CHAPTER 5 CONTAINMENT SYSTEM

5.1 CONTAINMENT SYSTEM STRUCTURES

5.1.1 DESIGN BASIS

The reactor containment completely encloses the entire reactor and reactor coolant system and ensures that essentially no leakage of radioactive materials to the environment would result even if gross failure of the reactor coolant system were to occur. The liner and penetrations will be designed to attain a sensitive and accurate means of monitoring and detecting any leakage through the containment. The structure will provide biological shielding for both normal and accident situations.

The reactor containment will be designed to safely withstand several conditions of loading and their credible combinations. The major loading conditions are:

a) Occurrence of a gross failure of the reactor coolant system which creates a high pressure and temperature condition within the containment.

b) Coincident failure of the reactor coolant system with an earthquake or wind.

The design pressure and temperature of the containment will be, as a minimum, equal to 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. Energy contribution from the steam system is included in the calculation of the containment pressure transient due to reverse heat transfer through the steam generator tubes. The supports for the reactor coolant system will be designed to withstand the blowdown forces associated with the sudden severance of the reactor coolant piping so that the coincidental rupture of the steam system is not considered credible. In addition, the design pressure will not be exceeded during any subsequent

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long-term pressure transient determined by the combined effects of heat sources such as residual heat and limited metal-water reactions, structural heat sinks and the operation of the engineered safeguards; the latter utilizing only the emergency electric power supply.

The design pressure and temperature on the containment structure will be those created by the hypothetical loss-of-coolant accident. The reactor coolant system will contain approximately 512,000 lbs. of coolant at a weighted average enthalpy of 595 Btu/lb. for a total energy of 304,000,000 Btu. In a hypothetical accident, this water is released through a double-ended break in the largest reactor coolant pipe, causing a rapid pressure rise in the containment. The reactor coolant pipe used in the accident will be the 29-in. ID section because rupture of the 31-in. ID section requires that the blowdown go through both the 29-in. and the 27-1/2-in. ID pipes and would, therefore, result in a less severe transient.

Additional energy release was considered from the following sources:

a) Stored heat in the reactor core.
b) Stored heat in the reactor vessel piping and other reactor coolant system components.
c) Residual heat production.
d) Limited metal-water reaction energy and resulting hydrogen-oxygen reaction energy.

The following loadings will be considered in the design of the containment in addition to the pressure and temperature conditions described above:

a) Structure dead load.
b) Live loads.
c) Equipment loads.
d) Internal test pressure
e) Earthquake.
f) Wind.

5.1.2 CONTAINMENT SYSTEM STRUCTURE DESIGN

5.1.2.1 General Description

The reactor containment structure is a reinforced concrete vertical right cylinder with a flat base and hemispherical dome. A welded steel liner with a minimum thickness of 1/4-inch is attached to the inside face of the concrete shell to insure a high degree of leak-tightness. The design objective of the containment structure is to contain all radioactive material which might be released from the core following a loss-of-coolant accident. The structure serves as both a biological shield and a pressure container.

The structure, as shown on Figure 5-1, will consist of side walls measuring 148-feet from the liner on the base to the springline of the dome, and has an inside diameter of 135-feet. The side walls of the cylinder and the dome will be 4-ft. 6-in. and 3-ft. 6-in. thick respectively. The inside radius of the dome will be equal to the inside radius of the cylinder so that the discontinuity at the springline due to the change in thickness is on the outer surface. The flat concrete base mat is 9-ft. thick with the bottom liner plate located on top of this mat. The bottom liner plate will be covered with 3-ft. of concrete, the top of which will form the floor of the containment. The internal pressure within the containment is self-contained in that the vector sum of the pressure forces is zero; therefore, there is no need for mechanical anchorage between the bottom mat and underlying rock. The base mat will be directly supported on rock.

The basic structural elements considered in the design of the containment structure will be the base slab, side walls and dome acting as one structure under all possible loading conditions. The liner will be anchored to the concrete shell by means of anchors so that it forms an integral part of the entire composite structure under all loadings. The reinforcing in the structure will have an elastic response to all loads with limited maximum strains to insure the integrity of the steel liner. The lower portions of the cylindrical liner will be insulated to avoid deformation of the liner due to restricted radial growth when subjected to a rise in temperature.

The containment structure is inherently safe with regard to common hazards such as fire, flood and electrical storm. The thick concrete walls are invulnerable to fire and only an insignificant amount of combustible material, such as lubricating oil in pump and motor bearings, is present in the containment.

Internal structures consist of equipment supports, shielding, reactor cavity and canal for fuel transfer, and miscellaneous concrete and steel for floors and stairs. All internal structures are supported on the mat with the exception of equipment supports secured to the intermediate floors.

A 3-ft. thick concrete ring wall serving as a partial radiation shield surrounds the reactor coolant system components and supports the polar-type reactor containment crane. A 2-ft. thick reinforced concrete floor covers the reactor coolant system with removable gratings in the floor provided for crane access to the reactor coolant pumps. The four steam generators, pressurizer and various piping penetrate the floor. Spiral stairs provide access to the areas below the floor. Missile protection for the units penetrating the reinforced concrete floor is provided as discussed in Section 5.1.2.6.

The refueling canal connects the reactor cavity with the fuel transport tube to the spent fuel pool. The floor and walls of the canal are concrete, with walls and shielding water providing the equivalent of 6-feet of concrete. The floor is 4 ft. thick. The concrete walls and floor are lined with 1/4-inch thick stainless steel plate. The linings provide a leakproof membrane that is resistant to abrasion and damage during fuel handling operation.

5.1.2.2 Design Load Criteria

The following loads will be considered to act upon the containment structure creating stresses within the component parts.

a) Dead load will consist of the weight of the concrete wall, dome, liner, insulation, base slab and the internal concrete. Weights used for dead load calculations will be as follows:

1.	Concrete	:	150 lb/ft^3
2.	Reinforcing Steel	:	490 lb/ft^3 using nominal cross-sectional areas of reinforcing as defined in ASTM for bar sizes.
3.	Steel Lining	:	490 lb/ft^3 using nominal cross-sectional area.
4.	Insulation	:	To be determined during design.

b) Live load will consist of snow and construction loads on the dome and major components of equipment in the containment. Snow and ice loads will be applied uniformly to the top surface of the dome at an estimated value of 20 pounds per square foot of horizontal projection of the dome. This loading represents approximately 2-ft. of snow, which is considered to be a conservative amount since the slope of the dome will tend to cause much of the snow which falls on it to slide off. A construction live load of 50 pounds per square foot will be used on the dome, but will not be considered to act concurrently with the snow load. Equipment loads will be those specified on the drawings supplied by the manufacturers of the various pieces of equipment.

c) The internal pressure transient to be used for the containment design and its variation with time is shown on the pressure-temperature transient curve, Figure 5-2. For the free volume of 2,610,000 cubic feet within the containment, the design pressure will be 47 psig. This pressure transient is more severe than those calculated for various loss-of-coolant accidents which are presented in Chapter 12.

d) Thermal expansion stresses due to an internal temperature increase caused by a loss-of-coolant accident will be considered. This temperature and its variation with time is shown on the pressure-temperature transient curve, Figure 5-2. The maximum temperature at the uninsulated section of the liner under accident conditions is 247°F. For the 1.25 times and 1.50 times design pressure loading conditions given in Section 5.1.2.4, the corresponding liner temperatures will be 285°F and 306°F respectively. The pressure-temperature transient curves for these loading conditions are shown in Figures 5-3 and 5-4 respectively. The maximum operating temperature is 120°F. The design 24 hour mean-low ambient temperature is -5°F.

e) The ground acceleration for the design earthquake has been determined to be 0.1g applied horizontally and 0.05 applied vertically. These values have been resolved as conservative numbers based upon recommendations from Dr. Lynch, Director of Seismic Observatory, Fordham University. A dynamic analysis will be used to arrive at equivalent design loads. Additionally, a hypothetical ground acceleration of 0.15 horizontal and 0.10 vertical will be used to analyze for the no-loss of function.

f) The American Standards Association "American Standard Code Requirements for Minimum Design Loads in Buildings and Other Structures" (A58.1-1955) designates the site as being in a 25 psf zone. In this code, for height zones between 100 and 499 feet, the recommended wind pressure on a flat surface is 40 psf. Correcting for the shape of the containment by using a shape factor of 0.60, the recommended pressure becomes 24 psf. The State Building and Construction Code for the State of New York stipulates a wind pressure up to 30 psf on a flat surface for heights up to 300 feet. For design, a 30 psf basic wind load will be used from ground level up.

g) Internal pressure will be applied to test the structural integrity of the vessel up to 115 per cent of the design pressure. This is applied only under controlled conditions. For this structure the test pressure will be 54 psig.

5.1.2.3 <u>Material Specifications</u>

Basically four materials will be used for the construction of the containment vessel. These are:

a) Concrete
b) Reinforcing Steel
c) Plate Steel Liner
d) Insulation

Basic specifications for these materials will be as follows:

a) Concrete shall be a dense, durable mixture of sound coarse aggregate, fine aggregate, cement, and water. Aggregates will conform to American Society for Testing Materials Specification C-33-64 "Standard Specifications for Concrete Aggregates." Aggregates shall consist of inert materials that are clean, hard and durable, free from organic matter and uncoated with clay or dirt. Fine aggregate shall consist of natural sand and the coarse aggregate of crushed stone. Portland cement will conform to American Society for Testing and Materials Specification C-150-65 "Standard Specification for Portland Cement," Type I (Normal), or Type II (moderate heat of hydration requirements). Whenever high early strength is required, Type III Cement will be used. Water will be free from any injurious amounts of acid, alkali, salts, oil, sediment or organic matter. The concrete will have a minimum density of 150 lb/ft^3. The 28-day standard compressive strength of the concrete will be 3,000 psi. Adequate means of control will be used in the manufacture of the concrete. To assure this value is attained as a minimum, concrete samples will be tested in accordance with the following ASTM Standards:

ASTM C-172 - Method of Sampling Fresh Concrete

ASTM C-31 - Method of Making and Curing Concrete Compression and Flexure Test Specimen in Field

ASTM C-39 - Method of Test for Compressive Strength of Molded Concrete Cylinders

All making and testing of concrete samples will be accomplished by an independent testing laboratory engaged by the architect engineer.

b) Reinforcing steel for the dome, cylindrical walls and base mat will be high-strength deformed billet steel bars conforming to ASTM Designation A432-65 "Specification for Deformed Billet Steel Bars for Concrete Reinforcement with 60,000 psi Minimum Yield Strength." This steel has a minimum yield strength of 60,000 psi, a minimum tensile strength of 90,000 psi, and a minimum elongation of 7 per cent in an 8-in. specimen. Reinforcing bars No. 11 and smaller in diameter will be lapped spliced or spliced by the Cadweld process. Bars No. 14S and 18S will be spliced by the Cadweld process only. A certification of physical properties and chemical content of each heat of reinforcing steel delivered to the job site will be required from the steel supplier. The splices used to join reinforcing bars will be tested to assure that they will develop at least 125% of the minimum yield point stress of the bar. The test program will require cutting out, at random, completed splices and testing to determine their breaking strength. The capacity of splices will be in accordance with ACI 318-63.

c) The plate steel liner will be carbon steel conforming to ASTM Designation A442-65 "Standard Specification for Carbon Steel Plates with Improved Transition Properties," Grade 60. This steel has a minimum yield strength of 32,000 psi and a minimum tensile strength of 60,000 psi with an elongation of 22 per cent in an 8-in. gauge length at failure. The liner will be 1/4-in. thick at the bottom, 1/2 in, thick in the first three courses except 3/4 in. thick at penetrations and 3/8-in. thick for remaining portion of the cylindrical walls and 1/2-in. thick in the dome. The liner material will be tested to assure an NDT temperature more than 30°F lower than the minimum operating temperature of the liner material.

