5.0 CONTAINMENT SYSTEM

This section describes the containment system. Unless otherwise noted, the containment systems for each of the two units are identical therefore, the following description and analysis are equally applicable to either unit.

The ice condenser reactor containment is an improved containment concept involving the very rapid absorption of energy released in the improbable event of a loss-of-coolant incident, by condensing the steam in a low temperature heat sink. This heat sink, located inside the containment, consists of a suitable quantity of borated ice in a cold storage compartment.

The containment system is designed to ensure that acceptable limits for leakage to the environment of radioactive materials are not exceeded even in the improbable event of a gross rupture of a reactor coolant system pipe. In addition, the concrete walls of the containment serve as a biological radiation shield for both normal and accident conditions.

Internal to the containment vessel are several subcompartment areas that are essential to the overall function of containment. One of these areas is the primary shield wall and its reactor cavity. This concrete structure that surrounds the reactor vessel is designed for the following criteria.

1. Provide support for the reactor vessel under the dead weight, seismic, and reactor coolant pipe rupture loading conditions.
2. Attenuate the neutron flux sufficiently to prevent excessive activation of plant compartments.
3. Reduce the residual radiation from the core, reactor internals, and reactor vessel to levels which will permit access to the region between the primary and secondary shields after plant shutdown.

Other structural elements essential to the function of containment are the divider barrier elements. These elements are discussed in Section 5.2.2.4.

The Containment System, together with the engineered safety features (Chapter 6), is designed to limit radiation doses under conditions resulting from the design basis accident (DBA) to less than Regulatory Guide 1.183 and 10 CFR 50.67 criteria at the site boundary and beyond. The DBA is defined as a double-ended rupture of the largest pipe in the reactor coolant system.

The steel-lined, reinforced concrete containment structure, including foundations, access hatches, and penetrations is designed and constructed to maintain full containment integrity when subject to accident temperatures and pressure, and the postulated earthquake conditions. The structure is designed for no loss of function under tornado or accident conditions described in Section 5.2.2. Systems are provided to remove heat from the containment to ensure integrity at the time of the DBA, or any less accident.

5.1 APPLICATION OF DESIGN CRITERIA

The reactor containment system is essential to the protection of the health and safety of the public. Consequently, this containment was designed, fabricated and erected to quality standards that reflect its importance.

Quality standards governing the design, selection of materials, fabrication and inspection of the containment system conform to the applicable provisions of recognized codes and good nuclear practice.

The reinforced concrete structure was designed in accordance with the applicable portions of codes ACI-318-63 and ACI-301-66. The structural steel components were designed in accordance with the American Institute of Steel Construction, AISC-69 specifications. Quality assurance programs, comprising test procedures and acceptance standards used, are identified in Section 5.2.2. The applicability of codes, tests standards and other quality assurance programs, including acceptance criteria, are also discussed in this section.

All components and supporting structures of the reactor containment were designed so that they would sustain no loss of function in the event of maximum conceivable ground acceleration acting in the horizontal and vertical directions simultaneously. The dynamic response of the structure is based on appropriate spectral characteristics of the site foundation. Damping of the foundation and structure was included in the design analysis. Other applicable natural phenomena which were considered in the design were flooding conditions, seiches and tornadoes.

Primary emphasis is directed to minimizing the risk of fire by use of thermal insulation and adhesives which do not support combustion, flame retardant wiring, adequate overload and short circuit protection, and elimination of combustible trim and furnishings. The facility is equipped with fire protection systems for controlling any fires, which might originate in plant equipment.

The Containment and Auxiliary Building Ventilation Systems can be operated from the control room of the corresponding unit, as required, to limit the potential consequences of fire. Critical areas of the containment, the control room and the areas containing components of engineered safety features, have detectors to alert the control room to the possibility of fire, so that prompt action may be taken to prevent significant damage.

The support features of all Class I equipment were designed to remain within allowable stress limits with Normal plus DBE seismic loads acting on the equipment.

Restraints for Mechanical Class I equipment located inside the containment building have been designed to remain within allowable stress limits during the blowdown postulated to occur by rupture of the largest line attached to the item.

Tornado loads are not relevant to the design of this equipment as all Class I buildings are themselves designed to withstand the tornado and any missiles it may generate.

The tornado can, however, result in reduction of ambient pressure within these structures. Slight variations in this ambient pressure may produce "drafts" in the buildings. Nevertheless, loading from this phenomenon would certainly be insignificant compared to the seismic loading and, as such, was not factored into the design of supports.

Class I equipment outside of the containment was not designed to withstand jet forces arising from failures of piping constituting part of the same train. A failure of this type was assumed to result in loss of the affected train. Class I equipment within the Auxiliary, Turbine and Screenhouse Buildings have generally been located such that equipment associated with each train is segregated in separate enclosures.

Generally, only that piping constituting part of the same train is routed through a given area. Class I equipment is protected such that a postulated break in a high energy line will not adversely affect the operability of both trains of safety related equipment.

The spectrum of missiles considered for the D.C. Cook Nuclear Plant is indicated in Table 5.1-1.

The applicable portions of the missile protection criteria as stated in Section 1.4 apply to Class I structures and equipment in this chapter.

5.2 APPLICATION OF DESIGN CRITERIA TO THE CONTAINMENT STRUCTURE

The following loads were considered in computing the required structural load capacity for the design of the containment.

a. The maximum credible energy release is based on pipe rupture in sizes up to, and including, a double-ended severance in a reactor coolant pipe.

b. Additional energy release is determined on the basis of the following sources:

   1. Stored heat from reactor core structural members
   2. Stored heat in the reactor vessel piping and other Reactor Coolant System components
   3. Core residual heat production
   4. An additional undefined energy margin of 50 x 106 Btu.

c. In addition to the pressure and temperature conditions resulting from the above conditions, the following loadings also are considered in the design of the containment:

   1. Structural dead load
   2. Live loads
   3. Equipment loads
   4. Internal test pressure
   5. Earthquake
   6. Wind, tornado and related missiles
   7. Uplift due to buoyant forces
   8. Internal negative pressure
   9. Dynamic effects resulting from plant equipment failures.

d. Post-accident pressure effects are determined by evaluating various malfunctions of emergency systems.

e. Pressure and temperature loadings are obtained by analyzing various loss-of-coolant accidents.

Isolation valves are supported to withstand, without impairment of valve operability, loadings including those from maximum potential seismic conditions.

The Ice Condenser is designed to absorb the energy released in a loss-of-coolant accident. Sufficient ice is included to absorb the energy released in a rupture of the largest reactor coolant pipe and, in conjunction with the other engineered safety features, maintain the containment pressure below design values. A discussion of the design bases of the other engineered safety features is included in Chapter 6.

A comprehensive program of testing was formulated for all elements vital to the functioning of the ice condenser. The program included performance tests of the ice condenser and door panels under actual coolant energy release conditions in the ice condenser full-scale section test facility. The program also includes inspection and testing of the installed ice condenser before and after the initial ice loading prior to initial plant startup, and inspections and testing throughout the plant operating lifetime.

The ice condenser has no active components important to fulfillment of its safety function and thus is not susceptible to failure of active components and the resulting consideration of additional capability to accommodate failures.

In any case, the ice condenser does have an excess of capability for both rate and quantity of energy released from the Reactor Coolant System. The door panels located at the inlet and outlet of the ice condenser are the only elements required to move during the accident. These items are considered as passive or static elements equivalent to rupture discs rather than active components requiring an external signal and energy source to function.

The ice condenser design includes suitable provision for visual inspections of the ice beds flow channels, door panels, and cooling equipment. The discussion of inspection for other containment pressure reducing systems is presented in Chapter 6.

The ice condenser is a completely static engineered safety feature containing no active components required to function during an accident condition. However, provision is made for periodic testing of elements of the ice condenser including door panels, inspection of the ice beds, and sampling of the ice.

The containment liner is enclosed within the containment and thus is not directly exposed to the temperature of the environs. The containment ambient temperature during operation is between 60 and 120°F, and the ice bed operating temperature is approximately 10-20°F, which is above the NDTT (Nil Ductility Transition Temperature) + 30°F for the liner material. Containment penetrations which are exposed to the environment are also designed to the NDTT + 30°F criterion.

The preoperational leak rate tests included an integrated leak rate test of the containment and a sensitive leak rate test of the penetrations and weld channels. The leak rate test is an integrated leak test at design pressure to verify that the structure leaks less than the allowable value. The sensitive leak rate test was performed by pressurizing the double penetrations at slightly above design pressure. This test was conducted with the containment at atmospheric pressure. These tests demonstrate the integrity of the double leakage barriers provided by the penetrations and the overall integrity of the containment. The preoperational leak tests of each unit containment demonstrated that the integrated leak rates were less than the leakage allowable ("La").

5.2.2 Containment System Structure Design

The general arrangement of the Ice Condenser Reactor Containment is shown on Figure 5.2.2-1 and 5.2.2-1A (Cross sections) and Figures 5.2.2-2 and 5.2.2-2A (Elevations).

The containment is divided into three main compartments. These are:

- The lower compartment.
- The upper compartment.
- The ice condenser compartment.

The lower compartment encloses the reactor system and associated auxiliary systems equipment. The upper compartment contains the refueling cavity, refueling equipment and polar crane used during refueling and maintenance operations. The upper and lower compartments are separated by a divider barrier. The ice condenser, which contains borated ice provided to absorb the loss-of-coolant accident energy, is in the form of an enclosed and refrigerated annular compartment, located circumferentially between the crane wall and the outer wall of the containment and extends from below to above the operating deck.

The reactor containment structure is a reinforced concrete vertical right cylinder with a slab base and a hemispherical dome. A welded steel liner with a nominal thickness of 3/8" at the dome and wall, and 1/4" at the bottom is attached to the inside face of the concrete shell, to insure a high degree of leak tightness. The containment structure is designed to contain the radioactive material, which might be released, following a loss-of-coolant accident. The structure serves as both a biological shield and a pressure container.

The structure as shown in Figure 5.2.2-3 consists of side walls measuring 113 ft (nominal) in height from the liner on the base to the spring line of the dome and has a nominal inside diameter of 115 ft. The thickness of the cylinder is 3 ft - 6 in and the thickness of the dome is 3 ft - 6 in at the spring line tapering uniformly to 2 ft - 6 in at the peak of the dome. The base mat consists of a 10 ft thick structural concrete slab, increasing to 20 ft adjacent to the recirculation sump area.

Figures 5.2.2-4, 5.2.2-4A, 5.2.2-4B indicate the typical re-bar pattern for the containment building side walls and dome.

In general the reinforcing consists of meridional and hoop reinforcing in both faces of the wall and dome. Radial shear reinforcing is provided where required. At the base of the containment wall, for a distance of ten (10) ft. above the base mat, inclined radial shear bars are provided. The bars are anchored by bond in the compression face of the wall and by hooking around the wall hoop reinforcing in the tension face of the wall.

Radial shear bars are not anchored by bond in regions of bi-axial tension.

Additionally tangential reinforcing was placed, in both faces of the containment side wall, inclined at an angle of 45^o to each side of a vertical such that the reinforcing runs diagonally up from the base slab to the right and to the left of the vertical in each face.

Where diagonal rebar was cut by an opening, additional #11 diagonals at 25" spacing were placed on the sides of the opening to compensate for those cut short by the opening; they are greater in number than those cut-off and extend approximately 10 ft. beyond the diameter of the opening at each end, to insure adequate anchorage.

The combination of vertical, horizontal and diagonally sloping bars places rebars across any potential crack plane.

The base slab reinforcing consists of circumferential and radially oriented re-bars.

The basic structural elements considered in the design of the containment structure are the base slab, the vertical cylinder and the hemispherical dome, all acting as one structure. The vertical cylindrical wall and the dome of the steel liner are anchored to the concrete by means of horizontal and vertical stiffener angles. In addition, Nelson studs welded to the stiffener angles extend into the concrete and are anchored behind the first layer of reinforcing, thereby preventing pull-out in case of local concrete cracking. The steel base liner is anchored to the concrete by welding it to continuous steel tee bars which in turn are welded to structural members anchored into the base mat. The base liner is covered by a 2 ft - 0 in. concrete mat.

The underground portion of the containment vessel is waterproofed in order to prevent possible corrosion of the reinforcing steel and liner plate due to seepage of ground water.

The waterproofing consists of a continuous impervious membrane, which is placed under the mat, and on the outside of the walls. The membrane placed under the mat extends up and around the walls and is taped to the membrane placed on the outside of the walls, thus providing a continuous waterproof surface.

The containment structure is inherently safe with regards to common hazards such as fire, flood and electrical storm. The concrete walls are invulnerable to fire, a minimum amount of combustible material, such as lubricating oil in the pump and motor bearings, is present in the containment. A system of lightning rods is installed on the containment dome as protection against electrical storm damage. The dead weight of the structure is a minimum of ten times the buoyancy force that may be exerted on the structure when the ground water table is two feet below grade.

5.2.2.1 Foundations

The general excavation scheme, dewatering scheme and foundation design was developed utilizing the data and data interpretation included in reports by A. & L. Casagrande.

- "Report on Foundation Investigation for Donald C. Cook Nuclear Power Plant", 2/20/68
- "Donald C. Cook Nuclear Power Plant Settlement Analyses of Containment Units Based on Investigation of Undisturbed Samples from Boring No. 105", 5/4/68
- "Report on Foundation Investigations for the Donald C. Cook Nuclear Power Plant", 8/6/68
- "Supplement to Report of August, 1968 on Report on Foundation Investigation for the Donald C. Cook Nuclear Power Plan", 4/69

The containment areas as well as the remainder of the plant areas were excavated to elevation 588'. The dewatering system which consisted of eductor wells was installed around the entire periphery of the general plant site excavation and the ground water level was lowered to the top of the clay stratum, approximately elevation 558'. The containment areas were then excavated to Elevation 583'-4".

In order to avoid disturbing the dense sand stratum beneath the containment base mat during excavation of the reactor pit, soldier piles were driven down to the clay stratum around the periphery of the reactor pit. Once these soldier piles were installed, the dense sand at elevation 583'4" was compacted with a vibratory compactor. This compaction was necessary due to disturbance of the top foot of this sand during the excavation phase of the work. The containment sub-slabs were formed and poured with the soldier piles being tied back to these sub-slabs with anchor rods.

Upon completion of the containment sub-slabs, the reactor pit was excavated and 1/4" steel plates were welded to the soldier piles to prevent the sand from sloughing into the excavation from beneath the sub-slab. Some sand did slough in during the excavation and plate installation creating a void behind the plates in some areas. These voids were filled by pressure grouting after concrete work was completed within the reactor pit.

The containment structures were constructed on mat foundations founded directly on the dense beach sands. These sands were studied in detail to determine their susceptibility to liquefaction under the maximum design earthquake. The relative densities of these sands were found to be in the range of values, which are not susceptible to liquefaction. The supporting data for this conclusion is contained in Appendix G of the Original FSAR. In addition, a complete settlement analysis was conducted to determine the anticipated total and differential settlement between major structures, the major portion of these settlements taking place during the construction period. Computed differential settlement does not exceed one (1) inch. The supporting data and detailed analysis is contained in the A. & L. Casagrande Report on the Foundation Investigations, August 26, 1968, page G-26, Item 3.

In order to monitor settlements of the containment structures, three permanent benchmarks were installed through each containment base slab 120 degrees apart and were positioned such that they are outside the containment building. These benchmarks extend to bedrock and are equipped with extensometers, which indicate directly the amount of settlement of the containment slabs. The installation is monitored at regular intervals to substantiate the conclusion of the settlement analysis. The monitoring has confirmed the predictions of the settlement analysis and the settlement activity has virtually ceased. The periodic monitoring was discontinued in 1981.

With the exception of the Class I Tanks, all remaining Class I Structures were handled in a manner similar to the containment structures, e.g., soldier piles were driven, excavation progressed with the installation of steel plates, sub-slabs were installed at the bottom of the excavation. Pressure grouting was also performed behind these plates to fill the small voids, which developed as a result of sloughing of the sand.

The Class I Tanks were founded on compacted backfill. The areas were first excavated down to the dense beach sands and then brought back to foundation grade with controlled compacted backfill.

The Underground area of the auxiliary and containment buildings have been waterproofed by means of a PVC 40 mil thick membrane. This membrane extends at least 5 feet above the maximum known GW level. The water-proofing used provides adequate protection against flooding of areas located below the highest GW level.

Underground structures such as tunnels have been designed to articulate. Where underground structures join main facilities the joint has been made non-moment resisting. The stress criteria used in evaluating the underground structure design is the same as that used in other class I structures. Typical design sketch of connections are shown in Figure 5.2.2-5.

The estimated potential static differential settlement after connection of inter-linking mechanical and electrical elements between the Containment Structure and the Auxiliary Building is 0.2" and between the Auxiliary Building and the Turbine Building is 0.1". This estimate was based on an assumption that 75% of the total settlement of the structure occurs during the construction phase.

There are no direct interconnecting building structural elements between the Auxiliary Building and the Containment Structure, nor between the Auxiliary Building and the Turbine Building. The interconnecting element between the Auxiliary Building and the Diesel (switchgear) Building exists only at the foundation slab elevation. Structural integrity of this joint is not required and the design of the structure has not considered that this particular joint is a necessity for the safety of the plant.

The magnitudes of dynamic motions are indicated in Tables 5.2-6 & 5.2-7 and Figs. 5.2.2-6 through 5.2.2-6D.

Since there are no direct interconnecting structural elements between the structures, and since as indicated in Figs. 5.2.2-6A through 5.2.2-6D, there is sufficient rattle-space provided between the structures, the dynamic differential motions as well as the static differential settlements pose no problem to the safety of the plant.

Following a seismic event, we may expect that the entire horizontal differential displacement might remain, however, we would expect to see some recovery of the dynamic vertical displacements.

The mechanical and electrical interconnecting elements between the various structures have been designed with consideration given to the effects of static and dynamic differential movements.

5.2.2.2 Design Load Criteria

The following loads are considered in computing the required structural loading capacity used in the design of the containment:

1. **Loss-of-Coolant Accident Loads**

   Pressure and temperature loads based on the maximum credible energy release resulting from a double ended rupture of the largest reactor coolant pipe. Pressure and temperature loadings are also considered for various smaller loss-of-coolant accidents.

   Additional energy release is added to that developed by coolant blowdown determined on the basis of the following sources:

   a. Stored heat from the reactor core structural members.

   b. Stored heat in the reactor vessel piping and other reactor coolant system components.

   c. Core residual heat production.

   d. An additional undefined energy margin of 50 x 106 Btu.

   Post-accident pressures and temperatures are determined assuming various active failures within emergency systems. Among the malfunctions considered are:

   a. Failure of one diesel generator.

   b. Failure of one element of an engineered safety system.

   The design considered the effects of internal pressure and liner temperature during the maximum loss-of-coolant accident and their variation with time as presented in Chapter 14. The containment design pressure is 12 psig.

   The thermal stresses due to internal temperature increase caused by a loss-of-coolant accident were considered. The lower region liner is evaluated at the increased temperatures of 244°F, 250°F and 256°F which correspond to the saturation temperature of pure steam at 1.0 P, 1.25 P and 1.5 P conditions respectively. The upper region liner is evaluated at temperatures of 196°F, 208°F, and 220°F, which correspond to steam air mixture saturation temperature at 1.0 P, 1.25 and 1.5 P conditions respectively.

   The containment wall sustains maximum unsymmetrical pressure loading of 14.8 psi, at each end wall area of the ice condenser lower plenum. These areas are represented by

Transient Mass Distribution (TMD) Nodes 40 and 45 (refer to Section 14.3.4.2.7.2 of U1 UFSAR). Refer to factored load equation (g), Section 5.2.2.3.

The 14.8 psi unsymmetrical pressure loading results from the double-ended loss of coolant accident and refers to the ice condenser compartment during the period of pressurization of the upper compartment, and represents a difference of pressure across the containment shell adjacent to the ice condenser compartment.

The 14.8 psi represents the resistance of the ice condenser internal structure to the passage of the lower volume steam around the ice baskets.

The 14.8 psi pressure has been considered in our analysis to peak near the bottom of the ice condenser, just above the inlet doors; with the pressure profile diminishing with height until it reduces to the upper volume pressure at the top of the ice condenser compartment. The analysis also considers the azimuthal reduction in pressure that occurs between the end walls of the ice condenser, within the ice condenser region.

2. **Steam Line Break Accident**

Pressure and temperature loads based on the maximum credible energy release resulting from double ended rupture of a main steam pipe.

Post-accident pressures and temperatures are determined assuming various active failures of emergency systems as in (1) above.

Also considered for the containment vessel and liner, is a local high pressure in the Fan Accumulator room of 16 psig (load combination (i) Section 5.2.2.3).

The 16 psig design pressure is due to an energy release caused by a main steam line break in the fan-accumulator room and is the instantaneous peak pressure in that room.

The maximum possible containment wall deformation, based on the assumption of a fully cracked concrete section, due to factored loading combination (i), is 0.71 inches outward, as shown in Figures 5.2.2-7 and 5.2.2-8.

The specific amount due to the factored instantaneous peak pressure of 24 psi in the fan-accumulator room is 0.59 inches, the corresponding rebar meridional strain is .0003, and hoop strain .00064.

This pressure of 24 psi is one and a half times the design pressure of 16 psi which itself includes additional margin over the actual calculated peak pressure of 15.40 psi.

Despite the increased pressure load due to factoring, the resulting values for the deformation and strains are still insignificantly small.

The pipe restraints provided to preclude undue localized damage to equipment, and excessive structural deformations are depicted in Figure 5.2.2-9.

3. **Structural Dead Loads**

Structural dead load consists of the weight of the concrete wall, hemispherical dome, liner, ice and ice condenser material, base slab and internal concrete. Weights used for dead load calculations are as follows:

a. Concrete - 145 lbs per ft3
b. Reinforcing Steel - 489 lbs per ft3 using nominal cross-sectional areas in reinforcing as defined in ASTM A615 for bar sizes.
c. Steel Liner - 489 lbs per ft3 nominal cross-sectional area.

4. **Live Loads**

Live load consists of snow and construction loads on the dome and the weight of major components of equipment within the containment. Snow and ice loads are applied to the top surface of the dome at an estimated value of 20 lbs per ft^2 of horizontal projection of the dome. This loading represents approximately two feet of snow. A construction live load of 50 lbs per ft^2 was used on the dome but not considered to act concurrently with snow load.

5. **Equipment Loads**

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

6. **Internal Test Pressure**

To test the structural integrity of the vessel an internal pressure of 134 percent of design pressure was applied under controlled conditions.

7. **Earthquake**

Earthquake loading is predicted upon an operating earthquake at the site and a design earthquake of greater intensity.

These earthquakes have a zero period horizontal ground acceleration of 0.10 g, and 0.20 g, respectively. Dynamic analysis is used to arrive at the equivalent design loads. A vertical component two-thirds of the magnitude of the horizontal component is applied simultaneously. The torsional effects on the Class I structures due to earthquake loading have been considered in the design of the structure.

Ductility of the concrete structures has been achieved by maintaining a low ratio of concrete stress to rebar stress.

Factored load combinations (d) and (g) (Section 5.2.2.3) cause the maximum tensile stress (30,500 psi) in the rebars, which is well within the allowable limit of Øfy = (36000 psi). The maximum compressive stress (400 psi) in the concrete is much less than the allowable limit of 0.85 Øf'c = (2680 psi).

In all areas of the containment structure meridional and hoop reinforcing are provided in both faces of the containment shell. The presence of compression rebars, although not needed for stress requirements, effectively reduces the compression strain in the structure, increasing the ductility.

As noted in Section 5.2.2, tangential reinforcing is provided in each face of the containment shell. Tangential shear forces due to earthquake, transient unsymmetrical pressures and transient unsymmetrical thermal loading are resisted by the diagonal rebar and the concrete.

All rebar are designed and properly anchored in the manner required under "ACI Code" proposed 1970 revision, "Appendix A," "Special Provisions for Seismic Design."

The auxiliary building is a "shear structure" and even though moment resisting concrete frames were not used to resist lateral loading, the details recommended by Blume, Newmark and Corning in "Design of Multistory Reinforced Concrete Buildings for Earthquake Motions" was followed.

It was assumed in the design of all reinforced concrete structures that concrete sections in tension were cracked and that the rebars take the entire tensile load.

8. **Wind and Tornado**

Wind loading for the containment structure is based on ASCE Paper 3269 "Wind Forces on Structures".* The "fastest mile of wind" for a 100 year period of recurrence for the site is 90 mph at 30 feet above the ground. Considering the site to be a coastal area, this results in the wind velocities and velocity pressures given in Table 5.2-1.

The structure is analyzed for tornado loading not coincident with accident or earthquake loads. Tornado wind velocity is converted to a velocity pressure in accordance with ASCE Paper 3269 "Wind Forces on Structures" and distributed in accordance with Table 4(f) in Paper 3269.

Gusting is not considered and there is no variation of wind velocity with height, for the height of the structure.

The tornado model considered is one with a "funnel" forward progression of 60 mph and a maximum peripheral tangential velocity of the wind "funnel" of 300 mph. A coincident pressure drop of 3 psi is considered to occur.

The containment structure is analyzed considering:

a. A large diameter "funnel" tornado with a distribution of maximum tangential velocity in a band at least 130' in width and 180' in height such that the full effects of the band are felt by the structure. The maximum tangential velocity is considered additive to the forward progression, so that the maximum wind velocity is considered to be 360 mph. This results in a tornado velocity pressure (at one atmosphere) of 330 psf, which is evaluated with an internal positive pressure of 3 psi.

b. To determine the effects of a non-uniform pressure distribution, a narrow diameter "funnel" tornado is assumed to pass directly over the structure, such that the center of the "funnel" is aligned with the center line of the containment structure. The maximum tangential velocity is considered additive to the forward progression in the right leading quadrant and subtractive in the left trailing quadrant, so that the maximum wind velocities are 360 mph and 240 mph respectively. Tornado velocity pressures are evaluated with an internal positive pressure of 3 psi. This type of pressure diagram results in smaller internal forces in the containment structure than the wide band distribution. Torsional stresses in

* "Wind forces on structures" paper No. 3269 Publ. by American Society of Civil Engineers Reprinted 1962

the containment structure due to tornado loading, were determined to be negligible.

Wind loads are distributed on the containment structure in accordance with ASCE Procedure Paper 3269.

Additionally a study was made to determine the funneling effect due to the closeness of the two containment structures.

The non-uniform pressure distribution over the containment as related to the conditions in this case were found in technical literature* and plotted on a circular graph.

The suction on the containment walls that face each other was found to be greater than that on the walls that face away from the line of symmetry of the two containments. The greatest local increase in suction due to the funneling effect is about 15%. The pressures on the windward and leeward sides were practically unchanged by the funneling effect. The 15% increase of suction was not significant enough to justify a revision of the analysis performed for symmetrical loading.

This procedure was repeated for several fictitious spacings between the two shells and the most critical results were plotted on the circular graphs (Figs. 5.2.2-10 and 5.2.2-10A). Two pressure curves were plotted on each graph. The first curve shows pressure distribution as per ASCE Paper #3269 "Wind Forces on Structures". The second curve shows pressure distribution according to the French Wind Code.

The no funneling effect analysis in the French Wind Code document and the ASCE Paper #3269 were not in agreement, and a proportional correction factor was applied to the "French Code Values" at each point in order to compensate for this discrepancy.

In designing the auxiliary building, no consideration was given to the influence of the size of the tornado funnel and the effects of the resulting non-uniform pressure distribution. Neither was the potential increase in the tornado forces that could result from the funneling effect created by the two adjacent reactor containment buildings considered in the design.

The exterior concrete walls from grade were designed to resist the full combined effects of rotational and translational tornado velocities for positive wind pressure and the combined effects of rotational and translational tornado velocities in conjunction with 3 psi pressure drop for negative wind pressure. The combination of tornado velocities and

* Guide Lines for Effect of Snow and Wind on Constructions (French Wind Code 1965) Section 3, 411-2.

3 psi pressure drop should conservatively take care of the funneling effect of the proximity of the two reactor containment buildings.

9. **Uplift Due to Buoyancy**

Uplift due to buoyant forces created by the displacement of ground water by the structure is considered. Computations are based on the ground water being two feet below ground elevation. This is one foot above the highest water level on record. No credit is taken for the restraint offered by the saturated soil. The effect on the structure of the lateral forces is considered.

10. **Internal Negative Pressure**

Loading due to an internal negative pressure of 2 psig is considered in the design. A pressure of this magnitude could result from the effects of cooling of the containment volume about 80^{o} F below the temperature at which the containment was sealed.

11. **Dynamic Effects Resulting From Plant Equipment Failures**

The approach taken in designing against the dynamic effects of equipment failures is discussed under Section 1.4 "Missile Protection Criteria".

Containment Design Pressures and Temperatures

The stated containment shell design pressure is 12 psig. Analysis of LOCA accidents shows that the compartments of the ice condenser containment can be subjected to localized pressures and temperatures varying from the stated value.

Figures 5.2.2-11 and 5.2.2-11A show in general these design pressure and temperature conditions. Table 5.2-8 lists the various localized structural element design pressures within containment. This table also includes reference to the applicable TMD analysis described in Section 14.3.4.2, where applicable. The design of the containment outer shell and the interior structures have included these conditions with similar margins as design basis. The radial and vertical steady-state thermal gradients used in the design of the containment structure are indicated for a typical summer day on Figure 5.2.2-12 and for a typical winter day on Figure 5.2.2-12A. Construction temperature is taken as 60^{o} F for both the liner and the cylinder and dome concrete.

The worst unsymmetrical load conditions (pressure and temperature) on the containment shell occurs during a main steam line break in one fan-accumulator compartment.

The load plots (Figures 5.2.2-13, to 5.2.2-50) of Section 5.2.2.3 include the unsymmetrical loading conditions for which D. C. Cook Plant is designed.

5.2.2.3 Design Stress Criteria

The design of the containment structure is based upon limiting load factors, which are the ratios by which loads are multiplied to assure that the loading deformation behavior of the structure is one of elastic, tolerable strain behavior. The load factor approach is used in this design for 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 a greater conservatism on those loads subject to variation and which most directly control the overall integrity of the structure. Furthermore this approach places minimum emphasis on the fixed gravity loads and maximum emphasis on accident and earthquake or wind loads.

The loads utilized in the design of the reinforced concrete containment structure are computed in accordance with the following equations:

a. $C = 1.5P + DL \pm .05\ DL + (T' + TL')$

b. $C = 1.25P + DL \pm .05\ DL + (T'' + TL'') + 1.25E$

c. $C = 1.25P + DL \pm .05\ DL + (T'' + TL'') + 1.25W$

d. $C = 1.0P + DL \pm .05\ DL + (T''' + TL''') + 1.0E'$

e. $C = DL \pm .05\ DL + (T) + W' + 1.0\ (p)$

f. $C = DL \pm .05\ DL + T$

g. $C = U.\ P. + DL \pm .05\ DL + T + E'$

h. $C = 0.95\ DL + 1.34\ P + TT$

i. $C = DL + 1.5P1 + T + TL$

The buoyancy forces due to ground water were considered. Where they aid the design they were omitted, and where they were a factor in the design they were added.

The structure is designed in accordance with Ultimate Strength Design Criteria for equations (a), (b), (c), (d), (e), (g) and (i) and to Working Stress Design Criteria for equation (f).

The structure is analyzed for stresses and deflections for the structural integrity test condition, equation (h). The effects of buoyancy are not considered for equation (h).

The symbols used in the above equations are as follows:

C	Required load capacity of section
DL	Dead load of structure and equipment loads.
P	Accident design pressure load (12 psi)
P1	16 psi (in fan-accumulator room due to main steam break)
T	Temperature gradient through the concrete and liner under operating conditions
T'	Temperature gradient through the concrete wall associated with 1.5 times design pressure (18 psi)
T"	Temperature gradient through the concrete wall associated with 1.25 times design pressure (15 psi)
T"'	Temperature gradient through the concrete wall associated with 1.0 times design pressure (12 psi)
TL'	Temperature in the liner associated with an accident pressure of 1.5 times design pressure (18 psi)
TL"	Temperature in the liner associated with an accident pressure of 1.25 times design pressure (15 psi)
TL"'	Temperature in the liner associated with a pressure of 1.0 times design pressure (12 psi)
TL	Temperature in the liner (320^{o}F) associated with 1.5 times main steam break design pressure (1.5 x 16 psi) due to fan-accumulator room main steam line break.
TT	Temperature gradient through the concrete and liner under test conditions
E	Operating basis earthquake
E'	Design basis earthquake

W	Wind load
W'	Tornado Load
(P)	3 psi differential due to ambient pressure drop due to tornado
U.P.	Unsymmetrical pressure of 14.8 psi (maximum)

Load condition (a) indicates that the containment has the capacity to remain elastic and withstand loads at least 50 percent greater than those calculated for the postulated loss-of-coolant accident alone.

Results of the analysis using load conditions (b) and (c) indicate that the containment has the capacity to remain elastic and withstand loadings at least 25 percent greater than those calculated for the postulated loss-of-coolant accident with a coincident operating basis earthquake or wind loading.

Load condition (d) indicates that the containment has the capacity to remain elastic and withstand loadings at least as great as those calculated for the postulated loss-of-coolant accident with a coincident design basis earthquake, as defined in Chapter 2.

Load condition (e) indicates that the containment has the capacity to remain elastic and withstand loadings at least as great as those calculated for operating load and temperature with a coincident design tornado.

Load condition (f) indicates that the containment has the capacity to remain elastic and withstand loadings at least as great as those calculated for operating conditions.

Load condition (g) indicates that the containment has the capacity to remain elastic and withstand loadings at least as great as that of a maximum unsymmetrical pressure of 14.8 psi in the ice condenser area coincident with a design basis earthquake.

Load condition (h) is for proof testing.

Load condition (i) indicates that the containment has the capacity to remain elastic and withstand local loadings at least 50 percent greater than that due to a steam line break in the fan-accumulator room.

Scaled load plots for moments, shears, deflection, longitudinal forces, and hoop tension, are shown in Figures 5.2.2-14 to 5.2.2-50. The legend for these plots is shown in Figure 5.2.2-13.

The temperature gradient through the wall is essentially linear, and is a function of the operating temperature internally and the average ambient temperature externally. Peak accident temperatures mainly affect the liner, rather than the concrete and reinforcing bars, due to the insulating properties of the concrete and the short duration of the accident temperature. By the time the temperature of the concrete within the interior of the concrete shell begins to rise significantly, the internal pressure and temperature in the containment shell due to maximum thermal gradient does not influence the capacity of the structure to resist the other forces. Temperature gradient effects induce stresses in the structure, which are internal in nature; that is, tension outside and compression in the inside of the shell. 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 the final load resisted across a horizontal and vertical section remains identical to that which is carried if the temperature effects 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 is analyzed utilizing load conditions (a), (b), (d), (e) and (f) with the inclusion of buoyant forces where they result in more severe conditions. It is also analyzed 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 "W" is used in lieu of the "E" in the appropriate load condition. A check is made to determine the maximum wind pressure that is tolerable under condition (d).

A study was made to determine the significance of "lobar motion" on the containment structure.

The result of this evaluation is that for a concrete containment the beam modes of vibration predominate response. The lobar effects are very low and therefore do not have a significant effect on design stresses in concrete shells, these stresses have, therefore, not been considered in design.

The initial determination of the required reinforcing was made by means of manual computations. After the initial determination of the required rebars, the containment was modeled for the "GENSHL 5 PROGRAM" and a computer analysis was made.

Since the criteria for the design states that the concrete does not carry tension, all layers of concrete in which tension was indicated to exist were then assumed to be cracked, by setting the values of E_c and u_c (for tension carrying layers) equal to zero where E_c and u_c are modulus of elasticity and poisson's ratio respectively.

A succession of computer runs, for all factored load conditions was made with modification to the rebar design and assumed cracked concrete layers until the final rebar design was achieved. The evaluation of stresses in individual layers was conservatively determined based on elastic analysis which assumed linear triangular compressive stress distribution in the concrete and tensile stress in the reinforcement based on transformed areas.

Stresses in the structure due to thermal changes were determined by the "GENSHL 5 PROGRAM". Thermal gradients are applied to the structural sections as part of the program loading data.

A "Finite Element Method" was used to analyze the personnel hatch opening and the equipment hatch opening. The boundary conditions used for this analysis were determined from the results of the "GENSHL 5 PROGRAM". For all loading combinations, the stresses in the rebars were maintained below the yield, and the compressive stresses in the concrete were kept below the ultimate, therefore plastic deformation does not occur.

Shrinkage induces cracking in the concrete and an initial compressive stress in the rebar and liner.

Design criteria requires that the concrete carry none of the tensile stresses. Therefore, in the analysis, the concrete that is in tension was considered as being cracked. Where, by analysis, the concrete was shown to have compressive stresses, the effects of the initial shrinkage induced tension would be to reduce the compressive stresses. This effect was not taken into account in the calculations.

The initial compression in the rebars, due to the concrete shrinkage, has not been considered as reducing the rebar tensile stress.

Concrete shrinkage does introduce initial compressive stress in the liner, and this initial stress has been considered to be additive to the liner compression stress due to operating and accident conditions.

The auxiliary building concrete was analyzed by conventional structural analysis techniques (i.e., by structural computer programs or manual computations). If the sections assumed in the analysis were satisfactory, reinforcing was determined in accordance with the design method in ACI-318-63. If the section assumed was not satisfactory, a new section was assumed and the procedure was repeated until the assumed section was found to be satisfactory in the analysis. The effects of temperature stresses were added directly when determining the section capacities.

Equilibrium checks of internal stresses and external loads were made. The computer program used for the analysis and design of the containment structure shell was "The GENSH 5 Multi-

Layer Static Shell Program: of the Franklin Institute Research Laboratory in Philadelphia, Pa." The output of this program lists the external loads at the section desired and the internal stresses at both surfaces of each layer of the section being analyzed. The equilibrium of the external loads and the internal stresses was checked at various points by manual computations to spot-check the computer output.

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

The design includes consideration of primary and secondary stresses. The design limit for tension members (i.e., the capacity required for the design load) is based upon the actual yield stress of the reinforcing steel.

No steel reinforcement experiences average strains beyond the tested yield point at the factored load. The load capacity of the structure, so determined, is reduced by a capacity reduction factor "ϕ" which provides 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 an actual capacity lower than the determined value.

The factor "ϕ" is 0.95 for tension members, 0.90 for flexure and 0.85 for bond and anchorage. A factor "ϕ" of 0.75 was used for all Class I structural members carrying loads in shear which were produced by earthquake alone. For Class I structural members carrying loads in shear produced by combinations of earthquake and LOCA loads, a factor "ϕ" of 0.85 was used. The capacity reduction factor of 0.75 for shear, which is more conservative than that required by the ACI code, was used here in recognition of the fact that the potentially large component of shear load associated with an earthquake can be considered to be dynamically applied thereby justifying some additional conservatism.

The load factors used in the equations of Section 5.2.2.3 to provide for the integrity of the containment structure are based on the same philosophy used in the ultimate strength procedure of ACI 318-63.

Because of the refinement of analysis and the restrictions on construction procedures, the load factors in the design primarily provide for a safety margin on the load assumptions. The load factors utilized in this criterion are based upon the load factor concept employed in Part IV-B of "Structural Analysis and Proportioning of Members-Ultimate Strength Design" of ACI 318-63. The load factor applied to earthquake or wind load is consistent with that utilized in ACI 318-63.

The reduction in the load factor applied to the pressure and thermal loads, when the design earthquake or maximum wind velocity is experienced is also consistent with ACI 318-63. Therefore applicable provisions of "Building Code Requirements for Reinforced Concrete" ACI 318-63 are utilized with the exception of the ice condenser wear slab. The applicable code for the ice condenser wear slab is ACI 318-71.

5.2.2.4 Divider Barrier

It is an essential requirement of the ice condenser containment that the steam and air flowing from the lower containment compartment in the event of a failure of a pipe in the Reactor Coolant System be routed to the upper compartment via the ice bed. To accomplish this, a structural barrier within the containment vessel separates the lower and upper containment compartments. This divider barrier includes the walls of the ice compartment, the upper deck, the compartments enclosing the upper portion of the steam generators and pressurizer, the gate separating the reactor cavity from the refueling canal, and portions of the walls of the refueling canal. The interior wall of the ice compartment also serves as the crane support wall.

It is not necessary to apply a vapor barrier to the exterior surface of the containment wall for the height of the ice condenser compartment. The exterior wall of the ice condenser is separated from the structural concrete and is composed of insulated wall panels which form a complete sheet metal vapor barrier for the refrigerated ice condenser compartment. This vapor barrier is the exterior surface of the insulation and is the warm side.

The operating deck portion of this barrier is supported at its outer radius by short reinforced concrete columns extending above the lower crane wall. The deck is supported at its inner radius by the reinforced concrete primary shielding wall around the reactor. The removable central portion of this deck spans the reactor cavity above the reactor vessel. The operating deck includes hatches above the reactor coolant pumps.

Other portions of the divider barrier are penetrated by hatches for general access and materials handling. The hatch covers and the bulkhead walls between the reactor cavity and the refueling canal are designed to limit post-accident leakage between the lower and upper containment volumes. Prior to plant heatup, the hatches in the operating deck are inspected to ensure that they are properly secured.

The divider barrier between the upper and lower containment compartment is designed to carry the differential pressure between the lower and upper compartments during the postulated loss-of-coolant accident under factored load conditions (a), (b) and (d). The portions of the divider barrier which enclose confined spaces in which a pipe rupture could occur; such as, the steam generator compartments and the slab above the reactor vessel are designed with consideration for differential pressures as a function of available relief area. In addition, the barrier is designed to withstand impact from credible missiles and the effects of fluid jets and pipe whip (where they could occur) without loss of function. For these conditions localized plastic action is accepted and structural ductility is considered in determining equivalent static loads.

Figures 5.2.2-11, 5.2.2-11A, and 5.2.2-51 to 5.2.2-55A indicate the elements of the divider barrier, the reinforcing used in the barrier elements and the pressure loading applied to these elements.

The crane wall, operating deck, steam generator and pressurizer enclosures, fan accumulator room end walls, reactor access opening cover (missile blocks) and vertical bulkhead, and the ice condenser floor slab and end wall, were analyzed utilizing finite element analyses or manual calculations. These analyses also utilized Dynamic Load Factors (DLF) where appropriate.

The Reactor Access Opening Cover and the Bulkhead were designed manually, considering them to be simply supported one-way slabs.

Reinforcing and concrete sections were designed using "Ultimate Strength Design" criteria for the accident conditions and "Working Stress Design" criteria for the operating conditions.

The loading combinations that were considered in the design are listed in section 5.2.2.3.

Additional loads that were considered in the design follow:

1. An internal uniform design pressure of 34.4 psi in the steam generator enclosure factored in accordance with the equations of sect. 5.2.2.3.
2. An internal design pressure of 15 psi in the pressurizer enclosure factored in accordance with the equations of sect. 5.2.2.3.
3. An 11.8 psi external design pressure on the upper compartment crane wall in the ice condenser area.
4. Thermal load.
5. Jet impingement force.
6. Missile impact force.
7. Pipe reactions and thrust force on the main steam line support anchors.
8. Steam generator lateral support loads due to earthquake and loss of coolant accident or main steam line break.
9. A pressure differential across the operating deck of 20.2 psi.

Shrinkage

The effects of shrinkage are to impose tensile stresses in the concrete and compressive stresses in the reinforcing steel. For a volume/surface area ratio of 12, a conservative value of shrinkage strain equal to 200 x 10^{-6} (in/in) based on the Matlock and Hansen Graph[1] was used. The computed concrete tensile stresses were 56 psi in the crane wall and 34 psi in the steam generator and pressurizer enclosures. These values were added to the stress values determined in the loading combinations.

Temperature

Two factors were considered in the calculation of thermal stresses.

1. A maximum thermal gradient of 20°F across the thickness of the barrier structure gives a tensile stress of 174 psi in the three-foot thick concrete cross-section and 168 psi in the two-foot thick concrete cross-section.
2. A maximum mean thermal rise of 50°F was considered axially in the hoop and meridional directions of the barrier structure.

The results from (1) and (2) were superimposed onto the values determined in the loading combinations.

Accident thermal load increments are of too short a duration to completely penetrate the concrete thickness during the blowdown interval. Thermal gradient values used at operating conditions are conservative and do not take into consideration the temperature drop at the skin surfaces of the wall. If this were done the values could be reduced.

Jet Impact

The unattenuated steam blast from a main steam pipe break inside the steam generator enclosure was considered. The failure of the main steam pipe occurs at the connection of the main steam piping at the nozzle at the top of the steam generator. The mode of failure is considered to be a circumferential double-ended rupture. The historical manual calculation of stresses was based on elastic analysis, assuming interaction of the following two major types of elements.

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[1] "Shape of Member on the Shrinkage and Creep of Concrete," Hansen & Matlock, ACI Journal 63/10, Feb. 1966.

a. Vertical strips of annulus sidewall acting as beams supported at the top and bottom.

b. Circular hoops, 1 ft. wide, around the steam generator enclosure wall.

These two elements act together to resist the worst accident combining the jet impact and the instantaneous internal pressure (20 psi). The computed maximum tensile stresses (original design) in the steam generator enclosure wall if resisted only by meridional bending elements was 259 psi in the concrete and 2,500 psi in the reinforcing. The combined action of elements in both the hoop and meridional direction resulted in much lower stresses.

The current finite element analysis evaluated an instantaneous uniform internal pressure of 34.4 psi in the enclosure with the unattenuated steam blast.

Missiles

The generation of missiles from the reactor control rod drive mechanism was considered in the design of the reactor access opening cover and the primary shield wall. The concrete was analyzed for missile penetration by the modified Petry formula (Ref. The Bureau of Yards and Docks of the U. S. Navy "Designing Bomb-Resistant Structures").

The maximum possible depth of penetration was found to be 0.66 inches in either the 4' -0" thickness of the reactor access opening cover or the primary shield wall. The minimum margin of safety against full penetration is equal to 48/0.66 = 72.

See Section 14.3.4 for a discussion of leakage through the barrier. Sensitivity coefficient leakage was found to be .081 psi in containment pressure increase per ft^2 of deck leakage. An upper bound for the maximum size break in the event of a DBA would be approximately seven times the design bypass area of 7 sq. ft. This was arrived at by taking the difference between containment design pressure and maximum pressure due to DBA and the above coefficient.

5.2.2.5 Structural Materials

The design of the containment vessel structure was based on specifications giving acceptable limitations of physical and chemical properties for the structural materials used. For certain materials, Indiana & Michigan Electric Company performed physical and/or chemical tests prior to selecting such materials for this project.

The organization, responsibilities, and general provisions for Quality Control are referenced in Sub-Chapter 1.7 and are described in a separate document entitled “Quality Assurance Program

Description". The specific quality control procedures imposed by Specification requirements are outlined herein.

Concrete

Structural concrete work has been performed in accordance with "Building Code Requirements for Reinforced Concrete" (ACI 318-63) and "Specifications for Structural Concrete for Buildings" (ACI 301-66) with the exception of the ice condenser wear slab. The applicable code for the ice condenser wear slab is ACI 318-71.

To supplement the requirements set forth by ACI Standards and Codes, The Bureau of Reclamation Concrete Manual was also used. Compressive strength testing of concrete was performed in accord with ACI 214-65 and ASTM C-39. All concrete used in Class I structures has a minimum compressive strength of 3,500 psi at 28 days.

The concrete used for the Unit 1 Steam Generator Replacement Project (SGRP) has a minimum compressive strength of 5,000 psi at 7 days. The enclosure concrete was furnished in accordance with Specification 23733-C-311(Q), Technical Specification for Purchase of Safety Related Ready-Mixed Concrete for Donald C. Cook Nuclear Plant Unit 1 Steam Generator Replacement Project.

For containment structures, the 28-day compressive strength of concrete is determined in accordance with the statistical methodologies outlined in ACI 214-65. The values utilized for input are obtained from the construction pour cards, which include the pour location, batch design, and compressive test results. This compressive strength value is utilized for determination of the design structural capacity utilizing the load combinations given in Section 5.2.2.3.

ACI-301, "Specification for Structural Concrete for Buildings", was followed in the construction of the Donald C. Cook Nuclear Plant, except where the project specifications have provided detailed instructions.

The Portland Cement used at D. C. Cook Nuclear Plant conforms to Specification for Portland cement, ASTM C-150, Type I.

In addition to the tests performed by the cement supplier (those tests specified in the "Specification for Portland Cement" ASTM C-150) the following tests were performed by the Sporn Materials Laboratory (now known as the AEP Civil Engineering Laboratory) for I & M Electric Co. to assure that the cement conforms to the ASTM C-150 Specification.

a. ASTM C 114 - Standard Methods for Chemical Analysis of Hydraulic Cement.

b. ASTM C 204 - Standard Method of Test for Fineness of Portland Cement by Air Permeability Apparatus.

c. ASTM A 191 - Standard Method of Test for time setting of Hydraulic Cement by the Vicat Needle.

All concrete contains fly ash which conforms to the "Specification for Fly Ash" ASTM C 618. Fly ash is substituted for cement in a maximum amount of 30% by weight.

Prior to the selection of fly ash a series of tests were conducted by the Sporn Materials Laboratory (now known as the AEP Civil Engineering Laboratory) to determine its chemical properties, thus assuring a high quality concrete. In addition, the Laboratory performed periodic tests on the fly ash to ensure that its properties were within the limits set forth in ASTM Specification C 618.

The concrete aggregates used at D. C. Cook Nuclear Plant conform to ASTM Specification C-33-64.

The Course aggregate used in this project was crushed dolomite and it was graded to the following limits:

Sieve Size	
Square Openings	Total % Passing by Weight
1"	85 - 95
3/4"	30 - 65
3/8"	0 - 10

Fine aggregate (sand) was obtained locally and had a fineness modulus of 2.9 ± 0.2. Fine aggregate was graded within the following limits.

Sieve Size	Total % Passing by Weight
# 4	95 - 100
# 8	80 - 95
# 16	60 - 75
# 30	35 - 60
# 50	10 - 30
# 100	2 - 8

The type and size of aggregate, slump, and additives was established to ensure high concrete quality of the specified strength and to minimize shrinkage and creep. Neither calcium nor any admixtures containing calcium chloride or other chlorides, sulphides, or nitrides were used.

Mixing water was controlled by periodic testing to ensure that it did not contain more than 1000 ppm of the above chemical constituents.

Repairs

If any repairs to the concrete are necessary, the material selection, surface preparation, application and inspection will be performed in accordance with the applicable procedures. For repairs required for load carrying capacity, the design strength of concrete used in repair shall have strengths equal to or higher than that used in the original construction.

Purpose of Concrete Admixtures

All structural concrete contains a water reducing admixture and an air entraining admixture meeting ASTM specifications C-494 and C-260-67 respectively. "Placewel R" was selected as the water reducing agent and "Aircon Double Strength" as the air entraining agent, both manufactured by Union Carbide Corporation. Dosage requirements for the basic design mixes were determined in accordance with Manufacturer's recommendations and trial mixes performed by the concrete laboratory. "Placewel R" was used primarily to reduce water requirements in the mixes and thus reduce the cement content without sacrificing workability or strength. "Aircon" was used primarily to increase the durability of the concrete.

Inspection and Surveillance

The following quality control measures outlined below apply to structural concrete.

Pre-Construction Tests

Prior to commencing concrete work for this project, the AEP Sporn Materials Laboratory (now known as the AEP Civil Engineering Laboratory) conducted a series of tests on different trial mixes (using the same materials selected for this project) to determine the mix proportions necessary to produce concrete conforming to the strength requirements specified. The majority of the concrete compression tests for these trial mixes showed a 7-day strength equal or greater than that expected at 28-days.

The methods used for sampling, making, curing and testing concrete specimens were in accordance with the following ASTM Standards.

a. ASTM C-192-66 - "Standard Method of Making and Curing Concrete and flexure Test Specimens in Laboratory."

b. ASTM C-39-64" Standard Method of Test of Compressive Strength of Molded Concrete Cylinders."

c. ASTM C-172-54 "Standard Method of Sampling Fresh Concrete".

d. ASTM C-31-65 "Standard Method of making and curing concrete compression and Flexure Test Specimens in the Field".

Field Materials Testing Laboratory

To monitor Quality Control on construction materials, I&ME Co. established a field testing Laboratory which was under the direct control of the Sporn Materials Laboratory (AEP C. E. Laboratory). The field testing Laboratory was manned by competent personnel experienced in the testing of construction materials.

Some of the tests conducted by the field Laboratory were:

a. Testing of coarse and fine aggregates.

b. Testing of concrete cylinders.

c. Concrete slump.

d. Air entrainment.

e. Reinforcing steel.

During testing operations the testing laboratory assigned an inspector at the batch plant to monitor the mix proportions of each batch of concrete produced by the batch plant. The concrete batch plant utilized for this project conformed in all respects, including provisions for storage and precision of measurements, with the "Standard Specifications for Ready Mixed Concrete" ASTM C-94-68.

The batch plant inspector periodically tested the mix ingredients and ensured that a tape record was provided for each batch, documenting the time loaded, the actual proportions of the mix, the amount of concrete, the concrete design strength, the portion of structure where it was to be placed, the identification of the transit mixer, and the reading on the revolution counters at the first addition of water.

Whenever ready-mixed concrete was required, it was mixed and transported in accordance with "Specification for Ready-Mixed Concrete", ASTM C-94-68. The minimum amount of mixing in truck mixers, loaded to maximum capacity, was 70 revolutions of drum or blades after all of the ingredients, including water, were in the mixer. The maximum number of revolutions at mixing speed was 100. Records were maintained as to the time and reading of the revolution counter when concrete was discharged.

Inspectors at the construction site inspected the placement of reinforcing and placement and curing of the concrete.

For Class I structures (containment vessel, auxiliary building and other structures) test cylinders and concrete compression tests were taken based on the following schedule:

Concrete Poured in cu. yds.	Samples taken
0 – 100	1 for each 100 cu. yds.
100 – 1000	1 for each 500 cu. yds.
1000 – 2000	1 for each 700 cu. yds
2000 and over	1 for each 1000 cu. yds.

A sample consisted of 2 cylinders to be tested at each of 3, 7 and 28 days.

For every mix design, and prior to the production of structural concrete, five (5) slump tests were made and an average value was established. This value was within the range of 3" to 5". Slump tests were also made at the time concrete test cylinders were cast. They were also made at the batch plant and at least each hour during pouring time.

During mass concrete operations, for obtaining the desired slump, the batch plant operator "holds back" a portion of the theoretical quantity of water, as determined by the approved design mix. As a result the concrete produced is of low slump since a portion of the full amount of water specified in the mix design was "held back".

The slump of the concrete was determined by means of an ammeter attached to the mixer drum motor. If the ammeter reading indicated low slump more water was added to bring the slump up to within the specified range of 3" to 5". The added amount of water was recorded.

The amount of "hold back" water was estimated based on the moisture content of the sand. The Cook Nuclear Plant practice was that no water was added to the concrete after it left the batch plant.

In addition to the slump control outlined above, at least two manual slumps were taken whenever test cylinders were cast. Furthermore, whenever a large pour was being made (500 cu. yds. or greater) one slump test was taken at the batch plant every hour for the duration of the pour.

Over the course of the project the average compressive strength of the 28-day cylinders either met or exceeded the specified compressive strength of 3500 psi.

All slump tests were conducted in accordance with the "Method of Test for Slump of Portland Cement Concrete" ASTM Specification C 143-58. Batch rejection was based on deviation from specified slump specifications. Pour removal would be based on an engineering analysis of core cylinder tests that would be instituted following the failure of strength cylinder tests to meet 90 percent of the specified average strength.

Concrete samples for the Cook Nuclear Plant were taken from the transport trucks at the site concrete laboratory which was located adjacent to the mixing plant. This is in conformance with ACI-214, section on "Tests and Specimens Required."

The concrete used in the Unit 1 steam generator replacement project (SGRP) conforms to the requirements of Specification 23733-C-301, Rev. 0, "Technical Specification for Purchase of Ready-Mixed Concrete," Specification 23733-C-302(Q), Rev. 0, "Technical Specification for Forming, Placing, Finishing and Curing of Concrete," and/or Specification 23733-C-311 (Q), Rev. 0, "Specification for Purchase of Safety Related Ready-Mixed Concrete." Concrete and grout testing was performed per Specification 23733-C-101(Q), "Technical Specification for Material Testing Services for Donald C. Cook Nuclear Plant Unit 1 Steam Generator Replacement Project."

The concrete and the grout used for the 1988 Unit 2 Steam Generator Repair work conform to the requirements of Specifications No. DCC-CE-150-QCN (Rev. 2, Change Sheets 1, 2 and 3) titled "Structural Concrete Mix Design," and No. DCC-CE-170-QCN (Rev. 1, Change Sheet 1) titled "Structural Concrete Specification for the Steam Generator Replacement."

Reinforcing Steel - Material and Specification

The reinforcing steel used at Cook Nuclear Plant was deformed new billet steel bars conforming to the requirements of "Standard Specification for Deformed Billet-Steel Bars for Concrete Reinforcement ASTM Designation A 615-68." This steel has a minimum yield strength of 40,000 psi.

The reinforcing steel used for the Unit 1 Steam Generator Replacement Project (SGRP) has a minimum yield strength of 60,000 psi.

Rebar Inspection and Testing

Certified reports of chemical and physical test performed on the reinforcing steel were submitted to the Engineer by the supplier. These tests conform to the requirements of "Standard Specification for Deformed Billet-Steel Bars for Concrete Reinforcement" ASTM Designation A615-68.

In order to assure that reinforcing steel met appropriate specifications, samples of rebar delivered to the job site were selected and tested to confirm compliance with the specified physical requirements and for certification of mill test reports.

The selection of the specimens was as follows:

Two specimens were taken for each heat of material. No samples selected included the end 12 inches of any bar delivered.

Prior to fabrication and/or delivery of the reinforcing to the job site, specimens were tested for ultimate strength, yield strength and elongation by Indiana & Michigan Electric Company. If any of these specimens failed to meet the requirements of the applicable specification for ultimate strength, yield strength or elongation, the heat of steel was resampled, this time selecting four specimens instead of two as were required originally. If any of these specimens failed to meet the requirements of the applicable specification for ultimate strength, yield strength or elongation, the entire heat was rejected.

All reinforcing was kept separated by size and heat and tagged with the manufacturer's identification number. This identification was maintained at least until the heat of steel met the aforementioned requirements.

To insure that only the specified reinforcing steel was received, the mill test reports for each shipment were checked against the mill test reports sent to the job site with the test specimens.

Only two grades of rebars were used during the entire project, both of which met the requirements as stated. This eliminated the possibility of substitution of an inferior grade of steel during erection.

Generally, grade 40 rebars were used during erection of all structures. If grade 40 was not available, grade 60 rebars (which are superior in strength) were used. However, only a very limited amount of grade 60 rebars were used and generally, the stresses were kept to grade 40 values.

Since the low operating temperature of the ice condenser would not have adverse affects on the reinforcing steel with respect to its physical properties, tests for determining the NDTT (nil ductility transition temperature) properties of the material were not required.

Reinforcing Steel Splices - Specifications

The main load carrying reinforcement is spliced by the Cadweld process or lap spliced. These Cadweld splices are designed to develop the average minimum ultimate tensile strength of the ASTM grade of reinforcing bars being spliced, with no splice falling below 125% yield. Lap splicing will be permitted for secondary or flexural load carrying bars up to and including No. 11. Lapped splices where used, have followed provisions of ACI Code 318-63, Section 805.

"Restoration of the steam generator enclosures during Unit 1 steam generator replacement performed limited weld repair and weld splices on concrete reinforcing steel in accordance with ANSI/AWS D1.4-98."

Cadweld splice staggers in the containment structure have been maintained between splices in adjacent bars for the foundation mat and the containment wall and interior structure. Cadweld splices were not staggered in the restoration of the walls and roofs of the Unit 2 steam generator enclosures, carried out in connection with the steam generator repair effort of 1988; specially qualified low strain Cadweld sleeves were used per ACI-349-85 Sect. 12.14.3.7 eliminating the need to stagger the splices. Cadweld splices also were not staggered in the restoration of the walls and roofs of the steam generator enclosures during the Unit 1 steam generator replacement project. Standard Cadweld sleeves were used that satisfied the requirements of the code of record for rebar splices, ACI 318-63 Section 805(d). No tack welding has been permitted.

Installation Procedure - Cadwelds

In addition to the manufacturer's splicing procedure, the following procedures were observed:

a. Cadweld splice sleeves and powder were stored in such a manner as to avoid wetting or soaking from snow and rain, to prevent rusting of splice sleeves and to prevent wetting of powder prior to field usage. When being used the powder was protected from water and moisture by water tight containers.

b. Rebar ends to be spliced were wire-brushed, by means of a powered wire brush, to remove all loose mill scale, red rust and adhering concrete.

c. Rebar ends which were wet, grease or mud covered were dried with a torch before wire brushing.

d. Rebar ends which were painted had the paint burned off by a torch before wire brushing.

e. A line was marked 12" ± 1/4" from the end of the bar with a paint marker. This line was used as a reference point to insure that the bar ends were centered in the splice sleeve.

f. Clean rebar ends were heated, to assure complete absence of moisture, immediately before the splice sleeve was placed into final splicing position.

g. With all packing materials, equipment and graphite pouring basin in position, the splice sleeve was heated externally, until it was warm to the touch, when the temperature was below 32°F or the humidity was above 65%.

Prior to production splicing, each operator and foreman or supervisor was instructed by a representative of the manufacturer. Each operator was required to prepare three (3) splices for each of the positions to be used in production work (horizontal, vertical and diagonal). These splices were tested. An operator was considered to be qualified if all three specimens for each splice position passed visual and tensile tests performed by the Owner's site personnel who were qualified in cadweld splicing. A list of qualified operators and their qualified test results is maintained at the job site. A manufacturer's representative from Erico Products, Inc. was present while the first one hundred (100) production splices were made to verify that proper procedures were being used and quality splices were obtained.

Inspection and Testing - Cadwelds

The manufacturer's Cadweld splice acceptance procedures were used. All completed splices were visually inspected at both ends of the splice sleeve and at the tap hole in the center of the splice sleeve. For the splice to be accepted, sound nonporous filler metal had to be visible at both ends of the splice sleeve and at the tap hole in the center of splice sleeve. Filler metal recessed 1/4" from the end of the sleeve, due to the packing material, was not considered to be a poor fill.

Randomly selected splices for each crew and position* were tensile* tested. Selected splices, excluding curved rebars of containment bottom slab and dome with radius less than 57'6", were tensile tested by Applicant's Testing Laboratory, in accordance with the following schedule for each crew, position, bar size and grade of bar.

One (1) production splice out of the first ten splices.

Two (2) production and two (2) sister splices out of the next 100 splices

One (1) production and two (2) sister splices out of the next and subsequent 100 splices.

Sister splices, where used, were made with test bars of 3 feet in length, spliced in sequence with production bars.

No reinforcing steel splices were checked by non-destructive inspection methods.

The Cadweld splices used in the restoration of the Unit 2 steam generator enclosure walls and slabs, in conjunction with the steam generator repair of 1988, were inspected and tested in accordance with the requirements of Supplement 3 to the Donald C. Cook Nuclear Plant - Unit No. 2 Steam Generator Repair Report titled "Inspection and Testing Program for Cadweld Mechanical Splices". For the Unit 1 steam generator replacement project of 2000, the purchase, installation, inspection and testing of Cadweld splices, including operator qualification, was performed in accordance with Specifications 23733-C-309(Q) and 23733-C-101(Q).

* Specifications required that no splice in the test series shall have a tensile value below 125% of the specified yield point stress of that grade of reinforcing bar to which it is being applied.

Liner and Anchors

Materials and Specifications

The steel for the liner and attachments conform, where applicable, to:

a. Specification for Low Carbon - High Manganese Normalized steel with Fine Grain Structure" ASTM A-442-66 Grade 60. The nominal liner plate thickness is 1/4" on the bottom and 3/8" on the shell and dome. The original material of construction was cancelled in 1991, discontinued and no longer commercially available. A suitable substitute for future liner plate repair replacement work is ASME SA 516 Grade 60.

b. "Specification for structural steel" ASTM A36-67 for rolled sections including weld channels and stiffeners.

c. The anchorages for the containment liner consist of structural angles conforming to ASTM A 36 Specification and L-shape Nelson Studs (3/8" dia). These studs conform to the requirements of ASTM A-108-69T "Low Carbon Steel".

Inspection and Tests - Anchors

To confirm the structural integrity of the Nelson stud to plate weldment, at the beginning of each day, each welder attached at least one test stud, which was tested by bending the stud, approximately 45 degrees toward the face of the plate. Whenever failure occurred in the weld, the welding procedure and/or technique was reviewed and corrected, and two successive studs were successfully welded and tested before further studs required by the design were welded to the liner plate. The test studs were allowed to remain in place, but were not considered as part of the regular stud pattern required by the design. All stud welds were visually inspected. Any stud on which a full 360 degree weld was not obtained was removed and replaced by a new stud.

Inspections and Tests - Liner

ASTM standard test procedures were employed to ascertain liner plate compliance with ASTM A 442-66 Specification. Certified copies of mill test reports describing the chemical and physical properties of the steel were submitted to I&M Electric Company for approval. Test for qualifying welding procedures and welders were performed by the fabricator and monitored by I & M Electric Co. The liner plate material was tested (one test for each heat of steel) to determine its nil ductility transition temperature. These tests were conducted in accordance with the Naval Research Laboratory's Report NRL 6300 on the drop-weight tear test. The tests were conducted at a maximum temperature of 30°F below the minimum service temperature of 0°F. In addition, the plates were impact tested by the liner fabricator in accordance with the applicable sections of Paragraph N330, Section III of the ASME Boiler and Pressure Vessel Code at the same temperature as the drop-weight tear test (-30°F).

Quality Control measures for welding and weld testing:

All welding electrodes used for the Donald C. Cook Nuclear Plant were kept in "holding ovens" at a temperature of 150°F. Welding electrodes were issued by the job foreman to welders as required.

However, no welding electrodes were allowed to be used if they were wet or if they had been removed from the holding ovens for more than four (4) hours.

a. All welders and welding procedures were qualified in strict accordance with the requirements of Part A Section IX of the ASME Code (1968).

b. All welds in the bottom (including the reactor pit and recirculation sump), cylindrical shell and dome liners were tested as follows:

Complete radiographic testing was done for the first 15 accessible feet of weld made by each welder and position, in accordance with Paragraph UW 51 Section VIII of the ASME Code.

Spot radiographic testing of welds was done for every 50 feet beyond that portion of the weld that was completely tested by radiography except as noted below.

One hundred percent (100%) of the welds in those areas of the liner which were impractical to be radiographed or spot radiographed were tested by the Magnetic Particle Test Method per Section VIII of the ASME Code.

All liner welds were 100% vacuum box tested.

Upon completion of the non-destructive testing of welds, all welded seams were covered by test channels, which were tested for strength and leakage as follows:

a. The channels were pressurized with air to 50 psig for 15 minutes (strength test).

b. Following the strength test, the channels were pressurized with a 20% by weight of Freon-Air mixture. By means of a halogen leak detector, having a sensitivity of $10E^{-7}$ standard cubic centimeters per second, 100% of the welds were tested for leakage. Furthermore, the weld channel zones (a group of connected channels) were tested at a pressure of 14 psig for two hours with no drop in pressure above acceptable limits taking into account pressure variations due to temperature variation.

The following additional documents were used to supplement the basic document (ASME Section III). Dates of references are the latest edition at the time of order placement.

a. ANSI B16.5 - Steel Pipe Flanges and Flanged Fittings

b. ASME Boiler and Pressure Vessel Code, Sections VIII, IX and II ANSI B16.11 Socket Weld Fittings

c. ANSI B16.11 Socket Weld Fittings

d. ASTM Standards

e. American Electric Power Service Corporation Specifications for Nuclear Piping, Piping Materials, Containment Liner

f. Westinghouse Electric Corporation Process Specification 83336KA and Appendices A & B.

g. USAS B31.1 - 1967.

5.2.2.6 Corrosion Protection

The portion of the containment building which is below the ground water table (GWT) at approximate elevation 585 has been waterproofed by means of a PVC 40 mil plastic membrane. Because of seasonal fluctuations in GWT, the membrane was applied well above the highest known GWT elevation.

In addition, Indiana Michigan Power Company conducted a series of tests to determine whether or not natural or man-made underground corrosion tendencies were present at the plant site. During these investigations two important factors were considered:

a. The ability of the soil to sustain or accelerate any corrosion cells that might be established.

b. The behavior of any man-made d.c. currents present.

Since it is known that soil electrical resistivity and acidity are good indicators of soil corrosion tendencies, the purpose of the tests was to measure these two parameters. The soil resistance to electrical charges was measured with Vibroground using the four-pin method. This method gives the average soil resistivity from the surface to the pin spacing. Five pin spacings varying from 10 to 50 feet were used at most test locations (for test locations see Figure 5.2-1). The values of 10,000 Ohm-centimeters or less are the values commonly considered conducive to corrosion.

The values measured are listed in Table 5.2-2. Acidity tests were made, where possible, by means of pH paper to determine the chemical aggressiveness of the electrolyte. Very slight acidity was found in the lake water, varying between 6.5 and 6.8. Tests were also made in the immediate plant site area and a pH of 6.5 was noted. These values are close to the neutral pH of 7 which is indicative of a passive environment.

To determine the presence of stray d.c. current, potential drop tests were made at the plant site. These tests indicate no stray currents were present. The area around the plant site was investigated for pipelines under cathodic protection. Two pipelines were found to run roughly parallel to the lakeshore and under cathodic protection with pipe to soil potentials averaging 2.25 volts. No rectifier units were found in a six-mile section of these lines and it was concluded that they have no effect in the plant area.

Based on the above investigation it was concluded that the underground environment at the plant site does not promote corrosion. However this does not preclude the possibility that man-made corrosion cells introduced into this environment will not promote corrosion. Realizing this fact, considerable care has been exercised to eliminate from the design all electrically connected dissimilar metals, foreign electrolytes in the vicinity of metals, stray d.c. currents and other corrosion promoting devices.

The exposed surface of the containment liner (vertical cylindrical shell and dome) was coated with Carbozinc No. 11 as primer and Phenoline white No. 305 as finish coat. The total thickness is approximately seven (7) mils. The outer surface of the steel is directly in contact with the concrete, which provides adequate corrosion protection due to the alkaline properties of the concrete.

If any repairs to the liner coatings are necessary, the repairs will utilize the original coating materials or equivalent.

For the containment reinforcing a 3 inch cover of concrete was provided. This is approximately 50% greater than that specified by ACI-318 code.

5.2.2.7 Structural Design for Jet Loads

An analysis was made to summarize the capability of the containment divider barrier and compartments to withstand the jet force effects of a reactor coolant loop (DBA) or steam line break inside the containment building.

Evaluation of additional high energy lines inside containment have been performed.[2] These High Energy Line Break (HELB) locations have been determined and evaluated from a source to target perspective. The LOCA and MSLB are bounding for these additional break locations.

The reactor coolant system is provided with pipe whip restraints. Both circumferential and longitudinal ruptures were considered in the original design of this restraint system. Circumferential ruptures were originally considered at all changes in direction and nozzle junctions in the RCS and connecting systems. Longitudinal ruptures were postulated to occur at selected locations within the reactor coolant pressure boundary.

Four restraints have been provided on each of the four main steam risers as well as two restraints on each steam line immediately before they exit the containment. Restraint cross sections are shown in Fig. 5.2.2-56.

In accordance with Generic Letter 84-04, Cook Nuclear Plant has implemented Leak-Before-Break (LBB) methodology. The Nuclear Regulatory Commission has reviewed and approved Cook Nuclear Plant's implementation of this methodology (references 1, 2, and 3). As part of the implementation of this methodology, selected Unit 1 and Unit 2 whip restraints on the cross-over leg of the Reactor Coolant System piping were modified to preclude interference with pipe movement, adjacent structures or adjacent components, and are non-functional.

This Leak-Before-Break (LBB) methodology eliminates the design requirement to consider the dynamic effects (pipe whip effects, blowdown jet forces, and main coolant loop and reactor vessel support loads) of postulated main coolant loop ruptures and Unit 1 pressurizer surge line ruptures.

The reactor coolant, main-steam and feedwater lines have been restrained outside and inside of the steam generator and pressurizer enclosures such that damage to the containment, safeguard systems and an increased severity of a LOCA would not occur from pipe whip or blowdown jet forces.

Based on the results included in NUREG/CR 2913, the effect of the jet impingement is limited within ten pipe diameters from postulated High Energy Line Breaks and ten diameter equivalent

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[2] "HELB Program – Target Evaluation Report", NED-2000-514-REP

for critical cracks. The critical crack size is defined to be one-half the pipe diameter in length and one-half the wall thickness in width. The impingement effects for a critical crack will be modeled as a rupture of a pipe with a diameter equivalent to the critical area.

The jet effects assessed are the result of conditions arising from the following postulated breaks:

Reactor Coolant Piping System

1. Reactor Vessel Outlet Nozzle - Partial Guillotine
2. Reactor Vessel Inlet Nozzle - Partial Guillotine
3. Steam Generator Inlet Nozzle - Guillotine
4. Steam Generator Outlet Nozzle - Guillotine
5. Reactor Coolant Pump Inlet Nozzle - Guillotine
6. Reactor Coolant Pump Outlet Nozzle - Guillotine
7. 50° Elbow on the Intrados - Split
8. Flow Entrance to the 90o Elbow - Guillotine
9. Loop Closure Weld in Crossover Leg - Guillotine

The above listed breaks (1–9) have been eliminated from requiring consideration of dynamic pipe break effects as a result of LBB methodology. They are maintained for historical purposes only.

10. Safety Injection/Primary Coolant Loop Connection - Guillotine
11. Pressurizer Surge/Primary Coolant Loop Connection - Guillotine (Unit 2 only)
12. RHR Primary Loop Connection - Guillotine
13. Surge Line Inlet to Pressurizer - Guillotine (Pressurizer Compartment) (Unit 2 only)

Main Steam Pipe System

14. Main Steam Line Nozzle of Steam Generator - Guillotine (Steam Generator Compartment)
15. Main Steam Line - Guillotine (Fan-Accumulator Compartment)

The original Westinghouse criteria for break locations in the RCS are illustrated in Figs. 5.2.2-56 and 5.2.2-56A. The restraints and physical geometry of the structures subject to jets, including the steam generator and pressurizer enclosures, the fan-accumulator rooms, and the operating deck are shown. The crane wall is subjected to reactions from the steam generator snubbers acting as rigid supports during an earthquake and/or DBA. The combined DBA and DBE load in the steam generator enclosure is 1600 kips at each reaction point and was factored into the design of the crane wall.

Additional break locations exist within the containment structure as determined by High Energy Line Break (HELB) analyses performed per the allowances given in Generic Letter 87-11. These break locations were evaluated for their impact on surrounding structures and components. The results of these evaluations are contained within the HELB evaluation report[3]. These breaks are of less magnitude (less mass and energy release) than the listed breaks and were determined to be bounded by those breaks. Additionally, refer to Unit 1 Section 14.3.4.2.4, Steam Generator Enclosure Evaluation, for the discussion of the bounding breaks within the Steam Generator Enclosure.

In addition to loading conditions (a) through (i), of Section 5.2.2.3, the containment barrier and associated enclosures were analyzed for jet effects using the following loading conditions:

$$(1.0 \pm .05)\ DL + 1.0F_I + 1.0T' \quad (1)$$

$$(1.0 \pm .05)\ DL + 1.25P + 1.0\ F_S + 1.0T' \quad (2)$$

Where:

F_I= equivalent static jet load effects at the initiation of the break.

F_S = equivalent static jet load effects during the saturated pressure phase.

Other terms as defined in Subsection 5.2.2.3.

These equivalent static jet load effects were determined from the time history forcing function at the point of postulated break and are considered to act on the affected structure under the following assumptions:

1. When the peak response of the structure is due to the initial and saturated jet impingements on the divider barrier.

[3] "HELB Program – Target Evaluation Report", NED-2000-514-REP

a. that the ductility factor is equal to 3 in regions where moment governs the design.

b. that the ductility factor is equal to 1.3 in regions where shear or diagonal tension governs the design.

2. When the peak response of the structure is due to the initial and saturated jet impingement on the internal structure other than the divider barrier.

   a. that the ductility factor is equal to 10.0 in region where moment governs the design.

   b. that the ductility factor is equal to 3.0 in regions where shear or diagonal tension governs the design.

In those cases where a calculated time history forcing function defined at the point of a break was not available, such forcing functions were conservatively defined as a rectangular pulse with zero rise time and a duration at least ten (10) times the fundamental period of the affected structure. The magnitudes of these forcing functions are:

$F_i = 1.2\ P_i\ A$ and

$F_s = 1.2\ P_s\ A$ where:

P_i = system normal operating pressure of the initiation of the break

P_s = saturation pressure evaluated from the piping pressure response after the postulated break.

