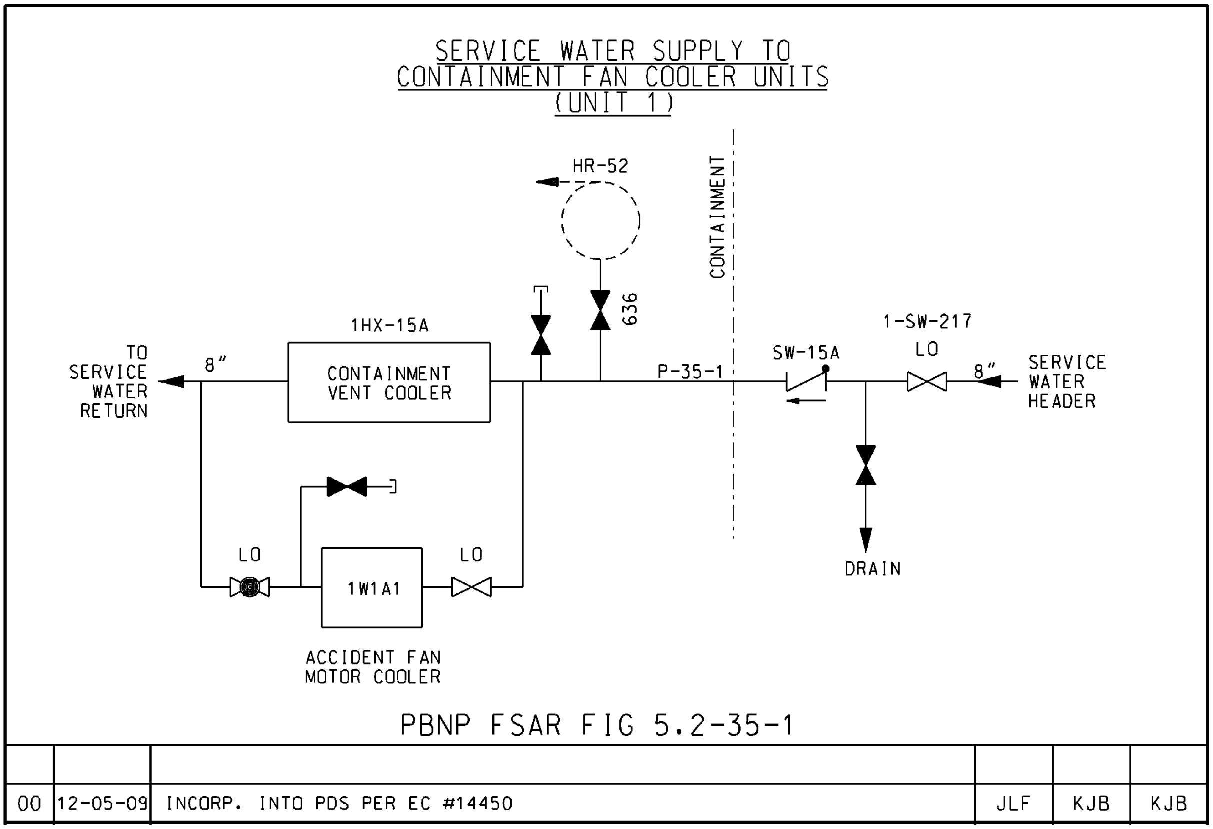

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | CONTAINMENT ISOLATION VALVES OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 34d | | WG-1788<br>WG-1789 | REACTOR COOLANT DRAIN TANK SAMPLE TO GAS ANALYZER/ WASTE DISPOSAL SYSTEM | 3/8” | G | COLD | 2 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 11

NOTE:

THIS PENETRATION MEETS CLASS 2 CONTAINMENT ISOLATION CRITERIA WITH AUTOMATICALLY OPERATED TRIP VALVES WG-1788 AND WG-1789 IN SERIES LOCATED OUTSIDE CONTAINMENT.

# Figure 5.2-35-1 SERVICE WATER SUPPLY TO CONTAINMENT FAN COOLER UNITS (UNIT 1)



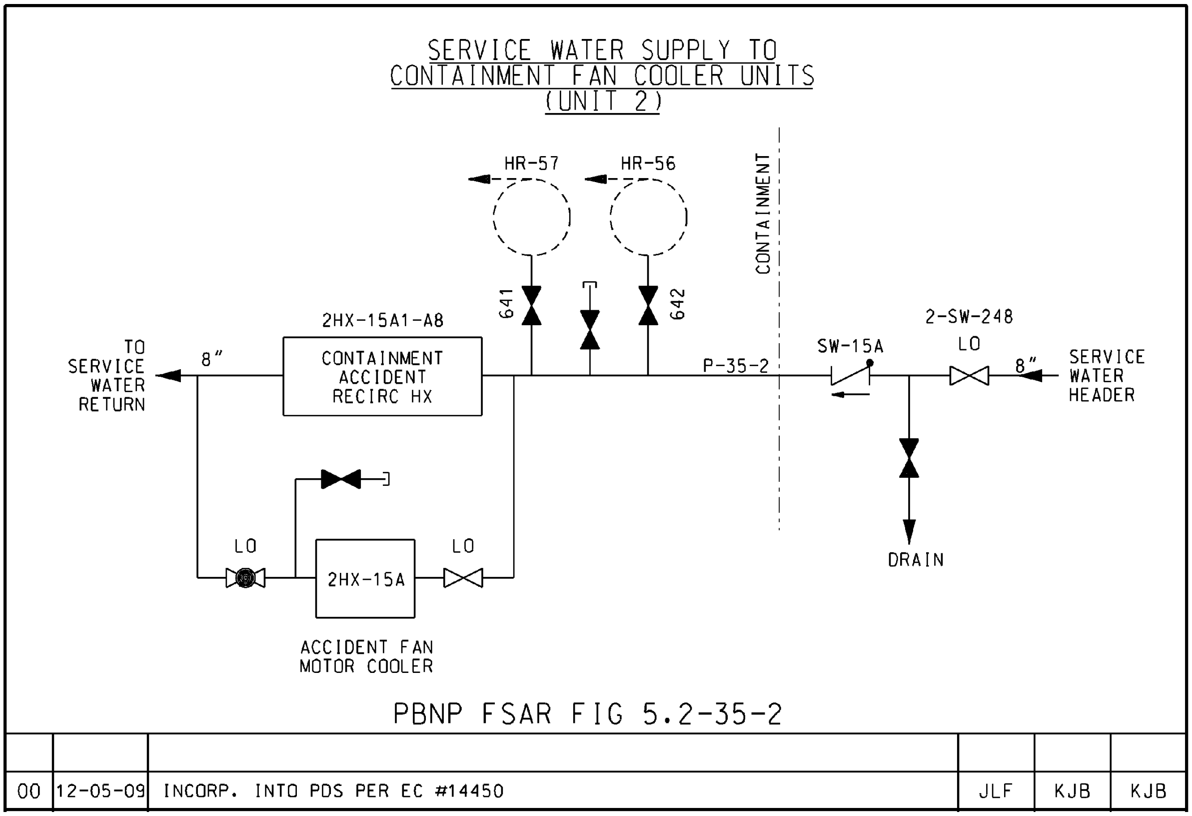

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 35-1 | CLOSED SYS. | SW-217 | VENTILATION COOLER WATER IN/SERVICE WATER | 8" | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (SW-217) LOCATED OUTSIDE CONTAINMENT. INSIDE CONTAINMENT THE SERVICE WATER SYSTEM IS A CLOSED SYSTEM.

Figure 5.2-35-2 SERVICE WATER SUPPLY TO CONTAIMENT FAN COOLER UNITS (UNIT 2)



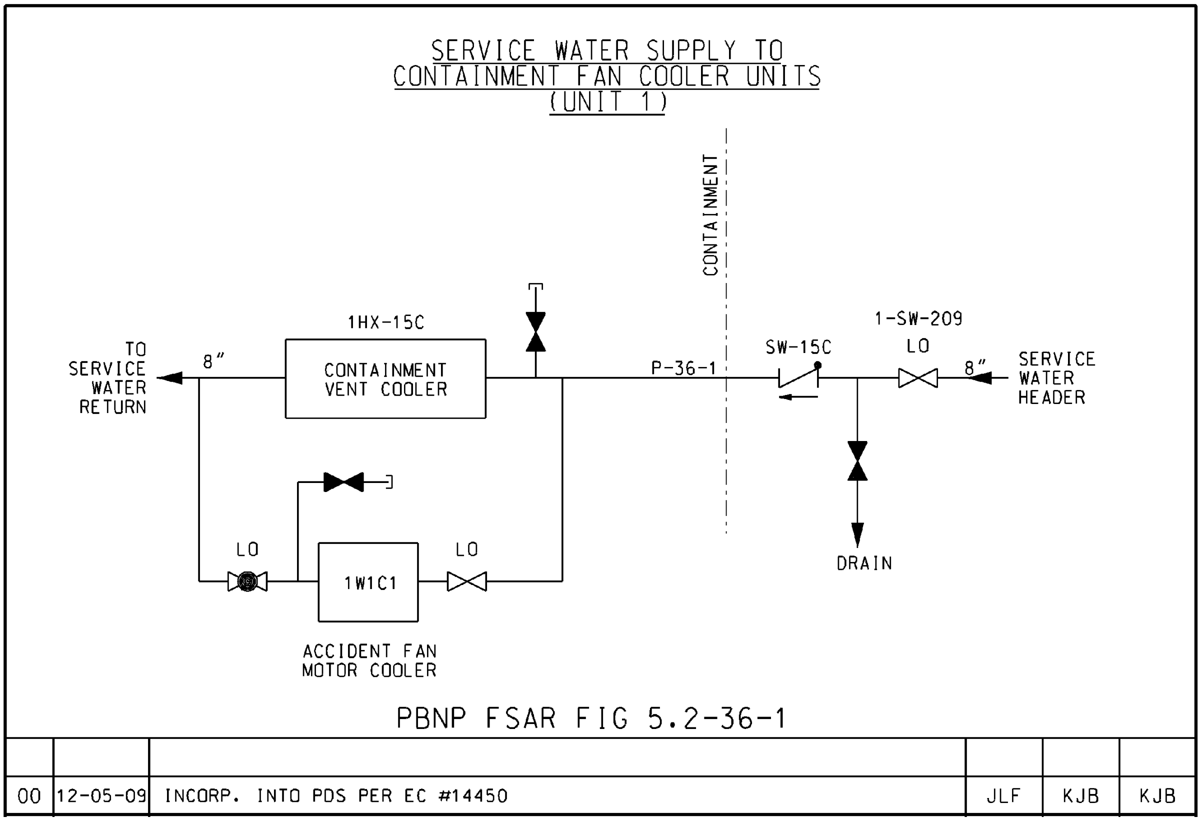

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 35-2 | CLOSED SYS. | SW-248 | VENTILATION COOLER WATER IN/SERVICE WATER | 8" | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (SW-248) LOCATED OUTSIDE CONTAINMENT. INSIDE CONTAINMENT THE SERVICE WATER SYSTEM IS A CLOSED SYSTEM.

Figure 5.2-36-1 SERVICE WATER SUPPLY TO CONTAIMENT FAN COOLER UNITS (UNIT 1)



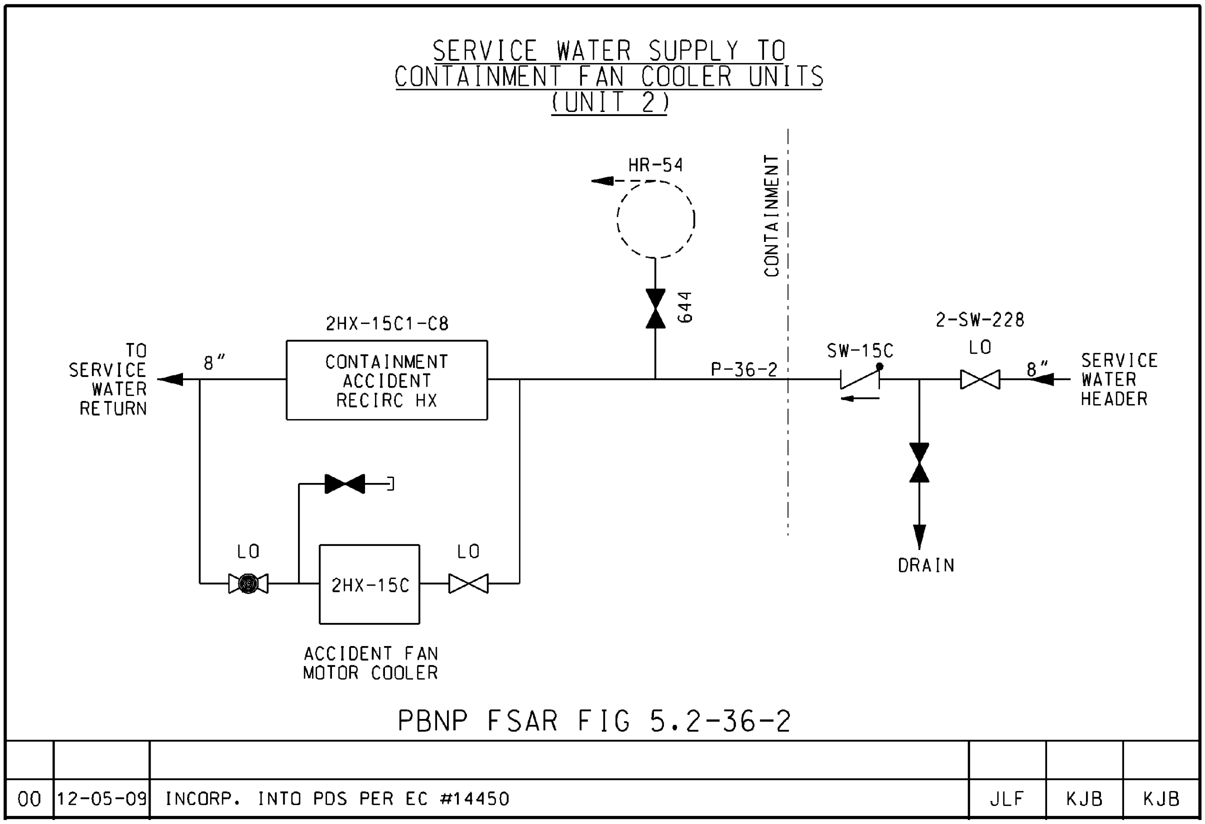

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 36-1 | CLOSED SYSTEM | SW-209 | VENTILATION COOLER WATER IN/SERVICE WATER | 8" | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (SW-209) LOCATED OUTSIDE CONTAINMENT. INSIDE CONTAINMENT THE SERVICE WATER SYSTEM IS A CLOSED SYSTEM.

# Figure 5.2-36-2 SERVICE WATER SUPPLY TO CONTAINMENT FAN COOLER UNITS (UNIT 2)



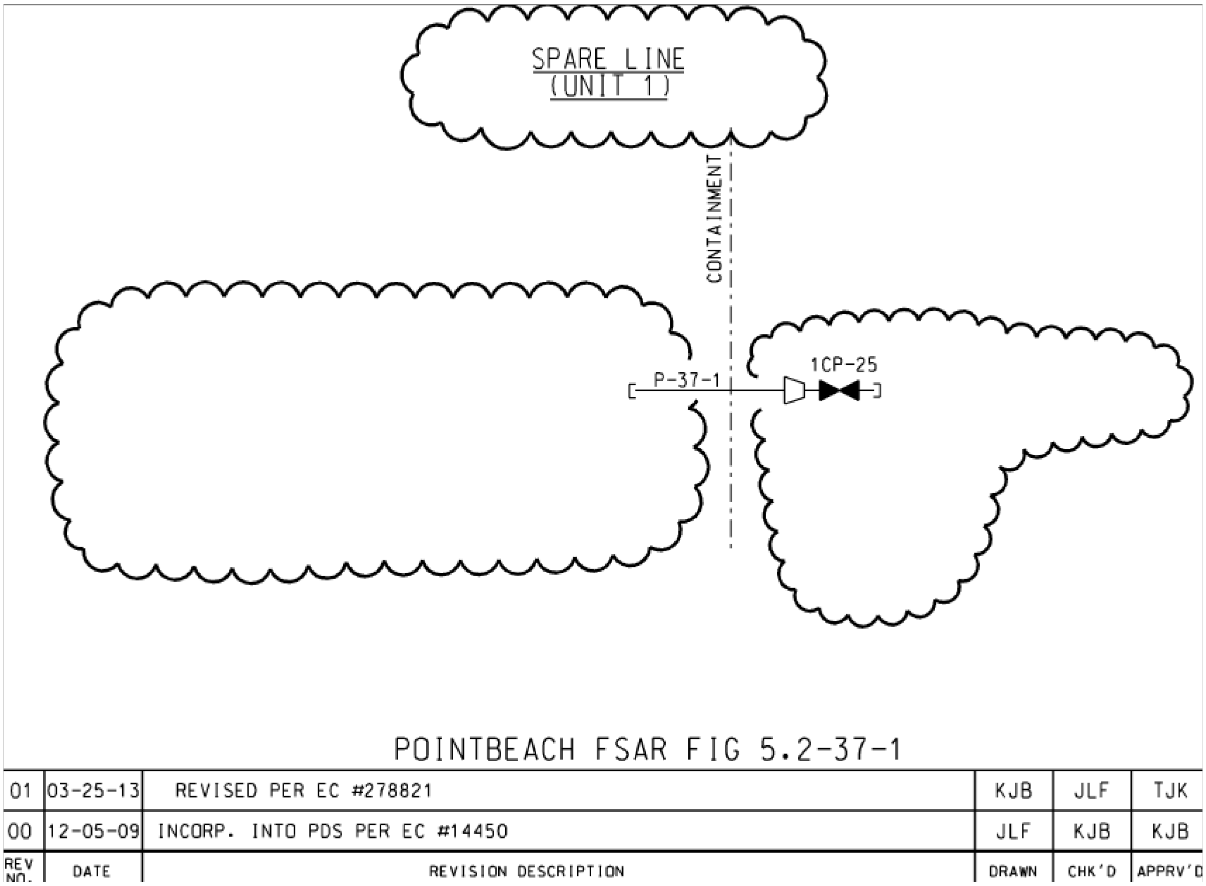

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | CONTAINMENT ISOLATION VALVES OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 36-2 | CLOSED SYS. | SW-228 | VENTILATION COOLER WATER IN/SERVICE WATER | 8" | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (SW-228) LOCATED OUTSIDE CONTAINMENT. INSIDE CONTAINMENT THE SERVICE WATER SYSTEM IS A CLOSED SYSTEM.

# Figure 5.2-37-1 SPARE LINE (UNIT 1)



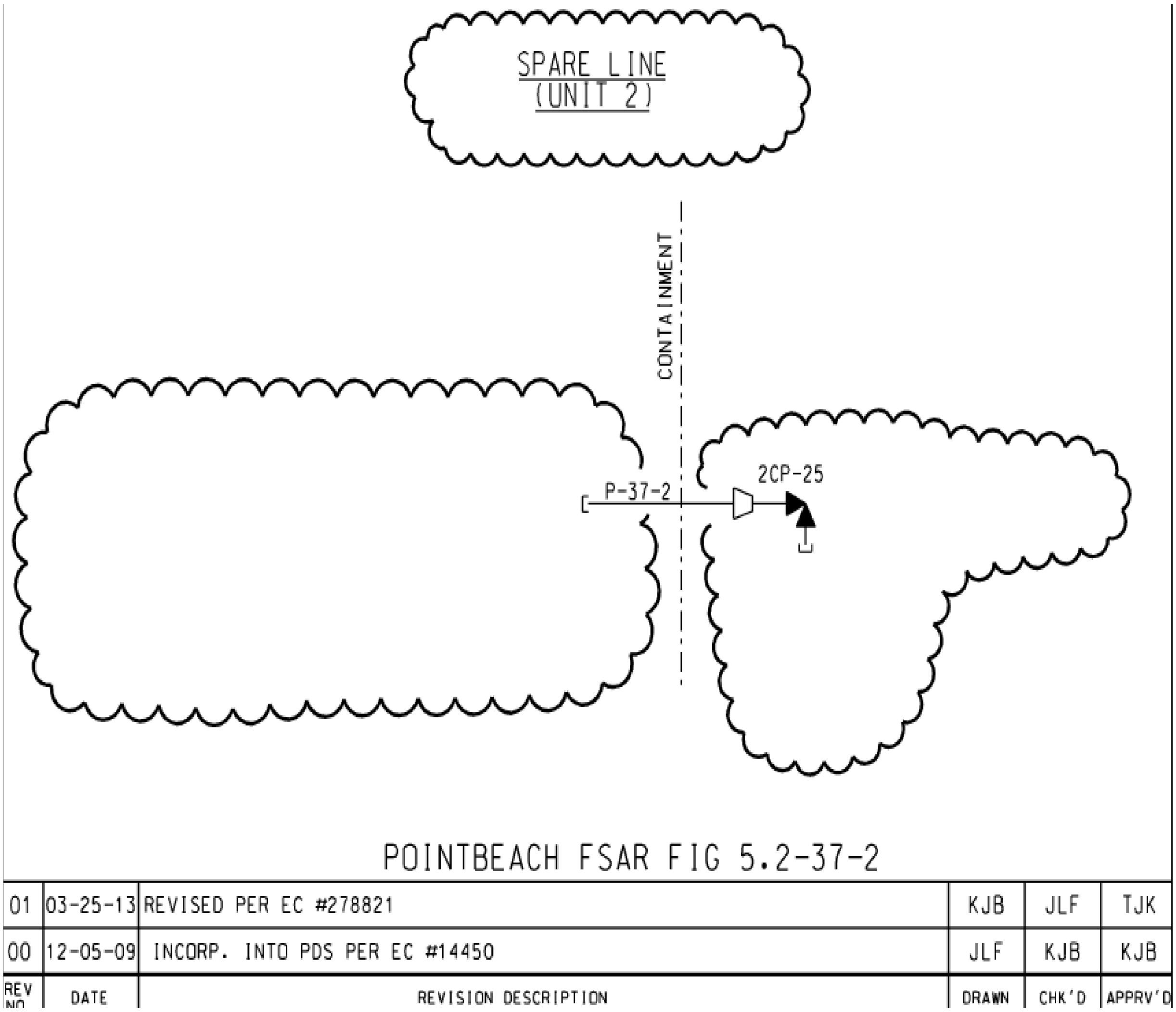

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | CONTAINMENT ISOLATION VALVES OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 37-1 | CAPPED | 1CP-25 | SPARE | 2” | Air | COLD | 5 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 5 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (1CP-25) LOCATED OUTSIDE CONTAINMENT AND WELDED CAP INSIDE CONTAINMENT.

Figure 5.2-37-2 SPARE LINE (UNIT 2)



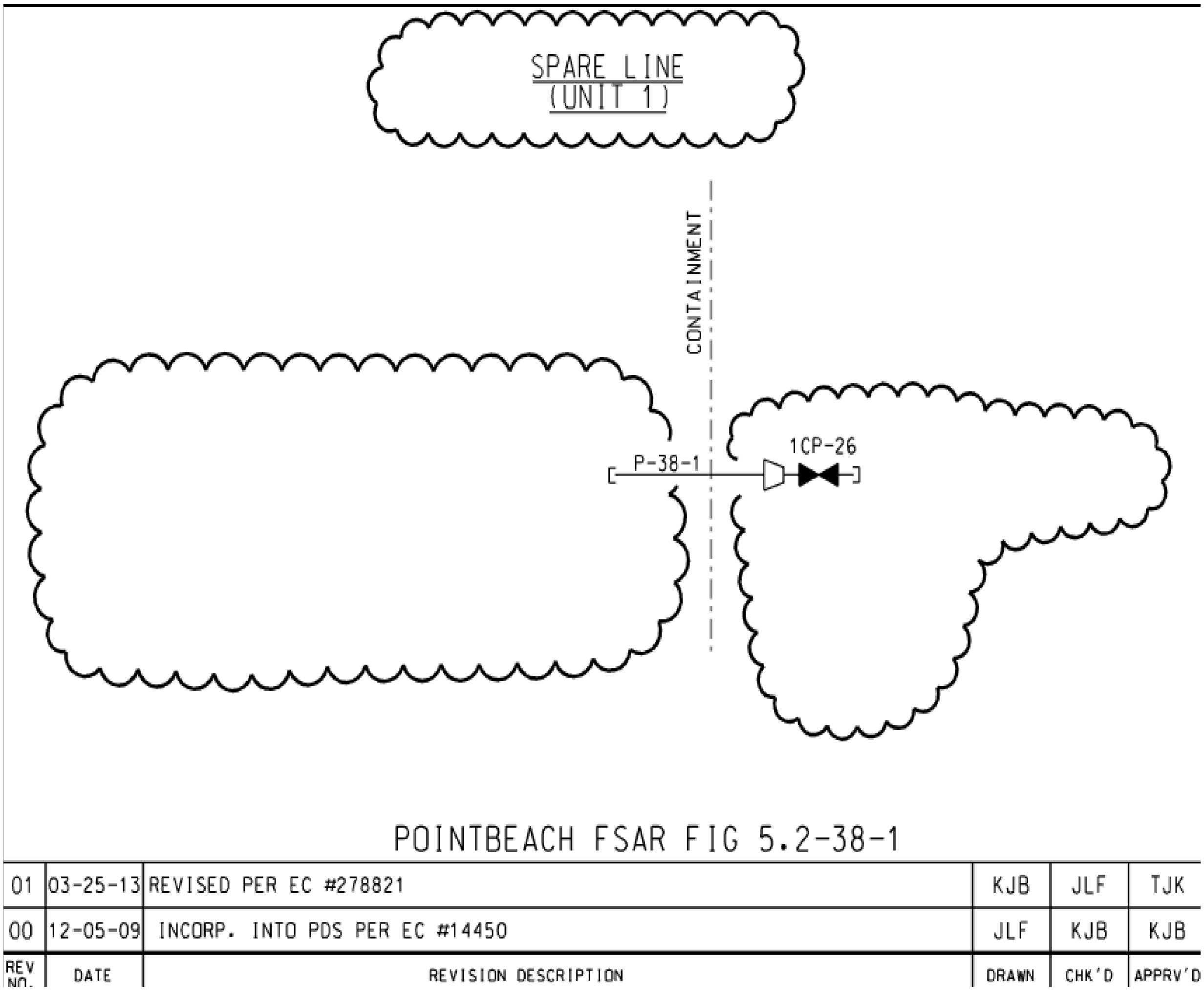

| PENETRATION | CONTAINMENT ISOLATION VALVES | | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. | CLASS |
|---|---|---|---|---|---|---|---|
| | INSIDE | OUTSIDE | | | | HOT>200 COLD<200 | |
| 37-2 | CAPPED | 2CP-25 | SPARE | 2” | Air | COLD | 5 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 5 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (2CP-25) LOCATED OUTSIDE CONTAINMENT AND WELDED CAP INSIDE CONTAINMENT.

Figure 5.2-38-1 SPARE LINE (UNIT 1)



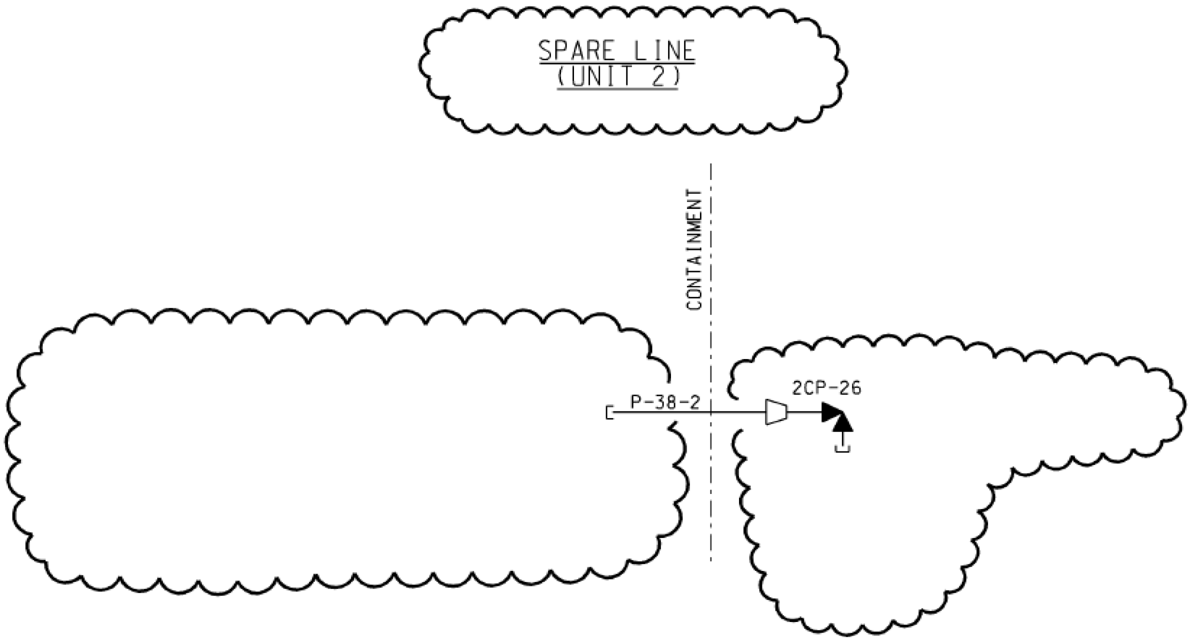

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 38-1 | CAPPED | 1CP-26 | SPARE | 2” | Air | COLD | 5 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 5 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (1CP-26) LOCATED OUTSIDE CONTAINMENT AND WELDED CAP INSIDE CONTAINMENT.

Figure 5.2-38-2 SPARE LINE (UNIT 2)




POINTBEACH FSAR FIG 5.2-38-2

| REV NO. | DATE | REVISION DESCRIPTION | DRAWN | CHK'D | APPRV'D |
|---|---|---|---|---|---|
| 01 | 03-25-13 | REVISED PER EC #278821 | KJB | KLF | TJK |
| 00 | 12-05-09 | INCORP. INTO PDS PER EC #14450 | JLF | KJB | KJB |

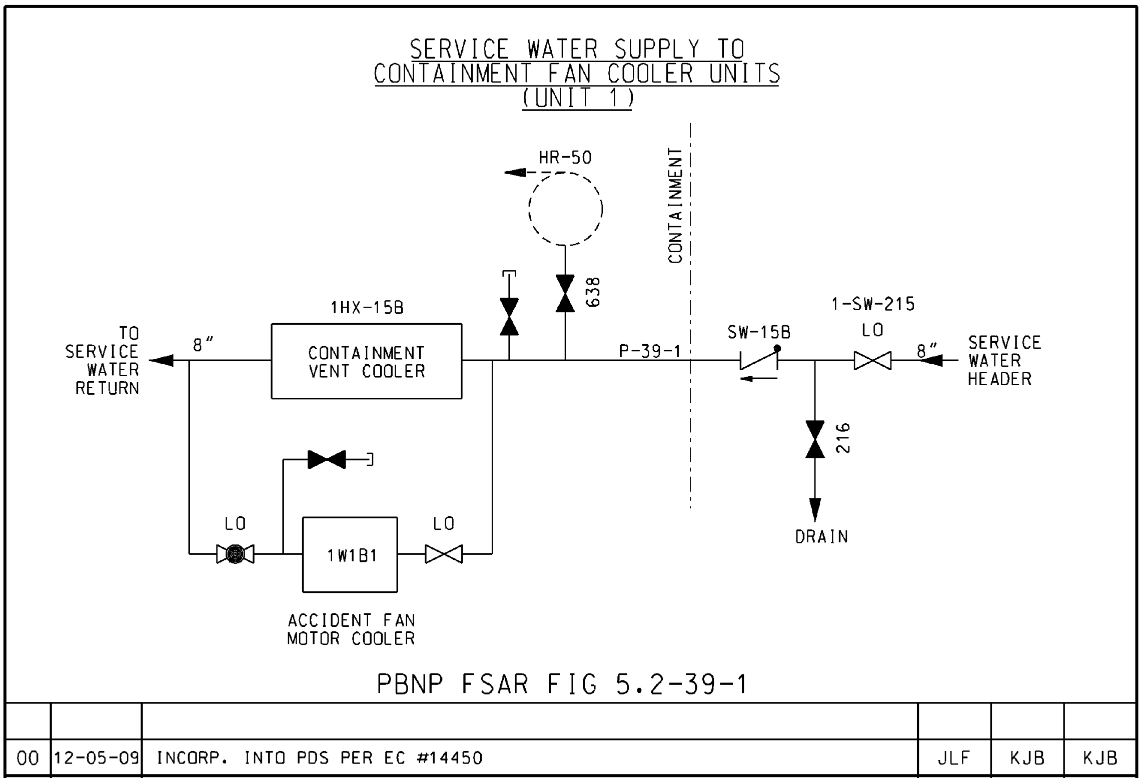
| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | CONTAINMENT ISOLATION VALVES OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 38-2 | CAPPED | 2CP-26 | SPARE | 2” | Air | COLD | 5 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 5 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (2CP-26) LOCATED OUTSIDE CONTAINMENT AND WELDED CAP INSIDE CONTAINMENT.