Impact testing will be done in accordance with Section N331 of Section III of the ASME Boiler and Pressure Vessel Code. A 100 per cent visual inspection of liner anchors will be made prior to pouring concrete.

d) A specific material for insulating the liner plate will be decided upon during design. This insulation shall be able to withstand the calculated temperature and pressure conditions associated with Figures 5-2, 5-3 and 5-4.

e) Quality of both materials and construction of the containment vessel will be assured by a continuous program of quality control and inspection by Consolidated Edison Company of New York, Incorporated, and/or its field representatives, and Westinghouse Atomic Power Division, and United Engineers and Construction, Inc., as described in Section 5.1.2.7.

5.1.2.4 Design Stress Criteria

The design is based upon limiting load factors which are used as the ratio by which loads will be multiplied for design purposes to assure that the loading formation behavior of the structure is one of elastic, tolerable strain behavior. The load factor approach is being used in this design as a means of making a rational evaluation of the isolated factors which must be 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. In the case of the containment structure, therefore, this approach places minimum emphasis on the fixed gravity loads and maximum emphasis on accident and earthquake or wind loads. The loads utilized to determine the required limiting capacity of any structural element on the containment structure are computed as follows:

a) $C = 1.0D \pm 0.05D + 1.5P + 1.0\ (T + TL)$

b) $C = 1.0D \pm 0.05D + 1.25P + 1.0\ (T' + TL') + 1.25E$

c) $C = 1.0D \pm 0.05D + 1.0P + 1.0\ (T'' + TL'') + 1.0E'$

Symbols used in these formulae are defined as follows:

- C: = Required load capacity of section.
- D: = Dead load of structure and equipment loads.
- P: = Accident pressure load as shown on pressure-temperature transient curves.
- T: = Load due to maximum temperature gradient through the concrete shell and mat based upon temperatures associated with 1.5 times accident pressure.
- TL: = Load exerted by the liner based upon temperatures associated with 1.5 times accident pressure.
- T': = Load due to maximum temperature gradient through the concrete shell and mat based upon temperatures associated with 1.25 times accident pressure.
- TL': = Load exerted by the liner based upon temperatures associated with 1.25 times accident pressure.
- E: = Load resulting from either design earthquake or wind, whichever is greater.
- T": = Load due to maximum temperature gradient through the concrete shell, and mat based upon temperatures associated with the accident pressure.
- TL": = Load exerted by the liner based upon temperatures associated with the accident pressure.
- E': = Load resulting from assumed hypothetical earthquake.

Load condition (a) indicates that the containment will have the capacity to withstand loadings at least 50 per cent greater than those calculated for the postulated loss-of-coolant accident alone. Results of preliminary analysis using load condition (a) are shown in Figure 5-5.

Load condition (b) indicates that the containment will have the capacity to withstand loadings at least 25 per cent greater than those calculated for the postulated loss-of-coolant accident with a coincident design earthquake. Results of preliminary analysis using load condition (b) are shown in Figure 5-6.

Mathematical solutions of load condition (c) indicates the containment will satisfy this relation for seismic loads of at least equal to those corresponding to the response of 0.15g horizontal and 0.10 vertical ground accelerations occurring simultaneously. Although the analytical results are not currently available in the graphic form presented for load conditions (c), the Indian Point Unit No. 3 containment will have the capacity to withstand loadings associated with the loss-of-coolant accident and a coincident earthquake, resulting in the above hypothetical ground accelerations, with no loss of function.

The temperature gradient through the wall is essentially linear on both the insulated and uninsulated portions and is a function of the operating temperature internally and the average ambient temperature externally. Accident temperatures mainly affect the liner, rather than the concrete and reinforcing bars, due to the insulating properties of the concrete. By the time the temperature of the concrete adjacent to the liner begins to rise significantly, the internal pressure and temperature in the containment shell due to maximum thermal gradient will not influence the capacity of the structure to resist the other forces. Temperature effects induce stresses in the structure which are internal in nature; tension outside and compression in the inside of the shell such that the resultant force is zero. Loading combinations concurrent with these temperature effects may cause local stresses in the outside horizontal and vertical bars to reach yield, however, as local yielding is reached, any further load is transferred to the unyielded elements. At the full yield condition, the magnitude of final load resisted across a horizontal and vertical section remains identical to that which would be carried if the temperature affects were not considered. Thus the overall carrying capacity of the structure and the factor of safety of the structural elements are not affected.

The mat will be analyzed utilizing load conditions (a), (b) and (c) and also for loads occurring only at operating conditions.

If the loads resulting from wind on any portion of the structure exceed those resulting from earthquake, the wind load will be used in lieu of design earthquake in the appropriate load condition. Although no hypothetical wind load will be assumed for load condition (c), a check will be made to determine the maximum wind pressure that is tolerable.

All structural components will be designed to have a capacity required by the most severe loading combination. The loads resulting from the use of these equations will hereafter be termed "factored loads."

The load factors utilized in these equations are based upon the load factor concept employed in Part IV-B, "Structural Analysis and Proportioning of Members Ultimate Strength Design" of ACI 318-63. Because of the refinement of the analysis and the restrictions on construction procedures, the load factors in the design primarily provide for a safety margin on the load assumptions.

The design will include the consideration of both primary and secondary stresses. The design limit for tension member (i.e., the capacity required for the design load) will be based upon the yield stress of the reinforcing steel.

No steel reinforcement will experience average strains beyond the yield point at the factored load. The load capacity so determined will be reduced by a capacity reduction factor "Ø" which will provide for the possibility that small adverse variations in material strengths, workmanship, dimensions, and control, while individually within required tolerances and the limits of good practice, occasionally may combine to result in under capacity. For tension members, the factor "Ø" will be established as 0.95. The factor "Ø" will be 0.90 for flexure and 0.85 for diagonal tension, bond and anchorage.

For the liner steel the factor "Ø" will be 0.95 for tension. For compression and shear, the liner stress will be maintained below 0.95 yield and elastic stability will be assumed.

The liner will be designed to assure that no strains greater than the strain at the guaranteed yield point will occur at the factored loads. Sufficient anchorage will be provided to assure elastic stability of the liner. The basic design concept utilizing stud anchorage of the liner plate to the concrete structure assures stud failure due to shear tension or bending stress without the stud connection causing failure or tear of the liner plate. The studs will be of sufficient size, strength and arrangement to accommodate the load imposed by both operating and incident conditions. The design considers the possibility of daily stress reversals due to ambient temperature changes for the life of the plant, and fatigue limit of the studs will exceed the design requirements. However, to accommodate possible fatigue failure in the plate-to-stud weldment, the depth of penetration to the liner plate will be controlled to avoid impairment of liner integrity.

5.1.2.5 Missile Protection

High pressure reactor coolant system equipment which could be the source of missiles is suitably shielded either by the concrete shield wall enclosing the reactor coolant loops and pressurizer or by the concrete operating floor to block any passage of missiles to the containment walls. The steam drum which forms an integral part of the steam generator represents a mass of steel which provides protection from missiles originating in the section of the containment within the crane wall and below the operating floor. A structure is provided over the control rod drive mechanism to block any missiles generated from fracture of the mechanisms.

Missile protection for the plant will be provided to comply with the following criteria:

a) The containment and liner shall be protected from loss of function due to damage by such missiles as might be generated in the loss-of-coolant accident for break sizes up to and including the double-ended severance of a main coolant pipe.

b) The engineered safeguards systems and components required to maintain containment integrity shall be 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 will be developed and implemented using the following considerations:

a) The reactor coolant system will be surrounded by reinforced concrete and steel structures and designed to withstand the forces associated with double-ended rupture of a main coolant pipe and designed to stop the missiles.

b) The structural design of the missile shielding will take into account both static and impact loads.

c) Missile velocities will be calculated considering both fluid and mechanical driving forces which can act during missile generation.

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

The type of missiles for which protection will be provided are:

a) Valve stems
b) Valve bonnets
c) Instrument thimbles and wells
d) Various types and sizes of nuts and bolts
e) Complete control rod drive mechanism,or parts thereof

The shielding will be designed to preclude the potential missile, assumed from failure of a main coolant pump flywheel, from reaching the containment liner and from damaging the engineered safeguards.

5.1.2.6 Quality Control

To insure perfection in plant design, construction, workmanship, materials and performance, a quality control program will be in affect for this project in which the following three principal organizations will have their respective responsibilities:

1. Consolidated Edison Company of New York, Inc. as owner and operator of the plant.

2. Westinghouse Electric Corporation, as the turnkey plant contractor and supplier of major equipment.

3. United Engineers and Constructors Incorporated, as architect engineer, construction managers and constructions.

The function and responsibility in the quality control program of each of the above organizations will be as follows:

Consolidated Edison Company of New York, Inc.

A qualified field representative will be assigned to the field during the construction period. His responsibilities will include continuous inspection of the construction of the containment building to insure that all materials used and work performed is strictly in accordance with the plans and specifications. The Consolidated Edison representative through instructions received from the home office will have the power to stop the construction until any discrepancies are corrected and the work once more is in compliance with the specifications and plans.

Although the Consolidated Edison representative will not be reporting to or working under the construction superintendent, he will be in constant communication and consultation with the superintendent in matters regarding quality control. In addition personnel from a qualified Material Testing Laboratory of the Company or its agents will be assigned to this project to monitor the inspection of the construction and obtain samples of the materials for testing.

Westinghouse Electric Corporation

For the assurance of plant integrity and quality, Westinghouse will perform the following functions regarding the containment building:

a) Review and approve the containment design criteria, material specifications and detail design before they are released for construction. This work will be done by qualified structural engineers of the Company's home office.

b) Review the construction and inspection methods proposed by United Engineers and Constructors Incorporated.

United Engineers and Constructors Incorporated

The responsibilities of United Engineers and Constructors Incorporated in the quality control of the containment building is as follows:

a) They will inspect all materials delivered to the job site, and examine all suppliers' certified test reports of physical and chemical properties.

b) They will inspect, in the shop, fabrication of major components of the containment structure.

c) They will maintain an adequate force of qualified supervisory personnel at all times.

d) They will supervise and be fully responsible for the quality of work performed by subcontractors.

e) They will maintain as a part of their field engineering force qualified personnel who will perform a thorough inspection of each construction operation.

No changes will be allowed without the approval of the engineer in charge of design.

5.1.3 STRESS ANALYSIS

5.1.3.1 General

The structural design of the containment will meet the requirements established by the latest edition of "The State Building and Construction Code for the

State of New York" so far as these provisions are applicable. All concrete structures will be designed, detailed and constructed in accordance with the provisions of "Building Code Requirements for Reinforced Concrete" (ACI 318-63) so far as these provisions are applicable.

5.1.3.2 Method of Analysis

Basically three separate structural components will be analyzed, each in equilibrium with loads applied to it and with constraints occuring at the juncture of the structures. The three components are:

a) The 135-ft. ID hemispherical dome.
b) The 135-ft. ID cylinder.
c) The base slab.

Mathematically, the dome and cylinder will be treated as thin-walled shell structures which will result in a membrane analysis. Since the thickness of the dome and cylinder is small in comparison with the radius of curvature (1/15) and there are no discontinuities such as sharp bends in the meridonial curves, the stresses due to pressure and wind or earthquake can be calculated by assuming that they are uniformly distributed across the thickness.

All membrane stresses will be carried by the reinforcement; some by the steel liner, but none by the concrete unless they are compressive stresses.

Since the concrete will not resist any tensile forces, there will be need for radial shear reinforcing in the lower portion of the wall in the form of hooked diagonal stirrups and diagonally bent bars as shown in Figure 5-1. There will also be need for diagonal shear reinforcing in the circumferential direction to resist earthquake shears for the full height of the wall and a distance above the spring line into the dome until a point is reached where the dome liner can resist the total shear.