A = cross sectional area of the pipe.

Based upon air analysis of piping pressure transients, F_s was taken as 2/3 F_i. For assumed slot failures, the break opening was taken as a length equal to twice the diameter of the pipe and having an area equal to the cross sectional area of the pipe. The jet was assumed to diverge with a solid angle equal to 10^o on each side.

For the purpose of calculating jet impingement loads, a displacement of one pipe diameter (i.e., outside edge to outside edge) was assumed unless such a displacement was physically impossible (i.e., in the sleeve through the reactor cavity shield). This is a conservative assumption for guillotine breaks of the reactor coolant system and the steam line, since hinges cannot form and the pipes will move laterally away from each other only slightly.

Stress Criteria

The allowable shears for the jet loads were determined by the following formulas:

a. Peripheral shear (governing in line of punching shear) Art. 1707, ACI 318-63

$$vu = \frac{vu}{b_o d}$$ 17-7 of ACI 318-63)

$$v_c = 4o\sqrt{f'_c}$$

where b_o = periphery of critical section

$$= 2 \quad P\left(R + \frac{d}{2}\right)$$

where R = radius of jet cone, with other symbols as defined on p. 318-71 of ACI 318-63.

b. Radial shear - Art. 1701, ACI 318-63

$$v_c < 3.5o\sqrt{f"c(1.0 - .002\frac{N}{Ag}}$$

where N = axial tension

and

$$v_c < 0(1.9\sqrt{f"c + 2500\frac{pwvd}{M'}}\ )$$ eq. 17-2 of ACI 318-63)

$$< 3.5\,\Phi\sqrt{f'_c}$$

where

$$M' = M + N\left(\frac{4t - d}{8}\right)$$ (eq. 17-3 of ACI 318-63)

For shears exceeding the values listed above, web reinforcing was added.

Results of the Analysis

The analysis for the jet loads involves a consideration of the "source" and the "target". Each postulated pipe break was considered as a source and the barrier or compartment internal structures were considered as targets. Each target was analyzed for the effects from each source.

All potential targets are protected from jet forces in at least one of the following manners:

a. The source and the target are physically separated or the break orientation is such that the structure is not a target.

b. The energy level of the source is insignificant relative to the target.

c. There is an interference between the source and target such that (a) and (d) apply.

d. The target is capable of resisting the jet impingement forces resulting from the postulated pipe break.

The original targets considered included the operating deck, the steam generator and pressurizer enclosures, the crane wall, the fan-accumulator rooms, the missile shield, the reactor cavity primary shield, the containment wall, and the fill slab. Note, that in all cases, the containment wall integrity was not affected by jet impingement. The results of the analysis are presented in Table 5.2-5. Only the primary target for each break is presented because the secondary targets are subjected to much lower forces.

This analysis was conducted in a conservative manner since (1) the break locations considered were more severe than those the Westinghouse position papers and App. B2 of ANS-20 indicated, (2) no energy dissipation due to distance or turbulent discharge was considered, and (3) the pipe was assumed to displace one pipe diameter when, in actuality, the pipe would not hinge.

This Leak-Before-Break (LBB) methodology eliminates the design requirement to consider the dynamic effects (pipe whip effects, blowdown jet forces, and main coolant loop and reactor vessel support loads) of postulated main coolant loop ruptures and Unit 1 pressurizer surge line ruptures.

5.2.2.8 Pipe Whip Restraint Design

The criteria for break postulation are provided in Section 5.2.2.7. The design requirements for the restraints are as follows:

The restraints were evaluated by either an equivalent static approach or using an energy balance approach.

The methodology for the static approach is described in Section 14.4.5.

The calculations, when using the energy balance approach, were performed by comparing the kinetic energy of the ruptured pipe imparted to the restraint system to the strain energy of the restraint system. Hot gaps at the restraints were considered in the calculations to account for the total kinetic energy. The blowdown thrust is time dependent and depends on the fluid conditions in the pipe.

The allowable ductility limits are noted in Section 5.2.2.7.

5.2.2.9 References for Section 5.2.2

1. NRC Safety Evaluation Report N85176, Dated 11/22/85, Safety Evaluation By The Office Of Nuclear Reactor Regulation Related To Amendment No. 76 To Facility Operating License No. DPR-58
2. NRC Safety Evaluation Report N99129, Dated 12/23/99, Safety Evaluation By The Office Of Nuclear Reactor Regulation Related To Amendment No. 236 To Facility Operating License No. DPR-58 And Amendment No, 218 To Facility Operating License No. DPR-74 Indiana Michigan Power Company Donald C. Cook Nuclear Plant, Units 1 and 2.
3. NRC Safety Evaluation Report Dated 11/08/00, Safety Evaluation By The Office Of Nuclear Reactor Regulation Request To Apply Leak-Before-Break Status To The Pressurizer Surge Line Piping At Donald C. Cook Nuclear Power Plant, Units 1 and 2.

5.2.3 Vessel Structural Analysis (Static)

Three separate containment vessel structural components were analyzed, each in equilibrium with the loads acting on it and with the constraints occurring at its juncture with other structures. The three structural components are:

a. The hemispherical dome
b. The right cylinder
c. The base mat

Since the thickness of the dome and cylinder are small in comparison with their radii of curvature (cylinder 3.5/57.5 = 1/16.4, dome 2.5/57.5 = 1/23.0), the dome and cylinder were treated as thin-walled shell structures.

All tensile stresses in the design were assumed to be carried by the reinforcing steel. No credit was taken in the design of the shell, for the capability of the liner to carry tensile, compressive or shear stresses.

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

The juncture of the cylinder to the dome is a point of discontinuity since the dome and cylinder have different radial stiffnesses under load.

The juncture of the cylinder to the base slab is a point of discontinuity. In the analysis, the cylinder base slab juncture was considered to be a point of infinite rigidity and at this point the cylinder does not expand or rotate under the internal pressure and temperature load conditions.

The containment vessel structure was analyzed in the following manner:

1. The forces due to pressure wind (or tornado), dead load and thermal considerations were determined by thin shell theory following procedures in "Thin Shell Concrete Structures" by D. Billington and "Stresses in Shells" fourth printing by Wilhelm Flugge.
2. The dome and cylinder were initially treated as independent structures and the primary systems were solved. The edges of the structures were considered free to displace (i.e., translate and rotate). This solution results in membrane stresses.
3. The magnitudes of the edge displacements were determined.
4. The amount of translational and rotational displacement due to unit edge loads at the boundaries were determined.
5. At the joint between dome and cylinder, compatibility was achieved by computing the magnitude of the edge effects required to eliminate the differential of displacement between the boundary of the dome and that of the cylinder.
6. The results of Step "5" are meridional and hoop stresses which were superimposed on the meridional and hoop membrane stresses resulting from the solution of the primary systems of Step "2" and meridional bending moments.

7. A similar procedure to that of Step "5" was followed for the lower edge of the cylinder, where the cylinder joins the base slab, to achieve compatibility of displacement between this boundary and the base slab.

For additional conservatism in the determination of meridional moments at the points of discontinuity, the concrete was considered to be fully cracked vertically. Poisson's Ratio was not considered and Young's Modulus was taken as the value specified in ACI 318-63, Section 1102. No variation of this value was considered.

The equivalent internal pressure load imposed on the containment shell due to thermal loads was determined considering the fact that commercially available plate could vary by +7 percent or -3 percent from its nominal thickness and that the actual yield point may exceed the minimum yield value by 30 percent.

The equivalent pressure load on the concrete shell, as determined from the liner thermal load, was based on plate being +7 percent greater than nominal thickness and plate stress 30 percent greater than minimum yield.

Unsymmetrical pressure and thermal loadings exist because of various relatively confined areas in the lower compartment and because the ice condenser does not cover the full 360 degrees of the containment structure. The effects of this asymmetry were evaluated.

The analysis of the containment structure for seismic loading was by beam flexure theory. See Appendix F of the Original FSAR. For the seismic analysis, a range of shell rigidities was considered to allow for various depths of crack in concrete.

The containment structure was designed by Ultimate Strength methods conforming to the behavior criteria of ACI Code 318-63, Part IV-B - "Structural Analysis and Proportioning of Members - Ultimate Strength Design."

Stress and strain limits conform to ACI-318-63. Capacity reduction factors are as indicated in Section 5.2.2.

Principal reinforcing used in the containment structure has a minimum yield strength of 40,000 psi and a minimum ultimate strength of 70,000 psi. Concrete has a minimum 28-day compressive strength of 3,500 psi. In the analysis the concrete was not considered to carry any tensile forces.

For containment structures, the 28-day compressive strength of concrete is determined in accordance with the statistical methodologies outlined in ACI 214-65. The values utilized for input are obtained from the construction pour cards, which include the pour location, batch design, and compressive test results. This compressive strength value is utilized for determination of the design structural capacity utilizing the load combinations given in Section 5.2.2.3. Additionally, as-tested reinforcing bar strength was utilized for the determination of design structural capacity for the control rod drive missile shield.

The radial shear carrying capability of the concrete at each section was evaluated according to the procedure of ACI-318-63, Part IV-B, Section 1701. Where shear reinforcing was required it was considered that all the shear at the section is carried by the shear reinforcing.

Where radial diagonal bars were required, they were not lap spliced with the main vertical or inclined tangential wall bars, but were either bent back and forth between the opposite faces of the wall to form a continuous stirrup or the bars were hooked about the main reinforcing to achieve positive anchorage.

Supplementary reinforcing which was added to accommodate local conditions such as discontinuity stresses was carried a sufficient distance beyond the region where it is required and anchorage was achieved by means of end plates cadwelded to reinforcing bars.

Dome

The analysis of the hemispherical dome was performed by the super position of the stresses resulting from gravity, accident pressure and thermal loads. In addition, earthquake or wind loading creates both direct and shear stresses in the dome.

Cylinder

The analysis of the cylinder was performed by the superposition of the stresses resulting from gravity, pressure and thermal loads, over-turning due to earthquake or wind, and shears due to earthquake or wind.

The concrete was reinforced circumferentially using steel hoops and vertically by vertical reinforcing. Tangential shear reinforcing as required to resist shear due to earthquake or wind was placed at 45^{o} to the vertical, (i.e., on each side of the vertical).

Although the cylinder wall was considered fixed at its juncture with the base slab, to determine the discontinuity stresses in the thin shell analysis, the effects of base slab edge rotation on the cylinder wall due to the elastic subgrade and the effects of base slab edge deformation due to accident internal pressure loading were determined. Then the cylinder base discontinuity stresses were modified as required.

There is no soil backfill along the lower part of the cylinder wall, therefore, the wall has no elastic restraint due to soil backfill.

The effects of penetrations through the cylinder wall were considered. Penetrations nine (9) inches or less in diameter do not significantly perturb the reinforcing pattern in the containment wall, therefore no special reinforcing considerations were made at these areas.

For penetrations with diameters between 9 inches and approximately 4 feet - 6 inches, the reinforcing was either terminated or bent around the opening. When necessary to achieve positive anchorage, terminated reinforcing was cadwelded to end plates at the periphery of the penetration. Supplemental reinforcing was added in the direction of the main reinforcing, and diagonally, to replace the terminated reinforcing. The area of supplemental reinforcing added is twice that of the terminated reinforcing and was placed adjacent to the penetration. The additional reinforcing was extended a sufficient length beyond the area, which was considered to be significantly affected by the stress concentration due to the penetration, so that the additional reinforcing develops its full ultimate strength at ultimate bond stress. The length of these additional reinforcing bars is based upon the applicable requirements contained in ACI 318-63. Consideration was also given to hooking the ends of this additional reinforcing to provide positive anchorage, where termination of the reinforcing steel occurs in a tensile zone.

The only openings in the concrete shell greater than approximately 4 feet -6 inches in diameter are:

a. The equipment hatch

b. The personnel access hatch

These large openings are reinforced with a thickened concrete ring beam around each opening.

The external loads applied at the openings are dead load, pressure due to incident conditions, temperature associated with the accident conditions and earthquake load. The design combinations considered are essentially the same as for the rest of the cylindrical shell and are considered according to the factored load equations in Section 5.2.2.3. Secondary stresses in the concrete ring beam result from the peripheral forces of the penetration itself due to the internal pressure of the accident condition, earthquake or tornado. Additionally, secondary stress is induced by the curvature of the ring to match the cylinder.

Analysis of the ring beam and the adjacent area was made using a finite element program by the Franklin Institute Research Laboratories.

Base Mat

The containment building base mat was analyzed by three independent methods. The STRUDL and GENSHL 5 computer programs were used and manual calculations were made as a check on the computer programs.

Dead load, soil reactions, thermal loads, wind loads, tornado loads and earthquake loads were considered in the design.

Three soil reaction distributions were considered for the static load condition. The most probable soil reaction is a fairly uniform bearing pressure as indicated in Case I in Figure 5.2.2-57. However, the soil reaction may vary linearly to a condition of maximum bearing pressure under the pit indicated as Case II of Figure 5.2.2-57 or it may vary linearly to a condition of maximum bearing pressure at the edges of the slab as indicated in Case III of Figure 5.2.2-57.

Lateral soil pressures on the walls of the reactor cavity and the refueling canal were considered in the analysis.

Seismic and wind or tornado conditions cause over-turning moments. The soil reactions for these conditions was directly super imposed onto the static cases as indicated in Case IA, IIA, and IIIA of Figure 5.2.2-57A.

The soil reactions were considered as member loads in the STRUDL computer program. The GENSHL 5 program has a provision for an elastic foundation material.

The dynamic model of the containment includes a rocking spring below the base slab, and a lateral spring at the base mat elevation. The soil below and around the base mat is accounted for by the stiffness of these springs, which were determined from the dynamic soil modulus and the base mat geometry.

The maximum component of soil pressure due to earthquake loads is 2.5 ksf for the "OBE" and 4.0 ksf for the "DBE".

The maximum soil pressures for both uniform and non-uniform soil pressure distributions including the DBE pressures are shown in Figures 5.2.2-58 and 5.2.2-58A. The maximum soil pressure under combined seismic and other appropriate loads is 14.8 ksf. This is a factor of safety of 2.4 based on the ultimate bearing capacity of the underlying clay stratum of 36 ksf. This factor of safety is conservative since it is based on the unconfined compression tests of the clay and since it neglects the influence of the sand layer overlaying the clay in distributing the load.

The stresses in the base slab resulting from the internal pressure due to the accident condition were treated separately. These stresses were then added to the stresses previously determined.

The edge deformations of the base slab for the accident condition were determined and the cylinder base discontinuity stresses were modified as stated previously in this subsection under "Cylinder".

The base slab was analyzed for the effects of a temperature gradient of 110°F on the inside surface of the structural concrete adjacent to the liner and a 45°F temperature on the outside of the concrete against the soil.

Loading was applied to the base slab in accordance with the factored load equations in Section 5.2.2.3.

Each loading condition for the entire containment structure was calculated separately and the method of superposition was used to obtain the resultant foundation loading, base moments and shears.

The loadings considered for the reactor cavity are:

1. Dead load (concrete)
2. 10 psi external pressure
3. 30 psi internal pressure
4. 65 psi internal pressure
5. Dead load (reactor)
6. Operating thermal load
7. Steam Generator #1 lateral load due to accident - radial
8. Steam Generator #1 lateral load due to accident - tangential
9. Steam Generator #2 lateral load due to accident - radial
10. Steam Generator #2 lateral load due to accident - tangential
11. Reactor lateral load due to Loss of Coolant Accident
12. Seismic lateral load due to Operating Basis Earthquake
13. Seismic lateral load due to Design Basis Earthquake

A. 1 + 4 + 5 + 6

B. 1 + 3 + 5 + 6

C. 1 + (1.2) 2 + 13 + 6 + [(7+8) or (9+10) or 11]

D. 1 + (1.5) 2 + 12 + 6 + [(7+8) or (9+10) or 11]

E. 1 + (1.8) 2 + 6 + [(7+8) or (9+10) or 11]

F. 1 + 5 + 6

The heat generation rates due to radiation in the primary concrete were calculated by using a point kernel analysis technique. In addition to the reactor core sources, the code considers the captured gamma and inelastic neutron scattering contributions outside the core and within the concrete.

A description of the analyses using the STRUDL and GENSHL 5 computer programs and the manual calculations follows:

STRUDL Computer Program

The circular slab was modeled as a gridwork of beams framed in the circumferential and radial directions. The wall and the slab of the reactor pit were modeled as a space frame connected with the circular mat as a continuous structure. The slab section under the containment wall and the crane wall were modeled to include the stiffening effects of the walls. The foundation mat was supported by vertical and horizontal soil springs, which represent the soil modulus of the elastic subgrade.

The soil spring stiffnesses were varied to achieve a soil pressure distribution to meet the criteria indicated in Figures 5.2.2-57 (Case II or Case III) and 5.2.2-57A (Case IIA or IIIA). The earthquake evaluation was made considering a dynamic soil modulus. Case I "Uniform Pressure Distribution" was not recorded since it resulted in smaller values than either II or III for both static and dynamic conditions.

GENSHL 5 Computer Program

To model the reactor pit, mat, containment wall and dome into the "GENSHL 5" program, which only takes bodies of revolution, the unsymmetrical shape of the reactor pit was replaced by a cylindrical body of revolution. Both translational and rotational soil spring constants were supplied directly to the foundation for Case II or IIA and Case III or IIIA as mentioned under the "STRUDL Program".

Factored load combinations (a) through (h) of subsection 5.2.2.3 including the unsymmetrical tornado and earthquake loads were run on both the STRUDL and the GENSHL 5 computer programs. Earthquake forces were introduced onto the foundation mat as a cosine function. The earthquake evaluation was made considering a dynamic soil modulus. The maximum compressive and shear stresses in the concrete and the tensile stresses in the reinforcing steel occur in the 10 ft. thick mat at the junction of the mat and the reactor wall for load combinations (b) and (d). According to the "GENSHL 5" program the computed maximum compressive and tensile stresses in the slab cross-section are -2400 psi and 36,000 psi respectively. The maximum vertical shear stress across the 10 ft. mat section is 160 psi. The shear stress in excess of 110 psi is taken by the shear reinforcing.

Manual Calculation (used as a check on the computer analysis)

The irregular shape of the mat, caused by the reactor pit allows only an approximate analysis. The reactor pit area was replaced by an equal sized slab of equivalent stiffness. The foundation mat was then analyzed as a circular plate on an elastic foundation. The reactor pit area was analyzed separately as a rigid frame.

Liner

The liner was designed considering loading due to normal operating, proof-testing and accident conditions. Earthquakes or tornadoes cause straining of the concrete, which is transferred to the liner because of the anchorage system attaching the liner to the containment wall. The stresses in the liner due to this transfer of strain are ±3550 psi for the "Design Basis Earthquake" and ±2300 psi for the "Operating Basis Earthquake" and were considered in the liner analysis.

All loads were analyzed separately and then combined in accordance with the factored load equations in Section 5.2.2.3.

The liner was also designed, and stiffeners were provided as required to resist the hydrostatic head due to the freshly poured concrete.

The liner was not considered to participate in resisting lateral shear in the design of the containment wall.

The containment liner functions as a leaktight barrier under all postulated operating and accident conditions.

The liner strain capability is limited by the weld material. Although the ultimate strain of the weld material is 17% in 2" (0.17"/"), the limiting allowable strain is conservatively set at 1.1% (0.011"/").

The computed compressive and tensile strains are 0.01003 in./in. (i.e., 1.003%) and 0.00917 in./in. (i.e., 0.9%) respectively, for hypothetical buckling of a liner panel.

Stress limits as stated were derived from Table N-424 of the ASME Boiler and Pressure Vessel Code-1968-Section III-Nuclear Vessels.

Because commercially available plate varies in thickness, the buckling analysis for the liner was made considering plate variations of +7 percent and -3 percent from nominal thickness.

The containment reinforcing was designed to yield point stress for the factored load equations. The ratio of liner steel area to reinforcing steel area is large for this type of low design pressure containment, because a nominal liner thickness of 3/8 inch for the cylinder and dome was imposed by construction considerations. This large ratio of liner area to reinforcing steel area, which was not considered in the design, precludes the liner being stressed in tension beyond its minimum yield stress.

Since the function of the liner is to act as an essentially gas-tight membrane, no credit was taken for the liner's ability to resist primary bursting stresses. This is an extremely conservative assumption since the liner is capable of carrying the design pressure within its tension yield capacity without any assistance from the concrete reinforcing steel. This fact results in two structural systems acting in parallel, either of which is capable of carrying the design pressure load elastically.

Cycling loads considered in the initial design of the liner were:

1. Thermal cycling due to annual outdoor temperature variations. Daily variations do not significantly penetrate the concrete shell to influence cycling on the liner.
2. Thermal cycling due to containment interior temperature varying during reactor system startup and shutdown was considered to be 200 cycles.
3. Thermal cycling due to accident condition was considered to be 1 cycle.
4. Cycling due to earthquake was considered to be 10 cycles.

Evaluations concluded that the fatigue analysis for the containment liner remains valid for the period of extended operation associated with license renewal.

At plate joints the liner anchorage was designed to accommodate a differential of load due to the variations of adjacent plate thicknesses of 10 percent of the nominal thickness.

Liner stresses around openings were analyzed in accordance with the procedures shown in the "Theory of Elasticity" by S. Timoshenko and J. W. Goodier. The analysis neglects the stiffening effect of the penetration sleeve and thus over-estimates the distortion due to the biaxial stress field.

The liner meets selected requirements of the ASME Pressure Vessel Code. The openings in the liner were compensated for in conformity with the philosophy of this code.

The liner plate is anchored to the concrete by additional angles around each penetration.

The bottom liner plate is welded at the joints to continuous structural members, which are embedded in and anchored to the concrete base slab.

The juncture of the cylinder and the base slab is fixed. There is no differential translation of the cylinder bottom with reference to the base slab. The only rotation, which could occur at this juncture, is that rotation which results due to the straining of the meridional reinforcing in the cylinder wall at the joint area. The liner juncture at the base was designed to accommodate this rotation.

Figures 5.2.2-59 and 5.2.2-59A illustrate the liner arrangement under the reactor and at the juncture of the base slab and cylinder. The behavior of the liner at the base of the containment wall was investigated for accident conditions. The cylindrical knuckle, which serves as a transitional member between the wall liner and the mat liner, was considered as an arch with fixed supports. There is no danger of buckling because in the accident case, the knuckle experiences only tensile stresses. Local cracking of the concrete at the anchors would not result in the loss of the anchor. This is because of the anchor length and because the anchors are tied back deeper into the concrete wall by Nelson Studs which are welded to them. The arrangement at the bottom of the reactor pit is somewhat different. The wall liner meets the liner of the floor slab at right angles. Both liners are welded at their junction to an anchorage angle embedded in concrete. Since the liner is protected from accident temperature by the concrete fill, the only stresses that exist are the axial stresses which are induced in the liner plate by normal temperature gradients. These direct compression stresses induced by the restraining concrete are low enough to be carried by the steel plate without either buckling or yielding of the liner between anchorages. As previously mentioned the strain limits developed for this design are conservatively set at 1.1% strain.

Lateral load transfer under the interior structure is accomplished by a series of interrupted keys in the base slab. The load transfer is through direct bearing. The maximum bearing stress is 2200 psi. The liner follows these keys so that there is no loss of liner leaktight integrity. See Figure 5.2.2-59B.

The fill concrete in the core of the containment is locked between the crane wall and the primary shield and therefore transfers its lateral load to both the crane wall and the primary shield.

The lateral load of the fill concrete in the annulus between the crane wall and the containment wall is transmitted to the crane wall by rebars embedded into the crane wall. See Figure 5.2.2-59B.

Uplift forces are not transmitted through the liner plate. All equipment uplift forces are transmitted by means of weldments anchored directly into the concrete. See the reactor coolant pump and steam generator support anchorages, Figure 5.2.2-59C and the ice condenser support column anchorage, Figure 5.2.2-59D.

The crane wall experiences some net uplift force and is anchored to the foundation slab by dowels which are welded to, but do not penetrate the liner. See Figure 5.2.2-59E. The maximum computed stress in the dowels is 10,000 psi.

The seams of the bottom liner plate are covered by weld channels. To prevent the imposition of lateral loads onto this channel due to the thermal expansion of the bottom fill concrete above the liner or due to earthquake, the weld channels, where required, were encased in a Styrofoam material before the fill concrete was placed.

Where loadings must be transferred through the liner, they are transferred through the liner in a direct path by means of structural weldments embedded into the concrete. The leak tight integrity of the liner is not impaired.

Internal Structure

In addition to the three basic containment vessel structural components, there exists an internal structural system consisting of the reactor shield, divider barrier and other internal components. This internal system is completely separated from the containment vessel shell at all elevations above the base slab, to prevent the imposition of restraints or concentrated loads on the containment vessel cylinder wall. The internal structure is a self-supporting reinforced concrete structure, capable of withstanding all loads to which it is subjected. The dynamic analysis considered independent movement of the interior and exterior structures and the maximum deflections obtained were used to determine the required separation of the two structures (i.e."rattle space").

An annulus space of 13 ft. exists between the crane wall and the containment wall. Within this annulus space are two slabs and a number of radial walls, which frame into the crane wall. All of these slabs and walls maintain a nominal 4-inch gap to the liner. When allowance is made for construction tolerances and liner weld test channel depths a clear rattle space of at least 1-3/8" remains, which is greater than the maximum differential motion calculated to occur between the internal structure and the containment shell.

Static and thermal loading conditions for the crane wall were analyzed in accordance with the procedure in "Theory of Plates and Shells", second edition by Woinowsky-Krieger. The crane wall was considered to be a complete cylinder for initial analysis. The section at the equipment hatch area was then removed and a vertical section of the cylinder at each side of this opening was considered to act as a vertical beam spanning between the crane girder and the floor. Restraint to radial deformation at the edges of the opening is provided by the end closure walls of the ice condenser compartment, which are oriented radially and considered to cantilever from the operating deck. Discontinuity moments were considered at the edges of this large opening and at the steam generator and pressurizer enclosures.

The forces and moments determined from manual computations for static and thermal loading conditions were used as a check for those forces and moments determined from the computer analysis. In the computer analysis, the internal structure was modeled as a space frame composed of a network of prismatic members. The computer program used was the "American Electric Power General Frame Analysis."

The internal cylinder was modeled as a grid work consisting of horizontal beams located at intervals along its height and vertical beams, which intersect the horizontal beams. The vertical beams extend from the top of the cylinder to the base slab or terminate at openings.

The steam generator and pressurizer enclosures were similarly modeled. The horizontal members were framed to the interior cylinder at the nodal points (intersections between vertical and horizontal members). The vertical members of the enclosures were framed to the nodal points of the floor (barrier slab) grid.

The floor slab and reactor primary shield were modeled in a similar manner.

The forces, moments and shears determined from the seismic dynamic analysis were superimposed on those determined from analyses of other loads in accordance with the factored load equations as indicated in Section 5.2.2.3.

It was assumed in the post LOCA containment pressure analysis that there will be minimal steam bypass of the ice condenser, limited by the divider barrier structure and its flexible seals. A flexible barrier located between the ice condenser compartment and the containment cylinder wall prevents the flow of steam and air from bypassing the ice condenser. The extent of the seal is shown in Figs. 5.2.2-60B and 5.2.2-60C.

The flexible seal does not carry pressure itself but it is backed up by a steel plate with which it is in contact. The backing plate and supporting steel seal assembly were designed to withstand a peak pressure loading created by a DBA (either LOCA or MSLB). The stresses within the DBS and transferred by it to the adjacent structures during a DBA and DBE have been shown to be within the AISC-69 code allowable stress limits. The seal material meets the minimum tensile strength and elongation requirements as stated in the Technical Specifications.

Under operating conditions the seal sees very little radiation, however, there may be some areas which could be exposed to a dosage of 40 MR/HR (0.0014×10^7 Rad. for 40 years continuous plant operation). Under accident conditions activity release assumptions, the seal material would see a dosage of 4.05×10^6 Rads. in 10,000 seconds. The seal material must remain functional during operating conditions within its material life and it must remain functional for two hours during accident conditions. It is required that ice condenser bypass be limited for the period of ice melt-down which is 5,500 seconds (approximately 1 1/2 hours).

The replacement seal material has been tested for the effects of exposure to operating temperature, accident temperature, radiation, and moisture in the presence of dilute borate solutions. The elongation properties of the seal material have been found to be acceptable after exposure to the items above.

The spacing between bolts holding the seal is at least 3". The maximum lateral movement between the containment wall and the top of the crane wall has been calculated as a function of elevation, and shown to be less than 1.3", and therefore less than the rattle space provided. An assumed movement of 1.3" represents less than 44% elongation in a 3" span. The flexible seal material has the capacity of at least 100% elongation before it will rupture, providing ample margin for the maximum expected displacements.

The differential movements and resulting stresses were calculated at each DBS location for a combination of a DBA and DBE. The stresses have been shown less than the maximum stresses allowed by the AISC-69 Code. Therefore, it is concluded that the DBS assemblies are capable of withstanding the forces of an accident or an earthquake, at all the locations where they are installed.

The replacement seal was field drilled during installation to match the bolt locations.

The seal is accessible for inspection and replacement. The divider seal is inspected at least once every eighteen months during a unit shutdown.

If the seal was not provided, a bypass area would exist between lower and upper containment represented by the annular gap in the seal assembly steel over the length of the seal assembly that forms a boundary between lower and upper containment. The impact of an opening in the seal is dependent on the location of the opening and the accident considered.

Dynamic Analysis for Seismic Loading

Computer runs were made with various soil shear moduli. The analyses showed that for a variation of ± 10% of the soil shear modulus the natural frequency of the structure varies within a range of ± 5%.

Assuming that the concrete modulus of elasticity varies by ± 10% results in an additional ± 5% variation in the natural frequency of the structure. Based on the above, it was concluded that the natural frequency of the structure must have a tolerance of ± 7.5% to reflect the possible variations in the soil and concrete properties.

To allow for soil and structure properties variations, the peaks on the response spectra curve were widened to include frequencies within ± 10% of the resonant frequency.

Containment Structure

The vessel was analyzed to determine its structural response to earthquake loading. A multi degree-of-freedom model of the structure was used. The interrelation of the containment vessel structure and the interior structure through the base and the rotation and translation of the composite structure on the subgrade was considered in the analysis.

The containment structure was modeled as two cantilever beams coupled at the base by a rigid foundation. A modal analysis was made using response spectra to determine the maximum probable peak accelerations at various elevations of the structure by means of the AEP computer program "Containment Vessel Program". Four percent modal damping was used for all modes for the "Operating Basis Earthquake" (10% G) coincident with LOCA. Seven percent modal damping was used for the "Design Basis Earthquake" (20%G) coincident with LOCA. Computed forces from the accelerations so determined were used as input to a shell of revolution model of the structure to determine the stresses.

The dynamic model is shown in Figure 5.2.2-61.

An evaluation was made of the natural frequency and mode shapes of the first three modes. These frequencies were used in conjunction with the response spectra and the appropriate damping factor to evaluate maximum displacements, velocities, and accelerations. The values of these parameters determined for each of the first three modes were adjusted by the modal participation factor and mode shape to obtain the moment and shear for each mode. The moments and shears of the individual modes were combined by computing the square root of the sum of the squares of the individual modal values as indicated in a paper by Dr. Nathan M. Newmark (25 May, 1967) "Design Criteria for Nuclear Reactors Subjected to Earthquake Hazards". Then the effect of the higher modes were evaluated by examining their contribution.

The formulation of the natural frequency equations made use of the stiffness method of analysis. The soil spring constants used for the rotation and translation of the structure were based on the results of field investigation. The percent of critical damping factor used for the 10 percent and 20 percent of gravity seismic conditions were a maximum of 4 percent and 7 percent respectively. The earthquake ground response spectra for the site are shown in Chapter 2.

Possible coupling of the internal structure and the containment vessel structure through the ice condenser internal support structure was considered.

The spring constant representative for the material used for the thick layers of insulation in the ice condenser compartment was 6 psi per inch of deflection. For a spring constant of this magnitude, it has been determined that the effects on the natural frequencies are less than 0.003 percent for the first mode, less than 0.60 percent for the second mode and less than 3.5 percent for the third mode. Moments vary by less than 1.5 percent and the shears by less than 0.20 percent.

Therefore, the effects were considered to be negligible and the mathematical model for seismic analysis considers the interior structure and the containment vessel structure to be uncoupled at all elevations above the base slab.

Torsional effects of unsymmetrically located items of too small a mass to affect the containment structure significantly were analyzed for their effect on local structural elements.

As stated in the discussion of the general analytical model (Appendix "F" of the Original FSAR), to evaluate the effects of the cracking of the concrete, provisions were made in the seismic program to input various percentages of concrete area for the structure.

Structural deflections, due to shear and flexural deformations, were determined for the containment vessel structure and for the interior structure at incremental intervals along the height. The deflections were determined for the individual modes and for the composite response. In the composite response, the rotational offset and the translational offset were included.

It was considered that under the design basis earthquake condition, the reinforcing steel may be stressed to its yield point and that under the operating basis earthquake the reinforcing steel may be stressed somewhat below its yield point. Since the maximum damping values stated include the effects of the soil, they are considered to be conservative.

The percentage of critical damping for use in the seismic analysis of the reinforced concrete structures is dependent upon the stress in the reinforcing steel.

The percentages indicated in Table 5.2-4 were used for the design analysis of the structures. For the condition of approximately yield stress level in the reinforcing steel, the maximum value of percentage critical damping is 7 percent. For stress levels of approximately 1/2 yield stress level, the value of percentage critical damping is 4 percent.

Two sets of percentage critical damping are indicated for the containment structure because, under a condition of seismic occurrence coincident with accident condition, the amount of cracking in the structure is much greater than for the condition of seismic occurrence without a coincident accident.

Auxiliary Building

The Cook Nuclear Plant auxiliary building is a complex structural system, asymmetric in plan, with heavy concrete slabs at various floor elevations. These floor slabs are interconnected with numerous concrete shear walls and or heavy cross-braced steel members. The overall height dimension is smaller than the plan dimensions. This low height to plan aspect ratio indicates that under lateral loads the predominate deformations of the long shear walls will be shear deformation. Consequently, the relative rotations of the slabs about horizontal axes do not cause significant deformations, but because of the asymmetrical mass-stiffness distribution, rotation of the slabs about a vertical axis could occur when this type of structure is subjected to lateral loads. Therefore, if a shear structure is modeled in an X-Y-Z axis system where the Z axis is vertical and the X and Y are parallel to the principal axes of the structure, three degrees of freedom, rotations about the X and Y axes,θ_x and θ_y, and the vertical translation, Δ_z, can be neglected in the model. The motions of the lumped masses in the model are restricted to a horizontal plane and each lumped mass is allowed the remaining three degrees of freedom Δ_x, Δ_y and θ_z.

In discussing the Cook Nuclear Plant auxiliary building model, the words "Model Slab" will be substituted for the words "lumped mass" because the mass of the actual structure is simulated in the model with virtual, infinitely rigid slabs located at the elevations of the major floor slabs and roofs of the structure. The actual slabs are considered to be infinitely rigid in their own planes. The rigid body motions of the model slabs consist of three degrees-of-freedom, horizontal translation in two perpendicular directions and rotation about a vertical axis. The model slabs are interconnected by weightless elastic springs which possess stiffness in the X or Y direction and which simulate the shear walls and vertical bracing in the structure. These springs are distributed horizontally on the model slabs so the torsional stiffness interconnecting two slabs is approximated.

Since the ends of the springs are considered to be horizontally distributed on the special extent of the model slabs, the model slabs are not point masses but may be thought of as rigid bodies with horizontal dimensions where a vertical dimension is meaningless because the mass of the actual structure is considered lumped in the planes of the model slabs.

Mass Properties:

Three coordinates are required to describe the motion of each model slab. Therefore, three mass parameters are associated with each model slab. These mass parameters for the ith slab of the model are:

M_{xi} associated with X translation

M_{yi} associated with Y translation

I_{oi} associated with rotation about a vertical axis

The mass parameter associated with X translation and Y translation is the same and equal to the mass of the slab. The mass polar moment of inertia, I_o, is about a vertical axis through the centroid of the slab.

Stiffness Properties:

When the stiffnesses of the structural components, which interconnect the slabs, were evaluated, the following assumptions were made:

1. All floor and roof slabs were rigid in their own planes (i.e., no joint can displace relative to another joint on the same slab).
2. Walls interconnecting slabs offer resistance to relative displacement of slabs in the direction of the long dimension of the wall only.
3. The stiffness of small reinforced concrete columns or walls and steel can be neglected because their stiffness is small compared to the stiffness of larger walls.

When resisting lateral loads applied parallel to the long dimension, most walls act as short, deep beams, therefore, the contribution of shear to the deflection must be considered in calculating the stiffness of a wall. The stiffness of an individual wall was calculated by the following formula:

$$K = \frac{1}{\Delta}$$

where

$$\Delta = \frac{Fh}{GA}$$

and

F = shear form factor

A = cross-sectional area of the wall

G = shear modulus of concrete

h = height of wall

The stiffness of the steel framing which acts as springs was evaluated with frame or truss analysis computer programs.

The horizontal flexibility of the soil, which supports the auxiliary building, was simulated with linear elastic springs distributed over the base of the model in two perpendicular directions.

Analytical Procedure:

The compilation of the mass-stiffness properties of the auxiliary building began early in the design process. As the design proceeded, the dynamic model was kept current with design changes. To facilitate the calculation, documentation and revision of the model's properties throughout the design process, a computer routine was used to compile input to the dynamic model.

Mass properties of each slab were coded on a card and the program used this data in compiling the mass matrix and the load vector.

Each structural component, which was considered a spring in the model was, assigned an identification number. For each spring, the identification number, stiffness, slabs with which the spring interconnects, and the horizontal distances of the end of the springs from the slab centroids (required to formulate torsional stiffness about a vertical axis) are coded on a card. The program uses this information to compile the stiffness matrix, and after the dynamic response is calculated, it again uses this information to distribute the inertia forces into the structural components by imposing calculated modal displacements on the springs.

Input data to the dynamic program consists of 10 groups of cards, which specify the mass-stiffness properties of the model, degrees of freedom, and the loading. This input is titled and printed as output in the following order:

1. Problem identification
2. Number of X springs
3. Number of Y springs
4. Rocking code
5. X spring constants and topology
6. Y spring constants and topology
7. Seismic loading code (direction of load)
8. Structural symmetry code
9. Slab masses and polar moments of inertia
10. Number of modes to be considered
11. Number of spectral data points or time history data points
12. Spectrum data or time history forcing functions
13. Slabs where responses are required.

Output from calculation done by the dynamic program consists of the following groups of information for each direction of excitation (X or Y or both):

1. Stiffness matrix (optional)
2. Mass matrix (optional)
3. Loading vector (optional)
4. Orthogonality check of eigenvector
5. Modal periods
6. Modal participation factors
7. Mode shapes normalized with respect to the mass matrix
8. Modal displacements
9. Modal inertia forces acting on the masses
10. Probable maximum displacements and inertia forces at slab centroids

11. Probable maximum shear forces in springs
12. Time history response if time history forcing function used as excitation
13. Slab response spectra (optional)

Seismic forces used in the structural design of the auxiliary building were obtained from exciting the dynamic model with the Operating Basis and Design Basis Earthquake Spectra. Two percent of critical damping was used in the analysis.

The equipment design criteria for Class I systems and components supported in the auxiliary building were developed by generating response spectra from the motions of the lumped masses in the dynamic model. Mass motions used to generate response spectra were obtained from a time history analysis of the dynamic model.

Input data for the seismic evaluation of Class I equipment was derived from the computer program. The information for equipment seismic input are natural frequency for each of the first three modes and response curves for the required elevation for the required equipment-damping values.

Seismic considerations for the Auxiliary Building superstructure supporting the Auxiliary Building East Crane were based on the ground response curves (scaled to 0.10g and 0.20g for the OBE and DBE, respectively) in accordance with Regulatory Guide 1.60, Rev. 1. Damping values in accordance with Regulatory Guide 1.61, Rev. 1 were used for the analyses.

5.2.3.1 References for Section 5.2.3

1. Report NED-2000-573-REP (Simplified Evaluations of Design Basis Compliance of Select Containment Building Structures).

5.2.4 Penetrations

In general, a penetration consists of a sleeve embedded in, and anchored to the concrete containment wall and welded to the containment liner. The weld to the liner is shrouded by a channel that must be exposed to containment pressure during the Type "A" Integrated Leak Rate Test (ILRT). The core pipe, electrical conductor cartridges, or air ducts pass through the embedded sleeves. Provision was made for differential expansion and misalignment between pipe, cartridge, or duct and sleeve. No significant loads are imposed on the liner. Pressurizing connections exist on these penetrations; however, only Zone 3 electrical penetrations are still being pressurized from the Containment Penetration and Channel Weld Pressurization System. All pressurizing connections, inside containment, must be open to containment pressure during the Type "A" ILRT. Spare penetrations CPN-71 and CPN-83 (Unit 1 only) were modified for use as service penetrations during outages by removing the weld caps and installing hinged closures.

An elastic stress analysis was performed for each penetration assembly using a finite element computer program.

In determining the penetration stresses, no consideration was given to the ability of a thickened liner to aid in resisting the applied loading.

The allowable stress intensities for the materials used in the penetration assemblies were determined from the criteria presented in ASME Pressure Vessel Code, Section III 1968 Ed, Figure N-414, Table N-421, and Table N-424 and the allowable stresses of USAS Piping Code B 31.1-1967 Ed.

Case	Core Pipe	Sleeve and Flued head
	B 31.1	ASME III
Normal	$S_{allowable} = 1.0\ S_{tabulated}$	$P_m = S_m$ $P_L = 1.5\ S_m$ $P_L + P_B = 1.5\ S_m$ $P_L + P_B + F = S_a$ $P_L + P_B + Q = 3.0\ S_m$
Upset*	$S_{allowable} = 1.2\ S_{tabulated}$	Same as above
	ASME III	ASME III
Emergency*	$P_m = S_y$ or $1.2\ S_m$ $P_L = 1.5\ S_y$ or $1.8\ S_m$ $P_L + P_B = 1.5\ S_y$ or $1.8\ S_m$	Same as core pipe.

* Includes seismic effects

Thermal protection of the concrete at the main steam penetrations (CPN-2, CPN-3, CPN-4 and CPN-5) is provided by penetration coolers; one cooler for the part of the penetration inside containment, and one cooler for the part of the penetration outside containment. Each inside and each outside penetration cooler has two independent and redundant cooling coils. This redundancy assures that the temperature of the adjacent concrete can be maintained below 200°F. For the inside containment penetration coolers, each redundant cooling coil has its own manual supply isolation valve and a return check valve. For the outside containment penetration coolers, each redundant cooling coil has its own manual supply and manual return isolation valve. Thus, in the unlikely event of a failure of one of the cooling coils, the faulty coil can be isolated from the redundant coil. This design ensures that the cooling function continues with the redundant coil.

A pair of cooling coils provides thermal protection of the concrete for other hot penetrations (CPN-6, CPN-7, CPN-8, CPN-9, CPN-10, CPN-16, CPN-34, CPN-37, CPN-47, CPN-66, CPN-77, CPN-78 and CPN-79). For this style of penetration cooler, each redundant cooling coil has its own manual supply and manual return isolation valve. Thus, in the unlikely event of a failure of one of the cooling coils, the faulty coil can be isolated from the redundant coil. This design ensures that the cooling function continues with the redundant coil. The redundancy of the cooling coils assures that the temperature of the adjacent concrete can be maintained below 200°F.

The thermal gradients at each hot penetration, for its operating condition, were determined to establish the cooling capacity required to limit concrete temperatures to 200°F, assuming a 120°F ambient condition. This general 200°F temperature limit assures protection of concrete properties. Calculated operating temperatures are also considered as input into stress analyses to ensure that total stresses do not exceed applicable stress limits.

Thermal protection of the concrete was not provided for containment penetrations and various floor and wall sleeves used intermittently to carry hot fluids as part of the alternate RHR flow path. These containment penetrations and sleeves, CPN-48, CPN-49, CPS-1, CPS-19, CPS-20, CPS-32, CPS-42, CPS-45, CPS-80, CPS-173, CPS-174 and CPS-181, were analyzed for operation without coolers and include evaluations for localized concrete temperatures over 200°F.

Stress analyses using a finite element computer program were performed to determine the stresses and strains in the penetration sleeves for the various factored operating and accident loading conditions. At the junction of the thickened liner and penetration sleeve, the strains determined were a maximum for the accident loading condition. The worst case occurred at an electrical penetration sleeve with a strain of 0.107%. The worst strain for a piping penetration sleeve was 0.055%. The allowable strain has been set at 0.5%.

Stresses in the plastic domain were not combined since the analysis performed did not require consideration of the full plastic strength of the pipe.

Normal shear, bending and torsional reactions from the pipe ruptures are transferred from the pipe sleeve to the containment wall by the system of circumferential and longitudinal lugs on the penetration sleeve.

NORMAL LOADS are transferred to the concrete by bearing under rings attached to the sleeve. The concrete at the perimeter of the ring was checked for punching shear and diagonal tension. When, for accident loads, the punching shear is greater than 500 psi or the diagonal tension is greater than 60 psi, shear reinforcing was added. The normal load imposes local bending on the wall. The magnitude of the resulting stresses were analyzed by elastic beam formulae. Where necessary, extra rebars were added in both the hoop and meridional direction.

SHEAR AND BENDING PIPE LOADS are transferred to the wall by a combination of bearing under the sleeve and radial shear at the perimeter of the rings in the concrete. The same criteria outlined above for normal loads was used for transferring these stresses to the reinforcing steel. The allowable bearing stress = 0.9 x 0.85 f'_c = 2680 psi.

TORSIONAL PIPE LOADS are transferred from the sleeve to the concrete by bearing under the longitudinal stiffeners. The allowable bearing is the same as is given above. These bearing stresses induce shear and tension stresses in the wall, but in all cases these stresses were found to be very small and no additional reinforcing was required.

Where reinforcing bars bent to clear penetrations were stressed to their yield points, the radial compressive stresses in the concrete under the bars were limited to 2500 psi.

The minimum radius of curvature is 3'-0".

In addition to the large bend radius, curved bars have been tied back to adjacent straight bars using #6 ties. See Figure 5.2.2-63.

Where penetrations larger than 4'-0" in diameter are required, the pressure, dead load, operating basis earthquake, design basis earthquake, wind, tornado, operating temperature, accident temperature and shrinkage loads were considered in the design of the openings. The secondary forces were considered by the computer program in the analysis.

The thickened liner around the penetrations was proportioned in accordance with the area replacement method given in the ASME Pressure Vessel Code, Section VIII. For the mechanical and electrical penetrations, a stress analysis using a finite element computer program was performed to determine the stresses in the thickened liner and the penetration sleeve resulting from the various factored operating and accident loading conditions. The thickened liner around the equipment hatch and personnel air lock was modeled with the thickened concrete shell and a finite element analysis was performed for the composite section using the FELAP computer program of the Franklin Institute. Liner stresses were computed for the factored operating and accident loading conditions. The stresses for the thickened liner and sleeve materials were compared with the stresses given in Table N-421, and Table N-424 of the ASME Pressure Vessel Code, Section III - 1968. In all cases the stresses obtained from the stress analysis were less than those specified. As a check on the computer analysis, manual calculations were performed for the operating thermal loads considering the thickened liner as a flat plate with the edges restrained and a uniform temperature change across the thickness. The following equation was used for these approximate calculations:*

$$f_1 = f_2 = \frac{\alpha E \Delta T}{(1 - \upsilon)}$$

Where:

f_1 = Principal meridional stress

f_2 = Principal Hoop Stress

α = Coefficient of Expansion

E = Modulus of Elasticity

ΔT = Uniform Temperature change across the plate thickness.

υ = Poisson's Ratio

* Timoshenko and Goodier, Theory of Elasticity, Second Edition, McGraw-Hill Book Co., p. 401.

In those areas where the yield stress has been reached, the resulting strains were checked and were found to be less than 0.5%.

The computer program used to calculate the liner stresses assumed that there is a compatibility of strain between the liner and the concrete wall. The liner is mechanically attached to the concrete wall by anchors and therefore is less stressed than the computed values.

To determine the critical buckling stress between anchors, the liner was analyzed as a flat plate. This assumption is conservative because the liner would have to buckle against its own curvature. For the analysis, it was assumed that the liner was fixed at the angles and that there was no differential radial movement of the boundaries. The analysis was based on an interaction curve given by A. Pfluger "Stabilitats probleme der Elastostalik", pages 404 and 405, Springer Verlag Berlin 1964. The critical stress resultants N_1 and N_2 are the stresses induced in the plate (see Fig 5.2.2-64) and are defined as $N_1 = K_5 N_e$ where $K_5 = 6.97$.

$N_2 = K_3 N_e$ where $K_3 = 4.00$

$$Ne = \frac{\Pi^2 Et^3}{12\,(1-\upsilon^2)\ x\ 1/b^2}$$

where:

E = Modulus of elasticity

υ = Poisson's ratio

t = Plate thickness

b = Plate width

a = Plate length

It can be seen from the interaction curve that for a = infinity the influence from N_1 can be neglected.

N_2 (Critical) = 60,000 psi

b = Span = 14" = spacing between anchors

(See Fig. 5.2.2-64)

The stress in the liner at operating temperature is -18.5 ksi; the factor of safety against elastic buckling equals $\frac{60{,}000}{18{,}500} = 3.24$.

The specified design stress limits are $\pm$20 ksi for operating condition and yield stress for accident condition.

The thickened liner between the penetration and the transition to 3/8" thickness is anchored by inverted angles with the leg welded to the liner and spaced at 13".

The unbalanced shear forces at the transition from the thickened liner to the nominal 3/8" wall liner thickness are taken by Nelson Studs.

The maximum shear force on a panel occurs during accident conditions when one panel is completely buckled while the adjacent ones remain unbuckled. The unbalanced shear force is transmitted to the concrete by bearing between the angle and the concrete.

The material for both the thickened and unthickened liner plate is A442 Gr. 60.

The stresses in the reinforced plate are transferred to the concrete wall by the angles and Nelson Stud Anchors, described above, and to the nominal 3/8" wall liner through the butt weld connecting the two plates.

The maximum strain is 0.11% for an unbuckled panel and 0.3% at the plastic hinges in a buckled panel. The allowable strain is 0.5%.

A. The Franklin Institute finite element computer program was used to analyze all stresses in the rebar and concrete around the equipment and personnel accesses. The procedure used was to analyze, by the FELAP program, rectangular areas of the wall 75' (Horiz) x 64' (Vert) and 54' (Horiz) x 46' (Vert) for the equipment hatch and the personnel hatch, respectively. These areas were divided into elements approximately 4' x 2'6" in elevation. Different material types across the wall were represented as separate layers. Boundary conditions taken from the GENSHL program results, material properties, loads and temperatures were input for each load condition. From the results, concrete layers carrying tension were allowed to crack and the reinforcing steel design was modified until the stresses were brought within the allowable values.

The openings were checked for operating loads, accident loads and test pressure loads.

1. At Normal Operating Condition

   The loads due to normal operating conditions are:

   a. Operating temperature
   b. Dead load
   c. Shrinkage
   d. Creep

The allowable stresses in the reinforcing steel and concrete due to the worst combination of operating loads were $0.5f_y$ = 20,000 psi for steel in tension and $0.45f'_c$ = 0.45x3500 = 1580 psi in concrete in compression.

2. Test Pressure

The thickened concrete around the openings was analyzed for the following loads under test conditions:

a. Internal pressure of 1.34 times accident pressure equal 1.34x12 = 16 psi

b. Dead load

c. Live load

d. Temperature transients at test conditions

e. Shrinkage

The allowable stresses due to the combinations of the above loads were increased 33% above the operating stresses since the test pressure is temporary.

3. At Factored Loads

The factored load combinations for ultimate design are as follows:

a. 1.5P + DL + 0.05DL + (T' + TL')

b. 1.25P + DL + 0.05DL + (T" + TL") + 1.25E

c. 1.0P + DL + 0.05DL + (T"' + TL"') + E'

The thickened concrete around the openings was checked for the above load combinations.

The capacity reduction factors used in the ultimate design were 0.95 for axial stresses, 0.9 for bending stresses, and 0.85 for diagonal tension. These factors result in allowable stresses in the reinforcing steel of 38,000 psi, 36,000 psi, and 34,000 psi, respectively. The allowable compression in the concrete is equal to 0.9x0.85x3500 = 2680 psi.

Personnel Hatch

The computed maximum meridional and hoop stresses in the rebar were 34,000 psi and 37,200 psi, respectively (load combination a).

Equipment Hatch

The computed meridional and hoop stresses in the rebar were 26,000 psi and 38,000 psi, respectively (load combination a).

The initial run of the FELAP Computer Program was made with an uncracked concrete section and manually estimated areas of reinforcing steel. The results showed which layers carried tension. These layers were then allowed to crack in both hoop and meridional directions for the next run. In subsequent runs, reinforcing steel areas and cracking were modified until the stresses were within acceptable limits. Therefore, it can be seen that the concrete is conservatively assumed not to carry biaxial or uniaxial tension, but that these stresses are carried by the reinforcing by design.

The FELAP Computer Program combined all normal and shear stresses due to axial load, two directional bending, two directional shear and tension. #8 sloping radial reinforcing steel bars were added under the personnel hatch which was the only place where the shear stresses were greater than 60 psi. Extra diagonal reinforcing steel bars were added where the tangential shear stress was greater than 40 psi. The design criteria for the thickened concrete around large openings was the same as for the rest of the containment wall.

The FELAP Computer Program was used to design the thickened part of the containment wall around the openings.

This was checked by comparing stresses at similar points on the GENSHL AND FELAP Programs.

The thickened portion of the wall had little effect on the typical wall rebar stresses except for the vertical sides of the equipment hatch where additional rebar was required to keep the rebar stresses below yield.

Shrinkage imposes tensile stresses in the concrete and compressive stresses in the rebar and liner. Since the compressive stress in the rebar reduces the tensile stresses due to accident loads, they were neglected but the tensile stresses in the concrete will reduce the margin against cracking when accident loads are imposed on the structure. The tensile stresses in the concrete due to shrinkage were calculated from the following formula:

$$f_c = \frac{\eta S_s \tau_s E_c}{(1 - v_s) A_c + (1 - v_c) \eta^A A_s} = 80\#/\text{sq.in.}$$

f_c = stress in concrete

η = ratio of modulus of elasticity of steel and concrete

As = total cross sectional area of steel

τs = shrinkage strain in concrete

The value of τs = 10-4 was taken from the paper by Matlock and Hansen which states that for a given water/cement ratio and aggregate, shrinkage decreases linearly as volume/surface ratio increases. The volume/surface ratio for the containment building wall at the personnel access is 72.*

The maximum volume/surface on the graph equals 8. To be on the conservative side, a volume/surface equal to 24 was used, which by extrapolation gave a shrinkage strain of 10^{-4}.

Torsional stresses were evaluated by the multi-layer FELAP computer program. The analysis this program performed was too complex to check by manual calculation comparing the thickened concrete to a circular plate.

Details of the reinforcing pattern used around large openings such as the personnel and equipment hatches are shown in Fig. 5.2.2-65 and 5.2.2-65A.

A factor of safety of 1.5 was applied to the accident pressure when combined with the associated accident temperature in factored load combination (a); a factor of safety equal to 1.25 when combined with associated accident temperature and operating basis earthquake in combination (b); and a factor of safety equal to 1.0 when combined with associated accident temperature and design basis earthquake in combination (c). The earthquake stresses around the openings are negligible, therefore combination (a) controls and 1.5 is the minimum Factor of Safety.

The allowable stresses for these combinations are ϕf_y or $\phi f'_c$ where ϕ= 0.95, 0.9, and 0.85 for axial, bending and diagonal tension, respectively.

The maximum stress computed by the FELAP Computer Program is 38,000 psi for load combination (a) and, therefore the stress in the rebar at design load would equal:

$$\frac{38{,}000}{1.5} = 25{,}300 \text{ psi}$$

giving a Factor of Safety against minimum yield equal to $\frac{40{,}000}{25{,}300} = 1.60$.

Equilibrium checks of internal stresses and external loads were made both for the GENSHL program and the FELAP program. All bodies modeled in the GENSHL program were checked for compatibility. This particular check was necessary to determine whether the lengths of the

* "Shape of Member on the Shrinkage and Creep of Concrete," Hansen & Matlock, ACI Journal 63/10, Feb. 1966.

bodies selected in the structure modeling were satisfactory. Additional and more detailed checks of the GENSHL Program were made at the following spots:

1. Locations of discontinuities in the geometrical shape such, as the juncture of the shell wall and base mat and the juncture of the shell wall and dome.
2. Locations of major changes in temperature conditions. In the meridional direction this occurs at the lower and upper limits of the ice condenser area (El. 642'-0" and the springline). In the hoop direction this occurs near the limits of the ice condenser area (Azimuths 150° and 210°).
3. Locations of localized accident conditions. The fan accumulator room where the unsymmetrical pressure and thermal loading cause high stresses (El. 630'-0" and Azimuth 90°).

For the FELAP program complete checks were made at the following locations:

1. At the personnel hatch.

   El. 618'-0" at Azimuth 325°. This is in the thickened portion of the concrete close to the haunch where stresses are relatively high.
2. At the equipment hatch.

   El 644'-0" at Azimuth 145°. This is the juncture of the containment shell and the haunch for the thickened portion at the hatch and also where the effect of the thermal condition in the ice condenser compartment can be felt.

<u>Procedures For Checking Results Of "Genshl" Program</u>

A. Compatibility (Internal Check)

   1. Moments and forces acting on the end of any element of the shell and its deformations are exactly equal to those at the adjacent end of the next element, as listed in the results of the computer analysis.
   2. The sum of the products of the internal stresses of all the cross-sectional layers of any element times the corresponding layer thicknesses is equal to the force resultants, axial or shear, given by the computer analysis. The sum of the products of the internal forces of all the layers times the corresponding arms from the centroid of the section is equal to the moment acting in that direction given by the computer.

3. The sum of all the force resultants due to each individual load times the factors for the specific combinations is equal to the final results from the superposition of all individual loads by the computer.

B. Equilibrium (External Check)

The summations of moments and forces given by the computer acting at any element of the shell as a free body are statically in equilibrium with external loads.

1. The axial force in the cylindrical shell, per ft. of circumference, due to internal pressure, given by the computer, is equal to 1/2 PR (meridional direction), and PR, per ft. of height of shell, (hoop direction).

   P = internal pressure (psi).

   R = internal radius in inches.

They are equal to zero for uniform thermal loadings.

For non-uniform or unsymmetrical thermal loadings the sum of the membrane forces throughout the whole cylindrical section of each harmonic function from the computer analysis is equal to zero.

2. In the check of seismic computations, the containment shell is divided into thirteen segments. The sum of the weight of each segment times the acceleration times the arm from the center of gravity of each segment to the base mat is equal to the sum of the resultant moments given by the computer analysis in the meridional direction.

The sum of the weight of each segment times the acceleration (% G) is equal to the sum of the resultant tangential shears at the base mat given by the computer analysis.

3. The curves plotted, based on the foundation settlements from the computer analysis times the corresponding soil modulus of elasticity, are close to the shapes of the foundation pressure distribution stated in the FSAR.

The sum of the computed soil pressures times the corresponding foundation areas is equal to the total loads acting on the mat plus the weight of the foundation mat itself. The discrepancies between the manually computed values and the GENSHL results are less than 10%. The greatest discrepancies appear at points of differences, either in the discontinuity of geometric shape, in the varying stiffness of different layer properties of adjacent elements or in varying loading conditions between adjacent elements.

The computer takes all these into consideration, makes the necessary compatibility corrections, and adds the local bending effects of the shell in addition to the membrane forces.

Procedures for Checking Results of "FELAP" Program

A. Internal Check

1. The sum of the internal stresses of all the layers given by the computer times their corresponding layer thicknesses, is equal to the force resultant in the same direction given by the computer at the middle of panel.
2. For any panel or a group of panels taken as a free body, the sum of all the forces given by the computer acting at the four nodal points of a panel is statically in equilibrium. Likewise, the sum of all the forces given by the computer at the exterior nodal points along the boundaries of a group of panels is statically in equilibrium.
3. Pass a horizontal section through the middle of panels within a certain area. The sum of stress resultants in the meridional direction given by the computer times the width of the corresponding panels is in equilibrium with the sum of forces in the meridional direction acting at exterior nodal points along the boundaries of that sectioned area.
4. Pass a vertical section through the middle of panels within a certain area. The sum of stress resultants in the hoop direction given by the computer times the height of the corresponding panels is in equilibrium with the sum of forces in the hoop direction acting at the exterior nodal points along the boundaries of that sectioned area.
5. The sum of the stress resultants of each individual load times the factors for the specific combination is equal to the final results from the superposition program given by the computer.

B. External Check

1. The sums of the forces acting at any nodal point joining any four panels are statically in equilibrium with the external loads. It is equal to zero in the uniform thermal loading and nodal point or the external loadings acting on the nodal point.

In all cases checked, the discrepancies between the manually computed values and the computer values was less than 10%.

5.2.4.1 Electrical Penetrations

Cartridge-type penetrations were used for all electrical conductors passing through the containment. This type of penetration is a hollow cylinder closed on both ends, through which the conductors pass. Each penetration cartridge provides a minimum of two pressure seals in series for each conductor. Each cartridge is provided with pressure connections to allow test pressurization for leak checking of the two pressure seals. There are a total of 108 electrical penetrations for the two units of the following types and quantities:

Type	Quantity
Power 5 Kv	16
Power 600 V	36
Control	24
Instrumentation	32

Figure 5.2-2 shows a typical electrical penetration.

The penetration sleeves which accommodate the electrical penetration cartridges are standard wall pipe of A333 Grade 6 carbon steel. Penetration sleeve ends were seal welded to weld rings, which are an integral part of the penetration cartridge.

Inspection and Testing

Electrical Penetrations - Prototype Tests

Prior to commencement of full production, a production prototype of the electrical penetrations listed in Table 5.2-3 successfully passed those tests indicated by X. Prototype testing compliance was allowed to be demonstrated by submittal of data from tests conducted on penetrations of equivalent type and design.

Upon completion of the above tests, each prototype successfully passed the High Potential and Leakage test prescribed.

In addition to the prototype test listed in Table 5.2-3 all materials used in the penetrations were quality control inspected, tested and approved for service under operating and accident radiation dosages.

Electrical Penetrations Production Tests

Each completed electrical penetration successfully passed the following tests prior to shipment:

1. Leakage
2. Conductor Continuity Test
3. High Potential Test
4. Insulation Resistance.
5. Corona Test (5kV penetrations only)
6. Impulse Test (5kV penetrations only)

5.2.4.2 Piping Penetrations

Piping penetrations are provided for all piping passing through the containment walls. The core pipe is contained within a sleeve that is welded to the containment liner. Several core pipes may pass through the same penetration assembly to minimize the number of penetrations required. In such cases, each core pipe is welded to the containment side end plate in the penetration assembly. In the case of a pipe carrying a hot fluid, the core pipe may be insulated and cooling may be provided to limit the concrete temperature abutting the sleeve to 200°F. This temperature limit assures protection of concrete properties.

The design ensures that, even under postulated accident conditions, potential resultant torsional, axial, bending and shear loads will not cause a breach of containment integrity. Penetrations were analyzed for the following conditions: a) Normal Operating Conditions; b) Transient Conditions; c) Seismic; d) Pipe Rupture (including consideration of the status of each pipe during the course of an accident). Loads on the penetration sleeve were combined following the principles in ASME Boiler and Pressure Vessel Code Section III. Penetrations were designed such that the rupture of connecting piping will not cause a loss of containment integrity.

Piping between the containment penetrations and the isolation valves outside the containment were designed in conformance with USAS B31.1 for design loads.

The mainsteam pipe penetration assembly is similar to the hot pipe penetration illustrated in Figure 5.2-3. The core pipe within the penetration has a structural capability greater than that of the pipes welded to it. The penetration sleeve and core pipe are joined by a flued head which has a structural capability not less than the core pipe within the penetration assembly. The penetration sleeve in turn has adequate structural capability.

A complete thermal analysis was made of the penetration assembly to determine thermal insulation requirements to be used in conjunction with expanded plate-type coolers to limit concrete temperatures. Calculated operating temperatures are considered as input into stress analyses to ensure that total stresses do not exceed applicable stress limits. Coolers were provided with redundant circuitry and capacity to ensure that concrete temperatures are maintained within appropriate temperature limits with one cooling coil out of service. Thermal analysis to determine the time dependent limitations with regard to the containment liner and concrete was performed to cover conditions of loss of cooling water.

The thermal growth of the penetration sleeve and stress at the anchors and liner weld was considered in establishing temperature limitations.

The penetration assembly is anchored into the containment wall with a structural capability based upon Normal, Upset, Emergency, Faulted and, Faulted (including DBE) conditions as defined in Table 2.9-1. The Faulted condition includes postulated pipe rupture for HELB lines as defined in section 14.4 of the UFSAR.

The penetration assembly was designed to withstand any strains imposed by the liner.

The radial deformation imposed by the liner on the penetration sleeve was considered to be uniform around the circumference of the penetration sleeve and the moments and hoop stresses in the penetration sleeve were determined.

Stresses in the penetration were limited to the values stated in ASME Boiler and Pressure Vessel Code, Section III.

Sump Penetration

Two piping penetrations in the containment sump area are of the pipe and outer sleeve design. The outer sleeve is welded directly to the base of the liner. The weld to the liner is covered by a pressurization channel that shall be exposed to containment pressure during Type “A” Integrated Leak Rate Test. The inner and outer pipes extend through the containment wall and are connected to an isolation valve and enclosure.

Fuel Transfer Penetration

A piping penetration, designated the fuel transfer tube penetration, was provided for fuel movement between the refueling canal in the containment and the transfer canal in the auxiliary building. The penetration consists of a stainless steel pipe installed inside a 24" pipe, as shown in detail on Figure 5.2-4. The inner pipe acts as the transfer tube and connects the containment refueling cavity with the fuel transfer canal in the auxiliary building.

The outer pipe is welded to the containment liner and provision was made for the employment of a seal ring for pressurizing welds essential to containment integrity. Bellows expansion joints were provided on the outer pipe to compensate for any differential movement between the inner and outer pipes and also between the containment and auxiliary building structures. These bellows do not serve as part of the containment pressure boundary.

Specification and Tests

Piping penetrations were designed to the intent of USAS B31.1 1967 Edition and N-Cases' (1955), and ASME Boiler and Pressure Vessel Code Section III 1968 Edition.

Material Specifications for the Piping Penetrations are as Follows

	ASTM A - 516 Gr 70
Penetration Sleeve	ASTM A - 106 Gr B
	ASTM A - 333 Gr 6
Penetration Reinforcing Rings	ASTM A - 442 Gr 60 [*]
Penetration Sleeve Reinforcing	ASTM A - 442 Gr 60 [*]
	ASTM A - 442 Gr 60 [*]
Bar Anchoring Rings, End Plates or Flued Heads	ASTM A - 350 LFI
	ASTM A -182 F 316 and F 304
Rolled Shapes	ASTM A - 442 Gr 60 [*]
Core Pipe	
	ASTM A - 106 Grades B and C
	ASTM A - 516 Gr 70
Carbon Steel	
	ASTM A - 155 KC 70 Class I
	ASTM A - 333 Gr 6
	ASTM A - 312 TP 304
	ASTM A - 358 Class I TP 304
Stainless Steel	ASTM A - 376 TP 304 and TP 316
	ASTM A - 213 (Type 316)
	ASTM A - 249 (Type 316)

NDTT has been considered where required for the materials listed above. The piping penetration assemblies were tested, prior to installation, by pressurizing the annulus between the core pipe and sleeve for 30 minutes during which time the exterior was checked for leaks using a soap

[*] or ASTM A 516 Gr. 70.

bubble solution. If any leakage was found, the assembly was repaired and the assembly retested. Following the soap bubble leakage test, the annulus was pressurized with a mixture of air and 20% by weight of Freon gas. The assembly was then tested for leakage using a halogen leak detector with a sensitivity of 10^{-7} standard cc per second. A mass spectrometer examination was substituted for the halogen leak detection test where it was deemed necessary.

5.2.4.3 Equipment Hatches and Personnel Locks

Equipment Access Hatches

An equipment hatch with an inside diameter of 20'-0" has been provided to enable passage of large equipment and components into the containment during plant shutdown.

Design requirements include:

a. The materials for the equipment hatch conform to the requirements of ASTM A-300 Specifications. The minimum plate thickness is 1 inch.

b. The design pressure is 12 psig, acting from the reactor side. The equipment hatch was fabricated and constructed as a Class "B" vessel in accordance with Section III of the ASME Code.

c. The hatch is equipped with double compression seals for leak tightness. A pressure connection has been provided between the seals for testing of the seals.

d. A removable floor has been provided capable of supporting a live load of 1,000 psf. (If the load being transferred throughout the equipment hatch exceeds the 1000 psf load, the barrel of the hatch, both inside and outside the containment will be shored by means of temporary supports to prevent a structural failure of the body ring of the hatch).

Personnel Locks

Two personnel access locks have been provided, one of which penetrates the flat head of the equipment hatch. Each personnel lock is a welded steel assembly with a door at each end equipped with a double compressible seal to insure leak tightness of the lock. For details, see Figure 5.2-5.

Design requirements include:

a. The materials for the locks conforms to the requirements of ASTM A-516 Grade 70 firebox quality and ASTM A-300 Specifications. The minimum plate thickness is 3/8". The design pressure is 12 psig. The personnel locks were fabricated and constructed as Class "B" vessels in accordance with Section III of the ASME Code.

b. The doors of the personnel locks are interlocked so that one door cannot be opened unless the other is sealed.

c. Each door is equipped with a pressure valve for equalizing the pressure across each door. At no time can the equalizing valves on both doors be opened.

d. A test connection has been provided between the double compressible seals for allowing periodic leak testing of the seals.

e. All shafts penetrating the locks have double O-ring seals and a test connection has been provided for periodic pressure testing for leak tightness.

f. An emergency air supply has been provided to the inside of the lock. This connection was designed to permit periodic testing.

g. The locks have been equipped with limit switches.

h. Indicating lights have been provided outside the lock at each door to indicate whether the opposite door is being operated.

The personnel locks were hydrostatically tested to 15 psig, i.e., 25% greater than the design pressure of 12 psig. Following the hydrostatic testing, the locks were tested for leak tightness by means of Freon-Air mixture, pressurized to the design pressure for 24 hours. All weld seams were checked with a Halogen leak detector.

Accessibility Criteria

Access to the containment during normal operation is limited and is controlled in compliance with the limits set forth in 10CFR20.

5.2.5 References for Section 5.2

1. NED-2000-326-REP, IPS-62 Prototype Test Report of Penetrations Assemblies for Donald C. Cook Nuclear Plant Units I & II.
2. NED-2000-327-REP, IPS-63 IST Conax Joule Heat Calculations for Cook U 1 & 2, Dated 10/22/71.
3. NED-2000-323-REP, IPS-52 IST Conax Corp Report on Spec for Factory Test of EPA for AEP DC Cook 1 & 2, Rev E, Dated 6/6/79.
4. WCAP-7332-L, "Indian Point Unit No. 2 Reactor Internals Mechanical Analysis for Blowdown Excitation," G.]. Bohm, February 1970.
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5.3 ICE CONDENSER

5.3.1 General Description

The Ice Condenser is a completely enclosed annular compartment located around approximately 300° of the perimeter of the upper compartment of the containment, but penetrating the operating deck so that a portion extends into the containment lower compartment. The lower portion has a series of hinged doors that are exposed to the atmosphere of the lower containment compartment which, for normal plant operation, are designed to remain closed. At the top of the ice condenser is another set of doors that are exposed to the atmosphere of the upper compartment; these also remain closed during normal plant operation. Intermediate deck doors are located below the top deck doors. These doors form the floor of a plenum at the upper part at the Ice Condenser and remain closed during normal plant operation.

In the ice condenser, ice is held in baskets arranged to promote heat transfer to the ice. A refrigeration system maintains the ice in the solid state. Suitable insulation surrounding both the ice condenser volume and the refrigeration ducts serves to minimize the heat transfer to the ice condenser boundaries.

In the event of a loss-of-coolant accident or steam line break in the containment, the pressure rises in the lower compartment and the door panels located below the operating deck (a portion of the divider barrier) open. This allows the air and steam to flow from the lower compartment into the ice condenser. The resulting pressure increase within the ice condenser causes the intermediate deck doors and the door panels at the top of the ice condenser to open, allowing the air to flow out of the ice condenser into the upper compartment. Steam entering the ice condenser compartment is condensed by the ice, thus limiting the peak pressure and temperature buildup in the containment. Condensation of steam within the ice condenser results in a continual flow of steam from the lower compartment to the condensing surface of the ice, thus reducing the lower compartment pressure. The divider barrier separates the upper and lower compartments and ensures that the steam is directed into the bottom of the ice condenser. Only a limited amount of steam can bypass the ice condenser through the divider barrier.

5.3.2 Description of Ice Condenser and Components

Included in this section are descriptions of the general arrangement of the ice condenser, the refrigeration-cooling system, the door panels at the top and bottom of the ice condenser, and the ice condenser internals, which form the flow channels and ice beds. Table 5.3.2-1 presents the principal design parameters for the Ice Condenser System.

5.3.2.1 General Arrangement

The general arrangement of the ice condenser is shown in Figure 5.3.2-1. The ice condenser is essentially a well-insulated cold storage room in which ice is maintained in an array of vertical cylindrical columns. The columns are formed by perforated sheet metal baskets and the space between the columns form the flow channels for steam and air. The ice condenser is contained in the annulus that is formed by the containment vessel wall and the crane wall, which is arranged circumferentially over a 300° arc. The refueling canal and equipment hatch are located in the remaining 60° arc.

The ice condenser compartment extends from below the operating deck to the top of the crane wall. The uppermost section of the ice condenser forms a plenum, which accommodates the air cooling equipment and provides access for ice loading and maintenance. Below the operating deck, the inner wall of the ice condenser incorporates the inlet doors, through which, following a DBA, the air/steam mixture from the lower containment volume passes into the ice condenser. The top deck of the ice condenser is formed by doors that are supported from radial beams, which are supported by the top of the crane wall. The intermediate deck doors and support frames form a partition between the upper plenum and the ice compartment.

The ice condenser is insulated at its external boundaries to maintain the total heat load on the cooling system to an acceptable level, and to minimize the temperature gradients on the inner surfaces of the ice compartment. In the region of the walls of the ice compartment, the insulation incorporates cooling air ducts, through which the heat gained is transferred to the coolers in the upper plenum. The temperature of the cooling air in the ducts and the ice is normally maintained between 10°F and 20°F. The floor of the ice compartment incorporates glycol cooling coils. The coils are embedded in the concrete top wear slab to absorb and transfer the heat gained to the refrigeration units.

The heat absorbed by the coolers is transferred to the refrigeration units outside the reactor containment by an ethylene glycol circulation system.

An instrumentation system monitors the ice bed temperature and the position of the inlet and personnel access doors.

5.3.2.2 Ice Support Structure

The ice support structure consists of the lower support structure, ice baskets, lattice frames and columns, and wall panel transverse beam members. These components support and position the mass of stored ice and carry all loads into the ice condenser structural floor and crane wall.

The structural steel lower support structure extends above the floor to provide a clear area behind the lower inlet doors. It consists of 24 horizontal platform assemblies, one per ice condenser bay, supported by 25 vertical portal frame assemblies. Each platform assembly is composed of three straight circumferential beam members and nine radial beam members. The portal frame assemblies consist of three columns, joined by plates, and attached by pins to clevises in the floor.

Five turning vane assemblies are incorporated per bay to turn, direct, and distribute the flow entering through the lower inlet doors during loss-of-coolant accidents. Built up perforated plate assemblies span between outer columns of the portal frame assemblies, acting as jet impingement shields. The portal frame plates provide for attachment of the lower inlet door shock absorbers.

Ice columns are supported vertically and horizontally at their bottoms by the lower support structure radial beams through pins and clevises. The ice columns are composed of part-length round perforated metal basket sections, filled with pieces of ice, and formed to allow exposure to the steam. Coupling rings are provided where two basket sections are joined together. Stiffening rings are located at the mid-section of 12-foot length baskets and at the top of each column. Internal supports are located at six-foot intervals within stiffening rings and couplings to provide vertical support for the ice in addition to the shear support provided by the baskets.

Ice baskets are assembled and lowered into lattice frames to form continuous columns of ice 48 feet long. The bottom ends of the columns are closed with wire mesh to minimize ice falling through. The overall column is composed of baskets in two-foot, three-foot and 12-foot lengths in any combination as long as a coupling ring or stiffening ring is provided at each lattice frame elevation. Ice is loaded from the top into assembled ice basket columns. The columns can be lifted and removed in sections and provisions are made for lifting and weighing entire columns for ice basket surveillance.