Figure 5.2-39-1 SERVICE WATER SUPPLY TO CONTAIMENT FAN COOLER UNITS (UNIT 1)



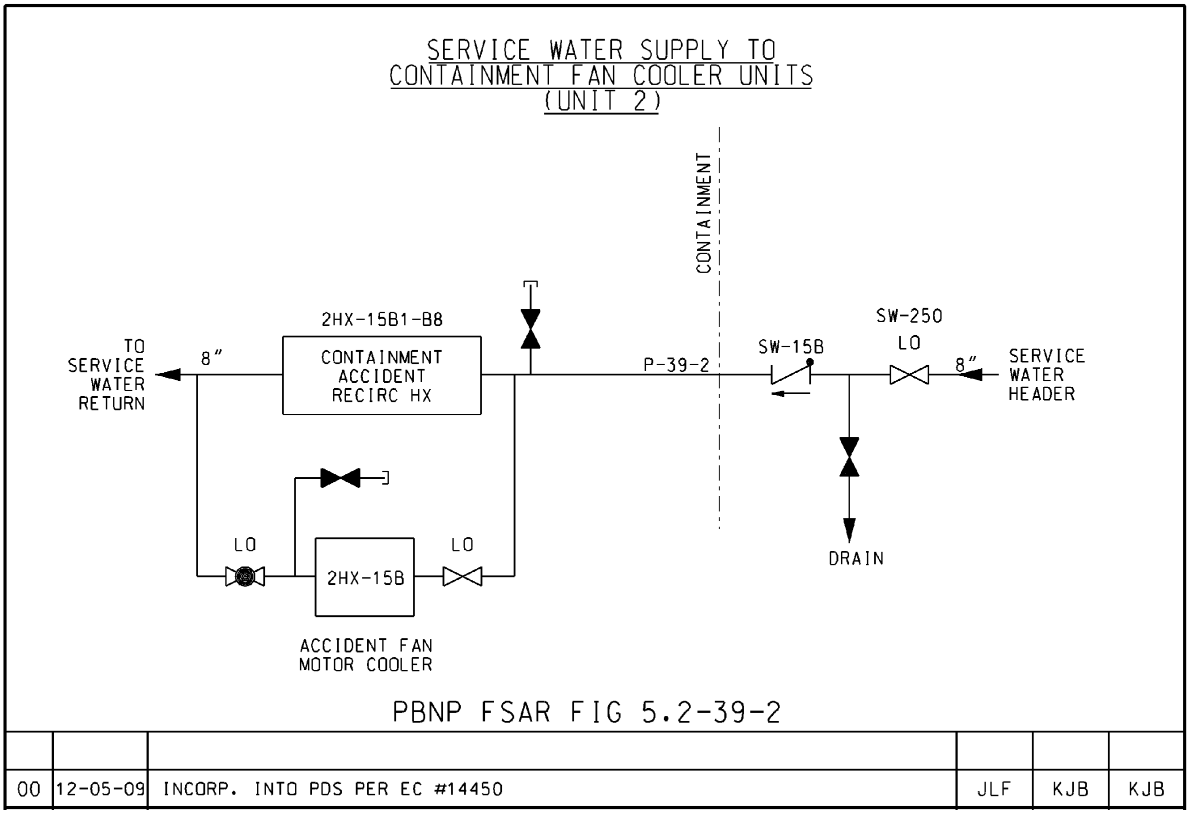

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 39-1 | CLOSED SYSTEM | SW-215 | VENTILATION COOLER WATER IN/SERVICE WATER | 8" | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (SW-215) LOCATED OUTSIDE CONTAINMENT. INSIDE CONTAINMENT THE SERVICE WATER SYSTEM IS A CLOSED SYSTEM.

Figure 5.2-39-2 SERVICE WATER SUPPLY TO CONTAIMENT FAN COOLER UNITS (UNIT 2)



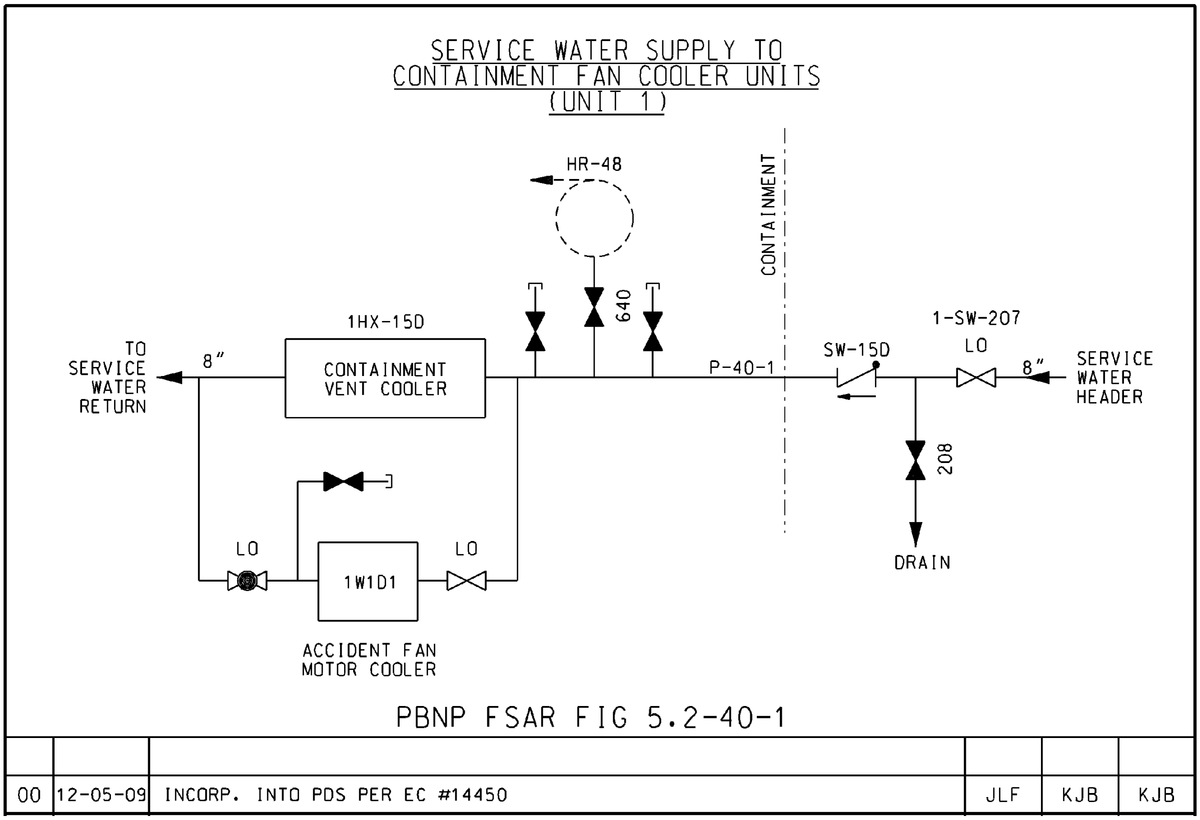

| PENETRATION | CONTAINMENT ISOLATION VALVES<br>INSIDE | <br>OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP.<br>HOT>200<br>COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 39-2 | CLOSED SYS. | SW-250 | VENTILATION COOLER WATER IN/SERVICE WATER | 8" | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (SW-250) LOCATED OUTSIDE CONTAINMENT. INSIDE CONTAINMENT THE SERVICE WATER SYSTEM IS A CLOSED SYSTEM.

Figure 5.2-40-1 SERVICE WATER SUPPLY TO CONTAIMENT FAN COOLER UNITS (UNIT 1)



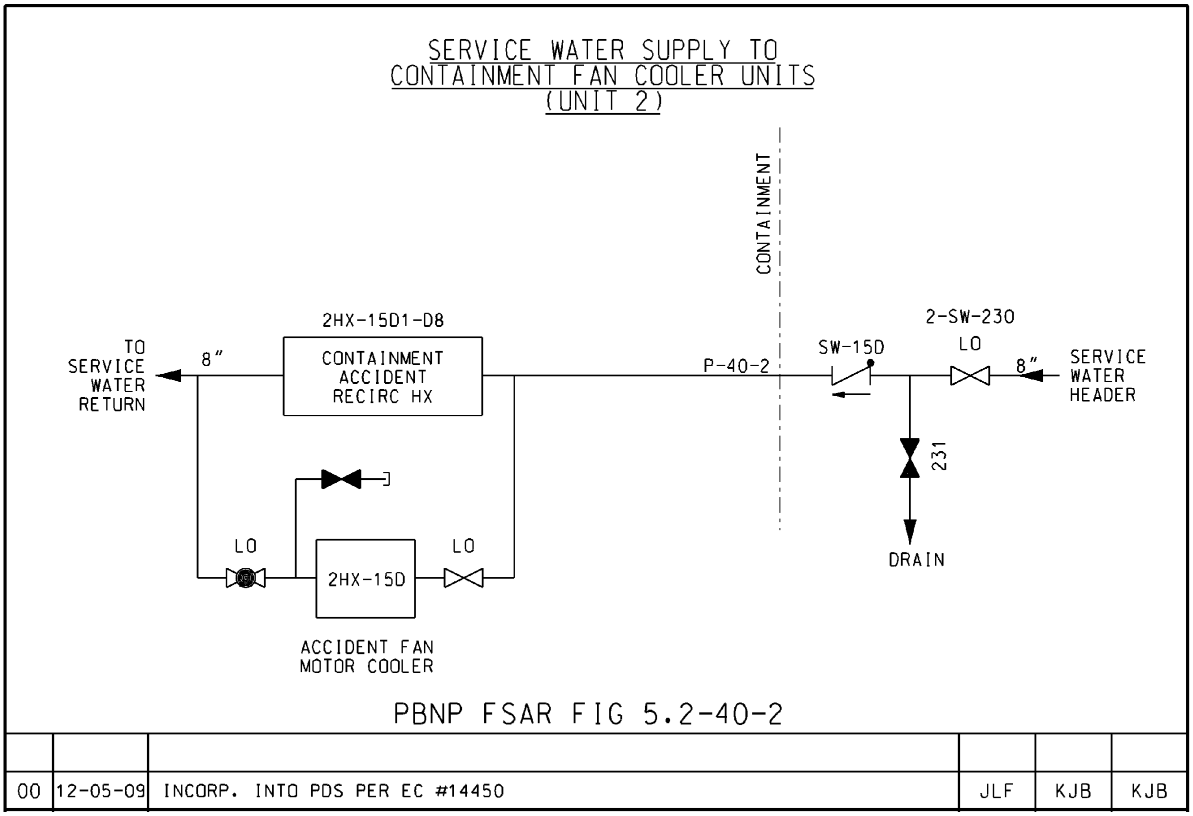

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 40-1 | CLOSED SYSTEM | SW-207 | VENTILATION COOLER WATER IN/SERVICE WATER | 8” | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (SW-207) LOCATED OUTSIDE CONTAINMENT. INSIDE CONTAINMENT THE SERVICE WATER SYSTEM IS A CLOSED SYSTEM.

Figure 5.2-40-2 SERVICE WATER SUPPLY TO CONTAIMENT FAN COOLER UNITS (UNIT 2)



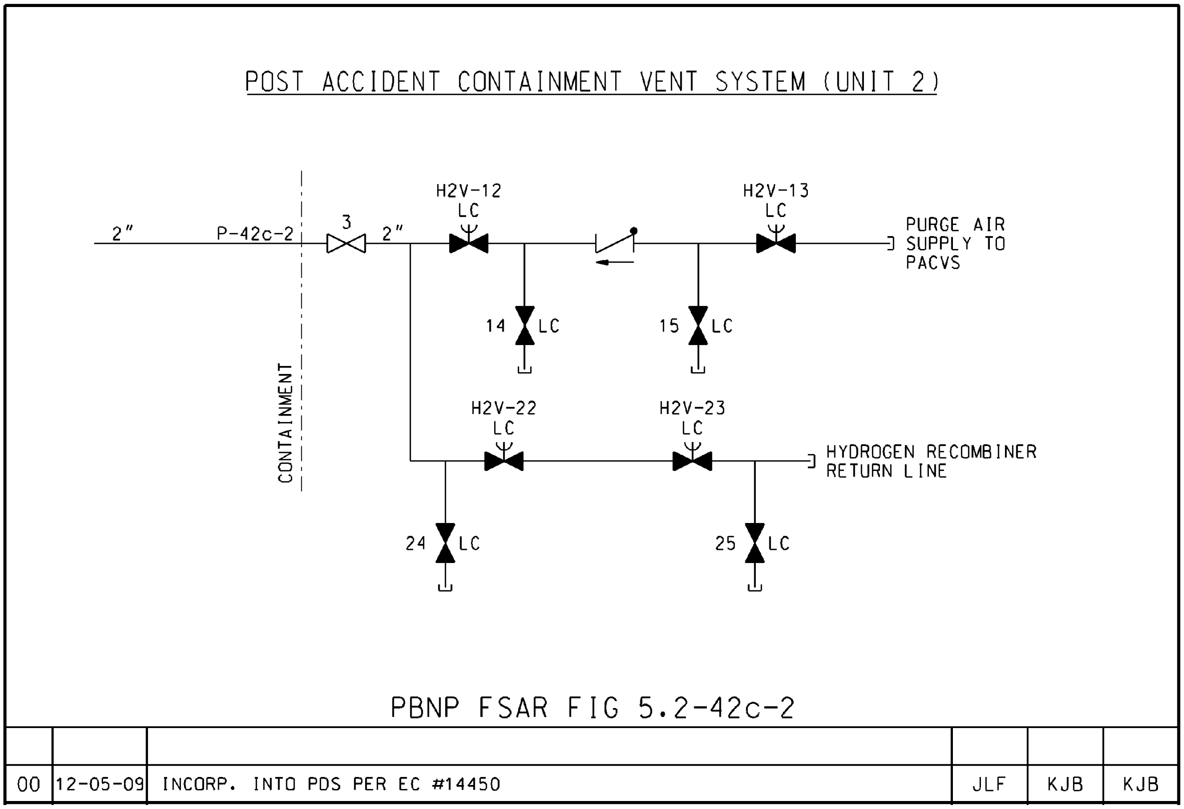

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 40-2 | CLOSED SYS. | SW-230 | VENTILATION COOLER WATER IN/SERVICE WATER | 8" | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (SW-230) LOCATED OUTSIDE CONTAINMENT. INSIDE CONTAINMENT THE SERVICE WATER SYSTEM IS A CLOSED SYSTEM.

# Figure 5.2-42c-2 POST ACCIDENT CONTAINMENT VENT SYSTEM (UNIT 2)




| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 42c-2 | | H2V-12<br>H2V-13 | PURGE AIR TO POST ACCIDENT CONTAINMENT VENT SYS./PACVS. | 2" | G | COLD | SPECIAL |
| | | H2V-22<br>H2V-23 | POST ACCIDENT CONTAINMENT VENT SYS $H_2$ RECOMBINER RETURN LINE /PACVS. | 2" | G | COLD | SPECIAL |

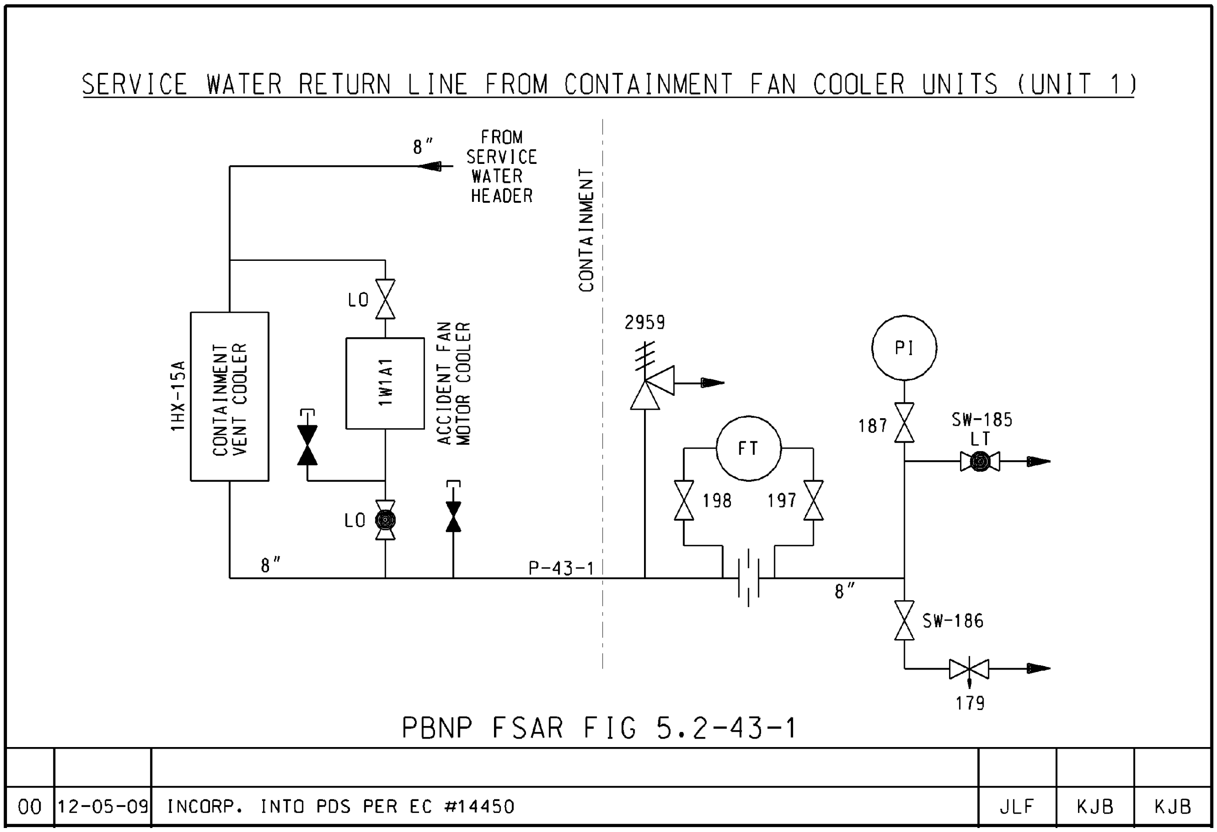
FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 5 & FIGURE 5.3-1 SHT. 2 & FIGURE 5.3-1 SHT. 3

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IDENTIFIED AS AN INTERMITTENT USE SYSTEM POST DBA.

1. PURGE AIR SUPPLY BRANCH - LOCKED CLOSED MANUAL VALVES H2V-12 AND H2V-13 OUTSIDE CONTAINMENT MEET CONTAINMENT ISOLATION CRITERIA.
2. HYDROGEN RECOMBINER BRANCH - LOCKED CLOSED MANUAL VALVES H2V-22 AND H2V-23 OUTSIDE CONTAINMENT MEET CONTAINMENT ISOLATION CRITERIA.

Figure 5.2-43-1 SERVICE WATER RETURN LINE FROM CONTAIMENT FAN COOLER UNITS (UNIT 1)



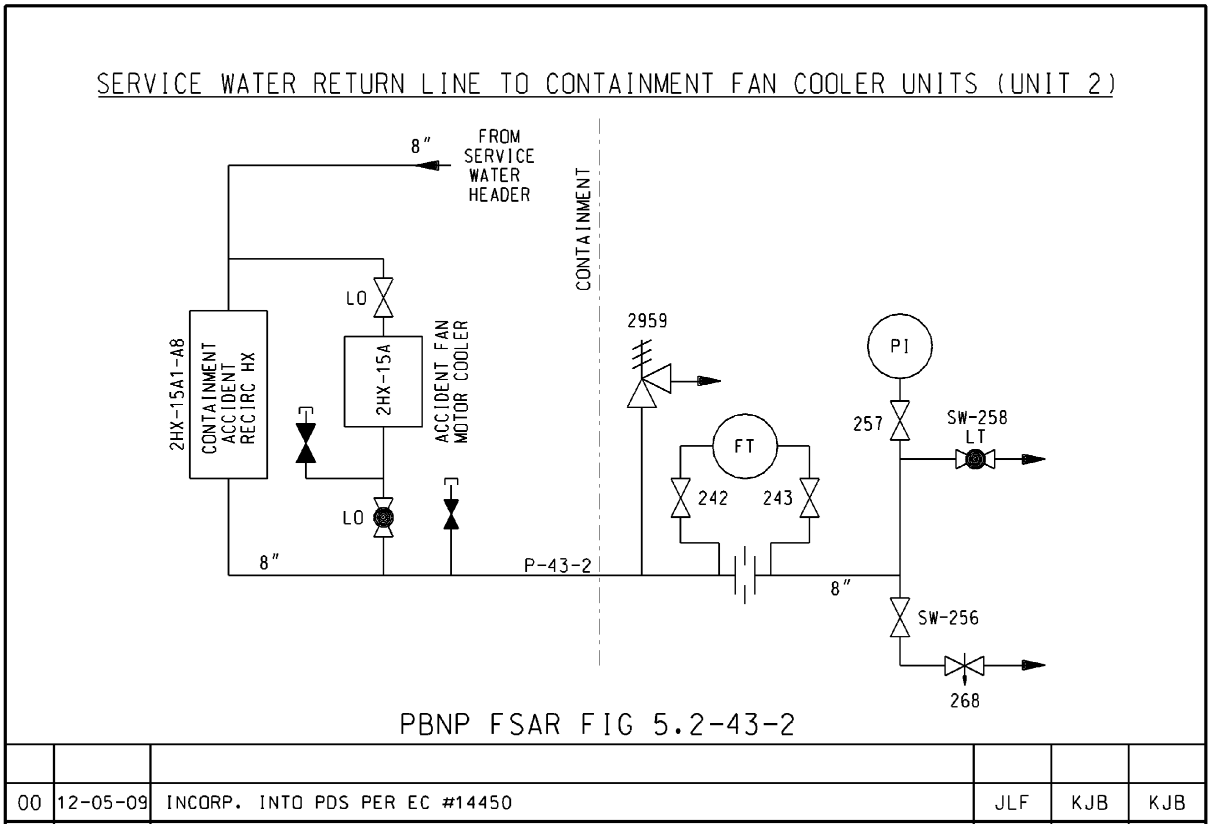

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 43-1 | CLOSED SYSTEM | SW-185 SW-186 | VENTILATION COOLER WATER OUT/SERVICE WATER | 8" | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH TWO MANUAL VALVES (SW-185 AND SW-186) LOCATED OUTSIDE CONTAINMENT. IT IS A CLOSED SYSTEM INSIDE CONTAINMENT.

# Figure 5.2-43-2 SERVICE WATER RETURN LINE TO CONTAIMENT FAN COOLER UNITS (UNIT 2)



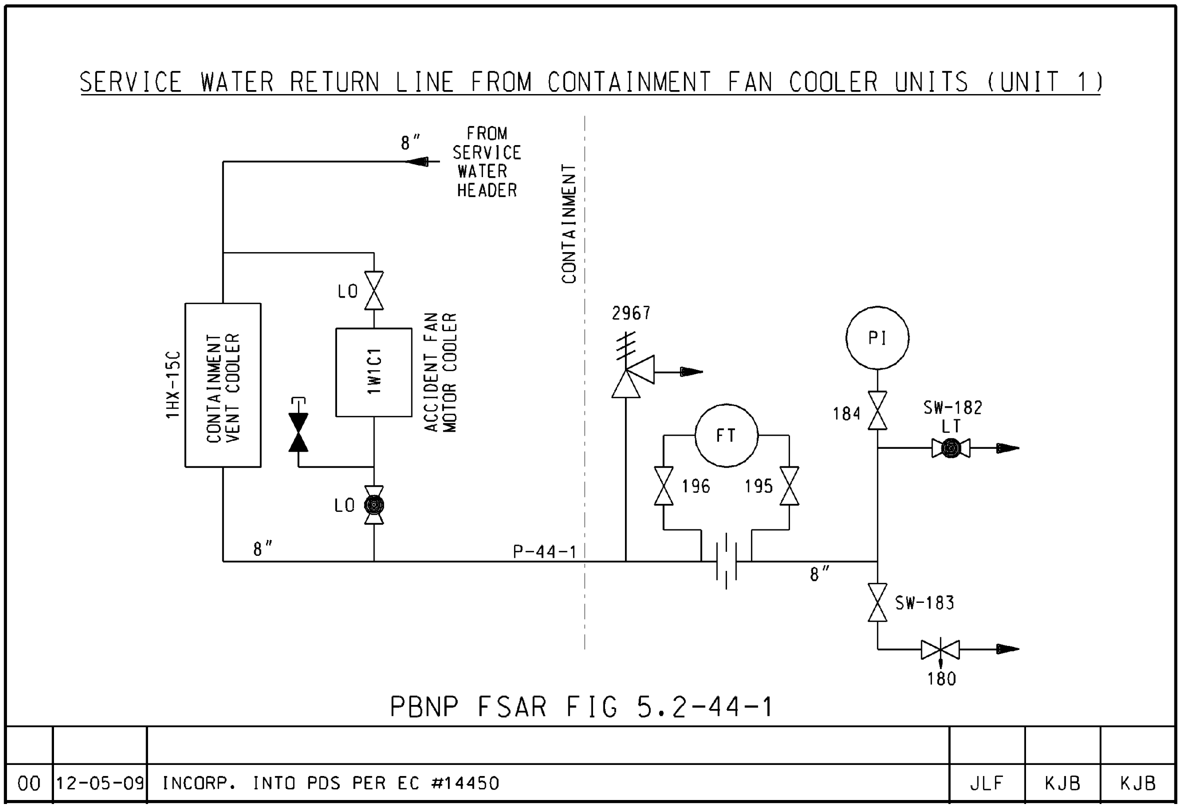

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 43-2 | CLOSED SYS. | SW-256<br>SW-258 | VENTILATION COOLER WATER OUT/SERVICE WATER | 8" | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH TWO MANUAL VALVES (SW-256, SW-258) LOCATED OUTSIDE CONTAINMENT. IT IS A CLOSED SYSTEM INSIDE CONTAINMENT.

Figure 5.2-44-1 SERVICE WATER RETURN LINE FROM CONTAIMENT FAN COOLER UNITS (UNIT 1)



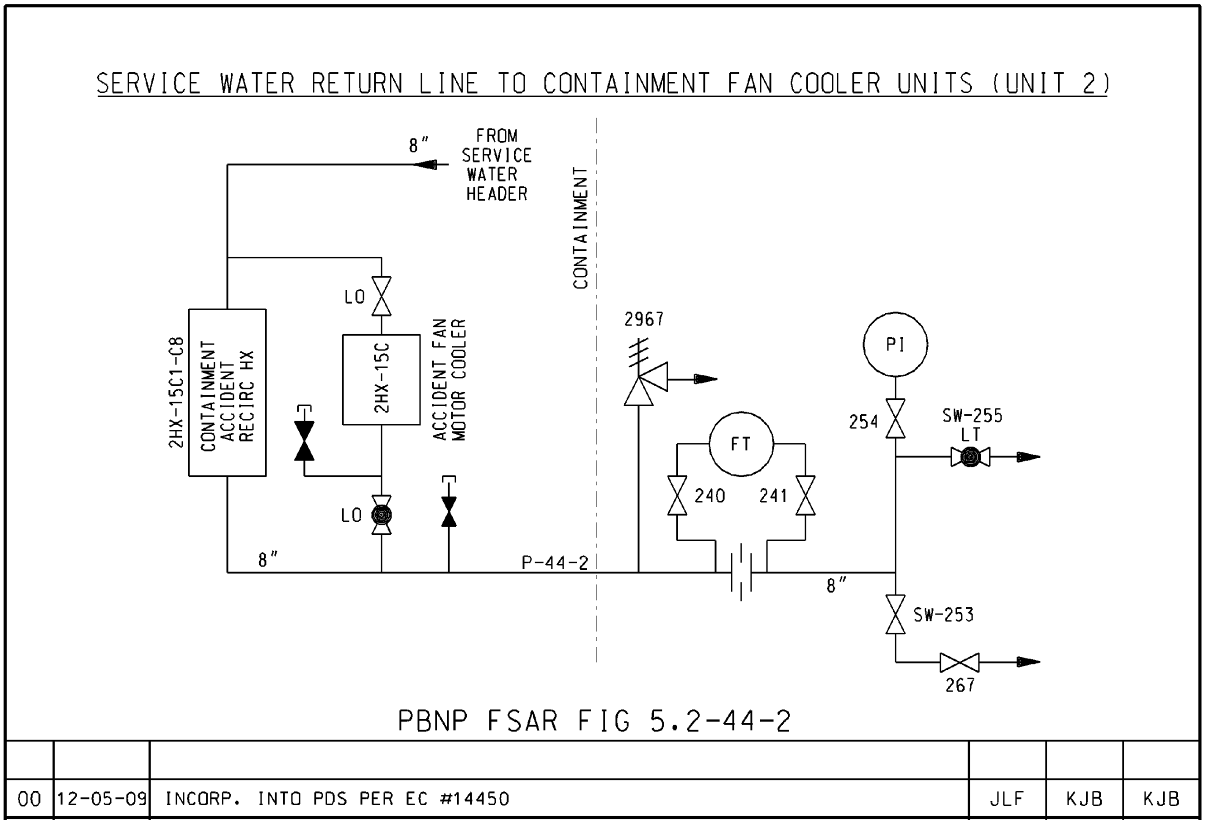

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 44-1 | CLOSED SYSTEM | SW-182 SW-183 | VENTILATION COOLER WATER OUT/SERVICE WATER | 8" | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH TWO MANUAL VALVES (SW-182 AND SW-183) LOCATED OUTSIDE OF CONTAINMENT. IT IS A CLOSED SYSTEM INSIDE CONTAINMENT.

# Figure 5.2-44-2 SERVICE WATER RETURN LINE TO CONTAIMENT FAN COOLER UNITS (UNIT 2)



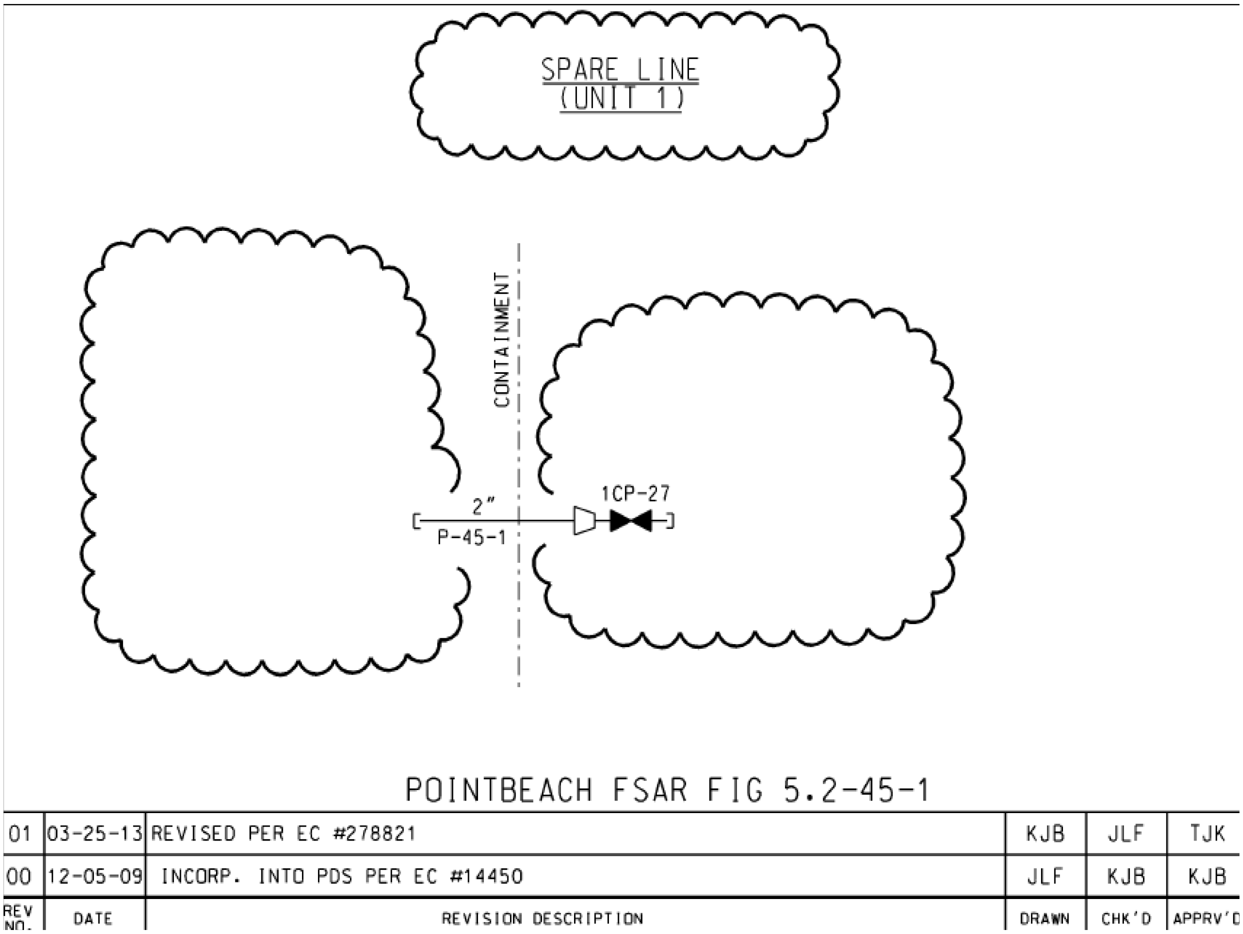

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200<br>COLD<200 | CLASS |
| 44-2 | CLOSED SYS. | SW-253<br>SW-255 | VENTILATION COOLER WATER OUT/SERVICE WATER | 8” | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH TWO MANUAL VALVES (SW-253, SW-255) LOCATED OUTSIDE CONTAINMENT. IT IS A CLOSED SYSTEM INSIDE CONTAINMENT.