The base slab will be treated as a flat circular plate supported on a rigid non-yielding foundation.

5.1.3.3 Dome Analysis

The analysis of the hemispherical dome will be performed by the superposition of membrane forces resulting from gravity, accident pressure and accident thermal loads. In addition, earthquake or wind loading create both direct and shear stresses in the dome and the operating temperature of the liner creates tension and compression. All of the combined direct stresses are developed in the reinforcing steel encased in the concrete. The liner of the dome above a certain point will be used to resist shear load and the anchorages will be designed to assure composite action. The dome reinforcing will be spliced to the vertical steel in the cylindrical concrete wall, so that a continuity between the dome and the cylinder is realized.

5.1.3.4 Cylinder Analysis

The analysis of the cylinder will be by the superposition of membrane forces resulting from gravity, pressure and thermal loads, over-turning due to earthquake or wind and shears due to earthquake or wind. The concrete will be reinforced circumferentially using steel hoops and vertically by straight bars. Diagonal bars will be placed to resist the horizontal and vertical shears due to earthquake or wind. The required capacity of the diagonal bars will be determined such that the horizontal component per foot of the diagonals will be equal to the maximum value of shear flow. A check will be made to insure that no net compressive force results in the diagonal bars because of the combination of seismic shear load and internal pressure load. Although, in the cylinder, the liner has some capacity available to resist the seismic shears, no credit will be taken for this capacity. Only in the upper area of the dome (beyond about 30° above the spring line) where the seismic shears are small will the liner be counted on to resist shear. For all of the cylinder and the lower areas of the dome, the diagonal reinforcing will be designed to accommodate all seismic shears. No credit will be taken for the dowel action of the vertical and horizontal bars in resisting seismic shear.

5.1.3.5 Discontinuity Stresses

Discontinuity stresses occur at changes in section or direction of the containment shell.

The juncture of the cylinder to the dome is a point of discontinuity since, under the internal pressure and temperature design conditions, the cylinder will tend to increase in diameter somewhat differently than the dome. To compute the unrestrained dimensional changes the dome and cylinder will be considered as steel membranes equivalent to the reinforcing steel. The moments and shears will be computed by equating the deformations of the cylinder and hemispherical dome at the point of juncture and solving for deflections, moment, and shears of the cylinder and the dome.

The juncture of the cylindrical wall and the base mat is another point of discontinuity. In determining discontinuity moments and shears, the mat is considered as offering complete fixity. If the entire concrete section of the wall is used in the evaluation of the flexural rigidity, a conservatively high value for moments and shears are obtained. As cracking occurs and the reinforcement takes up the load, a redistribution of stresses occur, and the stiffness of the wall is greatly reduced, thereby reducing the discontinuity moments and shears. In order to avoid the conservativeness of an overly stiff section, the cracked section will be considered in calculating the moments and shears. The differential equation:

$$D \frac{d^4 w}{dx^4} + \frac{E_s h}{a^2} W = Z$$

represents the basis of solution for problems of symmetrical deformation of circular cylindrical shells of constant wall thickness.

The solution of this differential equation is:

$$W = \frac{e^{-\beta x}}{2\beta^3 D} \left[\beta M_o (\sin\beta x - \cos\beta x) - (Q_o \cos\beta x)\right]$$

and its consecutive derivatives are as follows:

$$\frac{dw}{dx} = \frac{e^{-\beta x}}{2\beta^2 D} \left[2\beta M_o \cos\beta x + Q_o (\cos\beta x + \sin\beta x)\right]$$

$$\frac{d^2 w}{dx^2} = \frac{e^{-\beta x}}{2\beta D} \left[2\beta M_o (\cos\beta x + \sin\beta x) + 2Q_o \sin\beta x\right]$$

$$\frac{d^3w}{dx^3} = \frac{e^{-\beta x}}{D} \quad [2\beta M_o \sin\beta x - Q_o(\cos\beta x - \sin\beta x)]$$

For the fixed end condition,

$$(w)_{x=o} = -\frac{1}{2\beta^3 D}(\beta M_o + Q_o) = \delta$$

and

$$\left.\frac{dw}{dx}\right)_{x=o} = \frac{1}{2\beta^2 D}(2\beta M_o + Q_o) = 0$$

where D is the flexural rigidity of the cracked wall section - $in.^3$

w is the radial deflection of the wall based on elongation of reinforcing bars - in.

x is the distance from the intersection of the wall and base

E_s is the modulus of elasticity of steel reinforcing

a is the mean radius of the wall

h is the area of hoop steel per unit height of wall

Z is the load intensity

$$\beta = \sqrt[4]{\frac{E_s h}{4a^2 D}}$$

δ is the unrestrained radial deflection of wall

M_o is the moment at the base in-lb/in

Q_o is the shear at the base lb/in

Hence, the base moment and shear can be evaluated and the distribution of moments and shears above the base can be determined from the equations given above.

5.1.3.6 Large Openings

In the cylindrical section of the containment, where there are large openings for access hatchways and penetrations, the reinforcing bars (hoop, vertical and diagonal) will be continued without interruption around the openings.

No bar will terminate at any opening as illustrated around the penetration in Figure 5-1. Also additional bars will be furnished locally to take the stresses developed around these openings. Concrete will be locally thickened at the equipment access hatchway area to accommodate all the reinforcing bars required in this area.

The liner plate shall be locally thickened at the penetrations to take care of additional stresses.

5.1.3.7 Base Slab Analysis

As stated previously, the base slab will be treated as a flat circular plate supported on a rigid non-yielding foundation. For loads applied uniformly around the slab, the analysis considers only a single wedge which because of symmetry is representative of the entire base slab. For the case of concentrated loads, on the slab, the wedge upon which it rests will be assumed to carry the load. Earthquake and wind loading create a non-uniform loading on the slab. For earthquake loads in combination with pressure loads, the outer perimeter of the base slab tends to lift off its rigid foundation. The analytical model which simmulates this condition is a circular flat plate with a rigid central region acted upon by earthquake, pressure and dead loads.

5.1.3.8 Seismic Design

The design of the containment which is a Class I structure will utilize the "response spectrum" approach in the analysis of the dynamic loads imparted by earthquake. The seismic design will be based on the acceleration response spectrum curves developed by G. Housner. Seismic accelerations have been computed as outlined in the AEC TID-7024[1] and Portland Cement Publication[2].

Damping factors will be used as follows::

DAMPING FACTORS

	Component	Per Cent of Critical Damping
1.	Containment Structure	2.0
2.	Concrete Support Structure of Reactor Vessel	2.0
3.	Steel Assemblies:	
	(a) Bolted or Riveted	2.5
	(b) Welded	1.0
4.	Vital Piping Systems	0.5
5.	Concrete Structures above Ground:	
	(a) Shear Wall	5.0
	(b) Rigid Frame	5.0

As indicated in Section 5.1.2.2, ground accelerations used for design purposes will be 0.1g applied horizontally and 0.05g applied vertically. The natural period of vibration is computed by the Rayleigh method; in this method the containment structure is analyzed as a simple cantilever intimately associated with the rock base and with broad base sections of adequate strength to assure full and continued elastic response during seismic motions. Further, both bending and shear deformations are considered.

The structure is divided into sections of equal length and loaded laterally by dead weight of the section and any equipment and live load occurring at the section. Deflections caused by shear and moments are then determined and the end deflection is given the value $\phi' = 1.0$ with corresponding values determined for other sections. The natural period of vibration (T) for the structure is then determined by the relation

$$T = 2\pi \left[\frac{Y_o \Sigma \phi'^2 \, dm}{g \Sigma \phi' \, dm} \right]^{1/2}$$

This expression is derived by setting potential energy equal to kinetic energy and solving for T, wherein terms are defined as follows:

Y_o = Maximum Actual Deflection

ϕ' = $\dfrac{\text{Deflection of Section Under Consideration}}{\text{Maximum Actual Deflection}}$

g = Acceleration Due to Gravity

dm = Weight of Section Under Consideration

Using the derived period, T, and entering the acceleration spectral curves, Figures 5-7 and 5-8, and applying 2% critical damping, a spectral acceleration for the containment is selected. This value is derived to determine the base shear. The distribution of base shear will be upon a triangular loading assumption based upon the formula

$$F_x = \frac{V\, w_x\, h_x}{\Sigma\, w\, h}$$

where F_x = lateral force applied to a level designated as x

V = total lateral load or shear at the base

w_x = that portion of total load which is located at the level designated as x

h_x = height in feet above the base to the level designated as x

Σwh = summation of the products of all $W_x h_x$ for the structure

This formula yields a load distribution pattern with zero loading at the base to a maximum loading at the spring line of the dome. Above this line the loading will somewhat decrease due to a change in section and consequently change in weight. This load distribution allows the determination of shears and moments at any critical section through the containment from which the appropriate unit stresses are obtained.

5.1.4 PENETRATIONS

5.1.4.1 General

In general, a penetration consists of a sleeve embedded in the concrete wall and welded to the containment liner. The weld to the liner is shrouded by a continuously pressurized channel which is used to demonstrate the integrity of the penetration-to-liner weld joint. The pipe, electrical conductor cartridge, duct or equipment access hatch passes through the embedded sleeve and the ends of the resulting annulus are closed off, either by welded end plates, bolted flanges or a combination of these. Provision will be made for differential expansion and misalignment between pipe or cartridge, and sleeve. Pressurizing connections are provided to continuously demonstrate the integrity of the penetration assemblies.

5.1.4.2 Types

a) Electrical Penetrations

"Cartridge" type penetrations are used for all electrical conductors passing through the containment. The penetrations are provided with a pressure connection to allow continuous pressurization. Insulating bushings or fused glass seals will be used to provide a pressure barrier for the conductor. Figure 5-9 shows a preliminary design of typical electrical penetrations. There will be approximately 60 electrical penetrations.

b) Piping Penetrations

Double barrier piping penetrations are provided for all piping passing through the containment. The pipe is centered in the embedded sleeve which is welded to the liner. End plates are welded to the pipe at both ends of the sleeve. Several pipes may pass through the same embedded sleeve to minimize the number of penetrations required. In this case, each pipe is welded to both end plates. A connection to the penetration sleeve is provided to allow continuous pressurization of the compartment formed between the piping and the embedded sleeve. In the case of piping carrying hot fluid, the pipe will be insulated and cooling will be provided to maintain the concrete temperature adjoining the embedded sleeve at or below 150°F. The isolation features and criteria for piping penetrations are given in Chapter 6. Figure 5-10 shows typical hot and cold pipe penetrations.

c) Equipment and Personnel Access Hatches

An equipment hatch will be provided which will be fabricated from welded steel and furnished with a double-gasketed flange and bolted dished door. The hatch barrel is embedded in the containment wall and welded to the liner. Provision is made to continuously pressurize the space between the double gaskets of the door flanges and the weld seam channels at the liner joint, hatch flanges and dished door. Pressure is relieved from the double gasket spaces prior to opening the joints. The personnel hatch will be a double door, mechanically-latched, welded steel assembly. A quick-acting type, equalizing valve connects the personnel hatch with the interior of the containment vessel for the purposes of equalizing pressure in the two systems when entering or leaving the containment. The personnel hatch doors are interlocked to prevent both being opened simultaneously and to ensure that one door is completely closed before the opposite door can be opened. Remote indicating lights and annunciators situated in the control room indicate the door operational status. An emergency lighting and communication system operating from an external emergency supply is provided in the lock interior. Emergency access to either the inner door, from the containment interior; or to the outer door, from outside, is possible by the use of special door unlatching tools.

d) Special Penetrations

1. <u>Fuel Transfer Penetration</u>

   A fuel transfer penetration is provided for fuel movement between the refueling transfer canal in the reactor containment and the spent fuel pit. The penetration consists of a 20-inch stainless steel pipe installed inside a 24-inch pipe. The inner pipe acts as the transfer tube and is fitted with a pressurized double-gasketed blind flange in the refueling canal and a standard gate valve in the spent fuel pit. 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 a special seal ring for 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 5-11 shows a sketch of the fuel transfer tube.