Above the lower support structure, ice baskets are supported horizontally at six-foot intervals by lattice frames. The lattice frames are welded structural steel grid work assemblies mounted radially across the ice condenser annulus. The lattice frames are supported vertically by rectangular steel columns that, in turn, are bolted to the lower support structure. Slotted connections are provided at one side of each lattice frame to allow thermal expansion and contraction.

At the crane wall, the support columns are connected to wall panel transverse beam members that transmit horizontal loads to the crane wall structure by studs and embedded plates. The wall panel transverse beam members consist of parallel rectangular steel tubes joined by side plates via cross-bolts and insulating bushings. At the containment wall, the columns are free standing without connections to the wall. Clearance is provided to preclude contact between ice support components and the containment wall during all design basis conditions.

5.3.3 Design Considerations

The following subsections provide a summary of the ice condenser design considerations. The design considerations are presented in two categories: performance criteria, and structural and mechanical considerations. Specific criteria for individual components of the ice condenser are also presented as well as design considerations for normal, earthquake, and accident conditions.

5.3.3.1 Performance Criteria

The performance criteria considered in the design of the Ice Condenser System are described below:

a. The energy absorption capacity of the ice condenser is at least twice the capacity required to absorb all of the energy that can be released
   1. during the initial blowdown of the Reactor Coolant System for all reactor coolant pipe break sizes up to and including the hypothetical severance of the reactor coolant piping, or
   2. during any steam or feedwater system pipe break size up to and including the hypothetical severance of the main steam line inside the containment, without exceeding the containment design pressure.

b. After the types of accidents described in (a), the ice condenser system together with the containment spray system, has sufficient remaining heat absorption capacity such that subsequent heat loads are absorbed without exceeding the containment design pressure. The subsequent heat loads considered include stored and residual heat of the reactor core and coolant system plus a substantial margin for an undefined additional energy release.

c. Sufficient ice heat transfer area and flow passages are provided in the ice condenser so that the magnitude of the pressure transient resulting from the accidents described in (a) does not exceed the containment design pressure.

d. The lower containment compartment is bounded by the divider barrier so that essentially all of the energy released in this compartment is directed through doors at the bottom of the ice condenser.

e. The resistance to flow into the ice condenser is such that the maximum energy input into any section of the ice condenser does not exceed its design capability.

f. The force required to open the doors of the ice condenser is sufficiently low to allow the energy from any leakage of steam through the divider barrier to be readily absorbed by the containment spray system without exceeding the containment design pressure.

g. The inlet doors of the ice condenser are designed to open and distribute steam to the ice bed in accordance with design basis (e) above, for any postulated loss-of-coolant accident or steam line break.

h. Ice with a suitable concentration of sodium tetraborate is used in the ice condenser so that, in the event of an accident, the borated water resulting from the melted ice is available for cooling the core.

i. Raising the pH of the ice by adding boron to the ice as sodium tetraborate provides for the absorption and retention of iodine released from the core.

j. Condensation of steam in the ice condenser aids in the removal of iodine from the containment atmosphere.

5.3.3.2 Performance Capability

Because of the passive nature of the ice bed, the ice condenser function is not susceptible to the failure of active components; thus the consideration of additional capability to accommodate such a failure is not necessary. The ice condenser has an excess of capability for both the rate and quantity of energy released from the Reactor Coolant System or the Main Steam System for all postulated accidents.

The door panels and drain check valve flappers are the only components required to move during an accident. These items are considered to be passive or static components equivalent to rupture discs, rather than active components that require an external signal and energy source to function.

5.3.3.3 Testing and Inspection

The ice condenser design includes provisions for in-service visual inspection of the ice beds, flow channels, door panels, and cooling equipment. Samples of the ice can be taken to check additive concentrations. Ice baskets are capable of being weighed, lower inlet door panels and drain check valves can be inspected, and the lower inlet door opening force can be tested. Testing of the intermediate deck door opening force can be done during periods when the reactor is shut down or during normal (power) operations.

The containment sub-compartment analysis, contained in UFSAR section 14.3.4.2.3.4, assumes a maximum 15% flow blockage through the ice bed flow area.

5.3.3.4 Structural and Mechanical Design

The Structural and Mechanical Design criteria considered are described below:

a. The ice condenser internal structures necessary to maintain operability are capable of withstanding all loading combinations with the stress limits defined in the following Table:

Loading Combinations	**Stress Limits**
Normal plus Operating Basis Earthquake Loads	Within Code allowable
Normal plus Maximum Design Basis Hypothetical Earthquake Loads	Within yield after load redistributions
Normal plus Design Basis Accident Loads	Within yield after load redistributions
Normal plus Design Basis Earthquake plus Design Basis Accident Loads	Within yield after load redistributions

In addition to the stated stress limits, structural stability and deformation requirements are established to ensure that no loss of function under accident and design basis earthquake (DBE) loads occurs.

b. The structure, equipment mounting, supports and joints are designed to accommodate the maximum temperature range and gradients that will occur.

c. Structural loads are not transmitted between the ice condenser internals and the containment shell structure.

d. The ice condenser internals are designed for a lifetime consistent with that of the plant. Evaluations concluded that these internals will continue to meet the design and licensing basis requirements through the period of extended operation associated with license renewal.

e. The ice condenser environment is not conducive to corrosion. The materials of construction are selected to be effectively inert under all conditions of operation of the ice condenser. Corrosion is further prevented by inhibitors or protective coatings, where necessary and non-metallic materials are stable.

f. Materials in the ice condenser system were selected to be compatible with the general environmental conditions inside the reactor containment during normal operating and accident conditions. The choice of materials for the ice condenser insulation panels is compatible with the containment shell.

g. Sufficient redundancy is incorporated in the system design to provide a high level of assurance of plant availability.

h. The components that form the boundary of the ice condenser are continuously sealed to limit the ingress or egress of air and vapor, except where specific provisions are made for venting.

5.3.3.5 Specific Component Design Criteria

The specific Ice Condenser System component design criteria are described in the following sections.

5.3.3.5.1 Ice Support Structure

a. The structure is designed to maintain the ice in the required array to maintain the integrity of performance of the ice condenser. The thermal and hydraulic parameters of the ice condenser are maintained within the established limits consistent with ensuring that the containment design pressure limits are not exceeded.

b. The structure allows for loading, weighing, and removal of the ice baskets.

c. Any section of the ice baskets is capable of supporting the total weight of ice above and below that section.

5.3.3.5.2 Insulated Duct Panels and Insulation

a. The insulation limits the maximum total heat load on the ice condenser refrigeration system to a level that is consistent with the installed capacity.

b. The heat input to the ice bed is minimized by the insulation so that the ice bed performance capability will be maintained for a long period of time if the refrigeration system is shut down. In the region of the ice condenser, increased thermal conductivity due to humidity and compression during an accident will not detract from the performance of the ice condenser.

c. The galvanized sheet metal covers located on the inner faces of the duct panels are sealed, and the outer sheet metal covers adjacent to the crane wall and the end walls form a vapor barrier. Under normal operating conditions, the vapor barrier prevents significant loss of insulation capability due to humidity.

d. At the boundaries of the ice condenser where air-cooling is not incorporated, insulation is provided in a form that satisfies the structural and functional requirements of those areas.

e. The panel insulation is installed as prefabricated sections (fiberglass encapsulated in polyethylene bags) and can be removed and replaced if necessary after the ice condenser internals have been disassembled. Precompression of the ice condenser insulation from structural and leakage tests does not detract from its performance capabilities.

f. The performance of the insulation is not affected by the earthquake conditions.

g. Under accident conditions, the insulation does not affect the overall performance of the ice condenser.

h. The materials used for insulation are suitable for use in the reactor containment and systems.

i. The method of attachment of the panels and their positions relative to the ice baskets and support section structure precludes displacement of the panels during an accident.

5.3.3.5.3 Ice Condenser Doors

Normal Operation

a. The doors restrict the leakage of air into and out of the ice condenser to the minimum practicable limit.

b. The doors restrict the local heat input in the ice condenser to the minimum practicable limit.

c. The lower inlet doors are instrumented to provide indication of their position.

d. Provisions are made so that the lower inlet doors can be inspected and tested during reactor shutdown. Intermediate deck doors and top deck doors are accessible for inspection and/or test during normal (power) operation.

Earthquake Conditions

The doors are designed to withstand earthquake loadings so that the loads do not affect the operation of the ice condenser during normal and accident conditions. These loads are derived from the seismic analysis of the containment.

Accident Conditions

Lower Inlet Doors

a. The doors open (at least partially) in the event of a primary coolant or steam leak which produces an equalization of the cold air head differential pressure across the doors of 1/2 to 1 lb./sq. ft.

b. The inlet doors and door ports of the ice condenser are designed to distribute steam to the ice condenser to limit mal-distribution to less than 150 percent maximum, peak to average mass flow into the ice condenser, resulting from a postulated loss-of-coolant accident that causes the doors to open. That is, the ratio of the peak break flow entering any ice condenser bay to the average break flow entering each bay is limited to 1.5 for the accident transient.

c. The inertia of the doors is low, consistent with producing a negligible effect on initial pressure.

d. During blowdown, adequate flow area is provided for the effluent of condensate and melted ice to drain from the ice condenser, without impeding the distributed input of steam.

Intermediate and Top Deck Doors

During a DBA, the resulting differential pressure opens the doors to permit air to flow into the containment upper compartment.

Intermediate and Top Deck Vents

Venting of the ice condenser for small leak rates is provided by permanent vents in both the intermediate and top deck. This allows the inlet doors to open into the proportioning range.

Ice Condenser Drains

a. The drains have sufficient flow capacity to maintain a water level below the bottom of the lower inlet doors for all accident conditions except those conditions causing the lower inlet doors to travel to the fully open position.

b. The drains are provided with flapper valves to seal the ice condenser and to prevent the loss of cold air during normal operation. When the ice melts during a LOCA, the resulting borated water will flow through these drains to the lower containment and sumps.

c. The drain flapper valves are gravity loaded to hold shut against the cold airhead (1/2 to 1 lb./sq. ft.) in the ice condenser during normal operation. The pressure required to open the drain does not exceed 36 inches of water.

5.3.3.6 Ice Condenser Design Load Conditions

5.3.3.6.1 Normal Loads

For normal load conditions, the ice load is applied statically, and the only lateral load is due to any misalignment of the basket columns and lattice frames. The lattice frame and column structure does not carry any vertical components of load from the ice baskets. Horizontal load components from misalignment of the basket columns and lattice frame locations are minimized by properly adjusting the alignment during installation.

The resultant basket model considered for analysis comprises a bottom pin-jointed, vertical cylindrical shell that is laterally supported at six-foot intervals and vertically supported at the base. The vertical loading due to the ice is assumed to be applied in uniform shear above any section, and is combined with a hydrostatic load below that section, thus accounting for the worst condition of ice support.

The lower support structure carries a total static load from the ice bed that is uniformly distributed. In addition, the inner circumferential main beams support the weight of the insulated duct panels on the crane wall and the reactions at the feet of the inner columns that support the lattice frames.

5.3.3.6.2 Earthquake Loads

In addition to the seismic effects on the ice condenser structure due to the weight of the ice, seismic effects would be transmitted to the structure through the crane wall and floor. The behavior is analyzed using a response spectrum, accelerations, displacements, and relative motions of the walls, as determined from the dynamic analysis of the containment structure.

5.3.3.7 Ice Condenser Seismic Analyses

5.3.3.7.1 Introduction

The lattice frames, ice baskets, wall panels on the crane wall side, and lower support structure of the ice condenser structure form a complex structural system. The seismic analysis performed of this structure included a response spectra modal analysis and time history analysis. Non-linear time history analyses were performed in order to evaluate the effects of the gaps that exist between the lattice frames and ice baskets. The following sections present the models used, the analytical techniques employed, and the results obtained. For additional information on the seismic verification of the ice baskets, see Reference 6.

5.3.3.7.2 Linear Seismic Analysis

Horizontal Response Spectra Modal Analysis Models

To obtain a reasonable comparison between response spectra results and the results from the non-linear analysis for zero gap; the lattice frame-ice basket-lower support structural assembly was modeled as an interconnected system without gaps. A linear elastic dynamic analysis was performed using the response spectra defined for the site.

Each level of lattice frames encompasses an approximate 300° horizontal arc and consists of 72 lattice frames. One level of lattice frames was modeled so that the structural coupling between individual lattice frames could be evaluated.

It was determined that the structural coupling between individual lattice frames is negligible and that the fundamental response of the ice bed lattice frame is essentially that of the individual lattice frames acting independently. Therefore, a lattice frame can be uncoupled from those in its same level for modeling purposes.

A multi-level horizontal dynamic model was used to obtain the horizontal seismic response of the lattice frame ice basket assembly. Each level was represented by one lattice frame. Its stiffness properties were introduced into the model using matrices. Also, the lower support structure was represented by a stiffness matrix. The ice baskets were lumped in groups of nine and represented by lumped mass beam elements. A response spectra analysis was performed. The model was analyzed for out-of-plane as well as in plane motion to provide tangential and radial loads respectively.

Horizontal Seismic Response Spectra Analysis Parameters

The response spectra defined for the crane wall at elevation 687.5 feet were used for the analysis. The damping values of 5% for OBE and 10% for DBE were used to account for the gap effect between the ice baskets and lattice frame.

Vertical Response Spectra Modal Analysis

Two-thirds of the horizontal seismic response spectra was used for the vertical seismic response accelerations. The combined floor and lower support structure was modeled in the vertical direction. The full weight of the baskets with ice was used.

5.3.3.7.3 Non Linear Seismic Analysis

Ice Condenser Seismic Load Study Effect of Gaps

A clearance or gap is required at the ice basket supports for installation and maintenance reasons. The design value for the gap is 1/4 inch radially or 1/2 inch on the diameter.

The effect of the gap during a seismic excitation is two-fold. First, impact loads will be applied to the ice basket as it moves within the clearance, which could potentially produce higher loads in the ice basket than would exist if there were no gap. Second, the repetitive impacting at the ice basket supports will dissipate substantial amounts of energy. In summary, there will be higher damping within the structure than would exist if there were no gaps.

To fully understand the physical behavior of the ice condenser system during a seismic event, a number of time history dynamic analyses were performed. These analyses are described in detail in the following sections.

Time History Dynamic Input

Eight seismic time histories along the crane wall were used. They were derived from E1 Centro (both North-South and East-West), and Taft (both S 21 W and N 69 W), for both the OBE and DBE.

Description of Non-Linear Models

Six non-linear models of lattice frames uncoupled from those in the same elevation were used to determine the effect of ice basket impact on the ice condenser seismic loads as described below:

a. 2-mass model - One lattice frame was modeled with wall panel/cradle stiffness; a group of twenty-seven baskets was represented by a single mass. The 1/2-inch opening between ice baskets and lattice frames was represented by gap elements. Separate 2-mass models were used to develop horizontal tangential and radial lattice frame responses. Radial response was normal to the crane wall, and tangential response was tangent to the crane wall.

b. 12-foot model - the 12-foot beam model considered two 6-foot sections of 27 ice baskets with their associated lattice frames and impact elements. The ice baskets were modeled as a continuous beam 12 feet long.

c. 3-mass model - This model was used to assess the effect of phasing of the individual ice baskets and the lattice frame in the tangential direction on the impact seismic loads. Impact loads between the ice basket and lattice frame were determined from this model. Three rows of ice baskets were considered in the tangential direction across each lattice frame. Each lumped mass represented one ice basket of six-foot length. The impact stiffness between the lattice frame and ice basket was represented in the gap elements. The lattice frame was represented by truss elements between the ice baskets, and by a spring element that represented the wall panel/cradle and the lattice frame.

d. 9-mass model - This model was used to evaluate the effect of the phasing of the individual ice basket and the lattice frame in the radial direction. Impact loads between the ice basket and lattice frame were determined from this model. Nine rows of ice baskets in the radial direction along the lattice frame extending from the crane wall were represented in the model. Each basket was considered with its associated impact elements on each side and the effective properties of the lattice frame spanning each ice basket.

e. 48-foot beam model - The 48-foot beam model was a non-linear model that contained twenty-seven ice baskets modeled as a continuous beam. The local effect of each lattice frame was represented by a pair of impact elements, one on each side of the ice basket. The lattice frame and wall panel/cradle stiffness was represented by stiffness elements. The lower support structure was modeled by a stiffness element at the bottom of the ice baskets. This model investigated the influence of the full 48 feet height of ice basket column.

f. Phasing Link Mass Model - This model was used to determine the load in the links coupling each lattice frame in each level, and to obtain the embedment load that results from radial pull-out caused by out-of-phase behavior of adjacent lattice frames. Two 2-mass models were used, connected by the phasing link. The gap that exists in the phasing link was considered in the model.

Analytical Procedure

Using typical results obtained from the two-mass model, the input acceleration time histories were converted to displacement time histories by double integration. The displacement time histories were then input to the non-linear models previously described.

Seismic Design Loads

Seismic design loads were developed for the lattice frames, ice baskets, wall panels, and the lower support structure. The non-linear analyses performed to develop seismic design loads used 2% structural damping and 10% impact damping, and a nominal gap size of 1/2 inch on the diameter between the baskets and the lattice frames.

Design Load Verification Analyses

An extensive analysis program was instituted to assure the conservatism of the seismic design loads. The results of the analyses are discussed below.

Results from the two phasing models, namely, the three-mass tangential model and the nine-mass radial model, show that the ice baskets respond independently in phase or out of phase. Therefore, it is conservative to consider the ice baskets to be in phase. In the development of lattice frame seismic design loads, using the two-mass, 48-foot beam, and phasing link models, all ice baskets were conservatively assumed to be in phase.

The non-linear models were analyzed with zero gap and the results compared to the response spectra modal analysis results. Satisfactory agreement was obtained between the time history and the response spectrum modal analyses. It was found that the seismic loads obtained from the time history analyses were always greater than the response spectra seismic loads.

The wall panel loads determined for a 1/2 inch nominal gap were found to be unaffected by large changes in impact damping. Loads were imperceptibly different using 10% and 50% impact damping assumptions.

In order to verify that misalignment of the baskets or partially stuck baskets do not produce higher seismic loads, verification analyses were performed. The conclusions reached were:

1. The effect of stuck baskets due to freeze-over was examined by varying the lattice frame and ice basket masses over a range of values. The two-mass model was used for these studies. It was found that the wall panel load decreases with increasing freeze-over.
2. The effect of vertical misalignment and stuck baskets was examined with the 12-foot beam model. A decrease of more than 15% of wall panel load was obtained for the case of zero gap at the top and bottom of the basket, and 1/2-inch gap at center.

The effect of sublimation and ice melting during and after a DBA on the seismic loads was evaluated. These studies determined that the seismic loads are smaller than those obtained without sublimation or ice melt. This is due to the reduced ice mass, and an increased energy loss in the fracturing of ice. Thus, the case of a DBE occurring after a DBA is not a limiting condition. It should be further noted that after a DBA, the ice in the lower portion of the ice condenser has been used and no longer exists. Thus, the seismic loads in the lower portion of the ice condenser are significantly reduced.

5.3.3.8 Accident Loads

Accident loads were considered for the maximum postulated break size in the reactor coolant or main steam system piping. Accident loads include a pressure increase in the ice condenser and drag forces on the baskets and support structure due to the post-accident steam/air mixture moving into and through the ice condenser. Consideration was also given to temperature gradients between the top and bottom of the ice condenser, which develop from the heat transfer between the structural steelwork and steam condensed by the ice.

The maximum differential pressure between the ice condenser and the upper compartment was effectively applied across the insulated duct panels. The wall panels are designed and fastened to the walls in a manner that precludes significant steam channeling due to panel deflections, or leakage through the vapor barrier, for the full accident design pressure differential.

The vapor barrier joints are mechanically fastened, sealed joints. The fastening is designed to withstand the full pressure differential. The pressure differential is applied to the sealed joints in a manner that increases the sealing pressure applied on the sealants.

5.3.3.8.1 Description of Ice Condenser Blowdown Force Calculations

Introduction

This section describes the process used to calculate forces that could be imposed upon the various components in the ice condenser compartment during a loss-of-coolant accident (LOCA). Following a LOCA, a mixture of air, steam, and entrained liquid water flows into the ice bed through the lower inlet doors. This fluid stream is deflected upward by the turning vanes. As the fluid flows upward through the bed, vertical forces will be imposed on the radial support beams, the lattice frames and the ice baskets themselves.

Basis of Load Conditions

The Transient Mass Distribution (TMD) code (Reference 13) was used to calculate the variation of flow rates, fluid densities and local pressures at various locations throughout the containment during the transient following a LOCA. The blowdown mass and energy release used in the TMD analysis were determined from SATAN (Reference 14). A number of case studies were made to evaluate the effect of coolant pipe breaks at various locations in the lower compartment. The worst of these locations was used for the basis of the force calculations. The case used was a break located adjacent to one end of the ice bed. At this location, a greater percentage of the fluid from the break is forced to flow preferentially through the adjacent lower inlet doors, causing the greatest velocities and blowdown forces. Breaks were considered for both hot leg and cold leg reactor coolant pipes to determine the maximum value for each force.

Forces on Lower Support Structure Components

A large portion of the fluid entering each bay of the ice bed through a lower inlet door strikes the turning vanes and is directed upward between the radial beams. To be conservative, it was assumed that no dispersion of the fluid jet would occur prior to reaching the vanes; thus the velocity of fluid in the door port was used in the force calculations. Therefore, the amount of fluid entering the door that is turned by each vane is proportional to the ratio of the projected area of vane that is directly in line with the door port to the total door area.

For all turning vanes, except the vane on the floor, the load is made up of two components:

1. A horizontal momentum force that results from the change of the fluid velocity in the horizontal direction from the velocity existing in the door port to zero at the turning vanes.
2. A vertical force that is the reaction that results from the acceleration of the fluid leaving the vanes.

Horizontal Impingement Force on Back Wall

Since accessibility must be provided through each bay, turning vanes are not provided over the full height of the lower plenum. Some fluid will continue to flow under the vanes and impinge upon the back wall. The resulting force was calculated using the loss of momentum of the fluid stream. The wall is shielded with a plate fastened between the rear support columns. This plate is perforated to equalize the pressure across the plate.

Uplift Force on Ice Baskets

The fluid flowing through the ice bed would produce a vertical force that would tend to lift the ice baskets. This force would consist of two components:

a. A force due to the difference of pressure acting on the bottom and top end of the basket.

b. A friction force generated between the flowing fluid and the surface of the basket and ice.

In calculating the pressure force, the pressure on the bottom and top face of the basket was determined by the TMD code. The friction force produced on the basket by the flowing fluid was determined from a momentum balance between the bottom and top surfaces of the ice bed. A mixture of steam, water droplets, and air flows into the bottom of the bed; but due to condensation and water drop-out, only saturated air exits through the top. It was also assumed that, due to a higher pressure at the bottom of the ice bed, this friction force opposes the pressure differential acting on the fluid stream.

Calculation of the uplift force on the ice baskets was conservative since the fluid stream is also restrained by substantial interaction forces with the radial support beams, the lattice frames, the wall panels and by interaction with the condensate and melted ice that are suspended part way into the bed and draining downward, which were neglected in the momentum balance.

Tangential Force on Ice Baskets

Flow in the horizontal-circumferential direction within the ice bed could produce drag forces on the ice baskets. The tangential forces that might be produced were calculated by using the pressure difference between adjacent compartments in the TMD model. These differences were considered to be evenly divided across the rows of baskets between the TMD compartments. This gives an upper limit on the forces since a small amount of flow would greatly reduce the pressure difference.

Vertical Force on Lattice Frames

The flow of fluid through the ice condenser would also subject the lattice frames to vertical forces. The force on each lattice frame, located at six-foot intervals, was calculated using a drag force coefficient, the projected surface area and the velocity of the fluid flowing through the frame.

The velocity at each frame was calculated using flow rates and mixture densities from the TMD computer analysis, except that it was assumed that the condensate was entrained in the fluid stream until it has passed through the lattice frame at the 21-foot level. Design tests indicated that the steam would be condensed within the first 12.5 feet of the bottom of the ice bed during the initial blowdown mass and energy release (Reference 15).

Vertical Force on Radial Beams

The vertical forces imposed on the front and rear radial beams that support the ice baskets were calculated using an appropriate drag force coefficient, the projected area, and the local fluid velocities.

An average fluid velocity was first calculated from a TMD flow rate and mixture density. This was then modified to give a distribution along the front and rear radial beams, similar to the profile measured in the l/24-scale test, at a level approximately five feet above the beams (Reference 16).

Intermediate and Top Deck Forces

The vertical forces on the intermediate and top deck structures and on the Air-Handling Units were calculated using an appropriate drag force coefficient, the projected area, and the local fluid velocities.

5.3.4 Design Criteria

5.3.4.1 Overview

The criteria in the following sections specify the material and structural requirements for the ice condenser system. The criteria cover the following groups of structures:

a. Steel structural components (Section 5.3.4.3);

b. Appurtenances of the containment liner, i.e., air handling unit and wall panel support studs (Section 5.3.4.4);

c. Concrete wear slab (Section 5.3.4.5); and

d. Ice Condenser piping (Section 5.3.4.6).

5.3.4.2 Design Loads

The Ice condenser is designed to meet the loads described below. The following load combinations are defined for design purposes:

a. Dead Load + Operating Basis Earthquake loads (D + OBE);[4]

[4] Also considered is D +L

b. Dead load + Design Basis Accident induced loads (D + DBA);

c. Dead load + Design Basis Earthquake (D + DBE);

d. Dead load + Design Basis Earthquake + Design Basis Accident induced loads (D + DBE + DBA); and

e. Thermally induced loads (T).

The loads are defined as follows:

Dead Load (D) - Weight of structural steel and full ice bed at the maximum ice load specified.

Live Load (L) - Live load includes any erection and maintenance loads, and loads during the filling and weighing operation.

Thermal Induced Load (T) - Includes those loads resulting from differential thermal expansion during operation plus any loads induced by the cooling of ice containment structure from an assumed ambient temperature.

Accident Fluid Dynamic and Pressure Loads (DBA) - Includes those loads induced by any pressure differential or drag loads across the ice beds, and loads due to change in momentum.

Operational Basis Earthquake (OBE) - Those induced loads determined from the response of the ice bed and supporting structure to the OBE defined for the site.

Design Basis Earthquake (DBE) - Those induced loads determined from the response of the ice bed and supporting structure to the DBE defined for the site.

5.3.4.3 Criteria for Steel Structural Components

5.3.4.3.1 Applicability

These criteria apply to the design of the following ice condenser components:

a. Ice baskets and couplings;

b. Lattice frames and columns, including attachments and bolts;

c. Structural steel supporting structures including the lower support structure and door frames;

d. Ice condenser doors;

e. Wall panels and cooling duct support studs attached to the crane wall and end walls;

f. The supports of auxiliary components, which are located within the ice condenser cavity but which, have no safety function; and

g. Embedments

These components of the ice condenser are designed according to the American Institute of Steel Construction, AISC-69 specifications and the provisions of the following sections.

5.3.4.3.2 Behavior Criteria

Table 5.3.4-1 provides a summary of the allowable limits used in the design of Ice Condenser steel structural components.

For all cases, the stress analysis was performed by considering the load combinations that produced the largest possible stress values.

Where applicable, a stability analysis was performed for components that are in compression, per AISC-69.

The analysis, and conformance to the criteria presented in the following section, "Stress Criteria," was on the basis of elastic system and component analysis.

When a limit analysis was performed on the ice condenser structure, or parts thereof, using the Alternate Analytical Criteria method described below, justification was provided to show that the results of the elastic systems analysis were valid.

Stress Criteria

The stress limits for elastic analysis are described below:

a. **D + OBE**

Stress shall be limited to normal AISC-69, Part I Specification allowables (S). The members and their connections shall be designed to satisfy the requirements of Part I, Sections 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.15, 1.16, 1.17, 1.20, 1.21, and 1.22 of the AISC-69 Specification (stress increase in Sections 1.5 and 1.6 is disallowed for these loads). Where the requirements of Section 1.20 are not met, differential thermal expansion stresses shall be evaluated and the maximum range of the sum of mechanical and thermal induced stresses are limited to three times the appropriate allowable stresses provided in Sections 1.5 and 1.6 of the AISC-69 Specification.

b. **D + DBE, D + DBA**

Stresses shall be limited to normal AISC-69 Specification allowables given in Sections 1.5 and 1.6, increased by 33% (1.33S). No evaluation of thermal induced stresses or fatigue is required.

a. **D + DBE + DBA**

Stresses shall be limited to normal AISC-69 Specification allowables given in Sections 1.5 and 1.6, increased by 65% (1.65S). No evaluation of thermal induced stresses or fatigue is required.

For all cases, direct (membrane) mechanical stresses shall not exceed 0.7 Su, where Su is the ultimate tensile strength of the material.

Alternate Analytical Criteria

A Limit load analysis may be used as an alternate to the elastic analysis. Limit loads are defined using limit analysis by calculating the lower bound of the collapse load of the structure. Load factors are applied to the defined design basis loads and compared to the limit loads. The load factors determined for the design basis load are used to provide margins of safety of the structure against collapse. A load factor of 1.7 (Reference 20) shall be used when considering the mechanical loads due to dead weight and OBE. A load factor of 1.3 shall be used for either D + DBE or D + DBA. A load factor of 1.18 shall be used for D + DBE + DBA. The material shall be assumed to behave in an elastic-perfectly-plastic manner. The minimum specified yield strength shall be used. Mechanical plus thermal induced load combination and fatigue shall be analyzed in an elastic basis and satisfy the limits of the previous section, “Stress Criteria.”

Experimental or Test Verification of Design

In lieu of analysis, experimental verification of design using actual or simulated load conditions may be used.

In tests, size effect and dimensional tolerances (similitude relationships) that may exist between the actual component and the test models shall be accounted for to assure that the loads obtained from the test are a conservative representation of the load carrying capability of the actual component under postulated loading. The load factors associated with such verification are: 1.87 for D + OBE, 1.43 for D + DBA or D + DBE, and 1.3 for D + DBE + DBA. If the load factor of 1.87 for D + OBE cannot be met, a load factor of 1.7 will be used and those cases will be presented to the NRC for their review.

A single test sample is permitted, but in such cases test results shall be derated by 10 percent. Otherwise, at least three samples will be tested and the design will be based on the minimum loading carrying capability.

5.3.4.3.3 General Material Requirements

Materials shall conform to the requirements of the AISC-69 Specification, Section 1.4. When materials are required that are not listed in the AISC Building Code, these materials are selected from ASTM Specifications. Material certification for actual chemical analysis and actual mechanical properties tests is required with test procedures and acceptance criteria meeting the American Society of Testing Materials (ASTM) or AISC requirements. The notch toughness of materials for the ice condenser components are to meet the additional requirements described below.

Carbon steel, low-alloy steel shall be specified to fine grain practice except for materials used under items (f) and (g) below and shall be tested by Charpy V-notch (CVN) impact test. The material shall meet CVN 20 ft-lb for steels with a minimum specified yield stress above 32,000 psi and CVN 15 ft-lb for steels with specified yield stress of 32,000 (Reference 20) psi or below, at 30°F below the minimum service temperature which is +10°F. The Charpy V-notch impact testing shall be performed in accordance with the requirements of ASTM-A-370. Impact tests are not required for:

a. Materials with a nominal section thickness of 5/8 inch or less;

b. Bolting, including nuts, with a 1 inch nominal diameter, or less;

c. Bars and wire with a nominal cross-sectional area less than or equal to 1 square inch;

d. Austenitic stainless steels;

e. Non-ferrous materials;

f. Structural members subject to a net membrane compressive stress under all load conditions; and

g. Components that remain within the normal AISC code allowable limits for all load conditions.

The various materials, i.e., steel sheets, structural shapes, plates and bolting used in the Ice Condenser System were selected on the following bases:

a. Provide satisfactory service performance under design loading and environment and pre-service or construction performance.

b. Assure adequate fracture toughness characteristics at ice condenser design conditions.

c. Be readily fabricated and erected.

d. Be readily coated for corrosion resistance when required.

The materials are of high quality and are made by steelmaking practices that ensure fine grain materials where required. Principal candidate materials that meet the above bases are listed below. Other materials for specific applications were selected on a case by case basis.

5.3.4.3.4 Sheets

Steel sheets were selected for maximum bendability and formability. They are DQ-SK (drawing quality – special-killed) quality such as ASTM A622, A620, and A642. When higher strength, structural quality sheets were required, such as A606 and A607, they were made to fine grain practice. Equivalent materials can be substituted.

The ice baskets were fabricated from perforated sheet material (ASTM A569 or equivalent). The wall panels and cooling ducts were made from sheet material and associated supporting structural sections and plates.

5.3.4.3.5 Structural Sections, Plates, and Bar Flats

Structural sections, plates, and bar flats are High-Strength Low-Alloy steels selected for suitable strength, toughness, formability and weldability.

These steels, e.g. A441, A588, or A572, are made to fine grain practice. The notch toughness for sections over 5/8 inch thick is 20 ft-lb. CVN (Charpy V-Notch) energy absorbed at -20°F. These steels are readily oxygen-cut and possess good weldability qualities. Other AISC or ASTM materials that do not require fine grain practice may be used for components, which remain within normal AISC code allowable limits for all load conditions.

5.3.4.3.6 Bolting

High strength alloy steel, Type A320 L7 or equivalent bolting for low temperature service, is used for the lower support structure. Stocked bolting made from A325, A449, and ASTM A354 Grade B (SAE J429 Grade 8) or equivalent materials are used for other parts. These bolts must meet CVN 20 ft-lb at -20°F, for sizes greater than 1 inch in diameter.

5.3.4.3.7 Non-Metallic Materials

Non-metallic materials, such as gaskets, insulation, adhesives and spacers are selected for specific uses.

5.3.4.3.8 Loose Insulation

The bagged insulation consists of Fiberglas Aerocor Type PF-336 or equivalent insulation captured by an airtight polyethylene bag. The bagged insulation is positioned in the cavities of the cradle assemblies and the cavities between adjacent cradle assemblies and held in place by tape, wire or other mechanical means. Total containment of the bagged insulation in the above mentioned cavities is described below.

Cavities in the cradle assemblies:

The bagged insulation is contained at the top and bottom by the cross member bracing of the cradle assembly. It is contained at the sides by the mounting angles of the cradle assembly and at the front by the wall panel duct. Thus, containment of the insulation is assured during the DBA.

Cavities between cradle assemblies:

The bagged insulation in this area is contained by the floor and the seal strips. The seal strips are designed to withstand the pressure load associated with the DBA and are connected to adjacent wall panel ducts by tabs and tack welds. Thus, containment of the bagged insulation is assured.

5.3.4.3.9 Fabrication

During initial construction of the Ice Condenser System, all welding, including procedure and welder performance qualification was done in accordance with "AWS Structural Welding Code-1972," American Welding Society (AWS) Publication D1.1-72. In addition, during initial construction of the Ice Condenser System, the quality of welds was based upon Paragraph 9.25

of the AWS Code. The nondestructive examination criteria were in accordance with AWS D1.1-72, or existing site practices.

Subsequent modifications and/or repairs shall be in accordance with approved welding procedures in which the welders are qualified. Welding procedures and welder's performance qualifications shall be prepared in accordance with ANSI/AWS D1.1, "Structural Welding Code-steel", or ANSI/AWS D1.3, "Structural Welding Code – Sheet Steel."

Nondestructive examination procedures and acceptance criteria for completed welds, as a minimum, shall be in compliance the current edition of ANSI/AWS Structural Welding Code.

5.3.4.4 Design Criteria for Appurtenances

The appurtenances shall be designed according to subsection NE of the ASME Section III code. The appurtenances are studs welded to the containment liner of containment vessel. These studs transmit load from only the wall panels attached to the liner or containment vessel. The air handling units transmit only horizontal loads to the liner though the support studs. The material of the studs shall be fabricated from A108 Grade steel or equivalent.

5.3.4.5 Design Criteria for Concrete Wear Slab

The concrete floor wear slab is designed in accordance with the requirements of American Concrete Institute (ACI) 318-71.

5.3.4.6 Design Criteria for Ice Condenser Piping

Coolant piping in the ice condenser floor is designed to ANSI Standard Code for Pressure Piping – Refrigeration, ANSI B31.5-66, including addenda B31.5a.1968.

Other refrigeration piping is designed and installed to ANSI B31.1 (1967), "Power Piping Code."

Ice condenser drain piping is designed to ANSI B31.1, "Power Piping Code."

5.3.4.7 Environmental Effects

The environment within the ice bed is maintained below freezing and the absolute humidity is very low; therefore, corrosion of uncoated carbon steel is negligible.

To ensure that corrosion is minimized while the components of the ice condenser are in storage at the site or in operation in the containment, the components are galvanized, painted, or placed in a protective container. Galvanizing is in accordance with ASTM A123. Painting is in accordance with the American National Standard Institute (ANSI) N101.2-72, Protective Coatings (Paints) for Light Water Nuclear Reactor Containment Facilities.

Materials such as stainless steels and COR-TEN with low corrosion rates may be used without protective coatings.

5.3.4.8 Inservice Inspection

Inservice Inspection and surveillance requirements are specified in the Technical Specifications.

5.3.4.9 Design Criteria for Ancillary Equipment

Ancillary equipment are individual components selected for specific uses which are physically located within the ice condenser compartment that are not required to support the safety related function of the ice condenser. The design of ancillary equipment, including their supports, shall preclude generation of substantial missiles and/or debris, which could impede the ice condenser from performing its design function, when subjected to DBE and/or DBA loading.

5.3.5 Systems and Components

5.3.5.1 Floor Structure and Cooling System

5.3.5.1.1 Description

The ice condenser floor is a concrete structure containing embedded refrigeration system piping.

Figure 5.3.5.1-1 shows the general layout of the floor structure. The functional requirements for both normal and accident conditions can be separated into five groups: wear slab, floor cooling, insulation, sub-floor and the floor drains. Each group is described below.

5.3.5.1.2 Wear Slab

Functional Requirements

The wear slab is a concrete structure whose function is to provide a cooled surface and personnel access support for maintenance and/or inspection. The wear slab also serves to contain the floor cooling piping.

Design Criteria and Codes

The concrete wear slab is designed in accordance with American Concrete Institute (ACI) 318-71 requirements (See Section 5.3.4.5).

The maximum design accident temperature for the wear slab is 190°F.

Loading Conditions

The loading conditions for the wear slab system are specified in section 5.3.4.2.

Dead loads include weight of fallen ice, and containment wall panels. Live loads result from personnel traffic and maintenance activities in the lower plenum.

Design Pressures

The maximum pressure during a DBA is 19.1 psi, which includes a 20% margin and a dynamic load factor of 1.53.

Design Description

The wear slab is a 4 inch thick layer of high strength concrete which forms the exposed top surface area of the Ice Condenser floor. The concrete was prepared with air entrainment admixtures to minimize spalling from freeze/thaw cycles. Steel reinforcement was used in the wear slab to assure adequate and uniform strength. Additionally, a protective coating was applied to the top of the wear slab, which provides an additional water barrier.

Design Evaluation

The wear slab, during normal operating conditions, is subject to its dead weight, which consists of concrete, steel reinforcement, steel plates and piping. Six inches of 100% density ice is assumed to be uniformly distributed over the entire floor. The dead load plus seismic loads are insignificant because the highest load on the floor is contributed by blowdown pressure during design accident conditions.

The most severe loading condition is the combination of the dead load, the DBE seismic acceleration, and the pressure load. The results of the wear slab structural analysis are provided in Table 5.3.5.1-1 in the form of a stress ratio. These results demonstrate the structural integrity of the wear slab for the specified loading conditions.

5.3.5.1.3 Floor Cooling System

Functional Requirements

The floor cooling system removes heat flowing toward the ice condenser compartments from the lower crane wall and lower containment equipment rooms during normal operation. The floor cooling system is designed with defrost capability. The maximum glycol temperature during floor defrost is 70°F. During periods of wall panel defrosting, it is necessary to heat the floor to above 32°F. During an accident, the floor cooling is terminated by the containment isolation valves, which are closed automatically. The refrigeration system interface and cooling function is described in Section 5.3.5.12.

Design Codes

The floor piping is designed to ANSI Standard Code for Pressure Piping Refrigeration ANSI B31.5-66, including Addenda B31.5a 1968 (See Section 5.3.4.6).

Design Temperature; - 10°F.

Loading Conditions

The loading conditions for the Floor Cooling system are normal thermal, dead weight and OBE. The cooling function is not required to be maintained during and after DBA and /or DBE.

Design Description

The floor cooling system consists of ASTM A-333 Grade 6 or equivalent piping. The piping is embedded in the wear slab of each bay in a serpentine fashion thereby providing ample cooling of the wear slab surface. The cooling pipes contained in each wear slab rest on a steel plate, which extends across the full width of the floor for maximum effectiveness in intercepting heat passing up through the floor. Expansion joints are located at each bay and expansion material is located at the slab perimeter. Valves are provided in the glycol piping at the inlet and outlet of each bay to allow flow adjustment and to permit isolation of the piping loop should a leak develop. The floor cooling is monitored by a temperature sensing element located at the downstream end of the bay floor piping. The coolant contained in the piping is a corrosion-inhibiting glycol/water solution.

For defrosting purposes, electric heating of the glycol is provided. In general, components that require periodic maintenance, such as pumps, heaters and control valves are located outside of the ice condenser.

Design Evaluation

The pipe stress analysis results are included in Table 5.3.5.1-1. The analysis demonstrates that the piping is within the code allowable stresses.

5.3.5.1.4 Insulation Section

Functional Requirements

The cavity below the wear slab is filled with an insulation material to resist the flow of heat into the ice bed during all operating conditions.

Design Criteria

Design criteria are established by equipment specification covering thermal conductivity, compressive strength, and chemistry; see "Design Description."

Loading Conditions

The loading conditions for the insulation are normal dead weight, live load, seismic and DBA pressure loads transferred by the wear slab.

Design Description

The insulation section consists of a low density, closed cell, foam concrete-filled cavity. The nominal density of the foam concrete is 40 lbs/ft^3, the compressive strength is 110 psi. The thermal conductivity per inch of thickness is less than 1.0 BTU/hr-°F-ft^2. The bottom surface of the foam concrete contains a vapor barrier to provide additional assurance that the insulation section will retain a high level of thermal resistance. The top surface of the foam concrete is leveled with a course of grouting, which provides the seating surface for the floor plate.

Design Evaluation

The wear slab dead weight plus seismic plus DBA loads were conservatively assumed to be transferred to the foam concrete section. The compressive strength of the foam concrete is sufficient to accept these floor loads. As documented in Table 5.3.5.1-1, the stress ratio is less than or equal to 1.0.

5.3.5.1.5 Structural Subfloor

Functional Requirements

The structural sub-floor supports the loads of the wear slab, insulation section, floor cooling system, and lower structural support (including ice condenser vertical loads, and those horizontal tangential and radial loads imposed by the ice condenser) during normal operation and during accident conditions. Refer to Figure 5.3.5.1-1 for the general configuration of the structural sub-floor.

Design Criteria and Loading Conditions

The structural sub-floor was designed to accommodate the following loads:

D, OBE, DBE, DBA, door impact loading, and jet pressure loading on the outboard side of the perforated plate due to rapid door opening.

The load equations used are:

1. D + OBE + T (W.S.D.)
2. D + 1.0 DBE + 1.0 DBA + T (U.S.D.)
3. D + T + 1.5(P + PJ) + DI (U.S.D.)
4. D + 1.25 OBE + 1.25 (P + PJ) + DI + T (U.S.D.)

where

D = Dead Load

0BE = Operating Basic Earthquake Load

DBE = Design Basis Earthquake Load

DBA = Design Basis Accident Loads

T = Normal Operating Thermal Load

P = Pressure Differential across the floor

D_I = Door Impact Load

P_J = Drag Loads on the structure of the Ice Condenser

W.S.D. = Working Stress Design criteria on which the loads are based.

U.S.D. = Ultimate Strength Design criteria on which the loads are based.

5.3.5.1.6 Floor Drains

Functional Requirements

The floor drains are passive structural components during normal operation and are designed to minimize heat inflow and air outflow to the lower plenum. The section of floor drain pipe inserted vertically below the wear slab is designed to provide a high thermal resistance to minimize heat gain to the ice condenser. Under accident conditions the floor drains prevent any reverse air blowdown by employing flapper style check valves.

Design Codes

Refer to Section 5.3.4 for applicable codes and design criteria for the Floor Drain System.

Loading Conditions

The loading conditions for the floor drain system are specified in section 5.3.4.2.

Design Temperatures:

The maximum temperature during normal operation is 120°F. The maximum design accident temperature for the floor drains is 250°F.

Design Pressures:

The maximum opening pressure during normal operation is 1 psf. Minimum opening pressure during DBA is 18 inches of water. Maximum closing pressure during DBA is between 12 and 14 psi.

Design Description

Special consideration has been given in the design to prevent freezing of the floor drains and to minimize check valve leakage.

The floor drains employ a low thermal conductivity (transite) section of pipe, inserted vertically below the wear slab to minimize heat gain to the ice bed. The top of the drainpipe is covered with a grating and water-soluble covering. The drain check valves and water-soluble covering are designed to minimize any heat in-leakage and air out-leakage during normal operation. The valves are designed to tolerate a 15 psi back-pressure when closed. The check valves are in a warm environment, and no freezing will result.

The arrangement of the drain system adjacent to the lower inlet region of the ice compartment is shown on Figures 5.3.5.1-1 and 5.3.5.1-2.

Design Evaluation

The floor drain is a passive structural component during normal operation. During accident and seismic conditions, the check valve must withstand the blowdown back-pressure force as well as the seismic forces on the check valve.

During normal plant operation, the sole function of the valve is to remain in a closed position to minimize air leakage across the seat. To avoid unnecessary contamination of the valve seat, a drain line is connected immediately ahead of the valve, to drain any spillage or defrost water without causing the valve to be opened.

For a small pipe break, the water inventory in the ice condenser will be produced at the same rate as energy is added from the accident. The water collecting on the floor of the condenser compartment will then flow out through the drains. For intermediate and large pipe breaks, the ice condenser doors will be open and water will drain through both the doors and the drains.

Results of full-scale section tests performed at the Westinghouse Waltz Mill site show that, for the design blowdown accident, a major fraction of the water drained from the ice condenser, and no increase in containment pressure was indicated, even for the severe case with no drains (Reference 12). Although drains are not necessary for ice condenser performance following a large break, an approximately 18 ft^2 drain area is provided, of which approximately 13 ft^2 are required for small breaks. (Refer to chapter 14, Section 14.3.4.5.4.4.2 and 14.3.4.5.4.4.3). The total drain area is provided by 21 individual floor drains.

Air leakage during normal operation is negligible since the valve is held in a closed position by a vertical flapper with a hinge at the top and a greased seal. The valve is slightly angled from the vertical to hold the flap in place by gravity.

5.3.5.1.7 Floor Structure Composite Design Evaluation

The floor design is compatible with the ice condenser wall panel defrosting. The water resulting from the wall panel defrosting produces no adverse effect on the structural integrity of the floor. The use of concrete with entrained air affords ample resistance to the effects of water. Additionally, the floor structure contains many water seals and water vapor seals. The seals include: a protective surface coating on the wear slab top surface, a vapor barrier between the foam concrete and the structural sub-floor, a leveling course of grout on the top surface of the foam concrete, and a steel plate (in the wear slab) with lapping material in the plate-to-plate joints. As a result, the effect of water on the floor is negligible.

On the basis of the structural analysis performed on the floor structure, it is concluded that the floor is adequate for all anticipated loading conditions.

5.3.5.2 Wall Panels

5.3.5.2.1 Functional Requirements

The wall panels are designed to thermally insulate the ice bed, under normal operating conditions, from the heat of the crane wall, the containment wall, and the end walls. In addition, they are designed to provide a circulation path for cold air and a heat transfer surface next to the ice bed so that the ice is maintained.

The supporting structure of the wall panel also provides for transfer of radial and tangential loads from the lattice frame columns to the crane wall anchor embedments.

5.3.5.2.2 Design Criteria and Codes

The structural parts of the wall panels are designed to meet the requirements of the design criteria given in Section 5.3.4.

5.3.5.2.3 Loading Conditions

The loading conditions for the wall panels are specified in section 5.3.4.2.

Design Temperatures

The minimum temperature during normal operation is 10°F. The maximum design accident temperature for the wall panels is 250°F.

Design Pressures

The maximum design pressure during DBA is 21.7 psi, which includes a 20% margin and a dynamic load factor of 1.53.

5.3.5.2.4 Design Description

The wall panel design incorporates provisions for installation on the crane wall, containment wall, and end walls of the ice bed annulus. The crane wall panels extend from the bottom of the upper plenum to the lower support structure, where they are supported on the inner circumferential beams of the horizontal platform. The containment wall panels extend from the bottom of the upper plenum to the floor structure. The wall panels are shown in Figure 5.3.5.2-1.

Cooling ducts are incorporated in the design to provide flow from the air handlers in the duct adjacent to the ice bed, and to return flow in the outer duct of the panel. This provides an even distribution of duct face temperature. Front and rear ducts are provided with a "Glastrate", insulated divider strip to prevent any significant regenerative heat transfer between ducts. Each bottom panel provides a flow path between the inner and outer duct to allow return flow through the outer duct.

Ports are provided for containment liner inspection at three circumferential locations in the lower inlet plenum, between the portal frames of the lower support structure. The ports permit inspection of the containment liner without requiring removal of the wall panels.

5.3.5.2.5 Design Evaluation

The wall panels have been analyzed for seismic and DBA loading conditions as well as service loads.

The wall panels are bolted to transverse beam sections with a maximum span of approximately 24 inches.

Wall panel stress analysis was based on the general theory for sandwich plates presented in References l through 3. Elastic constants were determined by the method given in Reference 4.

A local stress analysis was also performed, considering the corrugated core to be an elastic foundation for the cover sheet, and the stability of the leg of the corrugated core was investigated (Reference 5). The stress ratios for of these analyses are presented in Table 5.3.5.2-1.

A transverse beam section was investigated for its ability to transmit the imposed seismic and DBA loads from the lattice frame column attachment to the crane wall. A two dimensional beam analysis utilizing the "STASYS" program was employed (Reference 17). Various loading modes were used as stated in section 5.3.4.2; the resulting stress ratios are summarized in Table 5.3.5.2-2.

Based on the analyses described above, it is concluded that the wall panel assembly meets the design criteria given in Section 5.3.4.

5.3.5.3 Lattice Frames and Support Columns

5.3.5.3.1 Functional Requirements

The lattice frame and support column assemblies:

a. Position the ice baskets in the ice bed and control the hydraulic diameter.

b. Provide lateral support for the ice baskets under normal, seismic, and accident loads.

c. Allow passage of steam and air through the space around the ice baskets.

d. Allow for basket installation and removal requirements.

5.3.5.3.2 Design Criteria and Codes

Structural Requirements

For structural design and material requirements, refer to Section 5.3.4.

Design Considerations

a. The lattice frames are designed to be compatible with the periodic weighing procedure for the ice baskets.

b. The structure is designed to position the ice columns in the required array to maintain the performance of the ice condenser, including the flow area around each ice column.

c. The lattice frame allows loading of the ice baskets in position, and permits lifting of complete basket columns for removal in sections.

General Thermal and Hydraulic Performance

a. The lattice frames space the ice basket columns so that the hydraulic diameter around each ice column is maintained for all modes of operation.

b. Differential thermal expansion between the crane wall and lattice frame structure, together with other applicable loads, does not stress the lattice frames or its associated supporting structure beyond the design limits, or adversely affect the spacing between lattice frames.

c. Forces across the lattice frames in the vertical direction due to blowdown loads, together with other applicable loads, do not overstress the lattice frame and supporting structure beyond the design limits.

Interface Requirements

a. **Lattice Frame to Ice Basket Columns** – The lattice frame locates and aligns the ice basket array. Sufficient clearance is provided to facilitate ice basket installation while limiting radial basket motion to 1/4 inch from nominal in any direction. The lattice frame structure is also capable of withstanding design and operating seismic and accident loading.

b. **Lattice Frame to Lattice Frame Column** - The lattice frames are bolted to the lattice frame columns. The lattice frame column bases are adjustable to assure that the frame and columns match during assembly.

c. **Lattice Frame Columns to Crane Wall Air Duct Panels** - The lattice frame columns are bolted to the wall panel cradles. Lateral seismic loading from ice baskets and lattice frame is transmitted to the crane wall through the lattice frame columns and the cradles. The studs at the crane wall shall be capable of meeting the structural design criteria.

d. **Lattice Frame Columns to Lower Support Structure** - The lattice frame columns interface with the lower support structures. The columns are mounted on the structures through adjustable column support stands to allow for accumulation of dimensional tolerances.

e. **Lattice Frame Columns to Intermediate Deck** - The top ends of the lattice frame columns at each bay support the intermediate deck doors, support frames, and support beams.

f. **Ice Condenser Temperature Monitoring System** - Allowance is made for mounting ice condenser temperature monitoring system components onto the lattice frames.

5.3.5.3.3 Loading Conditions

The loading conditions for the lattice frames and support columns are specified in section 5.3.4.2.

Loads include dead weight, live load, thermal expansion, seismic, and DBA loads transferred to the columns by the intermediate deck and doors.

Design Temperatures

The minimum normal temperature is 10°F and the maximum design accident temperature for the lattice frames and support columns is 250°F.

5.3.5.3.4 Design Description

The lattice frames are structural steel grid work structures located in the ice condenser annulus and fitted between the lattice frame support columns, clearing the wall panel air ducts. A typical lattice frame is shown in Figure 5.3.5.3-1.

The lattice frames are mounted radially across the ice condenser annulus for the full 300 degrees of annulus circumference at each of eight levels between the lower support structure and the intermediate deck.

The lattice frames are mounted to rectangular steel columns, which are placed at the crane side and at the containment side of the ice condenser annulus. One-inch diameter links connect adjacent lattice frames to prevent out-of-phase motion during seismic events. This linkage minimizes loads transmitted to the crane wall studs. The lattice frames are welded steel structures consisting of radial struts supported by welded cross bracing.

5.3.5.3.5 Design Evaluation

The lattice frames were analyzed using the ICES-STRUDLE II system of computer programs for frame analysis. STRUDLE is a general program that operates as a subsystem of the Integrated Civil Engineering System (ICES) program. The lattice frames were treated as three-dimensional structures composed of joints, support joints, and structural members connecting the joints.

The analysis of the loads for the individual maximums of D + OBE, D + DBE and D + DBA was determined. A survey was also conducted for the loading combinations of D + DBE + DBA for each lattice frame level at reference seismic orientation, 45 degrees, and 90 degrees to determine the maximum loading condition on the lattice frame. The survey showed that the highest loads occur on the lattice frame at the 33 ft. level, and that the combination of D + DBE + DBA produces the maximum stresses.

Maximum stresses were calculated at each structural member at the edge of the fillet weld for all loading conditions. The lattice frame code allowable stresses and resulting stress ratios are summarized in Table 5.3.5.3-1.

Fatigue stresses due to OBE loading were calculated and found to be within the allowable limits defined in Section 5.3.4.3.2. Table 5.3.5.3-2 includes the code allowable stress and the stress ratio for the fatigue analysis.

The vertical support columns and brackets that support the lattice frames were analyzed to determine their structural integrity. The worst load combinations of D + OBE, D + DBE, D + DBA and D + DBE + DBA were considered in the analysis. The vertical support members were also analyzed to determine their buckling characteristics. An analysis using classical buckling methods indicated that this phenomenon is not a concern. The resulting stress analysis indicated that the stresses in the supporting structure satisfy the design criteria defined in Section 5.3.4.

5.3.5.4 Ice Baskets

5.3.5.4.1 Functional Requirements

The function of the ice baskets is to contain borated ice to provide a means for absorbing the thermal energy that results from a LOCA or a steam line break in the containment structure. The baskets are arranged to promote heat transfer from the steam to the ice during and following these accidents. The function of the ice baskets is also to provide adequate structural support for the ice and maintain the geometry for heat transfer during or following the worst loading combinations.

5.3.5.4.2 Design Criteria and Codes

For ice basket and column structural design and material requirements refer to Section 5.3.4.

Design Considerations

a. The structural stability and deformation requirements are determined to ensure no loss of function under accident and design basis earthquake loads.

b. The ice baskets are designed to facilitate maintenance and for a lifetime consistent with that of the plant. Evaluations concluded that the ice baskets will continue to meet the design and licensing basis requirements through the period of extended operation associated with license renewal.

c. The structure is designed to maintain the ice in the required array to maintain the integrity of performance of the ice condenser.

d. Any section of the ice basket is capable of supporting the total weight of the ice above that section.

General Thermal and Hydraulic Performance Requirements

The ice baskets are fabricated from perforated sheet metal, which has sufficient open area to provide an adequate heat transfer surface area.

Interface Requirements

a. **Lattice Frame** - The lattice frames, located at 6-feet intervals, act as horizontal restraints along the length. The design provides a nominal 1/4-inch radial clearance between the ice baskets and the lattice frames. The lattice frame and basket coupling/stiffening ring elevations coincide to prevent damage to the basket during impact.

b. **Lower Support Structure** - Ice basket bottoms are designed to be supported by, and held down by, attachments to the lower support structure. The basket supports are designed for structural adequacy under accident and DBE loads and permit weighing of ice baskets.

c. **Basket Alignment** - The baskets are capable of accepting basket lifting and handling tools.

d. **Basket Loading** - The ice baskets are capable of being loaded by a pneumatic ice distribution system.

e. **External Basket Design** - The baskets are designed to minimize any external protrusions which would interfere with lifting, weighing removal and insertion.

f. **Basket Coupling** - The basket sections are capable of being coupled together in 48 feet columns.

g. **Basket Couplings and Stiffening Rings** - Couplings or rings are located at 6 feet intervals along the basket and have devices internal to the baskets to prevent the ice from falling down to the bottom of the ice column during and after a DBA and/or DBE.

5.3.5.4.3 Loading Conditions

The loading conditions for the ice baskets are specified in section 5.3.4.2. Ice Basket Weight:

The maximum ice basket weight is 1877 lbs.

Design Temperatures

The minimum normal operating temperatures is 10°F. The maximum design accident temperature for the ice baskets is 250°F.

5.3.5.4.4 Design Description

Ice is maintained in an array of vertical cylindrical columns, 48 feet high, and 12-inches in diameter. The columns are formed by perforated sheet metal baskets. The spaces between the columns form the flow channels for steam and air. Interconnection couplings and stiffening rings are located along the basket column and at the bottom of the baskets to prevent the ice in the basket from displacing axially in the event of loss of ice caused by sublimation or partial melt down due to accident conditions. A typical ice basket assembly is shown in Figure 5.3.5.4-1.

The bottom face of the basket allows water to flow out, and has attachments for mechanical connection to the lower support structure to prevent uplift of the baskets during DBE and DBA. The basket columns can be lifted and removed in sections, and provision is made for lifting and weighing the entire length of selected columns.

5.3.5.4.5 Design Evaluation

The perforated metal baskets of A-622 Low Carbon-Low alloy steel of 14 gage sheet have been evaluated by analyses and tests and found to be within the allowable limits defined in Section 5.3.4. A limit analysis was performed on the basket mesh to determine its adequacy, and classical strength of materials techniques were used on other basket regions. The stress analyses and test results of the ice basket were initially presented in WCAP-8304, "Stress and Structural Analyses and Testing of Ice Baskets". The analyses have been updated by:

WCAP-8887, "Ice Basket Stress Analysis - D.C. Cook",

"Ice Condenser Seismic Load Study - New Ice Basket Design", February 28, 1990,

"D. C. Cook Ice Condenser Ice Basket Design", October 1999.

The subsequent updated analyses revised loads for new design conditions and concluded the basket design was within allowable stress limits.

5.3.5.5 Crane and Rail Assembly

5.3.5.5.1 Functional Requirements

The crane and rail assembly was designed to carry components and tools into, out of, and within the ice condenser area during erection, maintenance, and inspection periods. Currently, however, the crane is located outside the ice condenser, its ice condenser access door has been permanently closed and its power supply conductor bars located in the ice condenser have been de-energized.

5.3.5.5.2 Design Criteria and Codes

The crane is designed in accordance with the requirements of the Electric Overhead Crane Institute Specification 61. It is designed so that it will not be derailed under any of the design loading conditions.

The rail is designed according to the design criteria in Section 5.3.4. These criteria provide assurance that the rail will maintain its structural integrity.

5.3.5.5.3 Loading Conditions

The crane is parked (without load) outside the ice condenser. The crane rail and supporting structure inside the ice condenser compartment are designed to withstand the loading conditions defined in Section 5.3.4.2. The crane, crane rail, and supporting structure located outside the ice condenser compartment are designed to withstand dead load and seismic loads.

5.3.5.5.4 Design Description

The crane is designed for a capacity of 3 tons. The bridge, boom and hoist of the crane are all motor operated. The total crane weight is approximately 7200 pounds.

5.3.5.5.5 Design Evaluation

The crane rails and supporting structures were analyzed as a part of the top deck structure (see Section 5.3.5.10). It was found that all stresses were maintained within the limits prescribed in the design criteria, Section 5.3.4.3.2, for all design conditions defined in 5.3.5.5.3. The code allowable stresses and the resulting stress ratios for the crane rail are summarized in Table 5.3.5.10-2.

5.3.5.6 Lower Support Structure

5.3.5.6.1 Functional Requirements

The lower support structure is designed to support and hold down the ice baskets in the required array. It is also designed so that there is an adequate flow area into the ice bed for the air and steam mixture in the event of a DBA.

The lower support structure has turning vanes that are designed to turn the flow of the air and steam mixture up through the ice bed in the event of a DBA. For such an event, the vanes would serve to reduce the drag forces on the lower support structural members, reduce the impingement forces on the containment across from the lower inlet doors and to distribute the flow more uniformly over the ice bed.

The lower support structure also has perforated plates that are designed to reduce the jet impingement forces on the containment across from the lower inlet doors in the event of a DBA.

5.3.5.6.2 Design Criteria and Codes

For structural design and material requirements, refer to Section 5.3.4.

5.3.5.6.3 Loading Conditions

The loading conditions for the lower support structure are specified in section 5.3.4.2.

Loads include dead weight, live load, thermal expansion, seismic, and DBA loads transferred by the ice baskets, crane wall panels, and lattice frame support columns.

Design Temperatures

The minimum temperature during normal operation is 10°F and the maximum design accident temperature for the lower support structure is 250°F.

5.3.5.6.4 Design Description

The lower support structure is contained in a 300-degree circular arc of the containment. The three-pier lower support structure consists of a horizontal platform assembly composed of three straight circumferential members and nine radial platform beams, which span between portal frame columns.

Each radial portal frame is comprised of three columns. The lower inlet door shock absorbers are mounted to the plates that are welded to the inner and middle columns of the portal frames of the lower support structure.

5.3.5.6.5 Design Evaluation

The lower support structure was analyzed using a finite element model. The ANSYS structural analysis program was used in the analysis (Reference 18). The seismic responses, in terms of equivalent acceleration and interface forces, in two horizontal directions (radial and tangential) and the vertical direction were developed from a modal seismic response analysis performed for a combined lattice frame-ice basket-lower support structure model. The dead weight, thermal, seismic, and accident loads were applied to the lower support structure as static forces.

The model is comprised of three dimensional beam elements with six degrees of freedom per node, flat triangular shell elements, each with six degrees of freedom per node such that both membrane and bending action of the plates are considered, and general six degrees-of-freedom lumped masses having a 6 x 6 diagonal mass matrix. No horizontal ice mass was considered since this effect on the seismic response was accounted for in the results of the dynamic analysis of the combined lattice frames-ice baskets-lower support structure model. No rotary inertia terms were used for the lumped masses.

Allowable design loads for D + DBE + DBA were developed for each connection (joint) based on an overall criterion of maintaining stresses below 90 percent of yield. Member forces and moments determined by the finite element analysis were then compared with the allowable values to confirm the integrity of the connection. For D + OBE, local member forces and moments from the finite element analysis were compared with the above allowable design loads reduced by a factor of 1/(1.7 x 0.9) or 0.654, consistent with maintaining stresses within normal AISC limits.

The code allowable stresses and the resulting stress ratios for the various structural members for the D+OBE and D+DBE+DBA design load cases are summarized in Table 5.3.5.6-1. As shown in the table, the resulting stress ratios are less than or equal to 1.0.

5.3.5.7 Embedments

5.3.5.7.1 Functional Requirements

Embedments in the crane wall are provided to transfer horizontal, radial and tangential loads from ice condenser internal components to the concrete crane wall structure. Vertical loads on internal components are transmitted to the lower support structure and floor and, thus do not act on the embedments.

5.3.5.7.2 Design Criteria and Codes

Refer to Section 5.3.4 for structural design and material requirements.

5.3.5.7.3 Loading Conditions

Loading conditions for the embedments are specified in Section 5.3.4.2.

Loads include horizontal seismic and DBA loads acting on and transmitted through the ice basket, lattice frames and support columns, and crane wall cradles.

Design Temperatures

Temperature during normal operation will approach the containment upper compartment temperature of 100°F, maximum. The maximum design accident temperature for the embedments is 256°F.

5.3.5.7.4 Design Description

Each embedment consists of a square, steel plate with four Nelson studs welded to it. For attachment of the wall panels, a one-inch diameter shoulder stud made from ASTM-A-434 steel is fillet-welded to the plate. For the last vertical row of embedments adjacent to each end wall, two expansion bolts are added to the embedment design to accommodate higher radial reactions to unbalanced tangential lattice frame loads.

5.3.5.7.5 Design Evaluation

Embedment design was qualified by testing using a simulated section of the crane wall and appropriate test load factors as defined in Section 5.3.4.3.2.

5.3.5.8 Lower Personnel Access Door

5.3.5.8.1 Functional Requirements

The lower personnel access door permits entry into the lower part of the ice condenser for inspection and maintenance during reduced power operation or reactor shutdown. There is one lower personnel access door per containment. In the closed position, it constitutes a thermal and vapor barrier (normal plant operation) and a pressure barrier (accident condition) between the ice condenser compartment and containment atmosphere.

5.3.5.8.2 Design Criteria and Codes

Refer to Section 5.3.4 for the applicable structural design and material requirements.

5.3.5.8.3 Loading Conditions

The loading conditions for the lower personnel access doors are specified in section 5.3.4.2.

Design Temperatures

Minimum inside temperature during normal operation is 10°F. The maximum outside temperature during normal operation is 120°F. The maximum design accident temperature for the lower personnel access door is 250°F.

Design Pressures

Maximum pressure during DBA is 19.1 psi, which includes a 20% margin and a dynamic load factor of 1.1.

5.3.5.8.4 Design Description

The general design of the lower personnel access door is shown in Figure 5.3.5.8-1. The lower personnel access door includes the door and frame assembly, gaskets, and fasteners. The door frame is bolted across a gasket strip to a fixed frame embedded in the concrete end wall. Additional bolting is attached to threaded inserts in the door opening. The door measures approximately 42 inches x 92-1/2 inches and opens by swinging out of the lower ice condenser end wall. The door frame is designed so that no frosting occurs at either the inner or outer surface. A replaceable gasket maintains a tight seal when the door is closed and remains flexible under the low operating temperatures.

Limit switches are installed on the door as part of the door position monitoring system, including switches located to indicate completely locked position of pressure wedges.

If this door is not fully closed and latched, an alarm annunciates in the control room and a status lamp will light on the CAS panel.

Design Evaluation

The lower personnel access door is normally closed during periods of reactor operation and is designed to remain closed during accident conditions. The lower personnel access door and frame were therefore analyzed to assess their loads and structural integrity for the dead weight plus seismic plus DBA load conditions.

Seismic analyses of the door and frame indicate that the stresses are insignificant in comparison with the stresses that occur during a LOCA. For the lower personnel access door analysis, Table 5.3.5.8-1 provides the load, the resulting stress ratio and its basis.

On the basis of the structural analysis performed on the lower personnel access door and frame, it is concluded that the structural integrity of the door is adequate for all anticipated loading conditions.

5.3.5.9 Lower Inlet Doors

5.3.5.9.1 Functional Requirements

The inlet doors at the bottom of the ice condenser are insulated panels mounted as vertically hinged pairs on an angle section frame between the concrete pillars supporting the crane wall, as shown in Figures 5.3.5.9-1, 5.3.5.9-2, and 5.3.5.9-3. The doors consist of a 1/2-inch composite panel with steel facings and a structural steel channel frame, and foam insulation backing that is enclosed with a stainless steel sheet.

The ice condenser inlet doors form the barrier to airflow through the inlet ports of the ice condenser for normal plant operation. They also provide the continuation of thermal insulation around the lower section of the crane wall to minimize heat input that would promote sublimation and mass transfer of ice in the ice condenser compartment. In the event of a LOCA, a pressure increase in the lower compartment causes the doors to open, venting air and steam into the ice condenser.

The door panels are provided with tension spring mechanisms that produce a small closing torque on the door panels as they open. The magnitude of the closing torque is equivalent to providing approximately a one pound per square foot pressure drop through the inlet ports with the door panels open to a position equivalent to the full port flow area. The zero-load position of the spring mechanisms is set such that, with zero differential pressure across the door panels, the gasket holds the door slightly open. This setting provides assurance that all doors will be open slightly upon removal of cold air head, thereby eliminating significant inlet maldistribution for very small incidents.

For larger incidents, the doors open fully and the flow distribution is controlled by the flow area and pressure drops of inlet ports. The doors are provided with shock absorber assemblies to dissipate the large door kinetic energies generated during large break incidents.

5.3.5.9.2 Design Criteria and Codes

Radiation Exposure

Maximum radiation at inlet door is 5 r/hr gamma during normal operations.

Structural Requirements

For structural design and material requirements, refer to Section 5.3.4.

Design Considerations – Accident Conditions

a. All doors shall open to allow venting of energy to the ice condenser for any leak rate that results in differential pressure in excess of the ice condenser cold head.

b. The force required to open the doors of the ice condenser is sufficiently low such that the energy from any leakage of steam through the divider barrier can be readily absorbed by the containment spray system without exceeding the containment design pressure.

c. The doors and door ports shall limit maldistribution to a 150 percent maximum, peak-to-average mass input for the accident transient, for any reactor coolant system release of sufficient magnitude to cause the doors to open.

d. The basic performance requirement for lower inlet doors for DBA conditions is to open rapidly and fully to ensure proper venting of released energy into the ice condenser. The opening rate of the inlet doors is important to ensure that the pressure buildup in the lower compartment due to the rapid release of energy to that compartment is minimized. The rate of pressure rise and the magnitude of the peak pressure in any lower compartment region are related to the confinement of that compartment. The time period to reach peak lower compartment pressure due to the design basis accident is approximately 0.05 seconds.

e. During large break accidents, the doors will be accelerated by pressure gradients, and stopped by the shock absorber system. During small break accidents, the doors will open in proportion to the applied pressure with restoring force provided by springs. Upon removal of pressure, the doors will close as a result of spring action.

f. The doors shall be of a simple mechanical design to minimize the possibility of malfunction.

g. The inertia of the doors shall be low, consistent with producing a minimal effect on initial pressure.

h. The door system provides a flow proportioning capability for small break conditions.

Design Considerations – Normal Operation

a. The door hinges and crane wall embedments, etc., support the dead weight of the door assembly during all conditions of operation. Door hinges are designed and fabricated to preclude galling and self-welding.

b. During normal operations, the outer surface of the door operates at a temperature approaching that of the lower compartment while the inner surface approaches that of the ice bed. During loss of coolant accidents, the outer surface will be subjected to higher temperatures on a transient basis. Resultant thermal stresses are considered in the door design.

c. The doors shall restrict the leakage of air out of the ice condenser to the minimum practicable limit, a design feature that was confirmed by testing (Reference 16).

d. The doors restrict local heat input in the ice condenser to the minimum practicable limit.

e. The doors are instrumented to provide indication of their closed position. Under zero differential pressure conditions, all doors remain nominally 3/8 inch open.

f. Provision is made for adequate means of inspecting the doors during reactor shutdown.

g. The doors are designed to withstand earthquake loadings without damage so as not to affect subsequent ice condenser operation for normal and accident conditions. These loads are derived from the seismic analysis of the containment.

Interface Requirements

a. The door frames are attached to the crane wall via studs and anchor bolts with a compressible seal. Attachment to the crane wall is critical for the safety function of the doors.

b. Sufficient clearance is required for the doors to open into the ice condenser. Items considered in this interface are floor clearance, lower support structure clearance and floor drain operation, and sufficient clearance (approximately six inches) to accommodate ice fallout in the event of a seismic disturbance occurring coincident with a LOCA. Original ice basket qualification testing (Reference 6) has shown that freshly loaded ice is considered fused after five weeks following ice loading. During periods of plant operation within five weeks of ice bed maintenance, an alternate method of ice fusion qualification is relied upon (Reference 21). Conservatisms in the original qualification testing, qualitative evaluation of operating experience in actual ice condensers, and design features of the ice condenser provide reasonable assurance that the ice condenser lower inlet doors will not be blocked by a seismic disturbance during this limited period. Additionally, in the event of an earthquake (OBE or greater) that occurs within five weeks following ice basket loading, plant procedures require a visual inspection of applicable areas of the ice condenser within 24 hours to ensure that opening of the ice condenser lower inlet doors in not impeded by any ice fallout that resulted from the seismic disturbance.

c. Steam line and feedwater lines are provided with jet shields where necessary, to prevent direct impingement on the lower inlet doors.

d. The forces from opening or stopping the doors are transmitted to the crane wall and lower support structure, respectively.

5.3.5.9.3 Loading Conditions

The loading conditions for the lower inlet doors are specified in section 5.3.4.2.

Design Temperatures

Minimum inside temperature during normal operation is 10°F. The maximum outside temperature during normal operation is 120°F. The maximum design accident temperature for the lower inlet doors is 250°F.

Design Pressures

The maximum closing differential pressure during normal operating is 1 psf.

Maximum opening differential pressure during DBA is 16.3 psi, which includes a 20% margin.

5.3.5.9.4 Design Description

Twenty-four pairs of insulated inlet doors are located on the ice condenser side of ports in the crane wall at an elevation immediately above the ice condenser floor. Each pair is hinged vertically on a common frame.

In order to dissipate the large kinetic energies resulting from pressures acting on the doors during a LOCA, each door is provided with a shock absorber assembly.

5.3.5.9.5 Design Evaluation

The lower inlet doors were dynamically analyzed to determine the loads and structural integrity of the door for the design basis load conditions.

Using TMD results as input, the door dynamic analysis was performed using the "Door" Program (Reference 19). This computer program was developed to predict door dynamic behavior under accident conditions. This program uses the door geometry and the pressures to calculate flow conditions in the door port. From the flow conditions, the forces on the door due to static pressure, dynamic pressure, and momentum are derived. These forces, and the door movement generated force, i.e., air friction, are used to find the moment on the door; from this the hinge loads are derived. Output from the program includes the door opening angle, velocity, and acceleration as functions of time, as well as both radial and tangential hinge reactions.

For the seismic analysis, the panels are considered to be rigid plates pinned at one edge and supported by the gasket spring connection to the frame. Because of the lightweight nature of the door panels, the dynamic loads and stresses due to a seismic occurrence are small in comparison to the possible accident loading conditions, which in many instances determines the design conditions.

For the LOCA analysis, the net load distributions on the door for both opening and stopping were determined by considering the applied pressures acting on the door and then solving the rigid body equations of motion such that the net forces and moments at the hinge point are zero. In the process, this produced expressions for the inertial forces in the door and the hinge reaction as functions of the applied pressure. Both square and triangular pressure distributions during door opening were considered in the analysis with identical results in terms of net door loading.

A summary of the LOCA analysis performed and its results are presented in Table 5.3.5.9-1. All portions of the door and frame have a stress ratio less than or equal to one. For materials and components not covered by the design criteria, i.e., bearings, non-metallic materials, etc., conservative acceptance criteria were established on the basis of the manufacturer's recommendations and/or engineering evaluations.

All ice condenser doors are designed with substantial margin, in all members and attachments, under maximum dynamic loading conditions. This margin provides assurance that the lower inlet doors will not become missiles.

On the basis of the structural analysis performed, the lower inlet door assemblies are adequate for all anticipated loading conditions.

5.3.5.10 Top and Intermediate Decks and Doors

The top deck, intermediate deck, containment liner, crane wall and end walls form the boundaries of the ice condenser upper plenum. The upper plenum houses the air handling units and the air distribution ducts to the wall panels and provides a working space for loading, weighing and maintaining the ice baskets. The top and intermediate decks and doors are discussed in this section.