Figure 5.2-45-1 SPARE LINE (UNIT 1)



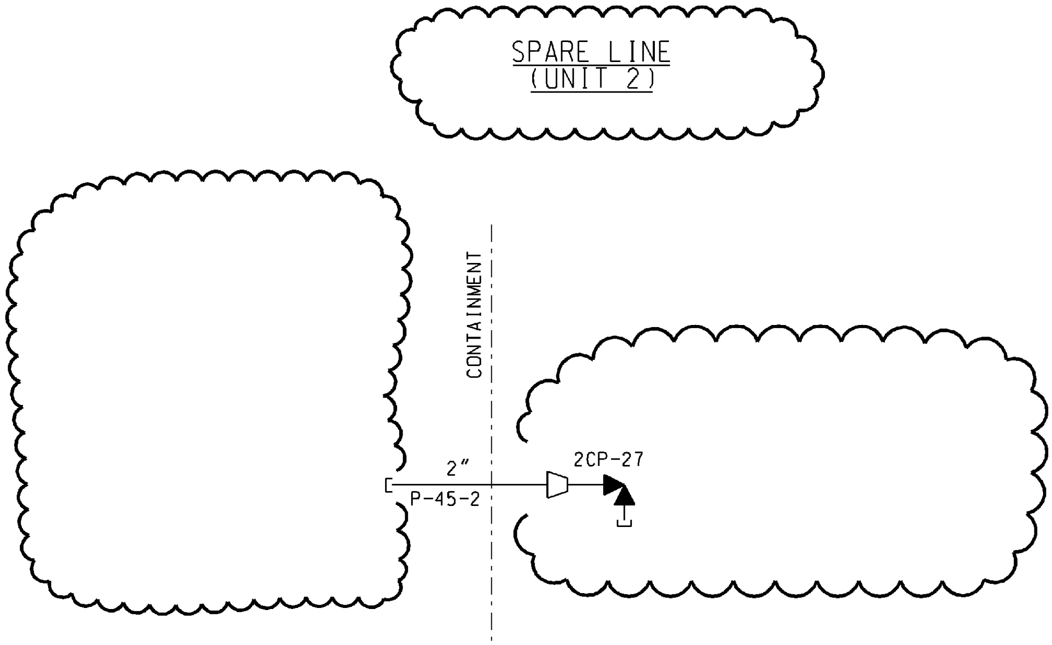

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 45-1 | CAPPED | 1CP-27 | SPARE | 2" | Air | COLD | 5 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 5 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (1CP-27) LOCATED OUTSIDE CONTAINMENT AND WELDED CAP INSIDE CONTAINMENT.

# Figure 5.2-45-2 SPARE LINE (UNIT 2)




POINTBEACH FSAR FIG 5.2-45-2

| REV NO. | DATE | REVISION DESCRIPTION | DRAWN | CHK'D | APPRV'D |
|---|---|---|---|---|---|
| 01 | 03-25-13 | REVISED PER EC #278821 | KJB | JLF | TJK |
| 00 | 12-05-09 | INCORP. INTO PDS PER EC #14450 | JLF | KJB | KJB |

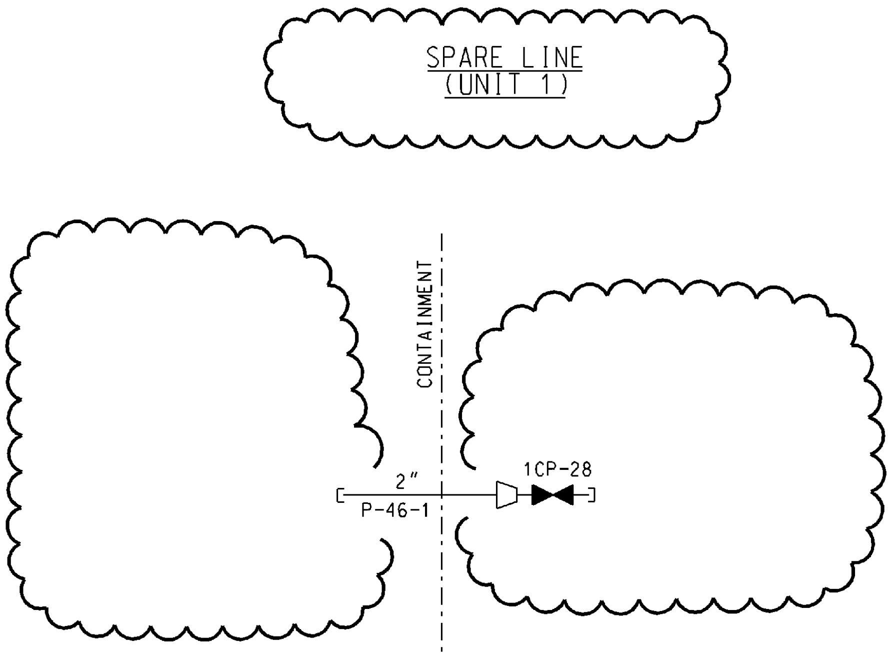
| PENETRATION | CONTAINMENT ISOLATION VALVES: INSIDE | CONTAINMENT ISOLATION VALVES: OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 45-2 | CAPPED | 2CP-27 | SPARE | 2” | Air | COLD | 5 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 5 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (1CP-27) LOCATED OUTSIDE CONTAINMENT AND WELDED CAP INSIDE CONTAINMENT.

# Figure 5.2-46-1 SPARE LINE (UNIT 1)




POINTBEACH FSAR FIG 5.2-46-1

| REV NO. | DATE | REVISION DESCRIPTION | DRAWN | CHK'D | APPRV'D |
|---|---|---|---|---|---|
| 01 | 03-25-13 | REVISED PER EC #278821 | KJB | JLF | TJK |
| 00 | 12-05-09 | INCORP. INTO PDS PER EC #14450 | JLF | KJB | KJB |

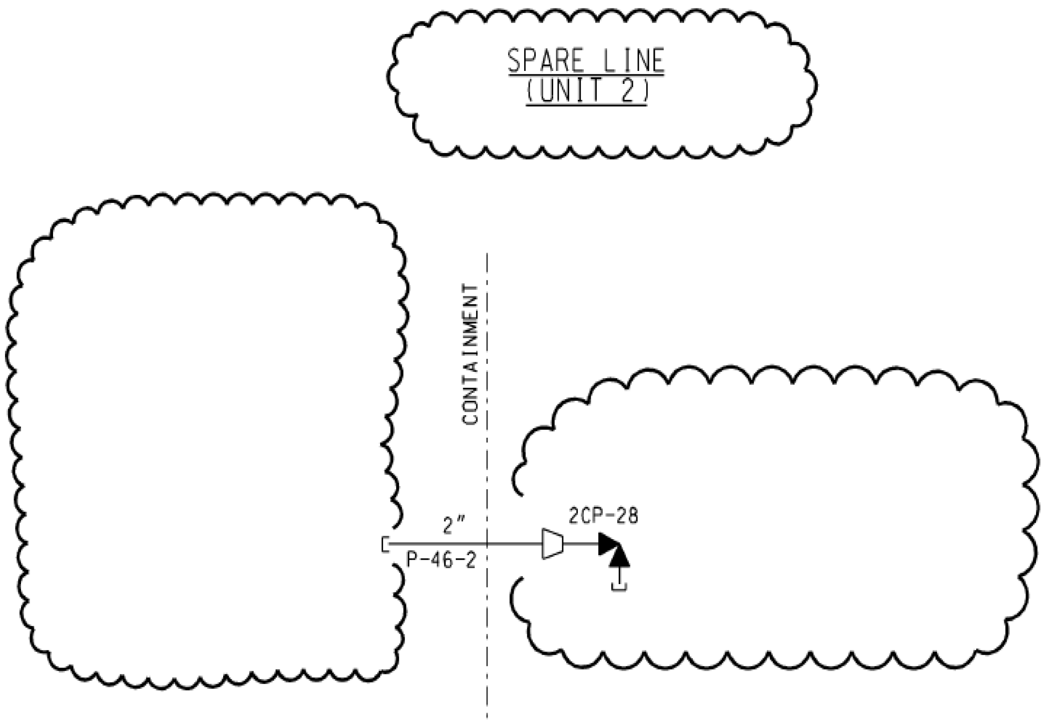
| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 46-1 | CAPPED | 1CP-28 | SPARE | 2" | Air | COLD | 5 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-3

NOTE:

THIS PENETRATION MEETS CLASS 5 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (1CP-28) LOCATED OUTSIDE CONTAINMENT AND WELDED CAP INSIDE CONTAINMENT.

# Figure 5.2-46-2 SPARE LINE (UNIT 2)




POINTBEACH FSAR FIG 5.2-46-2

| REV NO. | DATE | REVISION DESCRIPTION | DRAWN | CHK'D | APPRV'D |
|---|---|---|---|---|---|
| 01 | 03-25-13 | REVISED PER EC #278821 | KJB | JLF | TJK |
| 00 | 12-05-09 | INCORP. INTO PDS PER EC #14450 | JLF | KJB | KJB |

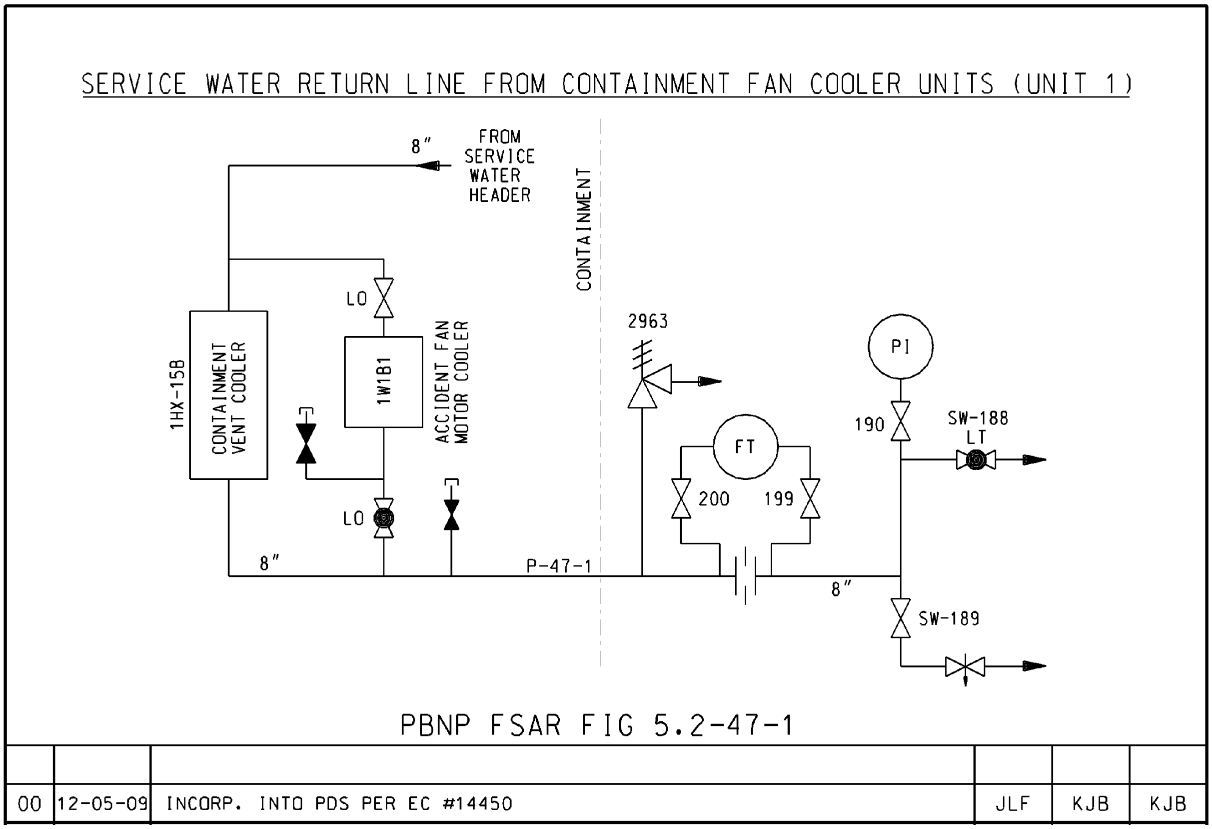
| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 46-2 | CAPPED | 2CP-28 | SPARE | 2” | Air | COLD | 5 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 5 CONTAINMENT ISOLATION CRITERIA. REQUIREMENTS ARE MET BY MANUAL VALVE (2CP-28) LOCATED OUTSIDE CONTAINMENT AND WELDED CAP INSIDE CONTAINMENT.

# Figure 5.2-47-1 SERVICE WATER RETURN LINE FROM CONTAINMENT FAN COOLER UNITS (UNIT 1)



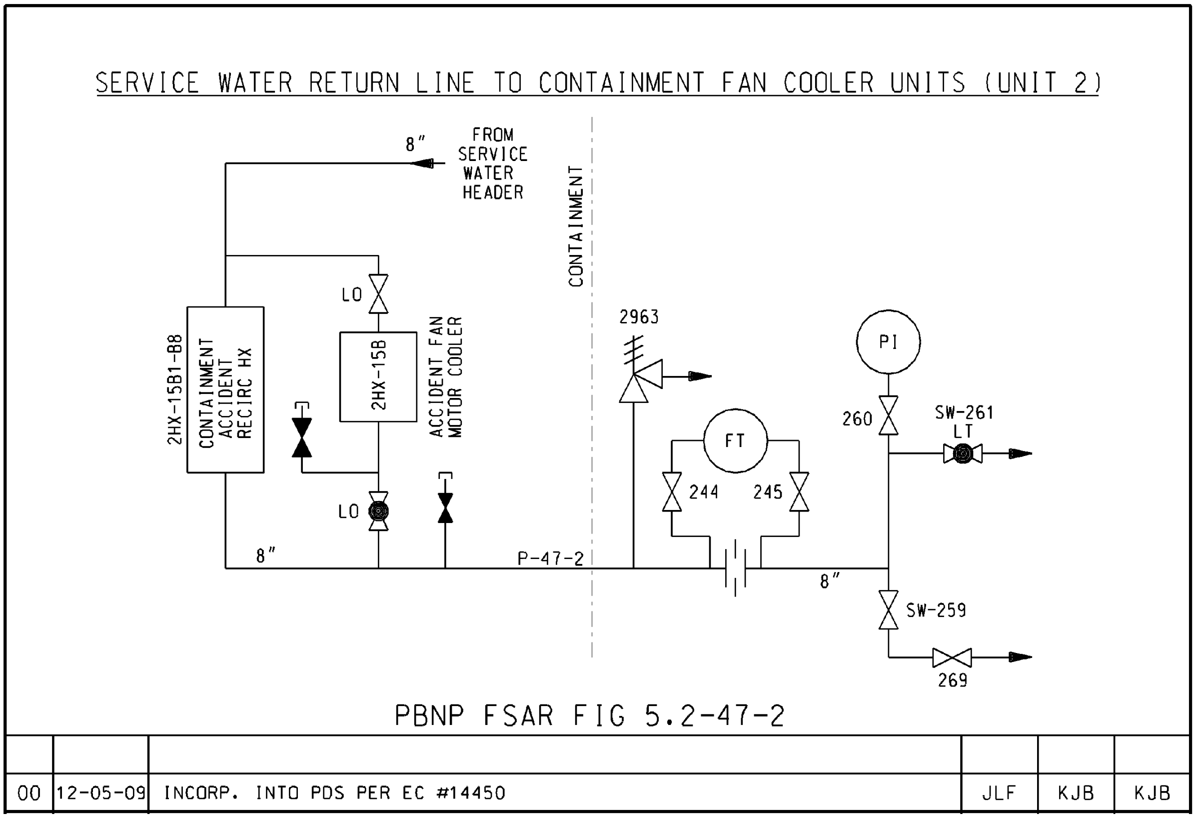

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 47-1 | CLOSED SYSTEM | SW-188<br>SW-189 | VENTILATION COOLER WATER OUT/SERVICE WATER | 8" | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH TWO MANUAL VALVES (SW-188 AND SW-189) LOCATED OUTSIDE CONTAINMENT. IT IS A CLOSED SYSTEM INSIDE CONTAINMENT.

Figure 5.2-47-2 SERVICE WATER RETURN LINE TO CONTAINMENT FAN COOLER UNITS (UNIT 2)



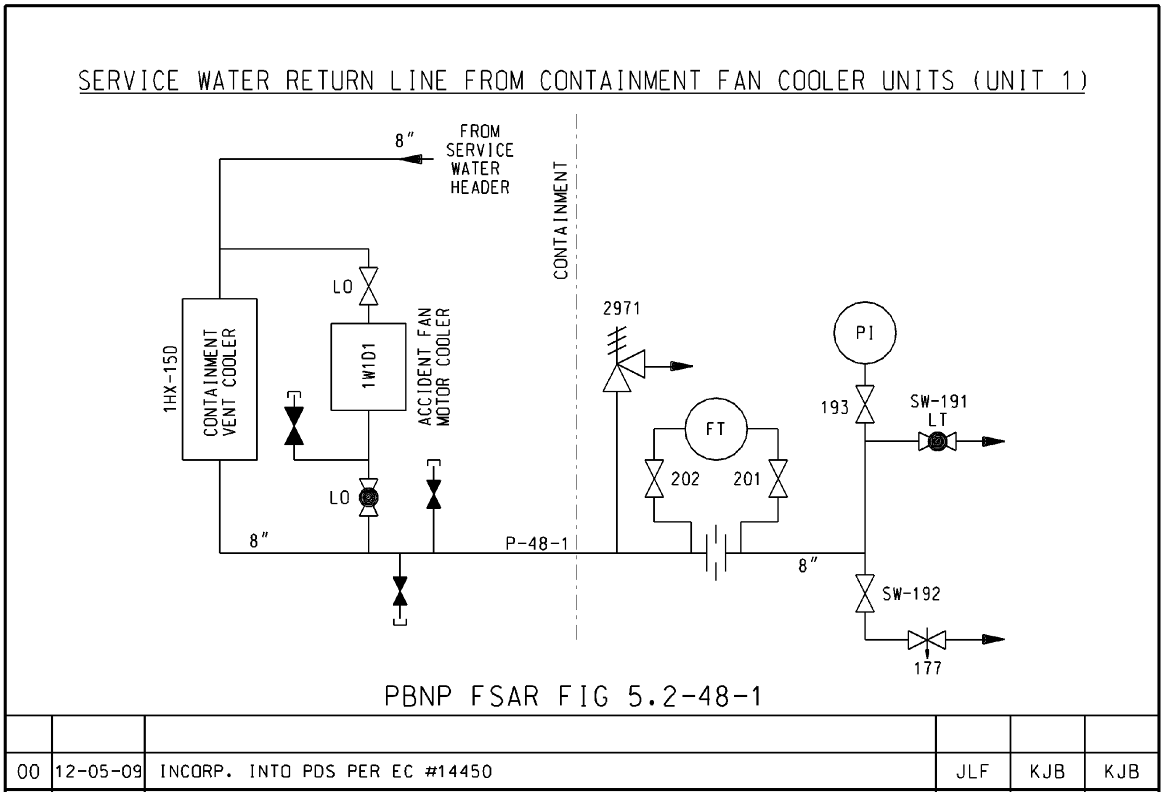

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 47-2 | CLOSED SYS. | SW-259<br>SW-261 | VENTILATION COOLER WATER OUT/SERVICE WATER | 8" | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH TWO MANUAL VALVES (SW-259, SW-261) LOCATED OUTSIDE CONTAINMENT. IT IS A CLOSED SYSTEM INSIDE CONTAINMENT.

# Figure 5.2-48-1 SERVICE WATER RETURN LINE FROM CONTAINMENT FAN COOLER UNITS (UNIT 1)



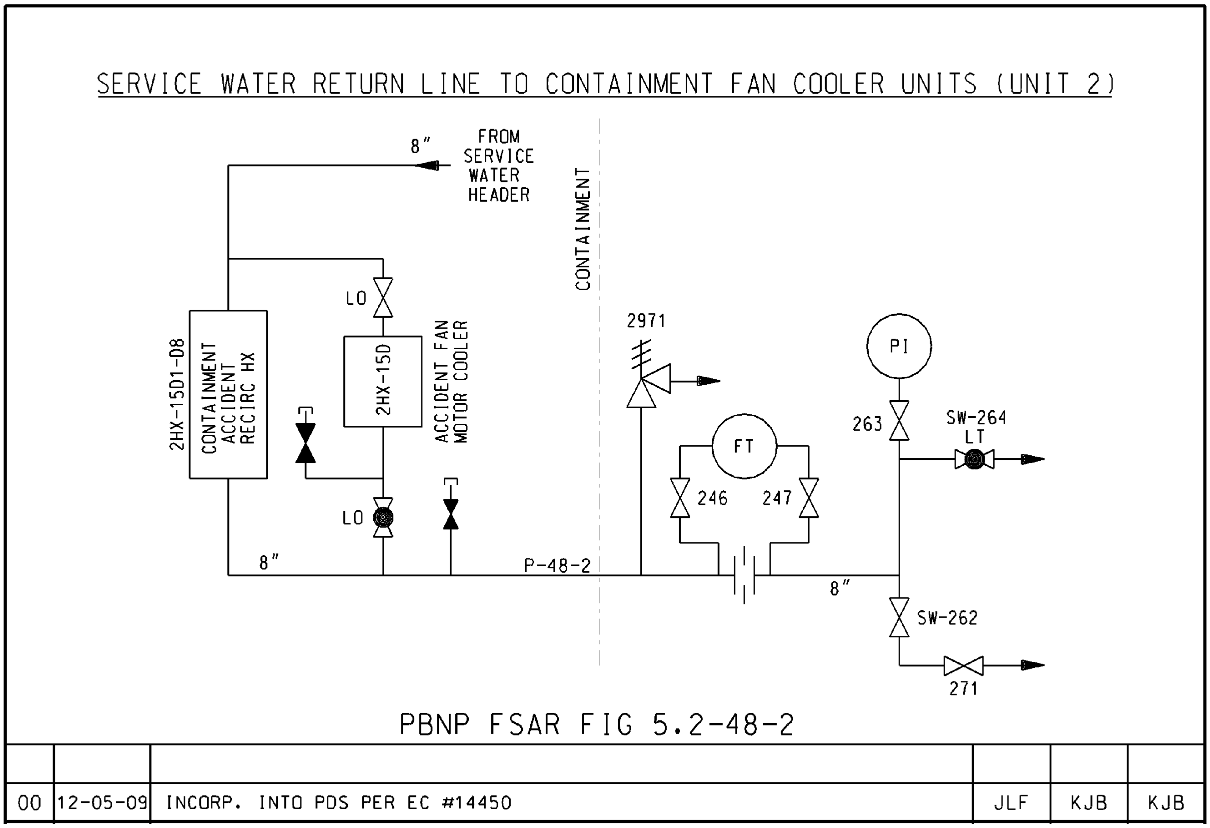

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200<br>COLD<200 | CLASS |
| 48-1 | CLOSED SYSTEM | SW-191<br>SW-192 | VENTILATION COOLER WATER OUT/SERVICE WATER | 8" | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH TWO MANUAL VALVES (SW-191 AND SW-192) LOCATED OUTSIDE CONTAINMENT. IT IS A CLOSED SYSTEM INSIDE CONTAINMENT.

Figure 5.2-48-2 SERVICE WATER RETURN LINE TO CONTAINMENT FAN COOLER UNITS (UNIT 2)



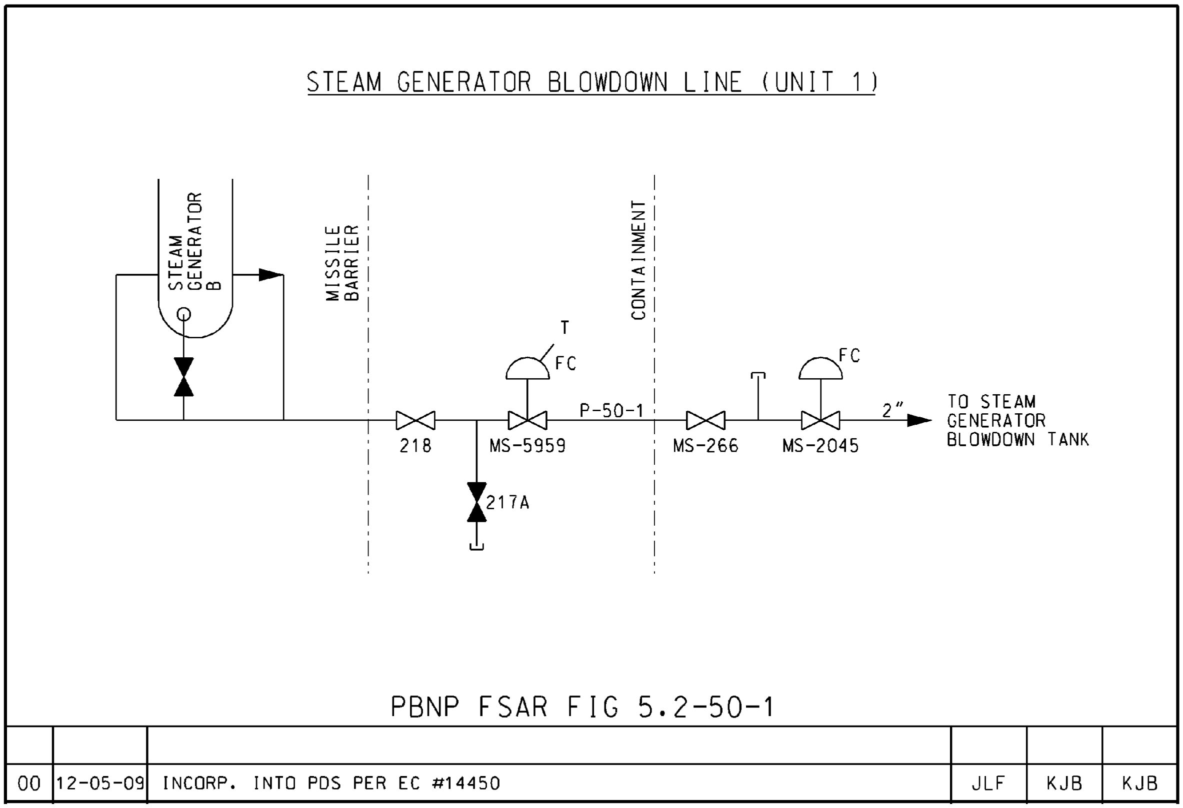

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 48 -2 | CLOSED SYS. | SW-262<br>SW-264 | VENTILATION COOLER WATER OUT/SERVICE WATER | 8" | W | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 9 & FIGURE 9.6-5

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH TWO MANUAL VALVES (SW-262, SW-264) LOCATED OUTSIDE CONTAINMENT. IT IS A CLOSED SYSTEM INSIDE CONTAINMENT.

Figure 5.2-50-1 STEAM GENERATOR BLOWDOWN LINE (UNIT 1)



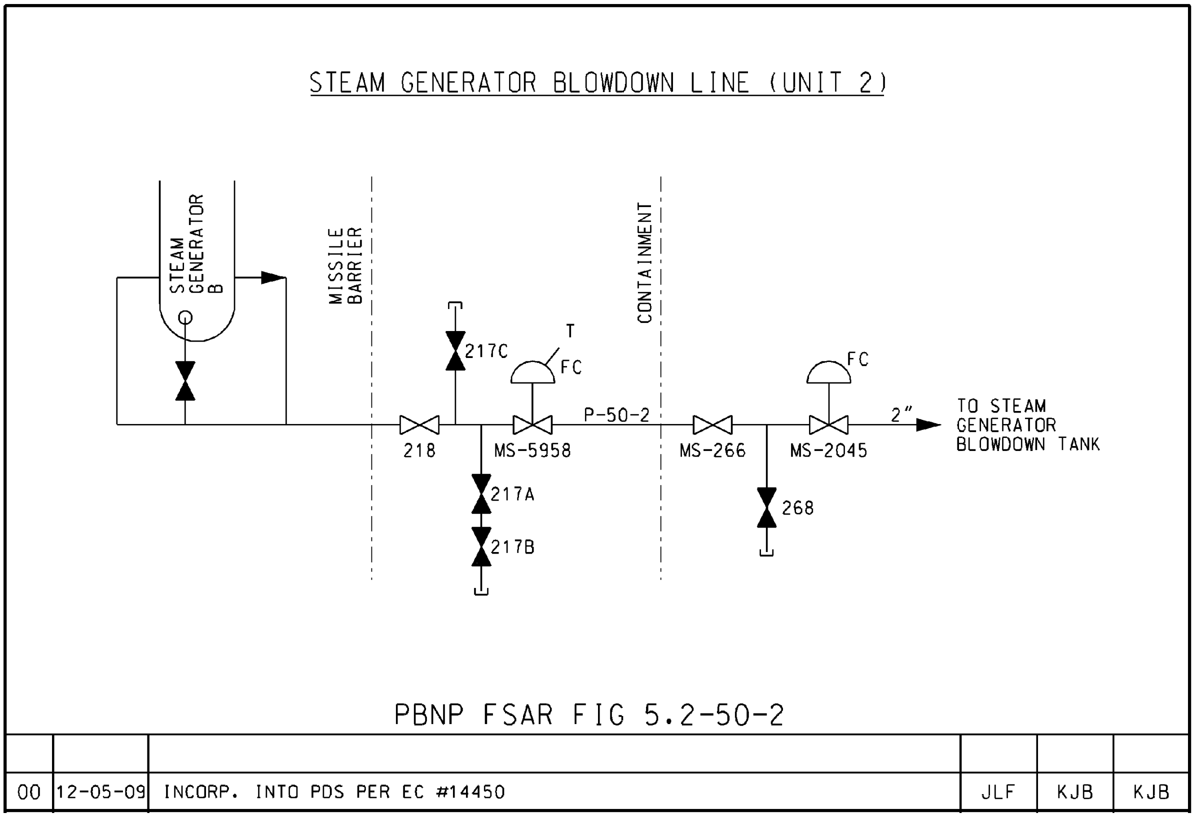

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 50-1 | MS-5959 CLOSED SYS. | MS-266 | STEAM GENERATOR BLOWDOWN/ SECONDARY SYSTEM | 2" | W | HOT | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIGURE 10.2-1 SHT. 1

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH A MANUAL VALVE (MS-266) LOCATED OUTSIDE CONTAINMENT. THE SYSTEM INSIDE CONTAINMENT IS A CLOSED SYSTEM. IN ADDITION, AUTOMATIC TRIP VALVE (MS-5959) IS AN ISOLATION VALVE INSIDE CONTAINMENT AND WAS ADDED AS A TMI COMMITMENT.

# Figure 5.2-50-2 STEAM GENERATOR BLOWDOWN LINE (UNIT 2)



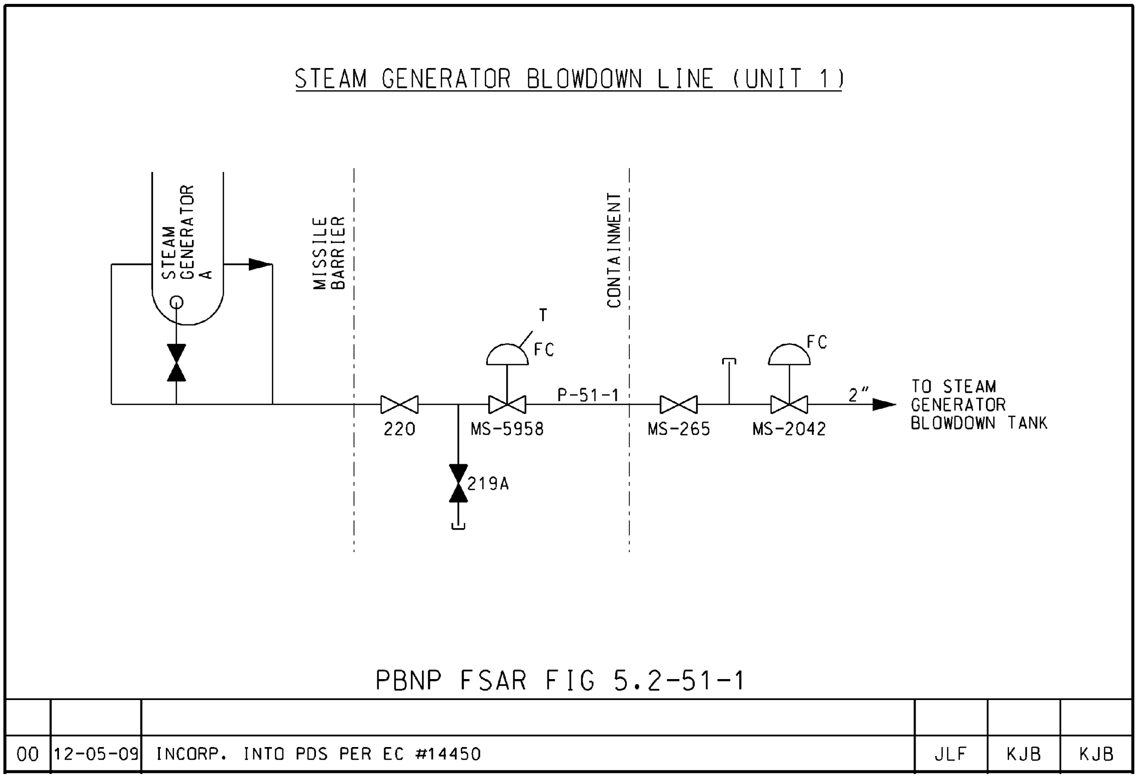

| PENETRATION | CONTAINMENT ISOLATION VALVES<br>INSIDE | <br>OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP.<br>HOT>200<br>COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 50-2 | MS-5958<br>CLOSED SYS. | MS-266 | STEAM GENERATOR BLOWDOWN/ SECONDARY SYSTEM | 2" | W | HOT | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIGURE 10.2-1 SHT. 1

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH A MANUAL VALVE (MS-266) LOCATED OUTSIDE CONTAINMENT. THE SYSTEM INSIDE CONTAINMENT IS A CLOSED SYSTEM. IN ADDITION, AUTOMATIC TRIP VALVE (MS-5958) IS AN ISOLATION VALVE INSIDE CONTAINMENT AND WAS ADDED AS A TMI COMMITMENT.