2. Containment Supply and Exhaust Purge Ducts

The ventilation system purge ducts are each equipped with two quick-acting tight-sealing valves (one inside and one outside of the containment) to be used for isolation purposes. The valves are manually opened for containment purging but are automatically closed upon a signal of high containment pressure or high containment radiation level. The space between the valves is pressurized above design pressure while the valves are normally closed during plant operation.

3. Sump Penetrations

The piping penetration in the containment sump area is not of the typical sleeve to liner design. In this case the pipe is welded directly to the base liner. The weld to the liner is shrouded by a test channel which is used to demonstrate the integrity of the liner.

4. Dome Penetration

An opening is located in the dome at the top of the vessel. This opening is for construction ventilation and will be permanently closed at the conclusion of the construction work.

5. Temporary Construction Openings

Temporary construction openings will be provided in positions most suitable for facilitating equipment access. Reinforcement of the liner is necessary in these areas. The opening will be permanently closed after the equipment is in place and before the containment is completed and finally tested.

5.1.4.3 Design of Penetrations

a) Criteria

Penetrations will conform to the applicable sections of ASA N6.2-1965, "Safety Standards 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 shell will conform in all respects to the requirements of ASME Section III Nuclear Vessels Code. The liner is basically not a load carrying member because it is subjected to strains imposed by the reinforced concrete; nevertheless, the liner will be reinforced at each penetration in accordance with the ASME Code Section VIII. The weldments of liner to penetration sleeve will be of sufficient strength to accommodate stress concentrations and will adhere strictly to ASME Code Section VIII requirements for both type and strength. The penetration sleeves and plates are designed to accommodate all loads imposed on them under operating conditions (thermal effects and internal penetrations and test pressures) and accident conditions (loads resulting from all strains, internal pressures, and seismic movements). The sleeves are designed to remain within ASME Code Section VIII stress limitations. Liner reinforcement will be designed to support penetrations in the appropriate portion of liner plate during shop testing, shipping and field erection.

b) Materials

The materials for penetrations including the personnel and equipment access hatches together with the mechanical and electrical penetrations will be carbon steel, will conform with the requirements of the ASME Nuclear Vessels Code and will exhibit ductility and welding characteristics compatible with the main liner material. As required by the Nuclear Vessels Code, the penetration materials shall meet the necessary Charpy V-notch impact values at a temperature 30°F below lowest service metal temperature which is 50°F within containment and -5°F outside of containment. Penetration expansion bellows will be suitably protected against field damage, such protection remaining as part of the permanent installation.

1. Piping Penetrations: Materials

Material Specification for the piping penetration are as follows:

Piping Penetration Material	Specification
Penetration Sleeve - 24" Ø and Under	ASTM - A333, Gr. 0
- Over 24" Ø	ASTM - A516, Gr. 60 to A300
Penetration Reinforcing Rings	ASTM - A442, Gr. 60
Penetration Sleeve Reinforcing	ASTM - A442, Gr. 60
Rolled Shapes	ASTM - A36

2. Electrical Penetrations: Materials

The penetration sleeves to accommodate the electrical penetration assembly cartridges will be Schedule 80 carbon steel in accordance with ASTM-A333, Gr. -0 except where otherwise noted. The electrical cartridges will be secured to the penetration sleeve such that all possible leak paths between the cartridge and sleeve will be blocked by a pressurized zone.

3. Access Penetrations: Materials

The equipment and personnel access hatch material will be as follows:

Item	Material Specification
Equipment Hatch Insert:	ASTM A300, Cl. 1, Firebox A-516, Gr. 60
Equipment Hatch Flanges:	ASTM A300, Cl. 1, Firebox A-516, Gr. 60
Equipment Hatch Head:	ASTM A300, Cl. 1, Firebox A-516, Gr. 60
Personnel Hatch:	ASTM A300, Cl. 1, Firebox A-516, Gr. 60

5.1.4.4 Leak Testing of Penetration Assemblies

A proof test will be applied to each penetration which will pressurize the necessary areas to 54 psig. This pressure will be maintained for a sufficient time to allow soap bubble and Freon sniff tests of all welds and mating surfaces. Any leaks found are to be repaired and retested; this procedure to be repeated until no leaks exists.

5.1.4.5 Construction

The qualification of welding procedures and welders will be in accordance with Section IX, "Welding Qualifications" of the ASME Boiler and Pressure Vessel Code. The repair of defective welds will be in accordance with Para. UW-38 of Section VIII "Unfired Pressure Vessels."

5.1.4.6 Testability of Penetrations and Weld Seams

All penetrations, the personnel air lock and the equipment hatches will be designed with double seals which will be normally pressurized at 50 psig. Individual testing at 115% of containment design pressure is also possible.

The containment ventilation purge ducts will be equipped with double isolation valves and the space between the valves will be permanently piped into the penetration pressurization system. The space can be pressurized to 115% of design pressure when the isolation valves are closed. The valve outside of containment is a conventional butterfly valve which will be leaktight with design pressure inside the containment. The valve inside of containment will be a butterfly valve of an inflatable seat design which will be leaktight with design pressure on either side of the flapper. The gas pressure for inflating the seat will be supplied from the penetration pressurization system or from a second reserve air supply to provide two independent sources of gas pressure. The shaft seals for all purge valves will consist of a double seal with a leak test space between which is permanently piped into the penetration pressurization system. The purge valves will fail in the closed position upon loss of power (electric or air).

All welded joints in the liner shall have steel channels welded over them on the inside of the vessel. During construction, the channel welds shall be tested by means of pressurizing sections with Freon gas and checking for leaks by means of a Freon sniffer. These welds are also then continuously pressurized at 50 psig.

5.1.4.7 Accessibility Criteria

The containment will be completely closed whenever the core is critical or whenever the primary system temperature is above 200°F and the pressure above 300 psig with nuclear fuel in place except as required for brief periods necessary to relieve the containment to keep the pressure below a reasonable level (1-2 psig).

Limited access to the containment through personnel air locks will be possible with the reactor at power or with the primary system at design pressure and temperature at hot shutdown. This type of access would be restricted to the areas external to the reactor equipment compartment, primarily for inspection and maintenance of the air recirculation equipment and the in-core ion chamber drives.

After shutdown, the containment vessel will be purged to reduce the concentration of radioactive gases and airborne particulates. This purge system will be designed to reduce the radioactivity level to doses defined by 10 CFR 20 for a 40-hour occupational work week, within 2-6 hours after plant shutdown. Since negligible fuel defects are expected for this reactor, much less than 1% fuel rod defects used for design, purging of the containment will normally be accomplished in less than 2 hours. To assure removal of particulate matter the purge air will be passed through a high efficiency filter before being released to the atmoshpere through the purge vent.

The primary reactor shield will be designed so that access to the primary equipment would be limited by the activity of the primary system equipment and not the reactor.

5.2 CONTAINMENT SYSTEM STRUCTURE -INSPECTION AND TESTING

Field and operational inspection and testing will be divided into three phases:

a) That taking place during erection of the Containment Building Liner; Construction Tests.

b) That taking place after the Containment Structure is erected and all penetrations are complete and installed; Pre-operational tests.

c) Monitoring during reactor operation; Post-operational tests.

5.2.1 CONSTRUCTION TESTS

During erection of the liner, the following inspection and tests will be performed:

5.2.1.1 Bottom Liner Plates

All liner plate welds will be tested for leak tightness by vacuum box. After completion of a successful leak test, the welds shall be covered by channels. A strength test will be performed by applying 54 psig air pressure to the channels in the zone for a period of 15 minutes.

In addition, the zone of channels shall be held at the 47 psig air pressure using a Freon-air mixture for a period of at least two hours with a drop in pressure not to exceed a pressure equivalent to a leakage of 0.05% of the containment building volume per day. Compensation for change in ambient air temperature will be made if necessary. Testing will be accomplished by use of both soap bubble techniques and halogen leak detectors.

5.2.1.2 Vertical Cylindrical Walls and Dome

Liner plate seam welds in the cylindrical walls and dome will be spot radiographed as follows: For each 50 lineal feet (maximum) of welding by each welder a 12-inch (minimum) radiograph will be made.

The liner plate to plate welds will be tested for leak tightness by vacuum box techniques. After successful completion of the spot radiography and vacuum box tests and subsequent repair of all defects, the channels will be welded in place over all seam welds in a predetermined zone. A strength test will then be performed on the liner plate weld and the channel weld by pressurizing the channel with air at 54 psig for 15 minutes. In addition, each zone of channel covered weld will be leak tested using a Freon-air mixture at 47 psig.

5.2.1.3 Penetrations

Strength and leak tests of individual penetration internals and closures and sleeve weld channels will be performed in a similar manner to the above and all leaks repaired and the penetration or weld channel retested until no further leaks are found.

5.2.2 PRE-OPERATIONAL TESTS

All penetrations and the welds joining these penetrations to the containment liner and the liner seal welds have been designed to provide a double barrier which can be continuously pressurized at a pressure higher than the design pressure of the containment. This blocks all of these potential sources of leakage with a high pressure zone and at the same time provides a means of monitoring the leakage status of the containment which is much more sensitive and accurate than the conventional integrated leak rate test.

After the Containment Building is complete with liner, concrete structures, and all electrical and piping penetrations, equipment hatch and personnel locks in place, the following tests will be performed:

a) Strength Test

A pressure test will be made on the completed building using air at 54 psig. This pressure will be maintained on the building for a period of one hour. During this test measurements and observations will be made to verify the adequacy of the structure design.

b) Gross Leak Rate Tests

The basis for the integrated leak rate tests which will be performed on the completed building at 47 psig will be the reference volume method. This leakage test will be performed with the double penetration and weld channel zones open to the atmosphere. The integrated leak rate to be demonstrated by this test will be equal to or less than 0.1% of the containment free volume per day. After it has been assured that there are no defects remaining from construction, a sensitive leak rate test will be conducted.

c) Sensitive Leak Rate Test

The sensitive leak rate test will include only the volume of the weld channels and double penetrations. Because this volume is about 1000 times smaller than the containment free volume, the sensitivity and accuracy attainable in this leak test is increased correspondingly over that attainable by integrated leak rate testing. The sensitive leak rate test will be conducted with the penetrations and weld channels at 50 psig and with the containment building at atmospheric pressure. The leak rate for the double penetrations and weld channel zones will be equal to or less than 0.2% of the containment free volume per day.