5.3.5.10.1 Top Deck

Functional Requirements

An array of blanket panels forms a thermal and vapor barrier atop the upper plenum, allowing limited movement of air through vents during plant operation and free outflow of air following DBA. A grating deck supports the blanket panels and accommodates limited personnel traffic. The top deck structure supports the grating as well as the rail assembly and the air handling units.

Design Criteria and Codes

For the structural design and material requirements, refer to Section 5.3.4. Additional material requirements are as follows:

a. The blanket material is fire resistant due to its own composition and a suitable cover sheet.

b. The blanket material is not a significant source of leachable halides in gaseous form, either by gradual diffusion of inherent ingredients or by radiolysis of component materials following a DBA.

c. The blanket material is not a significant source of leachable halides during exposure to containment spray following a DBA.

Design Considerations

a. Since the blanket panels are hinged on top of the crane wall, the major loads are applied directly into the crane wall.

b. A blanket panel must be flexible, i.e., be capable of deforming out of its plane in response to relatively low forces without disintegrating. Deformation of panels during DBA is permissible, but formation of missiles must be averted.

c. Deck structural integrity is essential to ice condenser performance during a DBA. Structural loads are a function of air pressure and flow relationships, which in turn are affected by deck characteristics.

d. The top deck structures are subjected to loads from the air handling unit and crane rail in addition to the deck design loads.

Thermal and Hydraulic Performance Requirements

a. Heat input to the plenum through the top deck assembly is limited to 13.5 BTU/hr-ft^2.

b. Resistance to airflow during a DBA is minimized, considering both inertia of panels and obstruction by grating. Panels may reclose or remain open following a DBA. Vent curtains are provided to open on a low differential pressure for small flow rates.

c. A vapor barrier is established on the upper surface of the blanket panels.

Interface Requirements

a. In the process of opening, adjacent blanket panels may interfere with each other or the polar crane. This is acceptable in view of their flexibility.

b. Sealing strips are installed to connect panel vapor barrier to adjacent panels, to the crane wall, to end walls, and to the containment liner, without transmitting appreciable loads to the containment liner.

c. The grating rests on, and is attached to, the cross beams between the top deck beams and transmits operating and drag loads to these structures. The structural members receive loads from the air handling units and from the deck itself.

d. During non-accident operation, there shall be no interference with the polar crane movement.

Loading Conditions

The loading conditions for the Top Deck are specified in section 5.3.4.2.

Live loads result from personnel traffic on the deck.

Loads on the deck include dead weight, live load, seismic, and DBA loads transferred by Air Handling Unit (AHU) Supports and the crane rails.

Design Temperatures

The minimum inside temperature during normal operation is 15°F. The maximum outside temperature during normal operation is 100°F. The maximum design accident temperature for the top deck is 190°F.

Design Pressures

Maximum differential pressure during DBA is 2.3 psi, which includes a margin of 20%.

Design Description

The top deck doors consist of foam insulating blankets encased in flexible stainless steel skins. These blankets are attached to the crane wall only. An increase in pressure below these flexible blankets will cause them to blow open over the top of the crane wall. This will permit the air to flow out of the ice condenser into the upper compartment.

A hinge bar clamps one edge of the blanket panel to the top surface of the crane wall. Anchor bolts transmit the hinge loads into the crane wall. Flexible seals are attached between the vapor barrier (top) surfaces of the blanket panels and containment liner and end walls.

A small vent area, approximately 20 sq. ft. is provided through the top deck to equalize pressure between the ice condenser and containment volumes during normal operating pressure fluctuations, and to permit small break LOCA steam/air flow through the ice bed.

The grating deck provides support for the top deck doors. It is supported from pairs of cross beams spanning the top deck beams, and its upper surface is flush with the top of the top deck beams. Figure 5.3.5.10-1 illustrates the typical top deck door configuration.

Design Evaluation

Top Deck Doors

The top deck doors were dynamically analyzed to determine the loads and structural integrity of the door for the design basis load conditions. Using results from the TMD code as input, the door dynamic analysis was performed using a separate computer code named the "Door" Program. This computer program was developed to predict door dynamic behavior under accident conditions.

For the LOCA analysis, the net load distributions on the door opening were determined by considering the applied pressures acting on the door, and then solving the rigid body equations of motion such that the net forces and moments at the hinge point are zero. In the process, this produced expressions for the inertial forces in the door and the hinge bar reaction as functions of the applied pressure. The resultant horizontal and vertical hinge loads, calculated by the "Door" Program, provided the inputs for a subsequent stress analysis.

A summary of the analysis performed and the results are presented in Table 5.3.5.10-1. All portions of the door have a stress ratio less than or equal to one. For materials and components not covered by Section 5.3.4, e.g., spring temper stainless steel, non-metallic materials, floor grating, etc., conservative acceptance criteria were established on the basis of the manufacturer's recommendations or ASTM minimum tensile properties.

The analysis of the effect of seismic occurrences on the top deck doors considers the supporting structures. The results of these analyses indicate very low loads and stresses, and seismic displacements will not affect the performance of these doors.

On the basis of the structural analysis performed on the top deck door assemblies, the doors are adequate for all anticipated loading conditions.

Top Deck Structure

The top deck structure was analyzed using the ANSYS finite element computer program. Three-dimensional beams represented the structural members, three-dimensional lumped masses represented the mass elements, and a stiffness matrix represented the flexible connections in the system. Geometric compatibility was maintained using three-dimensional rigid elements.

Two bays that are considered representative of the system were isolated and modeled. Conservatively, four air handling units were assumed to be located in the two-bay region - two next to the crane wall, and two next to the containment wall.

Stresses were calculated for the various combinations of dead load, thermal, seismic, and accident conditions. A modal analysis was performed to determine seismic amplification. Blowdown stresses were calculated using a computed dynamic load factor and a 20% margin added to TMD loads. The code allowable stresses and resulting stress ratios for the major members are listed in Table 5.3.5.10-2. The circumferential struts, cross members for the glycol tank, and crane rails outside of the ice condenser were analyzed and determined to be structurally acceptable. In conclusion all stresses for the top deck structure are within the limits of the design criteria given in Section 5.3.4.3.2.

5.3.5.10.2 Intermediate Deck

Functional Requirements

The intermediate deck forms the ceiling of the ice bed region and the floor of the upper plenum. It serves as a thermal and vapor barrier, which allows limited air movement, through vents, between regions during normal plant operation and free out flow of air and steam following DBA.

Design Criteria and Codes

Refer to Section 5.3.4 for the applicable structural and material criteria.

Design Considerations

a. Structural support is provided by radial beams attached to the top of the lattice frame columns.

b. Door panels are mounted in pairs, back to back, on a structural frame.

c. Door panels consist of slabs of rigid insulating materials, with sheet metal bonded to both faces and framed around the edges. The composite structure is designed to resist all design loads.

d. The deck forms an integral part of the ice condenser. Mechanical characteristics are incorporated to accommodate DBA flows and forces.

e. The deck is used intermittently as a walking surface for maintenance of the air handling units and inspection of the ice bed.

Thermal and Hydraulic Performance Requirements

a. Heat conduction through the intermediate deck is limited to 0.6 BTU/°F-hr-ft^2.

b. Resistance to airflow during a DBA is minimized, considering inertia of the door panels and obstruction by the frames. The panels may reclose or remain open following a DBA. Vent curtains are provided to open on low-pressure differential for small flow rates.

c. A vapor barrier is established on the lower surface of the door panels.

Interface Requirements

a. At the end of their movement, pairs of doors will collide. Distortion at the time is acceptable, provided analysis demonstrates that the doors will not become missiles.

b. Sealing strips are installed to seal the deck frames to the wall panels as a continuation of the vapor barrier.

c. Hinge loads, drag loads, and live loads are transmitted from the deck through the support beams to the lattice columns.

d. Cables from the temperature monitoring system penetrate the vapor barrier area of the deck.

e. The deck doors may be opened to permit access to certain ice baskets. If access is required to the baskets located below the deck frame, a deck assembly may have to be temporarily removed.

Loading Conditions

The loading conditions used for the Intermediate Deck Assembly are specified in section 5.3.4.2.

Live loads result from personnel traffic and maintenance operations on the deck.

Design Temperatures

The minimum temperature during normal operation is 15°F. The maximum Post-LOCA temperature for the intermediate deck is 190°F.

Design Pressures

Maximum differential pressure during DBA is 2.42 psi, which includes a margin of 20%.

Design Description

The intermediate deck doors enclose the top of the ice compartment and form the floor of the upper plenum. The doors and frames are supported by radial structural steel beams that, in turn, are supported by the lattice frame support columns. The door panels are comprised of structural steel framing and an insulation foam plastic core with bonded and mechanically fastened sheet metal facings. The doors are hinged horizontally and are normally closed. On an increase in pressure in the ice condenser compartment, these doors will open as required, allowing air to flow into the upper plenum.

The panels cover nearly all of the deck area. Pressure equalization vents are installed at three locations on the intermediate deck. Vertical curtains minimize diffusion of air under steady state conditions while permitting free movement of air in or out during momentary periods of pressure imbalance. Figure 5.3.5.10-2 shows the intermediate deck door arrangement.

Design Evaluation

The intermediate deck doors were dynamically analyzed to determine the loads and structural integrity of the door for the design basis load conditions.

Using the results of the TMD code as input, the door dynamic analysis was performed using a separate computer code, the "Door". This computer program has been developed to predict door dynamic behavior under accident conditions.

A summary of the analysis performed and the results obtained for the intermediate deck and doors are presented in Table 5.3.5.10-3. All portions of the doors, frames, and support beams have a stress ratio less than or equal to one during door opening. The general acceptance criterion was that stresses be within the allowable limits of the Design Criteria specified in Section 5.3.4.3.2.

On the basis of the structural analysis performed on the intermediate door assembly, it is concluded that the doors, support structure and door frames are adequate for all anticipated loading conditions.

The analysis of the effect of seismic occurrence on the intermediate deck and doors considers the supporting structures. The results of these analyses indicate very low loads and stresses, and seismic displacements will not affect the performance of these doors.

5.3.5.11 Equipment Access Door

5.3.5.11.1 Functional Requirements

The equipment access door was designed to permit movement of the crane, equipment and personnel into and out of the ice condenser plenum for ice loading and maintenance. The equipment access door has been permanently positioned in the up or closed position, and is provided with an integral personnel access door. In the closed position, the door constitutes a thermal and vapor barrier (normal plant operation) and a pressure barrier (accident condition) between the ice condenser air and the upper containment atmosphere.

The basic functions of the equipment access door are non-safety-related. It is important, however, to prevent failure of the door in any manner that may affect safety related components located nearby.

5.3.5.11.2 Design Criteria and Codes

The door is designed to comply with structural requirements of the Design Criteria in Section 5.3.4. As an added conservatism, stresses are held below AISC allowable levels for all loadings.

5.3.5.11.3 Loading Conditions

The loading conditions used for the Equipment Access Doors are specified in section 5.3.4.2.

Design Temperatures

The minimum inside temperatures during normal operation is 15°F. The maximum outside temperature during normal operation is 100°F. The maximum design accident temperature for the equipment access door is 190°F.

5.3.5.11.4 Design Description

An equipment access door is provided in each end wall. The equipment access door includes: the insulated door panel, a smaller personnel access door within the panel, a frame and hoist assembly, gaskets, and fasteners. The door frame is bolted across a gasket strip to a fixed frame that is embedded in the concrete end wall. All exposed surfaces are protected against corrosion by appropriate coating.

Limit switches are provided to monitor the movement of each door, and to indicate each door's position as a part of the door position monitoring system. The equipment access door is fixed in place and only the personnel access door is used.

5.3.5.11.5 Design Evaluation

The equipment access door is a non-safety related component. The door stresses during DBE + DBA loadings are well below the criteria provided in Section 5.3.4.3.2.

5.3.5.12 Glycol Refrigeration System

5.3.5.12.1 Functional Requirements

The glycol refrigeration system serves to cool down the ice condenser from the ambient conditions of the reactor containment and to maintain the desired temperature in the ice compartment. The refrigeration system includes a defrost capability for critical surfaces within the ice compartment. See Figures 5.3.5.12-1 and 5.3.5.12-1A for a composite view of the ice condenser glycol refrigeration system.

During a postulated LOCA, the refrigeration system is not required to provide any heat removal function. However, the refrigeration system components that are physically located within the containment must be structurally secured and the component materials must be compatible with the POST-LOCA environment.

5.3.5.12.2 Design Considerations

1. The design must provide a sufficiently insulated annulus such that, with a complete loss of all refrigeration capacity, sufficient time exists for an orderly reactor shutdown before the ice begins to melt. The insulation of the cavity is adequate to prevent the ice from melting for at least 7 days in the unlikely event of a complete loss of refrigeration capability.

2. The non-safety related design considerations are:
   a. Ice sublimation: Ice Sublimation and mass transfer shall be reduced to the lowest possible limits by maintaining essentially isothermal conditions within the ice bed and by minimizing local temperature gradients. A design objective was to limit the sublimation of the ice bed to less than 2 percent per year by weight. Actual sublimation is monitored via Technical Specification surveillance.
   b. An appropriate combination of refrigeration capacity and insulation capability shall be provided to maintain the average ice bed temperature in accordance with Technical Specification requirements, and cool the ice condenser from ambient containment temperatures down to 15°F in 14 days.

5.3.5.12.3 Design Description

The glycol refrigeration system serves as a central heat sink for the ice condenser. A circulating system of ethylene glycol solution carries the heat from the various heat transfer surfaces to the chiller packages. The refrigeration system has three stages:

- Refrigerant loop
- Glycol loop
- Air cooling loop

Each of these loops is discussed below.

Refrigerant Loop

Five 50-ton chiller packages are located in the auxiliary building and serve both ice condensers. Each package consists of two separate self-contained 25-ton units. Each unit is a closed refrigeration system consisting of a compressor, a condenser, an expansion valve, an evaporator, and related controls and accessories. See Figure 5.3.5.12-2 for refrigerant cycle diagram. Ethylene glycol solution is cooled during its passage through the evaporator, and heat is removed from the chiller unit by cooling water that flows through the condenser. The condenser cooling water is provided from the nonessential service water system. The chiller units operate individually to maintain a nominal outlet temperature of ethylene glycol at -5°F.

Glycol Loop

The glycol loop, shown in Figure 5.3.5.12-3, carries the heat removed from the ice condenser air handling units and the floor cooling system to the refrigerant cycle evaporator/cooler units. The liquid circulating through this cycle is corrosion inhibited 45 to 55% ethylene glycol solution. It is compatible with common piping, valve, gasket and packing materials (Reference 7). The piping and valve materials used in this loop are predominantly carbon steel with stainless or alloy trim. The piping and equipment carrying chilled ethylene glycol solution are covered with low temperature thermal insulation.

Six glycol-circulating pumps convey the cooled glycol from the ten refrigeration units to the air handling units (30 dual air handler units per containment) and to the ice condenser compartment floor cooling system of each containment. The heated glycol is then returned to the refrigeration units thereby completing the glycol loop. The heat is extracted from the ice condenser in its passage through the air handlers and from the floor cooling system. The ice condenser floor is kept cold by circulating the chilled glycol solution through pipe coils embedded in the concrete wear slab. During normal operation, one floor-cooling pump feeds a circular header, which distributes the coolant to individual coils located in each bay. A second circular header returns the flow to pump suction.

The floor cooling system and the isolation valves are discussed in Sections 5.3.5.1 and 5.3.5.12.5 respectively.

Air Cooling Loop

The ice condenser compartment is designed to be kept below the freezing point throughout the operating life of the plant. It is cooled below freezing prior to loading and maintained in accordance with Technical Specification temperature requirements. The temperature of the ice bed is maintained at the specified level by circulating chilled air through the boundary planes of the compartment. Starting in the upper plenum, which constitutes the top boundary, air enters one of 30 air handling units located in the plenum. Each air handling unit consists of two air handlers mounted in a common housing that cool the air and blow it down through the insulated duct panels lining the ice compartment walls.

As the uniformity of temperature in the ice bed is important to reduce the amount of sublimation occurring, the flow pattern of the duct work was designed to minimize temperature variations on the inner “ice bed side” surface. The cold air exiting the air handler units is distributed to the wall panel ducts, which are divided into two sections. The inlet section covers the entire front surface of the duct, except for the insulated lap strip region. The cold air flows down the length of the ice condenser wall to the top of the lower support structure or floor, then returns flowing up the backside facing the hot boundary. The inlet and outlet ducts are isolated from each other with insulation. The regenerative effect is very small since the two film coefficients on either side of the insulation provide a resistance that results in a relatively nominal or small heat flow from the hotter to the colder inside duct. The insulation between the containment wall or crane wall and the duct provides the primary resistance to reduce the heat flow into the ice bed.

An additional load is imposed on the refrigeration system due to the heat flow into the upper plenum. The walls of the plenum are also insulated by fiberglass panels, but the air flow from the duct panel exhaust to the air handling units circulates in the plenum, picking up heat input through the insulation and top deck doors. This ensures that moisture leaking into the ice condenser plenum is picked up by the air and freezes on the cooler coils. Together with the vapor barrier on the inner face of the insulated duct panels, this minimizes the ingress of moisture into the ice bed. See Figure 5.3.5.12-4 for a schematic flow diagram of the air cooling cycle.

5.3.5.12.4 Determination of Heat Inputs to the Ice Condenser

The design conditions for the hot boundaries of the ice condenser are:

a.	Lower containment, air temperature	120°F
b.	Upper containment, air temperature	100°F
c.	Outer containment wall	110°F
d.	Leakage at bottom of ice condenser	50 cfm

Item c. is the sol-air design temperature for a 50-year hot summer, plus an additional margin in the region of Michigan where the Cook Nuclear Plant units are located. The 1% 50 year maximum integrated average sol-air temperature for the region of interest is 96°F. The 1% factor is defined such that only 1% of the time weighted sol-air temperature during the summer months will be above the specified temperature. This data was obtained from the ASHRAE climatic guide for cooling and heating design conditions.

The major thermal boundaries of the ice condenser including the floor, cooled walls with ducts, lower inlet doors, and top deck support beams were analyzed using Westinghouse developed TAP-A, (or TAP-B), a program for computing transient or steady-state temperature distributions.

The TAP-A program is applicable to both transient and steady-state heat transfer in multi-dimensional systems having arbitrary geometric configurations, boundary conditions, initial conditions, and physical properties. The program can be utilized to consider internal conduction and radiation, free and forced convection, radiation at external surfaces, specified time dependent surface temperatures, and specified time dependent surface heat fluxes.

The TAP-B program is a variation of TAP-A but includes fluid coupling to the finite element model. The TAP-B variation was used to analyze the cooled wall panels. Since the duct air temperature distribution was included in the model it is possible to evaluate the temperature distribution of the surfaces of the wall panel facing the ice condenser over the complete length of the duct.

5.3.5.12.5 Design Evaluation

The refrigeration system is sized to maintain the required ice inventory even under worst case operating conditions. The total capacity of the chiller packages is sufficient to maintain both ice condensers. The refrigeration system is designed for maximum flexibility. The six circulating pumps and ten chiller units (5 packages) are provided with two sets of piping manifolds to conduct the ethylene glycol solution into and out of any combination of these components. Consequently, the associated systems can be refrigerated from the central source with a minimum of interaction, and a high degree of redundancy is available for normal plant operation.

Sublimation is a phenomenon observed in ice storage applications characterized by a transfer of ice mass from one area to another. The rate of sublimation within the ice condenser is dependent upon temperature gradients existing within the ice condenser compartment, and air leakage from the ice condenser. By design, as described in Section 5.3.5, the ice condenser compartment and various components forming portions of the ice condenser boundary are insulated to restrict heat transfer into the ice condenser enclosure, thereby minimizing temperature differences within the ice condenser compartment. As discussed in Section 5.3.5.12.3, the refrigeration system air handling units circulate air through cooling ducts located at the ice condenser compartment boundaries. These ducts are configured such that the cooling air does not communicate directly with the ice in storage, and are configured to minimize temperature variations on the inner side of the ice condenser compartment. Air leakage from the bottom of the ice condenser is limited by various design features including seals on the lower inlet doors, flapper-style check valves on the drain lines, and water-soluble paper coverings on the floor drain gratings.

The original sublimation rate was estimated to be on the order of 1% per year. Experience gained through ice weight surveillance testing at D.C. Cook and other ice condenser plants have determined that the sublimation rates are not uniform throughout the ice condenser volume and are on average slightly higher than that originally predicted. Based on D.C. Cook and industry experience, the basis for the Technical Specification ice basket ice weight surveillance assumes an ice sublimation rate of 10% over an 18 month surveillance interval. Performance of this surveillance, in conjunction with the ice condenser design features and inspections, ensure that sufficient ice mass will be maintained in the ice condenser throughout the operating cycle.

5.3.5.12.6 Refrigeration System - Components

The following discusses Refrigeration System components.

Air Handling Units (AHU)

Functional Requirements

During normal operation the air handling units serve to cool the air and to circulate the cooled air through the ice condenser wall panels to keep the ice subcooled in the ice beds.

Loading Conditions

The loading conditions for the Air Handling Unit (AHU) are normal thermal, dead weight, and OBE. During DBE and/or DBA the AHU is supported by the AHU support structure although the AHU is not required to maintain its cooling function.

Design Temperatures

The minimum temperature during normal operation is 15°F. The maximum design accident temperature for the air handling units is 190°F.

Design Criteria

Refer to Section 5.3.4 for the design criteria.

To minimize seismic loads, the AHU and supports are designed to have a natural frequency of approximately 20 Hz.

Material Requirements

All materials used in the AHU's are compatible with both normal and post LOCA environments.

Design Description

Each AHU is supported from its support structure, transmitting its major loads to top deck cross beams. See the AHU Support Structure Design Criteria for additional details.

Design Evaluation

Analysis of the AHUs was performed which showed that for the required loading conditions, all stresses were within the allowable values specified in Section 5.3.4.3.2.

Air Handling Unit Support Structure

Functional Requirements

The AHU support structure supports the Air Handling Unit package under all design conditions

Design Criteria

Refer to the Design Criteria Section 5.3.4.

Loading Conditions

The loading conditions for the Air Handling Unit Support Structure are specified in section 5.3.4.2.

Loads include dead weight, seismic and DBA loads transferred from the AHU.

Design Temperatures

The minimum temperature during normal operation is 15°F. The maximum design accident temperature for the air handling unit support structure is 190°F.

Design Description

The support structure supports the air-handling unit vertically and tangentially from the cross beam of the top deck structure and is radially hinged from channels attached to the crane wall or containment liner.

Design Evaluation

Analysis of the AHU support structure determined that the stresses for the required loading conditions were within the allowable values specified in Section 5.3.4.3.2. The code allowable stresses and the resulting stress ratios are listed in Table 5.3.5.12-1 for the AHU support beams.

Isolation Valves

Functional Requirements

Isolation valves are provided on each side of the glycol supply and return lines penetrating the containment - a total of four valves per ice condenser. During normal operation, the isolation valves are open, thereby permitting glycol coolant to flow between the containment and the chiller packages. During a LOCA, the automatic diaphragm valves shut, which terminates the glycol coolant flow and isolates the containment penetrations.

Design Criteria

The valves are designed and installed in conformance with the requirements of the containment isolation system, Section 5.4.

Design Description

The valves are 4-inch, 150 lb diaphragm valves, made from ASTM A-216, Grade WCB, normalized material with pneumatic operators. Materials and paints are corrosion resistant and present no material compatibility problems during either normal or accident conditions. Provisions exist for periodic leak testing of the isolation valves in place.

Design Evaluation

The valves constitute part of the reactor containment boundary. The valve operation satisfies the requirements of GDC 57 "Closed System Isolation". In addition, a small check valve is included within containment, which provides a passage for expanding liquid trapped between the automatic diaphragm valves, thereby avoiding a destructive pressure buildup. At the same time, the check valve prevents reverse flow (out of containment), and therefore, also satisfies the requirements of GDC 57.

The valves function under DBE and/or DBA conditions and seal against the circulating pump head. The valves meet the requirement of Section 5.4 and applicable portions of Section 5.3.4.

5.3.5.13 Air Distribution Ducts

5.3.5.13.1 Functional Requirements

The air distribution ducts distribute the cold air from all air handling units uniformly to the wall panels (See Figure 5.3.5.12.3).

5.3.5.13.2 Design Criteria

The air distribution ducts are permitted to deform during accident conditions but must not affect any safety-related components located nearby.

5.3.5.13.3 Loading Conditions

The loading conditions for the air distribution ducts are normal, thermal, dead weight and OBE.

Design Temperatures

The minimum temperature during normal operation is 10°F. The maximum design accident temperature for the air distribution ducts is 190°F.

5.3.5.13.4 Design Description

The air distribution ducts are located in the upper plenum. The ducts are made of galvanized sheet steel. The design includes expansion joints that separate each duct and each AHU. The expansion joints also serve as vibration breaks.

The air distribution ducts are a part of the refrigeration system and serve to distribute cold air to the wall panels thereby maintaining the readiness of the ice in the ice bed. The air distribution ducts are not required to function during an accident. The air distribution ducts are, therefore, non-safety related components. Refer to Section 5.3.5.12.3 for detailed discussions of the refrigeration system performance during normal operating conditions and of its ability to tolerate refrigeration component failures.

5.3.5.13.5 Design Evaluation

During a LOCA the air distribution ducts are permitted to deform. Any deformation will be outward toward the crane and liner wall insulation and therefore present no problem to nearby safety related components. The behavior of the air distribution ducts during design basis events is consistent with the functional requirements of the refrigeration system, Section 5.3.5.12.1.

5.3.5.14 Ice Machine

Three ice machines are installed in the auxiliary building. The machines are each capable of producing thirteen tons of borated ice per day, which is adequate for all recharging requirements. The ice is made in a shape and size convenient for handling, and provision is made for checking that ice loading and ice chemistry are maintained within the prescribed limits. The ice is moved into the containment through a normally closed penetration by a pneumatic conveying system. The system feeds ice through temporarily installed hoses to the ice baskets.

5.3.5.15 Ice Condenser Instrumentation

5.3.5.15.1 Functional Requirements

The ice condenser is a passive device requiring only the maintenance of the ice inventory in the ice bed. There are no actuation circuits, or equipment, which are required for the ice condenser to operate in the event of a LOCA. The instrumentation provided for the ice condenser serves only to monitor the ice bed status. Ice condenser temperature monitors, door position monitors, coolant liquid level monitors and valve position indications are displayed and alarmed. The instrumentation is designed for reliable operation including sufficient redundancy to ensure that the operator can accurately monitor the ice condenser status. Testing of the ice condenser instrumentation is performed in accordance with the Technical Specifications.

5.3.5.15.2 Design Description

Each equipment package (e.g. air handler, ice machine, chiller package) is provided with the controls needed to regulate its normal operation. The ice condenser instrumentation serves to monitor the operation of the equipment packages and the ice bed status by providing to the operator the following control room information:

a. Temperature Measurements

Monitoring the ice bed and plenum temperatures provides information about possible thermal gradients, as well as the general condition of the ice bed. The temperature recorder is located in the control room. The recorder monitors 96 independent temperatures. The recorder is provided with alarm switches and the alarm is activated if a pre-selected temperature setpoint is exceeded. The thermal status of Ice Condenser floor cooling and wall duct panels is monitored at 42 sensing points including eight wall monitoring points, 30 floor monitoring points and four glycol supply/return sensing points. The sensing points are recorded by an additional recorder mounted on the CAS sub-panel located adjacent to the Control Room.

A local temperature indicator is installed in each Air Handling Unit discharge duct.

b. Door Position Indications

The 48 lower inlet doors are arranged in pairs to cover the 24 openings. Each door has two limit switches that monitor its position. One of each door's switches is wired to an individual status lamp on the CAS sub-panel. The 48 remaining switches are connected in parallel to a common annunciator on the SV panel. Thus, if any door is open, there will be an alarm in the control room and the identity of the open door or doors can be determined by observing the status lamps

The lower personnel access door also has two limit switches: one lights a status lamp on the CAS sub-panel and the other actuates its own annunciator on Panel SV if the door is open. A lamp test feature is provided that lights all 49 status lamps simultaneously via a push button or from the CAS sub-panel.

There are two Ice Condenser equipment access doors; each houses an integral personnel door. The position of each of these two door sets is monitored by limit switches. The arrangement is such that if any one of the four monitored doors is not fully closed and latched, an alarm will annunciate on panel SV. A status lamp on the CAS sub-panel will light identifying which of the two door sets is causing the alarm.

c. Expansion Tank Level

Annunciation and display are provided to warn the operator of coolant level excursions in the glycol expansion tank. Four indications are provided corresponding to HI-HI, HI, LO, & LO-LO liquid levels. A LO-LO level also closes the outboard glycol containment isolation valves, and the Glycol Expansion Tank outlet valves. A loss of level would indicate a leak somewhere in the system or an erroneous valve operation. A high level would result from mal-operation or failure of the refrigeration system. Two independent sensors are provided for each pair of level indications.

d. Isolation Valves

Two position lights (open and closed lights) are provided for each of the four glycol system containment isolation valves.

5.3.5.15.3 Design Evaluation

The Ice Condenser monitoring instrumentation is a surveillance and alarm system only and performs no operational plant control or protection functions. As such, the instrumentation is not required to meet IEEE-279 or other standards applicable to protection equipment.

The ice condenser design provides adequate time for the proper evaluation of any adverse situations such that corrective action can be performed or an orderly plant shutdown can be scheduled and accomplished within the plant technical specification limits. The ice condenser monitoring instrumentation is tested and/or inspected on a periodic basis. In addition the ice condenser is defrosted as needed during outage periods, based on inspection and/or surveillance results. Following defrosts, lower inlet doors and flapper valves are tested to ensure the defrost did not impair the ability of these components to function. Likewise, the temperature recorders and alarms are active during the defrost periods and the performance is verified. Personnel access is provided to the upper plenum through personnel access doors integral to the equipment access doors, and to the lower structure plenum through any lower inlet door. This visual inspection can detect coolant leaks, abnormal ice melting, unseated doors or other anomalies and serves as an independent check, which will be used to verify the indications received in the control room. Sufficient redundancy is provided in the ice condenser instrumentation to assure accurate monitoring of the ice condenser status.

5.3.5.15.4 Sensitivity to Small Leaks

Consideration has been given to the possibility that a small leak from the reactor coolant system could melt ice without the leak or the ice melt being detected. Temperature detectors in the ice condenser and the inlet door position indicators would provide one indication of this condition. In order for steam to enter the ice condenser, the door opening differential pressure of one pound per square foot (psf), produced by the cold air density in the ice condenser, must first be overcome. Because of the holes in the operating deck, the reactor coolant leakage has to be high enough to generate sufficient differential pressure across the deck before the inlet doors would begin to open.

Calculations of the leakage required to generate a 1 psf differential pressure through an assumed 5 sq. ft. deck leakage area indicate that the reactor coolant leakage would be between 70 gpm and 240 gpm, depending on the mixture concentration of steam and air passing through the deck. These calculations take no credit for heat removal by structures and by the containment ventilation system. This range of leakage would quickly be detected by reactor coolant system instrumentation, and plant shutdown would be initiated. Also, this range of leakage into the containment would produce a range of maximum containment pressure rise rates between 9 and 14 psi per hour, which would quickly be indicated by the containment operating pressure alarm, and appropriate action would be initiated. Containment spray would be initiated either manually or automatically. Considering the current design basis value of 7 sq. ft. for the deck leakage area, the response of pressure change inside containment will be as previously prescribed.

Coolant leakages less than the range described above will not affect the ice condenser. Coolant leakages greater than this range would be handled by the ice condenser. Leakage through the deck up to the maximum of this range would be handled by the containment spray system. The spray system has the capability of limiting the steam partial pressure to 2 psi in the upper compartment.

5.3.6 Historical Information

Design Evaluation

As a result of extensive analytical work, autoclave tests, and full-scale section tests performed by Westinghouse, the design performance of the ice condenser has been established. Proprietary Westinghouse reports References 4, 5 and 6, which describe this analytical and test work in detail, were transmitted to the Division of Reactor Licensing of the Atomic Energy Commission for their review of the ice condenser concept.

An additional proprietary document, Reference 2, describes additional fullscale sections test and presents analysis of the ice condenser design performance and sensitivity to variations in important parameters specifically related to the Donald C. Cook Nuclear Plant. Also see updated Appendix J.

The effect of sodium tetraborate on the removal of iodine by the ice condenser is discussed in Reference 7.

The main conclusions derived from this effort can be summarized as follows:

a. The peak pressure in the containment resulting from a loss-of-coolant accident is limited to a very low value as a result of the rapid absorption of energy by the ice condenser.

b. Containment pressure is further reduced within a few minutes after the loss-of-coolant accident to a few psi, thus, the time at elevated pressure and hence the probability of leakage of fission products from the containment is substantially reduced.

c. The ice condenser performance is only slightly sensitive to blowdown rate and blowdown energy within the ranges of interest.

d. Reductions in heat transfer surface area of the ice by a large factor do not significantly affect ice condenser performance.

e. The response of the ice condenser to accident conditions is very rapid.

f. The ice condenser is essentially a static device, which does not require any power source, its operation during an accident does not depend upon the functioning of any other system.

g. Iodine removal is enhanced by the sodium tetraborate in the ice condenser.

Additional details are presented in Appendix J, "Ice Condenser Containment Analysis" and in Appendix M, "Ice Condenser Component Evaluation Report". For purposes of this FSAR update, the above reports have been updated to reflect applicable plant changes and to meld the responses to NRC OL-review questions into the text. In addition, the original Appendix N, "Ice Condenser Containment System Performance Evaluation Report" has been updated and placed into appropriate sections of the July 1982 FSAR Chapters, and applicable portions are incorporated within Appendix M. Both Appendices J and M follow Chapter 14 of this FSAR.

Ice Condenser Inspections

"After the ice condenser has been cooled and loaded with ice, sufficient time will elapse before the reactor plant is heated to temperature for initial power operation. During this period, a number of inspections are made of the ice condenser and its systems. After power generation begins, the surveillance program continues at the frequency specified by the Technical Specifications. Access to the upper plenum of the ice condenser compartment is possible while the reactor is at full power; therefore, inspections of the flow passages and ice bed, and performing chemical analysis of the ice composition is possible at any time. This surveillance capability also includes continuous monitoring of the cooling system for satisfactory operation and the ice condenser inlet doors, intermediate deck doors, and top deck doors to assure they are in the closed position".

5.3.6.1 Historical References

1. Deleted.
2. W. J. McCurdy, et. al., "Design and Performance Evaluation of the Ice Condenser Reactor Containment System for the Donald C. Cook Nuclear Plant," WCAP-7183 (March 1968), Proprietary; Supplement 1 (July 1968), Proprietary; Supplement 2 (August 1969), Proprietary.
3. Not Used
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5.4 CONTAINMENT ISOLATION SYSTEM

The containment isolation system provides the means of isolating the various pipes passing through the containment walls as required to prevent the release of radioactivity to the outside environment in the event of a design basis accident. The main steam, feedwater, steam generator blowdown, steam generator drain (Unit 2 only), and steam generator sampling systems are secondary piping connections to the steam generator shell which is considered an extension of the containment liner. The isolation valves in the main steam, feedwater, and steam generator blowdown piping are not subject to Type `C' leak testing because they do not provide a containment isolation function and their omission from leak testing is in compliance with the requirements set forth in 10 CFR 50, Appendix J, Option B.

5.4.1 Design Bases

The Cook Nuclear Plant was designed to the general design criteria stated in Sub-Chapter 1.4. The design of the piping, valving, penetrations, and areas in the vicinity of the penetrations was completed before July 1971 when the AEC General Design Criteria Nos. 54, 55, 56 and 57 were published in the Federal Register. The design bases applying to all the features of the containment isolation system at Cook Nuclear Plant are given in the following paragraphs.

Containment Isolation System Design Basis

Subsequent to an incident, there are at least two barriers between the atmosphere outside the containment and (1) the containment atmosphere, (2) the Reactor Coolant System or (3) closed systems inside the containment which are assumed vulnerable to accident forces. These barriers are listed in Table 5.4-1. The following conditions and definitions are used in the design of the containment isolation system to assure that the above is met:

1. The design pressure of all piping and connected equipment within the isolated boundary is greater than the design pressure of the containment
2. Lines connected to closed systems with a low probability of failure have at least one automatic shut-off valve. Low probability of failure systems are those systems that are as a minimum Seismic Class I, Quality Level 2 (a closed system may be quality level 3 if it is low energy) and protected from environmental forces (i.e. missiles, jet impingement, flood, etc.), as required.

3. All valves and equipment, which are considered to be isolation barriers, are protected, as required against missiles and water jets, both inside and outside the containment.
4. Lines which, due to safety considerations, must remain in service subsequent to certain accidents have as a minimum one remote-manual valve, except instrument sensing lines which have one manual valve.
5. All isolation valves and equipment are designed to operate as Class I seismic equipment.
6. The two barriers may consist of:
   a. two automatic isolation valves,
   b. an automatic isolation and a normally closed valve,
   c. an automatic isolation valve and a closed piping system or vessel inside or outside the containment,
   d. two normally closed valves,
   e. a normally locked or sealed closed valve and blind flange and/or combination of valves and caps or plugs.
7. A check valve on an incoming line or a locked or sealed closed valve is considered equivalent to an automatic valve.
8. Automatic isolation is provided in all cases except for those lines which are required to be operational in post-accident conditions or normally closed lines that are isolated by locked or sealed closed valves, blind flanges and/or combination of valves, caps or plugs.
9. Test connections that are used for testing of the containment isolation valves are designed such that there are at least two barriers between the outside atmosphere and (1) the containment atmosphere, (2) the reactor coolant system, or (3) closed systems inside containment that are assumed vulnerable to accident forces. One barrier may be the containment isolation valve itself, which is between the containment atmosphere and the test connection. For closed systems inside containment, which are Seismic Class I design with a low probability of failure, only one additional barrier is required. The closed system in this case is considered a barrier itself. Test connections are provided with normally closed valves and/or combination of valves and pipe caps or plugs and are

administratively controlled. The test connections that are within double barrier are designed safety-related, Seismic class I.

10. All normally closed valves and caps/blind flanges or plugs are administratively controlled to ensure containment integrity.
11. An exception to the requirement for two barriers applies to those penetrations, which carry instrument sensing lines. Such penetrations consist of single manual open valve and a closed system outside containment, which is considered an extension of the containment liner. These penetrations are identified under Class E piping below.
12. An exception to the requirements for Class A piping segments apply to those penetrations, which have AOV diaphragm type seat closure valves. Such penetrations which have this type of valve which produce a closure force sufficient to pressurize the containment segment in excess of maximum accident pressure but not fully close. These segments are isolated by at least one other isolation valve producing a closed system. The closed system piping inside containment is not seismic class 1, so if the piping inside containment fails the containment is not seismic class 1, so if the piping inside containment fails the containment isolation valves are capable of closing and maintaining the two barrier configuration. These penetrations are identified under a Class A Exception and in Tables 5.4-1.

NOTE: A seal may be used in lieu of a lock to satisfy the locking requirements discussed in the section above.

Containment Isolation Testing and Reliability

The containment isolation system is designed to provide such functional reliability and testing facilities as are necessary to avoid undue risk to the health and safety of the public. The air operated isolation valves close on loss of control power or air. The instrumentation and control circuits are redundant in the sense that a single failure cannot prevent containment isolation. Provision is made for periodic testing of the leak tightness and functioning of the isolation valves.

Test connections are locked closed and capped, flanged or plugged and are administratively controlled to ensure containment integrity. Therefore, no further testing of test connection leak tightness is required. This is consistent with the clarifications of Appendix J requirements discussed with the NRC during the CILRT inspections conducted February 9-15, 1989 (Inspection Report Nos. 50-315/89007 (DRS) and 50-316/89007 (DRS).

Containment Isolation System Protection

Adequate protection for containment isolation, including piping, valves, and vessels, is provided against dynamic effects and missiles which might result from plant equipment failures including a loss-of-coolant accident. Isolation valves inside the containment are located between the crane wall or some other missile shield and the outside containment wall. Isolation valves, piping or vessels which provide one of the isolation barriers outside the containment are similarly protected, as required.

Containment Isolation System Operation

No manual operation is required for immediate isolation of the containment. Automatic trip valves are provided in those lines which must be isolated immediately following an accident. Lines which must remain in service subsequent to certain accidents for safety reasons are provided with at least one remote manual valve, except instrument sensing lines that are provided with one manual valve.

Automatic trip valves may be operated by a manual switch. The position of each automatic trip valve is displayed in the main control room.

The instrumentation and controls for the system are described in more detail in Chapter 7.

Containment Isolation System Piping Classes

The functional classes of piping are used to further define the design bases.

Class A

Class A piping is open to the outside atmosphere, and is connected to the reactor coolant system, or is open to the containment atmosphere. Alternatively, Class A piping is piping that is not considered "low probability of failure" in design and is assumed to be vulnerable to accident forces.

For Class A piping the following is provided, as a minimum, for isolation subsequent to an incident:

a. Incoming Lines: Two auto-trip valves or a check valve and an auto-trip valve or two locked or sealed closed manual valves.

b. Outgoing Lines: Two auto-trip valves or two locked or sealed closed manual valves.

(Exception: For Unit 1: All NESW; DCR 205 & 206; QCR 919 & 920 and DCR 600 & 601 CIV AOV diaphragm valves.

For Unit 2: NESW to lower containment ventilation units and instrument ventilation units; DCR 205 & 206; QCR 919 & 920 CIV AOV diaphragm valves.

In the event that the pressure piping barrier remains intact following an isolation incident, the pressure piping membrane also serves as an isolation barrier. Under those conditions, the following is provided for minimum isolation subsequent to the incident:

a. Incoming Lines: One auto-trip valve along with an additional auto-trip valve that would close in the event the pressure piping barrier subsequently failed or one check valve and an auto-trip valve or two locked or sealed closed manual valves.

b. Outgoing Lines: One auto-trip valve with an additional auto-trip valve that would close in the event the pressure piping barrier subsequently failed or two locked or sealed closed manual valves.)

Class B

Class B piping is connected to a closed system outside the containment, and is connected to the Reactor Coolant System or is open to the containment atmosphere. For Class B piping the following is provided for minimum isolation subsequent to an incident:

a. Incoming Lines: One auto-trip valve or a check valve or one locked or sealed closed manual valve.

b. Outgoing Lines: One auto-trip valve or one locked or sealed closed manual valve.

Class C

Class C piping is connected to open systems outside the containment, and is separated from the Reactor Coolant system and the containment atmosphere by a closed system (membrane barrier). The membrane barrier shall be Seismic Class I and Quality level 2, unless low energy, in which case Quality level 3 is acceptable. For Class C piping, the following is provided for minimum isolation subsequent to an incident:

a. Incoming Lines: One check valve or one auto-trip valve or one locked or sealed closed manual valve.

b. Outgoing Lines: One auto-trip valve or one locked or sealed closed manual valve.

Class D

Class D piping must remain in service after a design basis accident. Piping of the engineered safety features falls into this category. For Class D piping the following is provided for minimum isolation subsequent to an incident.

a. Incoming Lines: One remote manual valve or a check valve or for instrument sensing lines, one manual valve.

b. Outgoing Lines: One remote manual valve.

Class E

Class E piping is connected to a normally closed system outside of the containment, and is separated from the reactor coolant system and the containment atmosphere by a closed valve and/or a membrane barrier.

For Class E piping, the following constitutes the minimum isolation provided:

All lines: A normally closed manual valve or a normally open manual valve for instrument sensing lines inside or outside the containment and/or a blind flange inside or outside the containment [EXCEPTION: a sensor bellows (membrane barrier) inside the containment and a hydraulic isolation (membrane barrier) outside the containment is used for sensing lines of the reactor vessel level instrumentation system (RVLIS)].

Class F

Secondary piping connected to the steam generator shell, specifically main steam, feedwater, steam generator blowdown, drain and sample lines. These lines are separated from both the RCS and containment by the steam generator shell, steam generator tubing and tube sheet including the lines within containment. These lines are considered an extension of the containment liner. As such, these lines are exempt from containment isolation requirements. These lines also have shutoff valves such as MSIVs and feedwater check valves that are intended for equipment protection and are not considered to be containment isolation valves. These valves are not subject to 10 CFR 50, Appendix J testing.

Class G

The Fuel Transfer (CPN-1), Ice Loading (CPN-57) and Return (CPN-80), Containment Thimble Removal (CPN-76), and Containment Service (CPN-71 and CPN-83) penetrations are special penetrations used only during outages. For Unit 2 only - CPN-67 also has a special penetration similar in design to the above which is considered as a service spare penetration.

Class G piping is required to have double isolation from the containment atmosphere. CPN-1 fulfills this requirement by two gaskets within its blind flange [Ref. FSAR Q&A 5.118]. The remaining penetrations fulfill the double isolation barrier requirement by having blind flanges on both the inboard and outboard side of the containment.

During power operations, where containment integrity is required, these special penetrations are closed by blind flanges. These blind flanges are type B Local Leak Rate Tested and type A Integrated Leak Rate Tested for verification of containment integrity.

5.4.2 Containment Isolation System Design

The general design basis covering the number and location of isolation valves required to assure reactor containment integrity is given in Section 5.4.1.

Check valves may be employed as one of the two barriers for incoming lines. Test connections and pressurizing means are provided to test each isolation valve or barrier for leak tightness. Either water or a gas is used as the pressurizing medium depending on the requirements of each case. Where it is necessary to make a quantitative leakage test, provision is made to:

a. measure the inflow of the pressurizing medium, or

b. collect and measure the leakage, or

c. calculate the leakage from the rate of pressure drop.

The test connections are isolated when not in use by closed manual valves and/or combination of valves and caps or plugs and administratively controlled to ensure containment integrity.

Isolation valves are missile protected, as required. Isolation valves, actuators, and control devices required inside the containment are located between the missile barrier and the containment wall. Isolation valves, actuators and control devices outside the containment are located outside the path of potential missiles or provided with missile protection. There are two levels of automatic containment isolation identified as Phase A and Phase B. Phase A isolation closes all lines penetrating the containment except essential lines such as Safety Injection and Containment Spray which are not isolated, and component cooling water to the reactor pumps and service water to the ventilation units which isolates on Phase B. (For Phase A and B initiating signals see Chapter 7 Instrumentation and Control.) All automatic isolation valves are able to be closed from the main control room. Position indicators are provided for each valve near its manual control switch in the main control room.

Specific administrative procedures govern the positioning of all isolation valves except check valves as well as any flanged closures during normal operation, shutdown and incident conditions. Check valves in incoming lines open only when the fluid pressure in the line coming from the outside is higher than the pressure on the containment side. Gravity or a spring holds the valve closed in the balanced pressure condition.

5.4.3 Design Evaluation

The containment isolation system provides two barriers (See Table 5.4-1) to prevent leakage of radioactivity at each containment opening. Either barrier is sufficient to keep the leakage within limits.

5.4.4 Test and Inspection

All valve leak testing for the Containment Integrated Leak Rate Test (CILRT) program and surveillance requirements are performed in accordance with Appendix J, Option B to 10 CFR 50 for Type A, B and C type testing. Also certain valves will be tested for operability in accordance with the applicable edition of the ASME Operation and Maintenance (OM) Code.

5.5 CONTAINMENT VENTILATION SYSTEM

5.5.1 General Description

The Containment Ventilation System is designed to maintain temperatures in the various portions of the Containment within acceptable limits for operation of equipment, and for personnel access for inspection, maintenance and testing as required. It also has capability for purging the Containment atmosphere to the environment via the plant vent. The system can also cleanup airborne contamination in the containment prior to personnel entry. There is one plant vent for each unit. In the event of a loss-of-coolant accident, portions of the Containment Ventilation System aid in reducing Containment pressure after blowdown and also limit the accumulation of hydrogen in potential "pockets" within the Containment.

The Containment Ventilation System is shown in Figures 5.5-1 and 5.5-2. It consists of eight, essentially independent, sub-systems as follows:

a. Containment Purge Supply and Exhaust System

b. Instrumentation Room Purge Supply and Exhaust System

c. Containment Pressure Relief System

d. Upper Compartment Ventilation System

e. Lower Compartment Ventilation System including Control Rod Drive Mechanism Ventilation System, Reactor Cavity Ventilation System and Pressurizers Compartment Ventilation System

f. Containment Instrumentation Room Ventilation System

g. Containment Air Recirculation/Hydrogen Skimmer System

h. Hot Sleeve Ventilation System

Unit No. 1 and Unit No. 2 are each supplied with a separate system. These systems are essentially identical. All ventilation systems with the exception of the purge and pressure relief systems are of the recirculating type (d through h, above).

The containment and instrumentation room purge exhaust and containment pressure relief systems discharge to the unit vent where they are monitored before release.

5.5.2 Design Bases

The Containment Ventilation System is designed to the following parameters:

a. Purge the containment atmosphere to the plant vent.

b. Limit containment pressure to 0.3 psig (maximum) during normal plant operations.

c. Maintain a maximum temperature of 100°F in the containment upper compartment during plant operation and a minimum of 60°F during plant shutdown to permit personnel access as required.

d. Maintain a maximum temperature of 120°F in the lower compartment (135°F inside the primary concrete shield) during plant operation and a minimum of 60°F during an outage.

e. Maintain a maximum temperature of 100°F and a minimum temperature of 60°F in the Containment Instrumentation Room.

f. Purge the In-core Instrumentation Room atmosphere to the unit vent during periods of personnel access to this room.

g. Ensure that a reliable supply of cooling air is provided to the Control Rod Drive Mechanisms.

h. Aid in reduction of Containment pressure in the event of an accident. (See Chapter 14.)

i. Ensure that, in the case of a loss-of-coolant accident, the minimum design flow from each potential hydrogen pocket is sufficient to limit the local concentration of hydrogen.

j. Maintain concrete temperature below 200°F at the crane wall sleeves serving the RHR system when that system is operating.

5.5.3 System Description

Containment Purge Supply and Exhaust System

One Containment Purge Supply and Exhaust System is supplied for each Containment structure so that, prior to entry, if required, radioactivity can be reduced to safe levels.

Purge air is supplied to the containment through two 16,000 cfm rated capacity supply fans and their associated filters and heating coils. Purged air is exhausted through two 16,000 cfm rated capacity exhaust fans and high efficiency particulate filters to the unit vent where it is monitored before release to the atmosphere. The purge-air supply and exhaust fans and filters are located in the Auxiliary Building.

There are four air penetrations of the Containment associated with this system, a supply and an exhaust penetration into both the upper and lower compartment. Each penetration has two fail-closed isolation valves. (These valves are normally closed when the purge systems are not in operation.)

The Containment Purge Supply and Exhaust System has a total rated fan capacity of 32,000 cfm.

The Containment Purge Supply and Exhaust System takes outside air through intake vents and passes it through medium-efficiency particulate filters (NBS Dust Spot Efficiency for atmospheric dust of 50%) and steam coils when necessary prior to discharge into the containment. Under normal system operation both fans are operating. The purge supply fans supply outside air into the upper containment and the lower containment, with more flow directed into the upper containment. The containment purge exhaust units draw air from the upper containment and the lower containment with more flow drawn from the lower containment, thus establishing a positive airflow from the upper to the lower containment.

The Containment Purge Supply and Exhaust System serves to provide:

1. a means of reducing the radiation level in the containment to a safe value for containment entry,
2. a continuous airflow through the containment during refueling operations,
3. heated air to the containment necessary for comfort of personnel working in the containment, and
4. a backup means of pressure relief, in the event that the containment pressure relief system is out of service.

The Containment Purge Supply and Exhaust System is not normally operated. If, prior to containment entry, the containment radiation monitors indicate radiation levels in the containment area in excess of the appropriate Federal regulations for radiation exposure to an individual worker (per 10 CFR 20), and if it is determined that the radiation level within the containment is at a safe level for purging, then the Containment Purge Supply and Exhaust System isolation valves will be opened and the system activated to reduce the radiation level within the containment to a safe value for containment entry.

The Containment Purge Supply and Exhaust System fans are operated remotely from the Control Room. The isolation valves close automatically upon a safety injection signal or a high containment radiation level.

During purge operations, the rate of purge can be controlled by the operator who has the option of operating any desired combination of the Containment Purge Supply and/or Exhaust System fans or by repositioning as necessary volume dampers (the volume dampers are located in the Auxiliary Building). Operation in this manner will also provide a means of vacuum relief in the event of a negative containment pressure. Because containment pressures can be controlled entirely by operation of the Containment Purge Supply and/or Exhaust System during purging operations, there will be no need to use the Containment Pressure Relief System during Containment Purge.

Purge operation is permitted in all operating modes. For Modes 1 through 4, the Cook Nuclear Plant purge estimate goal is two hundred and forty (240) hours each year for each unit. This purge estimate is based on a plant capacity factor of 93%, and accounts for two purge operations per week. Each purge operation is assumed to be approximately 2 1/2 hours in duration. The annual 240-hour purge operation time limit amounts to less than 3% of the estimated plant operation time in Modes 1 through 4. In Modes 1 through 4, purge operation is limited to one supply and one exhaust flow path.

Reasons to operate the system include the need to improve containment working conditions, e.g., reduce airborne activity, to perform surveillance and/or maintenance activities, or to relieve containment pressure if the containment pressure relief system is out of service. The purge/vent system is not intended to be used to routinely control containment atmosphere temperature and humidity. It is intended that purging and venting times will be as short as possible. Allowing purge operations in Modes 1, 2, 3, and 4 is more beneficial than a cooldown to Mode 5 from the standpoint of (a) imposing unnecessary thermal stress cycles on the reactor coolant system and its components and (b) reducing the potential for causing unnecessary challenges to the reactor trip and safeguards systems. The containment purge system is designed in accordance with the requirements of NRC Branch Technical Position CSB 6-4, Rev. 1. This includes, but is not limited to, an analysis of the impact of purging on ECCS performance, an evaluation of the radiological consequences of a design basis accident while purging, and limiting purge operation to using no more than one supply path and one exhaust path at a time. The purge isolation valves have been demonstrated capable of closing against the dynamic forces associated with a loss-of-coolant accident and are assured of receiving a containment ventilation isolation signal. Reset switches have been protected against inadvertent use in a manner, which facilitates the administrative controls governing their use. The purge and vent isolation valves do not use resilient seating/sealing material and are not subject to the type of environmental degradation common to resilient materials.

Instrumentation Room Purge Supply and Exhaust System

The Containment Instrumentation Room has a separate and independent purge system consisting of a 1000 cfm rated capacity supply unit and a 1000 cfm rated capacity exhaust unit.

The supply unit draws outdoor air through an intake louver, passes it through a medium-efficiency particulate filter and electric blast coil heaters and discharges it into the Containment Instrumentation Room. The exhaust unit draws air from the Containment Instrumentation Room, passes it through both high efficiency particulate air (HEPA) and charcoal filters and discharges it to the unit vent where it is monitored before release.

Both the Containment Instrumentation Room purge supply and purge exhaust penetrations have two isolation valves similar in type and function to those provided for the Containment Purge Supply and Exhaust System.

Containment Pressure Relief System

Containment pressure relief is provided by a 1000 cfm rated capacity exhaust unit composed of a fan, a HEPA filter and a charcoal filter. This system is located in the Auxiliary Building. There is a single penetration of the containment barrier for this system with two isolation valves similar in type and function to those provided for the Containment Purge Supply and Exhaust System.

A flow diagram of the Containment Pressure Relief System is shown in Figure 5.5-2. The system fan draws containment atmosphere through a register in the upper compartment where, prior to discharge to the plant vent, it is passed through a filter unit containing both HEPA and charcoal filters. Additional features of the system design include two isolation valves, an automatically operated flow regulating damper which limits flow through the filters to 1000 cfm, a backdraft damper in the duct to the unit vent to prevent backflow from the unit vent into the containment, and a bypass path around the fan so that containment pressure relief can be provided in the event the pressure relief unit fan fails to start.

The system can be operated manually from the Control Room any time that containment pressure exceeds ambient. However, if the containment pressure should reach a predetermined setpoint, an alarm will sound in the control room to alert the operator to actuate the system.

The operator action required to actuate the system consists of opening the normally closed isolation valves and starting the fan motor. Such operator action will limit the containment internal pressure to less than 0.3 psig for normal atmospheric fluctuations.

Whenever operation of the Containment Pressure Relief System occurs, the containment atmosphere will always be exhausted through the charcoal and HEPA filters in the unit. This should be sufficient to prevent any adverse radioactivity from being exhausted to the environment. The Containment Pressure Relief System isolation valves will automatically close on upon receipt of a containment ventilation isolations signal. This will prevent any further release of adverse radioactivity to the environment.

The containment pressure relief system is intended for use only for normal operation when it is necessary to reduce internal containment pressure. It is not intended for use when the Containment Purge Supply and Exhaust Systems are operating, since the Containment Purge Supply and Exhaust fans themselves provide the necessary means of controlling internal containment pressure. The Containment Purge Supply and Exhaust Systems provide a backup means to relieve containment pressure, in the event that the containment pressure relief is out of service. It exhausts through HEPA filters to the plant vent.

Upper Compartment Ventilation System

The upper compartment ventilation system consists of four free standing recirculating ventilating units (3 for normal operation, 1 standby). Each unit includes a 25,000 cfm rated capacity fan, water cooling coils and electric blast coil heaters.

The water for the cooling coils is supplied by the non-essential service water system. Any three of the four units have sufficient cooling capacity to maintain the temperature below 100°F during design summer conditions. Water flow to the cooling coils is regulated by modulating air-operated valves located outside the containment. These valves are controlled by proportional thermostats located on the ventilation unit intakes. Water flow to the cooling coils may also be manually regulated. The water for the cooling coils is supplied by the Containment Chilled Water Subsystem of the NESW.

Normally, three ventilation units operate continuously. Cooling is performed whenever the air temperature exceeds 90°F. The electric blast coil heaters are normally energized whenever the air temperature reaches 75°F. During Cold Shutdown, air temperature may be maintained as low as 65°F (60°F minimum allowable, refer to Technical Specifications 3.6.1.5).

Lower Compartment Ventilation System

The lower compartment ventilation system is the largest of the containment ventilation systems. It consists of four recirculation ventilation units composed of fans and water cooling coils, four booster fans for control rod drive mechanism ventilation, vent fans for reactor and pressurizer enclosure ventilation and associated duct work.

The four recirculation ventilation units are located in the annular space around the periphery of the lower chamber between the crane wall and the containment liner. Each unit is composed of water cooling coils and two 36,000 cfm rated capacity fans. The intake to these units is connected via a duct penetration through the crane wall to air intakes from the top of the four steam generator enclosures, the reactor coolant pump motor areas and the discharges from the control rod drive mechanism vent fans. Air is drawn from the above stated heat sources, passed through the water cooling coils and discharged into the annular space. The cooled air re-enters the lower chamber via openings in the crane wall and through the pipe tunnel below the annular space which also has openings in the crane wall into the lower chamber.

The four recirculation units are split into pairs; two units in each of the two fan rooms. Normally, both fans of one unit and one of the fans of the second unit in a given room limit the average containment air temperature to 110^{o}F. The water to the cooling coils is fed by the Containment Chilled Water Subsystem of the non-essential service water system. Water flow to each unit is modulated by an air-operated valve outside the containment which is controlled by a proportional thermostat in the recirculation unit intake. Water flow to the cooling coils may also be manually regulated.

There are four 20,000 cfm rated capacity fans (1 standby) which draw air through the control rod drive mechanism shroud and discharge it into the intake ducts of the four lower compartment recirculation units. The four fans are located outside the primary shield of the reactor vessel and are all connected via a common intake header to the control rod drive mechanism ventilation shroud. There are redundant temperature sensors in the intake header which actuate an alarm in the control room in the event that the air temperature leaving the shroud exceeds the setpoint.

Two 3000 cfm rated capacity booster fans draw air from the pipe tunnel and discharge it into the lower reactor cavity. This operation ensures a continuous flow of cool air at the base of the reactor vessel. Two 12,000 cfm rated capacity fans (1 standby) draw air from the top of the pressurizer enclosure and discharge into the suction side of the lower containment ventilation system. This operation prevents heat buildup at the top of the enclosure. (The steam generator enclosures are ventilated by ducts, which are also directly connected into the suction side of the lower containment ventilation system.)

Containment Instrumentation Room Ventilation System

The in-core instrumentation room temperatures are controlled by two free- standing, 9,600 cfm rated capacity recirculation ventilation units (1 standby). Each unit is composed of a fan, water cooling coil and electric blast coil heaters. The water for coils is supplied by the Containment Chilled Water Subsystem of the non-essential service water system. Water flow is regulated in the same manner as for the upper compartment ventilation units. The instrumentation room is nominally kept at a constant temperature of approximately 90°F during plant operation. The instrument room temperature is considered in the computation of containment lower compartment average temperature for which the allowable range is 60ºF to 120ºF.

Containment Air Recirculation/Hydrogen Skimmer System

The containment air recirculation/hydrogen skimmer system is the only safety related ventilation system within the containment. This system functions only in the event of a hi containment pressure signal. It consists of two redundant independent systems, which include fans, back draft dampers, valves, piping and ductwork.

Both containment air recirculation hydrogen skimmer system fans are located in the upper volume. The fans discharge, via the annular space between the crane wall and the Containment liner, into the lower compartment. The fans are provided with back draft dampers on the discharge to prevent backflow during initial blowdown.

Figure 5.5-2 shows the various components of this system and Figure 5.5-3 shows the recirculation flow patterns that are created by this system. The system includes provisions for providing both

1. general recirculation of containment atmosphere between the upper and lower compartments following a loss-of-coolant accident, and
2. limiting the improbable accumulation of hydrogen in restricted areas within the containment following a loss-of-coolant accident.

The system provides post-accident hydrogen mixing in select areas of containment. The potential areas of hydrogen pocketing are the top of the containment dome, and the lower compartment enclosures which include the three rooms in the annular space between the crane wall and the liner, the steam generator enclosures, and the pressurizer enclosure. The fans operate continuously after actuation, circulating air through the containment volume and purging all potential hydrogen pockets in containment at such a rate as to limit the local hydrogen concentration.

Each of the two independent systems fan has its own intake system composed of three separate headers. These headers draw 39,000 cfm from the upper compartment in the immediate vicinity of the fan, draw 1,000 cfm from the upper compartment at the top of the dome, and draw air from the potential hydrogen pockets in the lower compartment (this is the hydrogen skimmer header). Each header has volume control dampers in the line or at the air intake to balance flow. The hydrogen skimmer header is composed of two pipe branches, one which draws 500 cfm from the top of each double steam generator enclosure and pressurizer enclosure and one which draws 100 cfm from each of three rooms in the annular space. There is a normally closed, motor-operated hydrogen skimmer valve on each main hydrogen skimmer header to prevent ice condenser bypass during initial blowdown.

Within the time delays specified in Technical Specification 3.6.10 following receipt of a hi containment pressure signal the Air Recirculation/Hydrogen Skimmer System fans start and the motor operated valves in the hydrogen skimmer header serving the lower compartment enclosures open. The total system design air flow per train is 41,800 scfm.

Note: The airflows listed for the Containment Air Recirculation /Hydrogen Skimmer System are design flows.

Hot Sleeve Ventilation System

The hot sleeve ventilation system consists of two 3,000 cfm rated capacity fans (1 standby, 1 active), which blow air through the three crane wall sleeve penetrations associated with the Residual Heat Removal System so that the temperature of the concrete at the sleeves will not exceed 200^{o}F when the RHR system is operating.

5.5.4 Design Evaluation

The service water piping to containment includes connections for supplemental chillers. Thus the Containment Ventilation System provides adequate capacity to insure that proper temperatures are maintained in the various portions of the containment under operating and shutdown conditions in all types of weather. The Containment Purge Supply and Exhaust System provides the capability for changing the containment air prior to entry for refueling and maintenance. The Instrumentation Room can be purged independently of the balance of the containment so that entry may be achieved when necessary.

Containment Air Recirculation/Hydrogen Skimmer System

Each containment Air Recirculation/Hydrogen Skimmer System fan is designed to operate at a flow of 41,800 scfm against a pressure drop through the fan inlet, across the back-draft damper and associated ductwork, and through the ice condenser from the lower volume to the upper volume. The hydrogen skimmer system is in parallel with a portion of the above flow circuit, and therefore is considered in the overall pressure drop against which the fan must operate to assure proper flow distribution.

The containment Air Recirculation/Hydrogen Skimmer System has been analyzed considering both maximum and minimum ice condenser resistances in addition to the pressure drop through the inlet damper, backdraft damper and associated ductwork. The maximum pressure drop (5.4" w.g.) through the system represents a conservative estimate of conditions in the ice condenser just after blowdown assuming that neither the intermediate nor top ice condenser doors are open and that just the vent area above the ice condenser is available for air recirculation. The actual pressure drop through the ice condenser following a loss-of-coolant accident could be much less than the calculated value. At the lower ice condenser resistance, there would be more flow through the ice condenser and less flow through the skimmer system.

Containment Pressure Relief System

The Containment Pressure Relief System provides the capability for reducing the containment pressure during normal operations to compensate for normal changes in atmospheric pressure. Operating procedures require actuation of the Containment Pressure Relief System when the internal containment pressure reaches the predetermined setpoint. This action assures that internal containment pressure will not reach the Technical Specification limit during normal plant operations.

The automatic air-operated damper in the Containment Pressure Relief System provides a means of maintaining a constant air flow through the charcoal and HEPA filters in the unit. Regulation of the flow in this manner will optimize the iodine absorption capability of the impregnated activated charcoal by limiting the face velocity through the charcoal filters, thus providing a minimum residence time of airflow of 0.25 seconds in each of the six 2-inch deep charcoal beds in this unit.

The HEPA and charcoal filters in the Containment Pressure Relief System have an exceedingly high capability for removal of both airborne particulate matter and airborne radioactive iodine. Containment Pressure Relief System has more than adequate capacity for retention of both particulates and iodine for the intended use of the system. The impregnated activated charcoal has a minimum absorption capability of 2.5 mg. of iodine for every gram of charcoal (total charcoal in this unit is a minimum of 37,100 grams).

5.5.5 Incident Control

In the event of an incident the two independent Containment Air Recirculation/Hydrogen Skimmer System fans automatically start after the time delays specified in Technical Specification 3.6.10 following initiation of 2/3 hi containment pressure signals. The operation of either fan ensures the reduction of the containment pressure to the limits described in Chapter 14.

At the same time the Air Recirculation/Hydrogen Skimmer fans start, the hydrogen skimmer valves in the two Containment Air Recirculation/Hydrogen Skimmer headers open, thus causing the Air Recirculation/Hydrogen Skimmer System fans to continuously purge all potential hydrogen pockets in the Containment.

All other Containment Ventilation Systems are not designed for operation during a loss of coolant accident.

The occurrence of a High Containment Radiation Signal from the upper compartment area or lower containment particulate/noble gas monitors will automatically trip the purge fans and close all ventilation system isolation control valves, thus isolating the Containment.

5.5.6 Malfunction Analysis

Sufficient redundancy exists in all recirculation ventilation systems to ensure a normal operation with one active component out of service.

The two filter cleanup units provide redundancy for small leakage rates. The Containment Purge Supply and Exhaust System is fitted with dual supply and exhaust fans. The Containment Air Recirculation/Hydrogen Skimmer (CEQ) Systems are two redundant systems that are cooled from a common Component Cooling Water (CCW) header. The loss of either CEQ system or any component of either CEQ system will not impair system operation. In the event that flow to the CCW header is lost, procedural guidance is in place to ensure that it is expediently restored.

The Containment Purge Supply and Exhaust System is available for relieving containment pressure in the event that the containment pressure relief system is out of service.

5.5.7 Tests and Inspection

All systems are inspected, tested and balanced upon installation. Charcoal and particulate filters are individually tested before shipment, upon installation and periodically thereafter as required. Replacement filters will be tested in the same manner.

The Containment Air Recirculation/Hydrogen Skimmer fans were tested during installation and are tested periodically to ensure proper functioning. The initial test of these fans were conducted at both no flow and full flow, verifying the fan capability to deliver the required amount of air. The periodic fan tests are conducted at no flow to assure that the fan is still operable.

5.6 CONTAINMENT PENETRATION AND WELD CHANNEL PRESSURIZATION SYSTEM

5.6.1 Design Bases

Although portions of the Containment Penetration and Weld Channel Pressurization System (CPWCPS) have been abandoned in place, all segments of the system required to support the performance of the Containment Integrated Leak Rate Testing (ILRT) remain active to facilitate the testing. However, only the Zone 3 electrical penetrations are pressurized to ensure clean dry air is supplied to the inside of the penetrations to prevent the entry of moisture into the penetrations and detrimentally affecting the electrical cables.

Containment integrity is assured by performing regularly scheduled integrated leak tests in accordance with 10 CFR 50, Appendix J, therefore the CPWCPS is no longer needed or completely utilized as originally designed.

The system is not considered an engineered safety feature. The system is Seismic Class III, except for portions attached to the electrical penetrations outside containment, which are bounded by the Class I seismic criteria. An identical system exists for each unit.

5.6.2 System Design and Operation

The system is shown in Figure 5.6-1. The system's penetration air receivers are normally supplied with clean, dry air from the control air system. This air source is normally supplied by two plant air compressors (one from each unit) which are, in turn, backed up by one control air compressor (on each unit).

Air from the north penetration air receiver is regulated and supplied to the electrical penetrations. These penetrations are constantly pressurized. Check valves are installed on the supply line such that under a loss of control air, the electrical penetrations would remain pressurized.

Air from the south penetration air receiver is regulated and supplied to containment access test points. These points are the upper and lower personnel airlock seal test panels. The air is used for Type "B" testing of the inner and outer airlock door double seals.

Even though portions of the CPWCPS is abandoned in-place, all segments of the system required to support the performance of the Containment Integrated Leak Rate Testing (ILRT) must continue to be controlled to ensure compliance with Technical Specifications and 10 CFR 50 Appendix J, during future containment leakage testing. Areas under the weld channels must be exposed to containment test pressure or a justification must be provided for any portion of the CPWCPS that is to serve as a containment pressure boundary during the containment testing.

A flow alarm and pressure alarm are installed on the header between the north penetration air receiver and the electrical penetrations. These alarms alert the operator of high flow or low pressure due to leakage in the header. A local pressure indicator is also located on this header. Local test pressure connections are provided as necessary to allow for leak testing. Test connections have globe valves, which are closed when testing is not being performed.

5.6.3 Test During Erection

Following the successful completion of inspection of the seam welds, the channels were tested with air at a pressure of 50 psig for at least 15 minutes. Following this strength test, the channel fillet weld joints were tested using a tracer gas technique at a pressure of 14 psig for two hours. Allowable leakage did not exceed 0.025% of total containment free volume for all zones. The bottom liner weld channels were pressure tested prior to being covered with concrete.

5.6.4 Design Evaluation

Although portions of the Containment Penetration and Weld Channel Pressurization System (CPWCPS) have been abandoned in-place, all segments of the system required to support the performance of the Containment Integrated Leak Rate Testing (ILRT) remain active to facilitate the testing. However, only the Zone 3 electrical penetrations are pressurized to ensure clean dry air is supplied to the inside of the penetrations to prevent the entry of moisture into the penetrations and detrimentally affecting the electrical cables.

5.7 CONTAINMENT STRUCTURE INSPECTION AND TESTING

5.7.1 Structural Integrity

A structural integrity test, for each containment structure, was conducted after construction had been completed but prior to the loading of each ice condenser.

During the design and prior to testing, a detailed procedure for the test was formulated. This procedure took into account the results of tests of containment structures at other installations.

The structural integrity test was performed by pressurizing the containment in 4 psi increments to a pressure of 1.34 times the design pressure. Measurements of the structural response at selected locations for each increment of pressure loading were made.

The structural response was evaluated by comparing the test results, measurements and observations, with the acceptance criteria, which included performance predictions.

For the tests, the containment structures were pressured in four increments to a maximum test pressure of 16.1 psig. The containment was then depressurized in four increments. At each pressure level during pressurization and depressurization, strain, displacement and temperature measurements were taken.

The following measurements were recorded:

1. Radial displacement measurements were made at six elevations at five azimuths, and at four elevations at a sixth azimuth. The azimuths were separated by nearly equal intervals. The equipment hatch, which constitutes a major discontinuity and which interrupted the sixth azimuth, was instrumented to determine local displacement.
2. Vertical displacement measurements were made at six azimuths at an elevation just above the base, at three azimuths at the springline and at the dome apex in both units and in the reactor sump in Unit 1.
3. Measurements of liner strain were made at six elevations along three azimuths, at two penetrations and at the equipment hatch.
4. Strain measurements were made on 145 concrete reinforcing bars in Unit 1 and on 167 bars in Unit 2. Generally, the bars were located around the equipment and personnel hatches, near the base and at the springline.
5. Containment wall skin temperatures were measured at fifteen locations.

In so far as possible, measured strains and displacements were adjusted to take into account the effects of temperature, creep, shrinkage, strain gage drift, and variations in the modulus of elasticity of the concrete.

Based on concrete cylinder tests, the concrete compressive strength, f'c is approximately 5000 psi. The modulus of elasticity of the concrete in the containment is approximately 4.0 x 10^6 psi.

Concrete crack patterns were monitored at major discontinuities, such as the cylinder base, the springline and at main openings and penetrations. Crack patterns were highlighted with whitewash to increase their visibility, and locations of cracks on the outside surface of the containment were identified. Measurement and spacing of crack widths were made.

Care was exercised during construction to assure that no damage to the instruments, especially the strain gages, would occur. All strain gages were inspected prior to concrete pouring in the containment wall to ensure that no damage had occurred. Damaged instrumentation was replaced wherever possible.

Sufficient strain gages and other instrumentation were installed to assure redundancy of instrumentation.

The strain gages on reinforcing steel and associated instrumentation had a resolution of 0.4 micro inch per inch strain and an accuracy of 2 micro inches per inch. The strain gages on the steel liner had a resolution of 1 micro inch per inch and an accuracy of approximately 5 micro inches per inch.

The acceptance criteria required demonstration that the overall structure exhibit elastic behavior in the test range. Inelastic behavior at localized stress concentrations was considered acceptable. To assess the containment structural behavior, with regard to its overall and local response, a comparison of the test data with predicted values was made.

Acceptance criteria for the structural response for strains and displacements were determined considering the accuracy of the theoretical computations, which varies for different parts of the containment structure. The evaluation of stress is simpler in a plain shell than around openings and at boundaries, where it constitutes a complex analytical problem. At points of stress concentration, such as fillets and pockets in the concrete where high stress may exist, it is very difficult to theoretically compute these stresses. Such stresses, however, decrease rapidly within a small area and do not affect the overall integrity of a structure.

Gross Deformation Acceptance Criteria

The following criteria were used as a measure of containment structural performance during and after the strength test at 16.1 psig, which represents 134% of the design pressure of 12 psig:

1. The increase in containment diameter shall not exceed 0.0830 in. + 20 percent, or 0.0997 in. for LVDT measurement between El. 640 and El. 710'-6" when measured as an average of all readings.
2. Equipment Hatch distortions shall show the same trend as computed values and the maximum radial displacement shall not exceed 0.0437 inches.
3. The expected total vertical elongation of the containment wall measured at El. 710'-6" shall not exceed 0.0339 inches + 20 percent or 0.0402 inches.
4. At depressurization all gage readings are to return to between 10 and 30 percent of the maximum reading recorded at 16.1 psig.

Acceptance criteria for cracking was based on the depth and spacing of cracks as determined from the review of predicted strain.

The crack patterns were visually inspected to confirm consistency with the predicted tension stress pattern.

Test results can be found in the following Brewer Engineering Test Reports:

Unit 1 Report 495 Donald C. Cook Nuclear Plant Unit 1 Containment Structural Integrity Test Results June 15, 1973

Unit 2 Report 627 Donald C. Cook Nuclear Plant Unit 2 Containment Structural Integrity Test Results August 20, 1977

Both concrete and liner were visually inspected after the test. There was no visually discernable distortion of the liner plate due to the testing.

An engineering review of the test results was made and it was determined that the acceptance criteria were met.

5.7.2 Initial Containment (Pre-Operational) Leakage Rate Tests

Integrated Leakage Rate Tests

After completion of the containment and after loading the ice condenser, an integrated leakage rate test was carried out using a test procedure which was written using the American National Standard - ANSI N45.4-1972 and 10 CFR 50, Appendix J as guidelines.

The integrated leakage rate tests were conducted with the weld channel zones open to the containment atmosphere. The containment was pressurized to 12 psig, the containment design pressure, using air dried to a dew point below the coldest temperature in the ice condenser to eliminate the possibility of condensing water vapor during the test.

Sensitive Leakage Rate Tests

The sensitive leakage rate tests are performed using testing procedures written for testing liner weld channels and penetrations using 10 CFR 50 Appendix J as a guide.

Since the volumes contained in the weld channels and penetrations are significantly smaller than the containment free volume, the test sensitivity is correspondingly greater than that of an integrated leakage rate test. These tests are conducted with 12 psig in the weld channels and penetrations and with the containment at atmospheric pressure.