# Figure 5.2-51-1 STEAM GENERATOR BLOWDOWN LINE (UNIT 1)



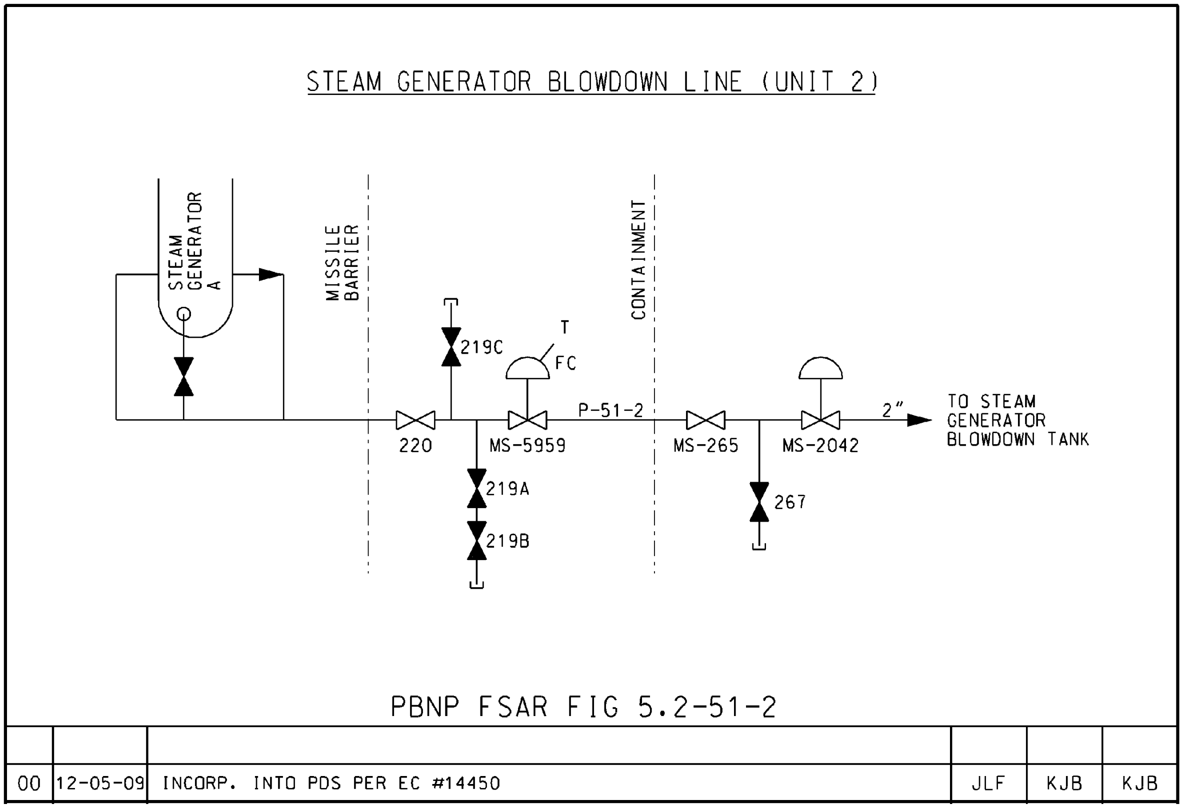

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | CONTAINMENT ISOLATION VALVES OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 51-1 | MS-5958 CLOSED SYS. | MS-265 | STEAM GENERATOR BLOWDOWN/ SECONDARY SYSTEM | 2" | W | HOT | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIGURE 10.2-1 SHT. 1

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH A MANUAL VALVE (MS-265) LOCATED OUTSIDE CONTAINMENT. THE SYSTEM INSIDE CONTAINMENT IS A CLOSED SYSTEM. IN ADDITION, AUTOMATIC TRIP VALVE (MS-5958) IS AN ISOLATION VALVE INSIDE CONTAINMENT AND WAS ADDED AS A TMI COMMITMENT.

Figure 5.2-51-2 STEAM GENERATOR BLOWDOWN LINE (UNIT 2)



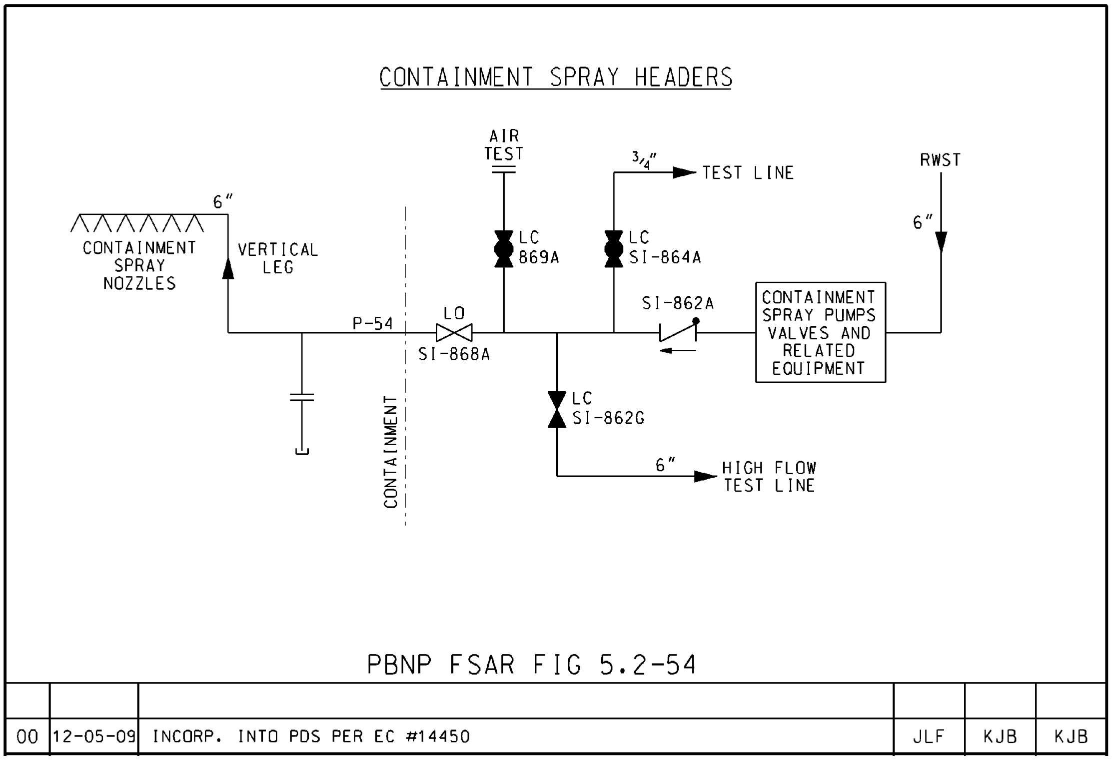

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 51-2 | MS-5959 CLOSED SYS. | MS-265 | STEAM GENERATOR BLOWDOWN/ SECONDARY SYSTEM | 2" | W | HOT | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIGURE 10.2-1 SHT. 1

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH A MANUAL VALVE (MS-265) LOCATED OUTSIDE CONTAINMENT. THE SYSTEM INSIDE CONTAINMENT IS A CLOSED SYSTEM. IN ADDITION, AUTOMATIC TRIP VALVE (MS-5959) IS AN ISOLATION VALVE INSIDE CONTAINMENT.

# Figure 5.2-54 CONTAINMENT SPRAY HEADERS




| PENETRATION | CONTAINMENT ISOLATION VALVES | | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. | CLASS |
|---|---|---|---|---|---|---|---|
| | INSIDE | OUTSIDE | | | | HOT>200 COLD<200 | |
| 54 | | SI-862A CLOSED SYS | CONTAINMENT SPRAY/SAFETY INJECTION SYS. | 6” | W | COLD | SPECIAL |
| | | SI-864A CLOSED SYS | CONTAINMENT SPRAY TEST/SAFETY INJECTION SYSTEM | 3/4” | W | COLD | SPECIAL |
| | | SI-862G CLOSED SYS | CS HIGH FLOW TEST / SI SYSTEM. | 6” | W | COLD | SPECIAL |

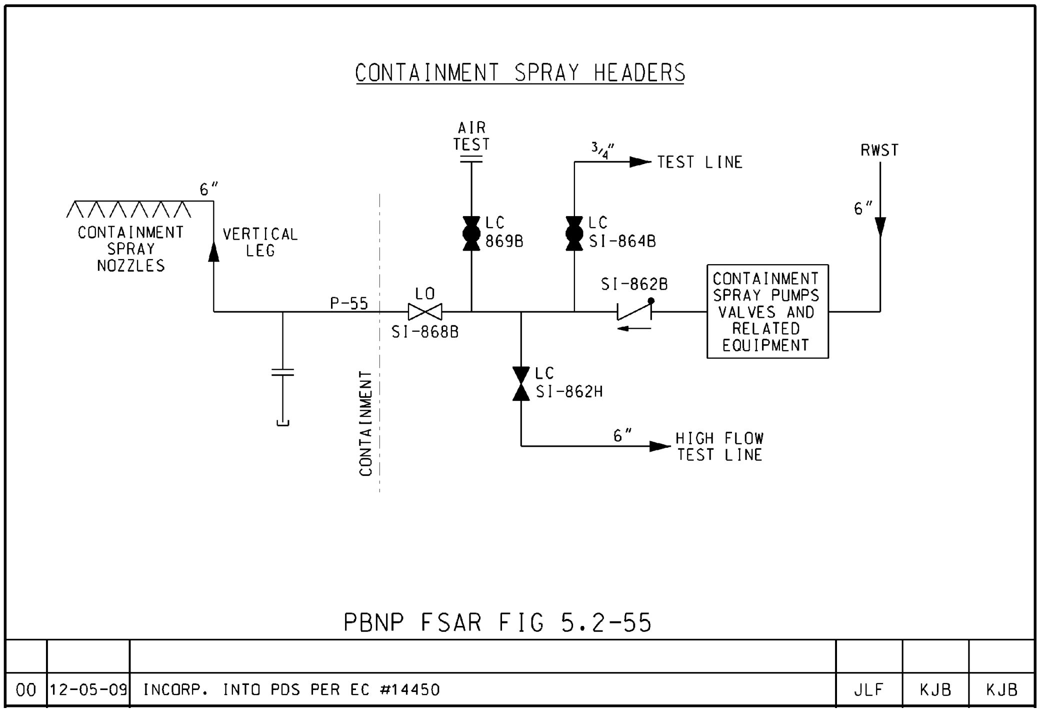
FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 6 & FIGURE 6.2-1 SHEET 1

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IDENTIFIED AS AN INTERMITTENT USE SYSTEM POST DBA.

1. CONTAINMENT SPRAY BRANCH - THIS BRANCH MEETS CONTAINMENT ISOLATION CRITERIA WITH CHECK VALVE SI-862A WHICH SERVES THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND A CLOSED SYSTEM OUTSIDE CONTAINMENT.
2. HIGH FLOW TEST LINE BRANCH -THIS BRANCH MEETS CONTAINMENT ISOLATION CRITERIA WITH LOCKED CLOSED MANUAL VALVE SI-862G WHICH SERVES THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND A CLOSED SYSTEM OUTSIDE CONTAINMENT.
3. TEST LINE BRANCH - THIS BRANCH MEETS CONTAINMENT ISOLATION CRITERIA WITH LOCKED CLOSED MANUAL VALVE SI-864A WHICH SERVES THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND A CLOSED SYSTEM OUTSIDE CONTAINMENT.

# Figure 5.2-55 CONTAIMENT SPRAY HEADERS




| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 55 | | SI-862B CLOSED SYS. | CONTAINMENT SPRAY/SAFETY INJECTION SYS. | 6" | W | COLD | SPECIAL |
| | | SI-864B CLOSED SYS. | CONTAINMENT SPRAY TEST/SAFETY INJECTION SYSTEM | 3/4" | W | COLD | SPECIAL |
| | | SI-862H CLOSED SYS. | CS HIGH FLOW TEST / SI SYSTEM. | 6" | W | COLD | SPECIAL |

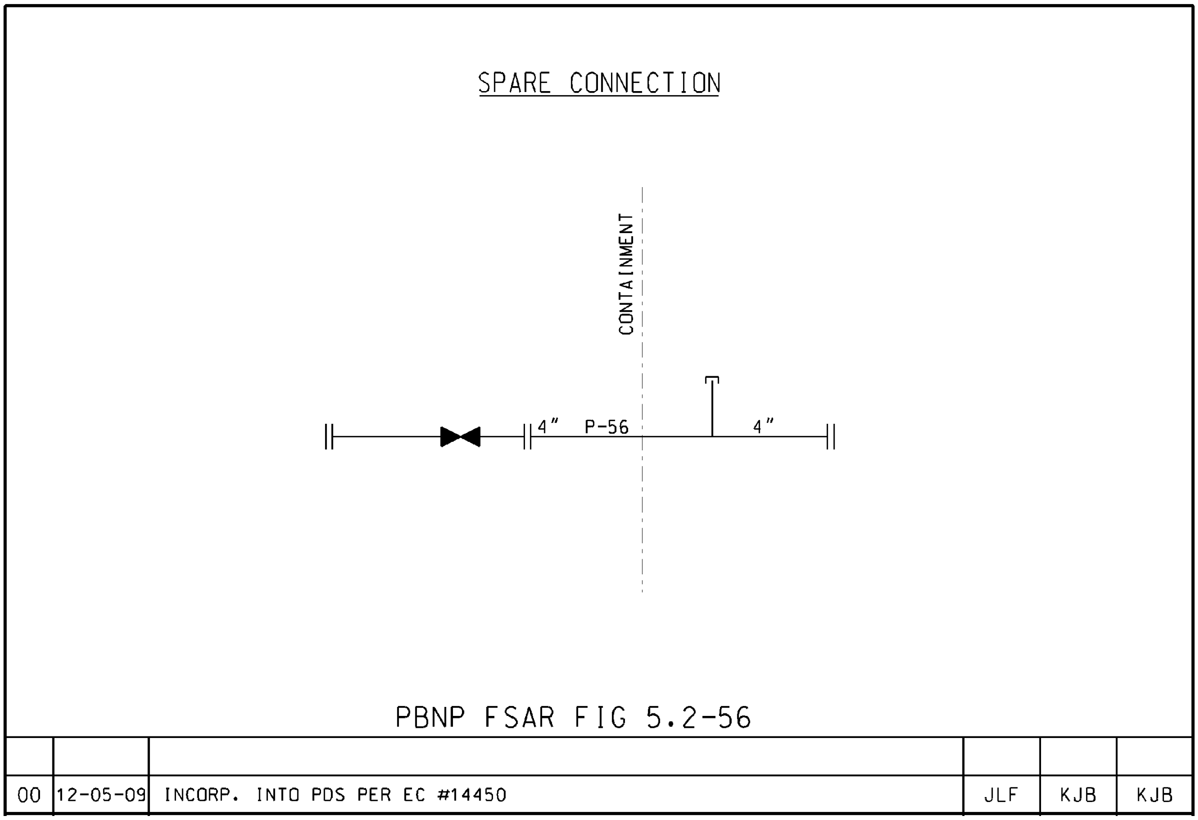
FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 6 & FIGURE 6.2-1 SHEET 1

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IDENTIFIED AS AN INTERMITTENT USE SYSTEM POST DBA.

1. CONTAINMENT SPRAY BRANCH - THIS BRANCH MEETS CONTAINMENT ISOLATION CRITERIA WITH CHECK VALVE SI-862B WHICH SERVES THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND A CLOSED SYSTEM OUTSIDE CONTAINMENT.
2. HIGH FLOW TEST LINE BRANCH -THIS BRANCH MEETS CONTAINMENT ISOLATION CRITERIA WITH LOCKED CLOSED MANUAL VALVE SI-862H WHICH SERVES THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND A CLOSED SYSTEM OUTSIDE CONTAINMENT.
3. TEST LINE BRANCH - THIS BRANCH MEETS CONTAINMENT ISOLATION CRITERIA WITH LOCKED CLOSED MANUAL VALVE SI-864B WHICH SERVES THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND A CLOSED SYSTEM OUTSIDE CONTAINMENT.

Figure 5.2-56 SPARE CONNECTION



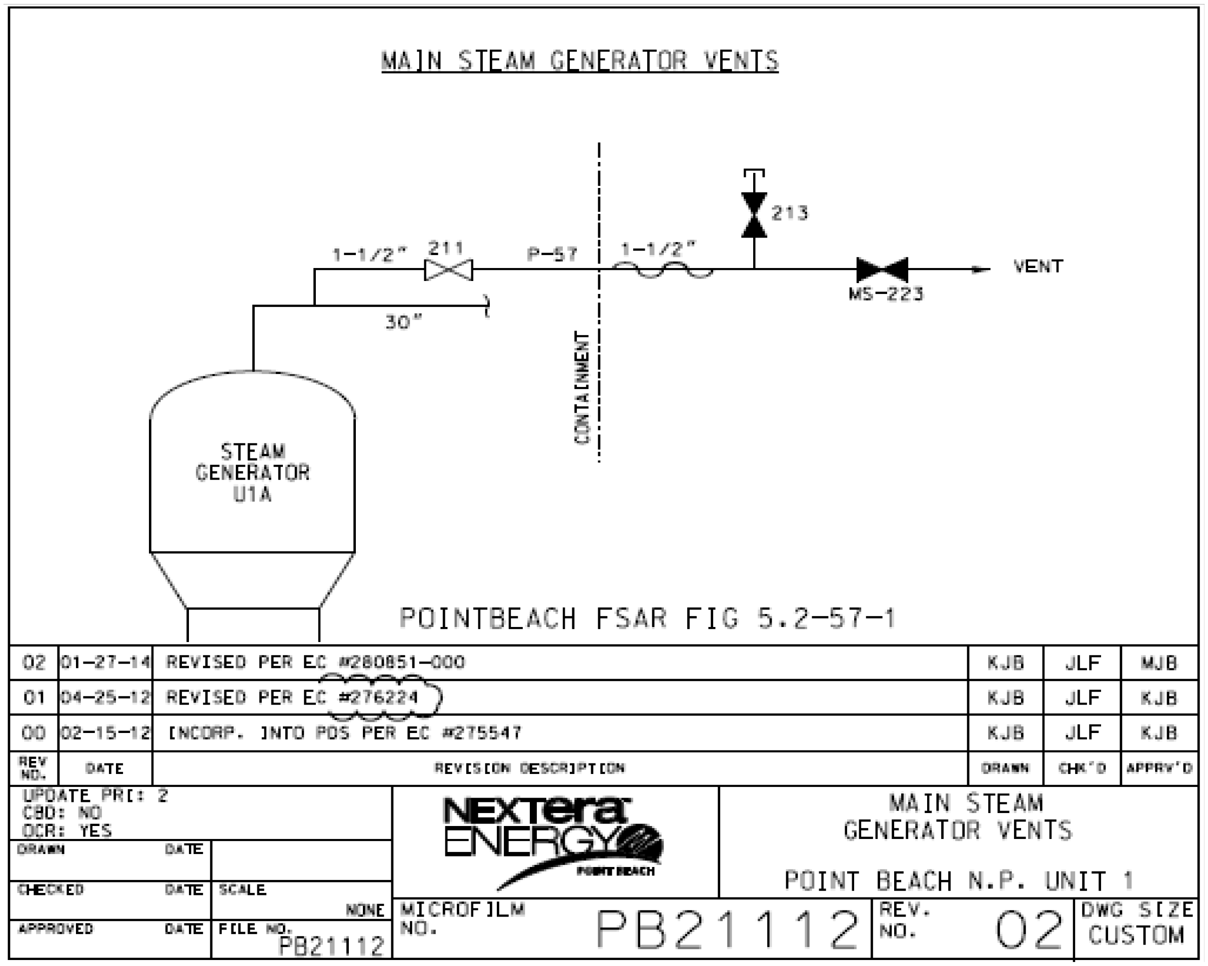

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 56 | BLANK FLG.. | BLANK FLG. | SPARE | 4" | G | COLD | 5 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIGURE 10.2-1 SHT. 1

NOTE:

THIS PENETRATION MEETS CLASS 5 SINCE THE BLANK FLANGES PROVIDE EQUAL OR GREATER PROTECTION THAN THE MANUAL VALVE AND BLANK FLANGE PROVIDED FOR IN THE CRITERIA.

# Figure 5.2-57-1 MAIN STEAM GENERATOR VENTS



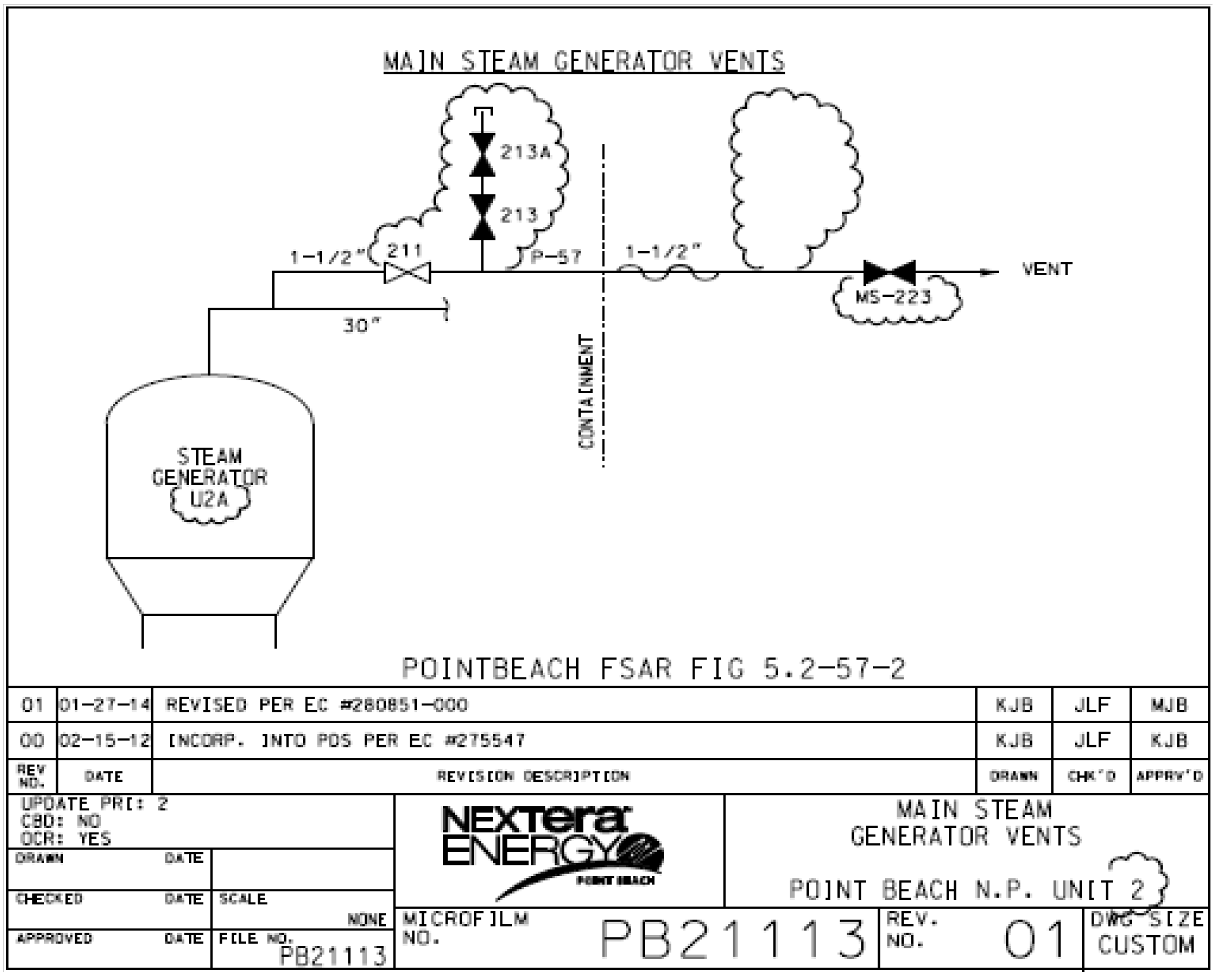

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 57 | CLOSED SYS. | MS-223 | STEAM GENERATOR VENTS/MS | 1-1/2” | G | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIGURE 10.1-1 SHT. 1

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH A MANUAL VALVE MS-223 OUTSIDE CONTAINMENT. THIS IS A CLOSED SYSTEM INSIDE CONTAINMENT.

# Figure 5.2-57-2 MAIN STEAM GENERATOR VENTS



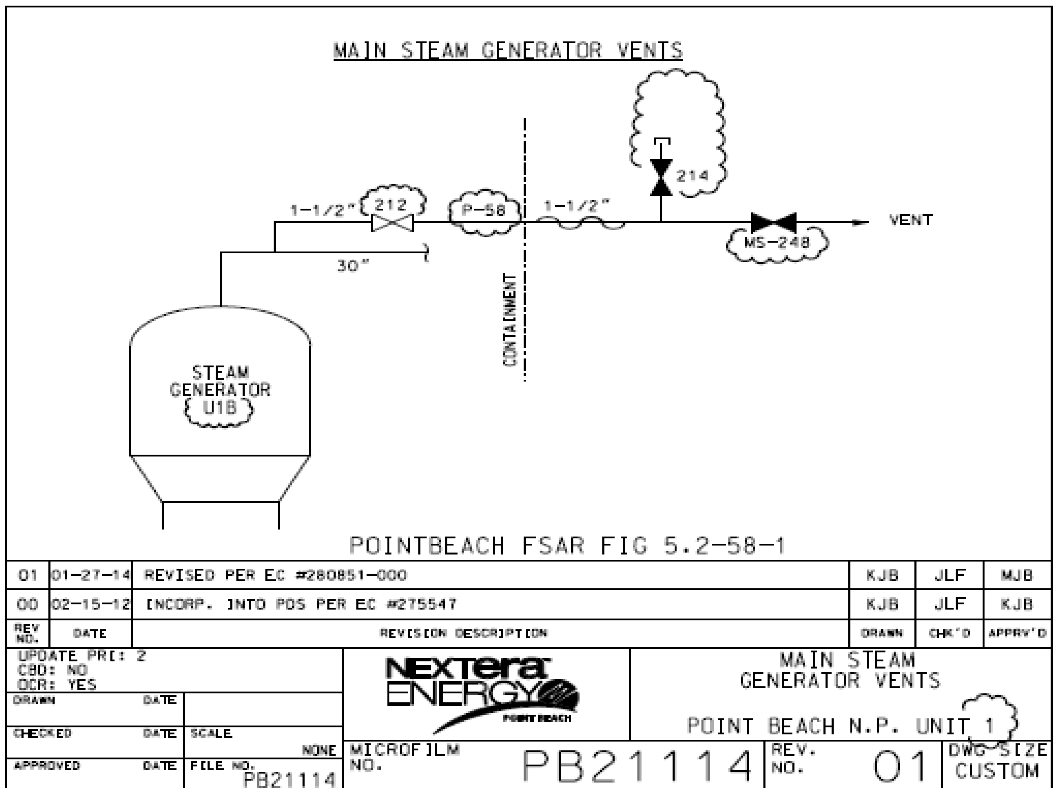

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 57 | CLOSED SYS. | MS-223 | STEAM GENERATOR VENTS/MS | 1-1/2" | G | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIGURE 10.1-1 SHT. 1

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH A MANUAL VALVE MS-223 OUTSIDE CONTAINMENT. THIS IS A CLOSED SYSTEM INSIDE CONTAINMENT.

Figure 5.2-58-1 MAIN STEAM GENERATOR VENTS



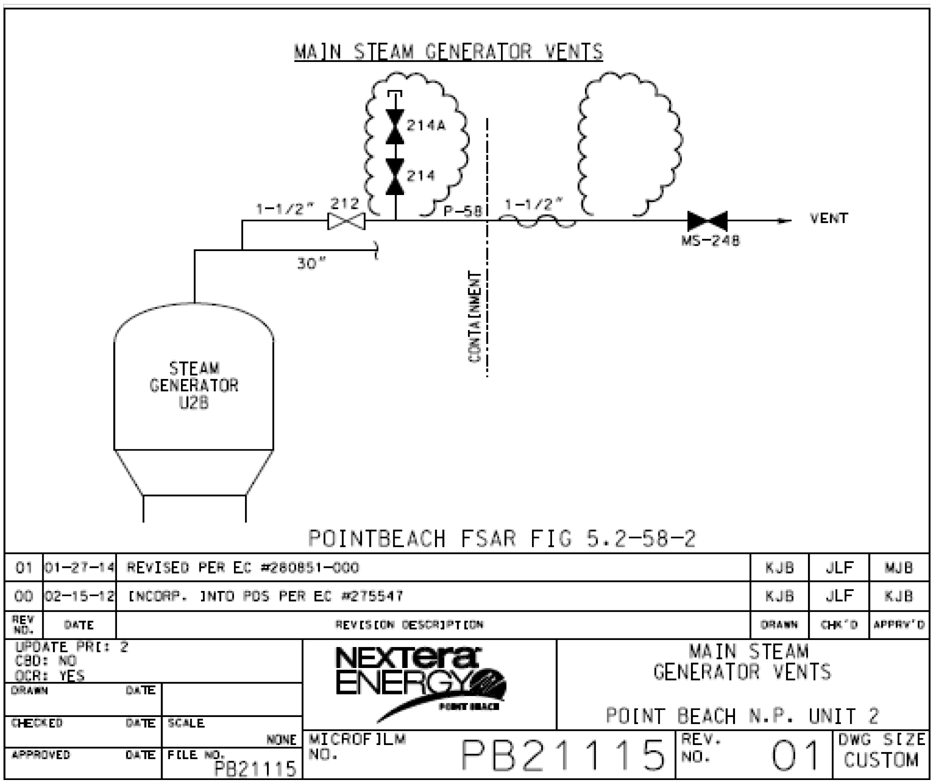

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200<br>COLD<200 | CLASS |
| 58 | CLOSED SYS. | MS-248 | STEAM GENERATOR VENTS/MS | 1-1/2” | G | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIGURE 10.1-1A SHEET 1

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH A MANUAL VALVE MS-248 OUTSIDE CONTAINMENT. THIS IS A CLOSED SYSTEM INSIDE CONTAINMENT.

# Figure 5.2-58-2 MAIN STEAM GENERATOR VENTS



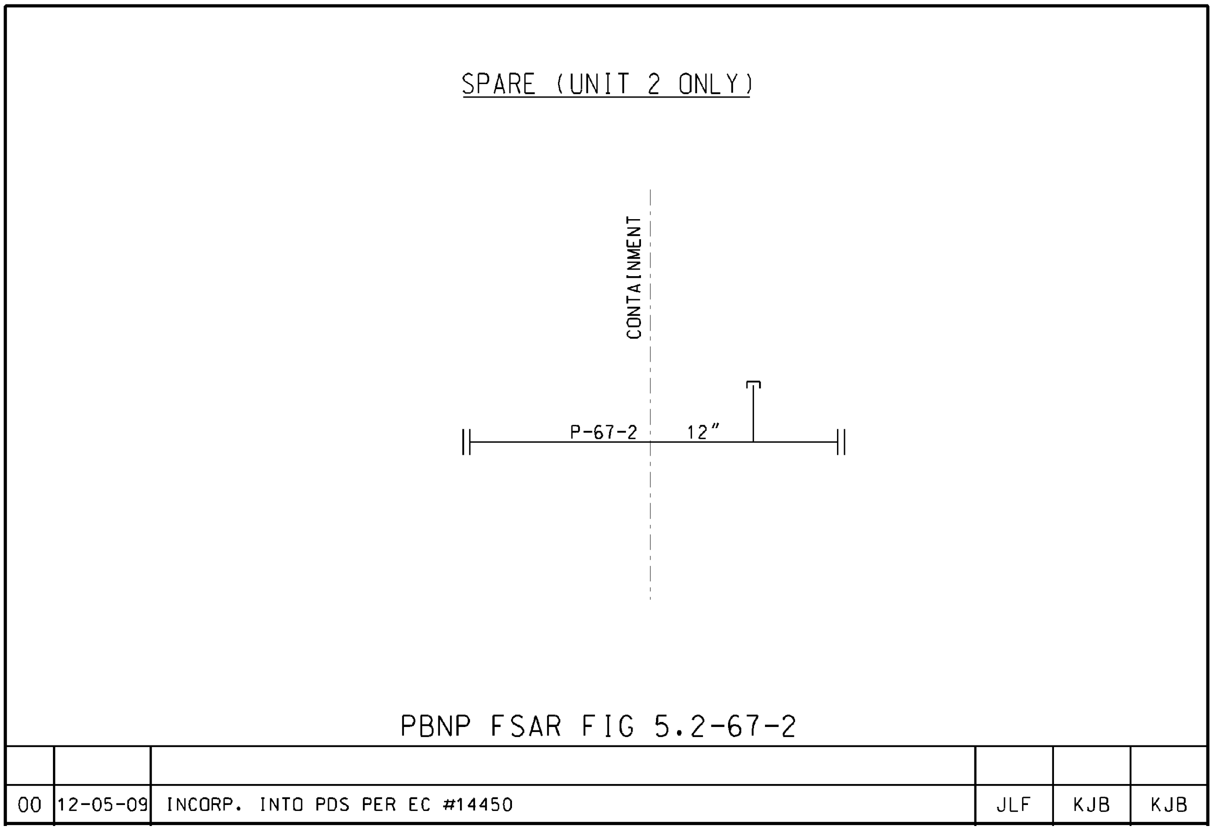

| PENETRATION | CONTAINMENT ISOLATION VALVES<br>INSIDE | <br>OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP.<br>HOT>200<br>COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 58 | CLOSED SYS. | MS-248 | STEAM GENERATOR VENTS/MS | 1-1/2" | G | COLD | 4 |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 10 & FIGURE 10.1-1A SHEET 1

NOTE:

THIS PENETRATION MEETS CLASS 4 CONTAINMENT ISOLATION CRITERIA WITH A MANUAL VALVE MS-248 OUTSIDE CONTAINMENT. THIS IS A CLOSED SYSTEM INSIDE CONTAINMENT.