5.2.3 POST-OPERATIONAL TESTS

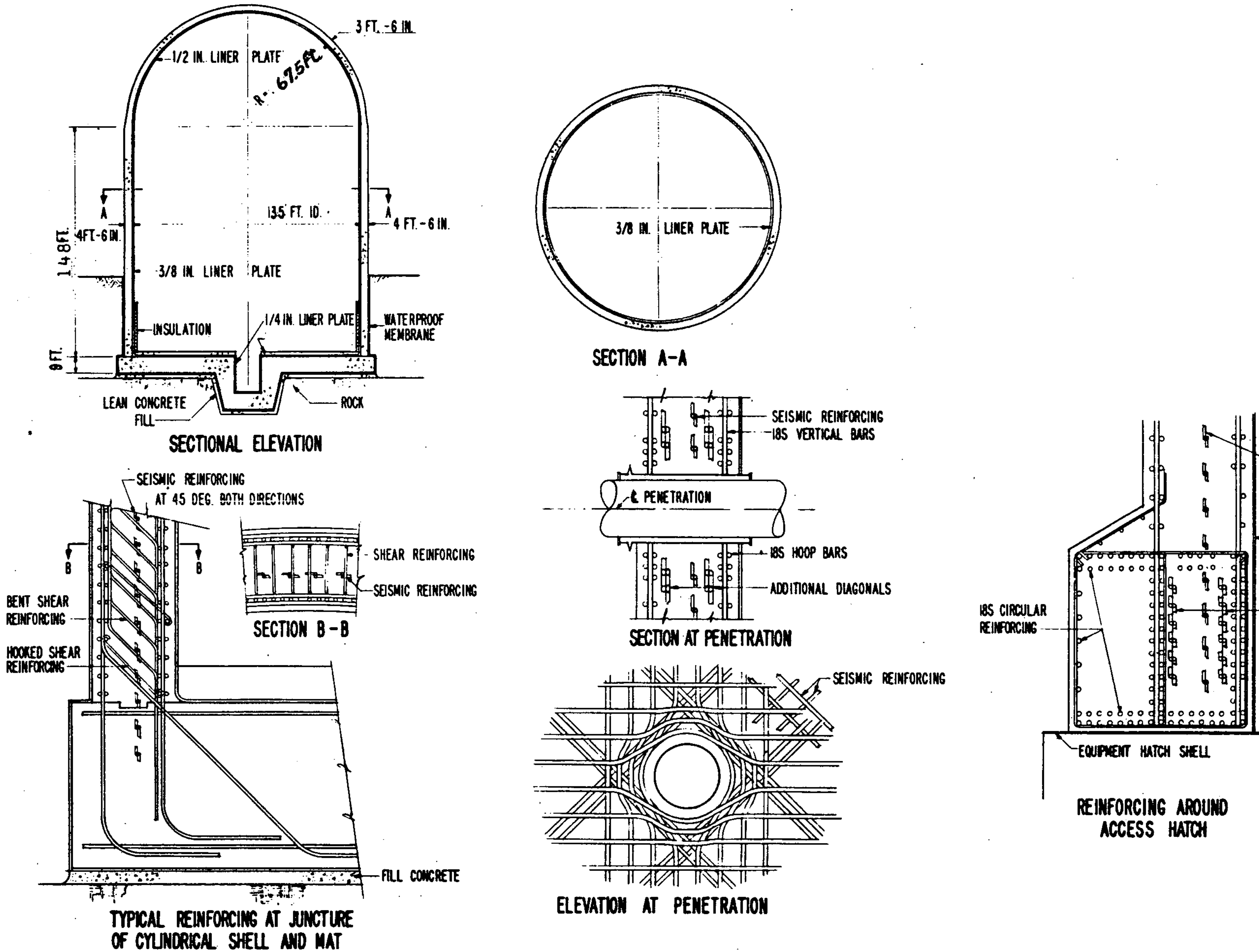
The double penetrations and the weld seam channels which are installed on the inside of the liner in the containment will be continuously pressurized to provide a continuous and very sensitive and accurate means of monitoring their status with respect to leakage. With this provision there is no need to perform integrated leak rate tests of the containment building unless major maintenance or modifications of the containment are made. To allow for this possibility, it will be permissible to pressurize the containment building at 54 psig, after the major modifications have been completed.

REFERENCES

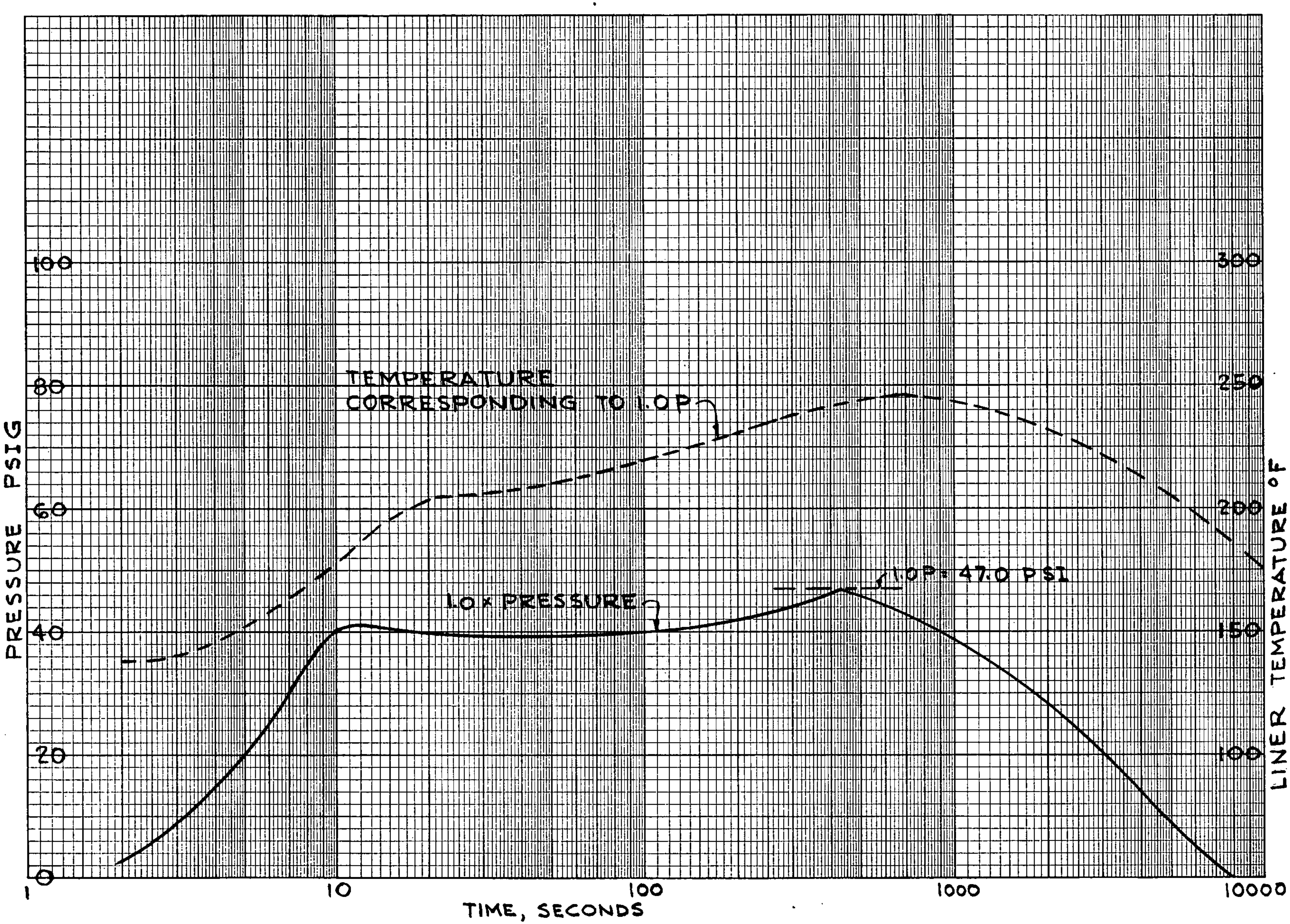
1. United States Atomic Energy Commission - 1963 - Nuclear Reactors and Earthquakes, TID-7024.

2. J. Blume, N. Newmark, L. Corning - Design of Multistory Reinforced Concrete Building for Earthquake Motions - Portland Cement Association - 1961.