5.7.3 Containment Periodic (Post-Operational) Leakage Rate Test

There is a small combined volume of enclosed space in the double barrier penetration, the penetration weld seam channels and the liner weld channels installed on the inside of the liner in the containment. Since it was easy to monitor these small volumes, a sensitive and accurate means of periodically monitoring their status with respect to leakage was provided but no longer used. .

Observations of the vessel will be made from platforms or by other means with special attention given to areas of major discontinuities.

Provisions have been made in the design of the Ice Condenser structure to permit periodic inspection of the containment liner in the area behind the ice condenser. Inspection of the liner is accomplished through "Inspection Ports" located around the ice condenser, to permit access to the liner.

Periodic leak testing of the containment is performed in accordance with the Technical Specifications 10 CFR 50 Appendix J, Option B, Type A, B, and C leak tests requirements. The leak rate test is done to determine the leak tightness of the containment vessel and containment isolation valves and not to measure the structural response of the containment. The leak rate test is performed with the ice in place and at the design pressure of 12 psig.

Accessibility into the containment is afforded by two personnel locks. One is at El. 612'-0" located at 242^{o} which enters directly into the instrumentation room, equipment, annulus. From there, it is possible to go in any of three directions:

1. Through a hatch in the El. 612'-0" floor and then by ladder down into the pipe annulus below El. 612'-0" and completely around the perimeter of the containment. From this pipe annulus by means of ladders and hatches, it is possible to get into each of the fan-accumulator compartments above El. 612'- 0".
2. Through a pressure type door directly into the lower containment inside the crane wall and then by a series of platforms, ladders, and stairways to have access to all equipment in the lower volume at El. 598'-9 3/8", El. 612'-0", El. 617'-9", El. 621'-0", El. 625'-0", El. 638'-0", and El. 642'-5". This provides access to the primary coolant loop piping and equipment ice condenser doors and control rod drive mechanism vent system fans.
3. By hatch and ladder access to the instrumentation tubing below the reactor vessel.

The second personnel lock is located at El. 652'-7½" which permits access from the auxiliary building directly onto the containment operating deck. This gives access to the refueling cavity. Also, from El. 652'-7½" between the crane wall and liner, there is a stair system down to El. 612'-0" where, by the use of a second, separate pressure-type door, it is possible to go directly into the lower volume. There is a stair system to the hydrogen recombiner and the ice condenser roof, platforms to the steam generator and pressurizer concrete enclosure roofs, and ladders to the polar crane and dome. Access to the dome is afforded by a caged ladder from the hydrogen recombiner floor to the circular platforms suspended from the dome for inspection of the upper containment spray piping.

Additional platforms are provided for access to the pressure connections for the shell and to the dome test zones located just above the containment spring line.

5.7.4 Containment Periodic Inspection

Periodic containment inspections, performed in accordance with ASME Section XI, Subsections IWE and IWL, are completed as required by 10 CFR 50.55a(g)(6)(ii)(B).

5.8 DISTRIBUTED IGNITION SYSTEM

A distributed ignition system (DIS) is provided to assure adequate hydrogen control capacity during a degraded core cooling event. The DIS utilizes thermal resistance heating elements (igniters) located throughout the containment building. The DIS will be manually actuated from the control room or either Emergency Diesel Generator (EDG) room upon either receipt of an automatic Phase B isolation signal or upon indication of an inadequate core cooling condition. The DIS may also be actuated upon receipt of a Safety Injection Signal.

The DIS performs a non-safety related (Standard Grade) function. The Environmental Qualification (EQ) provisions of 10 CFR 50.49 are not applicable to the DIS.

5.8.1 Distributed Ignition System Design

The DIS is a two-train system employing seventy (70) igniter assemblies located throughout the containment building. Each train of thirty-five (35) igniter assemblies is further divided into two groups; one group of seventeen (17) assemblies is in the general lower volume area and the second group of eighteen (18) assemblies is in the general upper volume area (including the ice condenser upper plenum volume).

Each igniter assembly is mounted in a sealed box housing. The igniter box is a water tight enclosure meeting NEMA-4 specifications. A copper plate is employed as a heat shield to minimize temperature rise inside the igniter box and a drip shield is utilized to minimize direct water impingement on the thermal element. The entire igniter assembly is seismically mounted so as to prevent any possible interferences with safety related equipment during/after a design basis seismic event.

Voltage regulation is provided. The voltage regulators are installed to regulate the voltage to the DIS igniters and reduce voltage fluctuations. The voltage regulation will help ensure the igniters temperature exceeds the minimum design basis value.

The normal and emergency power sources for each train of igniters meets Electrical Class 1E specifications. Electrical Train separation consistent with a Class 1E system is not a design requirement; however, the design reflects installation to Class 1E Train separation standards to the greatest extent practical. The DIS is a manual system controllable from the main control room or either EDG room. Two control switches per train are located on auxiliary relay panels A7 and A8 in the main control rooms. The control switches are of the two-position type, "off" and "on", and red and green indicating lights are provided above each switch. Control room annunciation will be provided to indicate loss of power and failure to operate due to hypothetical control circuit equipment malfunctions.

Two control switches are located in each EDG room; one for the upper containment igniters, and one for the lower containment igniters. The control switches are two-position type, "off" and "on". These switches do not have any indicating lights. A control switch is mounted on the front of each igniter starter enclosure.

5.8.2 Igniter Assembly

The igniter assembly is a 16" x 12" x 8" enclosure meeting NEMA-4 specifications. The igniter is protected from direct water impingement by a drip shield attached to the top of the enclosure. The igniter is mounted to the enclosure through a copper plate to reduce the temperature rise inside the enclosure. All electrical connections inside the igniter assembly, its associated conduit box, and the two splice boxes per train utilized in the DIS are protected with heat shrink tubing or electrical tape to enhance system performance in an adverse environment. In addition, all DIS cables inside containment are routed in conduit and hence are protected from the environment associated with hydrogen combustion. Access to the interior of the igniter assembly is through a hinged cover plate secured with screws. A bead of silicone rubber was placed around all bolt holes in the igniter assembly.

5.8.3 Igniter Assembly Locations

Igniter assemblies are distributed throughout the containment to promote combustion of lean hydrogen/air/steam mixtures. The DIS will minimize the potential for hydrogen accumulation and preclude detonations in the unlikely event of a degraded core cooling event similar in nature to the TMI-2 accident involving substantive hydrogen generation. The containment air recirculation/hydrogen skimmer system, in conjunction with upper and lower volume containment sprays, provides sufficient mixing so as to prevent the stratification or pocketing of hydrogen in the various compartments of the containment building.

Approximate igniter assembly locations and containment region designations for Technical Specification compliance are listed in Table 5.8-1 and Table 5.8-2. A general view of the containment structure is provided in Figure 5.8-1 and approximate igniter locations shown in Figures 5.8-2 through 5.8-4. The locations, igniter identification numbers, and containment region designation given are for Cook Nuclear Plant Unit 2 and are similar for Unit 1. Minor variations in igniter locations were required in consideration of physical interferences with existing equipment.

The containment pressure and temperature responses to hydrogen combustion have been estimated using the CLASIX computer code. This analysis is discussed in Reference 1.

The results of the CLASIX analyses show that the deliberate ignition of hydrogen would not pose a threat to containment integrity and would not result in environmental conditions more severe than the conditions to which the majority of the necessary equipment has been qualified for (Reference 2 and 3).

Regulatory Compliance

In response to the NRC's final hydrogen control rulemaking, 10 CFR 50.44, additional analyses of degraded core scenarios have been committed to. These analyses, which should verify earlier conclusions, will be described in a future FSAR update.

5.8.4 References for Section 5.8

1. Letter from Indiana & Michigan Electric Co., R. S. Hunter to Harold R. Denton, NRC, AEP:NRC:00500 dated January 12, 1981, "First Quarterly Report on Hydrogen Issues."
2. Westinghouse Offshore Power Systems (OPS), Florida Report No. 36A05 dated December 1980 as Attachment No. 1 to Reference 13.
3. Letter from Indiana & Michigan Electric Co., R. S. Hunter to Harold R. Denton, NRC, AEP:NRC:00500E dated July 2, 1981, Attachment No. 2.

Potential Missiles Considered in Class I (Seismic) Structure Design

Item	Description	Weight	Velocity	Impact Area	Origin
Bolted Wood Decking	12' x 12' x 4"	450 lbs	200 mph	4 ft^2	Tornado Borne
Corrugated Siding	4' x 4'	100 lbs	225 mph	0.25 ft^2	Tornado Borne
Passenger Car	-	4000 lbs	50 mph traveling on the ground	10 ft^2	Tornado Borne
Schedule 40 Pipe [1]	2 1/2" Dia x 8'	46 lbs	195 ft/sec	6.5 in^2	Tornado Borne
Reactor Control Rod Drive Mechanism	-	1623 lbs	25 fps for 3 ft travel to missile shield	11.3 in^2	Reactor Coolant Pressure Driven after R. C. Housing Mech. Failure
Unit 1 Turbine [2 3]					
Vane of Last Stage Bucket	-	54 lbs	1170 ft/sec	0.82 ft^2	Mech. Failure During Turbine Overspeed
Last Stage Wheel Segment	120° Segment	8264 lbs	409 ft/sec	8.43 ft^2	Mech. Failure During Turbine Overspeed

1 Considered as a missile only for design of the Auxiliary Building east of Spent Fuel Storage Pool.

2 Impact area for turbine items is the average of the minimum and maximum cross-section areas.

3 The missile information in this table is for the removed General Electric low pressure turbines as this analysis bounds other Unit 1 rotating elements. The current missile analysis for the low pressure turbines is based on the missile probability analysis discussed in Section 1.4.7.

Potential Missiles Considered in Class I (Seismic) Structure Design

Item	Description	Weight	Velocity	Impact Area	Origin
Unit 2 Turbine [2] [4]					
Vane of Last Stage Bucket	-	168 lbs	1135 ft/sec	1.87 ft^2	Mech. Failure During Turbine Overspeed
Disc 1 Segment	120° Segment	13,350 lbs	634 ft/sec	15.08 ft^2	Mech. Failure During Turbine Overspeed
Disc 2 Segment	120° Segment	12,100 lbs	574 ft/sec	13.92 ft^2	Mech. Failure During Turbine Overspeed
Disc 3 Segment	120° Segment	8,360 lbs	551 ft/sec	13.2 ft^2	Mech. Failure During Turbine Overspeed
Disc 4 Segment	120° Segment	16,600 lbs	595 ft/sec	15.7 ft^2	Mech. Failure During Turbine Overspeed

[4] In 2016, the Brown-Boveri turbines were retro-fitted with turbines manufactured by Alstom Power, Inc. Probability analysis (Reference 1.4.11.17) for the Alstom Unit 2 turbines indicates the probability of generation of a turbine missile (including overspeed conditions) is less than the NRC limit. Therefore, no additional missile analysis is required for the Unit 2 Alstom turbines. However, the missile information is still provided for the (removed) Brown-Boveri turbines, as these analyses are used in structural design criteria analysis that bounds other Unit 2 rotating elements as shown in Table 5.1-1.
The postulated turbine missile information in this table is for the removed Brown Boveri low pressure turbine that was considered in Class I (Seismic) structure design. The current missile analysis for the Unit 2 low pressure turbines is based on missile probability analysis discussed in Section 1.4.7.

Note:

1. Miscellaneous missiles such as valve stems, bonnets, instruments wells, thimbles, and pipe rupture whip were considered in the design of the structures where applicable; however, tornado generated and turbine missiles, or radiation and structural considerations, generally, were the determining factors in the design of Class I structures.
2. The population of missiles used in the TORMIS analysis was based on a physical walk down of non-safety-related buildings, trailers, fencing, trees and parking lots within a 2000 feet radius of the plant. Also included were missiles from plant buildings with siding not designed for tornado winds. This walk down resulted in a potential missile population in excess of 55,000 objects.

WIND VELOCITIES AND VELOCITY PRESSURES

Height (ft)	Ungusted Wind Velocity (mph)	Gusted Wind Velocity (mph)	Velocity Pressure (Gusted Wind) (psf)
0-50	90	99	25
50-150	115	126	41
150-400	145	159	65

SITE SOIL RESISTIVITY MEASUREMENTS

DATA TAKEN APRIL 10 AND 11, 1969

Location	Direction	Elevation (Feet)	Pin Spacing (Feet)	Reading (Ohms)	Multiplier	Average Ohm-Cm*
Unit No. 1 Reactor	North-South	584	50	2.2	191.5	21,000
			40	5.8	191.5	44,400
			30	9.9	191.5	56,900
			20	18.0		69,000
			10	100.0		191,500
Unit No. 2 Reactor	North-South	584	50	1.4	191.5	13,400
			40	2.0	191.5	15,300
			30	8.0	191.5	46,000
			20	25.0	191.5	95,900
			10	130.0	191.5	249,000
Between No. 1 and 2 Reactors	East-West	584	50	70.0	191.5	727,000
			40	19.0	191.5	145,600

Average Ohm-Cm = Reading Pin Spacing x Multiplier

* Actually Ohms per cubic centimeter

SITE SOIL RESISTIVITY MEASUREMENTS

DATA TAKEN APRIL 10 AND 11, 1969

Location	Direction	Elevation (Feet)	Pin Spacing (Feet)	Reading (Ohms)	Multiplier	Average Ohm-Cm*
			30	22.0	191.5	126,500
			20	26.0	191.5	99,700
			10	91.0	191.5	174,200
Unit No. 2 Turbine	North-South	589	50	4.3	191.5	41,100
			40	7.8	191.5	59,800
			30	22.0	191.5	126,500
			20	46.0	191.5	176,300
			10	110.0	191.5	210,800
Unit No. 1 Turbine	North-South	589	50	No. Reading	191.5	----
			40	4.9	191.5	36,800
			30	18.0	191.5	103,500
			20	40.0	191.5	153,300
			10	112.0	191.5	214,300

SITE SOIL RESISTIVITY MEASUREMENTS

DATA TAKEN APRIL 10 AND 11, 1969

Location	Direction	Elevation (Feet)	Pin Spacing (Feet)	Reading (Ohms)	Multiplier	Average Ohm-Cm*
Unit No. 1 Turbine	East-West	589	50	8.0	191.5	76,500
			30	21.0	191.5	120,800
			10	104.0	191.5	199,300
On Beach Near Water (Sand)	North-South	580	50	7.05	191.5	67,500
			40	5.40	191.5	41,400
			30	8.50	191.5	48,900
			20	13.0	191.5	49,800
			10	18.0	191.5	34,500

ELECTRICAL PENETRATION - PROTOTYPE TESTS

PENETRATIONS[1]

Test & Sequence	5 Kv Power Penetration	600 Volt Power & Control Penetration	Instrumentation Penetration
High Potential[2]	X	X	X
Leakage [2]	X	X	X
Ampacity	X	X	
Accident Operating Environment	X	X	X
Short Circuit	X	X	

[1] Prototype testing compliance was allowed to be demonstrated by the submittal of test data from tests conducted on penetrations of equivalent type and design as those furnished for Donald C. Cook nuclear Plant.

[2] Conducted after Ampacity, Accident Operating Environment, and Short Circuit Tests.

TABLE OF DAMPING VALUES

	Percent of Critical Damping	
Type of Structure	**Operating Basis Earthquake**	**Design Basis Earthquake**
Containment Structure and all internal concrete structures	4%*, 2%**	7%*, 5%**
Other conventionally reinforced concrete structures above grade, such as shear walls or rigid frames	2%	5%
Welded structural steel assemblies	1%	1%
Bolted or riveted steel assemblies	2%	2%
Piping	0.5%	0.5%

* Analyzed with accident conditions
** Analyzed without accident conditions

Note 1: See Section 5 .3 .3. 7 for the damping values utilized in the seismic qualification of the Ice Condenser.

Note 2: For the Dry Cask Storage Project, the East Auxiliary Building crane, crane rails and the Auxiliary Building columns supporting the crane rails were reanalyzed utilizing the guidance provided in Regulatory Guide 1.60, Rev.1 and the damping values specified in Regulatory Guide 1.61, Rev. 1 to increase the main hoist Maximum Critical Load (MCL) tol45 tons.

Note 3 : See WCAP-7332-L and WCAP-12828 for the damping values utilized in the seismic qualification of the reactor internals.

SUMMARY OF ANALYSES-JET FORCES IMPACTING ON INTERNAL STRUCTURES

Source	Diameter	Elevation	Jet Travel (ft)	Critical Target	Normal Operating Pressure Psia.	Jet Effect	Remarks
Break #1	29"I.D.	614'-0"	Note [1] (2)		2250	c	
#2	27.5"I.D.	614'-0"	Note (1) (2)		2250	c	
#3	29"I.D.	615'-0"±	23.0[2]	Crane Wall	2250	c	
#4	31"I.D.	612'-9"+	37.0 (2)	Operating Deck	2250	d	
#5	31"I.D.	607'-9"±	42.0(2)	Operating Deck	2250	d	
#6	27.5"I.D.	614'-0"	11.0(2)	Crane Wall	2250	d	
#7	29"I.D.	615'-3+	39.5(2)	Operating Deck	2250	c	
#8	31"I.D.	607'-9"±	42.0(2)	Operating Deck	2250	d	
#9	31"I.D.	603'- 8 1/4"	13.0(2)	Crane Wall	2250	d	
#10	27.5"I.D.	614'-0"	14.0	Crane Wall	2250	d	
#11[3]	29"I.D.	614'-0"	19.5[4]	Crane Wall	2250	c	
#12[5]	29"I.D.	614'-0"	20.0	Crane Wall	2250	c	
#13	11"I.D.	620'-0"±	6.0(4)	Pressurizer Slab	2250	d	
#14	30"I.D.	686'-10 3/16"	16.0	Steam Gen. Encl	1020	d	

[1] Jet blocked; restraints prevent further movement.
[2] This break does not require consideration of Jet Forces since LBB methodology adopted. Maintained for historical purposes.
[3] Surge line connection on loop 3 only.
[4] Unit 2 only. LBB accepted for Unit 1.
[5] 14" connection on loop 2 only.

SUMMARY OF ANALYSES-JET FORCES IMPACTING ON INTERNAL STRUCTURES

Source	Diameter	Elevation	Jet Travel (ft)	Critical Target	Normal Operating Pressure Psia.	Jet Effect	Remarks
#15	28"I.D.	635'-0"	4.0	Containment Wall	1020	d	

(Refer to Fig. 5.2.2-6)

SUMMARY OF DYNAMIC MOTIONS

	O.B.E.			D.B.E		
At Point	**Relative Differential Of Vertical Motion**	**Relative Differential Of Horizontal Motion**		**Relative Differential Of Vertical Motion**	**Relative Differential Of Horizontal Motion**	
		X Direction	**Y Direction**		**X Direction**	**Y Direction**
A	0.185"	0.234"	0.227"	0.253"	0.374"	0.344"
B	0.225"	0.234"	0.227"	0.321"	0.374"	0.344"
C	0.097"	0.149"	0.149"	0.187”	0.322"	0.289"
D	0.041"	0.180"	0.173"	0.071"	0.360"	0.330"
Betw. Aux. Bldg. & Turbine Bldg. E	0.094"	0.180"	0.173"	0.176"	0.360"	0.330"
Betw. Aux. Bldg. & Diesel Bldg. E	0.136"	0.169"	0.162"	0.276"	0.362"	0.299"
Betw. Diesel Bldg. & Turbine Bldg. E	0.094"	0.149"	0.149"	0.182"	0.322"	0.289"

DYNAMIC ROTATIONS

	O.B.E.		D.B.E.	
Structure	**X Earthquake**	**Y Earthquake**	**X Earthquake**	**Y Earthquake**
Containment	17.6 (10^{-5}) Radians	17.6 (10^{-5}) Radians	22.7 (10^{-5}) Radians	22.7 (10^{-5}) Radians
Aux. Building	3.05 (10^{-5}) Radians	1.43 (10^{-5}) Radians	6.10 (10^{-5}) Radians	2.81 (10^{-5}) Radians
Turbine Building	0.2 (10^{-5}) Radians	1.91 (10^{-5}) Radians	0.31 (10^{-5}) Radians	3.03 (10^{-5}) Radians
Diesel Building (Switchgear)	3.78 (10^{-5}) Radians	8.0 (10^{-5}) Radians	8.85 (10^{-5}) Radians	15.1 (10^{-5}) Radians

CONTAINMENT INTERNAL STRUCTURAL ELEMENT DESIGN PRESSURES

STRUCTURAL ELEMENT	TMD ANALYSIS (SECTION 14.3.4.2)		DESIGN PRESSURE CAPABILITY
	SUBCOMPARTMENT	NODES	
Unit 1 Elevation 640 slab (upward pressure)	Fan/Accumulator	27-42	17.19 psid [1]
Unit 1 Elevation 640 slab (downward pressure)	Loop	40-27	10.5 psid [1]
Unit 2 Elevation 640 slab (upward pressure)	Fan/Accumulator	27-42	16.02 psid [1]
Unit 2 Elevation 640 slab (downward pressure)	Loop	40-27	10.4 psid [1]
Unit 1 Azimuth 54 wall (CEQ Fan Room Wall)	Fan/Accumulator	57-25	14.99 psid [1]
Unit 1 Azimuth 126 wall (CEQ Fan Room Wall)	Fan/Accumulator	57-25	13.42 psid [1]
Unit 1 Azimuth 234 wall (Non-Divider Barrier)	Fan/Accumulator	27-29	15.60 psid [1]
Unit 1 Azimuth 307 wall (Non-Divider Barrier)	Fan/Accumulator	27-29	24.91 psid [1]
Unit 2 Azimuth 54 wall (CEQ Fan Room Wall)	Fan/Accumulator	57-25	15.16 psid [1]
Unit 2 Azimuth 126 wall (CEQ Fan Room Wall)	Fan/Accumulator	57-25	15.27 psid [1]
Unit 2 Azimuth 234 wall (Non-Divider Barrier)	Fan/Accumulator	27-29	16.25 psid [1]
Unit 2 Azimuth 307 wall (Non-Divider Barrier)	Fan/Accumulator	27-29	27.24 psid [1]
Unit 1 & 2 Steam Generator Enclosure (uniform)	N/A	N/A	35.1 psi [1]
Unit 1 & 2 Steam Generator Enclosure (stratified)	Steam Generator	55-25	50.3 psid [1]
Unit 1 & 2 Operating Deck	Loop	1-25, 6-25	20.2 psid [1]
Upper Crane Wall (above 640 slab)	Loop	7,8,9 - 25	11.8 psid [1]
Lower Crane Wall (below 640 slab)	Loop	1-25, 6-25	20.2 psid [1]
Upper Reactor Cavity (Primary Shield Wall)	Reactor Cavity	38-51	72.4 psid [1]
Lower Reactor Cavity	Reactor Cavity	2	20.8 psig
Ice Condenser End Wall at Lower Plenum	Loop	40-25	14.8 psid [1]
Ice Condenser End Wall for Lower 16 Feet of Ice Bed	Loop	7-25	11.8 psid [1]
Ice Condenser End Wall for Middle 16 Feet of Ice Bed	Loop	8-25	9.2 psid [1]
Ice Condenser End Wall for Top 16 Feet of Ice Bed	Loop	9-25	7.4 psid [1]
Reactor Missile Shield & Vertical Bulkhead	Reactor Cavity	38-59	53.9 psid [1]
Pressurizer Enclosure	Pressurizer	46-25	80 psid [2]
Reactor Cavity Reactor Vessel Annulus	Reactor Cavity	1-3	1000 psid [2]
RCS Loop Piping Annulus Through Primary Shield Wall	Reactor Cavity	1-46	2000 psid [2]

[1] Equivalent Design Pressure Capability Determined During 2001 Re-Analysis (The capabilities given in this Table represent the relative equivalent pressure capacities for the currently calculated accident pressures as given in Unit 1 UFSAR Section 14.3.4.2, when factored per the requirements of UFSAR Section 5.2

[2] Design Pressure Capability Determined During Initial Plant Licensing

ICE CONDENSER DESIGN PARAMETERS

Reactor Containment Volume (net free volume)	
Upper Compartment, ft^3	745,896
Ice Condenser, ft^3	126,940
Lower Compartment (active), ft^3	306,800
Total Active Volume, ft^3	1,179,636
Lower Compartment (dead-ended), ft^3	61,702
Total Containment volume, ft^3	1,241,338
Reactor Containment Air Compression Ratio[1]	1.41
Reactor power, MWt (design basis)	3391
Design Energy Release to Containment	
Initial blowdown mass release, lb	549,000
Initial blowdown energy release, Btu	346.7×10^6
Allowance for undefined energy release in addition to core residual heat, Btu	50×10^6
Ice Condenser parameters	
Required weight of ice in condenser, lb	REFER TO TECHNICAL SPECIFICATIONS
Dimensions of ice condenser	
O.D., ft	115
I.D., ft.	89
Average Arc length, ft	267
Width (less insulation panels), ft	11
Ice bed height, ft	48
Inlet door flow area, ft2	1000
Ice condenser flow area, ft2	1326
Ice Condenser inlet door opening pressure, lb/ft2	1/2 to 1.0
Ice boron concentration, ppm boron	1800-2300
Refrigeration cooling capacity (current as of 1/82)	

[1] Defined in Section 14.3.

ICE CONDENSER DESIGN PARAMETERS

Installed cooling capacity for compartment, Tons	75
Maximum compartment heat input, Tons (per unit)	35
Total cooling capacity for plant, Tons (capacity shared by two units)	250

ICE CONDENSER ALLOWABLE LIMITS[1]

Load Combination	Elastic Analysis			Limit Analysis (Load Factors)[2]	Test (Load Factors)
	Mechanical[3]	Mechanical & Thermal	Fatigue		
D + OBE	S[44]	3S	AISC-69 Part I	1.7	1.87
D + DBA	1.33 S	N/A	N/A	1.3	1.43
D + DBE	1.33 S	N/A	N/A	1.3	1.43
D + DBE + DBA	1.65 S	N/A	N/A	1.18	1.3

[1] For particular components that do not meet these limits specific justification shall be provided on a case by case basis.

[2] For mechanical loads only. Mechanical plus thermal expansion, combination and fatigue shall satisfy the elastic analysis limits.

[3] Membrane (direct) stresses shall be less than or equal to 0.7 Su (70% of ultimate stress).

[4] S = Allowable stresses as defined in Sections 1.5 and 1.6 of the AISC-69 Part I Specification.

SUMMARY OF RESULTS FOR WEAR SLAB STRUCTURAL ANALYSIS

Stress	Loading Condition	Stress Ratio[1]	Basis
Wear Slab Bending - Tension on Top	D+ DBE+DBA	≤ 1.0	A
Wear Slab Bending - Tension on Bottom	Defrost	≤ 1.0	A
Shear on Bottom Plate Shear Connections	Defrost	≤ 1.0	B
Tie-Down Bolt Tension	D+DBE+DBA	≤ 1.0	B
Shear in Grout at Tie-Down Bolts	D+DBE+DBA	≤ 1.0	A
Pipe Stress Due to Slab Loading	Defrost	≤ 1.0	B
Compression of Foam Concrete	D+DBE+DBA	≤ 1.0	C

NOTES:

A. Allowable stress per ACI 318-71

B. Allowable stress per AISC-69

C. Vendor Qualification Test

[1] $\frac{\text{Max Calculated Stress}}{\text{Code Allowable Stress}}$

SUMMARY OF RESULTS FOR WALL PANELS[1]

Item	Stress Ratio[2]	Basis
Maximum general membrane stress	≤ 1.0	Allowable from Section 5.3.4.3.2
Maximum local membrane stress	≤ 1.0	Allowable from Section 5.3.4.3.2
Load on Each Leg of Corrugated Core	≤ 1.0	Critical load by Formula of Reference 5

[1] For conservatism, a DBA pressure of 21.7 psig was used in the analysis. The DBA pressure of 21.7 psig includes a 20% margin. The dynamic load factor (DLF) is 1.53.

[2] $\frac{\text{Max. Calculated Stress}}{\text{Code Allowable Stress}}$

SUMMARY OF RESULTS FOR WALL PANEL TRANSVERSE BEAM STRESS

Loading Conditions	**D + OBE**	**D + DBE**	**D + DBE + DBA**
Allowable Stress Criteria, Section 5.3.4.3.2	1.0S	1.33S	1.65S
Bending Allowable Stress (Psi)	33,000	43,890	54,450
Combined Stress Ratio[1]	≤ 1.00	≤ 1.00	≤ 1.00

[1] $\frac{\text{Max. Calculated Stress}}{\text{Code Allowable Stress}}$

SUMMARY OF STRESS RESULTS FOR LATTICE FRAME

	D + OBE	D + DBA	D + DBE	D + DBA + DBE
Criteria	S per AISC-69	1.33S	1.33S	1.65S
Bending Allowable Stress(psi)	37,500[1]	49,875(1)	49,875(1)	68,060[2]
Combined Stress Ratio [3]	≤ 1.00	≤ 1.00	≤ 1.00	≤ 1.00

[1] ASTM-A441 with minimum yield strength = 50 K/in^2
[2] ASTM-A441 with actual yield strength = 55 K/in^2
[3] $\frac{\text{Max. Calculated Stress}}{\text{Code Allowable}}$

SUMMARY OF RESULTS OF FATIGUE ANALYSIS FOR LATTICE FRAME [1]

Member Type	Stress Ratio[2]	Allowable Stress range [3],psi
Radial Stringers	≤ 1.0	60,000
Fillet Welds	≤ 1.0	22,500

[1] Based on 400 OBE cycles
[2] $\frac{\text{Max. Calculated Stress}}{\text{Code Allowable Stress}}$
[3] AISC-69 specification, Appendix B

SUMMARY OF RESULTS FOR MEMBER STRESSES IN LOWER SUPPORT STRUCTURE COMPARED TO DESIGN ALLOWABLE MEMBER STRESSES

DESCRIPTION [1]	MAXIMUM STRESSES D+DBE+DBA				MAXIMUM STRESSES D+OBE				REMARKS [2]
	$\sigma_{allowable}$ ksi	Stress Ratio σ [3]	$\tau_{allowable}$ ksi	Stress Ratio τ [(3)]	$\sigma_{allowable}$ ksi	Stress Ratio σ [(3)]	$\tau_{allowable}$ ksi	Stress Ratio τ [(3)]	
Columns Line 1 - Inner	40.5	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Columns Line 1 - Middle	40.5	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Columns Line 1 - Outer	40.5	≤.1.0	23.4	≤.1.0	27.0	≤.1.0	18.0	≤.1.0	
Columns Line 2 - Inner	40.5	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Columns Line 2 - Middle	40.5	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Columns Line 2 - Outer	40.5	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Circumferential BEAMS - Inner	40.5	≤ 1.0	26.6	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Circumferential Beams - Middle	40.5	≤ 1.0	26.6	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Circumferential Beams - Outer	40.5	≤ 1.0	26.6	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Radial Beam 1	45.0	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Radial Beam 2	45.0	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Radial Beam 3	45.0	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Radial Beam 4	45.0	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Radial Beam 5	45.0	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Radial Beam 6	45.0	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Radial Beam 7	45.0	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Radial Beam 8	45.0	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	

[1] Columns, Line 1 – Odd column lines starting at the end wall
Columns, Line 2 – Even column lines starting at the end wall
Radial Beams – numbers from column line 1
[2] All Stresses Are Within Allowable Values
[3] Max. Calculated Stress
Code Allowable Stress

SUMMARY OF RESULTS FOR MEMBER STRESSES IN LOWER SUPPORT STRUCTURE COMPARED TO DESIGN ALLOWABLE MEMBER STRESSES

DESCRIPTION [1]	**MAXIMUM STRESSES D+DBE+DBA**				**MAXIMUM STRESSES D+OBE**				**REMARKS** [2]
	$\sigma_{allowable}$ ksi	Stress Ratio σ [3]	$\tau_{allowable}$ ksi	Stress Ratio τ (3)	$\sigma_{allowable}$ ksi	Stress Ratio σ (3)	$\tau_{allowable}$ ksi	Stress Ratio τ (3)	
Radial Beam 9	45.0	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Horizontal Bracing – Inner Platform	40.5	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Horizontal Bracing – Outer Platform	40.5	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Vertical Cross-Bracing	40.5	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Ice Basket Hold-Down Bars	40.5	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Turning Vane Assembly Mounting Plate - Column 1	40.5	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	
Turning Vane Assembly Mounting Plate - Column 2	40.5	≤ 1.0	23.4	≤ 1.0	27.0	≤ 1.0	18.0	≤ 1.0	

SUMMARY OF RESULTS FOR LOWER PERSONNEL ACCESS DOOR ANALYSES DUE TO LOCA

Item	Load	Stress Ratio[1]	Basis[2]
1	Shear stress of anchor rod	≤ 1.0	A
2	Shear stress of frame	≤ 1.0	A
3	Compressive stress of inner door panel	≤ 1.0	A
4	Compressive stress of U channel (door panel bracing)	≤ 1.0	A
5	Compressive stress of wedges	≤ 1.0	A

[1] $\dfrac{\text{Max. Calculated Stress}}{\text{Code Allowable Stress}}$

[2] A – Allowable stress from Section 5.3.4.3.2

SUMMARY OF RESULTS FOR INLET DOOR STRUCTURAL ANALYSIS – LOCA

ITEM	AREA	STRESS RATIO[1]	BASIS[2]
1	Bending of FRP Plate	≤ 1.0	D
2	Tension + Bending of Reinforcing Ribs	≤ 1.0	A
3	Slip of Plate/Rib Bolts	≤ 1.0	C
4	Compression + Bending of Compr. Sleeves	≤ 1.0	A
5	Bearing in Fiber Reinforced Plastic (FRP) Plate at Bolts	≤ 1.0	D
6	Pullout of Bolts from FRP Plate	≤ 1.0	D
7	Crushing of Foam Insulation	≤ 1.0	E
8	Shear of Foam Insulation	≤ 1.0	E
9	Tension in Hinge Adapter	≤ 1.0	A
10	Shear in Adapter/Rib Weld	≤ 1.0	A
11	Bending + Shear of Hinge Bar	≤ 1.0	A
12	Bearing Loads in Hinge Bearing	≤ 1.0	B
13	Bending + Shear + Torsion of Hinge Bracket	≤ 1.0	A
14	Tension in Bearing Housing	≤ 1.0	A
15	Unloading of Bracket/Frame Bolts	≤ 1.0	C
16	Bending of Door Frame	≤ 1.0	A
17	Pullout of 1" Anchor Bolts	≤ 1.0	E
18	Bending of Tie Bars	≤ 1.0	G
19	Extension of Proportioning Springs	≤ 1.0	F
20	Bending of Spring Housing Supports	≤ 1.0	A
21	Tension of Tie Bar Bolts	≤ 1.0	G
22	Bending of Frame Center Beam	≤ 1.0	A
23	Shear of Center Beam Connecting Bolts	≤ 1.0	A
24	Shear of Center Beam ½" Anchor Bolts	≤ 1.0	E

[1] $\frac{\text{Max. Calculated Stress}}{\text{Code Allowable Stress}}$

[2] Bases

a). Allowable value per AISC-69 limits.
b). Anti-Friction Bearing Manufacturers Association (AFBMA) Basic Dynamic Capacity.
c). Side load to overcome pre-tensioning.
d). Design load per manufacturer's recommendations.
e). Strength values per manufacturer's literature.
f). Stress to permanent set.
g). Allowable stress from Section 5.3.4.3.

SUMMARY OF RESULTS FOR TOP DECK DOOR STRUCTURAL ANALYSIS – LOCA

Item	Area	Stress Ratio[1]	Basis[2]
1	Hinge band direct tension	≤ 1.0	B
2	Hinge bar - bending	≤ 1.0	A
3	Anchor bolts - tension	≤ 1.0	A
4	Floor grating - bending	≤ 1.0	C
5	Insulation tip stress - tear	≤ 1.0	C
6	Insulation tip stress - tensile	≤ 1.0	C

[1] $\frac{\text{Max Calculated Stress}}{\text{Code Allowable Stress}}$

[2] Basis

A. Allowable value per Section 5.3.4.3.2

B. ASTM-177 minimum tensile with AISC allowable

C. Strength values per Manufacturer's literature

SUMMARY OF RESULTS FOR TOP DECK STRUCTURE

(STRESS LEVELS WITHIN THE ICE CONDENSER)

Description Of Member	Load Combination		Allowable Stress (ksi)	Stress Ratio[1]
Radial Beam	Blowdown Pressure (DL + DBA)		36.0	≤ 1.0
Radial Beam	Service Load (DL+OBE)		27.0	≤ 1.0
Radial Beam	Service Load (DL+Thermal Load+OBE)		81.0	≤ 1.0
Radial Beam	Design Load (DL+DBE)		36.0	≤ 1.0
Radial Beam	Design Load (DL+DBA+DBE)		45.0	≤ 1.0
Crane Rails	DL+LL		21.6	≤ 1.0
Crane Rails	DL+LL+Thermal		21.6	≤ 1.0
Circumferential Struts (A-36 steel)	DL+LL+Thermal		21.6	≤ 1.0
Circumferential Struts	DBA + DL		21.6	≤ 1.0
Circumferential Struts	DL+OBE		21.6	≤ 1.0
Circumferential Struts	DL+TH+OBE		21.6	≤ 1.0
Circumferential Struts	DL+DBE		21.6	≤ 1.0
Circumferential Struts	DL+DBA+DBE		21.6	≤ 1.0
Radial Beam[2]	Service Load (Dead Load+OBE)		27.0	≤ 1.0
Radial Beam[(2)]	Design Load (Dead Load+DBE)		36.0	≤ 1.0

[1] $\frac{\text{Max Calculated Stress}}{\text{Code Allowable Stress}}$

[2] Stress levels outside the ice condenser – crane mass located outside ice condenser compartment

SUMMARY OF RESULTS FOR INTERMEDIATE DECK AND DOOR ASSEMBLY STRUCTURAL ANALYSIS - LOCA

Item	Area	Stress Ratio[1]	Basis[2]
1	Bending of main support beams	≤ 1.0	A
2	Tension and bending hinge arm	≤ 1.0	A
3	Bending and shear of hinge pin	≤ 1.0	A
4	Hinge bracket bolts - tension	≤ 1.0	A
5	Hinge arm - tension across hole	≤ 1.0	A
6	Shear, hinge arm to box beam	≤ 1.0	A
7	Box beam bending	≤ 1.0	A
8	Shear of foam insulation	≤ 1.0	B
9	Skin plug welds - shear	≤ 1.0	A
10	Bending - door frame angles	≤ 1.0	A
11	Bending - door frame tie beam	≤ 1.0	A

[1] $\frac{\text{Max. Calculated Stress}}{\text{Code Allowable Stress}}$

[2] Basis

A. Allowable value per Section 5.3.4.3.2

B. Strength values per manufacturer's literature

SUMMARY OF RESULTS FOR AIR HANDLING UNIT SUPPORT BEAMS

(A500 GR B STEEL)

Load Combination		Allowable Stress, ksi	Stress Ratio[1]
DBA + DL		27.6	≤ 1.0
DL+OBE		27.6	≤ 1.0
DL+TH+OBE		27.6	≤ 1.0
DL+DBE		27.6	≤ 1.0
DL+DBA+DBE		27.6	≤ 1.0

[1] $\frac{\text{Max.Calculated Stress}}{\text{Code Allowable Stress}}$

UNIT 1 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-1	G	Blind Flange	N/A [1]	Fuel Transfer Tube	20	N/A
CPN-2	F	N/A [2]	N/A (2)	Steam Generator Main Steam Outlet	30	N/A
CPN-3	F	N/A (2)	N/A (2)	Steam Generator Main Steam Outlet	30	N/A
CPN-4	F	N/A (2)	N/A (2)	Steam Generator Main Steam Outlet	30	N/A
CPN-5	F	N/A (2)	N/A (2)	Steam Generator Main Steam Outlet	30	N/A
CPN-6	F	N/A (2)	N/A (2)	Steam Generator No.1 Blowdown Outlet	2	N/A
CPN-7	F	N/A (2)	N/A (2)	Steam Generator Feedwater Inlet	14	N/A
CPN-8	F	N/A (2)	N/A (2)	Steam Generator Feedwater Inlet	14	N/A
CPN-9	F	N/A (2)	N/A (2)	Steam Generator Feedwater Inlet	14	N/A
CPN-10	F	N/A (2)	N/A (2)	Steam Generator Feedwater Inlet	14	N/A
CPN-11	D	Closed System	CS-442-1 Check	Reactor Coolant Pump Seal Water Supply	2	N/A
CPN-12	D	Closed System	CS-442-2 Check	Reactor Coolant Pump Seal Water Supply	2	N/A
CPN-13	D	Closed System	CS-442-3 Check	Reactor Coolant Pump Seal Water Supply	2	N/A
CPN-14	D	Closed System	CS-442-4 Check	Reactor Coolant Pump Seal Water Supply	2	N/A
CPN-15	D	Closed System	SI-189 Check	R.C. Relief Valve Vent Header	4	N/A
CPN-16	D	Closed System	ICM-111 Remote Manual MOV	Residual Heat Removal Inlet to R.C. Cold Legs	12	N/A
CPN-16	D	Closed System	SV-102	Residual Heat Removal Inlet to R.C. Cold Legs	12	N/A
CPN-17	A	WCR-900 Auto Trip AOV [3]	WCR-901 Auto Trip AOV (3)	Non-Essential Service Water to Lower Containment Ventilation Unit #1	6	10

[1] Not required, 2 seals on inner flange per FSAR Q5.118.
[2] Not Required, extension of Containment Liner per FSAR Appendix Q.

UNIT 1 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-18	A	WCR-904 Auto Trip AOV (3)	WCR-905 Auto Trip AOV (3)	Non-Essential Service Water to Lower Containment Ventilation Unit #2	6	10
CPN-19	A	WCR-908 Auto Trip AOV (3)	WCR-909 Auto Trip AOV (3)	Non-Essential Service Water to Lower Containment Ventilation Unit #3	6	10
CPN-20	A	WCR-912 Auto Trip AOV (3)	WCR-913 Auto Trip AOV (3)	Non-Essential Service Water to the Lower Containment Ventilation Unit #4	6	10
CPN-21	A	WCR-902 Auto Trip AOV (3)	WCR-903 Auto Trip AOV (3)	Non-Essential Service Water from the Lower Containment Ventilation Unit #1	6	10
CPN-22	A	WCR-906 Auto Trip AOV (3)	WCR-907 Auto Trip AOV (3)	Non-Essential Service Water from the Lower Containment Ventilation Unit #2	6	10
CPN-23	A	WCR-910 Auto Trip AOV (3)	WCR-911 Auto Trip AOV (3)	Non-Essential Service Water from the Lower Containment Ventilation Unit #3	6	10
CPN-24	A	WCR-914 Auto Trip AOV (3)	WCR-915 Auto Trip AOV (3)	Non-Essential Service Water from the Lower Containment Ventilation Unit #4	6	10
CPN-25	D	Closed System	CCM-431 Remote Manual MOV	Component Cooling Water from the Pressure Equalizing Fans	1.5	N/A
CPN-25	D	Closed System	CCR-440 Remote Manual AOV	Component Cooling Water from the Main Steam Penetrations.	1.5	N/A
CPN-25	D	Closed System	CCW-244-25 Check Valve	Component Cooling Water to the Main Steam Penetrations	1	N/A
CPN-25	D	Closed System	CCW-243-25 Check Valve	Component Cooling Water to the Main Steam Penetrations	1	N/A

[3] Exception in Class A piping functional class applies to this penetration.

UNIT 1 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-25	D	Closed System	CCM-430 Remote Manual MOV	Component Cooling Water to the Pressure Equalizing Fans	1.5	N/A
CPN-26	A	WCR-923 Auto Trip AOV (3)	WCR-922 Auto Trip AOV (3)	Non-Essential Service Water from the Upper Containment Ventilation Unit #1	3	10
CPN-26	A	WCR-955 Auto Trip AOV (3)	WCR-945 Auto Trip AOV (3)	Non-Essential Service Water from the Reactor Coolant Pump #1 Motor Air Cooler	3	10
CPN-26	A	WCR-920 Auto Trip AOV (3)	WCR-921 Auto Trip AOV (3)	Non-Essential Service Water to the Upper Containment Ventilation Unit #1	3	10
CPN-26	A	WCR-941 Auto Trip AOV (3)	WCR-951 Auto Trip AOV (3)	Non-Essential Service Water to the Reactor Coolant Pump #1 Motor Air Cooler	3	10
CPN-27	A	WCR-927 Auto Trip AOV (3)	WCR-926 Auto Trip AOV (3)	Non-Essential Service Water from the Upper Containment Ventilation Unit #2	3	10
CPN-27	A	WCR-956 Auto Trip AOV (3)	WCR-946 Auto Trip AOV (3)	Non-Essential Service Water from the Reactor Coolant Pump #2 Motor Air Cooler	3	10
CPN-27	A	WCR-924 Auto Trip AOV (3)	WCR-925 Auto Trip AOV (3)	Non-Essential Service Water to the Upper Containment Ventilation Unit #2	3	10
CPN-27	A	WCR-942 Auto Trip AOV (3)	WCR-952 Auto Trip AOV (3)	Non-Essential Service Water to the Reactor Coolant Pump #2 Motor Air Cooler	3	10
CPN-28	Spare	Welded Closed	N/A	Spare	18 in sleeve	N/A
CPN-29	A	PA -343 Check Valve	PCR-40 MOV	Service Air	2	10
CPN-29	A	XCR-103 Auto Trip AOV	XCR-102 Auto Trip AOV	Instrument Air	1	10
CPN-30	Spare	Welded Cap	N/A	N/A	N/A	N/A

UNIT 1 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-30	E	NPX-151-V1 Manual	N/A	Dead Weight Test Connection	0.5	N/A
CPN-31	A	N-160 Check Valve	DCR-207 Auto Trip AOV	Nitrogen Supply to the Reactor Coolant Drain Tank	1	10
CPN-31	A	DCR-201 Auto Trip AOV	DCR-203 Auto Trip AOV	Vents from the Reactor Coolant Drain Tank and the Pressurizer Relief Tank	1	10
CPN-31	A	DCR-611 Auto Trip AOV	DCR-610 Auto Trip AOV	Drain from the Ice Condenser Vent	3	10
CPN-31	A	DCR-621 Auto Trip AOV	DCR-620 Auto Trip AOV	Drain from the Containment Ventilation Units	1	10
CPN-31	A	ECR-33 Auto Trip AOV	ECR-35 Auto Trip AOV	Containment Air Particulate and Noble Gas Detector Sample Return	1	10
CPN-32	A	SI-171 or SI-172 Manual Valves	SI-194 Manual Valve	Safety Injection Test Line and Accumulator Test Line	0.75	N/A
CPN-32	A	N-102 Check Valve	GCR-314 Auto Test AOV	Nitrogen Supply to the Accumulators	1	10
CPN-32	A	ECR-31 Auto Trip AOV	ECR-32 Auto Trip AOV	Sample Line to the Containment Air Particulate and Noble Gas Detector	1	10
CPN-32	A	ECR-535 Auto Trip AOV	ECR-536 Auto Trip AOV	Sample Line to the Containment Air Particulate and Radio Gas Detector -Lower Containment	0.5	10
CPN-33	Spare	Plugged	N/A	Spare	N/A	N/A
CPN-33	A	PW-275 Check Valve	NCR-252 Auto Trip AOV	Primary Water Supply to the Pressurizer Relief Tank	3	10
CPN-34	A	QCR-301 Auto Trip AOV	QCR-300 Auto Trip AOV	Letdown Line (CVCS)	2	10

UNIT 1 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-35	D	Closed System	CS-321 Check Valve	Charging Line (CVCS)	3	N/A
CPN-36	A	SF-153 Manual Valve	SF-151 Manual Valve	Refueling Water Supply to the Refueling Cavity	2.5	N/A
CPN-36	A	1-QCR-920 Auto Trip AOV (3)	1-QCR-919 Auto Trip AOV (3)	Demineralized Water to the Refueling Cavity	2	10
CPN-37	A	QCM-250 Auto Trip MOV	QCM-350 Auto Trip MOV	R.C. Pumps Seal Water & Excess Letdown Heat Exchanger Discharges	4	15
CPN-38	A	CCM-459 Auto Trip MOV	CCM-458 Auto Trip MOV	R.C.Pump Motor and Thermal Barrier Cooling Water Supply	8	60
CPN-39	A	CCM-451 Auto Trip MOV	CCM-452 Auto Trip MOV	R.C.Pump Motor and Thermal Barrier Cooling Water Discharge	8	60
CPN-40	A	DCR-205 Auto Trip AOV (3)	DCR-206 Auto Trip AOV (3)	Reactor Coolant Drain Tank Pump Suction	4	10
CPN-41	A	DCR-600 Auto Trip AOV (3)	DCR-601 Auto Trip AOV (3)	Containment Sump Pump Discharge to Waste Disposal	3	10
CPN-42	A	SF-159 Manual Valve	SF-160 Manual Valve	Refueling Cavity Drain to Purification System	3	N/A
CPN-43	D	Closed System	ICM-260 Remote Manual MOV	Safety Injection to the RCS Hot/Cold Legs	4	N/A

UNIT 1 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-44	D	Closed System	ICM-250 Remote Manual MOV or ICM-251 Remote Manual MOV	Boron Injection Inlet	3	N/A
CPN-45	D	Closed System	ICM-305 Remote Manual MOV	Residual Heat Removal Suction from Recirc Sump	18	N/A
CPN-46	D	Closed System	ICM-306 Remote Manual MOV	Residual Heat Removal Suction from Recirc Sump	18	N/A
CPN-47	D	Closed System	ICM-129 Remote Manual MOV	Residual Heat Removal Inlet to RHR Pumps	14	N/A
CPN-47	D	Closed System	SV-103 Relief Valve	Residual Heat Removal Inlet to RHR Pumps	14	N/A
CPN-48	D	Closed System	ICM-321 Remote Manual MOV	Residual Heat Removal to R.C. Hot Legs - Low Head S.I.	8	N/A
CPN-49	D	Closed System	ICM-311 Remote Manual MOV	Residual Heat Removal to R.C. Hot Legs - Low Head S.I.	8	N/A
CPN-50	D	Closed System	RH-142 Check Valve	RHR to Containment Spray	8	N/A
CPN-51	D	Closed System	RH-141 Check Valve	RHR to Containment Spray	8	N/A
CPN-52	D	Closed System	CTS-131W Check Valve	Upper Containment Spray Inlet	8	N/A
CPN-53	D	Closed System	CTS-131E Check Valve	Upper Containment Spray Inlet	8	N/A

UNIT 1 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-54	D	Closed System	CTS-127W Check Valve	Lower Containment Spray Inlet	6	N/A
CPN-55	D	Closed System	CTS-127E Check Valve	Lower Containment Spray Inlet	6	N/A
CPN-56	A	VCR-21 Auto Trip AOV or R157 Check Valve	VCR-20 Auto Trip AOV	Glycol to Ice Condenser Fan Coolers	3	10
CPN-57	G	Blind Flange	Blind Flange	Ice Loading Line	4	N/A
CPN-58	A	CCM-453 Auto Trip MOV	CCM-454 Auto Trip MOV	Reactor Coolant Pump Thermal Barrier Cooling Water Discharge	4	30
CPN-59	A	VCR-105 Auto Trip AOV	VCR-205 Auto Trip AOV	Upper Containment Purge Air Inlet	30	5
CPN-60	A	VCR-106 Auto Trip AOV	VCR-206 Auto Trip AOV	Upper Containment Purge Air Outlet	24	5
CPN-61	A	VCR-101 Auto Trip AOV	VCR-201 Auto Trip AOV	Purge Air Inlet (Instrumentation Room)	14	5
CPN-62	A	VCR-102 Auto Trip AOV	VCR-202 Auto Trip AOV	Purge Air Outlet (Instrumentation Room)	14	5
CPN-63	A	VCR-104 Auto Trip AOV	VCR-204 Auto Trip AOV	Lower Containment Purge Air Outlet	30	5
CPN-64	A	VCR-103 Auto Trip AOV	VCR-203 Auto Trip AOV	Lower Containment Purge Air Inlet	24	5
CPN-65	A	VCR-107 Auto Trip AOV	VCR-207 Auto Trip AOV	Upper Containment Pressure Relief Line	12	5

UNIT 1 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-66	A	NCR-105 Auto Trip AOV	NCR-106 Auto Trip AOV	Sample Line from the RCS Hot Legs	0.5	10
CPN-66	A	NCR-107 Auto Trip AOV	NCR-108 Auto Trip AOV	Sample Line from the Pressurizer Liquid Space	0.5	10
CPN-66	A	NCR-109 Auto Trip AOV	NCR-110 Auto Trip AOV	Sample Line from the Pressurizer Steam Space	0.5	10
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #1 Blowdown Sample	0.5	N/A
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #2 Blowdown Sample	0.5	N/A
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #3 Blowdown Sample	0.5	N/A
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #4 Blowdown Sample	0.5	N/A
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #1 Steam Space Steam Sample	0.5	N/A
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #2 Steam Space Steam Sample	0.5	N/A
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #3 Steam Space Steam Sample	0.5	N/A
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #4 Steam Space Steam Sample	0.5	N/A
CPN-67	A	ECR-416 Auto Trip AOV	ECR-417 Auto Trip AOV	Post Accident Sampling System	0.5	10
CPN-67	A	NS - 357 Check Valve	ECR-496 or ECR-497 Auto Trip AOV	Post Accident Sampling System Return	0.5	10
CPN-68	D	Closed System	ICM-265 Remote Manual MOV	Safety Injection to the RCS Hot/ColdLegs	4	N/A
CPN-69	Spare	Welded Closed	N/A	Spare	18 in sleeve	N/A
CPN-70	Spare	Welded Closed	N/A	Spare	1	N/A
CPN-70	Spare	Welded Closed	N/A	Spare	1	N/A

UNIT 1 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-70	Spare	Welded Closed	N/A	Spare	1	N/A
CPN-70	Spare	Welded Closed	N/A	Spare	1	N/A
CPN-70	Spare	Welded Closed	N/A	Spare	1	N/A
CPN-70	A	SM-1 Check Valve	ECR-36 Auto Trip AOV	Radiation Monitor ERS-2400 Isolation Valve	1	10
CPN-71	G	Blind Flange	Hinged Flange	Containment Service Penetration	18	N/A
CPN-72	D	Closed System	CCM-433 Remote Manual MOV	Component Cooling Water from the Pressure Equalizing Fans	1.5	N/A
CPN-72	D	Closed System	CCR-441 Remote Manual MOV	Component Cooling Water from the Main Steam Penetrations.	2	N/A
CPN-72	D	Closed System	CCW-244-72 Check Valve	Component Cooling Water to the Main Steam Penetrations	1	N/A
CPN-72	D	Closed System	CCW-243-72 Check Valve	Component Cooling Water to the Main Steam Penetrations	1	N/A
CPN-72	D	Closed System	CCM-432 Remote Manual MOV	Component Cooling Water to the Pressure Equalizing Fans	1.5	N/A
CPN-73	A	WCR-960 Auto Trip AOV (3)	WCR-961 Auto Trip AOV (3)	Non-Essential Service Water to the Instrument Room Ventilation Unit E	2.5	10
CPN-73	A	WCR-962 Auto Trip AOV (3)	WCR-963 Auto Trip AOV (3)	Non-Essential Service Water from the Instrument Room Ventilation Unit E	2.5	10
CPN-73	A	WCR-964 Auto Trip AOV (3)	WCR-965 Auto Trip AOV (3)	Non-Essential Service Water to the Instrument Room Ventilation Unit W	2.5	10
CPN-73	A	WCR-966 Auto Trip AOV (3)	WCR-967 Auto Trip AOV (3)	Non-Essential Service Water from the Instrument Room Ventilation Unit W	2.5	10

UNIT 1 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-74	A	XCR-100 Auto Trip AOV	XCR-101 Auto Trip AOV	Instrument Air	1	10
CPN-74	A	N-159 Check Valve	GCR-301 Auto Trip AOV	Nitrogen Supply to the Pressurizer Relief Tank	0.75	10
CPN-75	C	Closed System	CCR-460 Auto Trip AOV	Excess Letdown Heat Exchanger Component Cooling Water Outlet	4	10
CPN-75	C	Closed System	CCR - 462 Auto Trip AOV	Excess Letdown Heat Exchanger Component Cooling Water Inlet	4	10
CPN-76	G	Blind Flange	Blind Flange	Incore Flux Detection System	8	N/A
CPN-77	F	N/A (2)	N/A (2)	Steam Generator No.2 Blowdown Outlet	2	N/A
CPN-78	F	N/A (2)	N/A (2)	Steam Generator No.3 Blowdown Outlet	2	N/A
CPN-79	F	N/A (2)	N/A (2)-	Steam Generator No.4 Blowdown Outlet	2	N/A
CPN-80	G	Blind Flange	Blind Flange	Ice Loading Return	5	N/A
CPN-81	A	RCR-100 Auto Trip AOV	RCR-101 Auto Trip AOV	Sample Line from the Pressurizer Relief Tank to the Gas Analyzer	0.5	10
CPN-81	A	DCR-202 Auto Trip AOV	DCR-204 Auto Trip AOV	Sample Line from the Reactor Coolant Drain Tank to the Gas Analyzer	0.5	10
CPN-81	A	ICR-5 Auto Trip AOV	ICR-6 Auto Trip AOV	Sample Line from the Accumulators	0.5	10
CPN-82	A	CCR-456 Auto Trip AOV	CCR-457 Auto Trip AOV	Reactor Support Cooling Water Outlet	2.5	10
CPN-82	A	CCW-135 Check Valve	CCR-455 Auto Trip AOV	Reactor Support Cooling Water Inlet	2.5	10
CPN-83	G	Hinged Flange	Hinged Flange	Containment Service Penetration	N/A	N/A

UNIT 1 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-84	A	WCR-954 Auto Trip AOV (3)	WCR-944 Auto Trip AOV (3)	Non-Essential Service Water to the Reactor Coolant Pump #4 Motor Air Cooler	3	10
CPN-84	A	WCR-948 Auto Trip AOV (3)	WCR-958 Auto Trip AOV (3)	Non-Essential Service Water from the Reactor Coolant Pump #4 Motor Air Cooler	3	10
CPN-84	A	WCR-933 Auto Trip AOV (3)	WCR-932 Auto Trip AOV (3)	Non-Essential Service Water to the Upper Containment Ventilation Unit #4	3	10
CPN-84	A	WCR-934 Auto Trip AOV (3)	WCR-935 Auto Trip AOV (3)	Non-Essential Service Water from the Upper Containment Ventilation Unit #4	3	10
CPN-85	A	WCR-953 Auto Trip AOV (3)	WCR-943 Auto Trip AOV (3)	Non-Essential Service Water to the Reactor Coolant Pump #3 Motor Air Cooler	3	10
CPN-85	A	WCR-947 Auto Trip AOV (3)	WCR-957 Auto Trip AOV (3)	Non-Essential Service Water from the Reactor Coolant Pump #3 Motor Air Cooler	3	10
CPN-85	A	WCR-929 Auto Trip AOV (3)	WCR-928 Auto Trip AOV (3)	Non-Essential Service Water to the Upper Containment Ventilation Unit #3	3	10
CPN-85	A	WCR-930 Auto Trip AOV (3)	WCR-931 Auto Trip AOV (3)	Non-Essential Service Water from the Upper Containment Ventilation Unit #3	3	10
CPN-86	A	VCR-11 Auto Trip AOV or R156 Check Valve	VCR-10 Auto Trip AOV	Glycol Supply from Ice Condenser Fan Coolers	3	10
CPN-87	Spare	Welded Closed	N/A	Spare	6 in sleeve	N/A
CPN-88	Spare	Welded Closed	N/A	Spare	6 in sleeve	N/A
CPN-89	A	SM-8 Manual Valve	SM-10 Manual Valve	Upper Containment Radiation Sampling System	0.5	N/A
CPN-90	Spare	Welded Closed	N/A	Spare	6 in sleeve	N/A

UNIT 1 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-91	E	Membrane (Sensor Bellows)	HI [4]	Reactor Vessel Level Instrumentation System 1-NLS-111	0.5	N/A
CPN-91	E	Membrane (Sensor Bellows)	HI [(4)]	Reactor Vessel Level Instrumentation System 1-NLS-121	0.5	N/A
CPN-91	E	Membrane (Sensor Bellows)	HI [(4)]	Reactor Vessel Level Instrumentation System 1-NLS-131	0.5	N/A
CPN-91	E	PPP-302-V1 Manual Valve	N/A	Containment Pressure Transmitter	0.5	N/A
CPN-91	Spare	Welded Closed	N/A	Spare	0.5	N/A
CPN-91	Spare	Welded Closed	N/A	Spare	0.5	N/A
CPN-92	E	PPP-301-V1 Manual Valve	N/A	Containment Pressure Transmitter	0.5	N/A
CPN-92	A	SM-6 Manual Valve	SM-4 Manual Valve	Instrument Room Air Sample Piping	0.5	N/A
CPN-93	A	ECR-14 Auto Trip AOV	ECR-24 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 4	0.5	10
CPN-93	A	ECR-16 Auto Trip AOV	ECR-26 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 6	0.5	10
CPN-93	A	ECR-17 Auto Trip AOV	ECR-27 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 7	0.5	10
CPN-93	A	ECR-18 Auto Trip AOV	ECR-28 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 8	0.5	10

[4] Hydraulically Isolated (HI)

UNIT 1 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-93	A	ECR-19 Auto Trip AOV	ECR-29 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 9	0.5	10
CPN-94	E	PPP-300-V1 Manual Valve	N/A	Containment Pressure Transmitter	0.5	N/A
CPN-94	E	Membrane (Sensor Bellows)	HI (4)	Reactor Vessel Level Instrumentation System 1-NLS-120	0.5	N/A
CPN-95	A	ECR-11 Auto Trip AOV	ECR-21 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 1	0.5	10
CPN-95	A	ECR-12 Auto Trip AOV	ECR-22 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 2	0.5	10
CPN-95	A	ECR-13 Auto Trip AOV	ECR-23 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 3	0.5	10
CPN-95	A	ECR-15 Auto Trip AOV	ECR-25 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 5	0.5	10
CPN-95	A	ECR-10 Auto Trip AOV or ECR-20 Auto Trip AOV	NS-283 Check Valve	Containment Hydrogen Monitoring System - Hydrogen Sample Return	0.5	10
CPN-96	E	PPP-303-V1 Manual Valve	N/A	Containment Pressure Transmitter	0.5	N/A
CPN-96	E	PPX-301-V1 Manual Valve	N/A	Containment Pressure Transmitter	0.5	N/A
CPN-97	E	PPA-310-V1 Manual Valve	N/A	Containment Pressure Transmitter	0.5	N/A

UNIT 1 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-97	E	Membrane (Sensor Bellows)	HI (4)	Reactor Vessel Level Instrumentation System 1-NLS-130	0.5	N/A
CPN-98	E	PPA-312-V1 Manual Valve	N/A	Containment Pressure Transmitter	0.5	N/A
CPN-98	E	Membrane (Sensor Bellows)	HI (4)	Reactor Vessel Level Instrumentation System 1-NLS-110	0.5	N/A

UNIT 2 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-1	G	Blind Flange	N/A (1)	Fuel Transfer Tube	20	N/A
CPN-2	F	N/A (2)	N/A (2)	Steam Generator Main Steam Outlet	30	N/A
CPN-3	F	N/A (2)	N/A (2)	Steam Generator Main Steam Outlet	30	N/A
CPN-4	F	N/A (2)	N/A (2)	Steam Generator Main Steam Outlet	30	N/A
CPN-5	F	N/A (2)	N/A (2)	Steam Generator Main Steam Outlet	30	N/A
CPN-6	F	N/A (2)	N/A (2)	Steam Generator No.1 Blowdown Outlet	2	N/A
CPN-7	F	N/A (2)	N/A (2)	Steam Generator Feedwater Inlet	14	N/A
CPN-8	F	N/A (2)	N/A (2)	Steam Generator Feedwater Inlet	14	N/A
CPN-9	F	N/A (2)	N/A (2)	Steam Generator Feedwater Inlet	14	N/A
CPN-10	F	N/A (2)	N/A (2)	Steam Generator Feedwater Inlet	14	N/A
CPN-11	D	Closed System	CS-442-1 Check	Reactor Coolant Pump Seal Water Supply	2	N/A
CPN-12	D	Closed System	CS-442-2 Check	Reactor Coolant Pump Seal Water Supply	2	N/A
CPN-13	D	Closed System	CS-442-3 Check	Reactor Coolant Pump Seal Water Supply	2	N/A
CPN-14	D	Closed System	CS-442-4 Check	Reactor Coolant Pump Seal Water Supply	2	N/A
CPN-15	D	Closed System	SI-189 Check	R.C.Relief Valve Vent Header	4	N/A
CPN-16	D	Closed System	ICM-111 Remote Manual MOV	Residual Heat Removal Inlet to R.C. Cold Legs	12	N/A
CPN-16	D	Closed System	SV-102	Residual Heat Removal Inlet to R.C. Cold Legs	12	N/A
CPN-17	A	WCR-901 Auto Trip AOV (3)	WCR-900 AutoTrip AOV (3)	Non-Essential Service Water to Lower Containment Ventilation Unit #1	6	10
CPN-18	A	WCR-905 Auto Trip AOV (3)	WCR-904 Auto Trip AOV (3)	Non-Essential Service Water to Lower Containment Ventilation Unit #2	6	10

UNIT 2 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-19	A	WCR-909 Auto Trip AOV (3)	WCR-908 Auto Trip AOV (3)	Non-Essential Service Water to Lower Containment Ventilation Unit #3	6	10
CPN-20	A	WCR-913 Auto Trip AOV (3)	WCR-912 Auto Trip AOV (3)	Non-Essential Service Water to the Lower Containment Ventilation Unit #4	6	10
CPN-21	A	WCR-902 Auto Trip AOV (3)	WCR-903 Auto Trip AOV (3)	Non-Essential Service Water from the Lower Containment Ventilation Unit #1	6	10
CPN-22	A	WCR-906 Auto Trip AOV (3)	WCR-907 Auto Trip AOV (3)	Non-Essential Service Water from the Lower Containment Ventilation Unit #2	6	10
CPN-23	A	WCR-910 Auto Trip AOV (3)	WCR-911 Auto Trip AOV (3)	Non-Essential Service Water from the Lower Containment Ventilation Unit #3	6	10
CPN-24	A	WCR-914 Auto Trip AOV (3)	WCR-915 Auto Trip AOV (3)	Non-Essential Service Water from the Lower Containment Ventilation Unit #4	6	10
CPN-25	D	Closed System	CCM-431 Remote Manual MOV	Component Cooling Water from the Pressure Equalizing Fans	1.5	N/A
CPN-25	D	Closed System	CCR-440 Remote Manual AOV	Component Cooling Water from the Main Steam Penetrations.	1.5	N/A
CPN-25	D	Closed System	CCW-244-25 Check Valve	Component Cooling Water to the Main Steam Penetrations	1	N/A
CPN-25	D	Closed System	CCW-243-25 Check Valve	Component Cooling Water to the Main Steam Penetrations	1	N/A
CPN-25	D	Closed System	CCM-430 Remote Manual MOV	Component Cooling Water to the Pressure Equalizing Fans	1.5	N/A
CPN-26	A	WCR-922 Auto Trip AOV	WCR-923 Auto Trip AOV	Non-Essential Service Water from the Upper Containment Ventilation Unit #1	3	10

UNIT 2 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-26	A	WCR-945 Auto Trip AOV	WCR-955 Auto Trip AOV	Non-Essential Service Water from the Reactor Coolant Pump #1 Motor Air Cooler	3	10
CPN-26	A	WCR-921 Auto Trip AOV	WCR-920 Auto Trip AOV	Non-Essential Service Water to the Upper Containment Ventilation Unit #1	3	10
CPN-26	A	WCR-951 Auto Trip AOV	WCR-941 Auto Trip AOV	Non-Essential Service Water to the Reactor Coolant Pump #1 Motor Air Cooler	3	10
CPN-27	A	WCR-926 Auto Trip AOV	WCR-927 Auto Trip AOV	Non-Essential Service Water from the Upper Containment Ventilation Unit #2	3	10
CPN-27	A	WCR-946 Auto Trip AOV	WCR-956 Auto Trip AOV	Non-Essential Service Water from the Reactor Coolant Pump #2 Motor Air Cooler	3	10
CPN-27	A	WCR-925 Auto Trip AOV	WCR-924 Auto Trip AOV	Non-Essential Service Water to the Upper Containment Ventilation Unit #2	3	10
CPN-27	A	WCR-952 Auto Trip AOV	WCR-942 Auto Trip AOV	Non-Essential Service Water to the Reactor Coolant Pump #2 Motor Air Cooler	3	10
CPN-28	Spare	Welded Closed	N/A	Spare	18 in sleeve	N/A
CPN-29	A	PA-342 Check Valve	PCR-40 Auto Trip AOV	Service Air	2	10
CPN-29	A	XCR-102 Auto Trip AOV	XCR-103 Auto Trip AOV	Instrument Air	1	10
CPN-30	Spare	Welded Cap	N/A	N/A	N/A	N/A
CPN-30	E	NPX-151-V1 Manual	N/A	Dead Weight Test Connection	0.5	N/A
CPN-31	A	DCR-207 Auto Trip AOV	N-160 Check Valve	Nitrogen Supply to the Reactor Coolant Drain Tank	1	10

UNIT 2 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-31	A	DCR-201 Auto Trip AOV	DCR-203 Auto Trip AOV	Vents from the Reactor Coolant Drain Tank and the Pressurizer Relief Tank	1	10
CPN-31	A	DCR-610 Auto Trip AOV	DCR-611 Auto Trip AOV	Drain from the Ice Condenser Vent	3	10
CPN-31	A	DCR-620 Auto Trip AOV	DCR-621 Auto Trip AOV	Drain from the Containment Ventilation Units	1	10
CPN-31	A	ECR-33 Auto Trip AOV	ECR-35 Auto Trip AOV	Containment Air Particulate and Radio Gas Detector Sample Return	1	10
CPN-32	A	SI-171 or SI-172 Manual Valves	SI-194 Manual Valve	Safety Injection Test Line and Accumulator Test Line	0.75	N/A
CPN-32	A	N-102 Check Valve	GCR-314 Auto Test AOV	Nitrogen Supply to the Accumulators	1	10
CPN-32	A	ECR-31 Auto Trip AOV	ECR-32 Auto Trip AOV	Sample Line to the Containment Air Particulate and Radio Gas Detector	1	10
CPN-32	A	ECR-535 Auto Trip AOV	ECR-536 Auto Trip AOV	Sample Line to the Containment Air Particulate and Radio Gas Detector -Lower Containment	0.5	10
CPN-33	Spare	N/A	N/A	N/A	N/A	N/A
CPN-33	A	PW-275 Check Valve	NCR-252 Auto Trip AOV	Primary Water Supply to the Pressurizer Relief Tank	3	10
CPN-34	A	QCR-301 Auto Trip AOV	QCR-300 Auto Trip AOV	Letdown Line (CVCS)	2	10
CPN-35	D	Closed System	CS-321 Check Valve	Charging Line (CVCS)	3	N/A
CPN-36	A	2S-152 Manual Valve	2SF-154 Manual Valve	Refueling Water Supply to the Refueling Cavity	2.5	N/A

UNIT 2 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-36	A	QCR-919 Auto Trip AOV (3)	QCR-920 Auto Trip AOV (3)	Demineralized Water to the Refueling Cavity	2	10
CPN-37	A	QCM-250 Auto Trip MOV	QCM-350 Auto Trip MOV	R.C. Pumps Seal Water & Excess Letdown Heat Exchanger Discharges	4	15
CPN-38	A	CCM-458 Auto Trip MOV	CCM-459 Auto Trip MOV	R.C.Pump Motor and Thermal Barrier Cooling Water Supply	8	60
CPN-39	A	CCM-451 Auto Trip MOV	CCM-452 Auto Trip MOV	R.C.Pump Motor and Thermal Barrier Cooling Water Discharge	8	60
CPN-40	A	DCR-205 Auto Trip AOV (3)	DCR-206 Auto Trip AOV (3)	Reactor Coolant Drain Tank Pump Suction	4	10
CPN-41	A	DCR-600 Auto Trip AOV	DCR-601 Auto Trip AOV	Containment Sump Pump Discharge to Waste Disposal	3	10
CPN-42	A	SF-159 Manual Valve	SF-160 Manual Valve	Refueling Cavity Drain to Purification System	3	N/A
CPN-43	D	Closed System	ICM-265 Remote Manual MOV	Safety Injection to the RCS Hot/Cold Legs	4	N/A
CPN-44	D	Closed System	ICM-250 Remote Manual MOV or ICM - 251 Remote Manual MOV	Boron Injection Inlet	3	N/A
CPN-45	D	Closed System	ICM-305 Remote Manual MOV	Residual Heat Removal Suction from Recirc Sump	18	N/A
CPN-46	D	Closed System	ICM-306 Remote Manual MOV	Residual Heat Removal Suction from Recirc Sump	18	N/A

UNIT 2 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-47	D	Closed System	ICM-129 Remote Manual MOV	Residual Heat Removal Inlet to RHR Pumps	14	N/A
CPN-47	D	Closed System	SV-103 Relief Valve	Residual Heat Removal Inlet to RHR Pumps	14	N/A
CPN-48	D	Closed System	ICM-321 Remote Manual MOV	Residual Heat Removal to R.C. Hot Legs - Low Head S.I.	8	N/A
CPN-49	D	Closed System	ICM-311 Remote Manual MOV	Residual Heat Removal to R.C. Hot Legs - Low Head S.I.	8	N/A
CPN-50	D	Closed System	RH-142 Check Valve	RHR to Containment Spray	8	N/A
CPN-51	D	Closed System	RH-141 Check Valve	RHR to Containment Spray	8	N/A
CPN-52	D	Closed System	CTS-131W Check Valve	Upper Containment Spray Inlet	8	N/A
CPN-53	D	Closed System	CTS-131E Check Valve	Upper Containment Spray Inlet	8	N/A
CPN-54	D	Closed System	CTS-127W Check Valve	Lower Containment Spray Inlet	6	N/A
CPN-55	D	Closed System	CTS-127E Check Valve	Lower Containment Spray Inlet	6	N/A
CPN-56	A	R157 Check Valve or VCR-21 Auto Trip AOV	VCR-20 Auto Trip AOV	Glycol to Ice Condenser Fan Coolers	3	10
CPN-57	G	Blind Flange	Blind Flange	Ice Loading Line	4	N/A

UNIT 2 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-58	A	CCM-453 Auto Trip MOV	CCM-454 Auto Trip MOV	Reactor Coolant Pump Thermal Barrier Cooling Water Discharge	4	30
CPN-59	A	VCR-105 Auto Trip AOV	VCR-205 Auto Trip AOV	Upper Containment Purge Air Inlet	30	5
CPN-60	A	VCR-106 Auto Trip AOV	VCR-206 Auto Trip AOV	Upper Containment Purge Air Outlet	24	5
CPN-61	A	VCR-101 Auto Trip AOV	VCR-201 Auto Trip AOV	Purge Air Inlet (Instrumentation Room)	14	5
CPN-62	A	VCR-102 Auto Trip AOV	VCR-202 Auto Trip AOV	Purge Air Outlet (Instrumentation Room)	14	5
CPN-63	A	VCR-104 Auto Trip AOV	VCR-204 Auto Trip AOV	Lower Containment Purge Air Outlet	30	5
CPN-64	A	VCR-103 Auto Trip AOV	VCR-203 Auto Trip AOV	Lower Containment Purge Air Inlet	24	5
CPN-65	A	VCR-107 Auto Trip AOV	VCR-207 Auto Trip AOV	Upper Containment Pressure Relief Line	12	5
CPN-66	A	NCR-105 Auto Trip AOV	NCR-106 Auto Trip AOV	Sample Line from the RCS Hot Legs	0.5	10
CPN-66	A	NCR-107 Auto Trip AOV	NCR-108 Auto Trip AOV	Sample Line from the Pressurizer Liquid Space	0.5	10
CPN-66	A	NCR-109 Auto Trip AOV	NCR-110 Auto Trip AOV	Sample Line from the Pressurizer Steam Space	0.5	10
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #1 Blowdown Sample	0.5	N/A
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #2 Blowdown Sample	0.5	N/A
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #3 Blowdown Sample	0.5	N/A