Figure 5.2-67-2 SPARE (UNIT 2 ONLY)

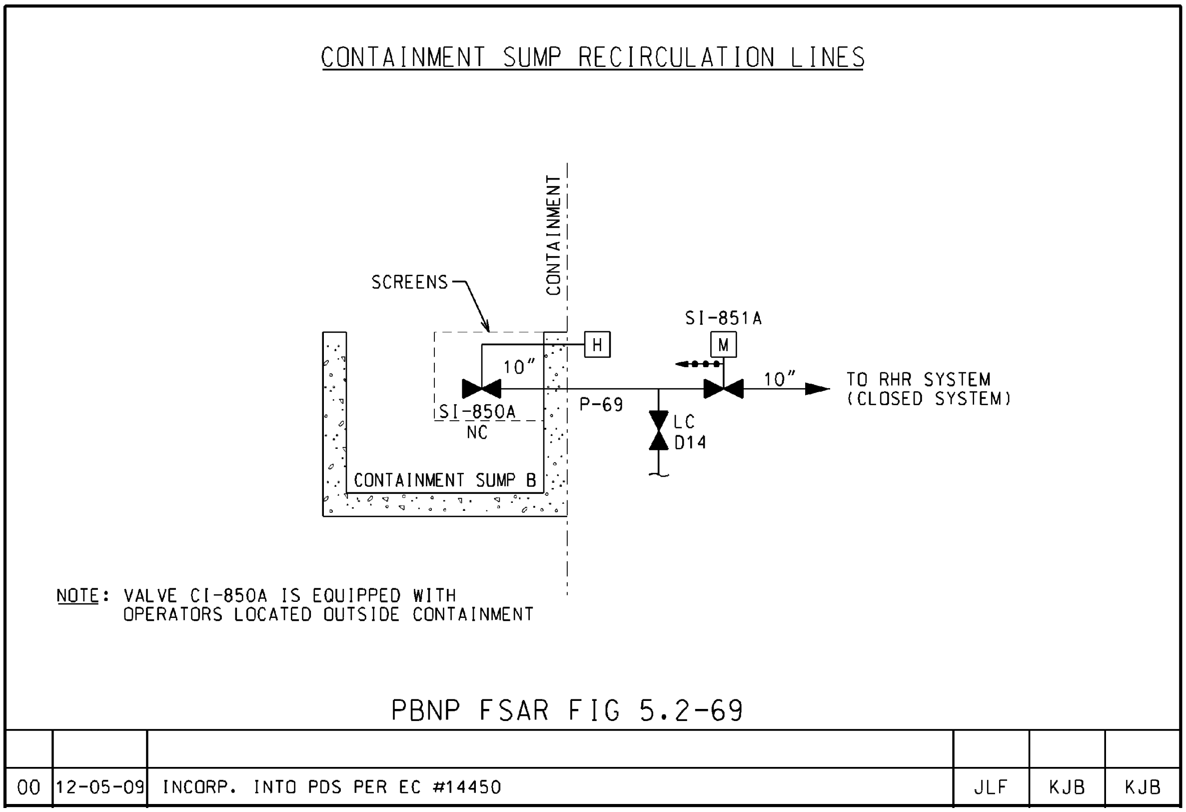



| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 67 | BLANK FLG.. | BLANK FLG. | SPARE | 12" | G | COLD | 5 |

NOTE:

THIS PENETRATION MEETS CLASS 5 CONTAINMENT ISOLATION CRITERIA WITH TWO BLANK FLANGES. THIS SPARE PENETRATION IS USED ROUTINELY FOR EDDY CURRENT TESTING FOR UNIT 2.

# Figure 5.2-69 CONTAINMENT SUMP RECIRCULATION LINES



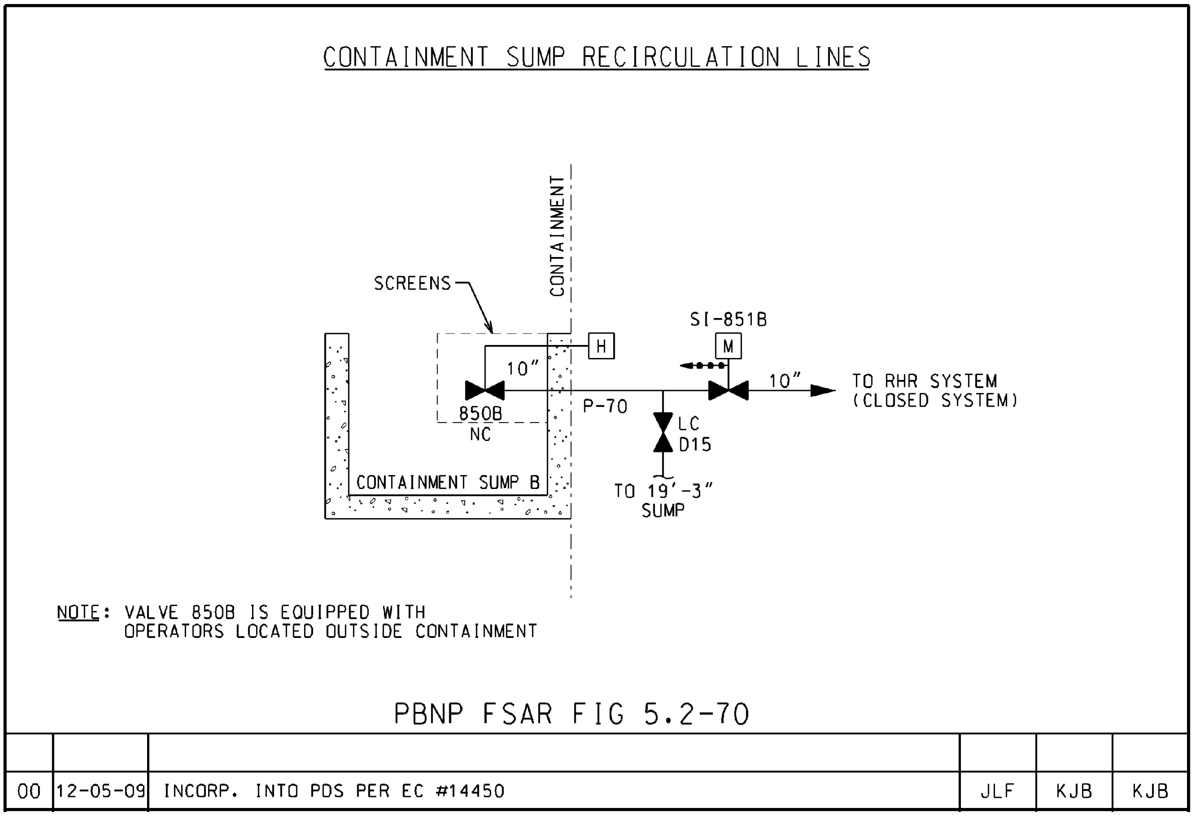

| | CONTAINMENT ISOLATION VALVES | | | | | TEMP. | |
|---|---|---|---|---|---|---|---|
| PENETRATION | INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | HOT>200 COLD<200 | CLASS |
| 69 | | SI-851A CLOSED SYS. | SUMP B RECIRCULATION LINES/SAFETY INJECTION SYSTEM. | 10" | W | COLD | SPECIAL |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 6 & FIGURE 6.2-1 SHEET 1

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IN USE POST DBA. THE CLOSED SYSTEM OUTSIDE CONTAINMENT PROVIDES THE CONTAINMENT ISOLATION BOUNDARY POST DBA.

# Figure 5.2-70 CONTAINMENT SUMP RECIRCULATION LINES



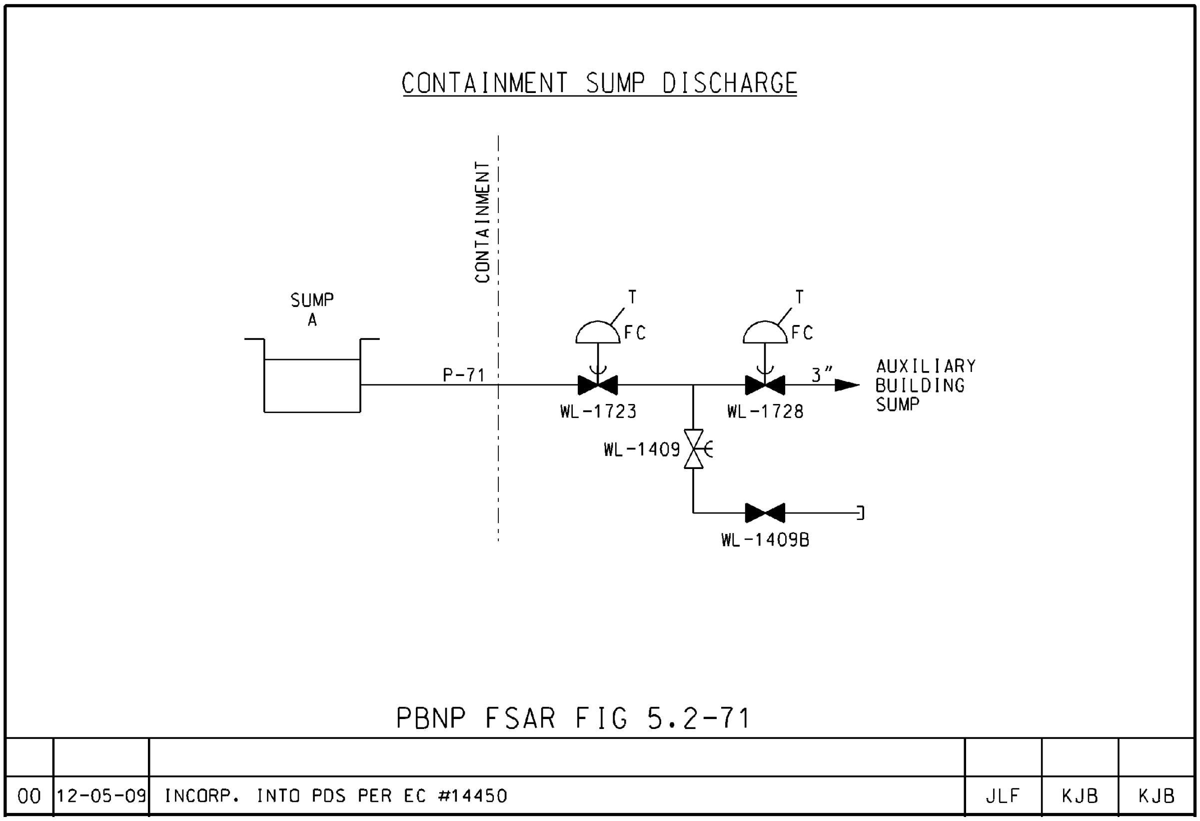

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | CONTAINMENT ISOLATION VALVES OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 70 | | SI-851B CLOSED SYS. | SUMP B RECIRCULATION LINES/SAFETY INJECTION SYSTEM. | 10" | W | COLD | SPECIAL |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 6 & FIGURE 6.2-1 SHEET 1

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IN USE POST DBA. THE CLOSED SYSTEM OUTSIDE CONTAINMENT PROVIDES THE CONTAINMENT ISOLATION BOUNDARY POST DBA.

Figure 5.2-71 CONTAINMENT SUMP DISCHARGE



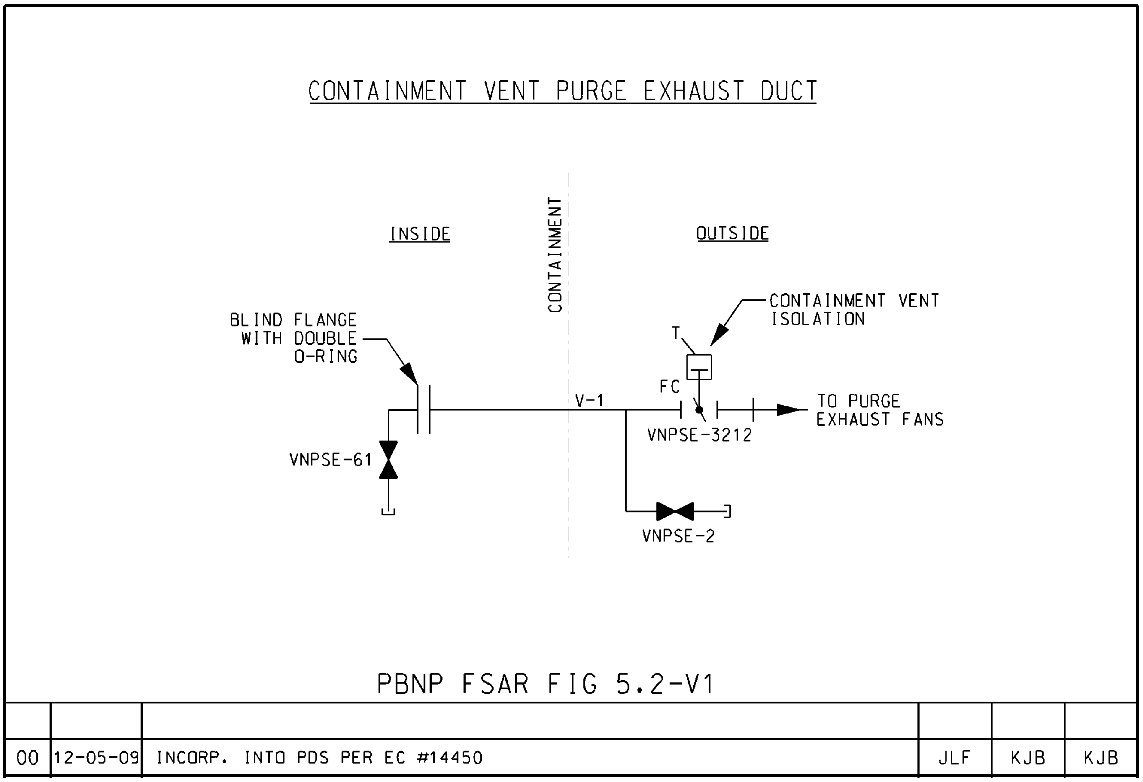

| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | OUTSIDE | BRANCH/SYSTEM | LINE SIZE | FLUID | TEMP. HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| 71 | | WL-1723<br>WL-1728 | SUMP A DRAIN TO AUXILIARY BUILDING SUMP/WASTE DISPOSAL SYSTEM | 3” | W | COLD | SPECIAL |

FOR FURTHER INFORMATION REFER TO FSAR CHAPTER 11 & FIGURE 11.1-1 SHEET 1

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND MEETS CONTAINMENT ISOLATION CRITERIA WITH AUTOMATIC TRIP VALVE WL-1723 AND AUTOMATIC TRIP VALVE WL-1728 OUTSIDE CONTAINMENT.

Figure 5.2-V1 CONTAIMENT VENT PURGE EXHAUST DUCT

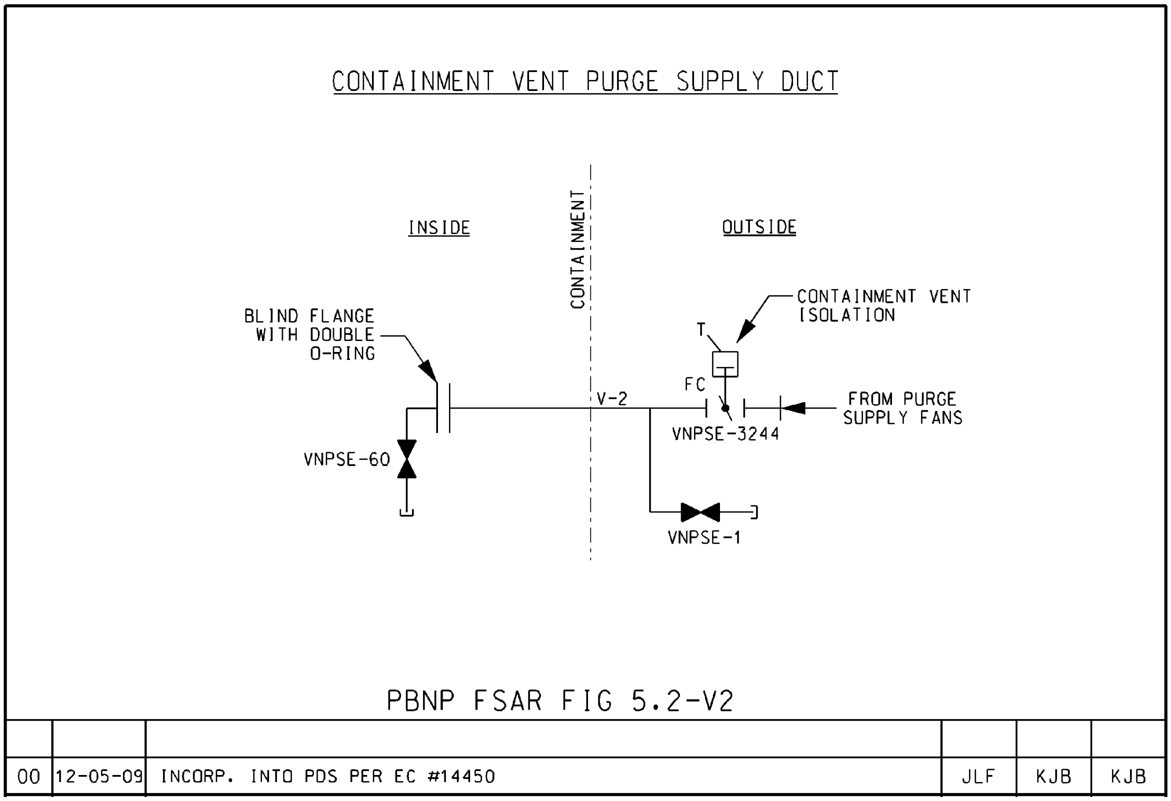



| PENETRATION | CONTAINMENT ISOLATION VALVES | | BRANCH/ SYSTEM | LINE SIZE | FLUID | TEMP HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| | INSIDE | OUTSIDE | | | | | |
| V-1 | BLIND FLANGE | NONE | PURGE VENT EXHAUST | 36" | G | COLD | SPECIAL |

NOTE:

VALVE VNPSE-3212 AND ITS UPSTREAM TEST CONNECTION ARE NOT CONTAINMENT ISOLATION VALVES. THEY PROVIDE CONTAINMENT CLOSURE DURING MODES 5 AND 6.

# Figure 5.2-V2 CONTAIMENT VENT PURGE SUPPLY DUCT

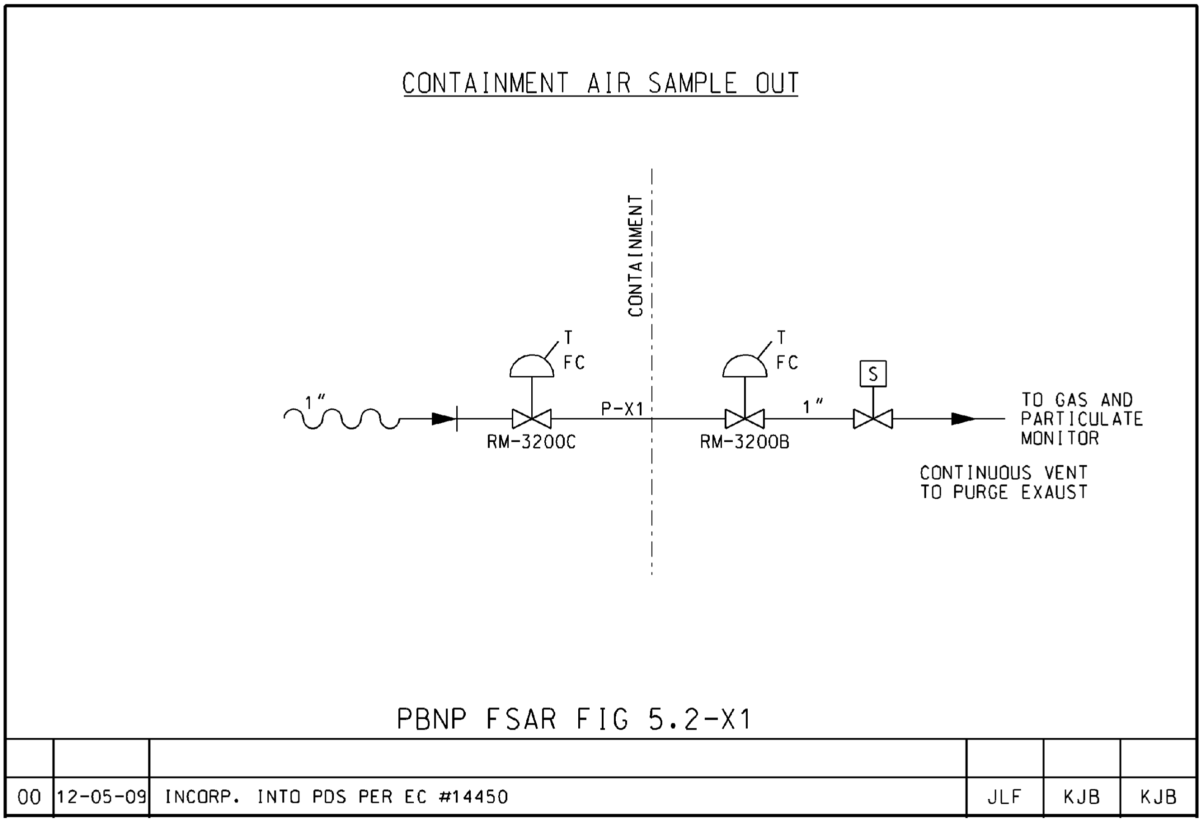



| PENETRATION | CONTAINMENT ISOLATION VALVES INSIDE | CONTAINMENT ISOLATION VALVES OUTSIDE | BRANCH/ SYSTEM | LINE SIZE | FLUID | TEMP HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| V-2 | BLIND FLANGE | NONE | PURGE VENT SUPPLY | 36” | G | COLD | SPECIAL |

NOTE:

VALVE VNPSE-3244 AND ITS DOWNSTREAM TEST CONNECTION ARE NOT CONTAINMENT ISOLATION VALVES. THEY PROVIDE CONTAINMENT CLOSURE DURING MODES 5 AND 6.

Figure 5.2-X1 CONTAINMENT AIR SAMPLE OUT




NOTE: PENETRATIONS ARE THROUGH THE UPPER PERSONNEL LOCK.

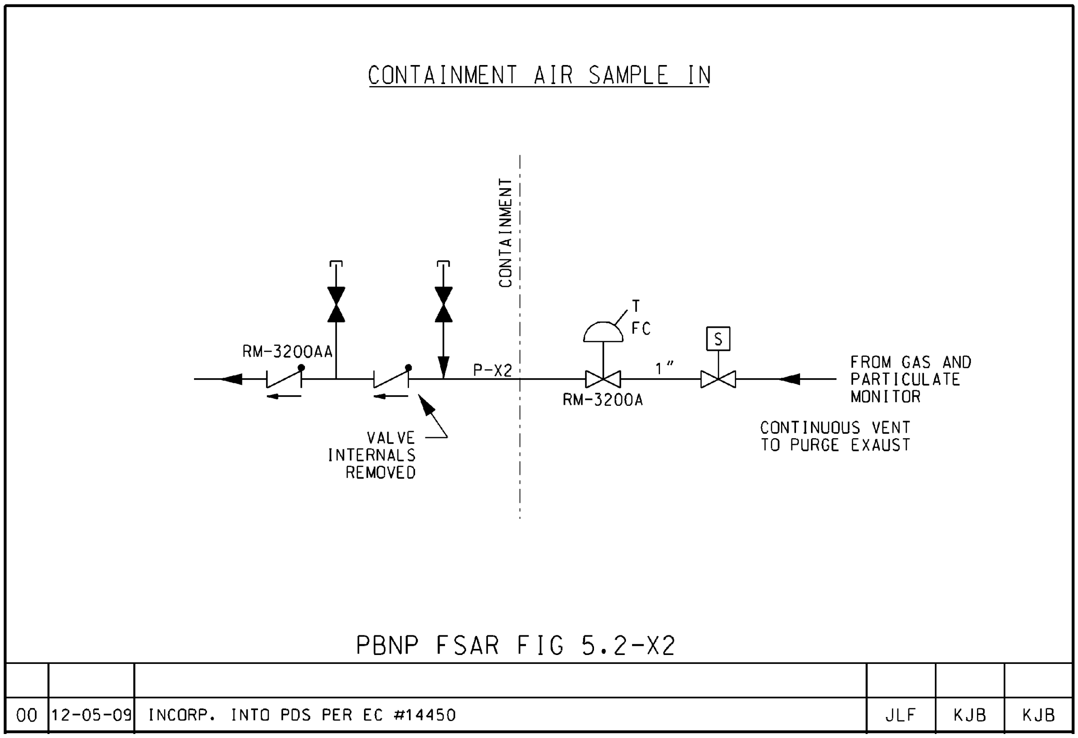
NOTE: CONTAINMENT ISOLATION SIGNAL APPLIED TO THESE VALVES MUST BE OVERRIDDEN IN ORDER TO USE THE MONITOR AFTER AN ACCIDENT.

| PENETRATION | CONTAINMENT ISOLATION VALVES | | BRANCH/ SYSTEM | LINE SIZE | FLUID | TEMP HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| | INSIDE | OUTSIDE | | | | | |
| X-1 | RM-3200C | RM-3200B | CONTAINMENT AIR SAMPLE (SUPPLY)/RM | 1" | G | COLD | SPECIAL |

NOTE:

THIS PENETRATION IS CLASSIFIED SPECIAL AND IS IDENTIFIED AS AN INTERMITTENT USE SYSTEM POST DBA. AUTOMATIC TRIP VALVE (RM-3200C) INSIDE CONTAINMENT AND AUTOMATIC TRIP VALVE (RM-3200B) OUTSIDE CONTAINMENT MEET CONTAINMENT ISOLATION CRITERIA.

Figure 5.2-X2 CONTAINMENT AIR SAMPLE IN




NOTE: PENETRATIONS ARE THROUGH THE UPPER PERSONNEL LOCK.

NOTE: CONTAINMENT ISOLATION SIGNAL APPLIED TO THESE VALVES MUST BE OVERRIDDEN IN ORDER TO USE THE MONITOR AFTER AN ACCIDENT.

| PENETRATION | CONTAINMENT ISOLATION VALVES | | BRANCH/ SYSTEM | LINE SIZE | FLUID | TEMP HOT>200 COLD<200 | CLASS |
|---|---|---|---|---|---|---|---|
| | INSIDE | OUTSIDE | | | | | |
| X-2 | RM-3200AA | RM-3200A | CONTAINMENT AIR SAMPLE (RETURN)/RM | 1" | G | COLD | 3 |

NOTE:

THIS PENETRATION MEETS CLASS 3 CONTAINMENT ISOLATION CRITERIA WITH CHECK VALVE (RM-3200AA) INSIDE CONTAINMENT SERVING THE PURPOSE OF AN AUTOMATIC TRIP VALVE AND AUTOMATIC TRIP VALVE (RM-3200A) OUTSIDE CONTAINMENT.

Figure 5.2-72 FUEL TRANSFER TUBE PENETRATION

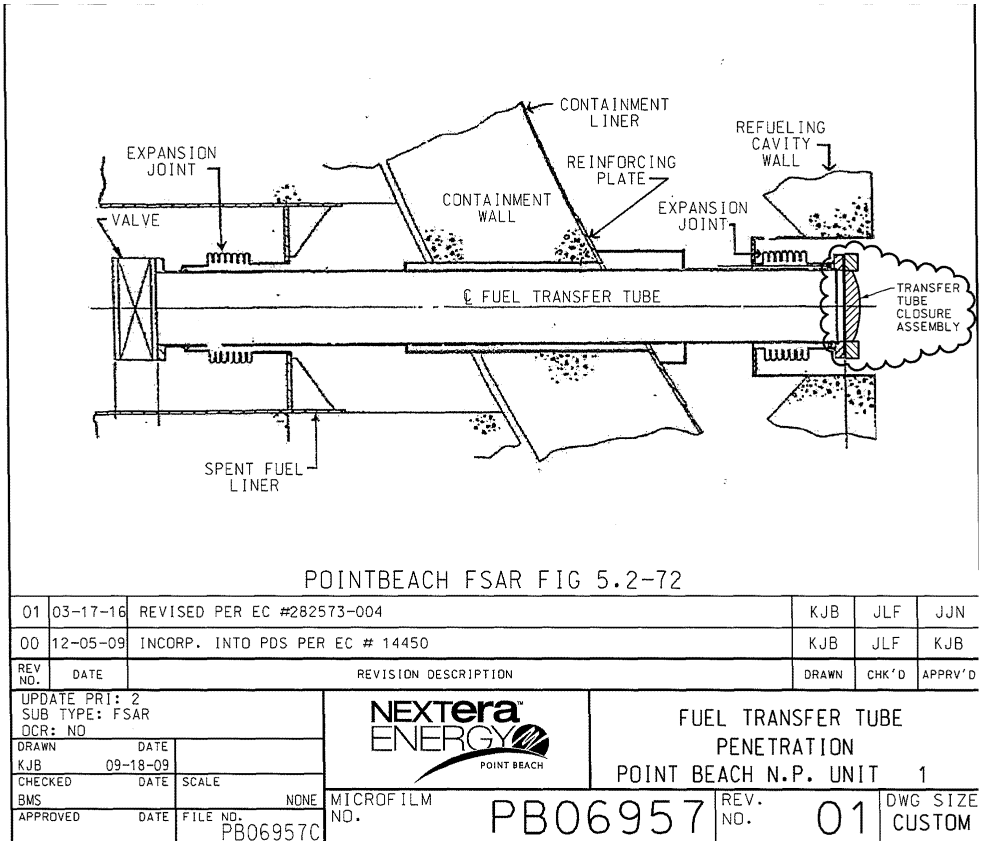
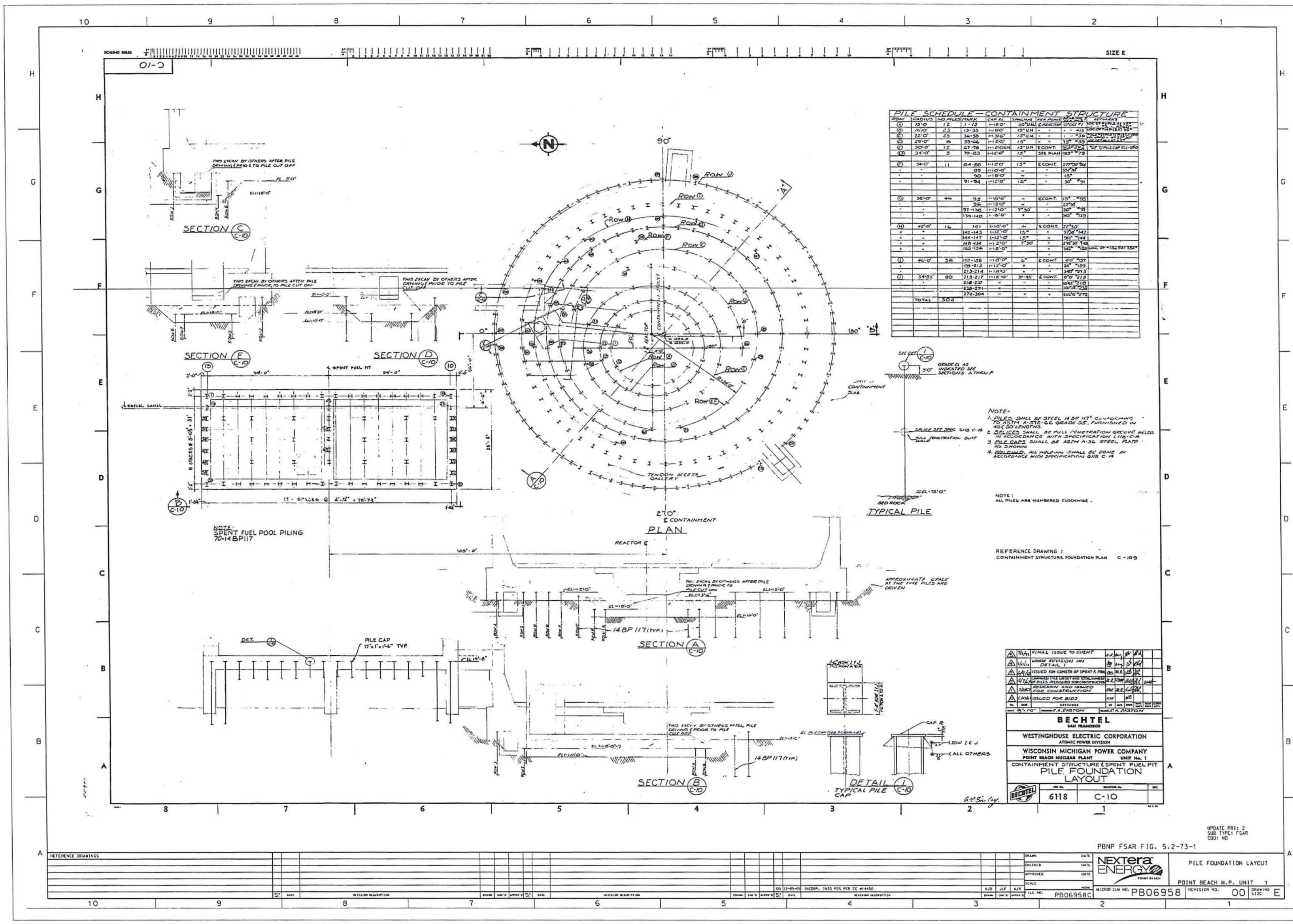


Figure 5.2-73-1 PILE FOUNDATION LAYOUT



# 5.3 CONTAINMENT VENTILATING SYSTEM

## 5.3.1 DESIGN BASES

### 5.3.1.1 PERFORMANCE OBJECTIVES

The containment ventilating systems are designed to accomplish the following:

1. Remove the normal heat loss from all equipment and piping in the containment during plant operation and to maintain a normal ambient temperature less than 105°F.