CONTAINMENT STRUCTURE

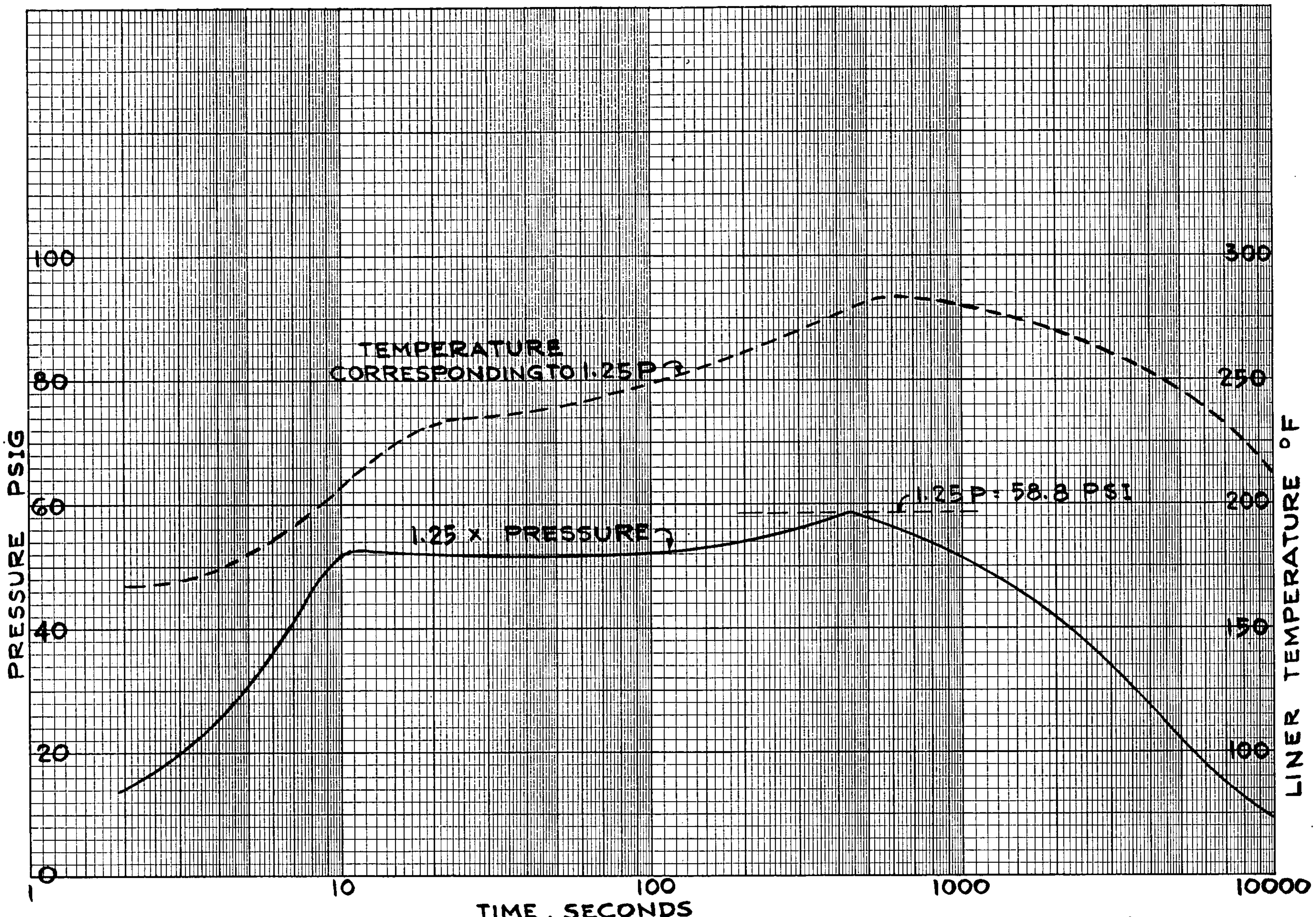


CONTAINMENT STRUCTURE
FIG. 5-1



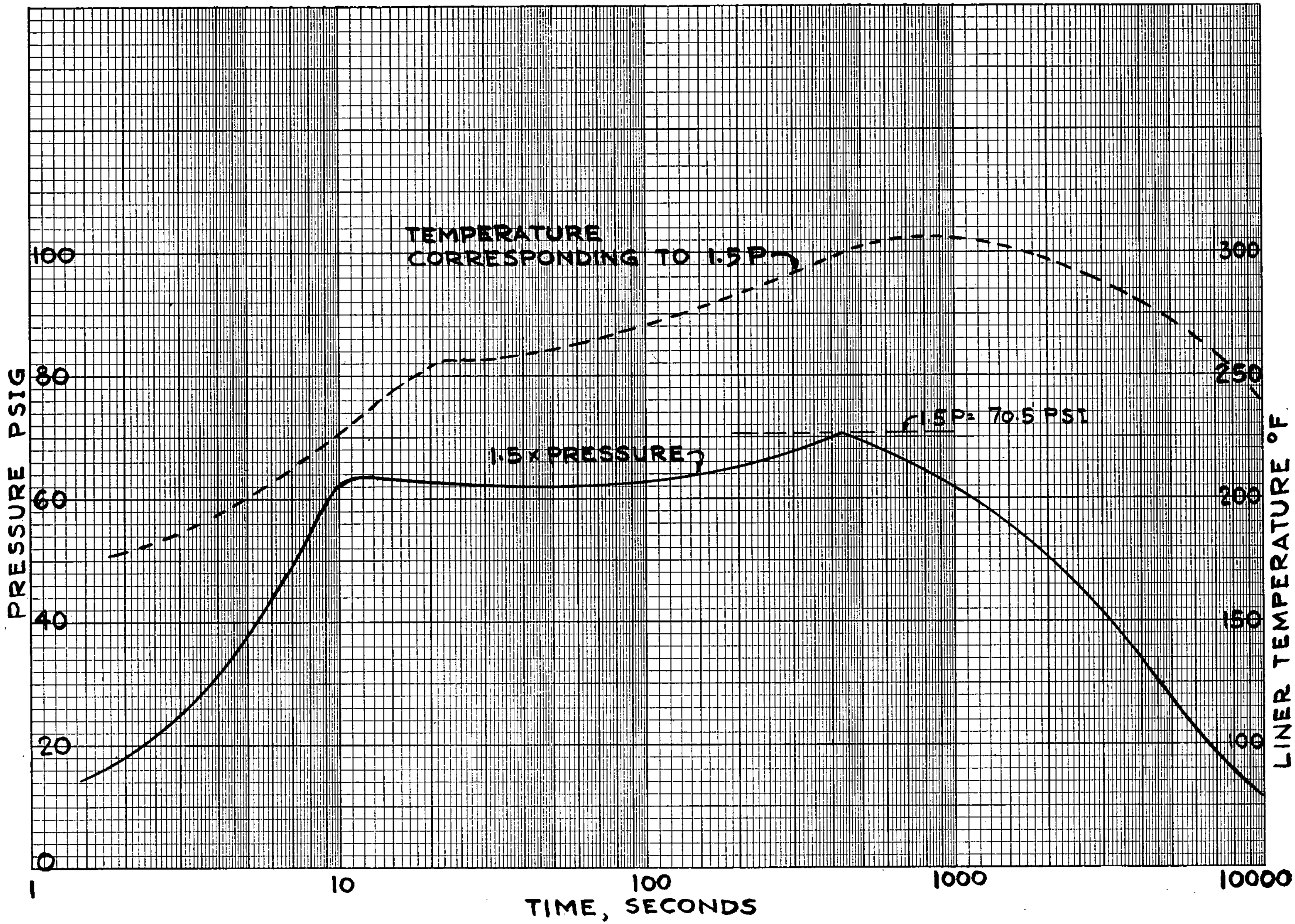
DESIGN PRESSURE-TEMPERATURE TRANSIENT

FIG. 5-2



1.25 TIMES DESIGN PRESSURE-TEMPERATURE TRANSIENT

FIG. 5-3



1.50 TIMES DESIGN PRESSURE-TEMPERATURE TRANSIENT

FIG. 5-4

C= 0.95D +1.5P+1.0(T+TL)