UNIT 2 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #4 Blowdown Sample	0.5	N/A
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #1 Steam Space Steam Sample	0.5	N/A
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #2 Steam Space Steam Sample	0.5	N/A
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #3 Steam Space Steam Sample	0.5	N/A
CPN-66	F	N/A (2)	N/A (2)	Steam Generator #4 Steam Space Steam Sample	0.5	N/A
CPN-67	A	ECR-416 Auto Trip AOV	ECR-417 Auto Trip AOV	Containment Sump Sample	0.5	10
CPN-67	A	ECR-496 Auto Trip AOV or ECR-497 Auto Trip AOV	NS-357 Check Valve	Post Accident Sampling System Return	0.5	10
CPN-67	G	Blind Flange	Blind Flange	For Maintenance to the Containment Annulus for Outage	2	N/A
CPN-68	D	Closed System	ICM-260 Remote Manual MOV	Safety Injection to the RCS Hot/Cold Legs	4	N/A
CPN-69	Spare	Welded Closed	N/A	Spare	18 in sleeve	N/A
CPN-70	Spare	Welded Closed	N/A	Spare	1	N/A
CPN-70	Spare	Welded Closed	N/A	Spare	1	N/A
CPN-70	Spare	Welded Closed	N/A	Spare	1	N/A
CPN-70	Spare	Welded Closed	N/A	Spare	1	N/A
CPN-70	Spare	Welded Closed	N/A	Spare	1	N/A
CPN-70	A	SM-1 Check Valve	ECR-36 Auto Trip AOV	Radiation Monitor ERS-2400 Isolation Valve	1	10
CPN-71	G	Blind Flange	Blind Flange	Containment Service Penetration	18	N/A

UNIT 2 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-72	D	Closed System	CCM-433 Remote Manual MOV	Component Cooling Water from the Pressure Equalizing Fans	1.5	N/A
CPN-72	D	Closed System	CCR-441 Remote Manual MOV	Component Cooling Water from the Main Steam Penetrations.	1.5	N/A
CPN-72	D	Closed System	CCW-244-72 Check Valve	Component Cooling Water to the Main Steam Penetrations	1	N/A
CPN-72	D	Closed System	CCW-243-72 Check Valve	Component Cooling Water to the Main Steam Penetrations	1	N/A
CPN-72	D	Closed System	CCM-432 Remote Manual MOV	Component Cooling Water to the Pressure Equalizing Fans	1.5	N/A
CPN-73	A	WCR-961 Auto Trip AOV (3)	WCR-960 Auto Trip AOV (3)	Non-Essential Service Water to the Instrument Room Ventilation Unit E	2.5	10
CPN-73	A	WCR-963 Auto Trip AOV (3)	WCR-962 Auto Trip AOV (3)	Non-Essential Service Water from the Instrument Room Ventilation Unit E	2.5	10
CPN-73	A	WCR-965 Auto Trip AOV (3)	WCR-964 Auto Trip AOV (3)	Non-Essential Service Water to the Instrument Room Ventilation Unit W	2.5	10
CPN-73	A	WCR-967 Auto Trip AOV (3)	WCR-966 Auto Trip AOV (3)	Non-Essential Service Water from the Instrument Room Ventilation Unit W	2.5	10
CPN-74	A	XCR-100 Auto Trip AOV	XCR-101 Auto Trip AOV	Instrument Air	1	10
CPN-74	A	N-159 Check Valve	GCR-301 Auto Trip AOV	Nitrogen Supply to the Pressurizer Relief Tank	0.75	10
CPN-75	C	Closed System	CCR-460 Auto Trip AOV	Excess Letdown Heat Exchanger Component Cooling Water Outlet	4	10

UNIT 2 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-75	C	Closed System	CCR-462 Auto Trip AOV	Excess Letdown Heat Exchanger Component Cooling Water Inlet	4	10
CPN-76	G	Blind Flange	Blind Flange	Incore Flux Detection System	8	N/A
CPN-76	A	SM-4 Needle Valve	SM-6 Needle Valve	Instrument Room Air Sample Piping	0.5	N/A
CPN-77	F	N/A (2	N/A (2)	Steam Generator No.2 Blowdown Outlet	2	N/A
CPN-78	F	N/A (2)	N/A (2)	Steam Generator No.3 Blowdown Outlet	2	N/A
CPN-79	F	N/A (2)	N/A (2)	Steam Generator No.4 Blowdown Outlet	2	N/A
CPN-80	G	Blind Flange	Blind Flange	Ice Loading Return	5	N/A
CPN-81	A	RCR-100 Auto Trip AOV	RCR-101 Auto Trip AOV	Sample Line from the Pressurizer Relief Tank to the Gas Analyzer	0.5	10
CPN-81	A	DCR 202 Auto Trip AOV	DCR-204 Auto Trip AOV	Sample Line from the Reactor Coolant Drain Tank to the Gas Analyzer	0.5	10
CPN-81	A	ICR-5 Auto Trip AOV	ICR-6 Auto Trip AOV	Sample Line from the Accumulators	0.5	10
CPN-82	A	CCR-456 Auto Trip AOV	CCR-457 Auto Trip AOV	Reactor Support Cooling Water Outlet	2.5	10
CPN-82	A	CCW-135 Check Valve	CCR-455 Auto Trip AOV	Reactor Support Cooling Water Inlet	2.5	10
CPN-83	Spare	Capped per RFC-2895	N/A	Containment Weld Channel Pressurization Air Supply	0.5	N/A
CPN-83	Spare	Capped per RFC-2895	N/A	Containment Weld Channel Pressurization Air Supply	0.5	N/A
CPN-84	A	WCR-954 Auto Trip AOV	WCR-944 Auto Trip AOV	Non-Essential Service Water to the Reactor Coolant Pump #4 Motor Air Cooler	3	10

UNIT 2 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-84	A	WCR-948 Auto Trip AO	WCR-958 Auto Trip AOV	Non-Essential Service Water from the Reactor Coolant Pump #4 Motor Air Cooler	3	10
CPN-84	A	WCR-933 Auto Trip AOV	WCR-932 Auto Trip AOV	Non-Essential Service Water to the Upper Containment Ventilation Unit #4	3	10
CPN-84	A	WCR-934 Auto Trip AOV	WCR-935 Auto Trip AOV	Non-Essential Service Water from the Upper Containment Ventilation Unit #4	3	10
CPN-85	A	WCR-953 Auto Trip AOV	WCR-943 Auto Trip AOV	Non-Essential Service Water to the Reactor Coolant Pump #3 Motor Air Cooler	3	10
CPN-85	A	WCR-947 Auto Trip AOV	WCR-957 Auto Trip AOV	Non-Essential Service Water from the Reactor Coolant Pump #3 Motor Air Cooler	3	10
CPN-85	A	WCR-929 Auto Trip AOV	WCR-928 Auto Trip AOV	Non-Essential Service Water to the Upper Containment Ventilation Unit #3	3	10
CPN-85	A	WCR-930 Auto Trip AOV	WCR-931 Auto Trip AOV	Non-Essential Service Water from the Upper Containment Ventilation Unit #3	3	10
CPN-86	A	VCR-11 Auto Trip AOV or R-156 Check Valve	VCR-10 Auto Trip AOV	Glycol Supply from Ice Condenser Fan Coolers	3	10
CPN-87	Spare	Welded Closed	N/A	Spare	6 in sleeve	N/A
CPN-88	Spare	Welded Closed	N/A	Spare	6 in sleeve	N/A
CPN-89	A	SM-8 Manual Valve	SM-10 Manual Valve	Upper Containment Radiation Sampling System	0.5	N/A
CPN-90	Spare	Welded Closed	N/A	Spare	6 in sleeve	N/A
CPN-91	E	Membrane (Sensor Bellows)	HI (4)	Reactor Vessel Level Instrumentation System	0.5	N/A

UNIT 2 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-91	E	Membrane (Sensor Bellows)	HI (4)	Reactor Vessel Level Instrumentation System	0.5	N/A
CPN-91	E	PPP-302-V1 Manual Valve	N/A	Containment Pressure Transmitter	0.5	N/A
CPN-92	E	PPP-301-V1 Manual Valve	N/A	Containment Pressure Transmitter	0.5	N/A
CPN-93	A	ECR-14 Auto Trip AOV	ECR-24 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 4	0.5	10
CPN-93	A	ECR-16 Auto Trip AOV	ECR-26 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 6	0.5	10
CPN-93	A	ECR-17 Auto Trip AOV	ECR-27 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 7	0.5	10
CPN-93	A	ECR-18 Auto Trip AOV	ECR-28 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 8	0.5	10
CPN-93	A	ECR-19 Auto Trip AOV	ECR-29 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 9	0.5	10
CPN-94	E	PPP-300-V1 Manual Valve	N/A	Containment Pressure Transmitters	0.5	N/A
CPN-94	E	Membrane (Sensor Bellows)	HI (4)	Reactor Vessel Level Instrumentation System	0.5	N/A
CPN-95	A	ECR-11 Auto Trip AOV	ECR-21 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 1	0.5	10
CPN-95	A	ECR-12 Auto Trip AOV	ECR-22 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 2	0.5	10

UNIT 2 CONTAINMENT PENETRATION ISOLATION BARRIERS

Containment Penetration Number	Class	Barrier Number 1	Barrier Number 2	Line Isolated (Service)	Line Size (in)	Closure Time (Sec.)
CPN-95	A	ECR-13 Auto Trip AOV	ECR-23 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 3	0.5	10
CPN-95	A	ECR-15 Auto Trip AOV	ECR-25 Auto Trip AOV	Containment Hydrogen Monitoring System - From Sample Point ESR - 5	0.5	10
CPN-95	A	NS-283 Check Valve	ECR-10 Auto Trip AOV or ECR-20 Auto Trip AOV	Containment Hydrogen Monitoring System - Hydrogen Sample Return	0.5	10
CPN-96	E	PPP-303-V1 Manual Valve	N/A	Containment Pressure Transmitter	0.5	N/A
CPN-96	E	PPA-312-V1 Manual Valve	N/A	Containment Pressure Transmitter	0.5	N/A
CPN-97	E	PPA-310-V1 Manual Valve	N/A	Containment Pressure Transmitter	0.5	N/A
CPN-97	E	Membrane (Sensor Bellows)	HI (4)	RVLIS (NLS-130)	0.5	N/A
CPN-98	E	Membrane (Sensor Bellows)	HI (4)	RVLIS (NLS-110, NLS-120)	0.5	N/A

CONTAINMENT REGIONAL DESIGNATION / IGNITER ASSEMBLY LOCATIONS
UNIT 1

TRAIN 'A'			TRAIN 'B'		
Region	**Compartment/Area**	**No.**	**Region**	**Compartment/Area-Elevation**	**No.**
1	Upper Volume Dome Area - 760'	A-13	1	Upper Volume Dome Area - 760'	B-13
1	Upper Volume Dome Area - 760'	A-14	1	Upper Volume Dome Area - 760'	B-14
1	Upper Volume Dome Area - 760'	A-15	1	Upper Volume Dome Area - 760'	B-15
2	Upper Volume Dome Area - 748'	A-16	2	Upper Volume Dome Area - 748'	B-16
2	Upper Volume Dome Area - 748'	A-17	2	Upper Volume Dome Area - 748'	B-17
2	Upper Volume Dome Area - 748'	A-18	2	Upper Volume Dome Area - 748'	B-18
3	Ice Cond. Upper Plenum 709'	A-1	3	Ice Cond. Upper Plenum 709'	B-1
3	Ice Cond. Upper Plenum 709'	A-2	3	Ice Cond. Upper Plenum 709'	B-2
4	Ice Cond. Upper Plenum 709'	A-3	4	Ice Cond. Upper Plenum 709'	B-3
4	Ice Cond. Upper Plenum 709'	A-4	4	Ice Cond. Upper Plenum 709'	B-4
4	Ice Cond. Upper Plenum 709'	A-5	4	Ice Cond. Upper Plenum 709'	B-5
5	Ice Cond. Upper Plenum 709'	A-6	5	Ice Cond. Upper Plenum 709'	B-6
5	Ice Cond. Upper Plenum 709'	A-7	5	Ice Cond. Upper Plenum 709'	B-7
6	Outside #2 SG Enclosure 662'	A-12	6	Outside #2 SG Enclosure 659'	B-12
6	Outside #3 SG Enclosure 662'	A-11	6	Outside #3 SG Enclosure 659'	B-11
7	Outside #1 SG Enclosure 662'	A-8	7	Outside #1 SG Enclosure 659'	B-8
7	Outside #4 SG Enclosure 662'	A-9	7	Outside #4 SG Enclosure 659'	B-9
7	Outside PRZ Enclosure 662'	A-10	7	Outside PRZ Enclosure 659'	B-10
8	East Fan/Accumulator Room 635'	A-25	8	East Fan/Accumulator Room 630'	B-25
8	East Fan/Accumulator Room 632'	A-26	8	East Fan/Accumulator Room 634'	B-26
9	West Fan/Accumulator Room 632'	A-27	9	West Fan/Accumulator Room 634'	B-27
9	West Fan/Accumulator Room 634'	A-28	9	West Fan/Accumulator Room 634'	B-28
10	Instrument Room 623'	A-35	10	Instrument Room 630'	B-35
11	Primary Shield Wall 643'	A-19	11	Primary Shield Wall 646'	B-19
11	Primary Shield Wall 640'	A-20	11	Primary Shield Wall 646'	B-20
11	Primary Shield Wall 644'	A-21	11	Primary Shield Wall 648'	B-21
11	Primary Shield Wall 641'	A-22	11	Primary Shield Wall 648'	B-22
11	Primary Shield Wall 642'	A-23	11	Primary Shield Wall 646'	B-23

CONTAINMENT REGIONAL DESIGNATION / IGNITER ASSEMBLY LOCATIONS

UNIT 1

TRAIN 'A'			TRAIN 'B'		
Region	**Compartment/Area**	**No.**	**Region**	**Compartment/Area-Elevation**	**No.**
11	Primary Shield Wall 642'	A-24	11	Primary Shield Wall 646'	B-24
12	Inside #1 SG Enclosure 689'	A-30	12	Inside #1 SG Enclosure 689'	B-30
13	Inside #2 SG Enclosure 689'	A-34	13	Inside #2 SG Enclosure 689'	B-34
14	Inside #3 SG Enclosure 689'	A-33	14	Inside #3 SG Enclosure 689'	B-33
15	Inside #4 SG Enclosure 689'	A-31	15	Inside #4 SG Enclosure 689'	B-31
16	Inside PRZ Enclosure 689'	A-32	16	Inside PRZ Enclosure 687'	B-32
17	Vicinity PRT-618'	A-29	17	Vicinity of PRT-618'	B-29

KEY

SG – Steam Generator
PZR – Pressurizer
PRT – Pressurizer Relief tank

Note: The locations given are for Cook Nuclear Plant Unit 1. For similar locations, in some cases the igniter assembly identification numbers are different, between Unit 1 and Unit 2.

IGNITER ASSEMBLY LOCATIONS [1]

UNIT 2

TRAIN 'A'			TRAIN 'B'		
No.	**Compartment/Area**	**Elevation**	**No.**	**Compartment/Area**	**Elevation**
A-1	Ice Cond. Upper Plenum	708'	B-1	Ice Cond. Upper Plenum	709'
A-2	Ice Cond. Upper Plenum	709'	B-2	Ice Cond. Upper Plenum	709'
A-3	Ice Cond. Upper Plenum	709'	B-3	Ice Cond. Upper Plenum	709'
A-4	Ice Cond. Upper Plenum	709'	B-4	Ice Cond. Upper Plenum	709'
A-5	Ice Cond. Upper Plenum	709'	B-5	Ice Cond. Upper Plenum	709'
A-6	Ice Cond. Upper Plenum	710'	B-6	Ice Cond. Upper Plenum	709'
A-7	Ice Cond. Upper Plenum	709'	B-7	Ice Cond. Upper Plenum	709'
A-8	Inside #1 SG Enclosure	686'	B-8	Inside #1 SG Enclosure	686'
A-9	Inside #2 SG Enclosure	686'	B-9	Inside #2 SG Enclosure	686'
A-10	Inside #3 SG Enclosure	686'	B-10	Inside #3 SG Enclosure	686'
A-11	Inside #4 SG Enclosure	686'	B-11	Inside #4 SG Enclosure	685'
A-12	Inside PZR Enclosure	682'	B-12	Inside PZR Enclosure	686'
A-13	Outside #1 SG Enclosure	659'	B-13	Outside #1 SG Enclosure	662'
A-14	Outside #2 SG Enclosure	662'	B-14	Outside #2 SG Enclosure	659'
A-15	Outside #3 SG Enclosure	662'	B-15	Outside #3 SG Enclosure	659'
A-16	Outside #4 SG Enclosure	662'	B-16	Outside #4 SG Enclosure	659'
A-17	Outside PZR Enclosure	662'	B-17	Outside PZR Enclosure	659'
A-18	Primary Shield Wall	647'	B-18	Primary Shield Wall	642'
A-19	Primary Shield Wall	648'	B-19	Primary Shield Wall	637'
A-20	Primary Shield Wall	648'	B-20	Primary Shield Wall	636'
A-21	Primary Shield Wall	648'	B-21	Primary Shield Wall	636'
A-22	Primary Shield Wall	641'	B-22	Primary Shield Wall	637'

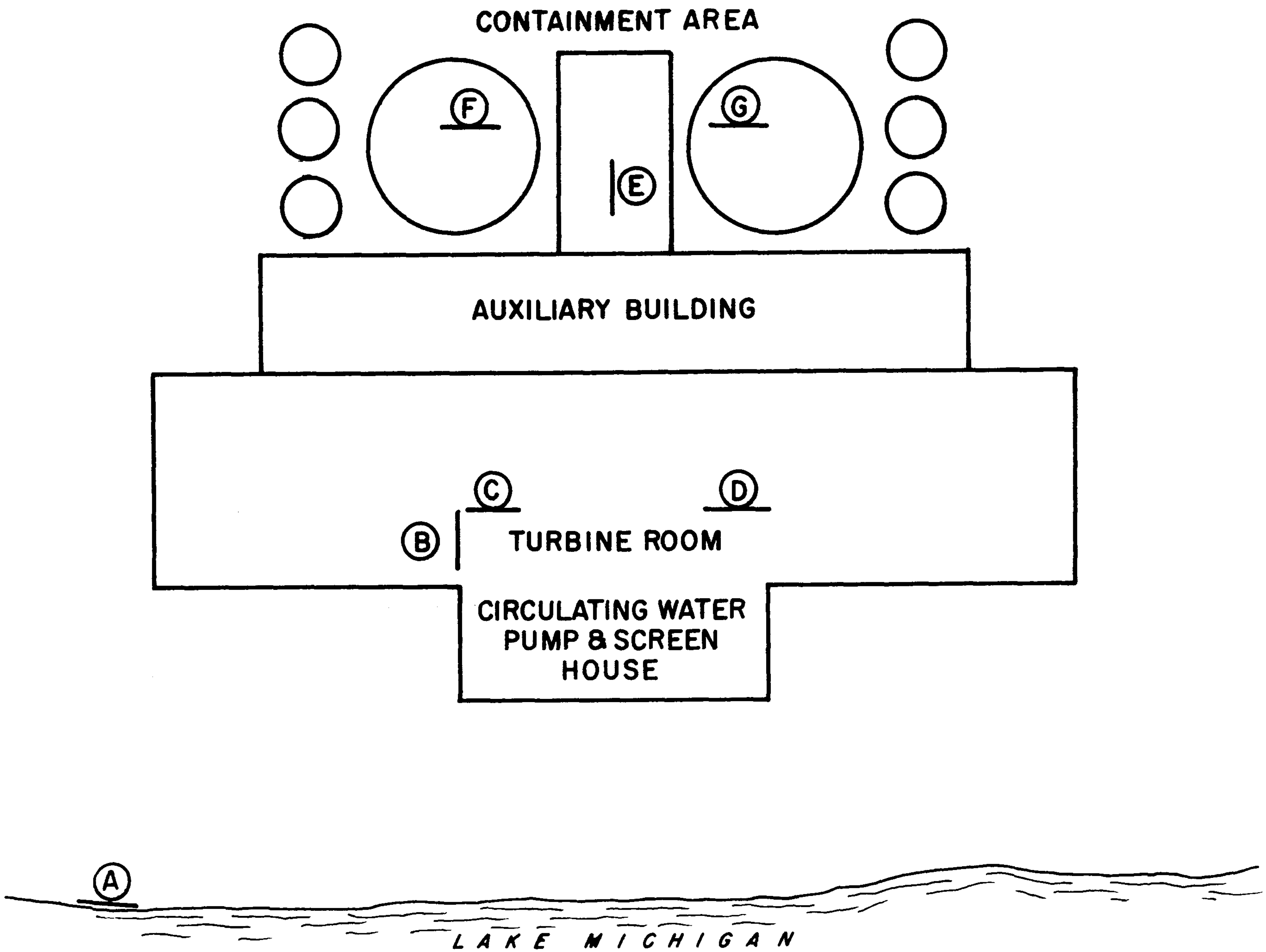
[1] The locations given are for Cook Nuclear Plant Unit 2 and are typical for Unit 1.

IGNITER ASSEMBLY LOCATIONS [1]

UNIT 2

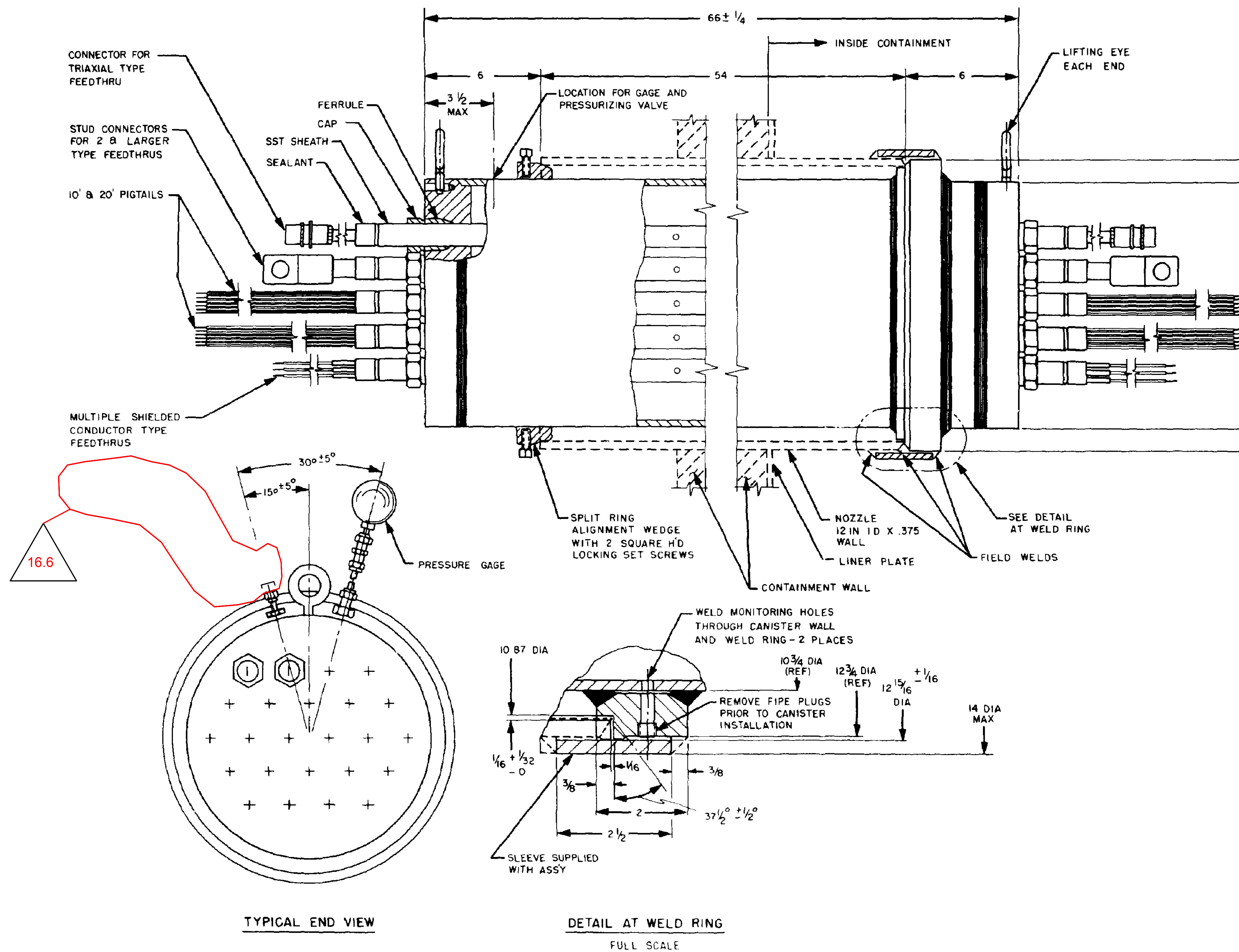
TRAIN 'A'			TRAIN 'B'		
No.	**Compartment/Area**	**Elevation**	**No.**	**Compartment/Area**	**Elevation**
A-23	Primary Shield Wall	648'	B-23	Primary Shield Wall	645'
A-24	East Fan/Accumulator Room	631'	B-24	East Fan/Accumulator Room	630'
A-25	East Fan/Accumulator Room	629'	B-25	East Fan/Accumulator Room	629'
A-26	West Fan/Accumulator Room	629'	B-26	West Fan/Accumulator Room	623'
A-27	West Fan/Accumulator Room	634'	B-27	West Fan/Accumulator Room	634'
A-28	Vicinity of PRT	618'	B-28	Vicinity of PRT	618'
A-29	Upper Volume Dome Area	760'	B-29	Upper Volume Dome Area	760'
A-30	Upper Volume Dome Area	760'	B-30	Upper Volume Dome Area	760'
A-31	Upper Volume Dome Area	760'	B-31	Upper Volume Dome Area	760'
A-32	Upper Volume Dome Area	748'	B-32	Upper Volume Dome Area	748'
A-33	Upper Volume Dome Area	748'	B-33	Upper Volume Dome Area	748'
A-34	Upper Volume Dome Area	748'	B-34	Upper Volume Dome Area	748'
A-35	Instrument Room	620'	B-35	Instrument Room	620'

KEY: SG - Steam Generator
PZR - Pressurizer
PRT - Pressurizer Relief Tank



LOCATION OF RESISTIVITY TEST

FIGURE 5.2-1
JULY 1982



DATE	NO.	DESCRIPTION	APPD.
	16.6	REVISED PER UCR 99-UFSAR-1350	

REVISIONS

INDIANA MICHIGAN POWER COMPANY

DONALD C. COOK

NUCLEAR PLANT

BRIDGMAN MICHIGAN

A TYPICAL ELECTRICAL PENETRATION

DWG. NO. **FSAR FIG. 5.2 - 2**

ARCH		ELEC		MECH		STR	

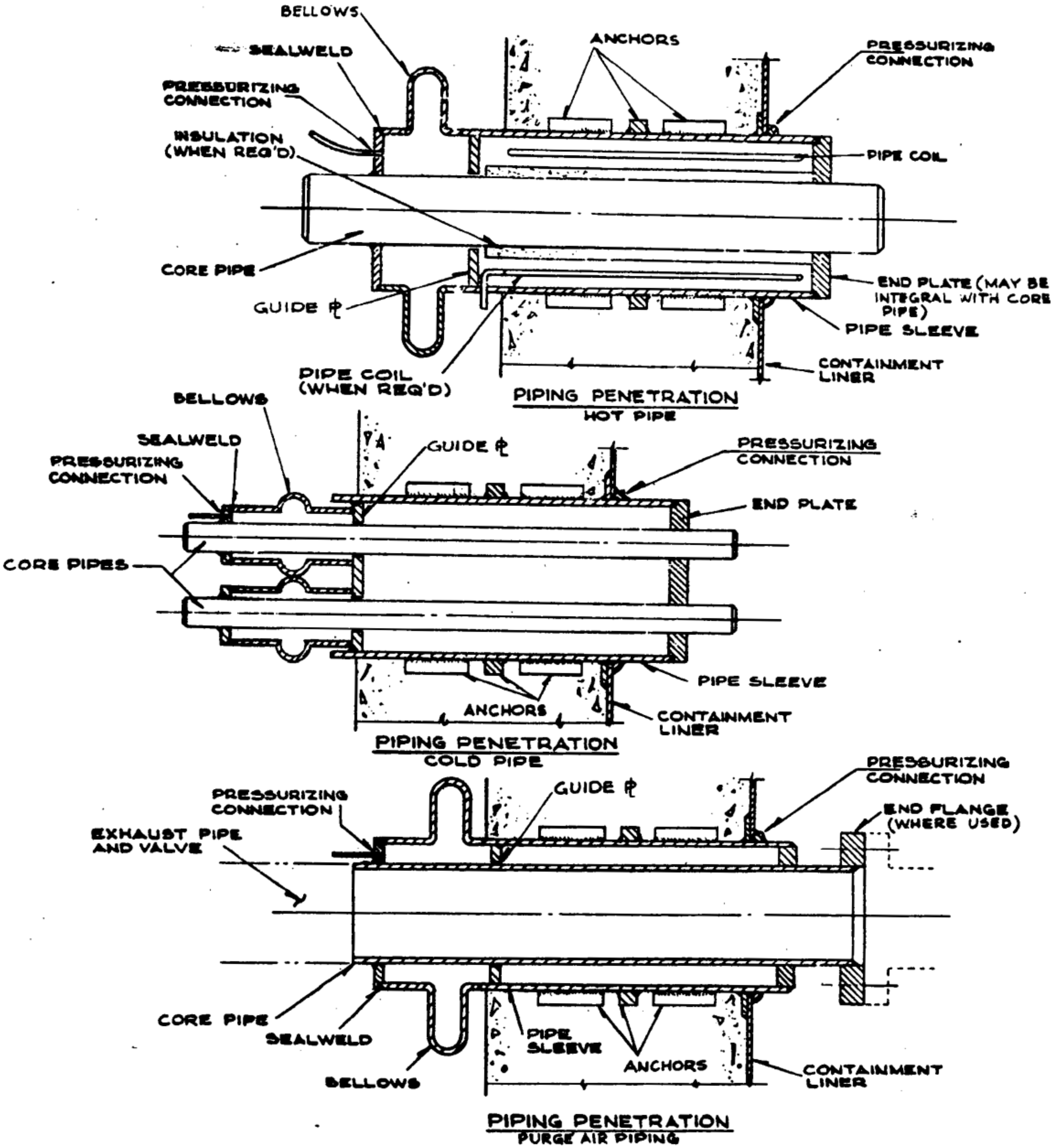
SCALE: DR:

DATE: CH:

DESIGN ENGINEERING DIVISION:

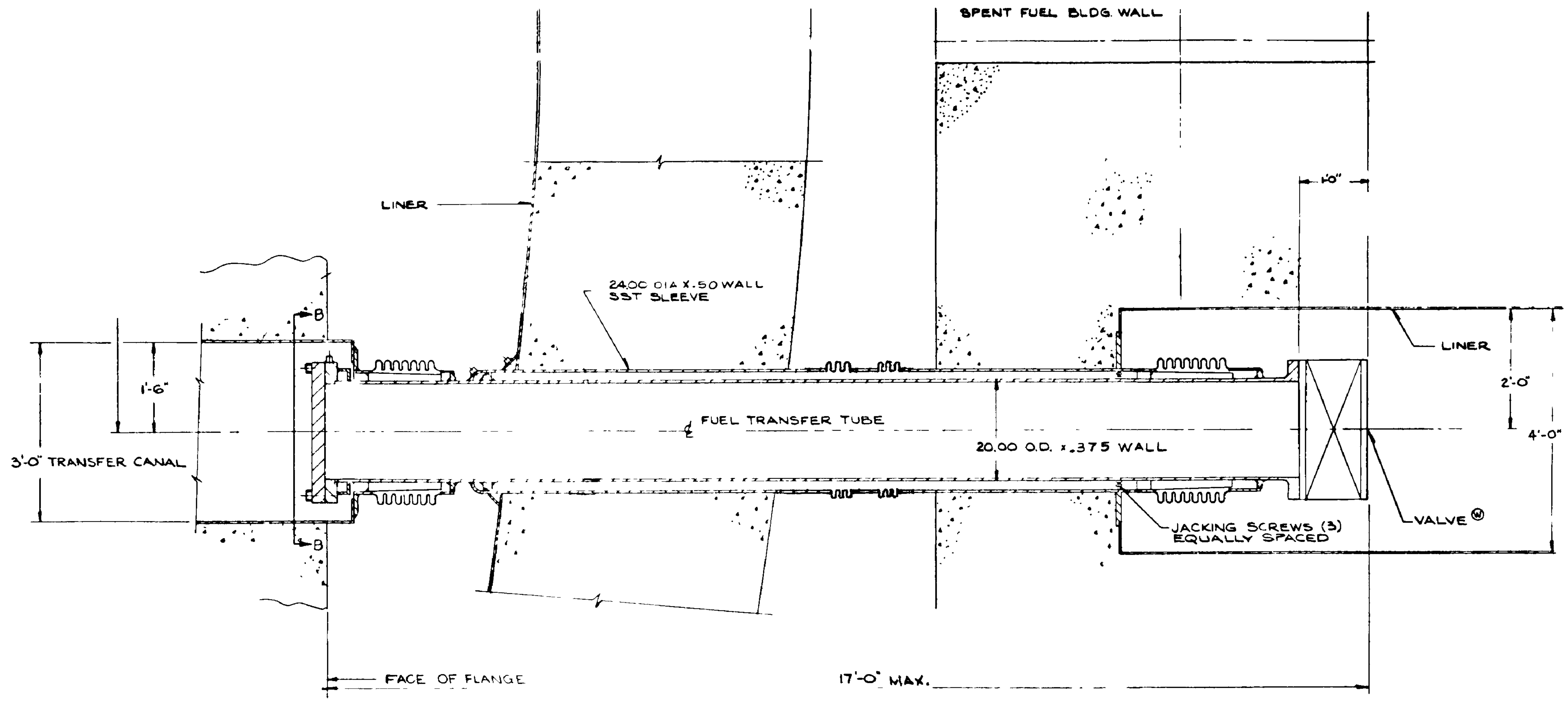
AEP AMERICAN ELECTRIC POWER

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215



TYPICAL PIPING PENETRATIONS

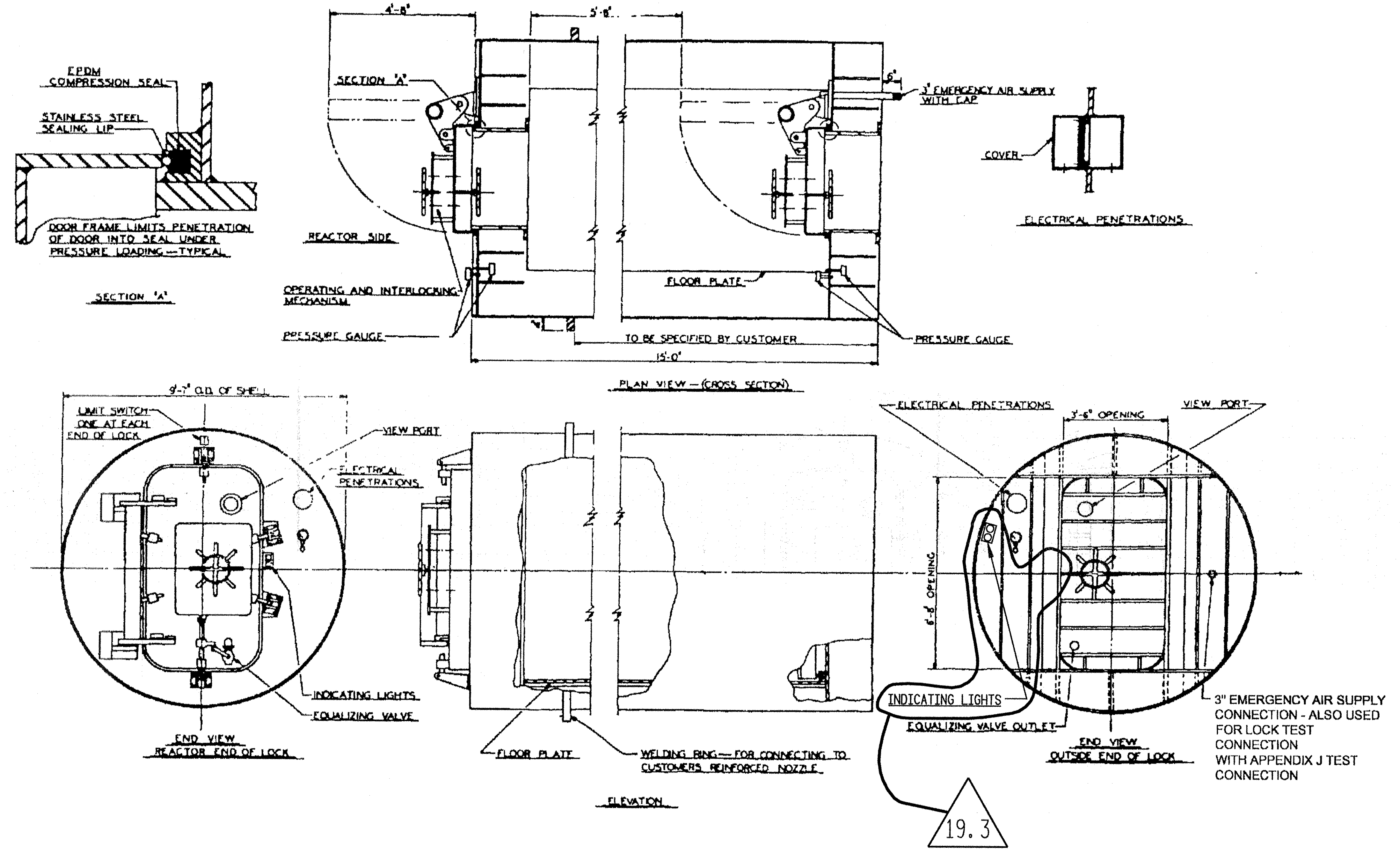
FIGURE 5.2-3



TYPICAL FUEL TRANSFER TUBE

FIGURE 5.2-4

JULY 1982



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DATE	NO.	DESCRIPTION	DR.	CHK'D	APP'D
	19.3	REVISED PER UCR-1691.			

REVISIONS

AMERICAN ELECTRIC POWER COOK NUCLEAR PLANT NUCLEAR GENERATION GROUP BRIDGMAN, MICHIGAN	TITLE PERSONNEL LOCKS, TYPICAL ARRANGEMENT & DETAILS	REV. NO. 19.3
	DWG. NO. FSAR FIG. 5.2-5	SH 1 OF 1

Removed per Regulatory Issue Summary 2015-17

FIGURE 5 2 2-1

INDIANA & MICHIGAN ELECTRIC CO
DONALD C COOK
NUCLEAR PLANT
BRIDGMAN MICHIGAN

PLANT ARRANGEMENT
SECTIONS "G-G", "H-H", "J-J" & "K-K"
UNITS Nº 1 & 2

DR NO 12-5963

ARCH | ELEC | MECH | STR

SCALE 1/ 20-0
DR
CH AFB
SQ LDR
DATE 12-15 70
APPROVED BY
ENGINEER NG DV
DESIGN DV

AMERICAN ELECTRIC POWER SERVICE CORP
2 BROADWAY NEW YORK

JULY 1982

Removed per Regulatory Issue Summary 2015-17

fsar-fig-5.2.2-1A_21-2.dgn 3/7/2008 10:22:43 AM

DWG NO FSAR FIG. 5.2.2-2

Removed per Regulatory Issue Summary 2015-17

NO.	DESCRIPTION
16.6	REVISED PER UCR 99-UFSAR-1307

REVISIONS

INDIANA MICHIGAN POWER COMPANY

DONALD C. COOK

NUCLEAR PLANT

BRIDGMAN MICHIGAN

PLANT ARRANGEMENT
MEZZANINE FLOOR
EL 609'-0"
UNITS NO. 1 & 2

DWG. NO. FSAR FIG. 5.2.2 - 2

ARCH		ELEC		MECH		STR	

SCALE: DR:
DATE: CH:

DESIGN ENGINEERING DIVISION:

AMERICAN ELECTRIC POWER

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

Removed per Regulatory Issue Summary 2015-17

FIGURE 5.2.2 - 2A

INDIANA & MICHIGAN ELECTRIC CO
DONALD C. COOK
NUCLEAR PLANT
BRIDGMAN MICHIGAN

PLANT ARRANGEMENT
REACTOR BUILDING
MAIN FLOOR ELEV 650'-0"

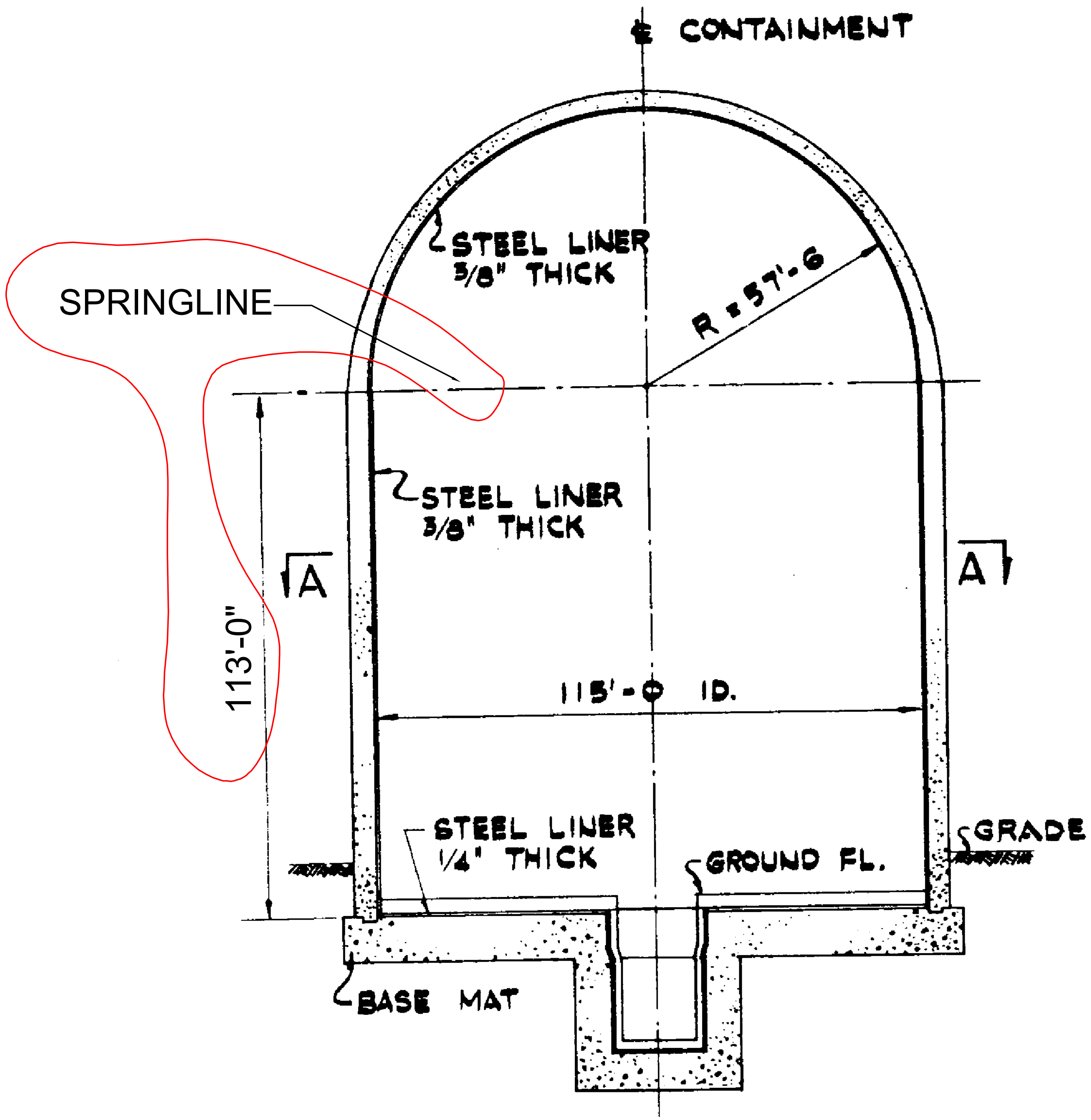
DR NO 12-5970

ARCH | ELEC | MECH | STR

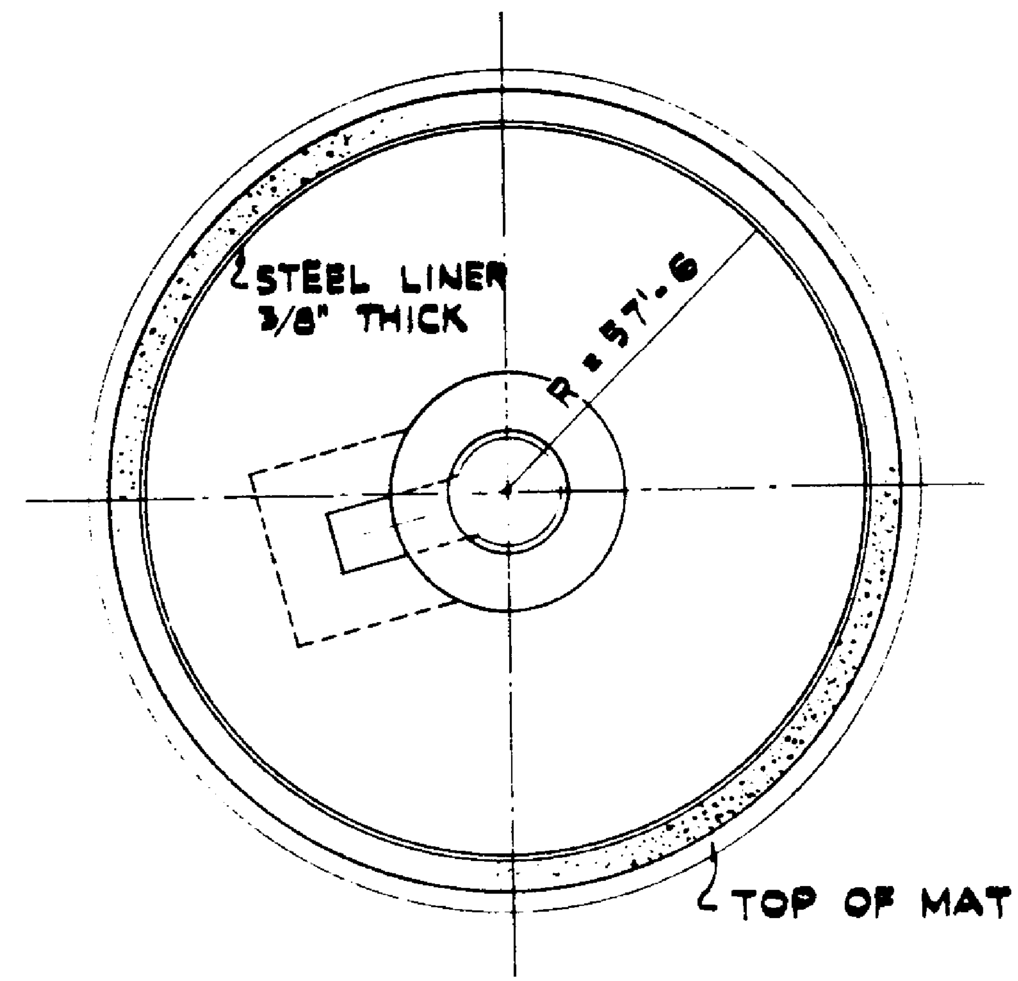
SCALE 1"=20'
DR C.BARKLEY
CH AFB
ENGINEERING DIV
DESIGN DIV
APPROVED BY

AMERICAN ELECTRIC POWER SERVICE CORP
2 BROADWAY NEW YORK

JULY 1982



SECTIONAL ELEVATION



SECTION A - A

DATE	NO.	DESCRIPTION	APPD.
	17	REVISED PER UCR 637	

REVISIONS

INDIANA MICHIGAN POWER COMPANY
DONALD C. COOK
NUCLEAR PLANT
BRIDGMAN MICHIGAN

UNITS NO. 1 & 2
CONTAINMENT
SECTIONAL ELEVATION

DWG. NO. FSAR FIG. 5.2.2-3

ARCH | ELEC | MECH | STR

SCALE: - DR: -
DATE: - CH: -
DESIGN ENGINEERING DIVISION:

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

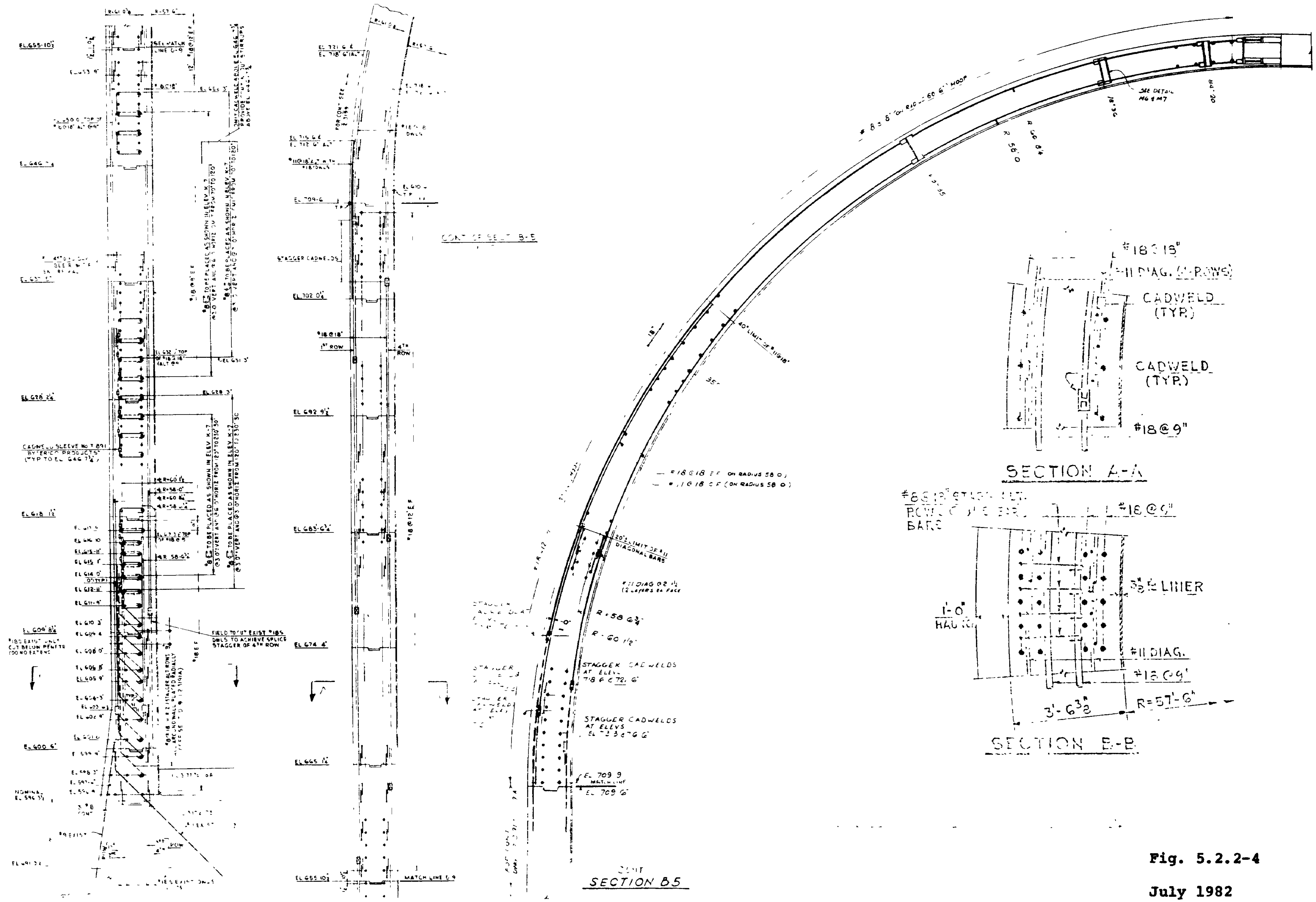
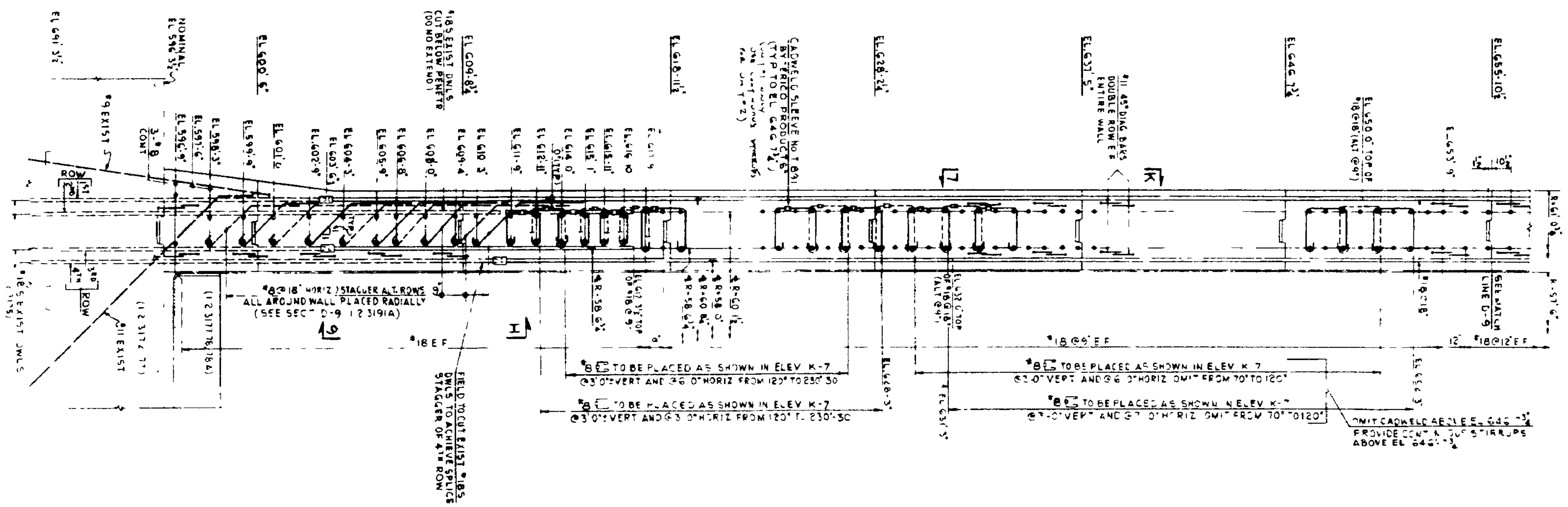


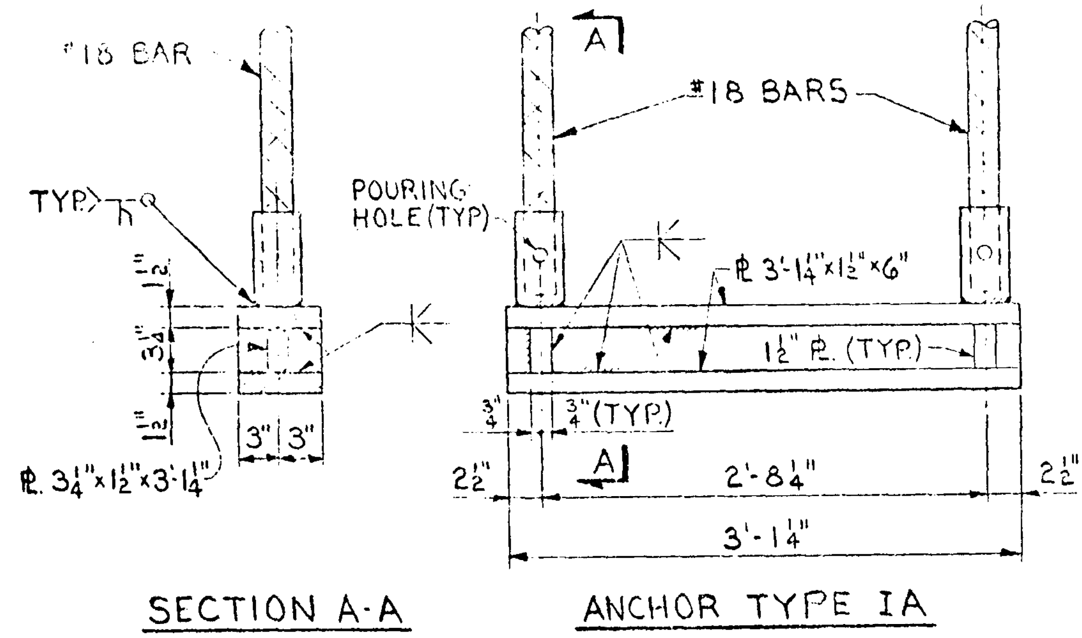
Fig. 5.2.2-4

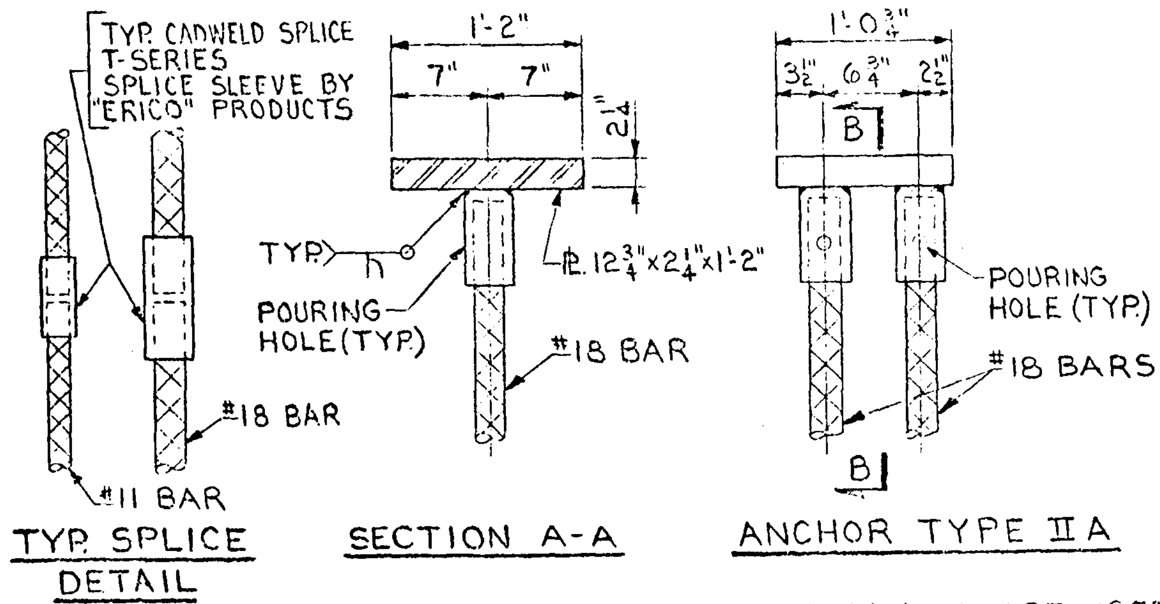
July 1982



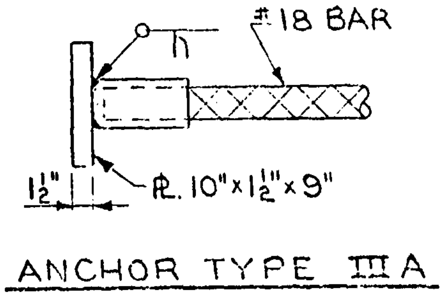
CONTAINMENT BUILDING
Typical Wall Section

5.2.2-4A
July 1982





NOTE: ANCHORS TYPE IA & IIA ARE USED FOR #18 VERTICAL RE-BARS ONLY.
ANCHORS TYPE III ARE USED FOR #18 VERT. & HORIZ. RE-BARS.
ALL #18 & #11 BAR SPLICES ARE CADWELDED. (TYP. SPLICE DETAIL)

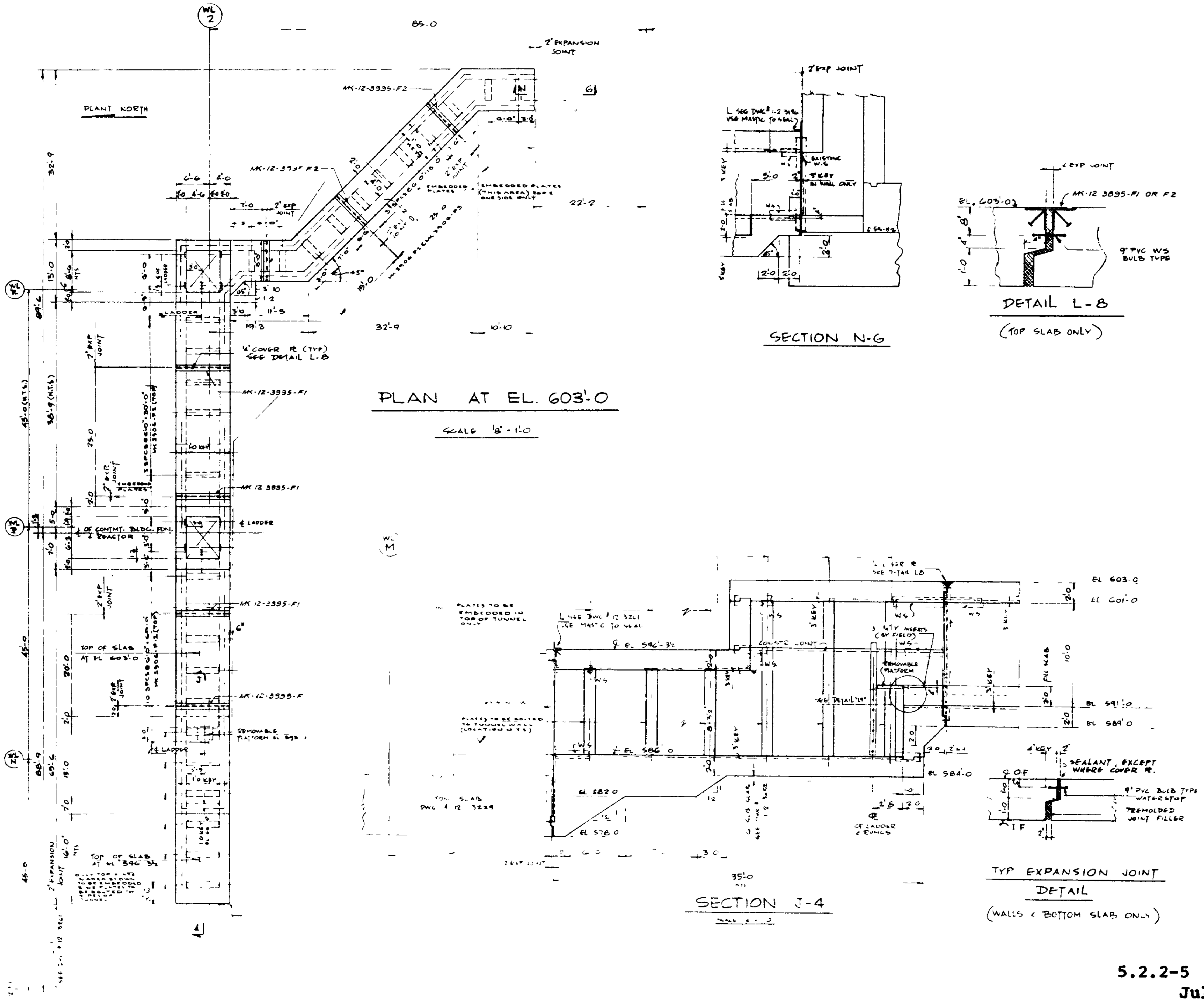


5.2.2.-4B

CONTAINMENT BUILDING
RE-BAR ANCHOR DETAILS

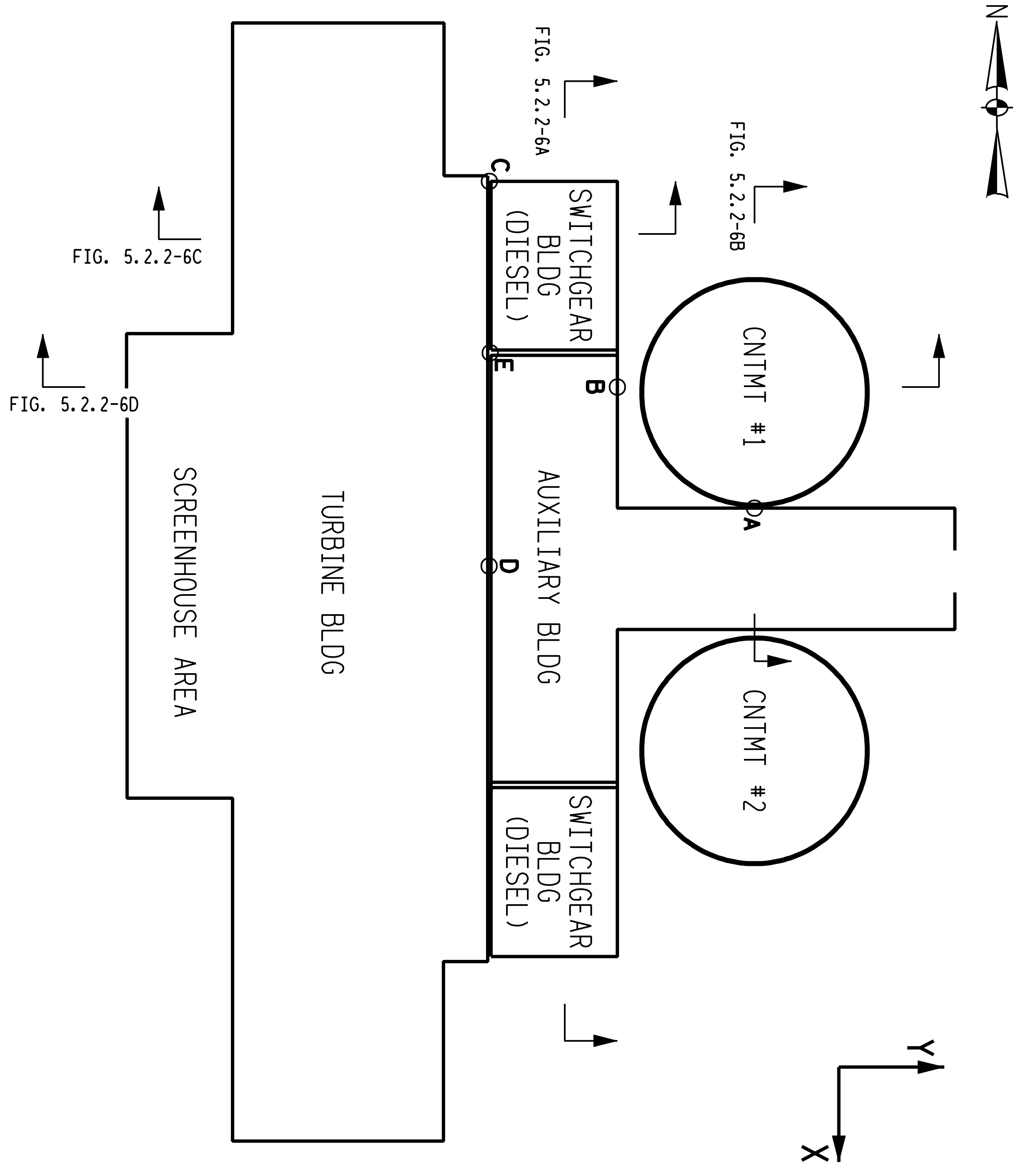
D.C. COOK NUCLEAR POWER PLANT
BRIDGMAN MICHIGAN

July 1982



5.2.2-5
July 1982

AMERICAN ELECTRIC POWER - COOK NUCLEAR PLANT



DATE	NO.	DESCRIPTION	DR.	CHK'D.	APP'D.
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FILENAME: fsar-fig-5-2-2-6 19-1.dgn

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OTHER:

REF. DWGS:

UNIT NO. 12

SH. OF

DR. | CK'D. | APP'D. | DATE:

DRAWING NO. FSAR FIG. 5.2.2-6

REV. NO. 19.1

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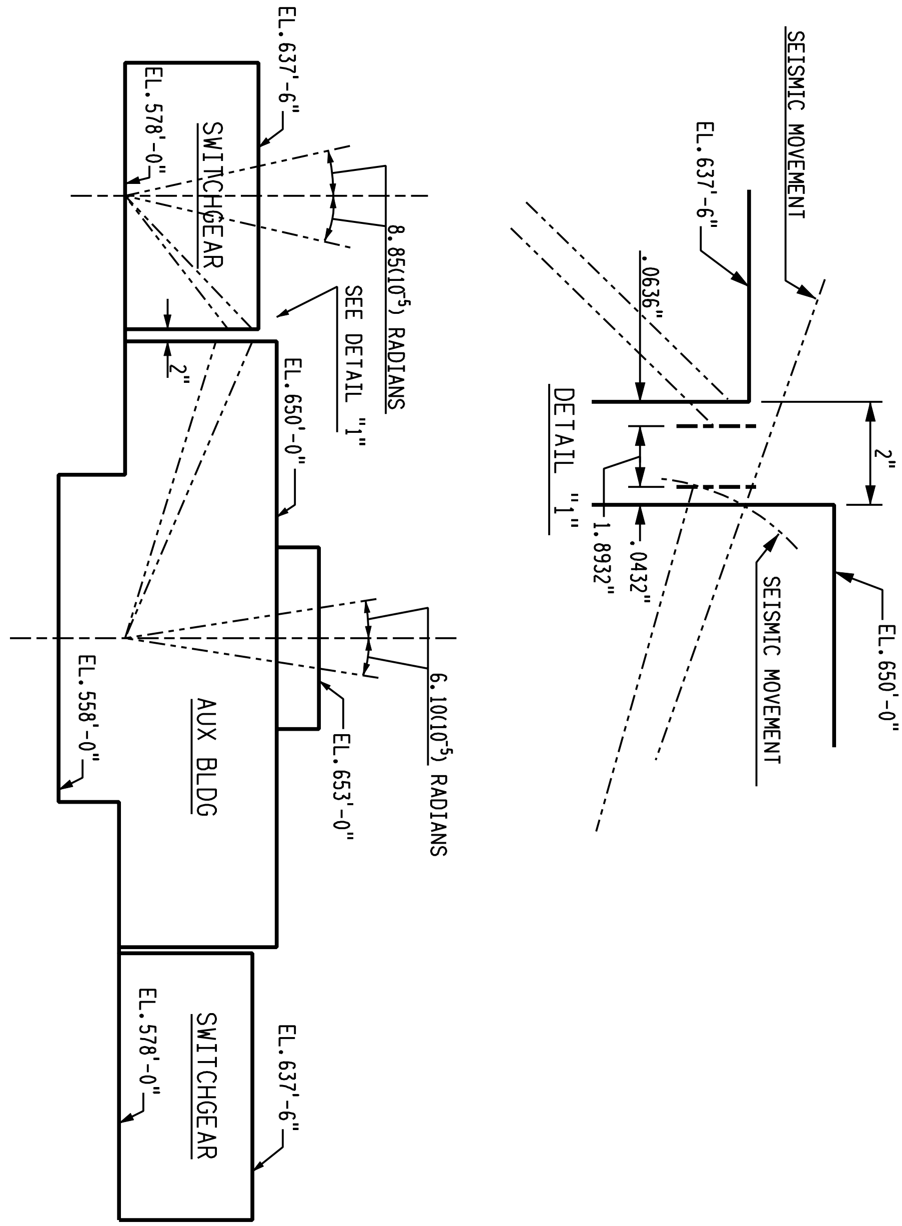
AMERICAN ELECTRIC POWER - COOK NUCLEAR PLANT



DATE	NO.	DESCRIPTION	DR.	CHK'D.	APP'D.
	19.1	REVISED PER UCR-1738			

FILENAME: fsar-fig-5-2-2-6a 19-1.dgn REVISIONS

OTHER:

REF. DWGS:

DR. CK'D. APP'D. DATE:

TITLE - BUILDING DYNAMIC ROTATIONAL MOTIONS

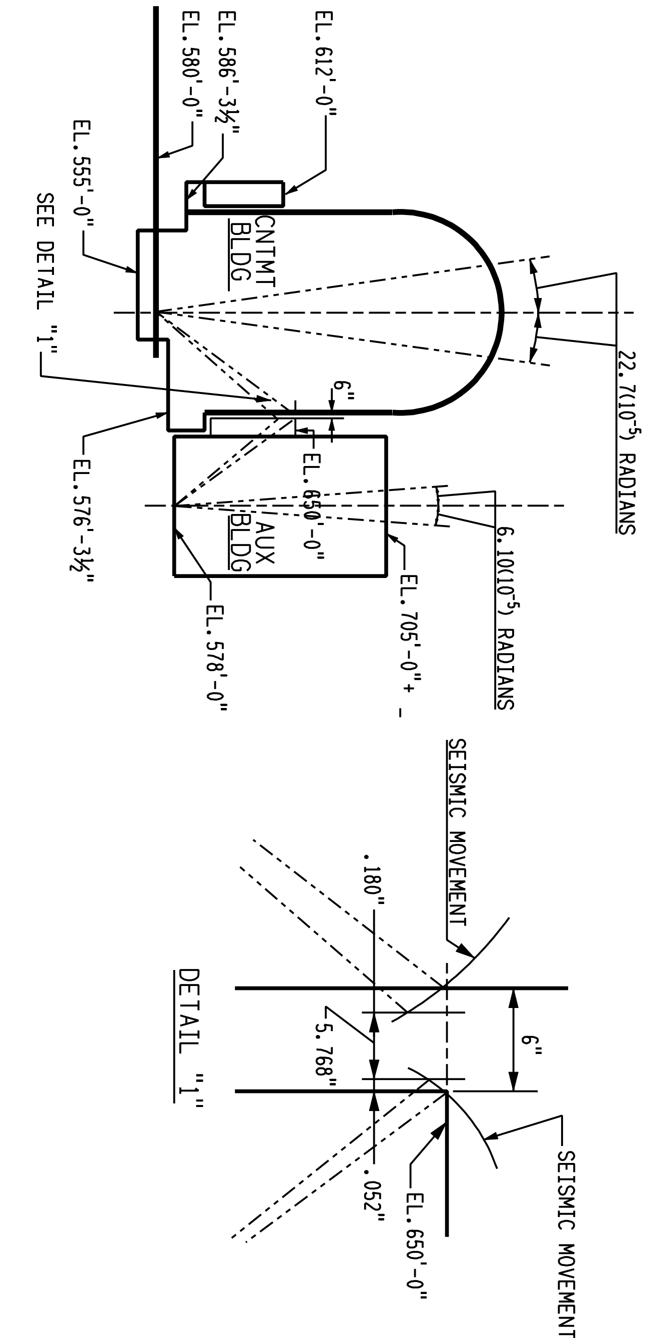
UNIT NO. 12

SH. OF

DRAWING NO. FSAR FIG. 5.2.2-6A

REV. NO. 19.1

AEP AMERICAN ELECTRIC POWER - COOK NUCLEAR PLANT



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	19.1	REVISED PER UCR-1738			

FILENAME: fsar-fig-5-2-2-6b 19-1.dgn

REVISIONS

OTHER:

REF. DWGS:

DR. | CK'D. | APP'D. | DATE:

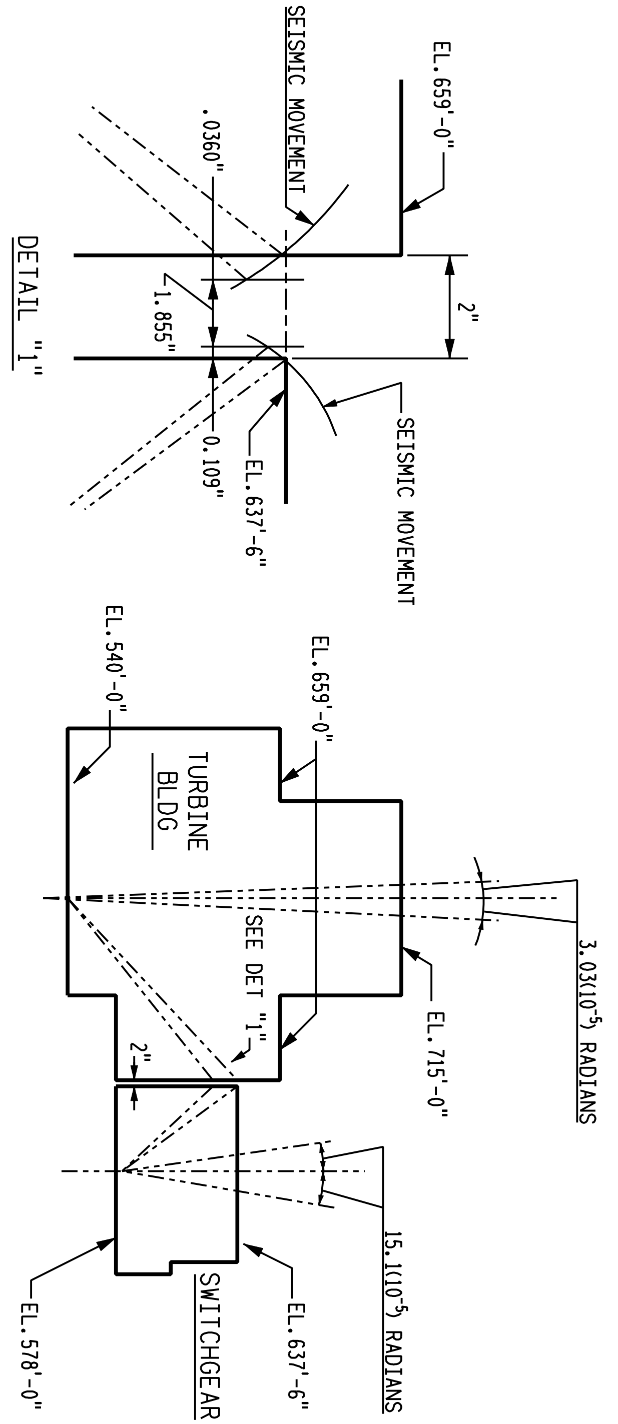
TITLE - BUILDING DYNAMIC ROTATIONAL MOTIONS

UNIT NO. 12

SH. OF

DRAWING NO. FSAR FIG. 5.2.2-6B

REV. NO. 19.1



DATE	NO.	DESCRIPTION	DR.	CHK'D.	APP'D.
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FILENAME: fsar-fig-5-2-2-6c 19-1.dgn

REVISIONS

OTHER:

REF. DWGS:

DR. CK'D. APP'D. DATE:

TITLE - BUILDING DYNAMIC ROTATIONAL MOTIONS

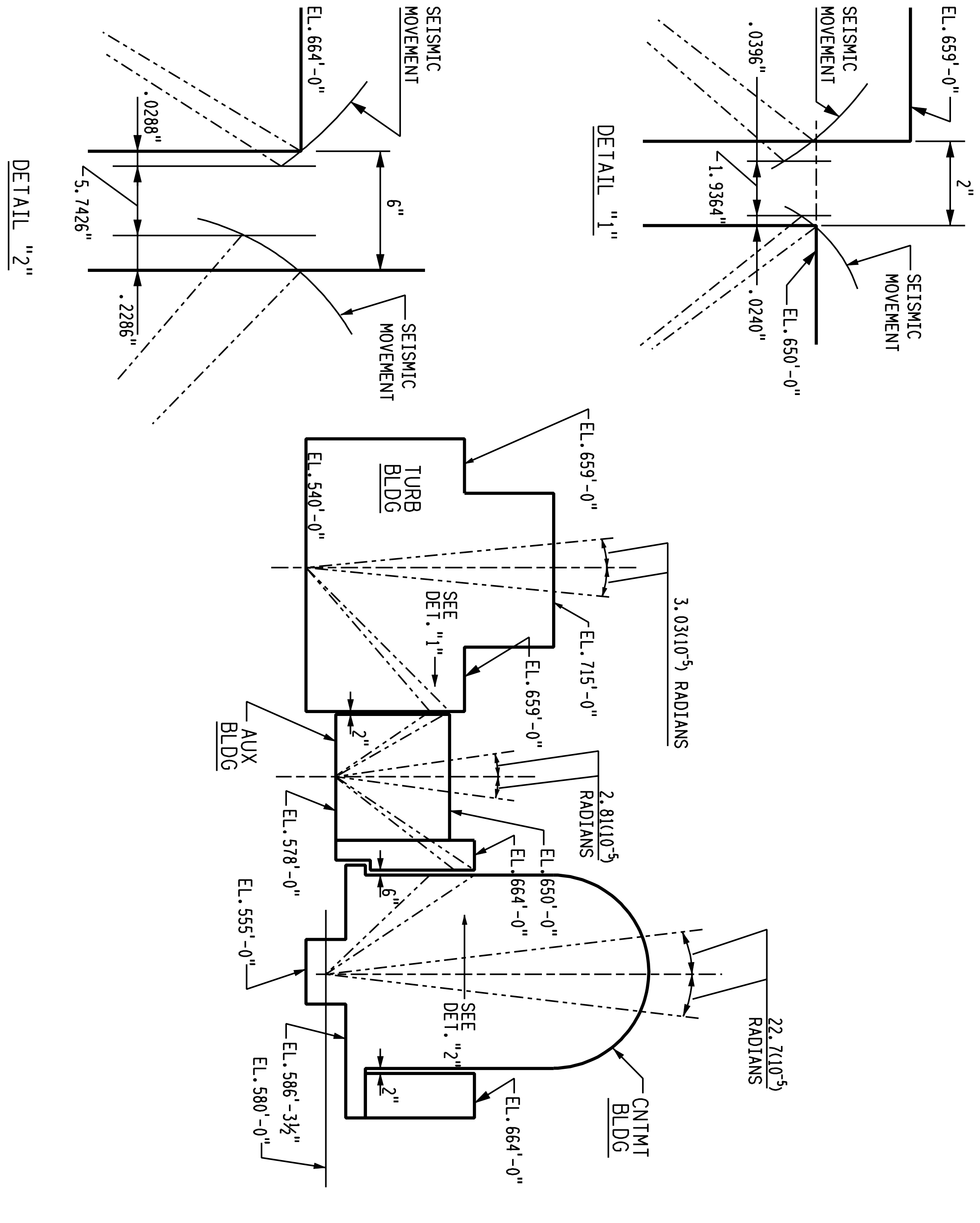
UNIT NO. 12

SH. OF

DRAWING NO. FSAR FIG. 5.2.2-6C

REV. NO. 19.1

AMERICAN ELECTRIC POWER - COOK NUCLEAR PLANT



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FILENAME: fsar-fig-5-2-2-6d 19-1.dgn

REVISIONS

OTHER:

REF. DWGS:

DR. | CK'D. | APP'D. | DATE:

TITLE - BUILDING DYNAMIC ROTATIONAL MOTIONS

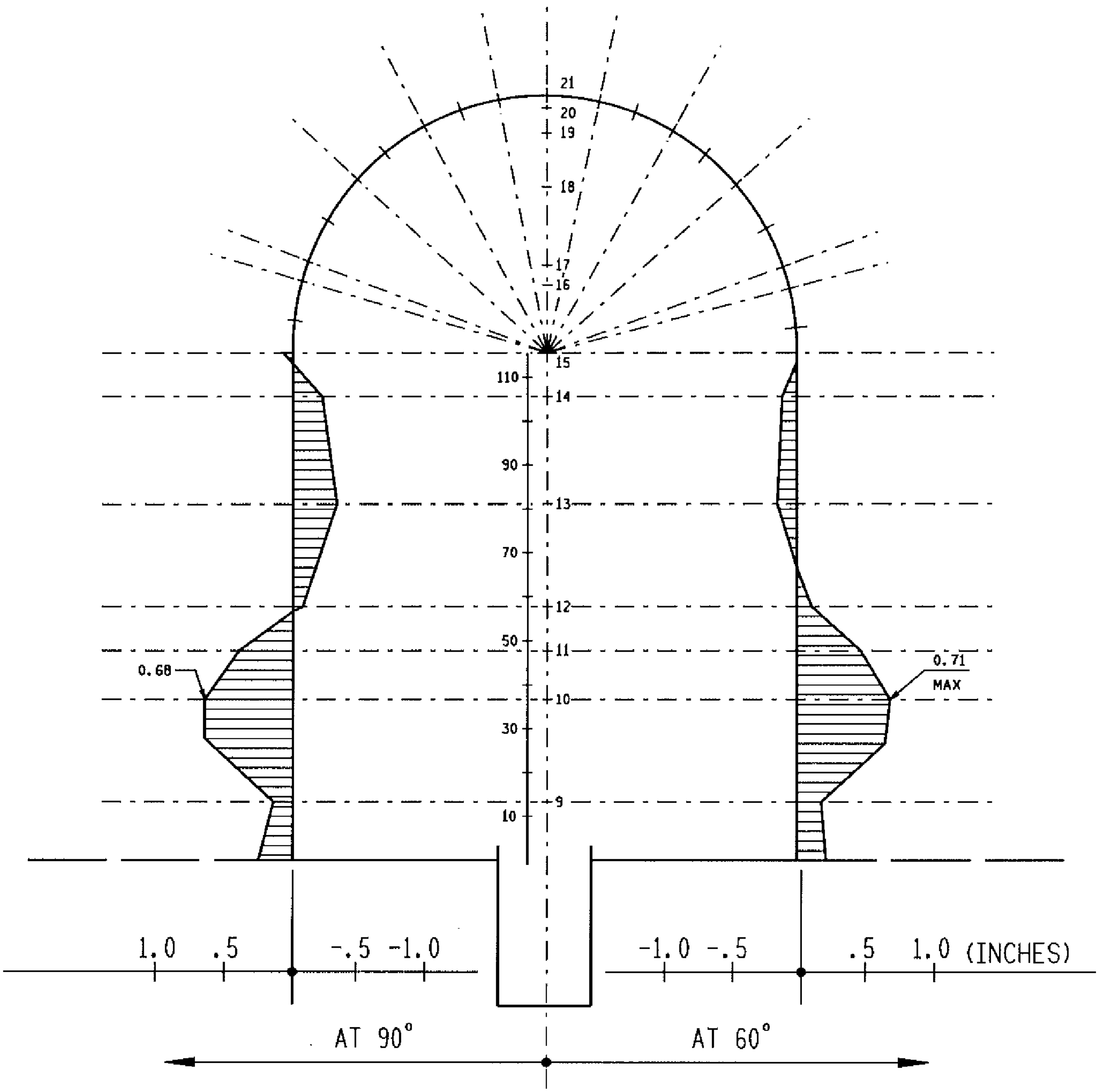
UNIT NO. 12

SH. OF

DRAWING NO. FSAR FIG. 5.2.2-6D

REV. NO. 19.1

COOK NUCLEAR PLANT
W DEFLECTION (INCHES)
LOAD COMBINATION (I) = DL + 1.5P1 + (TL+T) (AS LISTED IN ANSWER 5.1)



NOTE: ORIENTATION IS FOR COMPUTER USE.