2. Provide sufficient air circulation and filtering throughout all containment areas to permit safe and continuous access to the reactor containment within two hours after reactor shut-down assuming defects exist in no more than 1% of the fuel rods.

3. Provide for positive circulation of air across the refueling water surface when necessary to minimize personnel inhalation hazards during shutdown.

4. Provide a minimum containment ambient temperature of 50°F during reactor shutdown.

5. Provide for purging of the containment vessel to the plant vent for dispersion to the environment.

6. Provide for depressurization of the containment vessel following an accident. The post-accident design and operating criteria are detailed in Chapter 6.

In order to accomplish these objectives, the following systems are provided:

1. Containment Air Recirculation Cooling System (VNCC)

2. Control Rod Drive Mechanism Cooling System (VNCRD)

3. Reactor Cavity Cooling System (VNRC)

4. Refueling Water Surface Ventilation System (VNRF)

5. Purge Supply and Exhaust System (VNPSE)

6. Containment Cleanup (Charcoal Filter) System (VNCF)

7. Post-Accident Containment Venting System (PACV)

8. Radiation Monitoring System (RM)

### 5.3.1.2 DESIGN CHARACTERISTICS - SIZING

The design characteristics of the equipment required in the containment for cooling, filtration and heating to handle the normal thermal and air cleaning loads during normal plant operation are presented in Table 5.3-1. In certain cases where engineered safeguards functions are also served by the equipment, component sizing is determined from the heavier duty specifications associated with the design basis accident detailed further in Chapter 6.

## 5.3.2 SYSTEM DESIGN AND OPERATION

The containment air recirculation, control rod drive mechanism cooling, reactor cavity cooling, refueling water surface ventilation, purge supply and exhaust, containment cleanup (charcoal filter) and post-accident containment ventilation systems are shown in Figure 5.3-1. The containment ventilation ductwork (except the CRDM cooling system ductwork), fans (except the refueling water surface supply and exhaust fans and the CRDM cooling system fans), filters, coils, and housings within the containment are designed as Seismic Class I structures.

The containment clean-up fans, control rod drive mechanism cooling fans, and reactor cavity cooling fans are direct driven units, each with standby units for redundancy. Each of the associated systems, except the refueling water surface ventilation system is provided with flow switches to verify existence of air flow in the associated duct system. The purge system containment isolation valves are provided with limit switches to indicate valve positions.

### 5.3.2.1 CONTAINMENT AIR RECIRCULATION

Containment air recirculation is summarized in this section, and discussed in more detail in Chapter 6. The air recirculating cooling function, during normal operation, is accomplished using three of the four air cooling units (with 2 fans/unit) discharging to a common duct to assure adequate distribution of filtered and cooled air throughout the containment. However, as service water temperature increases beyond 75° up to 80°, operation of four air cooling units may be required to maintain containment temperature within Technical Specification Limits (Reference 5). Each cooling coil in an air handling unit is designed to transfer up to $1.57 \times 10^6$ BTU/hr to the service water system during normal plant operation. Each of the two fan cooler trains, consisting of two fan cooler units, must be capable of transferring heat at a rate of $60 \times 10^6$ BTU/hr for a limiting design basis accident condition.

Each air cooling unit consists of the following equipment arranged so that, during normal operation, air flows through the assembly in the following sequence: inlet screen, roughing filter, cooling coil, vaneaxial fans, backdraft damper and a discharge header which is common to all four units. Roughing filters are installed during refueling outages with a significant potential for a dusty containment atmosphere.

In the event of a loss-of-coolant accident, only two of the four units are required to function. These cooling units, in conjunction with one train of containment spray, have sufficient capacity to maintain the containment pressure within design limits after a loss-of-coolant accident. For each of these two units, only one of the two vane-axial fans would continue to operate. Air flow through the idle fan would be prevented by means of backdraft dampers. The air is then distributed through the common discharge header into the containment atmosphere.

The normal air flow rate per air handling unit is 58,000 cfm (both accident and normal fans operating) and the design post-accident flow rate is 33,500 cfm (Reference 6) (accident fan only) at 60 psig containment pressure. Periodic air flow measurements are taken to evaluate accident fan performance.

The air recirculating cooling units are located in the space between the loop compartment wall and the containment wall on three elevations. The shielded location makes inspection of the equipment possible at power under controlled access conditions and immediately after a hot shutdown.

The fans, motors, electrical connections and all other equipment in the containment necessary for operation of the system under accident conditions are capable of operating under the environmental conditions existing following a loss-of-coolant accident.

During power operation, containment integrity is maintained with no release from the containment air recirculation ventilation system to the atmosphere. Prior to purging the containment air, particulate and radiogas monitor indications of the closed containment activity levels are used to determine routine releases from the containment.

During power operation, the containment particulate and radiogas monitor indications help determine the desirability of using the containment cleanup (charcoal filter) system or the purge supply and exhaust systems or both for pre-access cleanup.

When containment purging for access following reactor shutdown is in progress, releases from the plant vent are continuously monitored with a radiogas monitor.

Four additional systems supplement the main containment air recirculation cooling systems. These systems include:

1. Containment cleanup (charcoal filter) system;

2. Control rod drive cooling system;

3. Refueling water surface ventilation system; and

4. Reactor cavity cooling system.

Containment Cleanup (Charcoal Filter) System

The containment cleanup (charcoal filter) system draws contaminated air from the containment. The air is then drawn across a filter assembly which consists of a roughing filter, HEPA filter and a charcoal filter, passes through the system fan and is then discharged into containment.

CRDM Cooling System

The control rod drive cooling system consists of fans and duct work to draw air through the control rod drive mechanism shroud and eject it to the main containment atmosphere. One hundred percent redundancy is provided by a standby fan.

Refueling Water Surface Ventilation System

The refueling water surface ventilation system may be used during refueling operations to remove contaminants emanating from the water pool above the fuel elements. This is accomplished by the supply fan drawing air from the containment atmosphere and supplying it above the water surface. This air then mixes with containment air and is exhausted by the refueling surface exhaust fan to the purge exhaust system where it is filtered and discharged to atmosphere. The system is not required to assist in mitigating a fuel handling accident or operate during refueling operations.

Reactor Cavity Cooling System

The reactor cavity cooling system, consisting of cooling coils, fans, and ductwork is arranged to supply cooled air to the annulus between the reactor vessel and the primary shield and to the nuclear instrumentation external to the reactor. One hundred percent redundancy is provided by a standby fan. The cooling coils are maintained for air flow resistance.

### 5.3.2.2 CONTAINMENT PURGE SYSTEM

The containment purge system is independent of any other system and includes provisions to both supply and exhaust air from the containment. The supply system includes outside air connection to roughing filters, heating coils, fans, duct system, and supply penetration with one butterfly valve and one blind flange in series. The exhaust system includes an exhaust penetration with one butterfly valve and one blind flange in series, duct system, filter bank with roughing and HEPA filters, and exhaust fans. The blind flanges located inside containment provide containment isolation during normal operation (MODES 1 through 4). The filters in one bank may be temporarily removed, should the air activity levels permit. Both supply and exhaust systems include two fans with isolating dampers so that purging can be performed at half or full flow rate. The full flow rate is 25,000 cfm.

The purge supply and exhaust system includes four pre-heaters and four heaters with a total capacity of 2,028,000 Btu/hr, which may be used to maintain a minimum temperature of 50°F during winter shutdowns.

In accordance with Technical Specifications, containment integrity shall not be violated when a nuclear core is installed unless the reactor is in the cold shutdown condition. Therefore, purging of the containment is prohibited unless the reactor is in the cold shutdown condition.

### 5.3.2.3 ISOLATION VALVES

The containment purge supply and exhaust butterfly valves are located outside containment (see Figure 5.2-V1 and Figure 5.2-V2 in Section 5.2) and are used during plant shutdowns to provide containment closure. Blind flanges with double O-rings are installed inside containment to provide containment isolation during normal operation (MODES 1 through 4). Penetration leakage can be checked by using the test connection between the blind flange O-rings. The butterfly valves are designed for rapid closing by a Train "A" Containment Ventilation Isolation Signal (see Table 7.3-1) to limit a radioactivity release to the atmosphere. A reset function is provided as described in Section 7.3.3.3.c, Containment Isolation Reset, to allow opening the purge inlet and outlet valves after the actuation signals are no longer present. Instrument air is used to operate the butterfly valves and inflate the boot seal style seats in the valves (Reference 4).

### 5.3.2.4 POST ACCIDENT CONTAINMENT VENTING SYSTEM

The NRC eliminated the hydrogen release associated with a design basis loss of coolant accident from 10 CFR 50.44 and the associated requirements that necessitated the hydrogen recombiners and the containment post accident hydrogen vent and purge system (Reference 1, Reference 2, and Reference 3). As a result of this regulatory change, the availability of and capability to install hydrogen recombiners has been removed from the licensing and design basis. In addition, the post accident containment purge system has been removed from the licensing basis. However, the capability to facilitate post accident containment purging is being maintained for beyond design basis accident management.

5.3.2.5 CONTAINMENT VENTING DURING NORMAL OPERATION (Radiation Monitoring System)

During normal reactor operation at power, the containment may be continuously vented by use of the containment gaseous and particulate sampling and monitoring penetrations. (See Figure 5.2-X1 and Figure 5.2-X2.) The containment air sample is routed through a calibrated full view rotameter and flow transmitter and then to the RE-211, containment air particulate, and RE-212, containment noble gas monitors. Details of the RE-211 and RE-212 monitors are provided in Section 11.5. The containment air sample flow is normally routed back to the containment atmosphere. When the unit is in cold shutdown and the containment purge exhaust fans are operating, the containment air sample returns are normally routed to the containment purge exhaust stack. The flow transmitter output and signals from the RE-211 and RE-212 are wired to the plant computer to allow continuous computation of radiation releases.

Use of this continuous containment ventilation system precludes the buildup of pressure inside the containment which would normally result from instrument air leakoff to various instrumentation and valve operators and during containment atmosphere heatup due to primary system temperature increase. If containment pressure reaches approximately 1 psig, the RE-211/212 radiation monitoring forced ventilation pump is placed in service which discharges to the purge exhaust filter units. The system is automatically isolated in the event of a containment isolation signal.

5.3.3 <u>REFERENCES</u>

1. NRC Safety Evaluation 2004-0008, dated August 13, 2004, “Point Beach Nuclear Plant Unit 1 and 2 - Issuance of Amendments Re: Relocation of Requirements for Hydrogen Monitors (TAC Nos. MC 1904 and MC1905).”

2. 2003 Federal Register Vol. 68, No. 179, September 16, pages 54123 - 54138.

3. 2003 Federal Register Vol. 68, No. 186, September 25, pages 55416 - 55421.

4. SCR 2008-0066, “Isolation of Purge Valve T-Seal Backup Nitrogen,” March 27, 2005.

5. Calculation 129187-M-0022, “Verification of Adequacy of Containment Fan Cooler Units during Normal Operations under Extended Power Uprate (EPU) Conditions”, Revision 1, December 16, 2008.

6. NPL 2006-0097 Letter 5/31/06, “Re-analysis of Point Beach Nuclear Plant (PBNP) Design Basis Radiological Accidents Using Alternate Source Term Methodology: Design Input Transmittal of Common and LOCA Input Parameters”.

7. SCR 2012-0191-1, “EC 277852 - Abandonment of Unit 2 Cavity Cooler SW Piping,” November 24, 2012.

8. SCR 2012-0197, “EC 277917 - Abandonment of Unit 1 Cavity Cooler SW Piping,” January 16, 2013.

9. SCR 2013-0188-01, “Reduction of CFC Heat Removal Requirement,” dated November 21, 2013.

Table 5.3-1 PRINCIPAL COMPONENT DATA SUMMARY

Page 1 of 2

| System | Units Installed | Unit Capacity | Units Required for Normal Operation |
|---|---|---|---|
| **Containment Recirculating** | | | |
| Cooling Coils - Normal | 4 | $1.57 \times 10^6$ BTU/hr | 3 |
| Cooling Coils - DBA | 4 (2 per train) | $60 \times 10^6$ BTU/hr per train | N/A |
| Roughing Filters* | 4 | | 0 |
| Fans | 8 (per unit) | | 3 |
| Fan Pressure | | | |
| Normal Conditions | | 6.94 in. $H_2O$ | |
| Accident Conditions | | 8.05 in. $H_2O$ | |
| Fan Capacity - Normal op. fan | 4 | | 3 |
| Normal Conditions | | 29,000 cfm | |
| Accident Conditions | | | |
| Fan Capacity - Accident fan | 4 | | 3 |
| Normal Conditions | | 29,000 cfm | |
| Accident Conditions | | 33,500 cfm | |
| **Control Rod Drive Cooling** | | | |
| Fans, Standard Conditions | 2 | 14,000 cfm | 1 |
| Fan Pressure | | 14 in. $H_2O$ | |
| Fan Motors | 2 | 50 hp | 1 |
| **Reactor Cavity Cooling** | | | |
| Plenum | 1 | | 1 |
| Fans, Standard Conditions | 2 | 28,000 cfm | 1 |
| Fan Pressure | | 7 in. $H_2O$ | |
| Fan Motors | 2 | 40 hp | 1 |
| Cooling Coils | 2 | not applicable | 1 |
| **Purge Supply** | | | |
| Fans, Standard Conditions | 2 | 12,500 cfm | Optional |
| Fan Pressure | | 4 in. $H_2O$ | |
| Fan Motors | 2 | 15 hp | |
| Pre-heat Coils | 4 | 372,000 BTU/hr | Optional |
| Re-heat Coils | 4 | 135,000 BTU/hr | Optional |
| Air Filters, Roughing | | 25,000 cfm | 1 |
| **Purge Exhaust** | | | |
| Fans, Standard Conditions | 2 | 12,500 cfm | Optional |
| Fan Pressure | | 7.5 in. $H_2O$ | |
| Fan Motors | 2 | 25 hp | Optional |
| Plenums | 2 | 12,500 cfm | Optional |
| Filters, 12 HEPA Cells/Unit | 2 | 12,500 cfm | Optional |

Table 5.3-1 PRINCIPAL COMPONENT DATA SUMMARY

Page 2 of 2

| System | Units Installed | Unit Capacity | Units Required for Normal Operation |
|---|---|---|---|
| Refueling Canal Supply | | | |
| Fan, Standard Conditions | 1 | 11,000 cfm | 1 |
| Fan Pressure | | 2.0 in. $H_2O$ | |
| Fan Motor | 1 | 7.5 hp | 1 |
| Refueling Canal Exhaust | | | |
| Fan, Standard Conditions | 1 | 22,000 cfm | |
| Fan Pressure | | 3.0 in. $H_2O$ | |
| Fan Motor | 1 | 15 hp | 1 |
| Containment Cleanup (Charcoal Filter) System | | | |
| Fans, Standard Conditions | 2 | 5,400 cfm | Optional |
| Fan Pressure | | 9.0 in $H_2O$ | |
| Fan Motors | 2 | 15 hp | Optional |
| Filters, 6 HEPA Cells/Unit | 2 | 5,400 cfm | Optional |
| Charcoal Filters, 16 Cells/Unit | | 5,400 cfm | Optional |

Figure 5.3-1 UNITS 1 & 2 CONTAINMENT VENTILATION SYSTEM FLOW DIAGRAM (Sheet 1)

[redacted]

Figure 5.3-1 UNIT 1 CONTAINMENT VENTILATION SYSTEM FLOW DIAGRAM (Sheet 2)

[redacted]

Figure 5.3-1 CONTAINMENT VENTILATION SYSTEM FLOW DIAGRAM (Sheet 3)

[redacted]

# 5.4 SYSTEM DESIGN EVALUATION

## 5.4.1 RELIANCE ON INTERCONNECTED SYSTEMS

The containment leakage limiting boundary is provided in the form of a single, carbon steel liner on the vessel. Each system whose piping penetrates this boundary is designed to maintain isolation of the containment from the outside environment. Provision is made to periodically monitor leakage by pressurizing penetrations or double barriers at individual potential leak paths.

## 5.4.2 SYSTEM INTEGRITY AND SAFETY FACTORS

### 5.4.2.1 PIPE RUPTURE - PENETRATION INTEGRITY

The penetrations for the main steam, feedwater, and steam generator blowdown and sample lines are designed so that the penetration is stronger than the piping system and that the vapor barrier will not be breeched due to a hypothesized pipe rupture. Details of the main steam and feedwater penetrations are shown in Figure 5.1-2.

### 5.4.2.2 CONTAINMENT STRUCTURE COMPONENTS ANALYSIS

The details of radial, longitudinal and horizontal shear analysis for the containment reinforced concrete are given in Section 5.1.2.4.

## 5.4.3 PERFORMANCE CAPABILITY MARGIN

The containment structure is designed based upon limiting load factors which are used as the ratio by which accident and earthquake loads are multiplied for design purposes to ensure that the load/deformation behavior of the structure is one of elastic, low strain behavior. This approach places minimum emphasis on fixed gravity loads and maximum emphasis on accident and earthquake loads. Because of the refinement of the analysis and the restrictions on construction procedures, the load factors primarily provide for a safety margin on the load assumptions. Load combinations and load factors utilized in the design which provide an estimate of the margin with respect to all loads are tabulated in Section 5.1.2.2.

# 5.5 MINIMUM OPERATING CONDITIONS

## 5.5.1 CONTAINMENT INTEGRITY

Containment integrity will be maintained unless the reactor is in the cold shutdown or refueling conditions (MODES 5 or 6).

The reactor coolant system and cold shutdown condition assure that no steam will be formed and hence there would be no pressure buildup in the containment if a reactor coolant system rupture were to occur. During movement of recently irradiated fuel assemblies inside the containment (MODE 6), the containment is maintained closed or in a condition conducive to rapid closure.

## 5.5.2 EXTERNAL PRESSURE AND INTERNAL VACUUM

The containment is designed to withstand an internal design vacuum condition of 2 psi which is equivalent to an external pressure loading with a differential of 2 psi from outside to inside. This condition will accommodate either a barometric pressure rise to 31 in. Hg after the containment is sealed at 29 in. Hg, or an interior containment cooldown from 120°F to 50°F. Therefore, operation of purge valves is not necessary due to barometric pressure changes during normal operation or cooldown conditions, and vacuum breakers are not required.

## 5.5.3 LEAKAGE

A containment leakage rate of 0.2 weight percent of the contained air per 24 hours at an internal pressure of 60 psig under hypothetical accident conditions with 2 of 4 air recirculation units operating will maintain public exposure well below 10 CFR 50.67 values.

# 5.6 CONSTRUCTION

## 5.6.1 CONSTRUCTION METHODS

### 5.6.1.1 APPLICABLE CODES

The following codes of practice are used to establish standards of construction procedure:

| | | |
|---|---|---|
| ACI 301 | - | Specification for Structural Concrete for Buildings (Proposed) |
| ACI 306 | - | Recommended Practice for Cold Weather Concreting |
| ACI 318 | - | Building Code Requirements for Reinforced Concrete |
| ACI 347 | - | Recommended Practice for Concrete Formwork |
| ACI 605 | - | Recommended Practice for Hot Weather Concreting |
| ACI 613 | - | Recommended Practice for Selecting Proportions for Concrete |
| ACI 614 | - | Recommended Practice for Measuring, Mixing and Placing Concrete |
| ACI 315 | - | Manual of Standard Practice for Detailing Reinforced Concrete Structures |
| ASME | - | Boiler and Pressure Vessel Code, Sections III, VIII and IX |
| AISC | - | Steel Construction Manual |
| PCI | - | Inspection Manual |

### 5.6.1.2 CONCRETE

Cast-in-place concrete was used to construct the containment shell. The base slab construction was performed utilizing large block pours. After the completion of the base slab steel liner erection and testing, an additional 18 in. thick concrete slab was placed to provide protection for the floor liner.

The concrete placement in the walls was done in 10 ft. high lifts with vertical joints at the radial center line of each of six buttresses. Cantilevered jump forms on the exterior face and the interior steel wall liner served as the forms for the wall concrete.

The dome liner plate, temporarily supported by 18 radial steel trusses and purlins, served as an inner form for the initial 8 in. thick pour in the dome. The weight of the subsequent pour was supported in turn by the initial 8 in. pour. The trusses were lowered away from the liner plate after the initial 8 in. of concrete reached design strength, but prior to the placing of the balance of the dome concrete.

The horizontal and the vertical construction joints were prepared by dry sandblasting followed by cleaning and wetting. Horizontal surfaces were covered with approximately 1/4 in. thick mortar of the same cement-sand ratio as used in the concrete immediately before concrete placing.

### 5.6.1.3 REINFORCING STEEL

Prior to placing, visual inspection of the shop fabricated reinforcing steel was performed to ascertain dimensional conformance with design specifications and the drawings. This was followed by a check “in place” performed by the placing inspector to assure the dimensional and location conformance.

Mill test results were obtained from the reinforcing steel supplier for each heat of steel to show proof that the reinforcing steel has the specified composition, strength, and ductility. Splices in reinforcing bar are lap splices in accordance with ACI 318-63.

Welding of reinforcing steel was not generally permitted but where required was performed by qualified welders in accordance with AWS D12.1, "Recommended Practice for Welding Reinforcing Steel, Metal Inserts, and Connections in Reinforced Concrete Construction." Tack welding was not permitted.

### 5.6.1.4 POST TENSIONING SYSTEM

The post tensioning system used is the BBRV system as furnished by the Inland-Ryerson Construction Products Company. (See Figure 5.6-1)

Each tendon consists of ninety 1/4 in. diameter button-headed wires, two anchor heads and two sets of shims. The tendon sheathing system consisting of spirally wound sheet metal tubing connects to a mild steel "Trumplate" (bearing plate and trumpet) at each end.

Tendons were delivered to the site coated with temporary rust preventive (Dearborn Chemicals NO-OX-ID 500) and encased in polyethylene bags. Each tendon was precut to exact length, with one end unfinished and the other end shop button-headed, and with its anchor head attached.

The tendon installation prestressing procedure was carried out as follows:

1. To assure a clear passage for the tendons, a "sheathing rabbit" was run through the sheathing following placement of the concrete.

2. Tendons were uncoiled and pulled through the sheathing unfinished end first.

3. The unfinished end of the tendons were pulled out with enough length exposed so that field attachment of the anchor head and buttonheading could be performed. To allow this operation, trumplates on the opposite end had an enlarged diameter to permit pulling in the shop finished ends with their anchor heads.

4. The anchor heads were attached and the tendon wires button-headed.

5. The shop finished end of the dome and hoop tendons were pulled back and the stressing jacks were attached to both ends. Vertical tendons were stressed only from the top end.

6. The post tensioning was done by jacking to the permissible overstressing force to compensate for friction and inserting shims under the anchor head. Proper tendon stress was achieved by comparing both jack pressure and tendon elongation against previously calculated values. The elongation of some of the post tensioned tendons exceeded the calculated value by more than the 5% allowed by the manufacturer's QA manual. Independent evaluations conducted by the manufacturer, Inland-Ryerson, and the principal architect-engineer, Bechtel Power Corporation, concluded that the variance in elongation was not detrimental but resulted in an increased strength of the structure. The vertical tendons were prestressed from one end, while the horizontal and dome tendons were tensioned from both ends.

7. The grease caps were bolted into anchorages at both ends and made ready for pumping the tendon sheathing filler material.

8. The tendon sheaths and grease caps were filled with sheathing filler and sealed.

### 5.6.1.5 LINER PLATE

Construction of the liner plate conforms to the applicable portions of Part UW of Section VIII of the ASME Code. Specifically, paragraphs UW-26 through UW-38, inclusive, applied in their entirety. In addition, the qualification of all welding procedures and welders was performed in accordance with Part A of Section IX of the ASME Code. All liner angle welding was visually inspected prior to, during and after welding to ensure that quality and general workmanship met the requirements of the applicable welding procedure specification.

The erection of the liner plate was as follows: After the floor insert plates on the foundation slab were placed and welded, and concrete was poured flush, the wall liner plates were erected in 60° segments and 10 ft. high courses. This pattern was followed to the dome spring line, and then the permanent steel dome trusses were placed. During the period of erection of wall liner plates, the floor liner plate was placed and welded.

The tolerances on liner plate erection are as follows:

The radial location of any point on the liner plate does not vary from design radius by more than ±1 1/2 in. A 15 ft. long template curved to the required radius was used to verify that the following tolerances were not exceeded:

1. A maximum 3/4 in. deviation when placed against the completed surface of the shell within a single plate section.

2. A maximum 1 in. deviation when placed across one or more welded seams.

Maximum measured inward deflection (toward the center of the Unit 1 structure) of the 1/4 in. plate between the angle stiffeners was 1/16 in. as measured using a 15 in. straightedge placed horizontally, and 1/8 in. with the straightedge placed across the welded seam at the buttresses.

### 5.6.1.6 TENDON SHEATHING FILLER MATERIAL

The material used in filling cavities in the tendons and as a protective and lubricating compound in the tendon conduits, as fabricated by Viscosity Oil Company, is essentially a modified refined petroleum oil base which contains no solvent. It contains certain proprietary chemical additives and inhibitors to prevent corrosion of the steel. It has a pour point of 110°F to 115°F and is applied at approximately 130°F to drive air and vapor from the voids before solidifying to a soft gel. It is pumped into all voids surrounding the tendon after installation. It is compatible to "NO-OX-ID 500," in which the tendons were dipped after fabrication.

In addition to factory quality control tests, samples were analyzed by an independent laboratory for field quality control and acceptance as follows:

> Water soluble chloride (Cl) was determined by ASTM
> Method D512-62T with a limit of accuracy of 0.5 ppm

Water soluble nitrates ($NO_3$) were determined by ASTM Method D992-52 with a limit of accuracy of 0.01 mg per liter. Finally, water soluble sulfides (S) were determined by ASTM Method D-1255-65T with a limit of accuracy of 1 ppm.

Stability data going back ten years from the time of construction indicates that the filler material will not deteriorate during the 40-year life of the plant. Actually its chemical composition, being about 98% petroleum jelly, indicates that it would possess the normal stability of the linear hydrocarbons subjected to ambient temperature levels.

Galvanic corrosion normally occurs underground, under water or in the presence of a corrosive medium. Atmospheric conditions may cause surface attack but there is no galvanic corrosion unless metals of two different electrochemical levels are present and the medium between them permits current flow. Consequently if the materials used are steel, and precautions are taken to prevent water from providing a conducting path between them, there should be no galvanic corrosion (Reference 1).

If an electrolyte were to surround a stressed tendon, there is a possibility that the surface of the tendon would develop certain anodic corrosion centers (Reference 2). However, the corrosion would be caused by the fracturing of the naturally protecting oxide film on the surface of the steel. Work done by Greene (Reference 3) and Unz (Reference 4) indicates that there is very little change in electric potential by extremely high stresses.

### 5.6.1.7 MATERIALS

1. Concrete

Ingredients

| | |
|---|---|
| Cement | ASTM C-150 Type II |
| Flyash | ASTM C-350 Air |
| Air Entraining Agent | ASTM C-260 |
| Water Reducing Agent | ASTM C-494 Type D (Plastiment) |
| Aggregate | ASTM C-33 (Fine aggregate is alluvial sand. Coarse aggregate is crushed dolomite.) |

No Calcium Chloride was used in the concrete.

Strengths

| | |
|---|---|
| Base Slab | 4,000 psi at 90 days |
| Walls and Dome | 5,000 psi at 28 days |

Principal Placement Properties

| | |
|---|---|
| Slump, maximum | 2-3 in. at form |
| Air Content | 3-5% at mixer |
| Temperature | Max. 70°F |

2. Reinforcing Steel

ASTM Specification for reinforcing steel is the following:
A-15 Billet Steel - Intermediate Grade
A-432 Billet Steel - High Strength

3. Prestressing Tendons and Associated Hardware

| Material | Material Specifications |
| --- | --- |
| Tendon Wires | ASTM-A421 |
| Bearing Plate | ASTM-A36 |
| Anchor Head | AISI-1141-special quality |
| Shims | SISI-C1026 |
| (from cut tubes) | AISI C 102 6 |
| (from burned plates) | ASTM-A36 |
| (stamped) | 40/50 carbon steel |

4. Liner Plate

Liner plate conforms to ASTM Specification A-442, Grade 60, flange quality.

5. Steel Foundation Piles

The type of pile chosen was standard steel H-pile with a nominal capacity of 200 tons. The pile material conforms to ASTM Standard A-572-66, Grade 55. The piles are approximately 65 to 75 feet long under the containment structure. These lengths exceeded permissible shipping lengths; therefore, the piles were field-spliced by full-penetration butt welding.

Mill test reports were submitted by the pile fabricator to verify that the chemistry, ductility, and strength of the piling material were as specified.

6. Penetrations and Assemblies

Elements resisting containment pressure:

Pipe Material ASTM-A333

Plate Material ASTM-A516, Grade 70, Fire Box Quality

In both of the above materials, impact specimens were Charpy V-Notch tested and met the requirements of Paragraph N-1211(a) of Section III of the ASME Code at a test temperature of -45°F.

Miscellaneous

| | |
|---|---|
| Penetration Anchor Bolts | ASTM-A-307, Grade A |
| Penetration H. S. Anchor Bolts | ASTM-A193, Grade B7 |
| Steel Arc-Welding Electrode | ASTM-A2333 and A599, Type E6010 |
| Truss Bolts | ASTM-A325-64 |
| Structural Steel for Inserts and Supports | ASTM-A36-63T |
| Flued Heads | ASTM A-350-LF 1 and ASTM-A182, Grade F304 or F316 |
| Internal Caps | ASTM A420, WPL1 and ASTM A403, Type 304 |

7. Sheathing Filler

The tendon sheathing filler material used has the following limitations specified for deleterious water soluble salts:
Chlorides (Cl) 1 ppm ASTM D512-62T
Nitrates ($NO_3$) 4 ppm Hack Chemical Procedure
Sulfides (S) 1 ppm ASTM D1255

Temporary corrosion protection of the tendons and the interior face of sheathing was used.

5.6.1.8 QUALIFICATION OF CONCRETE MATERIALS

Aggregates

Acceptability of aggregates is based on the following ASTM tests. These tests were performed by Walter Flood and Co. in Chicago, Illinois.

| TEST | ASTM |
|---|---|
| Los Angeles Abrasion | C-131 |
| Clay Lumps Natural Aggregate | C-142 |
| Material Finer than No. 200 Sieve | C-117 |
| Mortar Making Properties | C-87 |
| Organic Impurities | C-40 |
| Potential Reactivity (Chemical) | C-289 |
| Potential Reactivity (Mortar Bar) | C-227 |
| Sieve Analysis | C-136 |
| Soundness | C-88 |
| Specific Gravity and Absorption | C-127 |
| Specific Gravity and Absorption | C-128 |
| Petrographic | C-295 |

Mixes

Design mixes and the associated tests were run by the concrete testing laboratory (Walter Flood & Co.) in accordance with ACI 613. During construction, the field inspection personnel made minor modifications that were necessitated by various aggregate gradation or moisture content. The following tests were run in determining the design mixes:

| | ASTM |
|---|---|
| Air Content | C-231 |
| Slump | C-143 |
| Bleeding | C-232 |
| Making and curing cylinders in Lab | C-192 |
| Compressive Strength Tests | C-39 |

CONCRETE DESIGN MIXES

| Concrete Strength | Cement Sks/Yd | Flyash* Sks/Yd | Sand | 3/4” | 1 1/2" | 3" | Water |
|---|---|---|---|---|---|---|---|
| | | | PROPORTIONS BY WEIGHT | | | | |
| 3000 psi | 4.47 | 0.79 | 1463 | 1940 | - | - | 231 |
| @28 days | 4.26 | 0.74 | 1338 | 1028 | 1063 | - | 222 |
| 4000 psi | 4.13 | 1.37 | 1420 | 1960 | - | - | 234 |
| @90 days | 3.94 | 1.32 | 1283 | 1024 | 1091 | - | 228 |
| | 3.74 | 1.26 | 1149 | 662 | 761 | 906 | 217 |
| 5000 psi | 5.82 | 1.03 | 1322 | 1793 | - | - | 280 |
| @28 days | 5.60 | 0.99 | 1210 | 937 | 1032 | - | 265 |

*Based on one sack = 94 lbs.

Water Reducing Agent

Walter Flood & Co. was engaged to perform the necessary strength and shrinkage tests of various water reducing agents to establish the particular additive with the most desirable characteristics for this application. On the basis of these tests, “Plastiment”, manufactured by Sika Chemical Corporation, was selected.