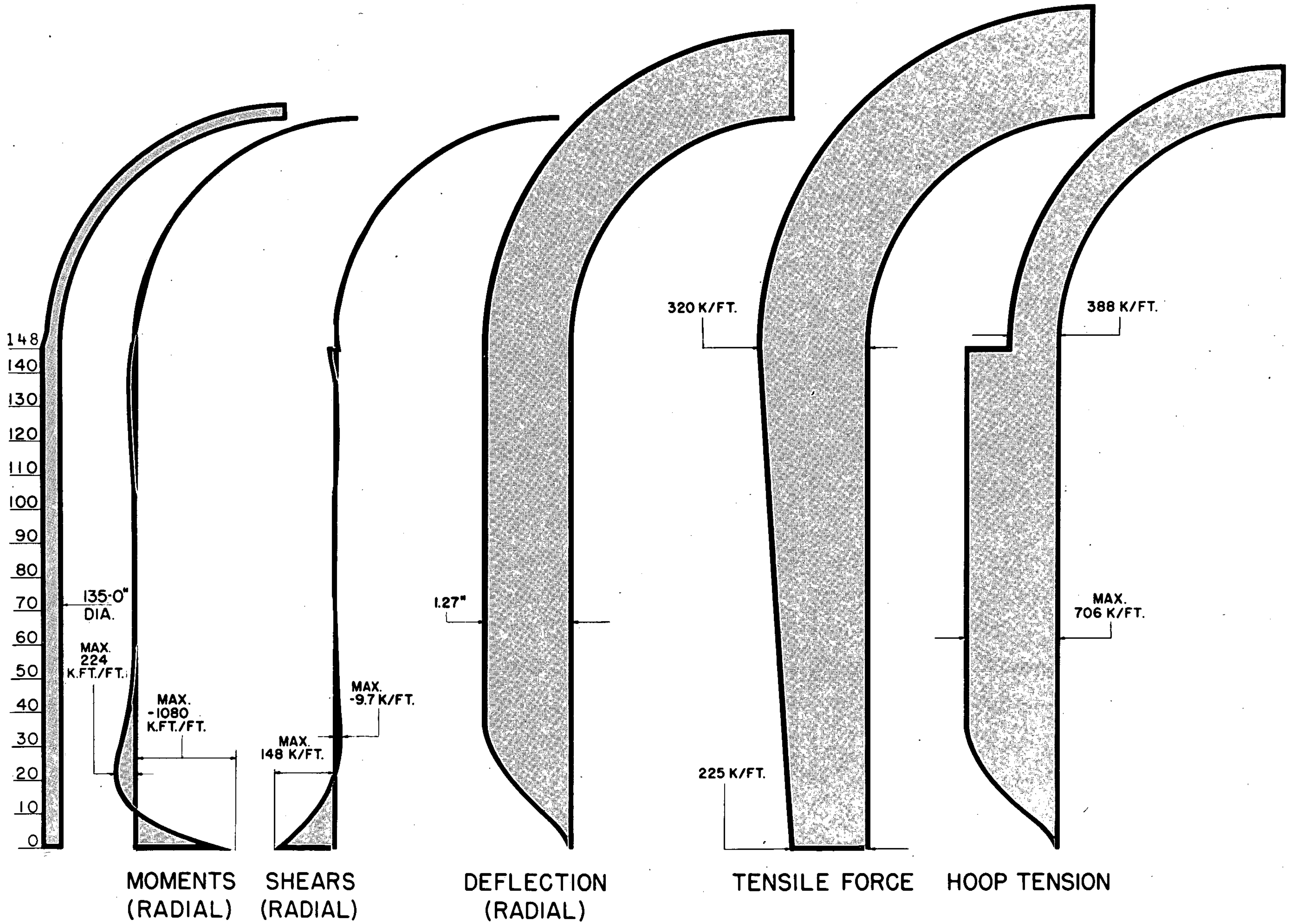


FIG. 5-5

$$C = 0.95D + 1.25P + 1.0(T' + TL') + 1.25E$$

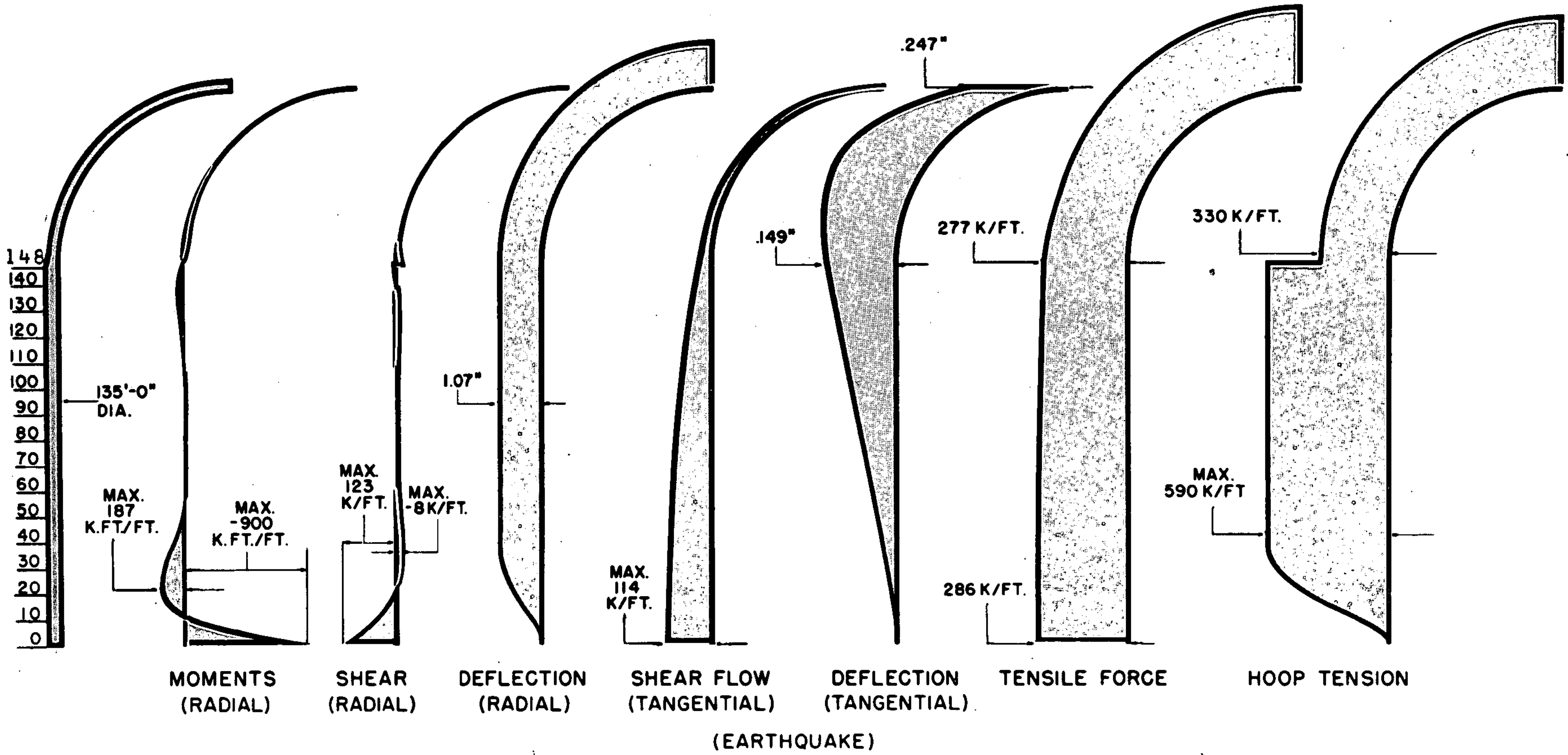
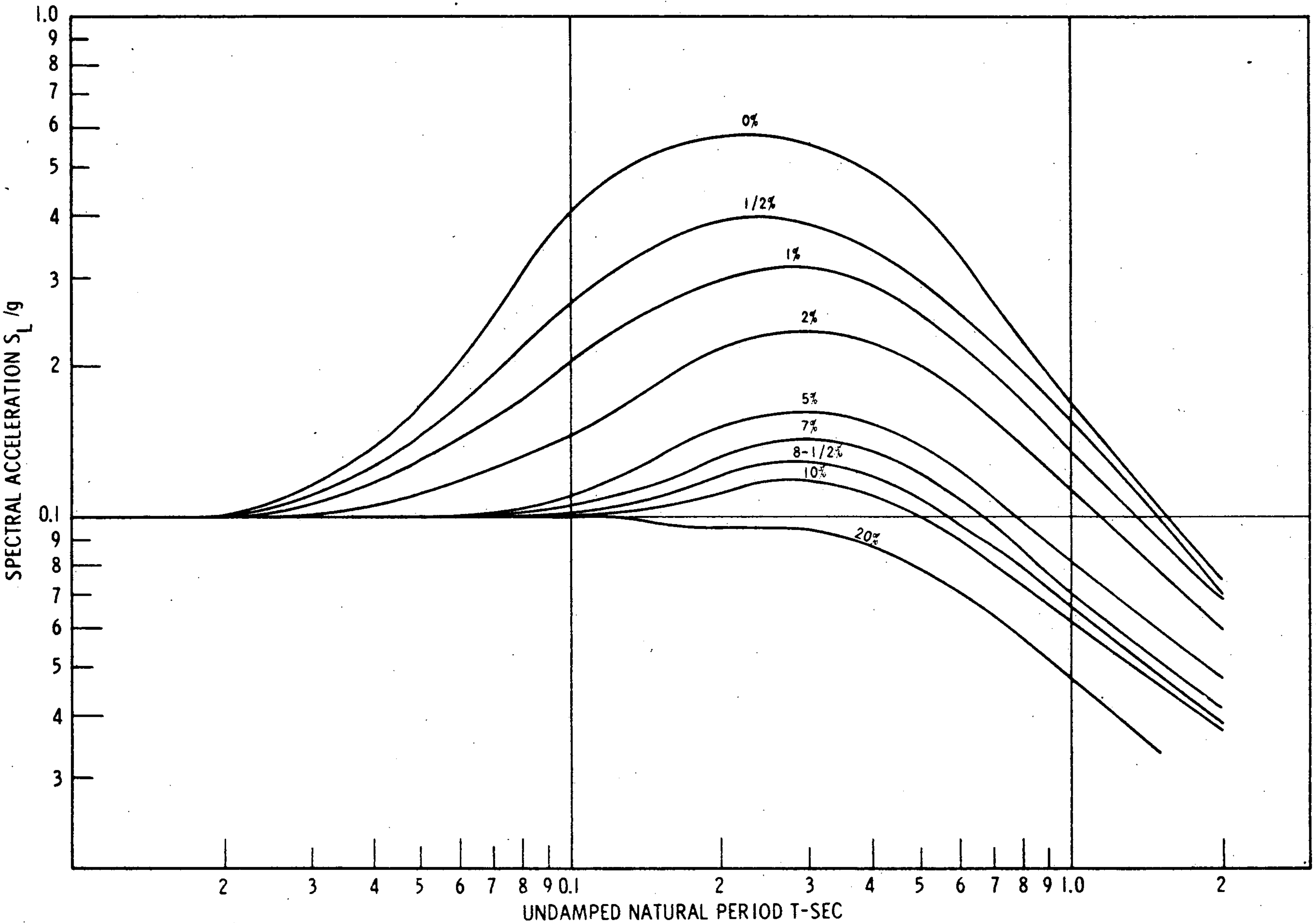
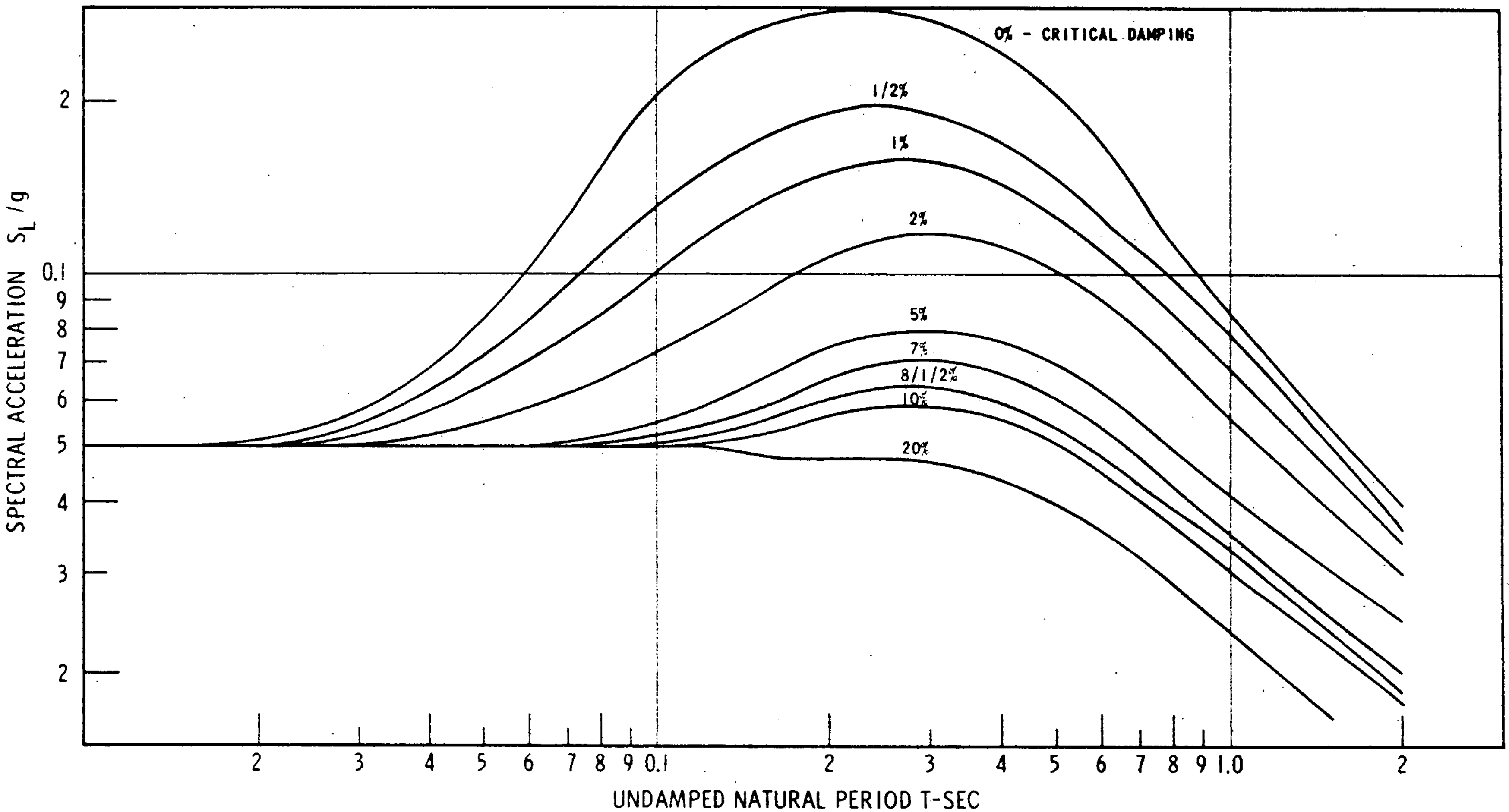