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	16.3	INCORPORATED UCR # 98-UFSAR-0711	PMZ		

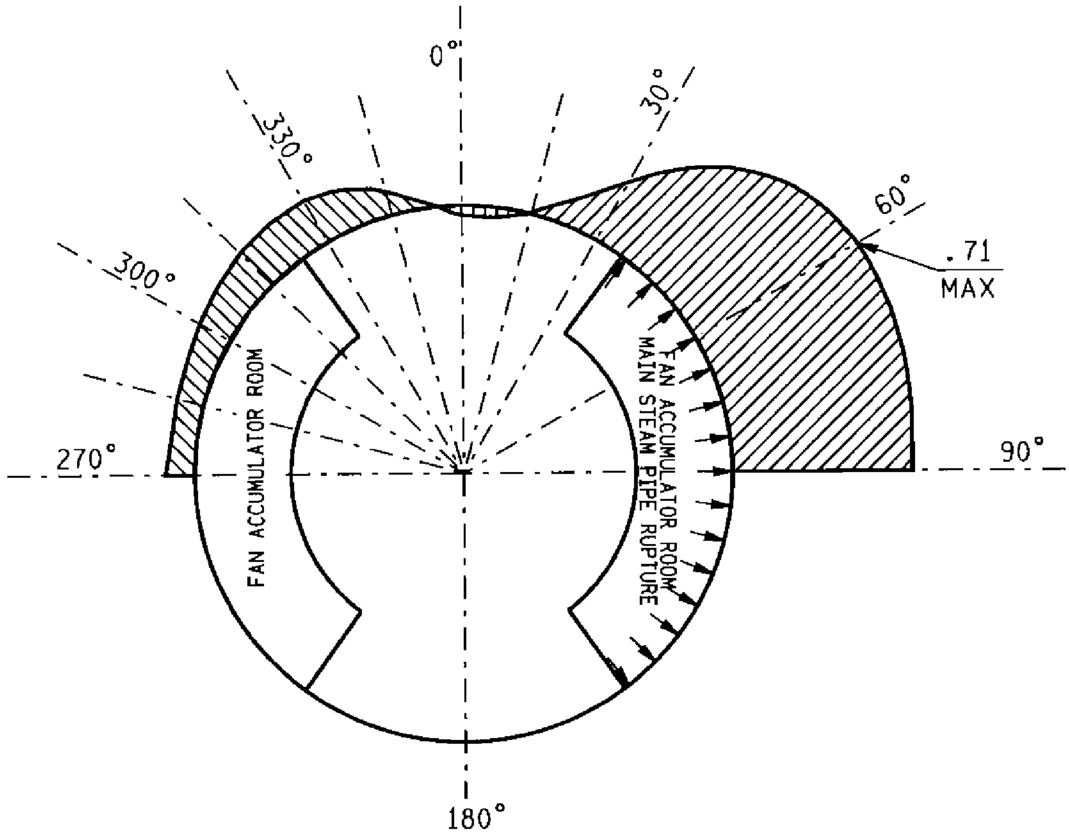
REVISIONS

AMERICAN ELECTRIC POWER COOK NUCLEAR PLANT NUCLEAR GENERATION GROUP BRIDGMAN, MICHIGAN	TITLE W DEFLECTION (INCHES)	REV. NO.
	DWG. NO. FSAR FIG. 5.2.2-7	SH 1 OF 1

FILENAME: FSAR-FIG-5-2-2-7.163

COOK NUCLEAR PLANT

W (DEFLECTION) INCHES
LOAD COMBINATION (I) = DL + NORMAL THERMAL + (24+.9T)=[DL + 1.5P1 + (TL+ T)]
(AS IN ANSWER 5.1)



W (DEFLECTION) DIAGRAM AT BODY 10. STATION II (EL.632'-0")

SCALE 0 .5 1.0 INCHES

NOTE: ORIENTATION IS FOR COMPUTER USE.

DATE	NO.	DESCRIPTION	DR.	CHK'D	APP'D
	16.3	INCORPORATED UCR #98-0711	PMZ		

REVISIONS

AMERICAN ELECTRIC POWER COOK NUCLEAR PLANT NUCLEAR GENERATION GROUP BRIDGMAN, MICHIGAN	TITLE W DEFLECTION (INCHES)	REV. NO.
	DWG. NO. FSAR FIG. 5.2.2-8	SH 1 OF 1

FILENAME: FSAR-FIG-5-2-2-8.163

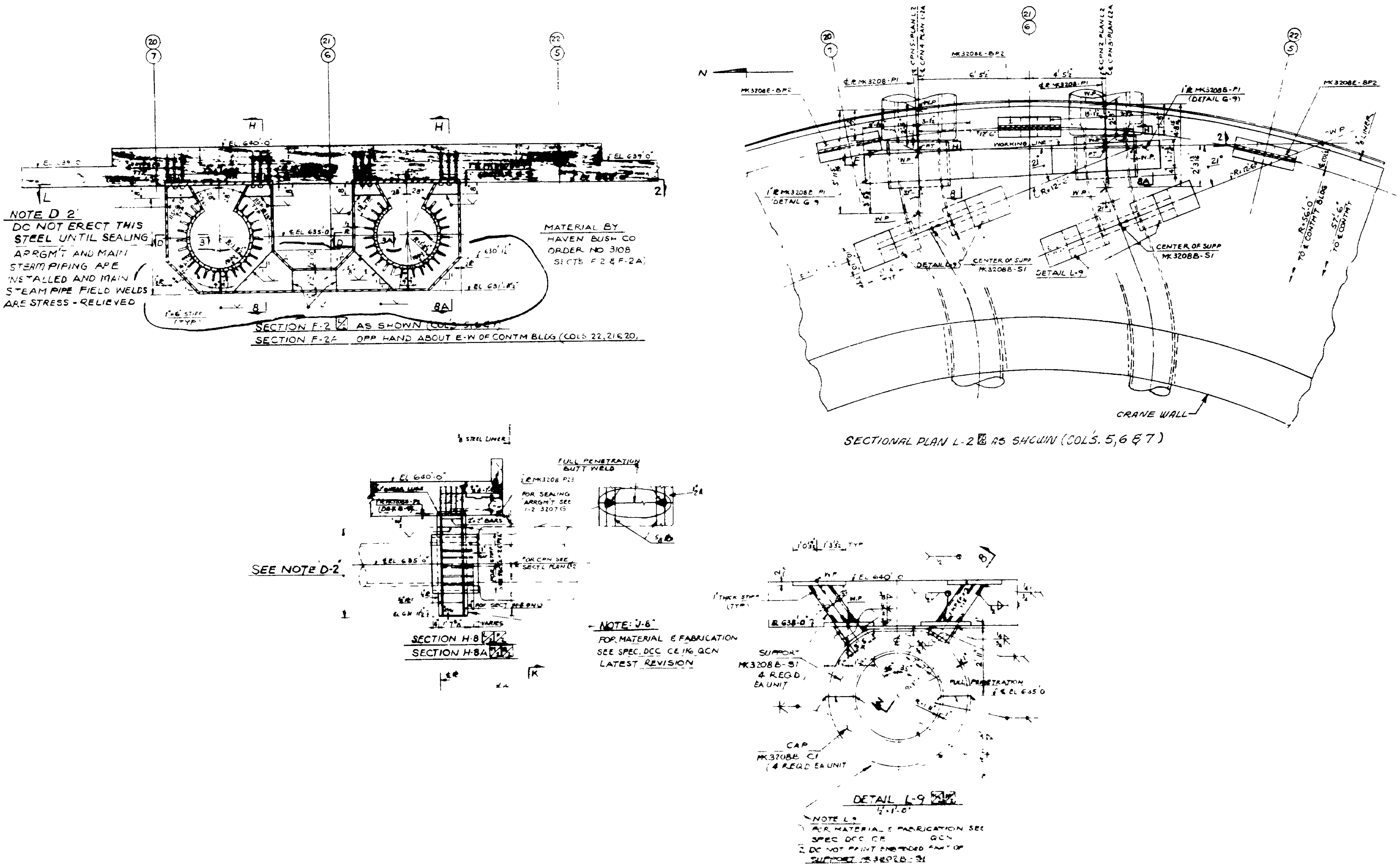


Fig. 5.2.2-9

July, 1982

TORNADO LOAD FACTOR Ce

	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
e/d · 1.0	1.0	.35	-1.05	-1.2	-0.4	-0.27	-0.27	-0.27	-0.4	-1.2	-1.05	.35
ASCE	1.0	.30	-1.2	-1.7	-0.9	-0.4	-0.4	-0.4	-0.9	-1.7	-1.2	.3
e/d : 0.1	.87	.6	.8	-1.35	-0.3	-0.18	-0.18	-0.18	-0.23	-1.55	-1.55	0
e/d = 0.1 (Corr)	.87	.5	.9	-1.91	-0.68	-0.27	- .27	- .27	- .51	-2.2	-1.77	0

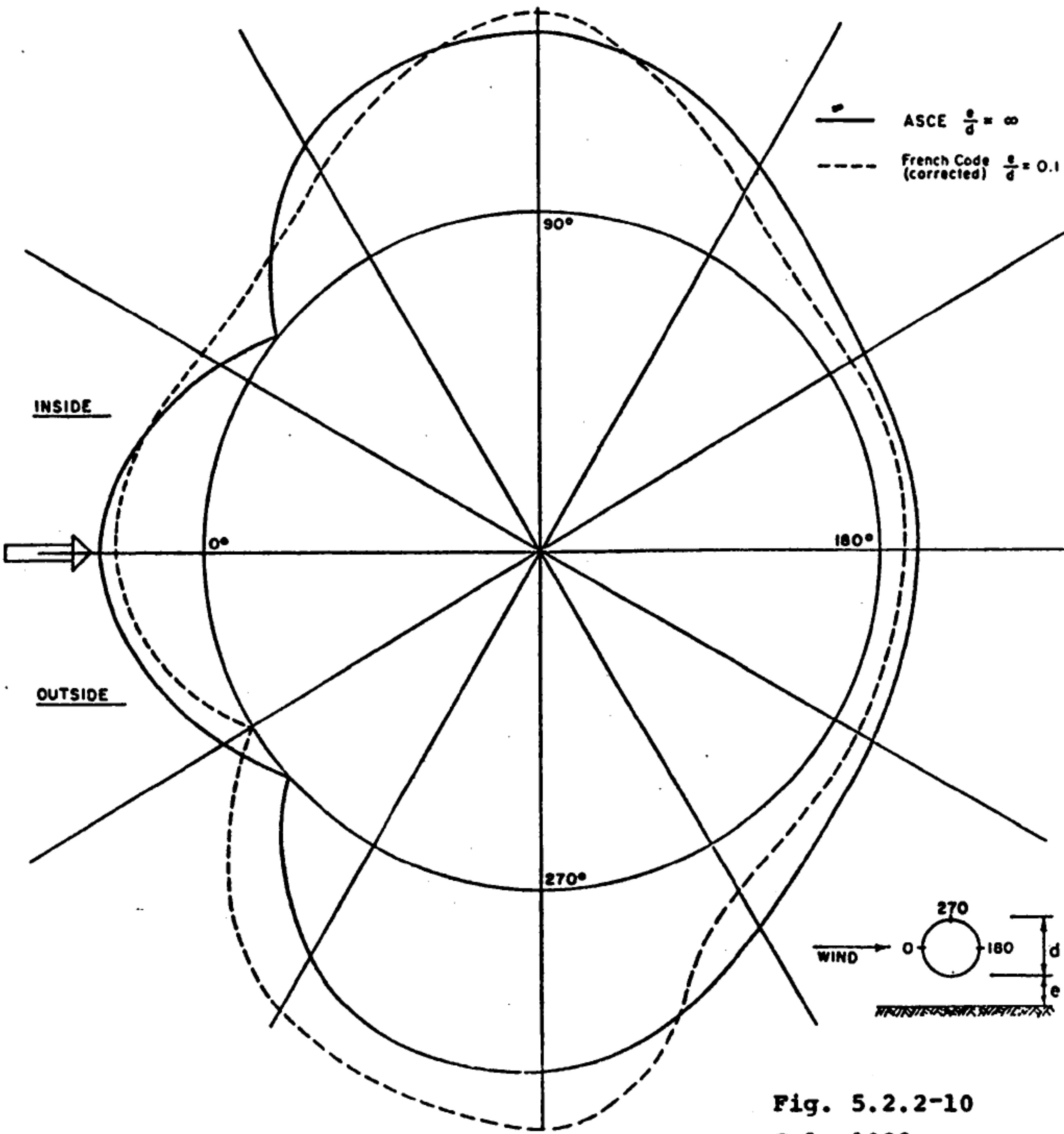


Fig. 5.2.2-10
July 1982

TORNADO			LOAD FACTOR Ce									
	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
e/d = 1.0	1.0	0.35	-1.05	-1.2	-0.4	-0.27	-0.27	-0.27	-0.40	-1.2	-1.05	0.35
ASCE	1.0	0.30	-1.2	-1.7	-0.9	-0.4	-0.4	-0.4	-0.90	-1.7	-1.2	0.30
e/d = 0.2	0.95	0.70	0.6	-1.67	-0.4	-0.23	-0.23	-0.23	-0.30	-1.35	-1.27	0.15
e/d 0.2 (Corr)	0.95	0.60	-0.7	-2.36	-0.90	-0.34	-0.34	-0.34	-0.70	-1.90	-1.45	0.13

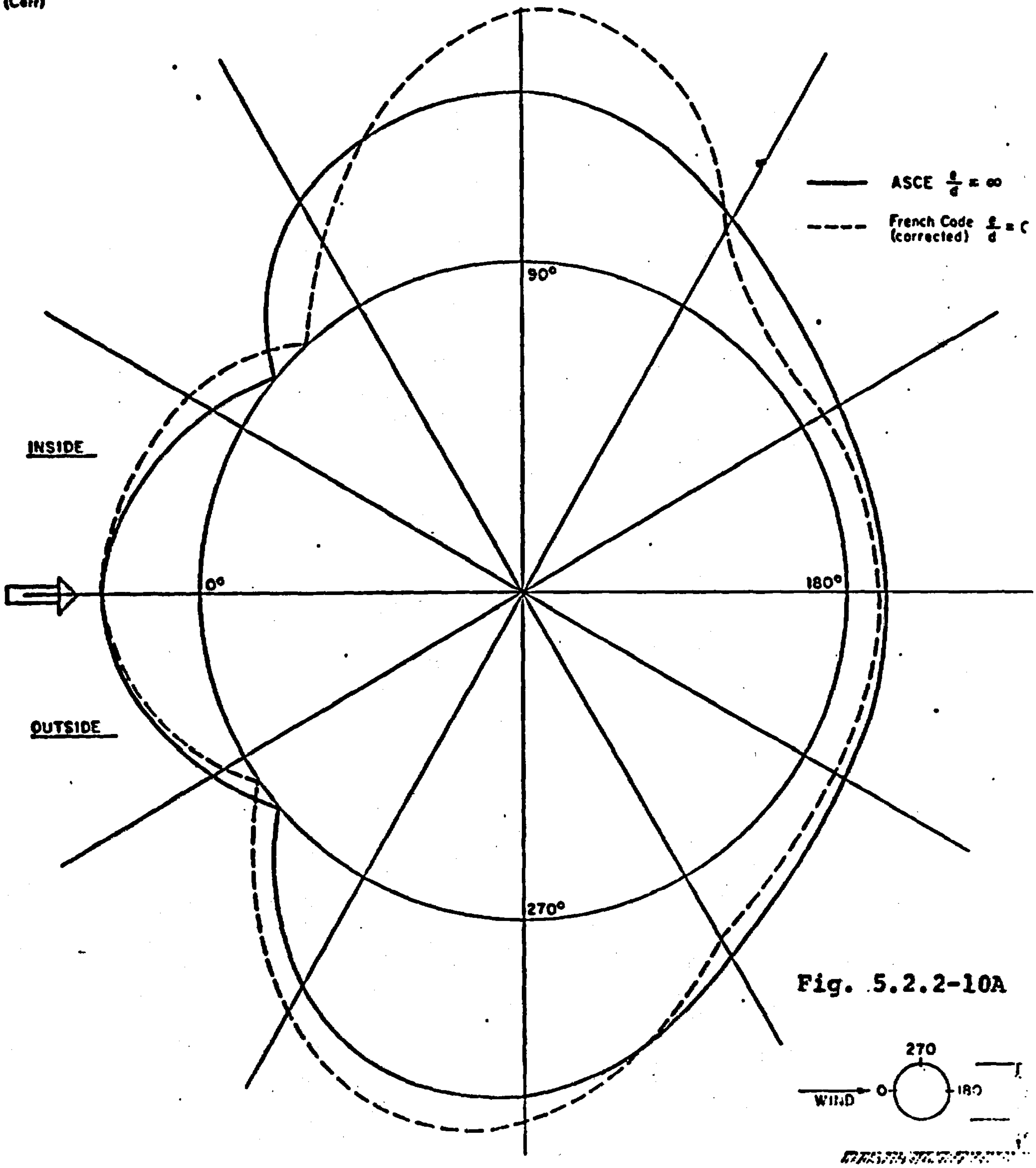
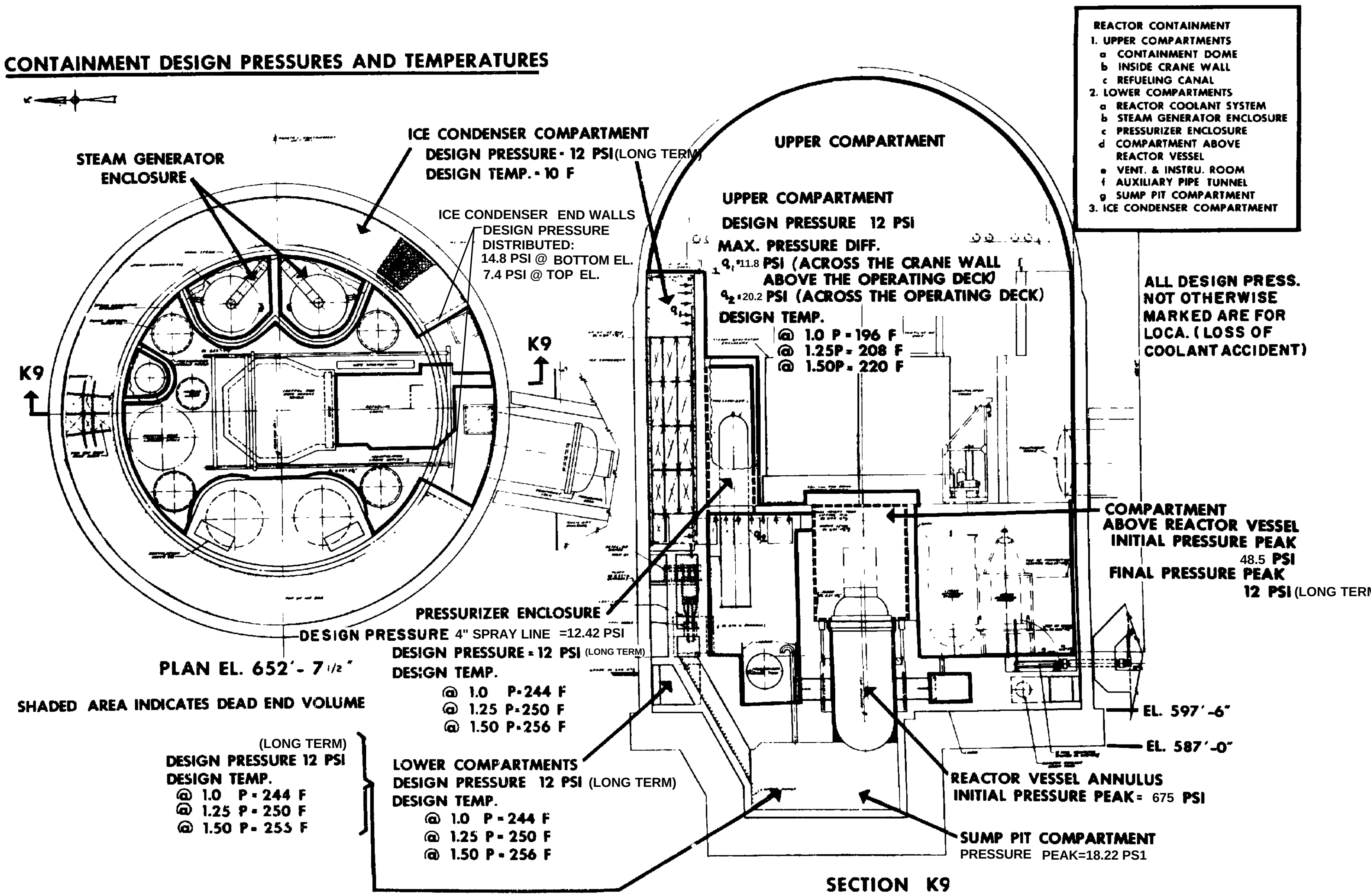


Fig. 5.2.2-10A

CONTAINMENT DESIGN PRESSURES AND TEMPERATURES



DATE	NO.	DESCRIPTION	APPD.
	17.1	REVISED PER UCR 0850	

REVISIONS

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INDIANA MICHIGAN POWER COMPANY
DONALD C. COOK
NUCLEAR PLANT
BRIDGMAN MICHIGAN

CONTAINMENT DESIGN TEMPERATURES AND PRESSURES

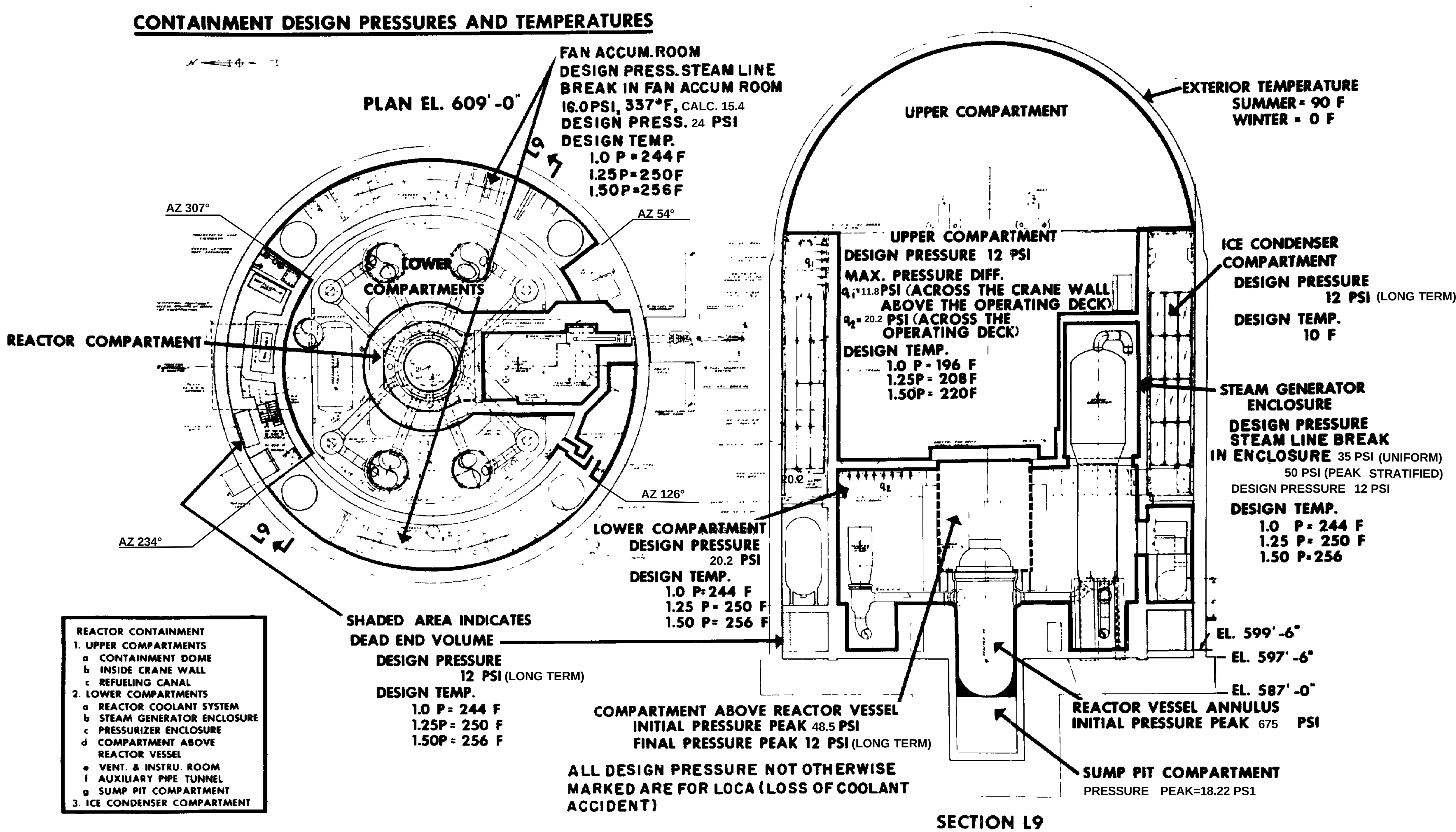
DWG. NO. FSAR FIG. 5.2.2-11

ARCH | ELEC | MECH | STR

SCALE - | DR -
DATE - | CH -

DESIGN ENGINEERING DIVISION

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215



DATE	NO.	DESCRIPTION	APPD.
	17.1	REVISED PER UCR 0850	

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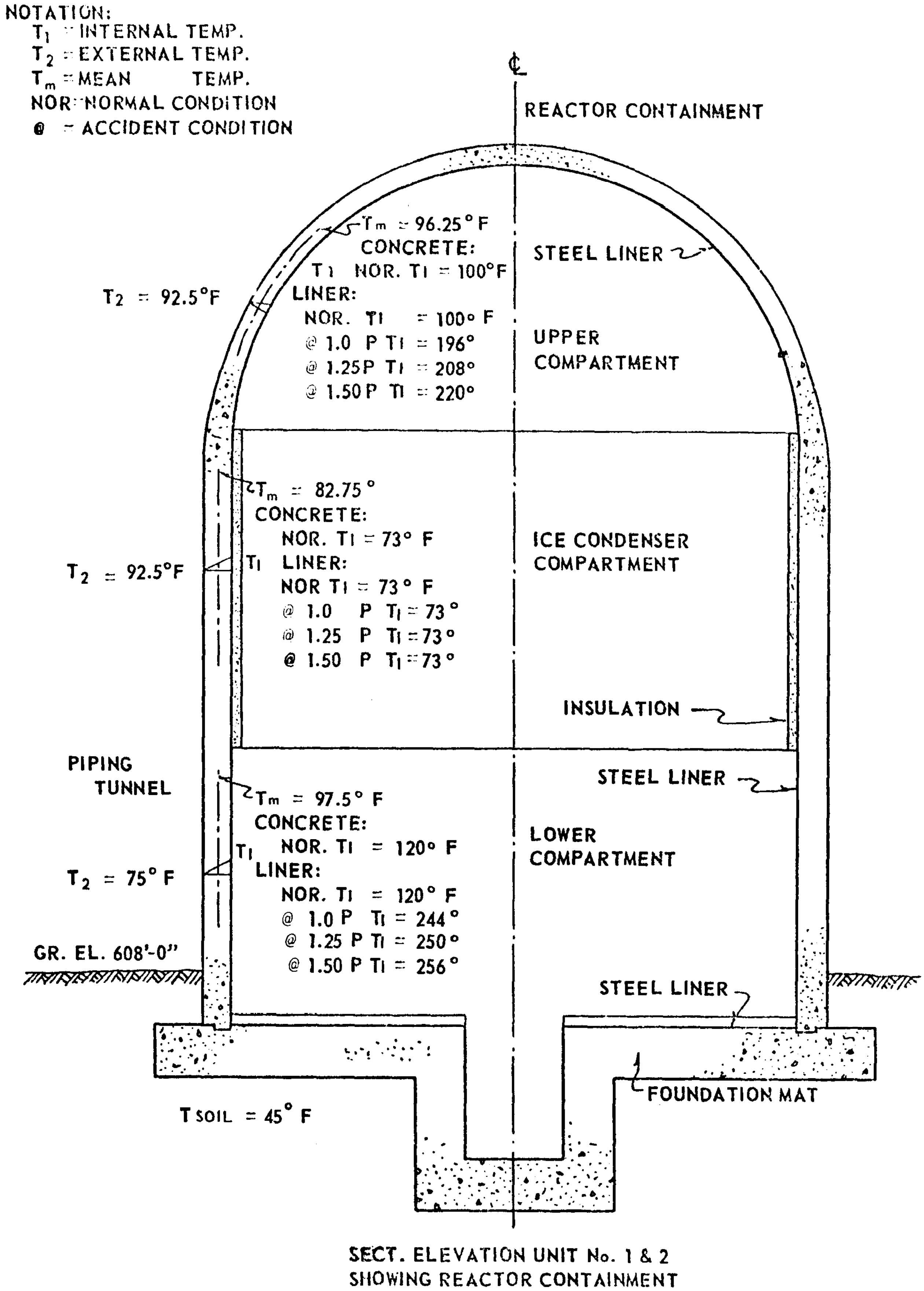
INDIANA MICHIGAN POWER COMPANY
DONALD C. COOK
NUCLEAR PLANT
BRIDGMAN MICHIGAN

CONTAINMENT DESIGN TEMPERATURES AND PRESSURES

DWG. NO. FSAR FIG. 5.2.2-11A

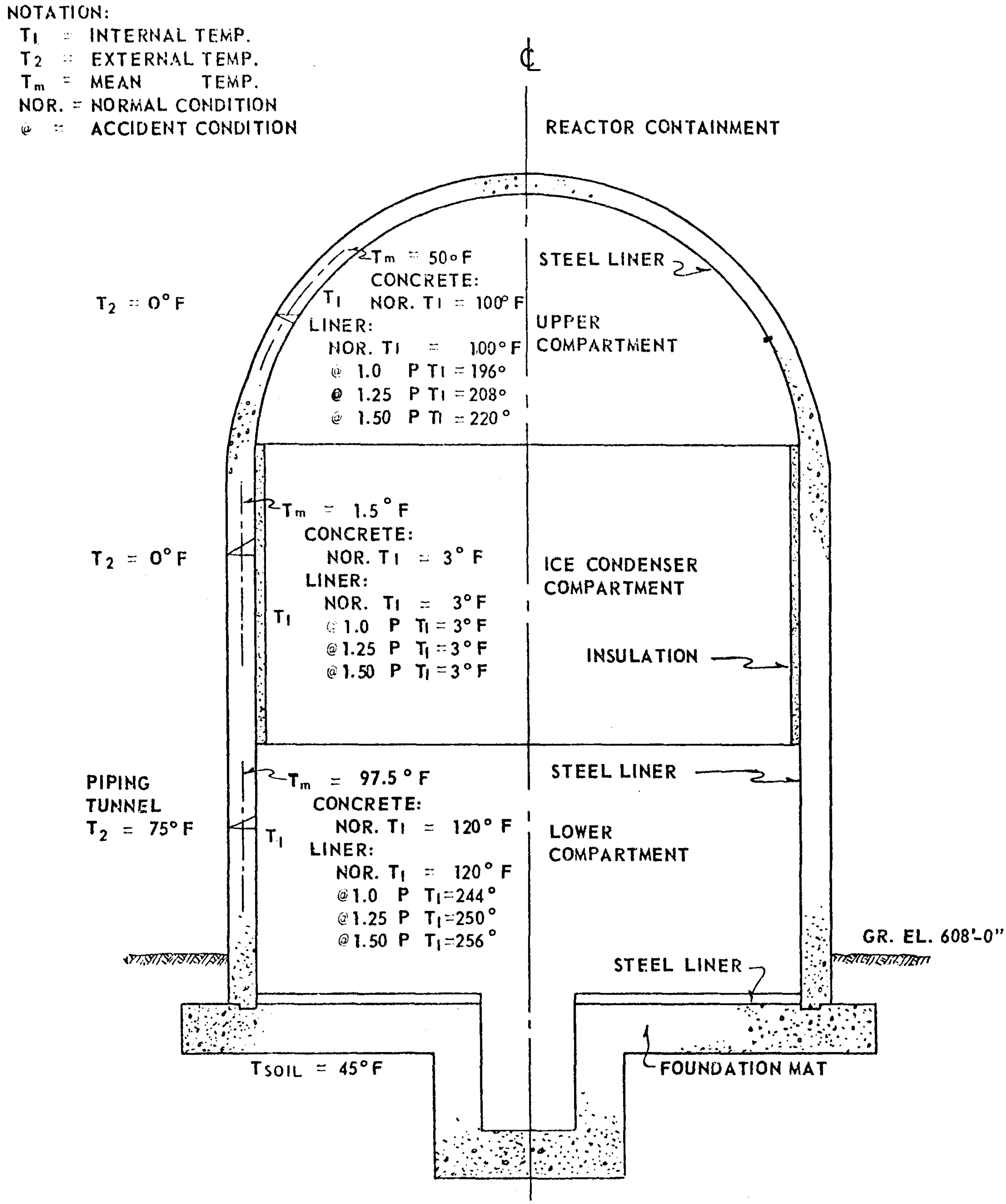
AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215



SECT. ELEVATION UNIT No. 1 & 2
SHOWING REACTOR CONTAINMENT
THERMAL GRADIENTS USED FOR THE
DESIGN IN SUMMER OPERATION

Fig. 5.2.2-12

July 1982



SECT. ELEVATION UNIT NO. 1 & 2
SHOWING REACTOR CONTAINMENT
THERMAL GRADIENTS USED FOR THE
DESIGN IN WINTER OPERATION

Fig. 5.2.2-12A

July 1982

"11" Meridional Direction - (Vertical)

"22" Hoop Direction - (Horizontal & Radial)

M Moment (Kips-in/in.)

N Axial Force (Kips/in.)

W Radial Deformation (Inches)

S Rebar Stresses -(Pound/Square In.)

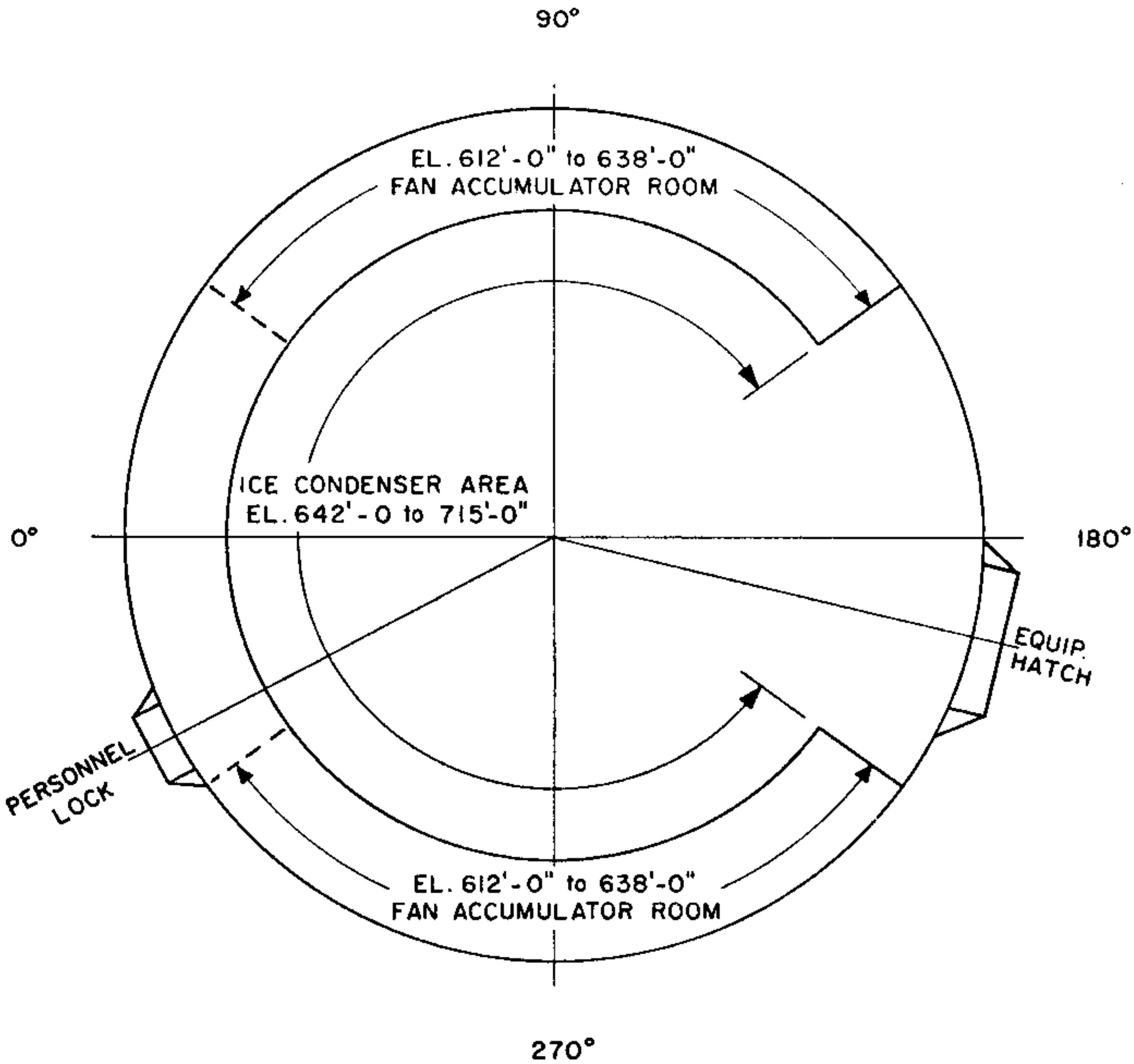
Q13 Radial Shear (Kips/Inch)

Q12 Tangential Horizontal Shear (Kips/Inch)

Legend for Figures 5.2.2-14 to 5.2.2-50

FIG. 5.2.2-13

JULY, 1982



ORIENTATION FOR COMPUTER RESULTS

Fig. 5.2.2-14

July 1982

COOK NUCLEAR PLANT

FINISH 4M - (5/11/71) DEAD WEIGHT(M11&M22)(0° & 180°)

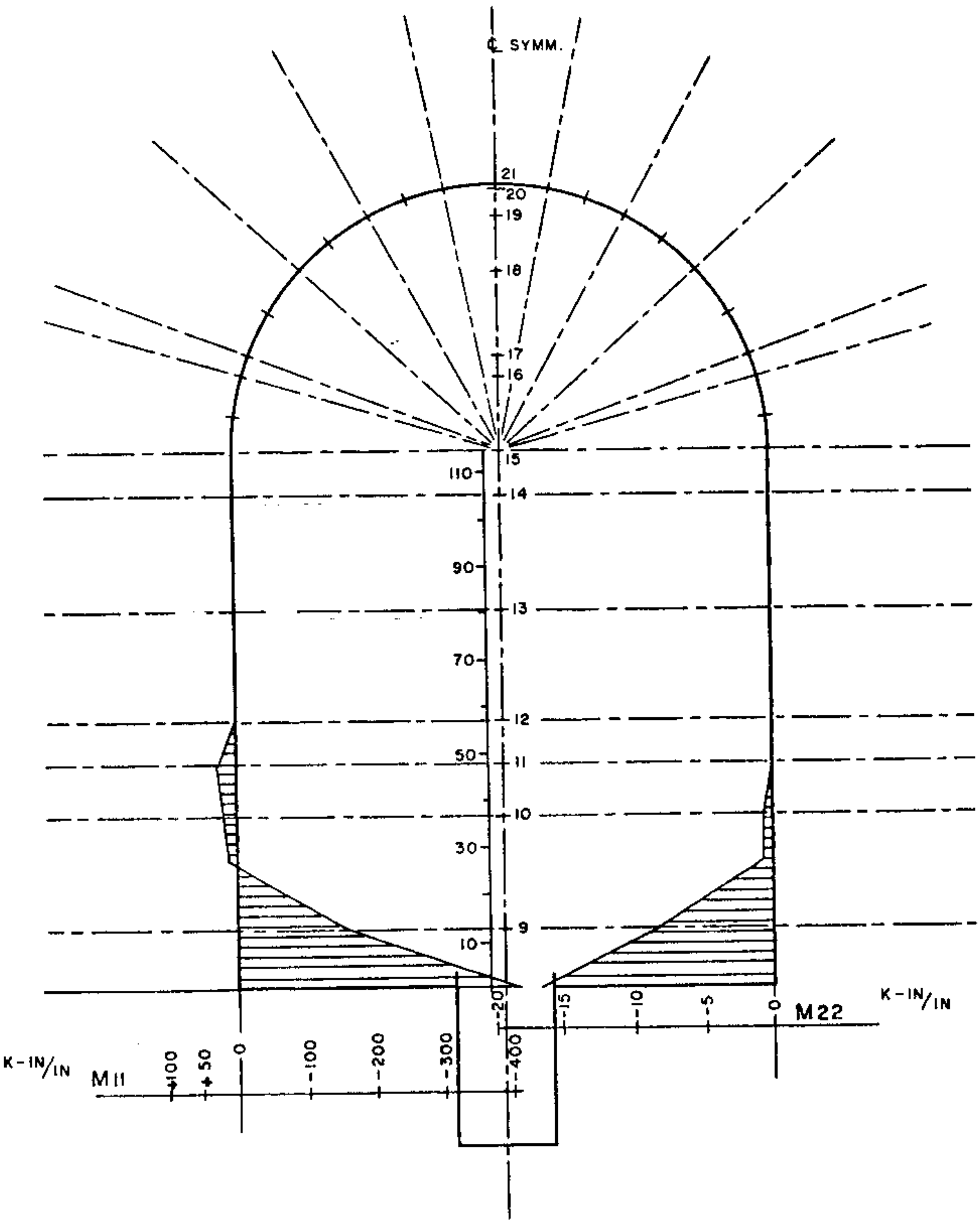


Fig. 5.2.2-15
July 1982

COOK NUCLEAR PLANT

FINISH 4M (5/11/71) DEAD WEIGHT(N11&N22) (0° & 180°)

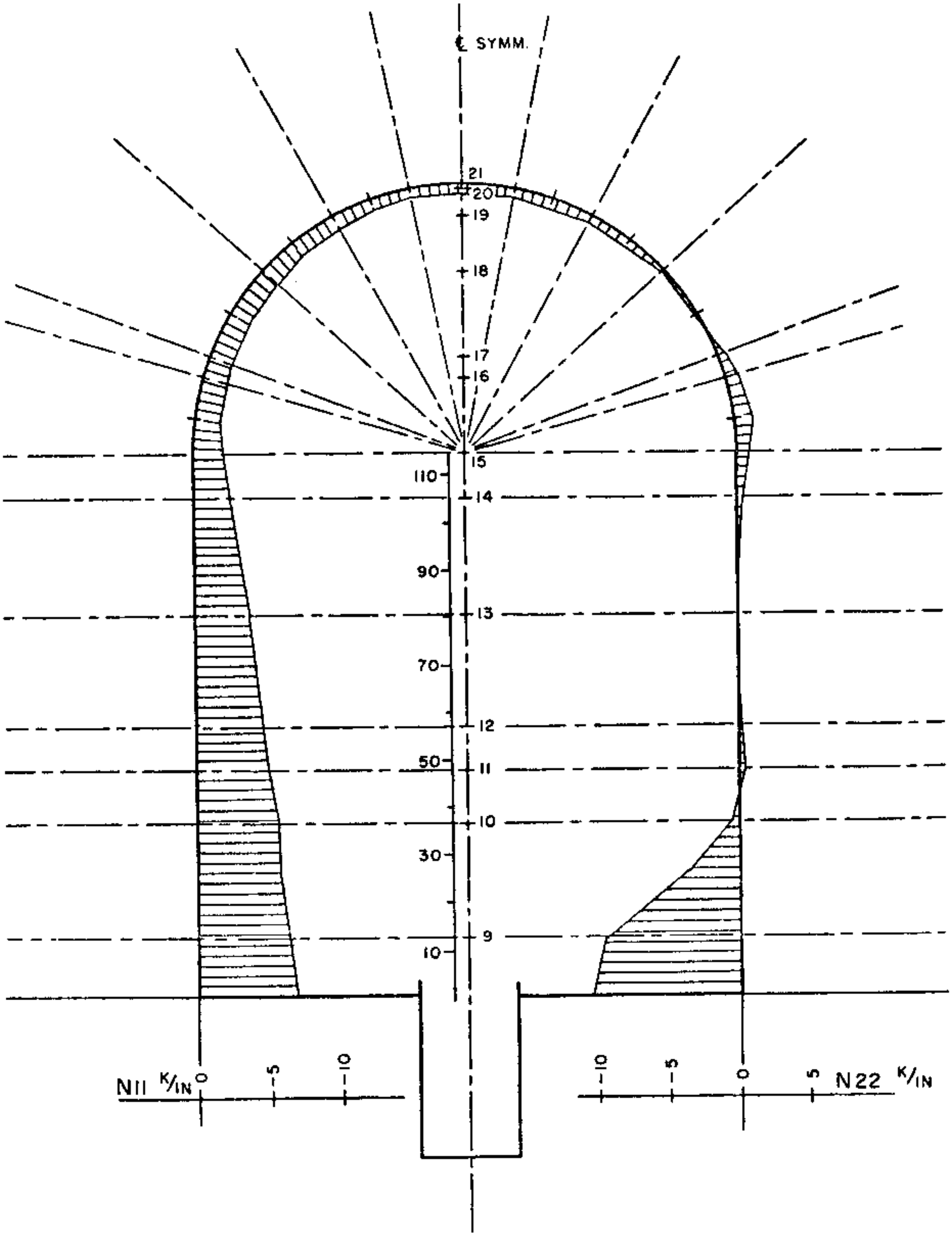


Fig. 5.2.2-16
July 1982

COOK NUCLEAR PLANT

FINISH 4M (5/11/71) DEAD WEIGHT(W DEFL.& Q.13)(0° & 180°)

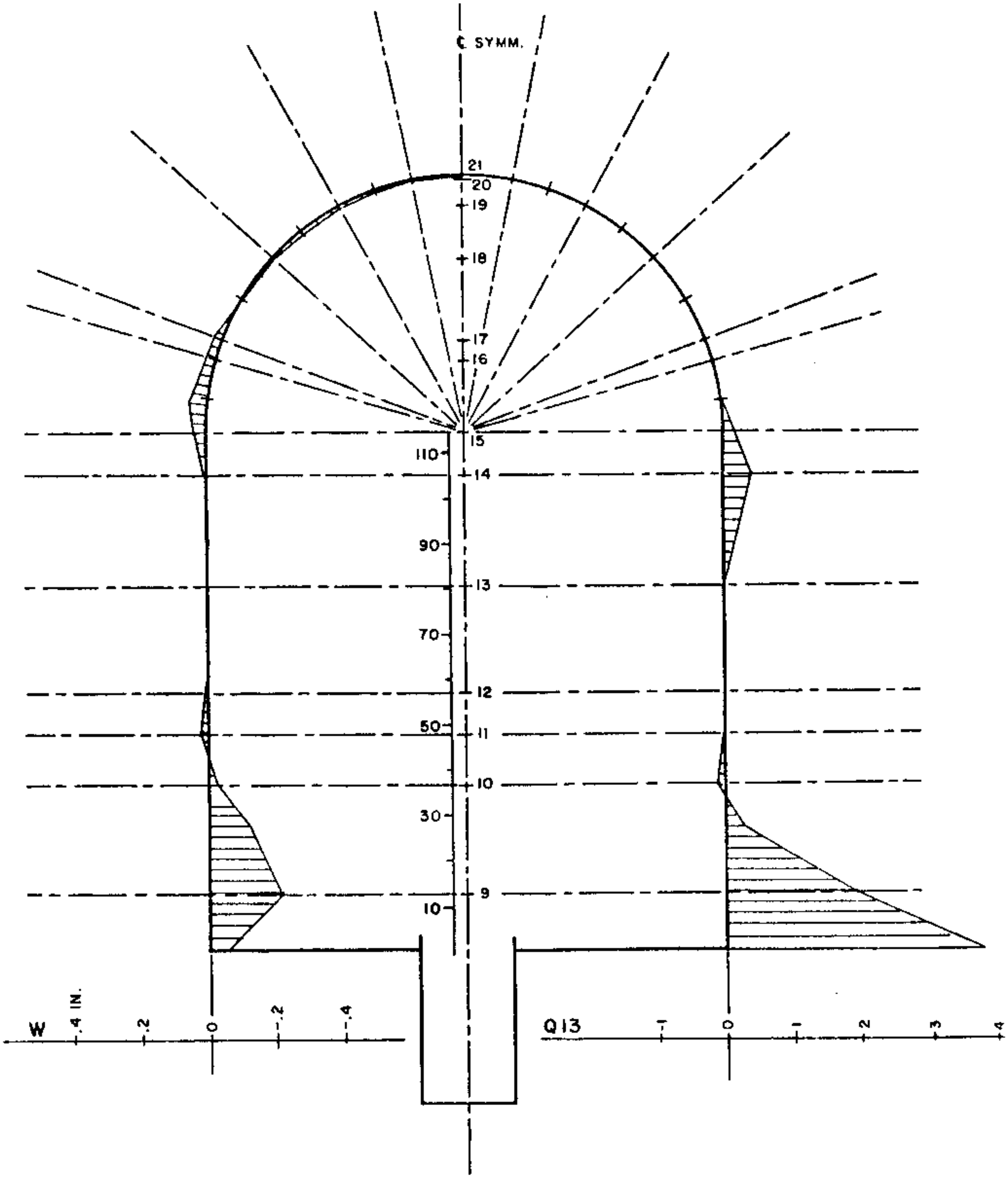


Fig. 5.2.2-17
July 1982

FINISH 4M (5/11/71) DEAD WEIGHT(S11 & S22)(0° & 180°)

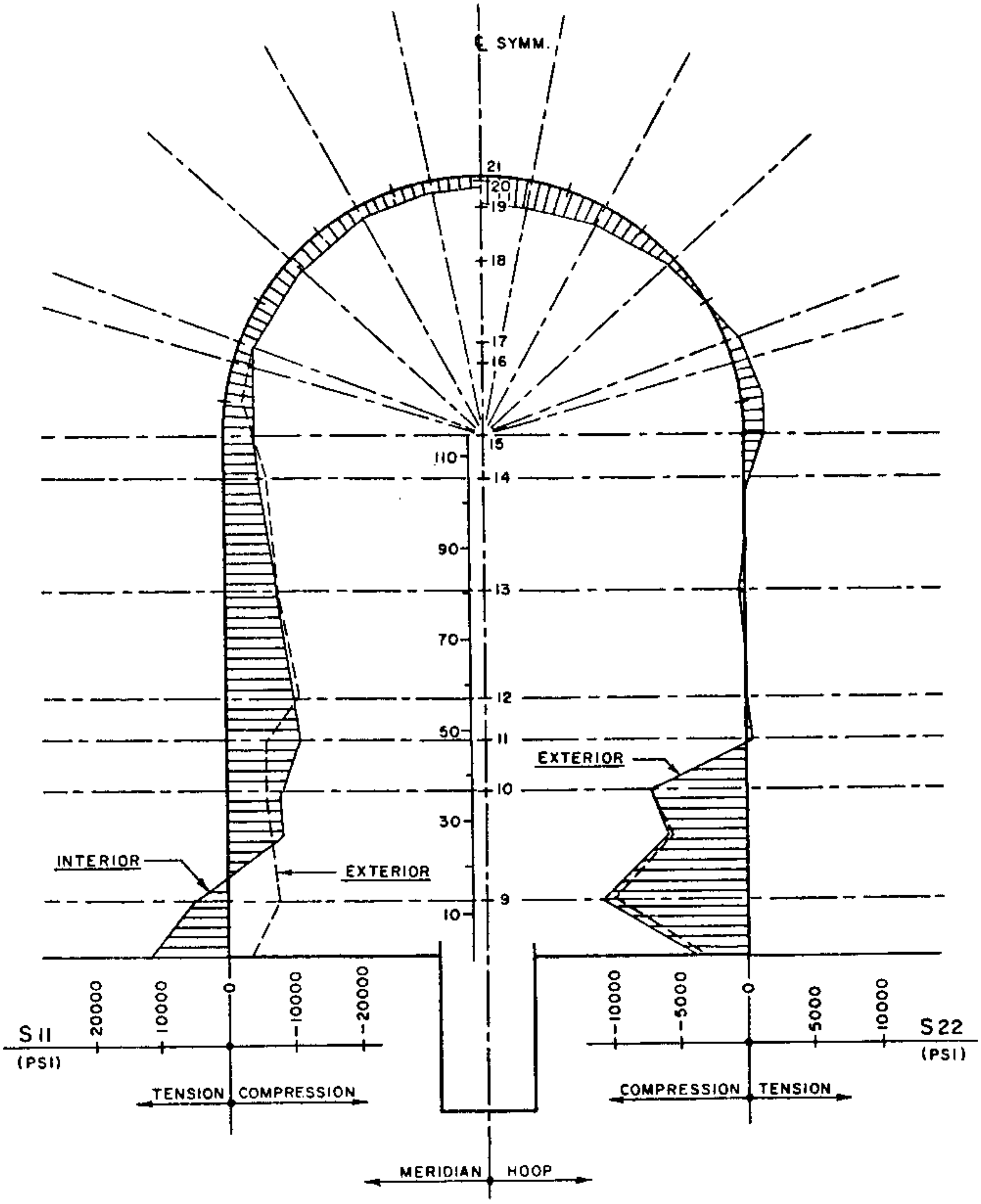


Fig. 5.2.2-18

July 1982

FINISH 4T (5/11/71) INTERNAL PRESSURE (0° & 180°)

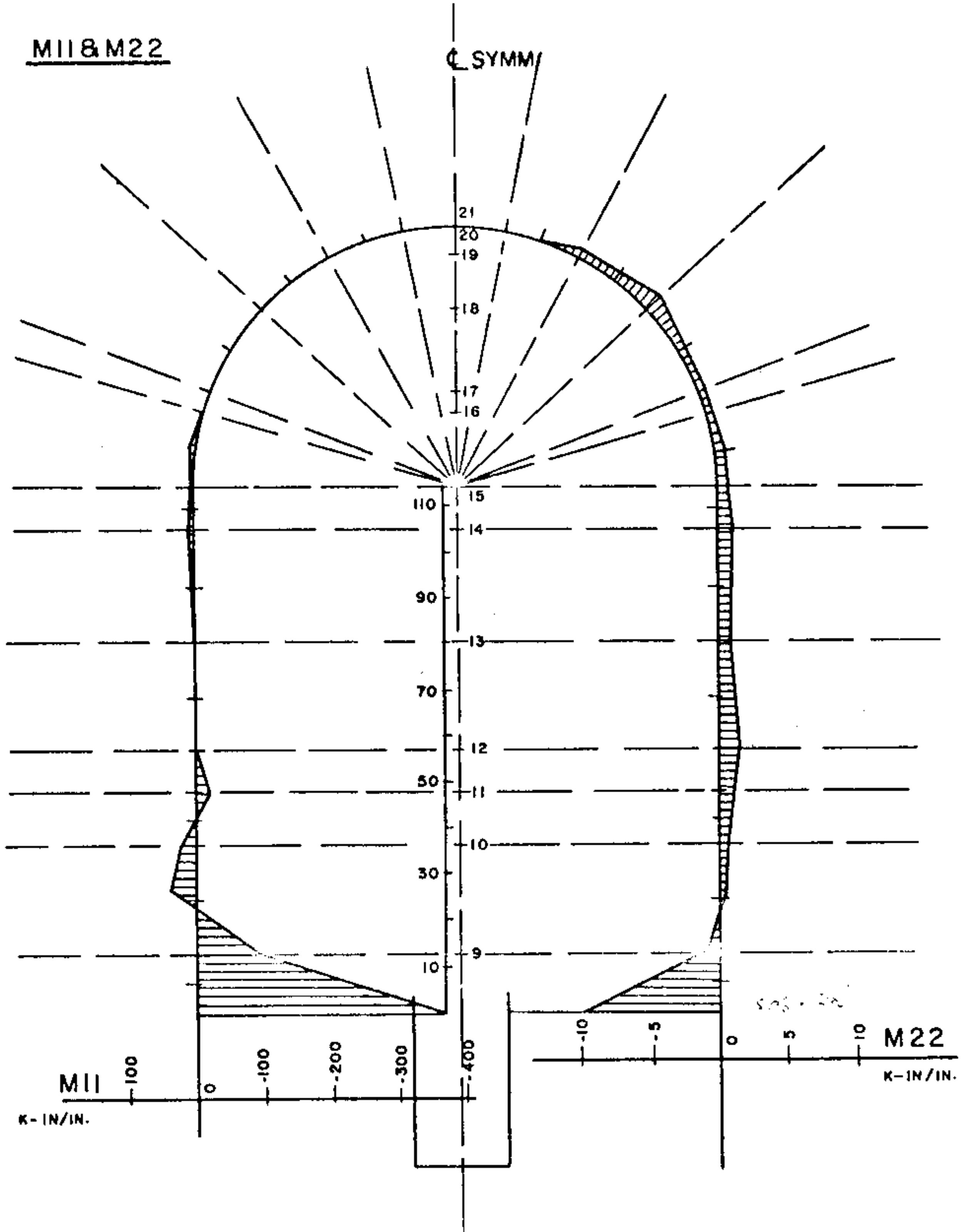


Fig. 5.2.2-19

July 1982

FINISH 4M (5/11/71) INTERNAL PRESSURE(N11&N22) (0°)

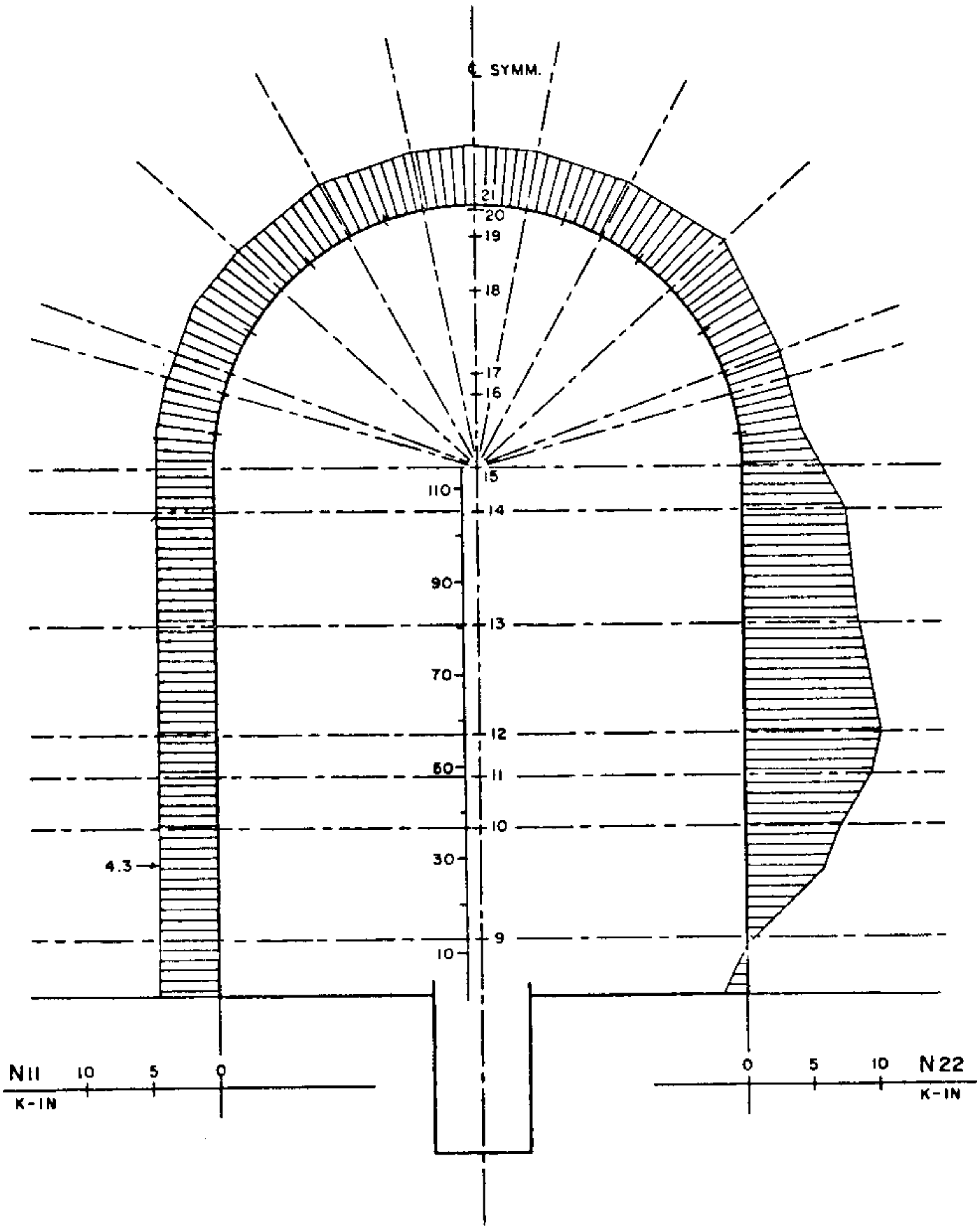


Fig. 5.2.2-20

July 1982

COOK NUCLEAR PLANT

FINISH 4M (5/11/71) INTERNAL PRESSURE(W & Q.13) (0°)

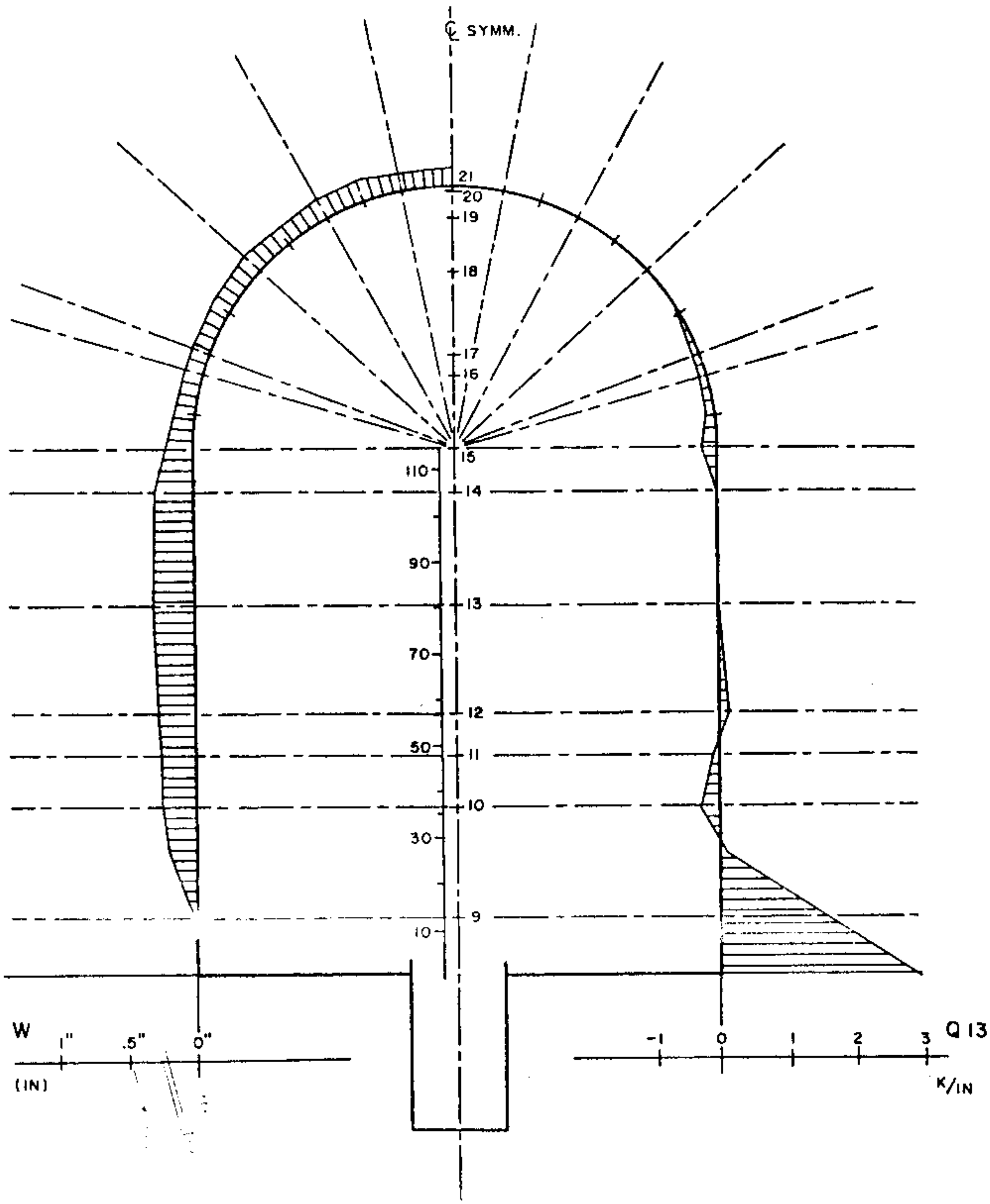


Fig. 5.2.2-21

July 1982

FINISH 4M (5/11/71) INTERNAL PRESSURE(S11 & S22) (0°)