Studies of concrete creep and other properties were conducted at the University of California in Berkeley under the direction of Professor David Pirtz.

### 5.6.2 MATERIALS OF CONSTRUCTION IN CONTAINMENT

All materials in containment are reviewed from the standpoint of insuring the integrity of equipment of which they are constructed and to insure that deterioration products of some materials do not aggravate an accident condition. In essence, therefore, all materials of construction in containment must exhibit resistance to the post accident environment or, at worst, contribute only insignificant quantities of trace contaminants which have been identified as potentially harmful to vital safeguards equipment. Table 5.6-1 lists typical materials of construction used in the reactor containment system. Examples of equipment containing these materials are included in the table.

Corrosion testing showed that of all the metals tested only aluminum alloys were found incompatible with the alkaline sodium borate solutions. Aluminum was observed to corrode at a significant rate, with the generation of hydrogen gas. Since hydrogen generation can be hazardous to containment integrity, a detailed survey was conducted to identify all aluminum components in containment.

Table 5.6-2 lists those aluminum components in the Units 1 and 2 containments that may be wetted by containment spray or submerged in the containment sump. The 1100 and the 6000 series aluminum alloys are generally the major types found in containment. This inventory reflects the determination to exclude as much as practicable the use of aluminum in the containment. (Reference 18 and Reference 20)

#### 5.6.2.1 CORROSION OF METALS OF CONSTRUCTION IN DESIGN BASIS EMERGENCY CORE COOLING SOLUTION

Emergency core cooling components are austenitic stainless steel and, hence, are quite corrosion resistant to the alkaline sodium borate solution, as demonstrated by corrosion tests performed at Westinghouse Pressurized Water Reactor Division (PWRD) and Oak Ridge National Laboratory (ORNL) (Reference 5). The general corrosion rate, for Type 304 and 316 stainless steels, was found to be 0.01 mils/month in pH 10 solution at 200°F. Data on corrosion rates of these materials in the alkaline sodium borate solution have also been reported by ORNL (Reference 6, Reference 7) to confirm the low values.

Extensive testing was also performed on other metals of construction which are found in the reactor containment. Testing was performed on these materials to ascertain their compatibility with the spray solution at design post accident conditions and to evaluate the extent of deterioration product formation, if any, from these materials.

Metals tested include Zircaloy, Inconel, aluminum alloys, cupronickel alloys, carbon steel, galvanized carbon steel and copper. The results of the corrosion testing of these materials are reported in detail in Reference 1. Of the materials tested, only aluminum was found to be incompatible with the alkaline sodium borate solution. Aluminum corrosion is discussed subsequently. The following is a summary of the corrosion data obtained on various materials of construction exposed for several weeks in aerated alkaline (pH 9.3 - 10.0) sodium borate solution at 200°F. The exposure condition is considered conservative since the test temperature (200°F) is considerably higher than the long-term design basis accident temperature.

| Material | Maximum Observed Corrosion Rate (mil/month) |
|---|---|
| Carbon Steel | 0.003 |
| Zr-4 | 0.004 |
| Inconel 718 | 0.003 |
| Copper | 0.015 |
| 90 - 10 Cu-Ni | 0.020 |
| 70 - 30 Cu-Ni | 0.006 |
| Galvanized Carbon Steel | 0.031 |
| Brass | 0.010 |

Tests conducted at ORNL (Reference 6, Reference 7) also have verified the compatibility of various materials of construction with alkaline sodium borate solution. In tests conducted at 284°F, 212°F, and 130°F stainless steels, Inconel, cupronickels, Monel, and Zircaloy-2 experienced negligible changes in appearance and negligible weight loss.

Corrosion tests at both PWRD and ORNL have shown copper suffers only slight attack when exposed to the alkaline sodium borate solution at DBA conditions. The corrosion rate of copper, for example, in alkaline sodium borate solution at 200°F is ~ 0.015 mil/month (Reference 5). The corrosion of copper in an alkaline sodium borate environment under spray conditions at 284°F and 212°F have been reported by ORNL. Corrosion penetrations of less than 0.02 mil was observed after 24 hours exposure at 284°F (see Reference 7, Table 3.13) and a corrosion rate of less than 0.3 mil per month was observed at 212°F (see Reference 6, Table 3.6).

It can be seen therefore that the corrosion of copper in the post accident environment will have a negligible effect on the integrity of the material. Further, the corrosion product formed during exposure to the solution appears tightly bound to the metal surface and hence will not be released to the Emergency Core Cooling solution.

The corrosion rate of galvanized carbon steel in alkaline sodium borate (3,000 ppm B, pH 9.3) is also low. Tests conducted in aerated solutions showed the corrosion rate to be 0.031 mil/month for a temperatures of 200°F. It can be seen therefore that the corrosion of zinc (galvanized) in alkaline borate solution is minimal and will not contribute significantly to the post accident hydrogen buildup.

Consideration was given to possible caustic corrosion of austenitic steels by the alkaline solution. Data presented by Swandby (Reference 8) (Figure 5.6-4) show that these steels are not subject to caustic stress cracking at the temperature (285°F and below) and caustic concentrations (less than 1 weight percent) of interest. It can be seen from Figure 5.6-4 that the stress cracking boundary minimum temperature, as defined by Swandby, coincides with a high free caustic concentration (~40%) and is considerably above (~80°F) the long-term post accident design temperature. Further, from Figure 5.6-4 a temperature in excess of 500°F is required to produce stress corrosion cracking at sodium hydroxide concentration greater than 85%.

It should be noted when considering the possibility of caustic cracking of stainless steel that the sodium hydroxide - boric acid solution is a buffer mixture wherein no free caustic exists at the temperatures of interest - even should the solution be concentrated locally through evaporation of water and hence the above consideration is somewhat hypothetical with regard to the post accident environment.

### 5.6.2.2 CORROSION OF METALS OF CONSTRUCTION BY TRACE CONTAMINANTS IN EMERGENCY CORE COOLING SOLUTION

Of the various trace elements which could occur in the emergency core cooling (ECC) solution in significant quantities, only chlorine (as chloride) and mercury are adjudged potentially harmful to the materials of construction of the safeguards equipment.

The use of mercury or mercury-bearing items, however, is prohibited in containment. This includes mercury vapor lamps, fluorescent lighting and instruments which employ mercury for pressure and temperature measurements and for electrical equipment. Potential sources of mercury, therefore, are excluded from containment and hence no hazard from this element is recognized.

The possibility of chloride stress corrosion of austenitic stainless steels has also been considered. It is believed that corrosion by this mechanism will not be significant during the post accident period for the following reasons:

1. <u>Low Temperature of ECC Solution</u>

   The temperature of the ECC solution is reduced after a relatively short period of time (i.e., a few hours) to about 150°F. While the influence of temperature on stress corrosion cracking of stainless steel has not been unequivocally defined, significant laboratory work and field experience indicates that lowering the temperature of the solution decreases the probability of failure. Hoar and Hines (Reference 9) observed this trend with austenitic stainless steel in 42 weight percent solutions of $MgCl_2$ with temperature decrease from 310°F to 272°F. Staehle and Latanision (Reference 10) present data which also shows the decreasing probability of failure with decreasing solution temperature from about 392°F to 302°F. Staehle and Latanision (Reference 10) also report the data of Warren (Reference 11) which showed the significant change with decrease in temperature from 212°F to 104°F. The work of Warren, while pertinent to the present consideration in that it shows the general relationship of temperature to time to failure, is not directly applicable in that the chloride concentration (1,800 ppm Cl) believed to have effected the failure was far in excess of reasonable chloride contamination which may occur in the ECC solution.

2. <u>Low Chloride Concentration of ECC Solution</u>

   It is anticipated that the chloride concentration of the ECC solution during the post accident period will be low. Throughout plant construction, surveillance was maintained to ensure that the chloride inventory in containment would be maintained at a minimum. Controls on use of chloride-bearing substances in containment include the following:

   a. Restriction in chloride content of water used in concrete;

   b. Prohibition of use of chloride in cleaning agents for stainless steel components and surfaces;

   c. Prohibition of use of chloride on concrete etching for surface preparation;

   d. Use of non-chloride bearing protective coatings in containment;

   e. Restriction of chloride concentration in safety injection solution, 0.15 ppm chloride maximum.

   The effect on decreasing chloride concentration on decreasing the probability of failure of stressed austenitic stainless steel has been shown by many experimenters. Staehle and Latanision (Reference 10) present data of Staehle which shows the decrease in probability of failure with decrease in chloride concentration at 500°F. Edeleanu (Reference 12) shows the same trend at chloride concentrations from 40% to 20% as $MgCl_2$ and reported no failures in this experiment at less than about 5% $MgCl_2$.

Instances of chloride cracking at representative ECC solution temperatures and at low solution chloride concentration have generally been on surfaces on which concentration of the chloride occurred. In the ECC system, concentration of chlorides is not anticipated since the solution will operate subcooled with respect to the containment pressure and further the containment atmosphere will be 100% relative humidity.

3. Alkaline Nature of the ECC Solution

The ECC solution will have a solution pH within the acceptable range of 7.0 to 10.5 after the addition of spray additive (NaOH). The minimum pH in the containment sump needed to keep iodine in the iodate form is 7.0. A pH of greater than 7.0 assures the iodine removal effectiveness of the containment spray. The maximum pH is based on Equipment Qualification considerations and is set at 10.5 (Reference 19). Numerous investigators have shown that increasing the solution pH decreases the probability of failure. Thomas et al (Reference 13) showed that the failure probability decreases with increasing pH of boiling solutions of MgCl. More directly applicable, Scharfstein and Brindley (Reference 14) showed that increasing the solution pH to 8.8 by the addition of NaOH prevented the occurrence of chloride stress corrosion cracking in a 10 ppm Cl (as NaCl) solution at 185°F. Thirty stressed stainless steel specimens, including Type 304 as received, Type 347 as received and Type 304 sensitized, were tested. No failures were observed.

Other test runs by Scharfstein and Brindley showed the influence of solution pH on higher chloride concentrations, up to 500 ppm Cl; however, in these tests the pH adjusting agents were either sodium phosphate or potassium chromate. The authors express the opinion, however, that in the case of the chromate solution, chloride cracking inhibition was simply due to the hydrolysis yielding pH 8.8 and not to an influence of the chromate anion. A similar hydrolysis will occur in the borate solution.

Studies conducted at Oak Ridge National Laboratory by Griess and Bocarella (Reference 15) on Type 304 and Type 316 stainless steel U-bend stress specimens exposed to an alkaline borate solution (0.15M NaOH - 0.28M $H_3BO_3$) containing 100 ppm chloride (as NaCl) showed no evidence of cracking after 1 day at 140°C, 7 days at 100°C, 29 days at 55°C. These extreme test conditions, combined with the fact that some parts of the test specimens were subjected to severe plastic deformation and intergranular attack before exposure, show that the probability of chloride induced stress corrosion cracking in a post accident environment are very low indeed.

In summary, therefore, it is concluded that exposure of the stainless steel engineered safety feature components to the ECC solution during the post accident period will not impair its operability from the standpoint of chloride stress corrosion cracking. The environment of low temperature, low chlorides and high pH which will be experienced during the post accident period will not be conducive to chloride cracking.

### 5.6.2.3 CORROSION OF ALUMINUM ALLOYS

Corrosion testing has shown that aluminum alloys are not compatible with alkaline borate solution. The alloys generally corrode fairly rapidly, at the post accident condition temperatures, with the liberation of hydrogen gas. A number of corrosion tests were conducted in the PWRD laboratories and at ORNL facilities. A review of applicable aluminum corrosion data is given in Table 5.6-3 and Figure 5.6-2.

### 5.6.2.4 COMPATIBILITY OF PROTECTIVE COATINGS WITH POST ACCIDENT ENVIRONMENT

The investigation of materials compatibility in the post accident design basis environment also included an evaluation of protective coatings for use in containment.

The results of the protective coatings evaluation presented in WCAP-7198-L (Reference 16) showed that several inorganic zincs, modified phenolics and epoxy coatings are resistant to an environment of high temperature (320°F maximum test temperature) and alkaline sodium borate. Long-term tests included exposure to spray solution at 150-175°F for 60 days, after initially being subjected to a conservative DBA cycle. The protective coatings, which were found to be resistant to the test conditions, that is, exhibited no significant loss of adhesion to the substrate nor formation of deterioration products, comprise virtually all of the protective coatings recommended for use in containment. The Amercoat Corp. products, Dimetcote and Amercoat 66, were the primary protective coatings used in the containment, hence, the protective coatings will not add deleterious products to the core cooling solution. It should be pointed out that several test panels of the recommended types of protective coatings were exposed for two design basis accident cycles and showed no deterioration or loss of adhesion with the substrate.

Procedures and programmatic controls developed with consideration for the guidance provided in EPRI TR-109937, "Guideline on Nuclear Safety-Related Coatings," ensure that the applicable requirements for the procurement, application, inspection, and maintenance of Service Level I coatings in containment are implemented. Service Level I coatings are used in areas where coating failure could adversely affect the operation of post-accident fluid systems and, thereby, impair safe shutdown. For more information on committed standards relating to containment coatings, see Section 1.4.

### 5.6.2.5 EVALUATION OF THE COMPATIBILITY OF CONCRETE-ECC SOLUTION IN THE POST ACCIDENT ENVIRONMENT

Concrete specimens were tested in boric acid and alkaline sodium borate solutions at conditions conservatively (320°F maximum and 200°F steady state) simulating the post DBA environment. The purpose of this study was to establish:

1. The extent of debris formation by solution attack of the concrete surfaces; and

2. The extent and rate of boron removal from the ECC solution through boron - concrete reaction.

Tests were conducted in an atmospheric pressure, reflux apparatus to simulate long-term exposure conditions and in a high-pressure autoclave facility to simulate the DBA short-term, high-temperature transient.

For these tests the total surface area of concrete in the design containment which may be exposed to the ECC solution following a DBA was estimated at 6.3 x $10^4$ sq. ft. This value includes both coated and uncoated surfaces. The ECC solution volume for a reference plant was considered at approximately 313,000 gallons and the surface-to-volume ratio from these values is ~29 $in^2$/gal. The surface-to-volume ratios for the concrete - boron tests used were between 28 and 78 $in^2$/gal. of solution. Table 5.6-4 presents a summary of the data obtained from the concrete-boron test series.

Testing of uncoated concrete specimens in the post accident environment showed that attack by both boric acid and the alkaline boric acid solution is negligible and the amount of deterioration product formation is insignificant. Other specimens covered with modified phenolic and epoxy protective coatings showed no deterioration product formation. These observations are in agreement with Orchard (Reference 17) who lists the following resistances of Portland Cement concrete to attack by various compounds:

| | |
|---|---|
| Boric Acid | - Little or No Attack |
| Alkali Hydroxide Solution under 10% | - Little or No Attack |
| Sodium Borate | - Mild Attack |
| Sodium Hydroxide over 10% | - Very Little Attack |

Exposure of uncoated concrete to spray solution between 320°F and 210°F has shown a tendency to remove boron very slowly, presumably precipitating an insoluble calcium salt. The rate of change of boron in solution was measured at about 130 ppm per month with pH 9 solution at 210°F for an exposed surface of about 36 sq. in. per gallon of solution (much greater than any potential exposure in the containment). The boron loss during the high-temperature transient test (320°F maximum) was about 200 ppm. Table 5.6-3 shows a representation of the boron loss from the ECC solution versus time by a boron-concrete reaction following a DBA. The time period from 0-6 hours shows the loss during a conservative high temperature transient test, ambient to 320°F to 285°F. The data from 6 hours to 30 days is based on 210°F data.

A depletion of boron at this rate poses no threat to the safety of the reactor because of the large shutdown margin and the feasibility of adding more boron solution should sample analysis show a need for such action.

### 5.6.2.6 MISCELLANEOUS MATERIALS OF CONSTRUCTION

1. <u>Sealants</u>

Candidate sealant materials for use in the reactor containment system were evaluated in simulated DBA environments. Cured samples of various sealants were exposed in alkaline sodium borate solution, pH 10.0, 3,000 ppm to a maximum temperature of 320°F.

Table 5.6-5 presents a summary of the sealant materials tested together with a description of the panel's appearance after testing. Three generic types of sealants were tested: butyl rubber, silicone, and polyurethane. Each of the materials was the “one package” type, i.e., no mixing of components was necessary prior to application. The materials were applied on stainless steel and allowed to cure well prior to testing.

The test results showed that silicone sealants tested were chemically resistant to the DBA environment and are acceptable for use in containment.

2. PVC Protective Coating

Tests were conducted to determine the stability of the polyvinyl chloride protective coating, of the type which might be used on conduit in the DBA environment. Samples of the PVC exposed to alkaline sodium borate solutions at DBA conditions showed no loss in structural rigidity and no change in weight or appearance.

A sample of PVC-coated aluminum conduit (1" O.D. x 8 in. length) was irradiated by means of a Co-60 source, at an average dose rate of 3.2 x $10^6$ rads/hr to a total accumulated dose of 9.1 x $10^7$ rads. The specimen was immersed in alkaline sodium borate solution (ph 10, b = 3,000 ppm) at 70°F. Visual examination of the coating after the test showed no evidence of cracking, blistering or peeling and the specimen appeared completely unaffected by the gamma exposure. Chemical analysis of the test solution indicated that some bond breakage had occurred in the PVC coating as evidenced by an increase in the chloride concentration. The gamma exposure of ~$10^8$ rad resulted in a release to the solution of 26 mg of chloride per sq. ft. of exposed PVC surface. Considering a total surface area of PVC coating present in containment (~500 $ft^2$) and an ECC solution volume of 313,000 gal., the chloride concentration increase in the ECC solution due to irradiation of the coating would be ~0.01 ppm.

It is concluded, therefore, that PVC protective coating will be stable in the DBA environment.

3. Fan Cooler Materials

Samples of the following air handling system materials were exposed in an autoclave facility to the DBA temperature-pressure cycle:

a. Moisture separator pad
b. High efficiency particulate filter media
c. Asbestos separator pads
d. Adhesive for joining separator pads and HEPA filter media corners
e. Neoprene gasketing material.

The materials were exposed in both the steam phase and liquid phase of a solution of sodium tetraborate (15 ppm B) to simulate the concentrations expected downstream of the fan cooler cooling coils. Examination of the specimens after exposure showed the following:

a. Moisture separator pads were somewhat bleached in color but maintained their structural form and showed good resiliency as removed in both liquid and steam phase exposure.

b. High efficiency particulate filter media maintained its structural integrity in both the liquid and steam phase. No apparent change.

c. Asbestos separator pads showed some slight color bleaching, however, both steam and liquid phase samples maintained their structural integrity with no significant loss in rigidity.

d. Adhesive material for the HEPA/separator pad edges showed no deterioration or embrittlement and maintained its adhesive property.

e. Neoprene gasketing material is also satisfactory in both the steam and liquid phase. The material showed only weight gain and a shrinkage of 15% to 30% based on a superficial, one flat side area. The gasket thickness decreased about 10%. The gasket material was unrestrained during the exposure and hence the dimensional changes experienced are greater than those which would result in the fan cooler unit.

4. Power and Instrumentation Cable

Power and instrumentation cables have been subjected to the following series of tests and have shown acceptable performance.

a. Thermal aging of the cable. (The EQ program will manage thermal aging, as described in Chapter 15. NRC SE dated 12/2005, NUREG-1839)
b. Exposure to radiation ranging up to $2.0 \times 10^8$ rads.
c. Exposure to temperature, steam and chemical environment simulating post accident conditions.

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19. Point Beach Calculation 2000-0036, "pH of Post LOCA Sump and Containment Spray," Revision 2, July 31, 2007.

20. Engineering Evaluation 2007-0009, Revision 0, “Unit 2 Aluminum Inventory,” August 16, 2007.

Table 5.6-1 MATERIALS OF CONSTRUCTION IN REACTOR CONTAINMENT

| Material | Equipment Application |
| --- | --- |
| 300 Series Stainless Steel | Reactor coolant system, residual heat removal loop, spray system, safety injection system, CRDM shroud material. |
| 400 Series Stainless Steel | Valve materials |
| Inconel (600, 718) | Steam generator tubing, reactor vessel nozzles, core supports, and fuel rod grids |
| Galvanized Steel | Ventilation duct work, I&C conduit, miscellaneous tructural steel |
| Aluminum | See Table 5.6-2 for a detailed listing |
| Copper | Miscellaneous tubing, fan cooler material |
| 70-30 Cu Ni | Fan cooler material |
| 90-l0 Cu Ni | Fan cooler material |
| Carbon Steel | Component cooling loop, structural steel, main steam piping, etc. |
| Polyvinyl chloride | Conduit sheathing, electrical insulation |
| Protective Coatings | General use on carbon steel structures and equipment, concrete |
| Inorganic Zincs<br>Epoxy<br>Modified Phenolics | |
| Silicones-Neoprenes | Ventilation duct work gasketing, sealants |

Table 5.6-2 UNIT 1 - INVENTORY OF ALUMINUM IN CONTAINMENT

Page 1 of 2

| | | IN SPRAY | | IN SUMP | |
|---|---|---|---|---|---|
| | ITEM | MASS (lbs.) | SURFACE AREA (in2) | MASS (lbs.) | SURFACE AREA (in2) |
| a. | Fuel Manipulator Crane Equipment | 9.7 | 446 | 0 | 0 |
| b. | Fuel Transfer Equipment | 2 | 500 | 0 | 0 |
| c. | Air Motor Covers for RC-552A, -552B | 18.8 | 800 | 0 | 0 |
| d. | Reflectors on Polar Crane Lights | 60 | 27150 | 0 | 0 |
| e. | Limit Switch Cases on RH-700, SI-841A/B | 36 | 1260 | 0 | 0 |
| f. | Limit Switch Cases on SI-852A/B | 1 | 30 | 0 | 0 |
| g. | Handwheels on Personnel & Escape Hatches | 8.8 | 340 | 0 | 0 |
| h. | Limit Switches on RC-552A & B, SI-835A, SI-844B, CV-312, CC-761A | 12.0 | 840 | 0 | 0 |
| i. | Fischer I/Ps: I/P-431A & I/P-431B, SI-957 | 13.2 | 522 | 0 | 0 |
| j. | Air Regulators on RC-430, RC-431A, B, & C, RC-552A & B, SC-955, SI-835A, SI-844B, CV-312, CC-761A, SI-957, RM-3200C | 16.25 | 2600 | 0 | 0 |
| k. | ILRT Electrical & Brackets (Mod 85-280) | 16.48 | 1600 | 0 | 0 |
| l. | Snubber Components for 19-HS-15, 20-HS-16, 26-HS-2501R-43, 33-HS-601R-73, 34-HS-601R-80 | 7.5 | 192.3 | 0 | 0 |
| m. | Reactor Cavity Neutron Dosimetry | 3.5 | 265 | 0 | 0 |
| n. | ASME Pressure Vessel Code Class Tags | 0.044 | 25 | 0 | 0 |
| o. | RE-102 housing & alarm horn | 3.06 | 304 | 0 | 0 |
| q. | Knobs on compressed gas bottles | 2.42 | 104 | 0 | 0 |
| r. | 4-way valve knobs on PT-131 and FT-614 | 2 | 83 | 0 | 0 |
| s. | PT-1004 & TT-1058 housings | 0 | 0 | 26.2 | 2,148 |
| t. | Operator on SC-955 | 6.8 | 278 | 0 | 0 |
| u. | SG Channel Head Blowers & Receptacles | 60.9 | 2236 | 0 | 0 |
| v. | 480 VAC receptacle PR-23 | 5.2 | 159 | 0 | 0 |
| w. | PT-493 | 7.8 | 322 | 0 | 0 |
| x. | RCP oil sump alarm panels | 0.45 | 29.5 | 0 | 0 |
| | Totals for metallic aluminum | 294 | 40,085 | 26 | 2,148 |

Table 5.6-2 UNIT 2 - INVENTORY OF ALUMINUM IN CONTAINMENT

Page 2 of 2

| | | IN SPRAY | | IN SUMP | |
|---|---|---|---|---|---|
| | ITEM | MASS (lbs.) | SURFACE AREA (in2) | MASS (lbs.) | SURFACE AREA (in2) |
| a. | Limit Switch case & knob on RH-720 | 12.5 | 435 | 0 | 0 |
| b. | Fuel Manipulator Crane Equipment | 12.3 | 515 | 0 | 0 |
| c. | Fuel Transfer Equipment | 2.00 | 500 | 0 | 0 |
| d. | Air Motor Covers for RC-552A, -552B | 0 | 0 | 18.8 | 800 |
| e. | Reflectors on Polar Crane Lights | 60.0 | 27,200 | 0 | 0 |
| f. | Limit Switch Cases on RH-700, SI-841A/B | 36.0 | 1,260 | 0 | 0 |
| g. | Limit Switch Cases on SI-852A | 0.450 | 14.7 | 0 | 0 |
| h. | Handwheels on Personnel & Escape Hatches | 8.82 | 340 | 0 | 0 |
| i. | Limit Switches on RC-431A, RC-552A & B, RC-557, SI-835A, and SI-844A & B | 10.0 | 700 | 4.00 | 280 |
| j. | Fischer I/Ps: I/P-431A & I/P-431B | 8.80 | 348 | 0 | 0 |
| k. | Air Regulators on RC-430, RC-431A, B, & C, RC-552A & B, RC-557, CV-1296, CV-313A, SC-955, SI-835A, and SI-844A & B | 12.5 | 2,000 | 3.75 | 600 |
| l. | ILRT Electrical & Brackets (Mod 85-280) | 16.5 | 1,600 | 0 | 0 |
| m. | Snubber Components for 21-2HS-27, 20-2HS-26, 12-2HS-22, 23-2HS-30, and 13-2HS-23 | 8.68 | 274 | 1.27 | 30.3 |
| n. | Reactor Cavity Neutron Dosimetry | 3.50 | 265 | 0 | 0 |
| o. | ASME Pressure Vessel Code Class Tags | 0.0440 | 25 | 0 | 0 |
| p. | 4 aluminum ferrules (cable strain reliefs) | 0.01 | 10 | 0 | 0 |
| q. | RE-102 housing & alarm horn | 3.06 | 304 | 0 | 0 |
| r. | Knobs on compressed gas bottles | 2.42 | 104 | 0 | 0 |
| s. | 4-way valve knobs on 2FT-413 | 2 | 83.1 | 0 | 0 |
| t. | PT-1004 & TT-1058 housings | 0 | 0 | 26.2 | 2,148 |
| u. | 480 VAC receptacles | 10.5 | 318 | 0 | 0 |
| v. | 120 VAC receptacle | 0.54 | 44.2 | 0 | 0 |
| w. | SG Channel Head Blowers & Receptacles | 60.9 | 2,236 | 0 | 0 |
| x. | Operator on SC-955 | 6.80 | 278 | 0 | 0 |
| y. | RCP oil sump alarm panels | 0.450 | 29.5 | 0 | 0 |
| | Totals for metallic aluminum | 279 | 38,883 | 54 | 3,858 |

Table 5.6-3 CORROSION OF ALUMINUM ALLOYS IN ALKALINE SODIUM BORATE SOLUTION

| Data Point | Temperature °F | Alloy Type | Test Duration | Corrosion Rate mg/ $dm^2$/hr | pH | Exposure Condition | Reference |
|---|---|---|---|---|---|---|---|
| 1 | 275 | 5053 | 3 hrs. | 96.2 | 9 | Solution | WCAP-7153 Table 9 |
| 2 | 275 | 5005 | 3 hrs. | 840 | 9 | Solution | WCAP-7153 Table 9 |
| 3 | 200 | 6061 | 320 hrs. | 15.4 | 9.3 | Solution | WCAP-7153 Table 8 WCAP-7153 Figure 9 |
| 4 | 210 | 5052 | 7 days | 53.0 | 9 | Solution | WCAP-7153 Table 7 WCAP-7153 Figure 8 |
| 5 | 210 | 5052 | 2 days | 14.0 | 9 | Solution | WCAP-7153 Table 5 |
| 6 | 210 | 5005 | 2 days | 27.1 | 9 | Solution | WCAP-7153 Table 5 |
| 7 | 284 | 5052 | 1 day | 54 | 9.3 | Spray | ORNL-TM-2425, Table 3.13 |
| 8 | 284 | 5052 | 1 day | 31.5 | 9.3 | Solution | ORNL-TM-2425, Table 3.13 |
| 9 | 212 | 6061 | 3 days | 126 | 9.3 | Spray | ORNL-TM-2368, Table 3.6 |
| 10 | 212 | 6061 | 3 days | 110 | 9.3 | Solution | ORNL-TM-2368, Table 3.6 |
| 11 | 150 | 6061 | 7 days | 2.9 | 9.3 | Solution | PWRD recent data |
| 12 | 150 | 5052 | 7 days | 4.2 | 9.3 | Solution | PWRD recent data |

Table 5.6-4 CONCRETE SPECIMEN TEST DATA

| Concrete-Boron Test No. | Total Exposure Period (Days) | Surface/Volume ($in^2$/gal). | Exposed Weight Change (Grams) | Initial Specimen Weight (Grams) | Visual Exam |
|---|---|---|---|---|---|
| 1 | 24 | 28 | -22.4 | 560.0 | No apparent change |
| 3 | 28 | 20 | +21.5 | 404.0 | Light, yellowish, deposit on specimen |
| 4[(a)] | 72 | 38 | 0 | 641.2 | No apparent change - coating adhesion excellent |
| 5 | 72 | 43 | -0.2 | 769.5 | Light, hard deposit on specimen |
| 6 | ~4[(b)] | 54 | -- | 601.4 | No apparent change - small amount of sand particles in test can |
| 7 | 175 | 23 | +11.0 | 457.0 | No apparent change |
| 8[(a)] | 175 | 38 | +26.5 | 751.0 | No apparent change - coating adhesion excellent |
| 9[(a)] | ~5[(b)] | 78 | +4.0 | 702.0 | No apparent change - coating adhesion excellent |

(a) These specimens coated with Phenoline 305. All others were uncoated.
(b) These tests were high temperature DBA transient conditions. All others at 195-205°F.