FIG. 5-6

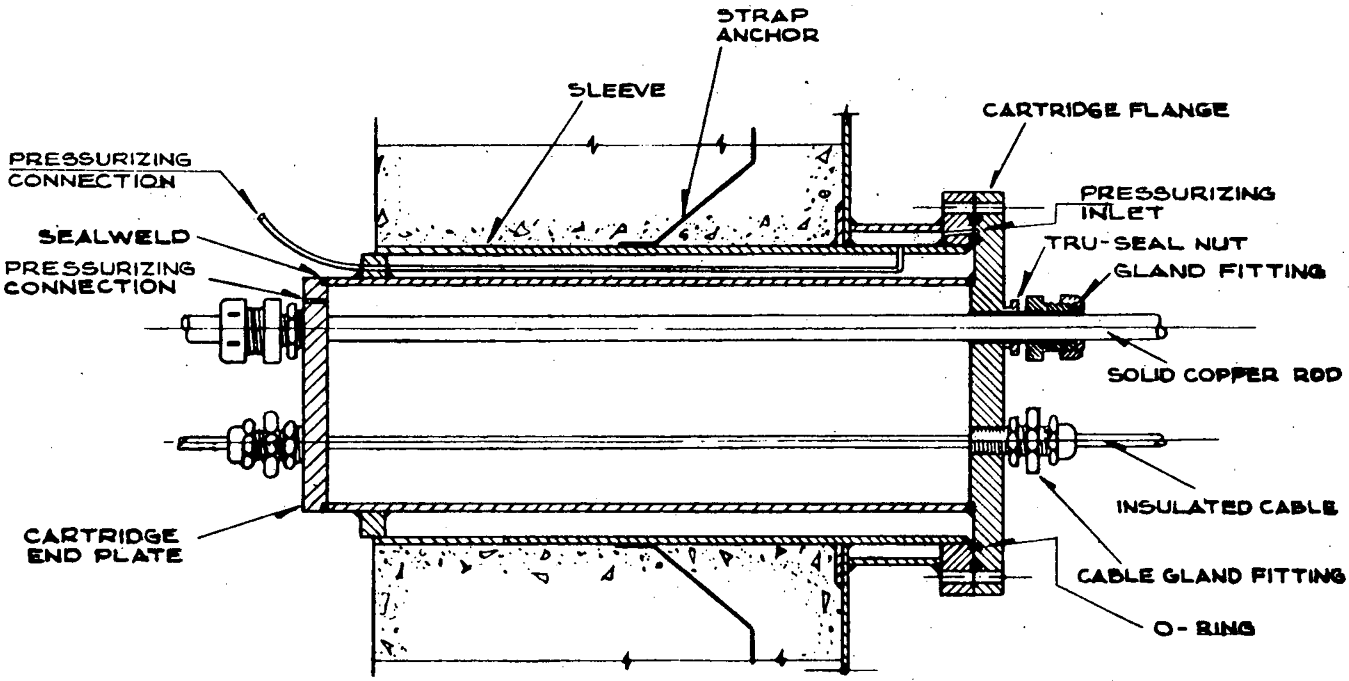


10% OF GRAVITY RESPONSE SPECTRA
FIG. 5-7

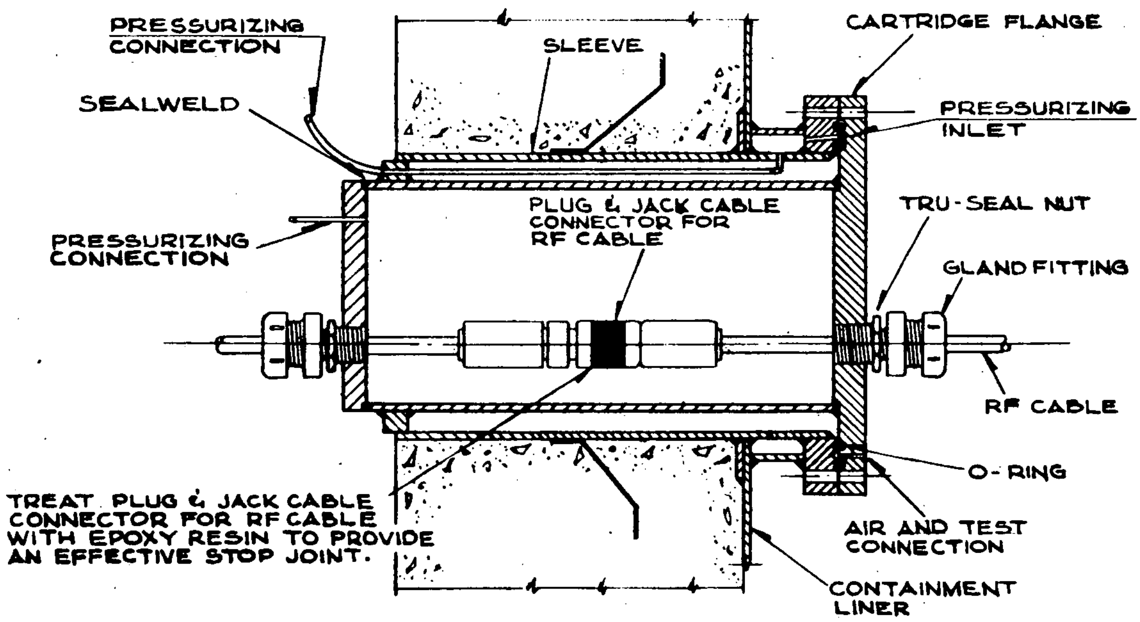


5% OF GRAVITY RESPONSE SPECTRA

5% OF GRAVITY RESPONSE SPECTRA
FIG. 5-8

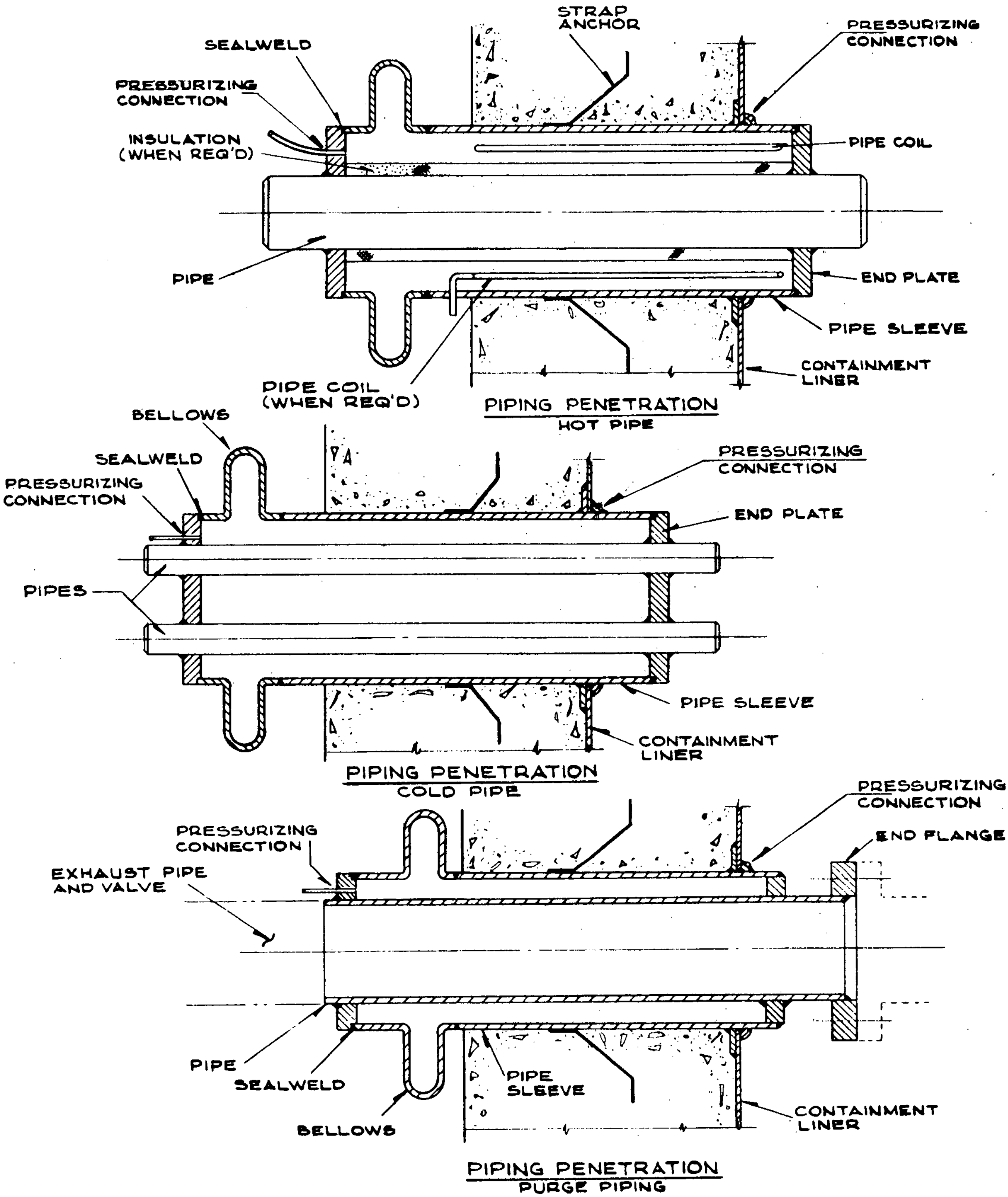


ELECTRICAL PENETRATION
STRAIGHT THROUGH CONDUCTOR

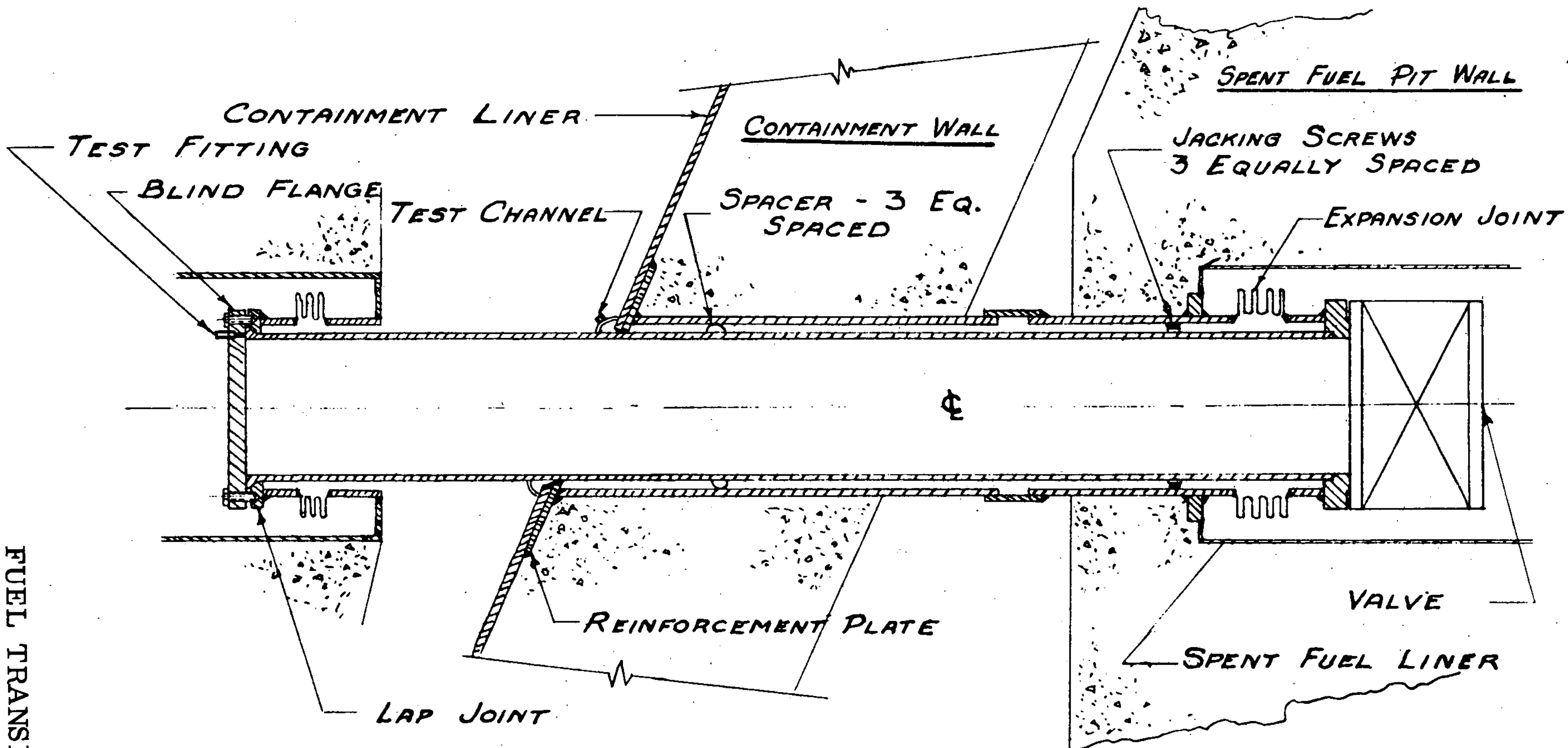


ELECTRICAL PENETRATION
JOINTED CONDUCTOR

TYPICAL ELECTRICAL PENETRATIONS
FIG. 5-9



TYPICAL PIPING PENETRATIONS
FIG. 5-10



FUEL TRANSFER TUBE PENETRATION

(CONCEPTUAL DRAWING)

FUEL TRANSFER TUBE
FIG. 5-11

SECTION 6

PSAR Section	Page	Remarks
6.2	6-3	Listing a) through j) and the following paragraph for the sequential loading of the emergency diesel generators has been superseded by the material in Supplement 1, Item 17 (F - 1.0).
6.2	6-3	Delete the last sentence of the General Description which reads "In addition .... is uninhabitable." and refer to GDC 11 of Supplement 1, Item 1, page 16 for control of the plant if access to the control room is lost.
6.2.1.1	6-3	Further information to supplement the last paragraph on the page on the ECCS design criteria is found in Supplement 1, Item 1, page 58 on GDC 44 as revised in 11/68.
6.2.1.2	6-5	Additional information to item (f) on the ability of the system to withstand a passive failure during recirculation is found in Supplment 1, Item 1, GDC 44 page 59 and in Supplement 5 under Item 1.
6.2.1.3	6-6	In addition to the components of the SIS listed in the second paragraph of the page, the design includes a boric acid injection tank as shown in Supplement 5, Item 1.
6.2.1.4	6-11	Under item (d), number 1, the nomenclature for the containment sump referenced is the recirculation sump as shown in Figure 1 of Item 1, Supplement 5.
6.2.2	6-40	The containment spray system flow diagram has been revised as shown in Figure 1 of Supplement 5 under Item 1. The system has sodium hydroxide as a chemical additive instead of sodium thiosulfate.
6.2.2.2	6-40	Additional information on the system design and operation will be found in Supplements 1 and 5. a) System Operation: Supplement 1, Item 14 (C-5.0-7.0) presents information on the operational design of the containment spray system. The manual actuation for the addition of sodium hydroxide to the spray solution referenced in Item 14 (C-5.0-7.0), page 2 has been revised to be automatic as referenced in Supplement 5, Item 12.

PSAR Section	Page	Remarks
		b) The containment heat removal function of the spray system is described in Item 2 (1 - 8) of Supplement 1 to the PSAR.
		c) The containment spray research and development program is described in Item 4 of Supplement 1 and in Item 6 of Supplement 5 to the PSAR.
		d) The iodine removal function of the spray system is described in Item 14 (C-2.0-4.3) of Supplement 1 to the PSAR.
6.2.2.3	6-43	Item (b) should be deleted and replaced by the sodium hydroxide tank description found on page 3 of Item 14 (C-5.0-7.0) in Supplement 1.
6.2.3	6-43	A diagram of the containment ventilation system is found in Supplement 1 under Item 2(1-6). An additional diagram showing the containment ventilation system along with the primary auxiliary building ventilation system is given in Supplement 5 under Item 2.
6.2.3.2	6-44	The information presented in the last two sentences on this page referring to accident condition operation of the fan cooler units has been superseded by the material presented in Item 14 (C-1.0-1.4) of Supplement 1.
6.2.3.4	6-47	Additional information on the design of the cooling coils is found on page 1 of Item 14 (C-1.0-1.4) of Supplement 1.
		Information on the heat removal effectiveness is found on pages 2 through 12 of Item 14 (C-1.0-1.4) of Supplement 1.
6.2.3.4	6-49	Information on the environmental testing of the fan cooler motors under accident conditions is found in Supplement 7, Question 6 (i).