Table 5.6-5 EVALUATION OF SEALANT MATERIALS FOR USE IN CONTAINMENT

| Sealant Type | Manufacture | Post Test Appearance |
|---|---|---|
| Butyl Rubber | A | Unchanged, flexible |
| Silicone | B | Unchanged, flexible |
| Silicone | B | Unchanged, flexible |
| Polyurethane | C | Sealant bubbled and became very soft. Solution permeated into bubbles. |
| Polyurethane | C | Sealant swelled and became soft, solution permeated into material. |
| Polyurethane | C | Sealant swelled, very soft and tacky, solution permeated into material. |

Figure 5.6-1 CONTAINMENT STRUCTURE - PRESTRESS TENDON HARDWARE ASSEMBLY (Sheet 1)

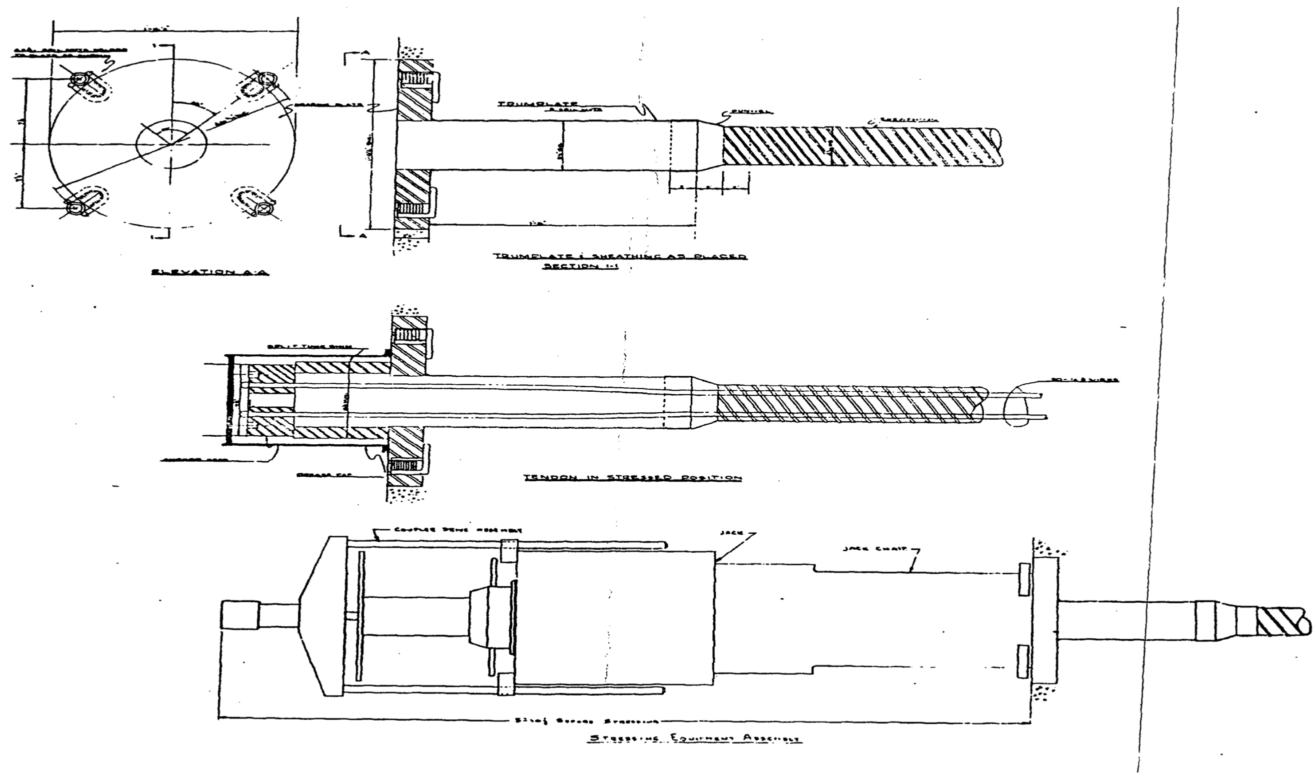


Figure 5.6-1 CONTAINMENT STRUCTURE - PRESTRESS TENDON HARDWARE ASSEMBLY (Sheet 2)

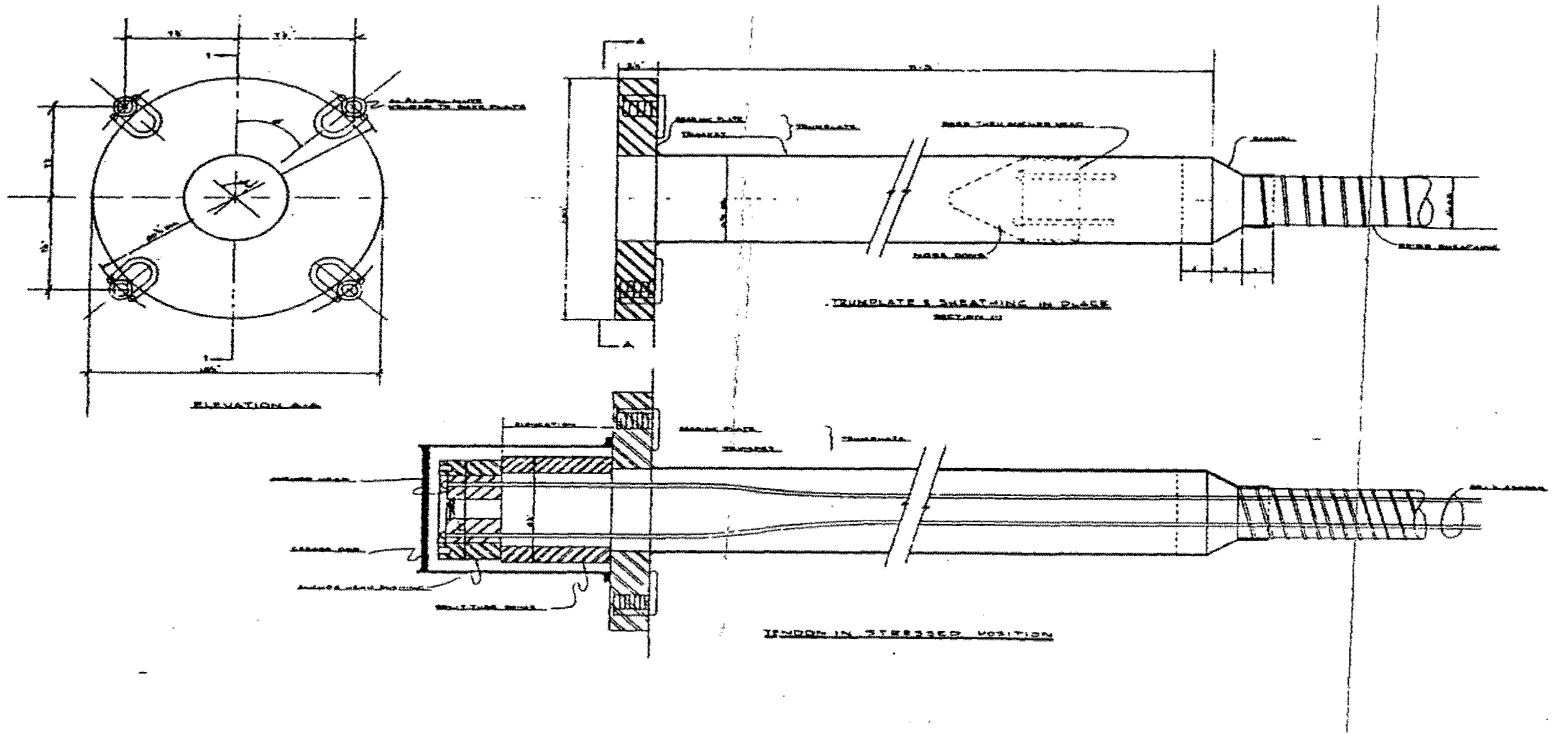


Figure 5.6-1 CONTAINMENT STRUCTURE - PRESTRESS TENDON HARDWARE ASSEMBLY (Sheet 3)

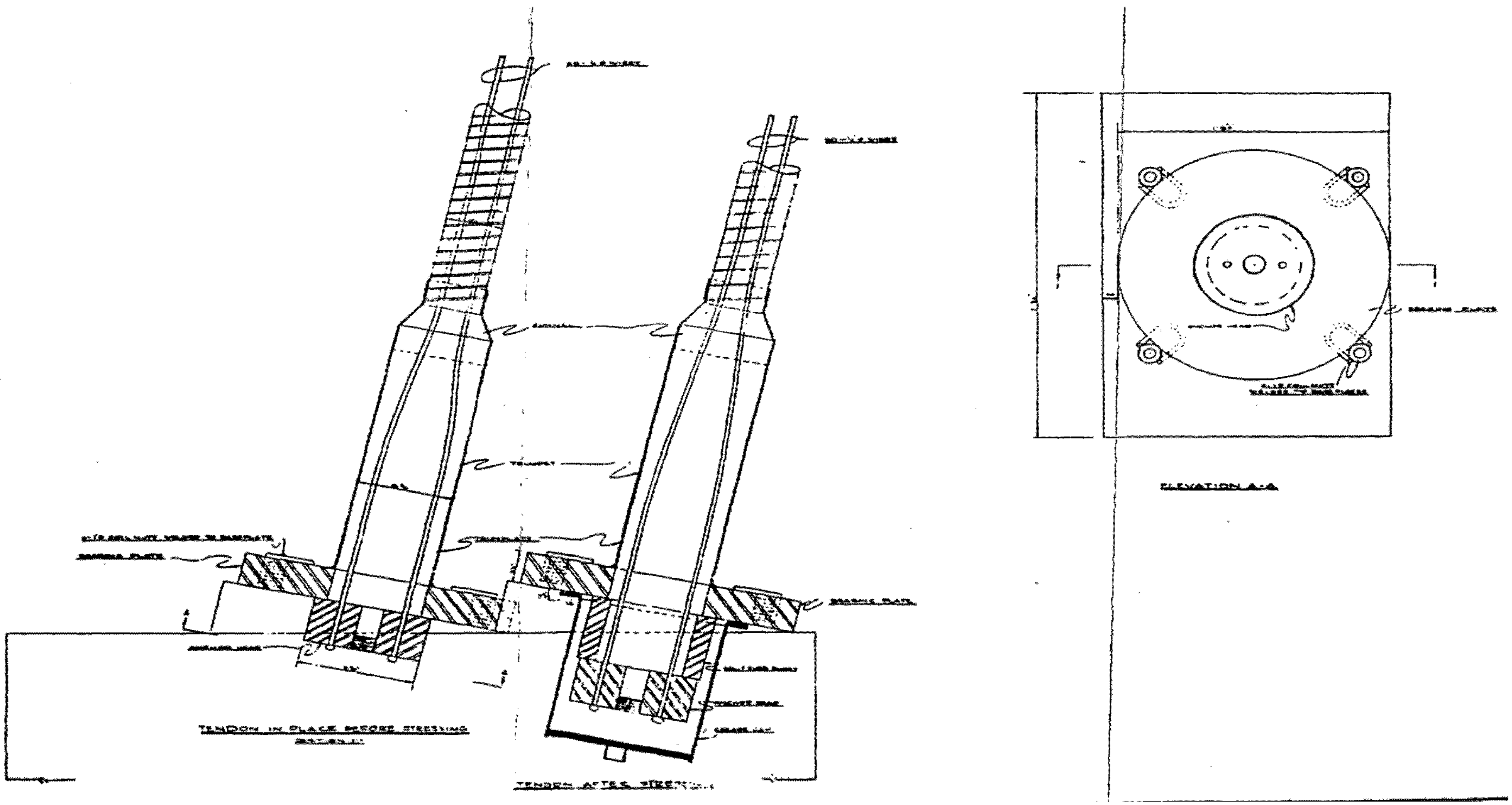


Figure 5.6-1 CONTAINMENT STRUCTURE - PRESTRESS TENDON HARDWARE ASSEMBLY (Sheet 4)

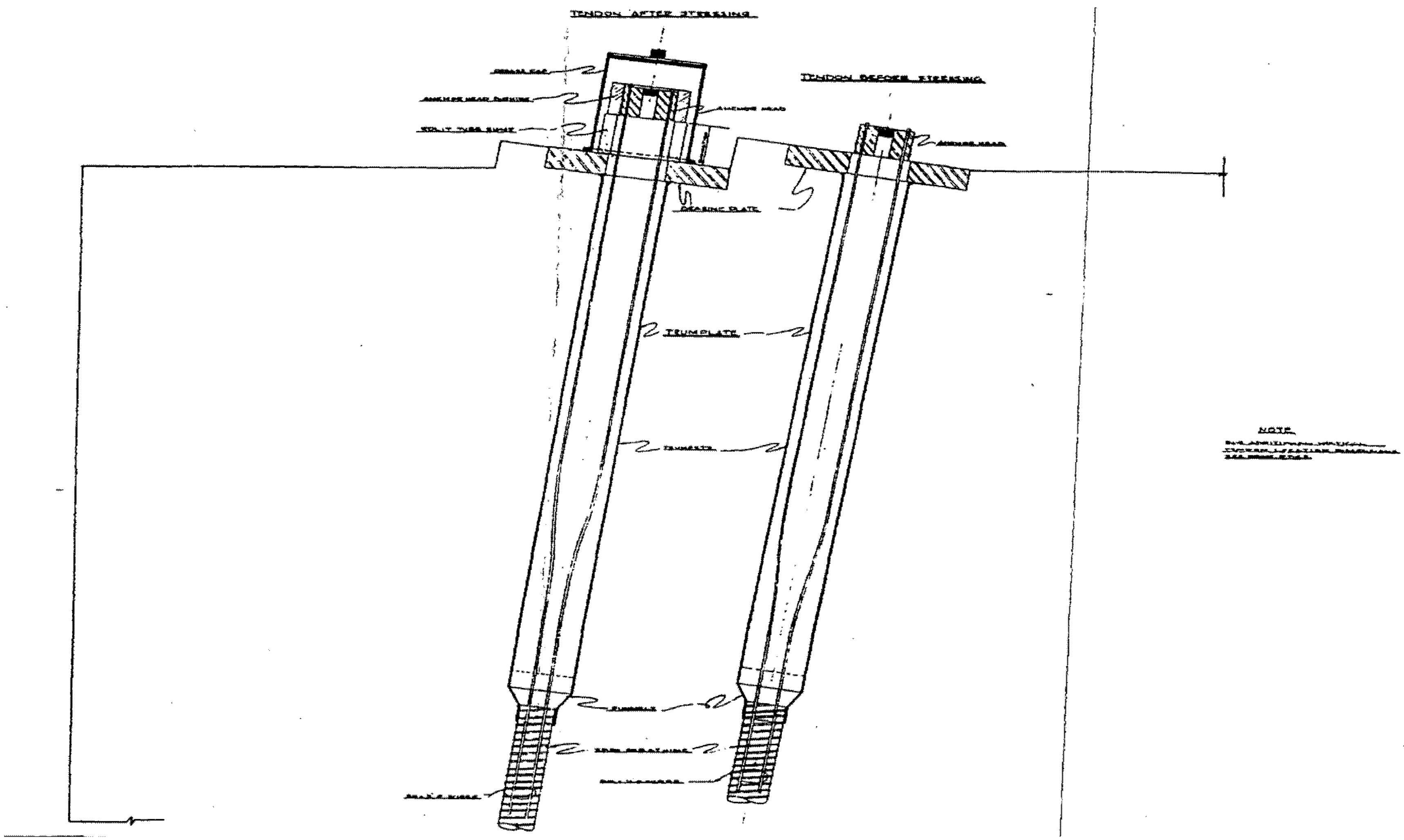


Figure 5.6-2 ALUMINUM CORROSION IN DBA ENVIRONMENT

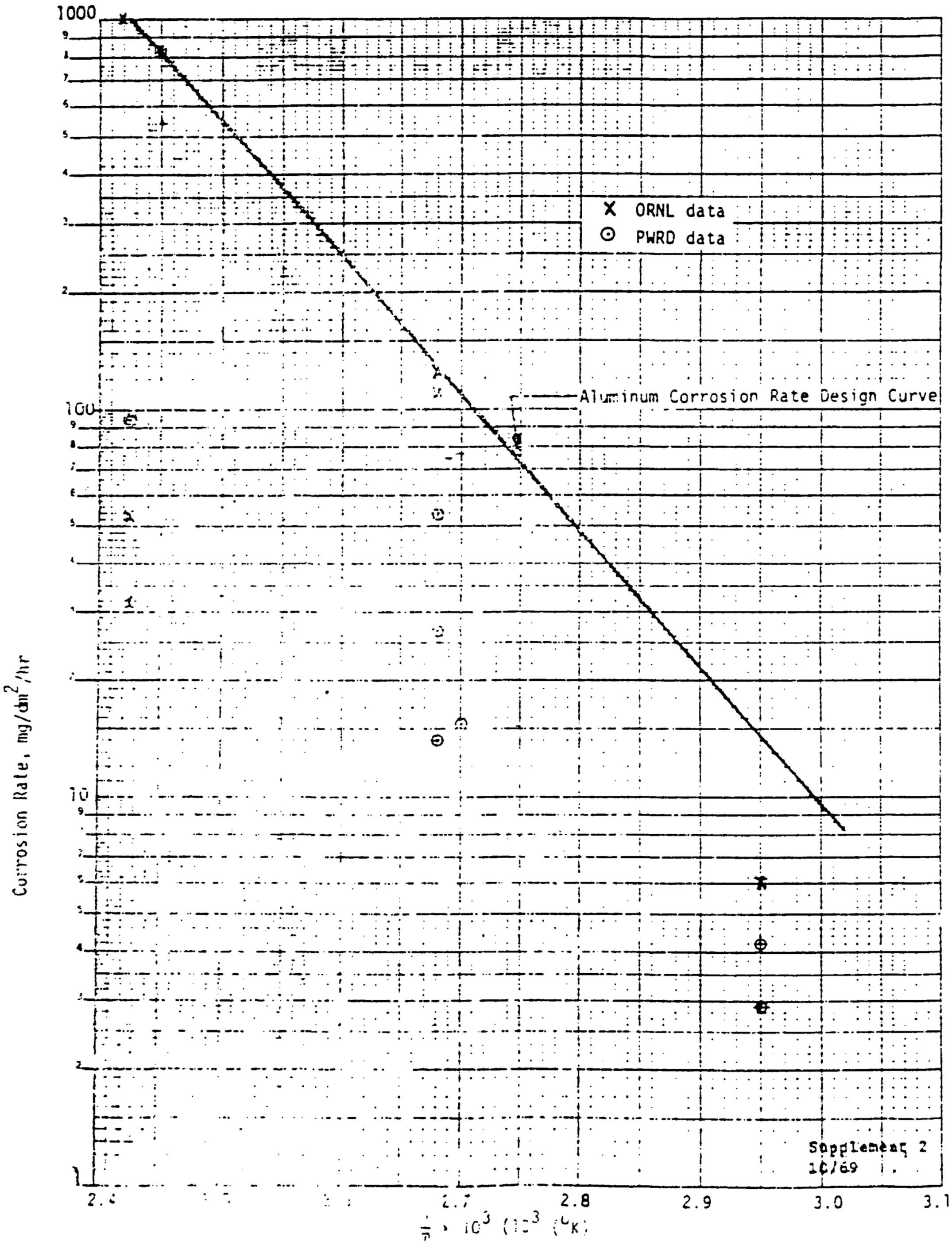


Figure 5.6-3 BORON LOSS FROM BORON - CONCRETE REACTION FOLLOWING A DBA

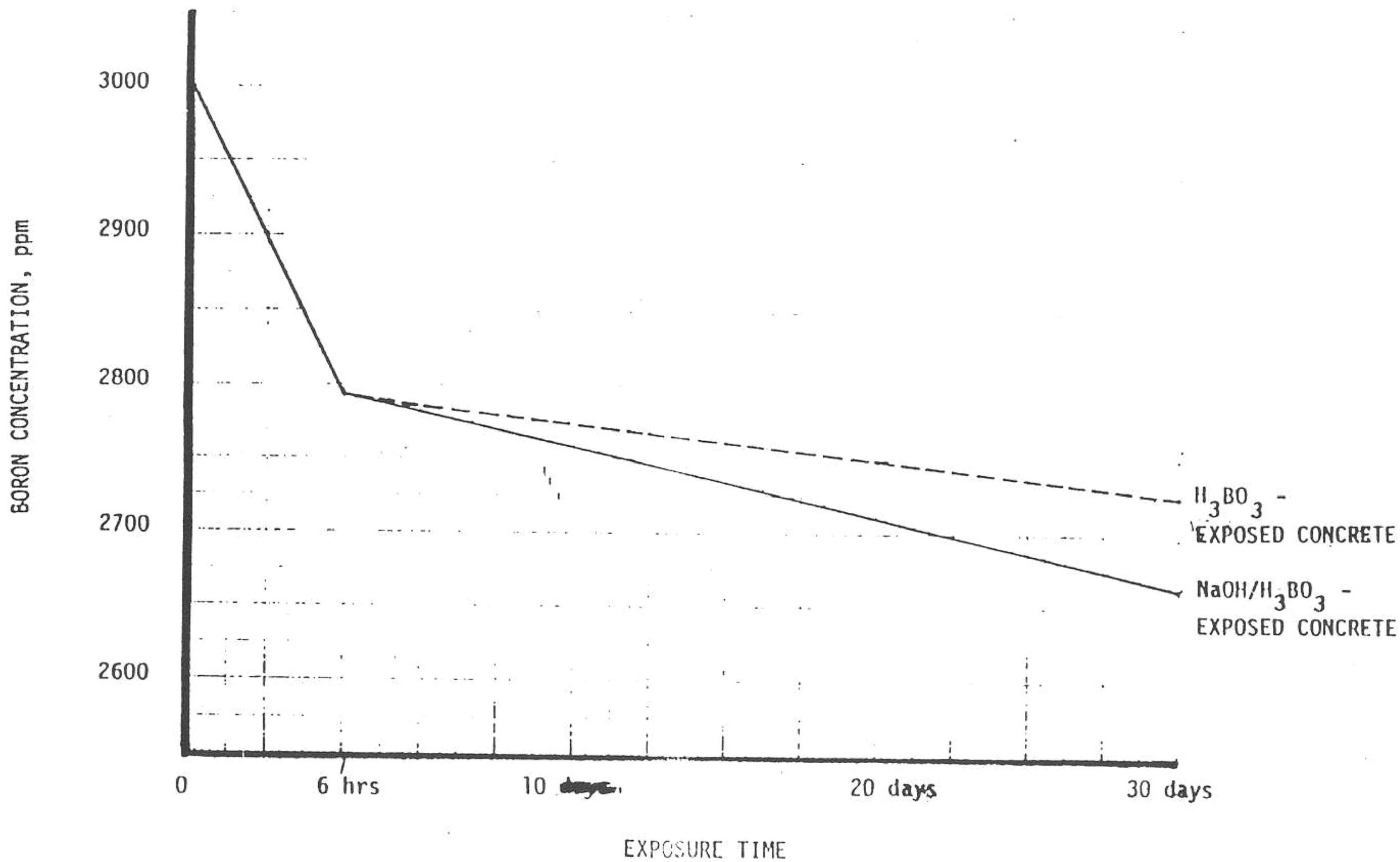
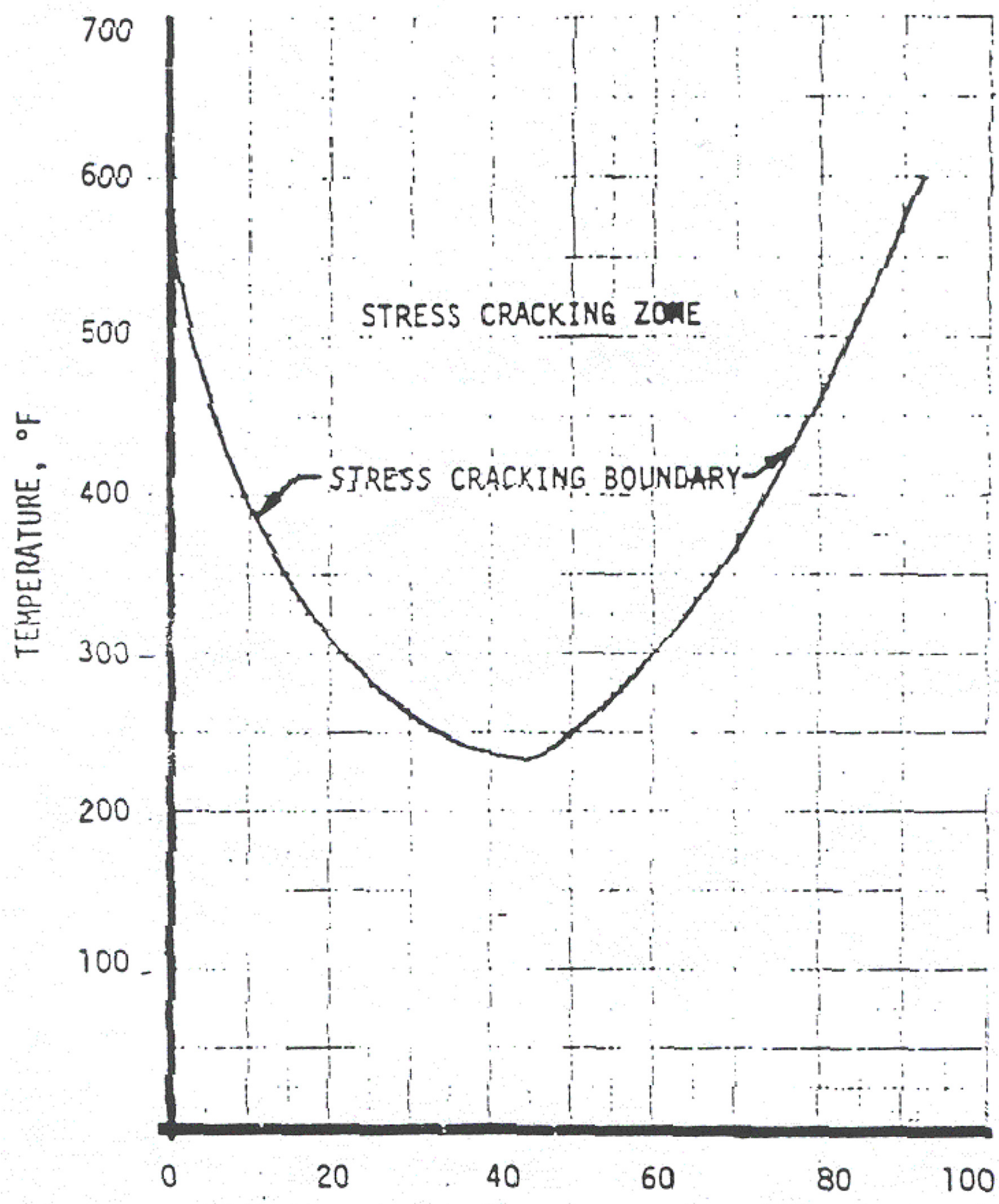


Figure 5.6-4 TEMPERATURE - CONCENTRATION RELATION FOR CAUSTIC CORROSION OF AUSTENITIC STAINLESS STEEL
(AFTER SWANDBY, R.K. CHEM. ENG. 69, 186 NOV. 12, 1962)



## 5.7 TESTS AND INSPECTIONS

Initial Containment Leakage Rate Testing

Criterion: Containment shall be designed so that integrated leakage rate testing can be conducted at the peak pressure calculated to result from the design basis accident after completion and installation of all penetrations and the leakage rate shall be measured over a sufficient period of time to verify its conformance with required performance. (GDC 54)

After completion of the containment structure and installation of all penetrations and weld channels, an initial integrated leakage rate test was conducted at 115% of the peak calculated accident pressure and maintained for a minimum of 24 hours, to verify that the leakage rate was within the acceptance criteria.

Periodic Containment Leakage Rate Testing

Criterion: The containment shall be designed so that an integrated leakage rate can be periodically determined by test during plant lifetime. (GDC 55)

A leak rate test is performed as per the requirements of 10 CFR Part 50, Appendix J and in accordance with Technical Specification Surveillance Requirement SR 3.6.1.1.

Provisions for Testing of Penetrations

Criterion: Provisions shall be made to the extent practical for periodically testing penetrations which have resilient seals or expansion bellows to permit leak tightness to be demonstrated at the peak pressure calculated to result from occurrence of the design basis accident. (GDC 56)

A piped connection is provided at each test point such that all penetrations with resilient seals or expansion bellows may be checked for leaktight integrity at any time throughout the operating life of the plant.

Most penetrations are designed with double seals or leak chase test channels so as to permit pressurization of the interior of the penetration or of potential leakage paths whenever a leak test is required (Reference 5). The large access openings, such as the equipment hatch and personnel air locks, are tested by pressurizing the entire hatch to test pressure. This procedure tests the door seals as well as all electrical and mechanical penetrations in the hatches.

Gross leakage from the piping or electrical penetrations is monitored by measurement of the makeup air flow. Penetrations are local leak tested separately.

Provisions for Testing of Isolation Valves

Criterion: Capability shall be provided to the extent practical for testing functional operability of valves and associated apparatus essential to the containment function for establishing that no failure has occurred and for determining that valve leakage does not exceed acceptable limits. (GDC 57)

Capability is provided to the extent practical for testing the functional operability of valves and associated apparatus during periods of reactor shutdown.

Initiation of containment isolation employs coincidence circuits which allows checking of the operability and calibration of one channel at a time. Removal or bypass of one signal channel places that circuit in the half-tripped mode.

Local leak tests of containment isolation valves are performed as required during periods of reactor shutdown.

The main steam and feedwater barriers and isolation valves in systems which connect to the reactor coolant system are hydrostatically tested to measure leakage.

Valves in the emergency core cooling systems (safety injection and residual heat removal) are not considered to be isolation valves in the usual sense inasmuch as the system would be in operation under accident conditions. The pressure boundary integrity of these closed systems outside containment is monitored by the leakage reduction and preventive maintenance program (FSAR Section 6.2.3).

## 5.7.1 PREOPERATIONAL TESTING

### 5.7.1.1 CONTAINMENT STRUCTURE INSTRUMENTATION

The purpose of instrumenting and testing a prestressed concrete containment structure is to provide a means for comparing the actual response of the structure to the loads induced during post tensioning and pressure testing with the predictions of the design calculations and known material capabilities. If the response is within the predicted ranges, the assumptions of the analyses are met; the design techniques are assumed to be verified.

The Point Beach containment structures are very similar to each other and to the Turkey Point and Palisades structures; but different in that the Point Beach containment structures are somewhat smaller and founded on piles. The Point Beach containment mat thickness is approximately equal to the maximum pile spacing, thus the design of the mat and the containment is not significantly different from the other containments cited.

The containment at Palisades and one containment at Turkey Point are extensively instrumented. At each of the containments, there are approximately 400 sensors. In addition, deformation measurements were made at about 25 locations on the structures. Testing demonstrated the validity of the design concepts and methods as well as provided a means for comparison of the differences between the predicted range of phenomena and that measured. Verification of the design concepts and methods for the containments cited provided verification for the same design concepts and methods used on Point Beach.

The tests at Palisades and Turkey Point were made to demonstrate that the design concepts and methods result in a containment that can withstand the applied loads. Since the Point Beach containment was designed with similar concepts and methods, the demonstration at Point Beach was not as extensive as that for Palisades and Turkey Point containments. There are therefore no provisions for strain gages to measure local strains for the Point Beach containment.

Prior to reactor fuel loading and operation, containment structural integrity was demonstrated by a pressure proof test. The post tensioning and the pressure test permitted verification that the structural response due to the induced loads was consistent with the predicted behavior and that of one or both of the extensively instrumented containments. The means for verification were obtained by measurements of the structure's deformation.

The measurements determined the deformations resulting from prestressing and pressure loads. Of necessity, the measurements included deformations resulting from thermal gradients caused by the unpredictable weather conditions which existed at the time of measurement.

The measurement techniques used allowed measurements of displacement to within 0.05 in. or less during post tensioning. The system for measuring the deflections employed electronic measuring devices located inside the containment. This method was capable of equal or better accuracy than the optical method initially proposed and was free of adverse effects due to the weather. These deflections, in turn, were correlated with measurements made on another containment structure for verification of consistency of structural behavior. The results of the tests are reported in Reference 1 and Reference 2.

### 5.7.1.2 LEAK TIGHT INTEGRITY TESTS

The objectives of these tests are:

1. To determine the initial integrated leak rate for comparison with the 0.4%/24 hr. of containment air weight at 60 psig and 286°F specified as the maximum permissible. Following License Amendments 240 and 244, the maximum permissible leak rate was changed to 0.2%/24 hr.

2. To determine the characteristic leak rate variation with pressure so as to allow retesting at pressures less than design pressure.

3. To institute a performance history summary of both local leak and integrated leak rate tests.

The guidelines established for the tests were:

1. The methods and equipment used during the initial tests were such that they could be used for subsequent retests, thus avoiding test result variations due to changes of the methods or equipment.

2. The leak test equipment is calibrated before the initial test and, if the equipment does not remain in place for subsequent retests, it is replaceable with either a similarly calibrated device or made such that it can be recalibrated in place.

3. The equipment consists of the necessary flowmeters, pressure, temperature sensors and moisture sensors.

4. The initial leak rate was measured using the Absolute Method of a period of not less than 24 hr. (unless proof has been established that the method allows measurement in a lesser time period). The integrated leakage was verified by adding to the integrated leakage (or

pumping back) a quantity of air that is measured by an independent measurement technique.

Prior to the integrated leak rate test, local leak testing is made on leak chase weld test channels, electrical penetrations, piping penetrations, across valve seats and along valve stems, and on equipment and personnel hatches where those items are a part of the containment envelope during the design basis accident. The test methods used are “soap bubble,” halogen leak detectors, pressure decay or rise, rotometers, or sonic detection, as appropriate, for the individual item being tested. The containment is pressurized to 5 psig and the local leak survey is made. The containment pressure is then increased for the pressure leak rate test.

An initial integrated leak rate test was performed at design pressure and at 50% design pressure, and is used for comparison with later containment pressure tests at 50% design pressure. The results of the initial integrated leak test are reported in Reference 3 and Reference 4.

Integrated leakage rate tests are performed as per the requirements of Appendix J to 10 CFR 50 and as specified in Technical Specification Surveillance Requirement SR 3.6.1.1.

#### 5.7.1.3 STRUCTURAL INTEGRITY TESTS

After construction, the containment was pressurized to prove the structural integrity of the vessel. The objectives of these tests were:

1. To provide direct verification that the structural integrity as a whole is equal to or greater than necessary to sustain the forces imposed by test pressure.

2. To acquire deformation measurements for comparisons with calculated deformation.

To achieve the above objectives, the response of the structure was measured at selected pressure levels with the highest being 1.15 times the design pressure. De facto indication that the structure is capable of withstanding internal pressure results from these tests.

#### 5.7.1.4 TEST PROCEDURES AND INSTRUCTIONS

In order that the structural and leak tight integrity tests could be carried out in the same time period, and to minimize the chances of test error, the test was specifically designed for this structure. To record and transmit the test requirements, a step-by-step test procedure was written and was complemented by data acquisition, verification, reduction and collation instructions as well as data interpretation standards.

#### 5.7.1.5 TENDON SURVEILLANCE

Provisions are made for an in-service surveillance program, throughout the life of the plant, intended to provide sufficient in-service historical evidence to maintain confidence that the integrity of the containment structure is being preserved. This program consists of tendon surveillance supplemented by a corrosion inspection program.

To accomplish these programs, randomly selected tendons from each tendon group are inspected. The quantity selected from each tendon group is specified in accordance with ASME Section XI, Subsection IWL, as required by 10 CFR 50.55a.

The tendon surveillance program for structural integrity and corrosion protection consists of visual and physical inspections as described in the Technical Specifications. The visual inspection checks for indications of abnormal material degradation, generally without dismantling the tendon. The physical inspection is more comprehensive. It involves a visual inspection followed by: (1) a lift-off test of each surveillance tendon to measure its pre-stressing force, (2) a de-tensioning of one tendon from each group, (3) a wire removal from each de-tensioned tendon for corrosion and tensile inspections, and (4) grease inspections and tests.

The inspection of the randomly selected tendons is sufficient to indicate any tendon corrosion that could possibly appear.

The inspection intervals, measured from the date of the initial proof test, are as follows:

One year from initial testing;

Three years from initial testing; and

Every five years thereafter.

Section 15.2.2, ASME Section XI, Subsections IWE and IWL ISI Program, contains additional provisions for the period of extended operation. (NRC SE dated 12/2005, NUREG-1839)

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3. Initial Integrated Leak Rate Test of the Reactor Containment Building, Point Beach Nuclear Plant Unit 1, June 25, 1970.

4. Initial Integrated Leak Rate Test of the Reactor Containment Building, Point Beach Nuclear Plant Unit 2, March 12, 1971.

5. 50.59 Evaluation 2008-002, Rev. 0, “U2-2CPP28 and 2CPP34 Removal of Leak Chase Channel,” approved April 17, 2008.