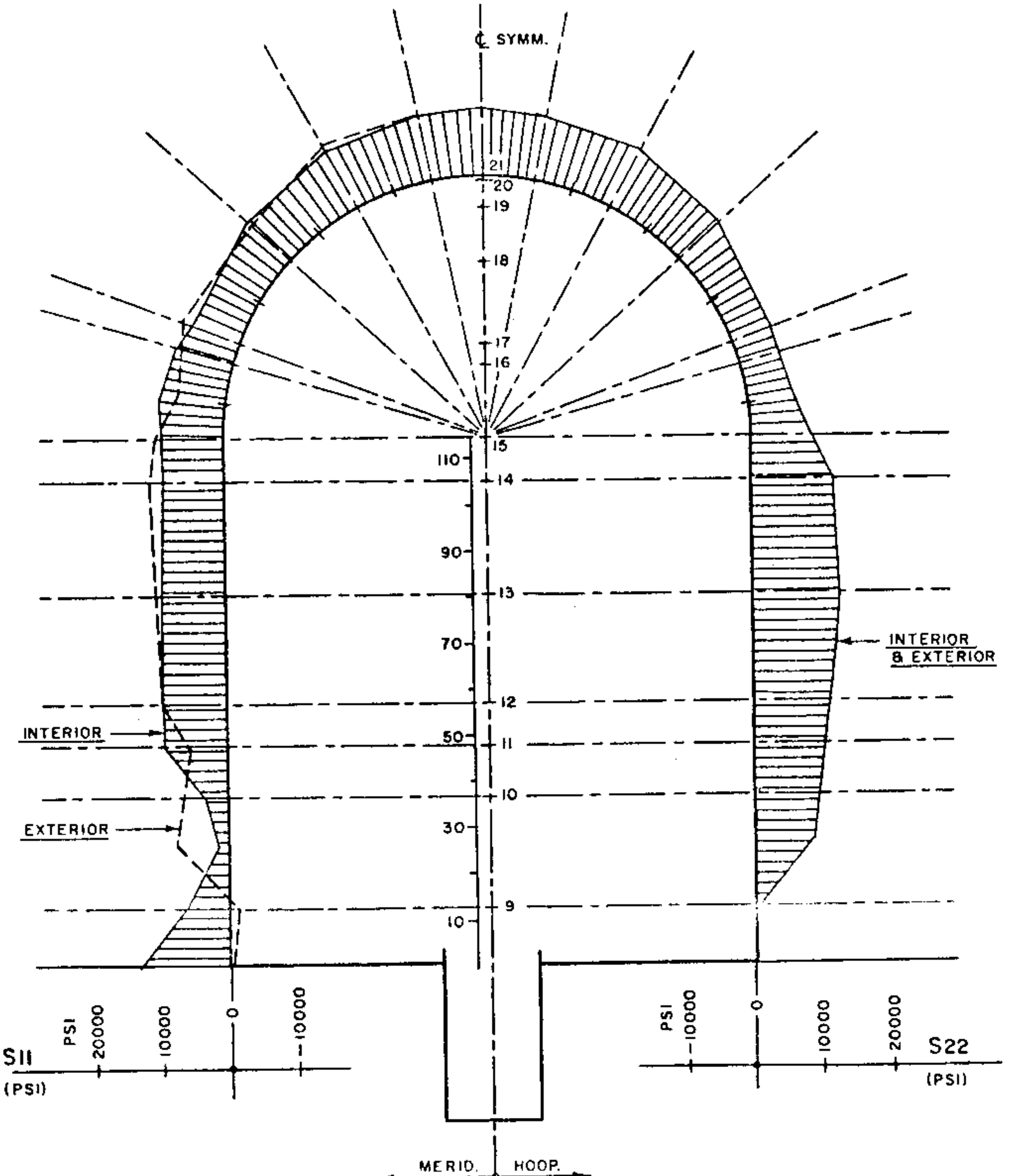


Fig. 5.2.2-22

July 1982

SUPE 2A| GNSLOONO & GNSLOOTO - OPERATING BASIS EARTHQUAKE
(8/3/71) FOR (0°): OPP. SIGN FOR (180°)

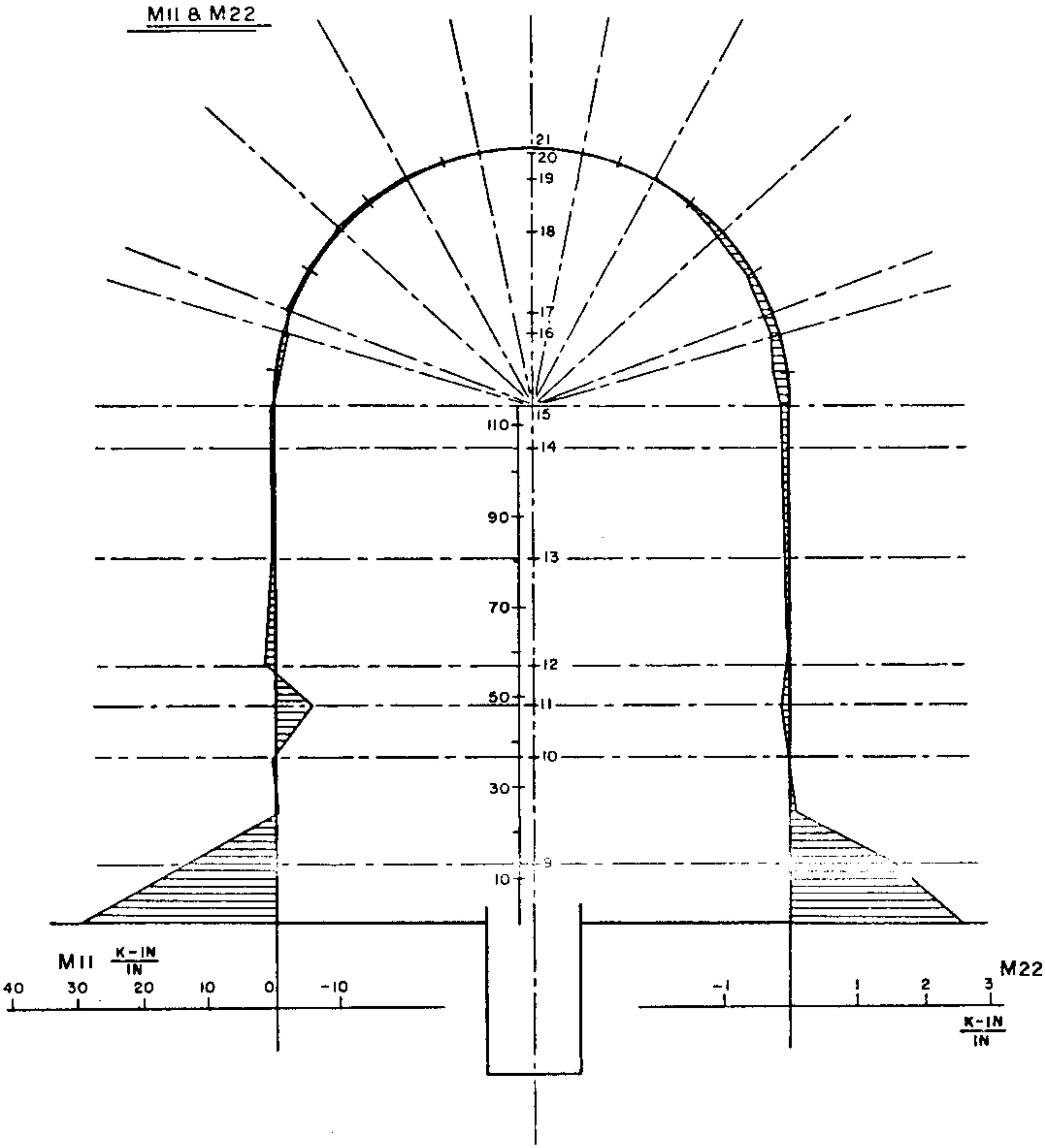


Fig. 5.2.2-23
July 1982

SUPE 2A| GNSLOOMO & GNSLOOTO - OPERATING BASIS EARTHQUAKE
(8/3/71) FOR (0°): OPP. SIGN FOR (180°)

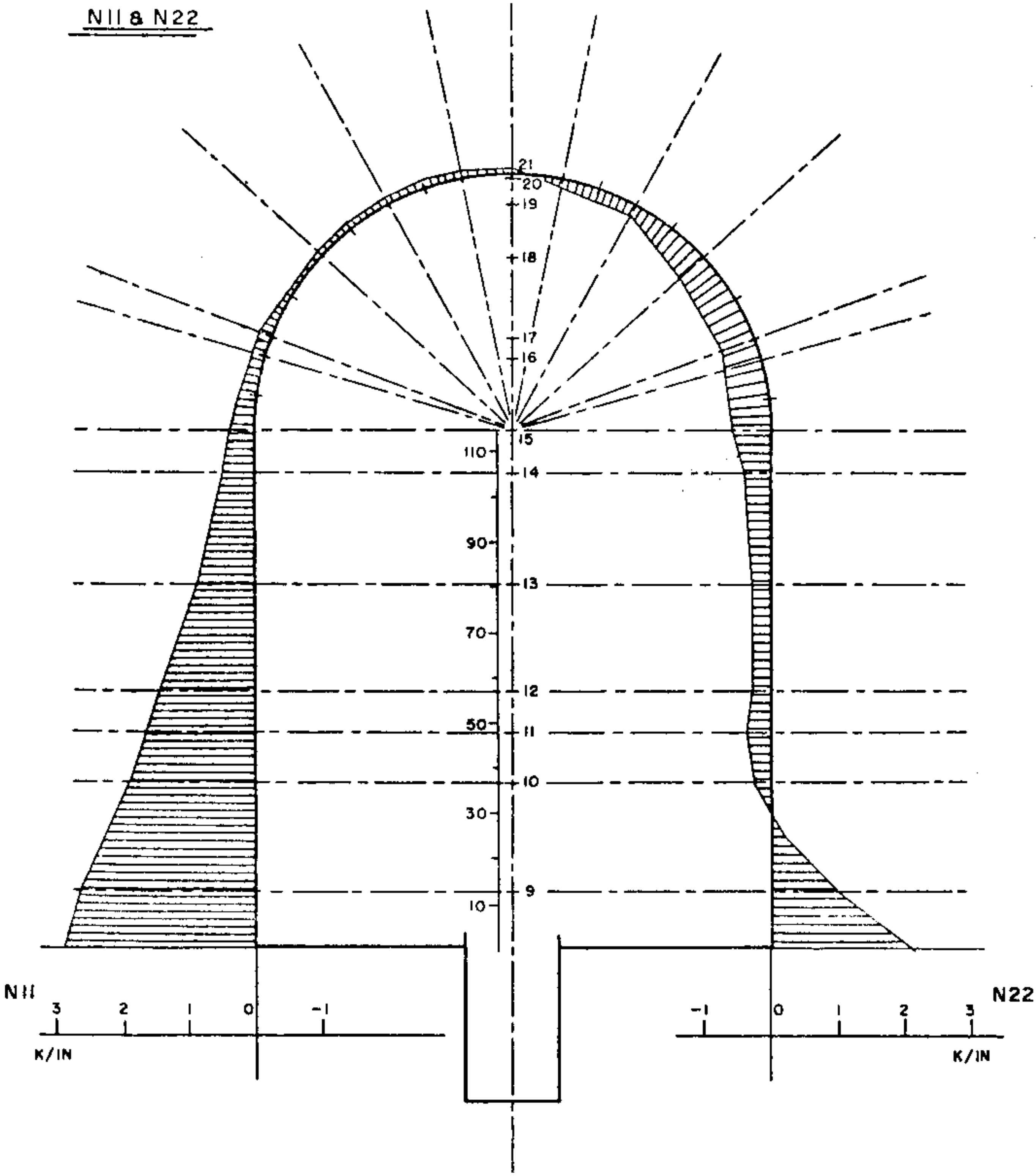


Fig. 5.2.2-24
July 1982

COOK NUCLEAR PLANT

SUPE 17A - OPERATING BASIS EARTHQUAKE
W (DEFLECTION) INCHES

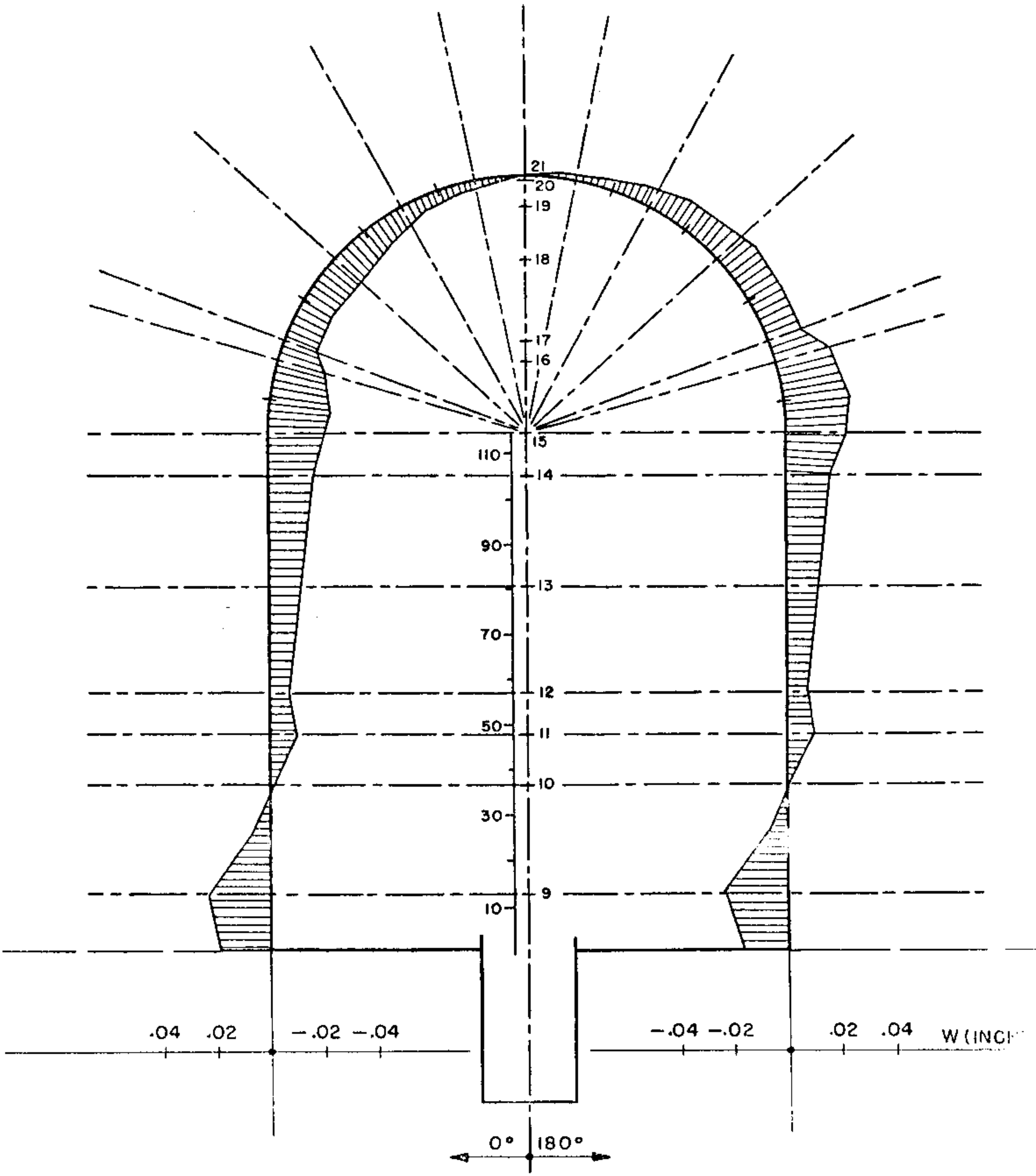


Fig. 5.2.2-25
July 1982

COOK NUCLEAR PLANT

SUPE 17A - OPERATING BASIS EARTHQUAKE
Q12 & Q13 (KIPS/INCHES)

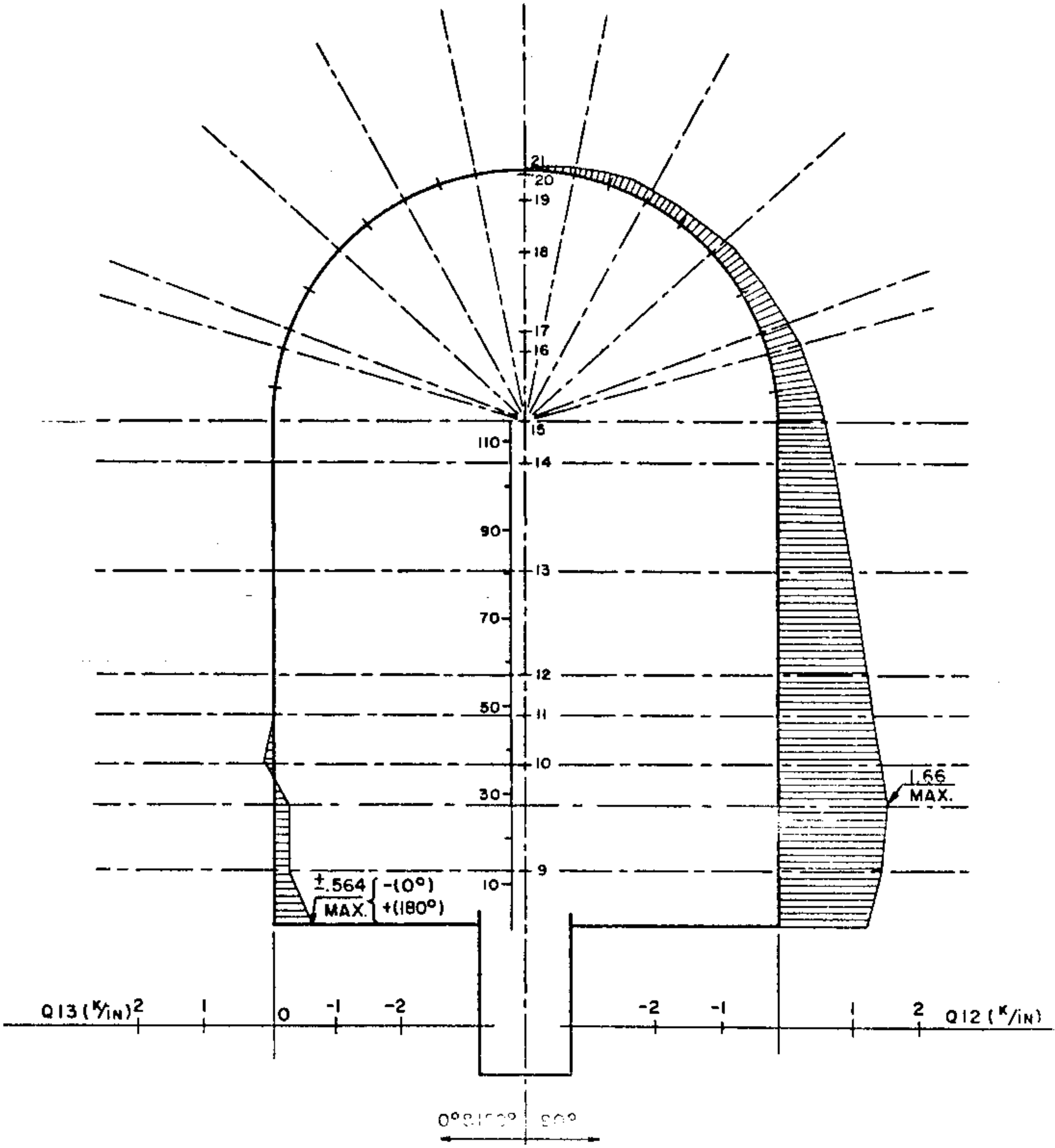


Fig. 5.2.2-26
July 1982

SUPE 2A|GNSLOOMO & GNSLOOTO - OPERATING BASIS EARTHQUAKE
(8/3/71) FOR 0°: OPP. SIGN FOR 180°

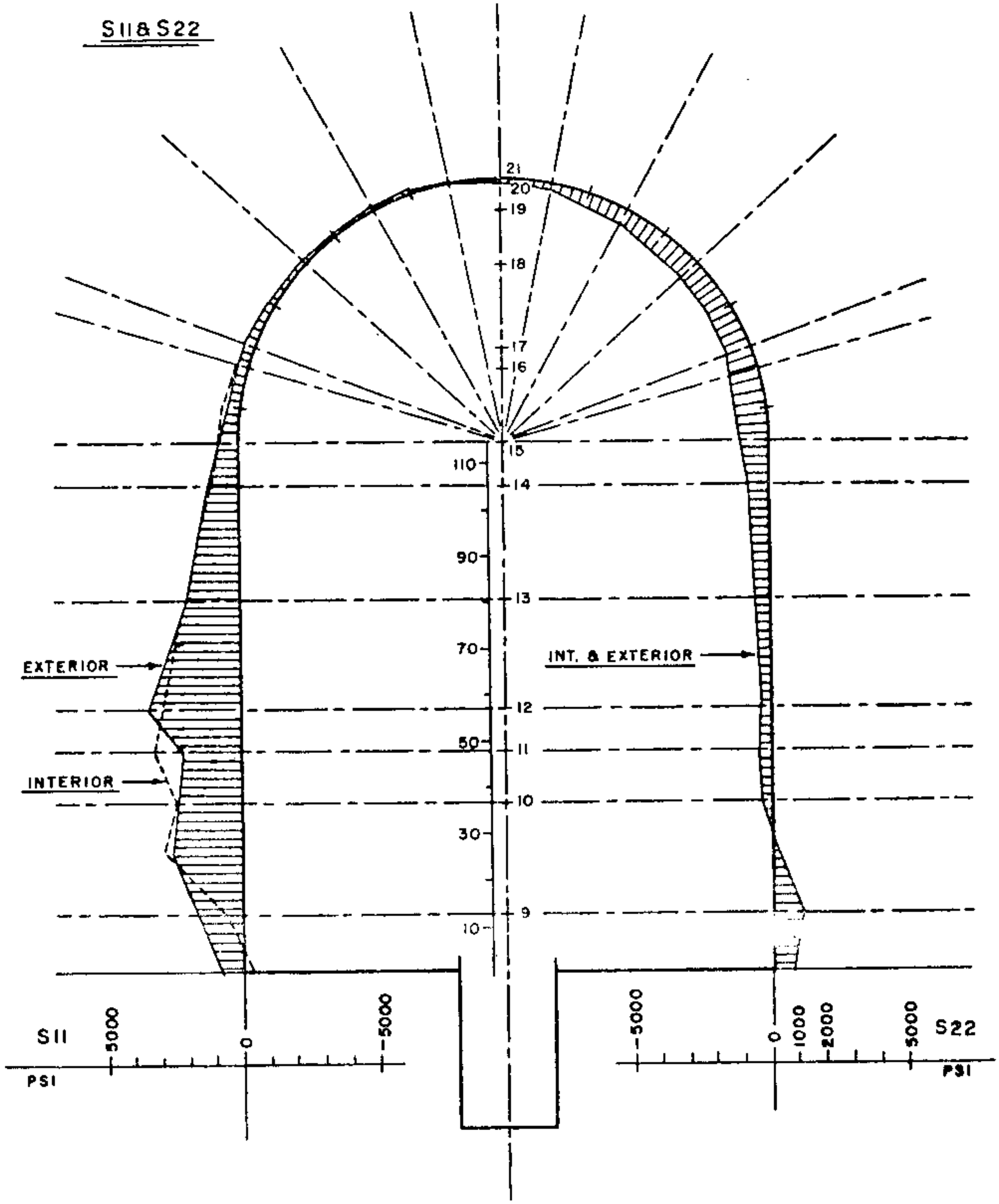


Fig. 5.2.2-27
July 1982

COOK NUCLEAR PLANT

SUPE 17A/GNSLOOT1 & GNSLOOM3 WIND CONDITION
M11 & M22 MERID. & HOOP MOMENTS

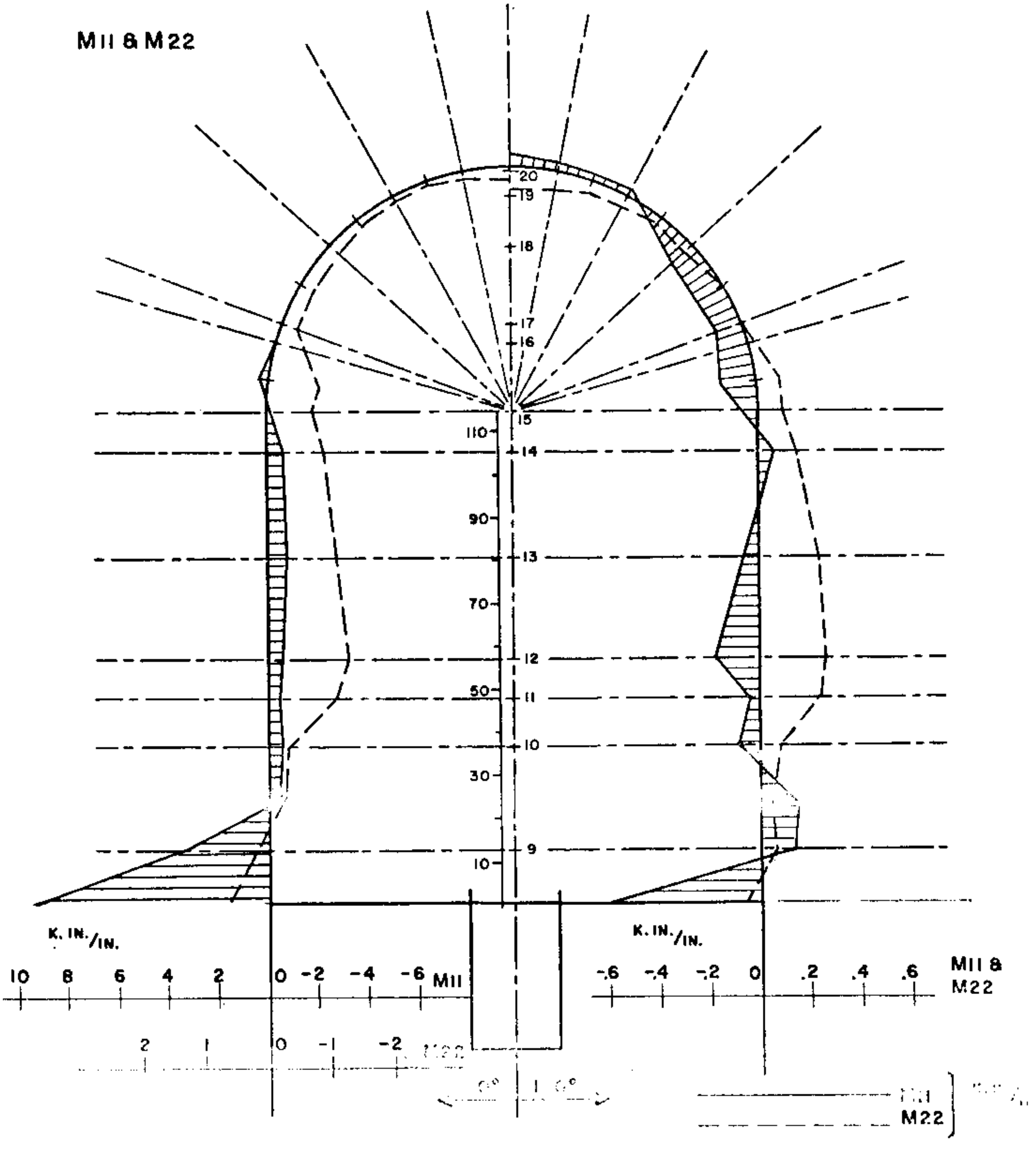


Fig. 5.2.2-28
July 1982

COOK NUCLEAR PLANT

CUPE 17A/GNSLOCT1 & GNSLOOM3 WIND CONDITION - N11 & N22

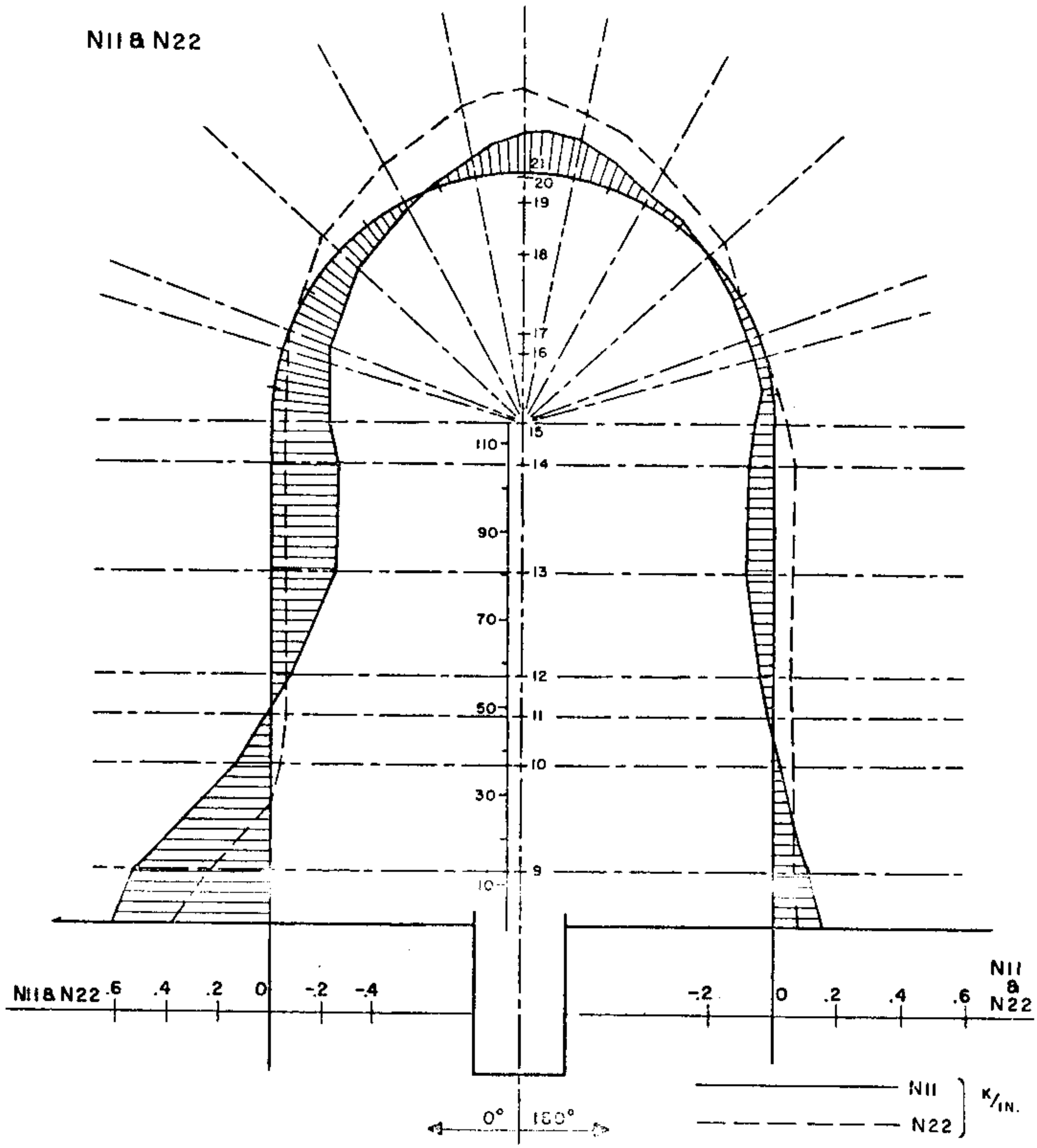


Fig. 5.2.2-29
July 1982

SUPE 2A|GHSLOOTO & GNSLOOMO - WIND CONDITION

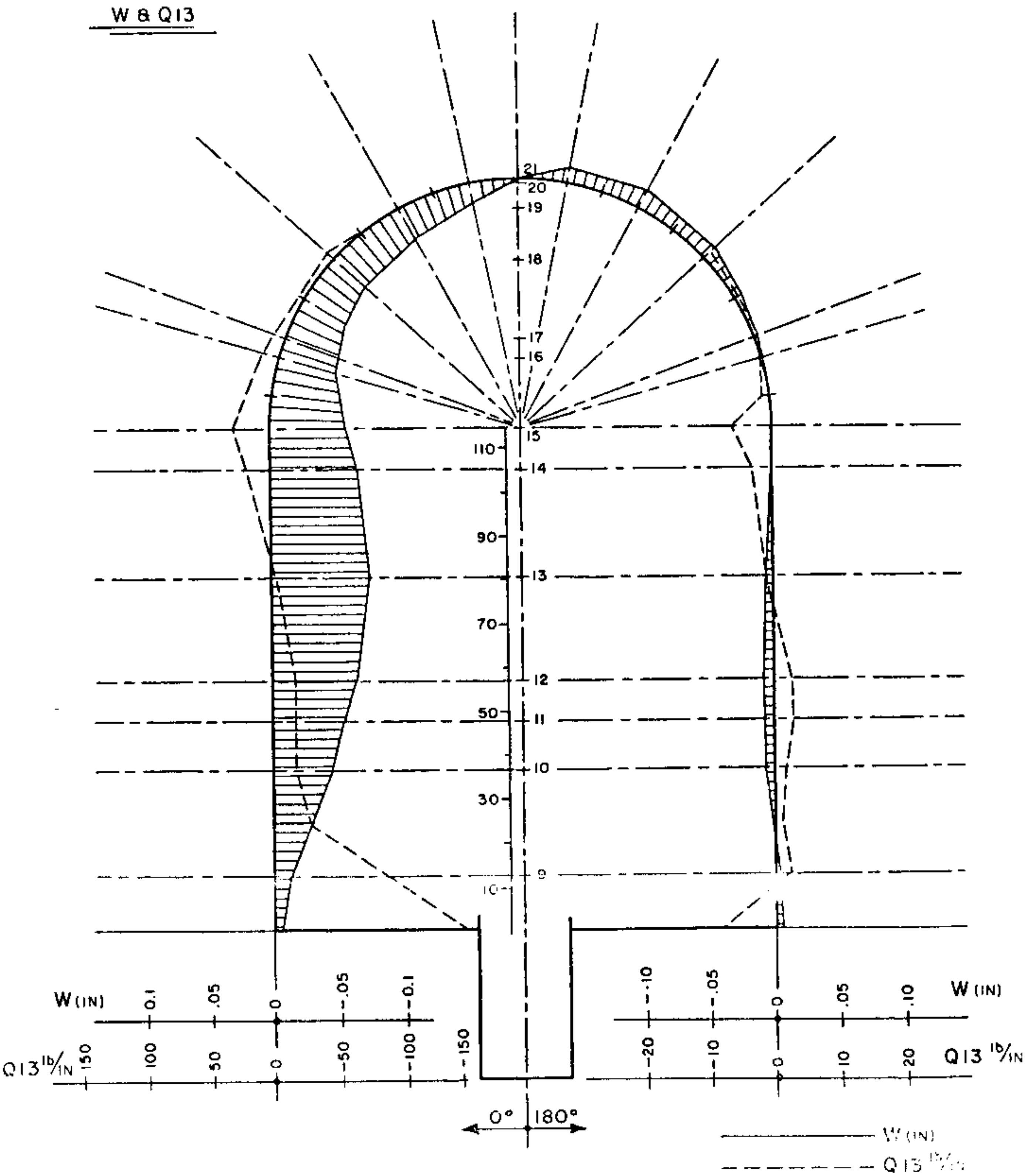


Fig. 5.2.2-30

July 1982

SUPE 17A/GNSLOOT1 & GNSLOOM3 WIND CONDITION -
S11 REINF. STRESSES MERIDIAN

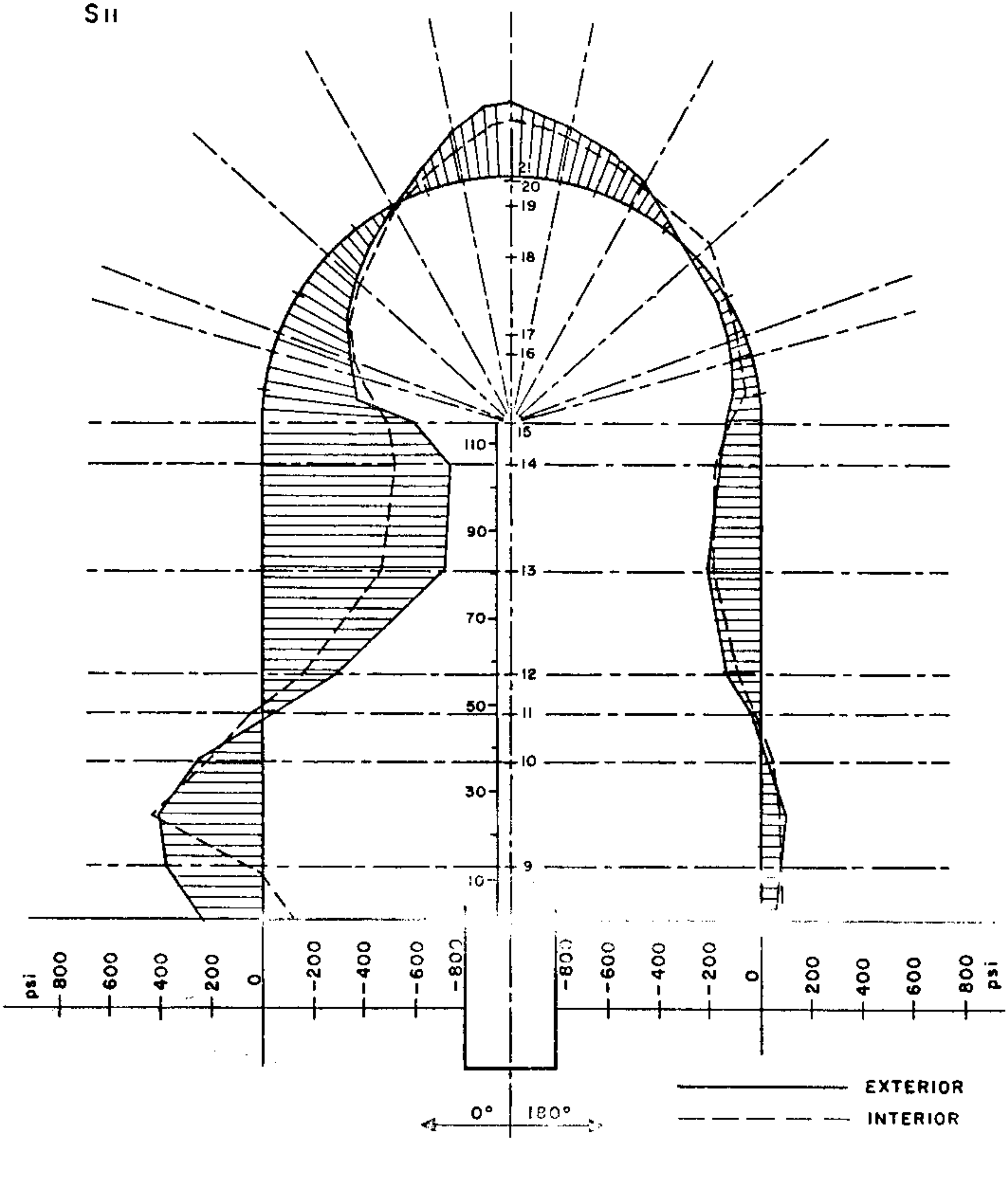


Fig. 5.2.2-31

July 1982

COOK NUCLEAR PLANT

SUPE 17A/GNSLOOT1 & GNSLOOM3 WIND CONDITION-

S22 REINF. STRESSES HOOP

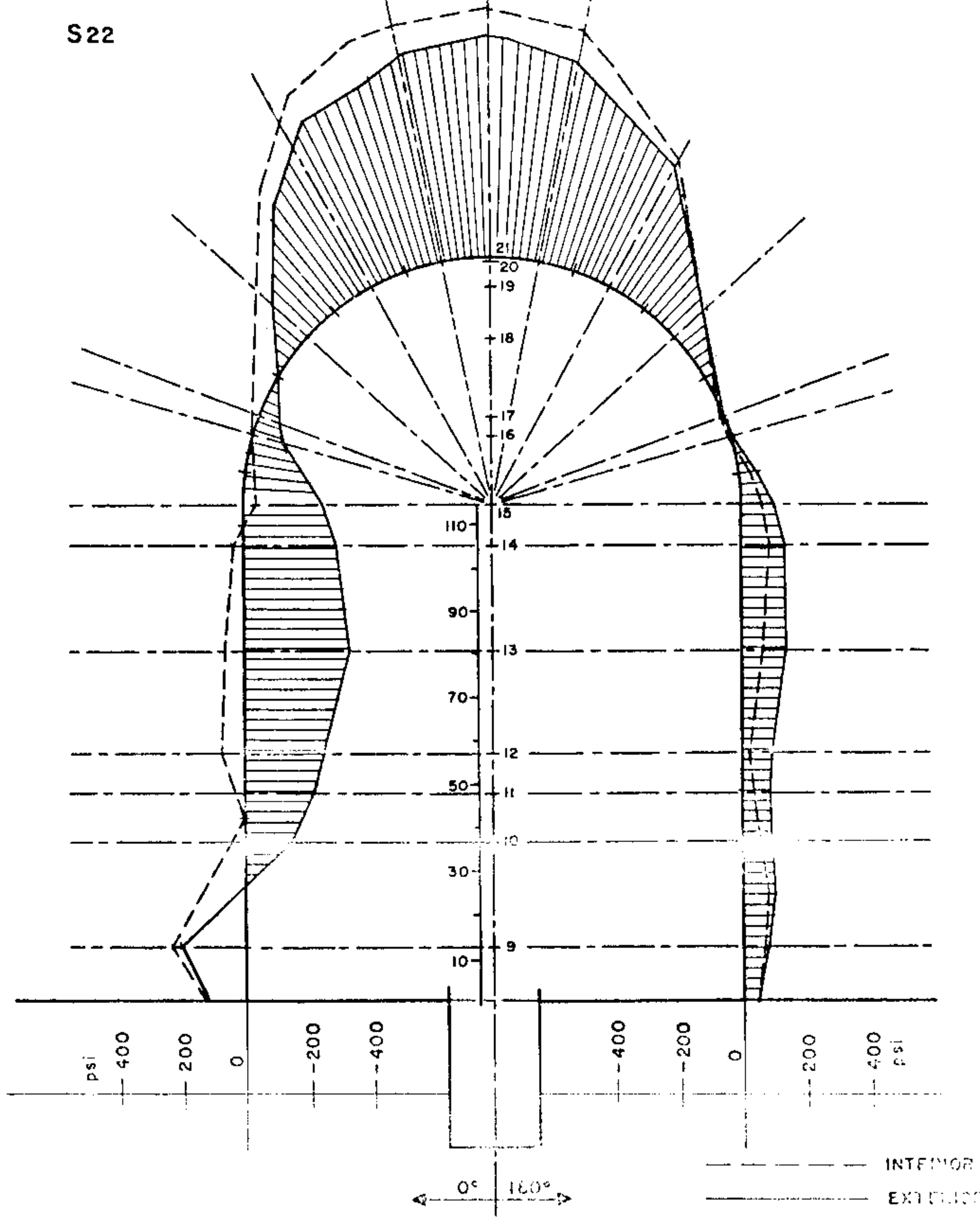


Fig. 5.2.2-32
July 1982

COOK NUCLEAR PLANT

SUPE 2A|GNSLOOTO & GNSLOOM1 LINER THERMAL - ACCIDENT

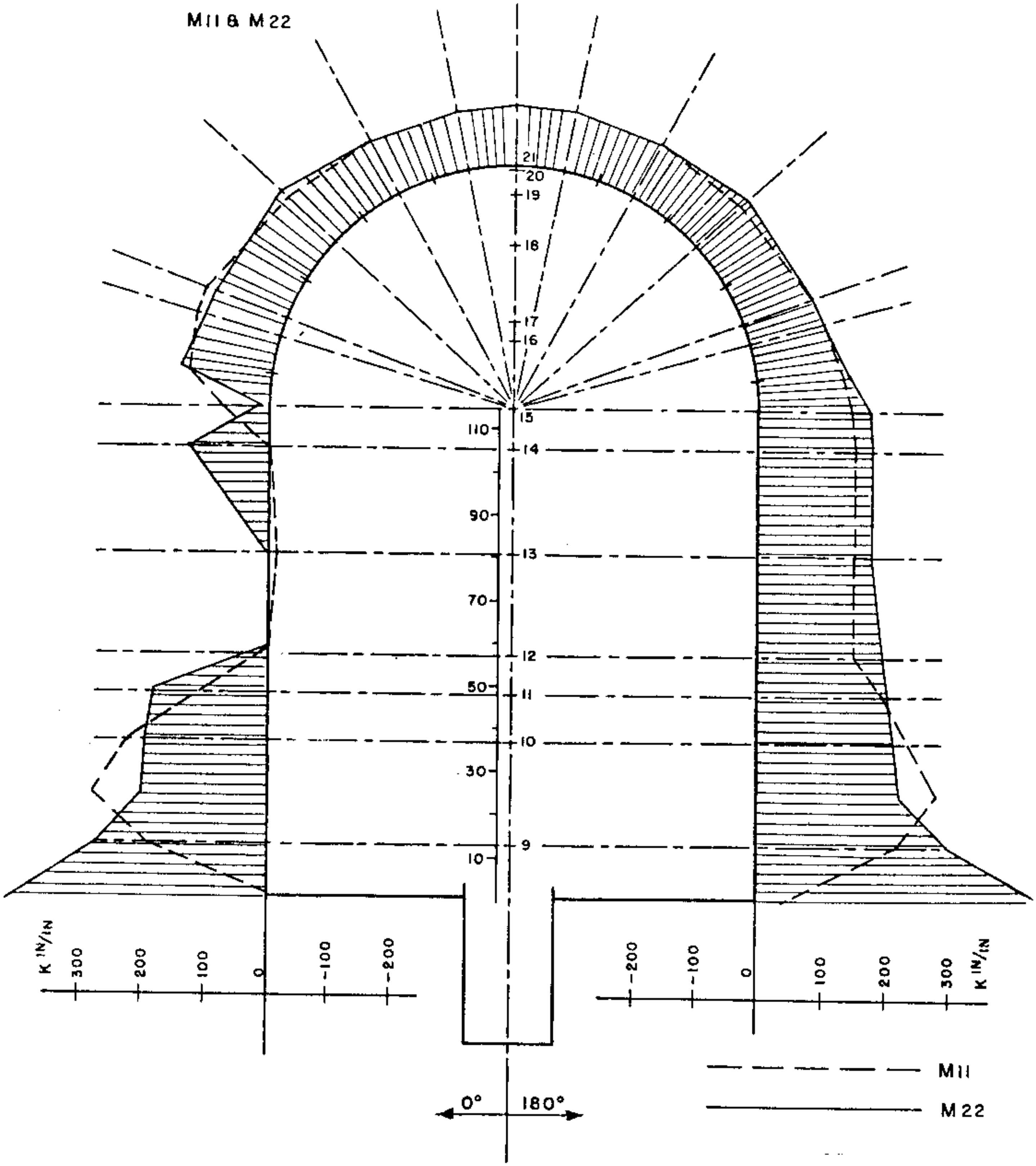


Fig. 5.2.2-33

July 1982

COOK NUCLEAR PLANT

SUPE 2A|GNSLOOM1 & GNSLOOTC LINER THERMAL ACCIDENT

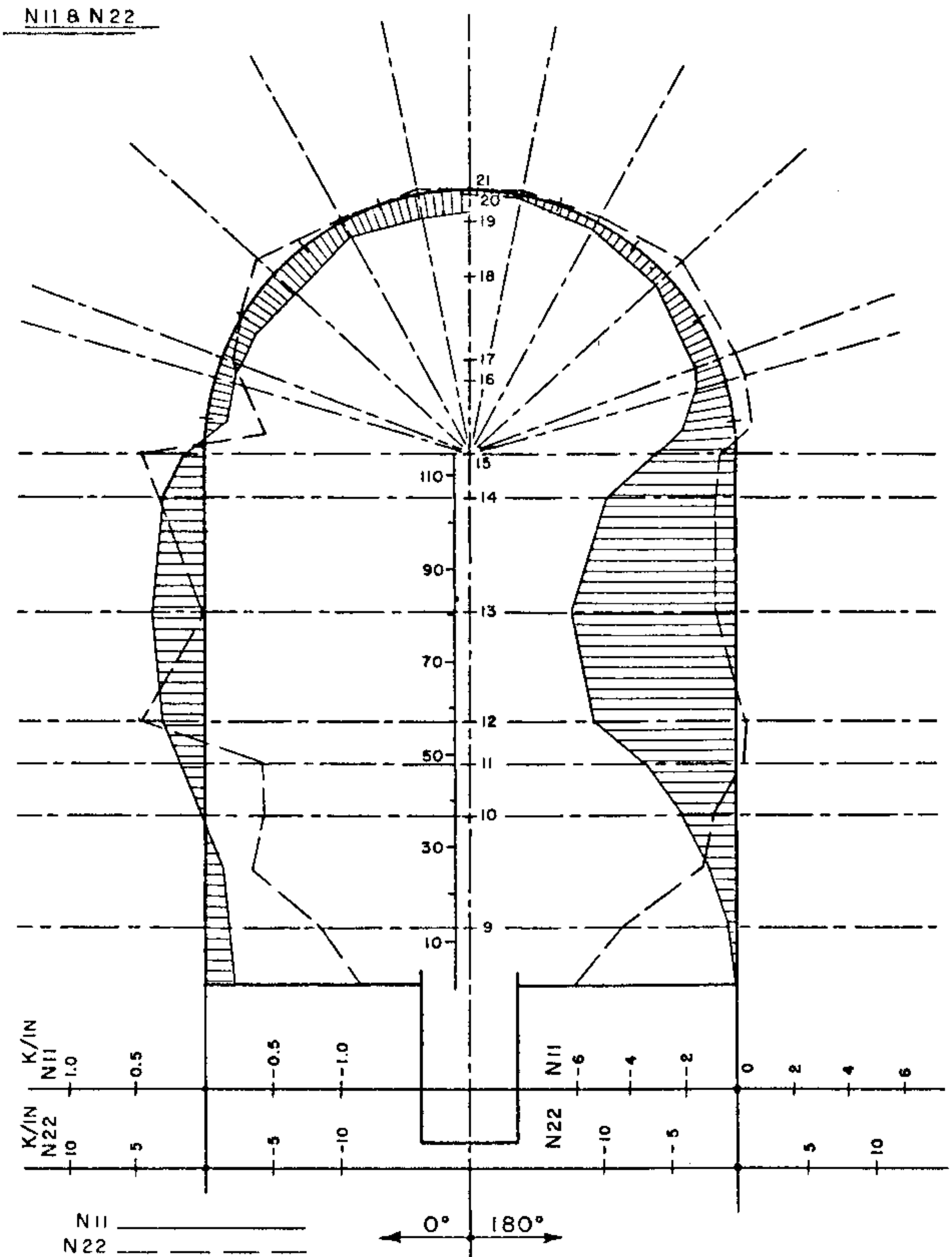


Fig. 5.2.2-34

July 1982

COOK NUCLEAR PLANT

SUPE 17A - LINER THERMAL ACCIDENT
W (DEFLECTION) INCHES

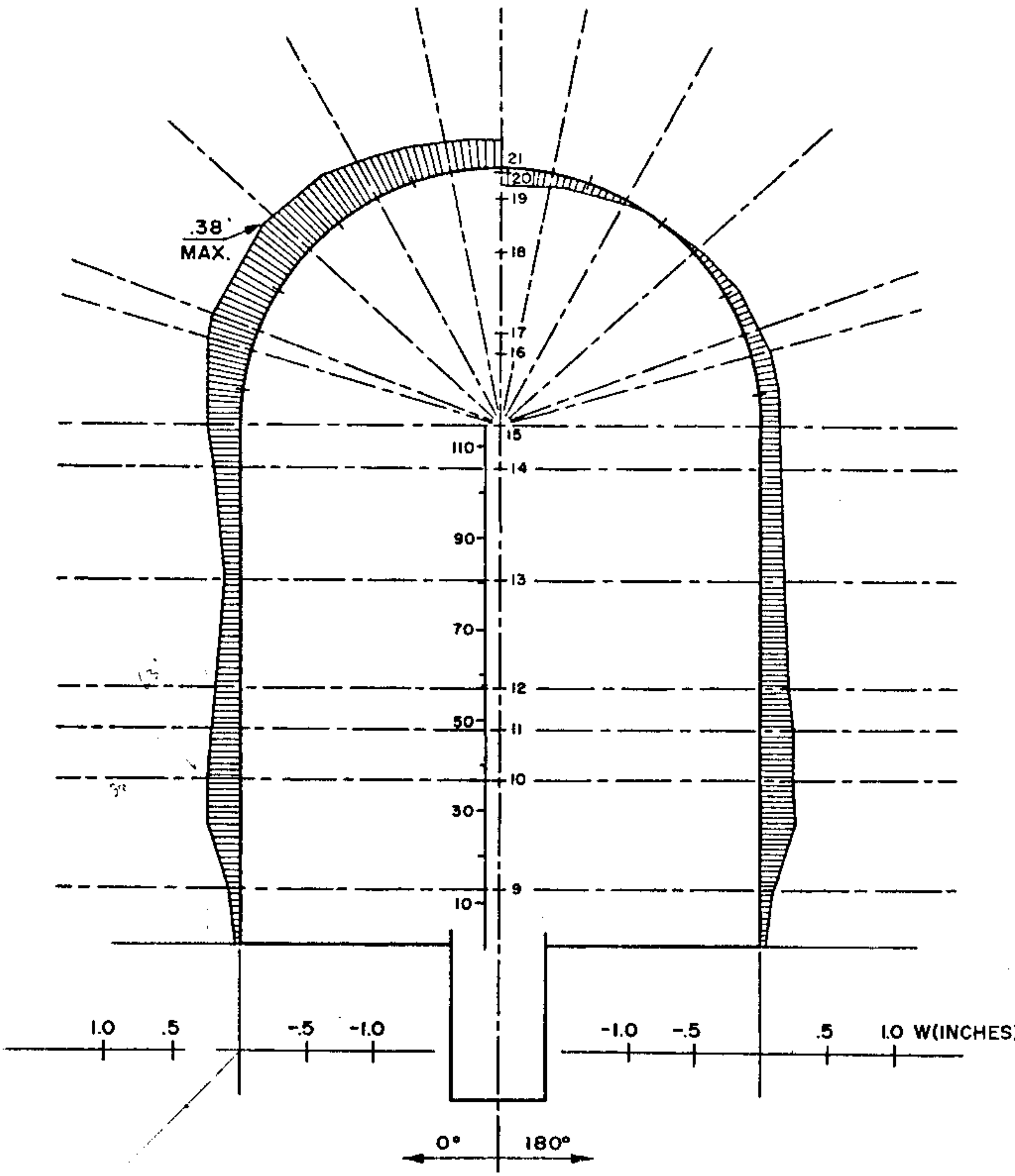


FIG. 5.2.2-35

July 1982

COOK NUCLEAR PLANT

SUPE 17A - LINER THERMAL ACCIDENT
Q12 & Q13 - (KIPS/INCH.)

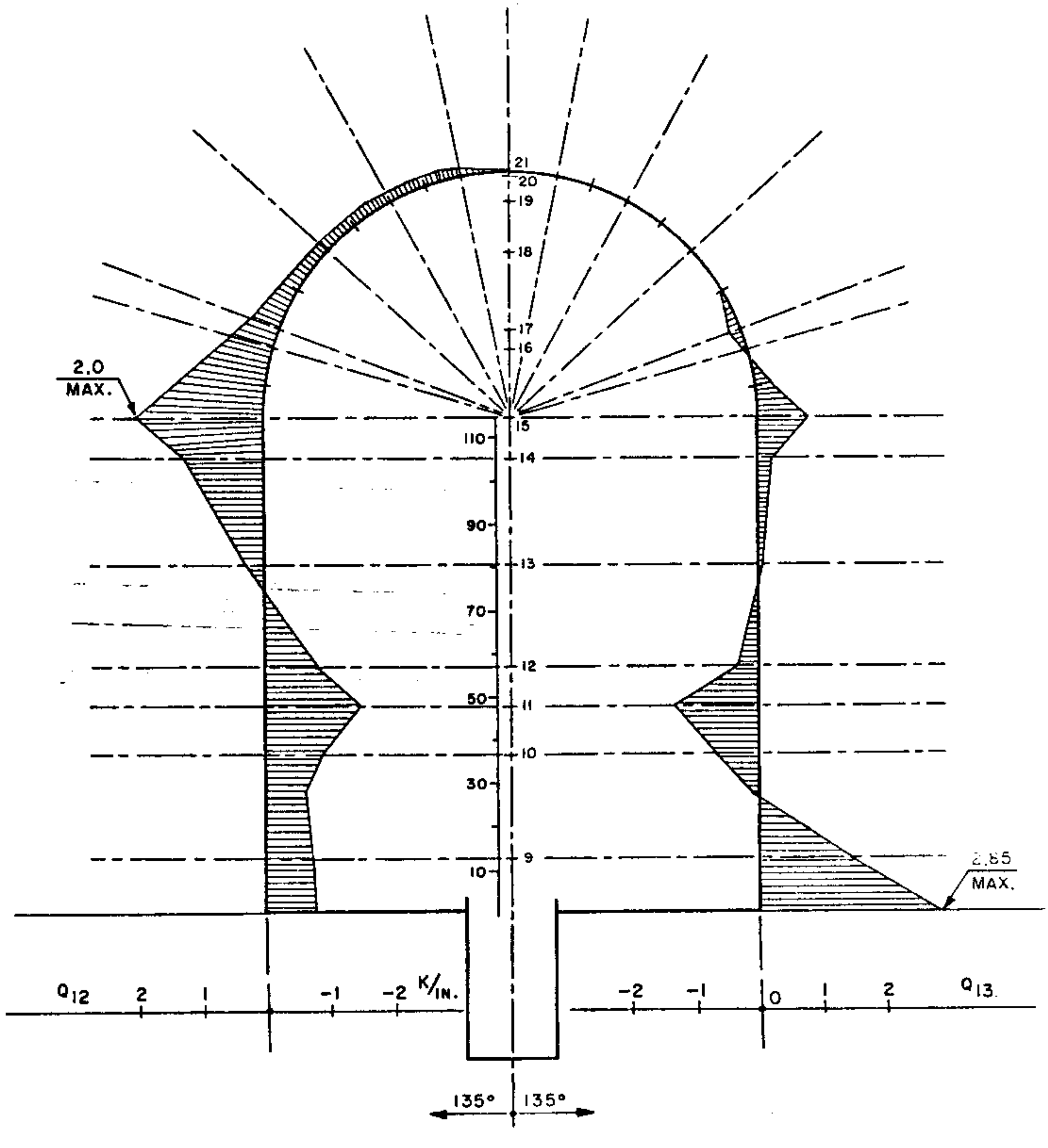


FIG. 5.2.2-36

July 1982

SUPE 2A|GNSLOOM1 & GNSLOOTO LINER THERMAL ACCIDENT

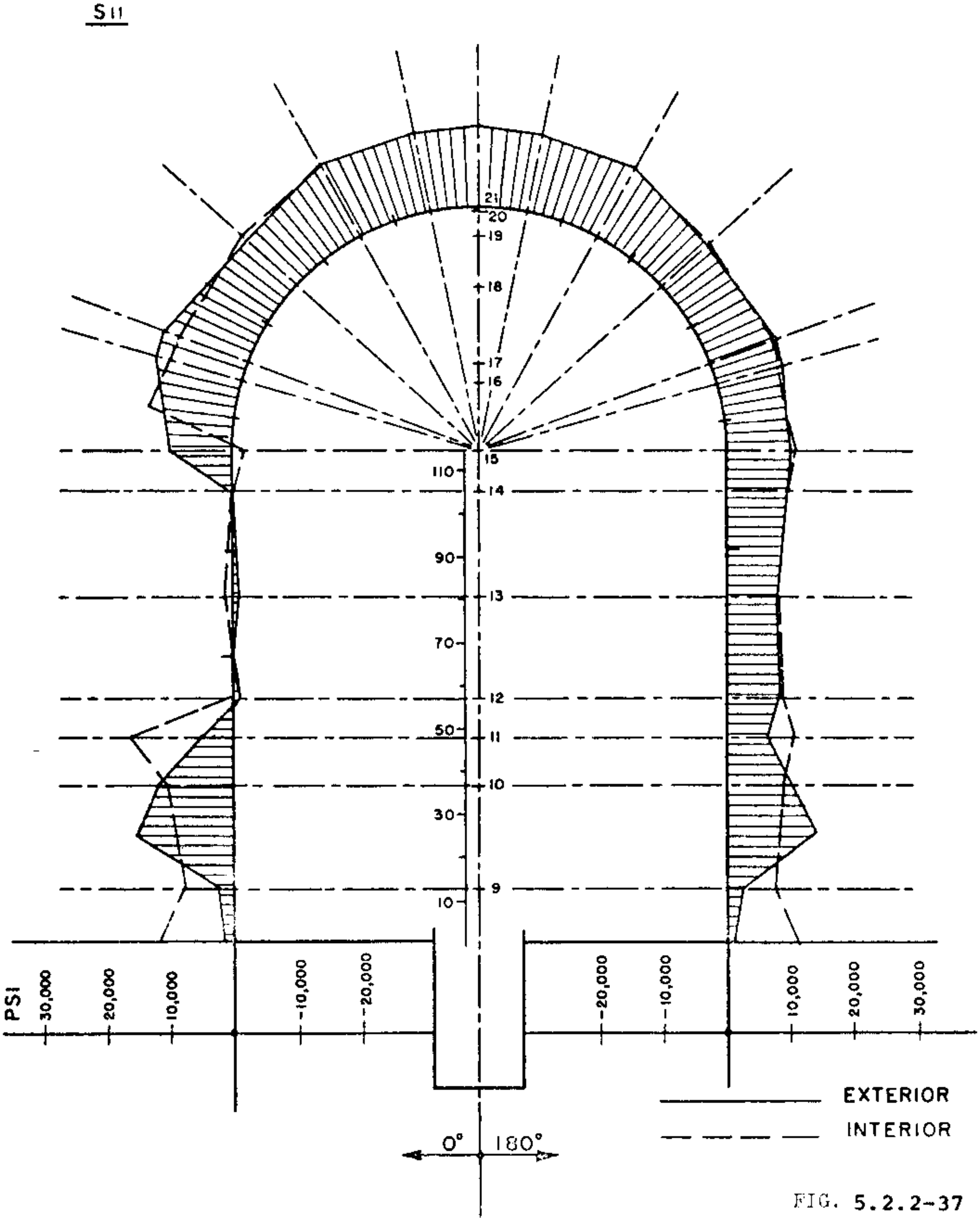


FIG. 5.2.2-37

July 1982

COOK NUCLEAR PLANT

SUPE 2A|GNSLOOM1 & GNSLOOTO LINER THERMAL ACCIDENT

S22

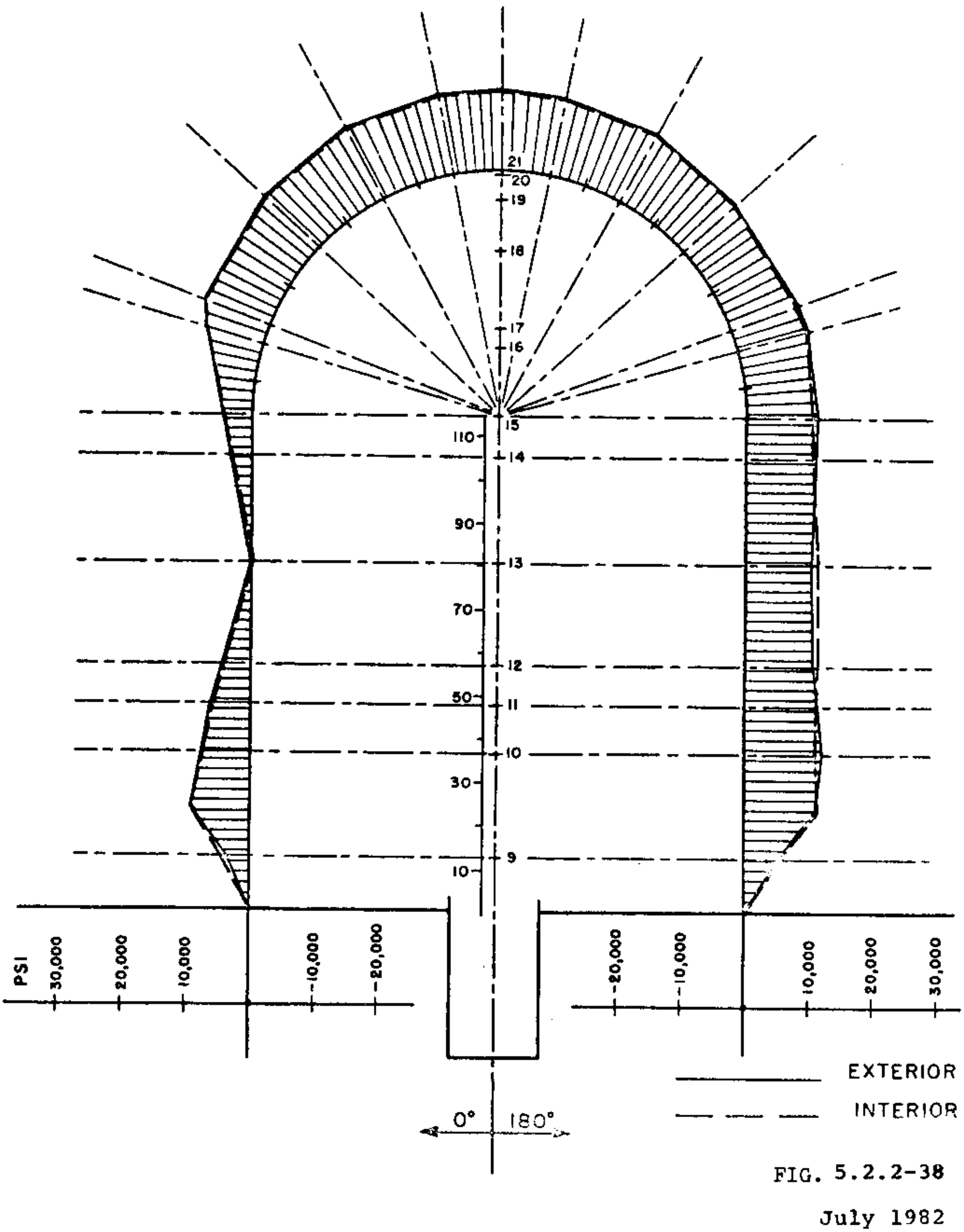


FIG. 5.2.2-38

July 1982

COOK NUCLEAR PLANT

SUPE 2A|GNSLOOMO & GNSLOOTO CONCRETE THERMAL
(NORMAL & ACCIDENT)

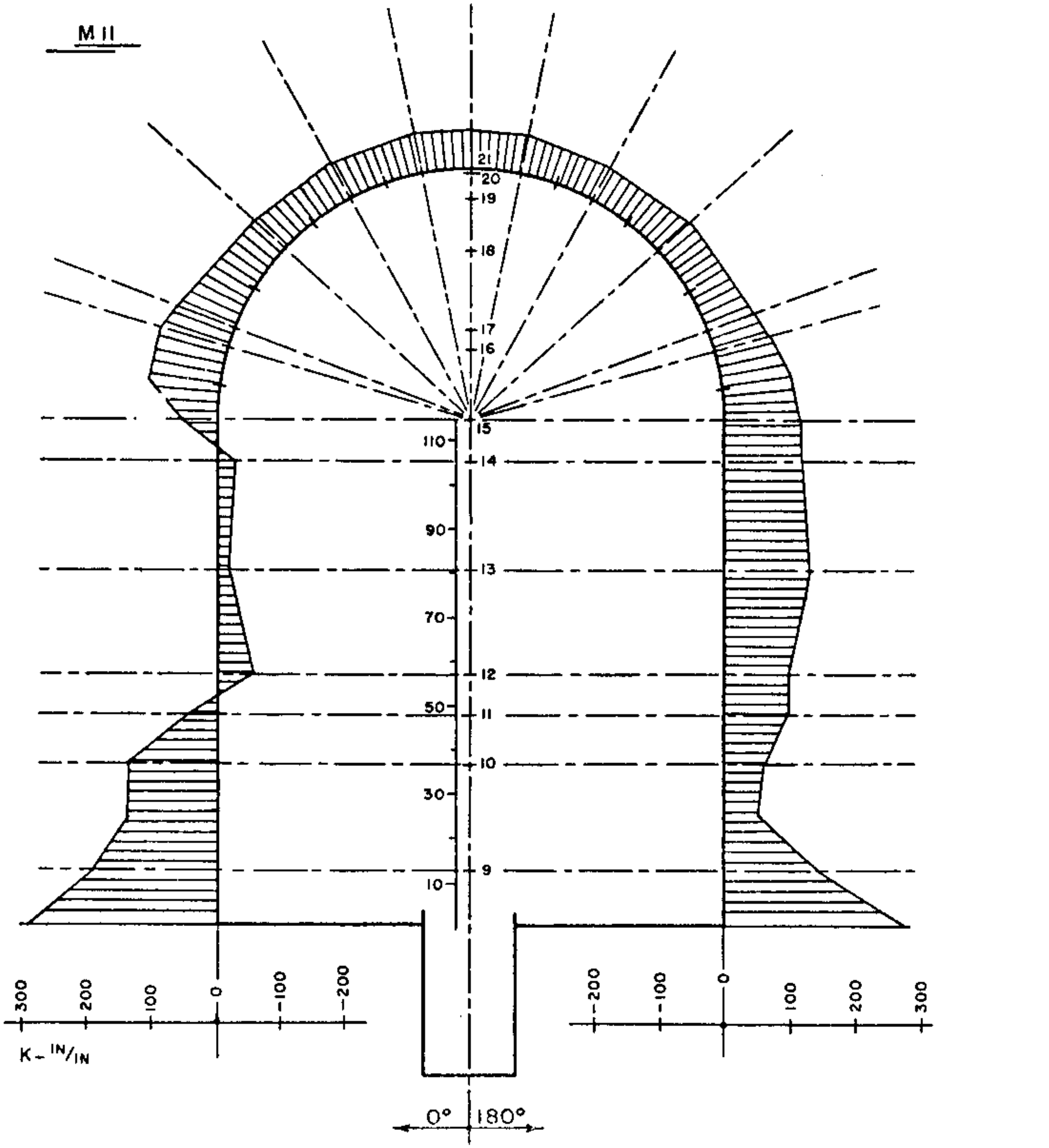


FIG. 5.2.2-39

July 1982

SUPE 2A|GNSLOOM0 & GNSLOOTO CONCRETE THERMAL
(NORMAL & ACCIDENT)

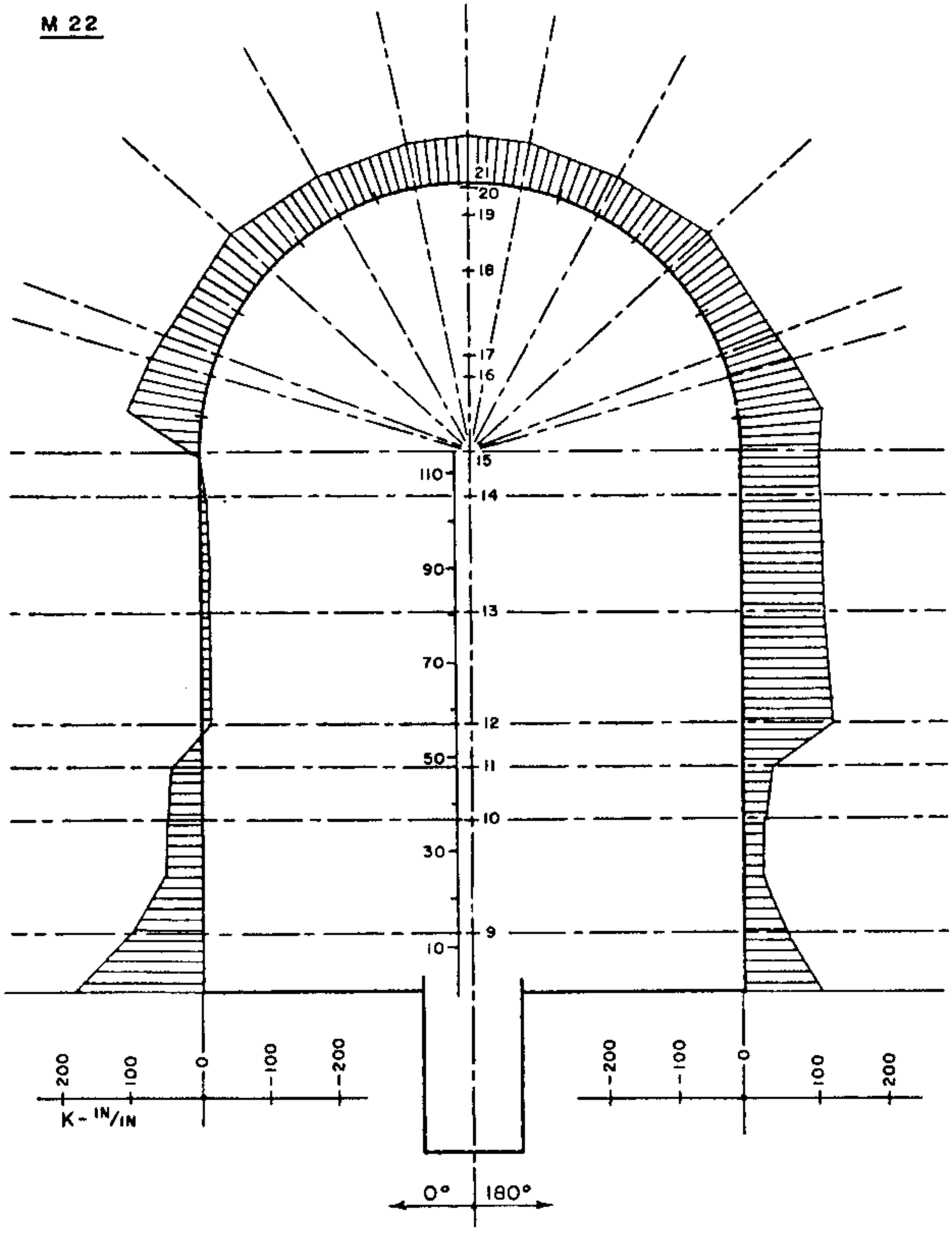


FIG. 5.2.2-40

July 1982

SUPE 2A|GNSLOONO & GNSLOOTO CONCRETE THERMAL
(NORMAL & ACCIDENT)

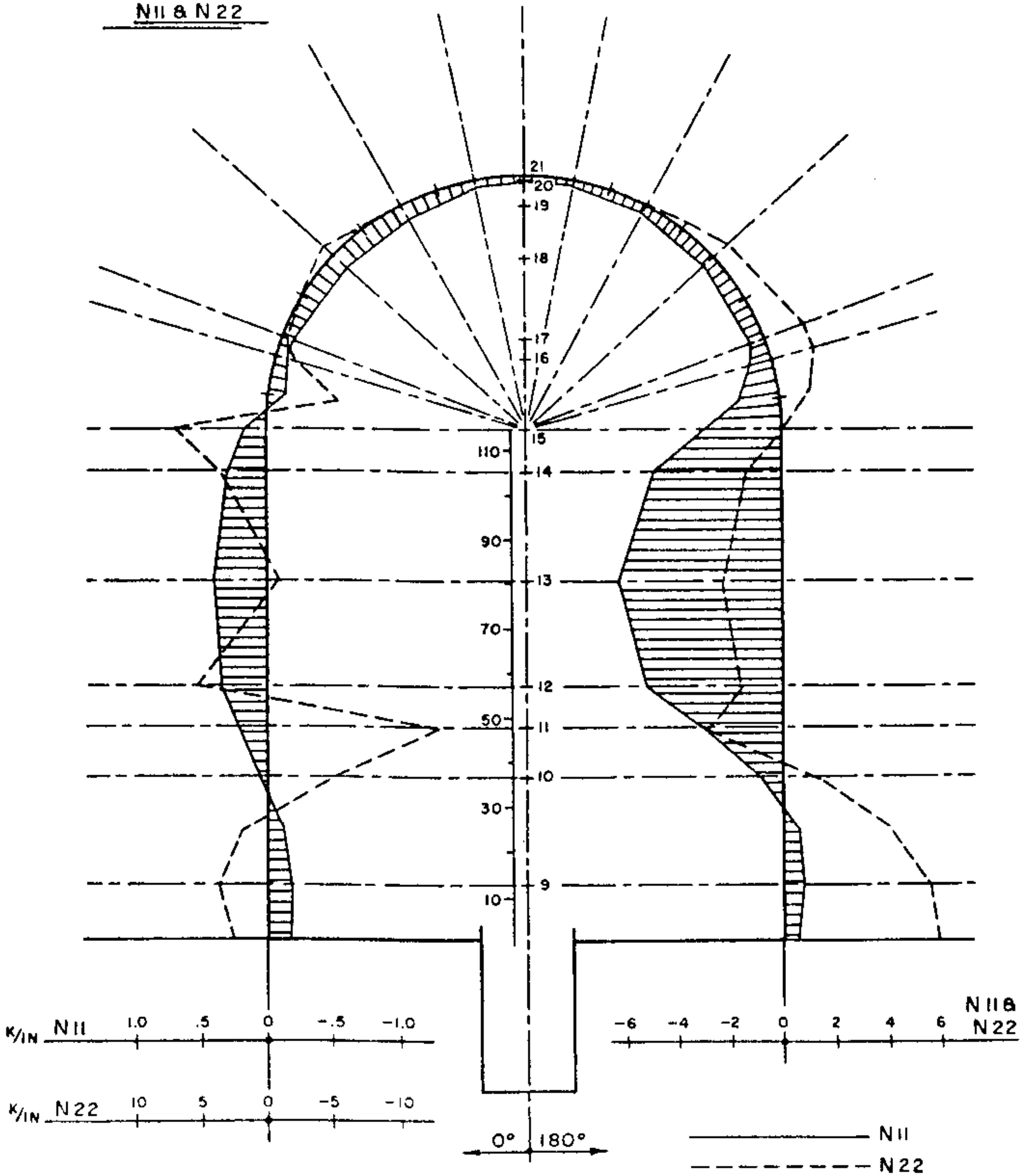


FIG. 5.2.2-41
July 1982

COOK NUCLEAR PLANT

SUPE 17A - CONCRETE THERMAL (NORMAL & ACCIDENT)
W (DEFLECTION. INCHES)

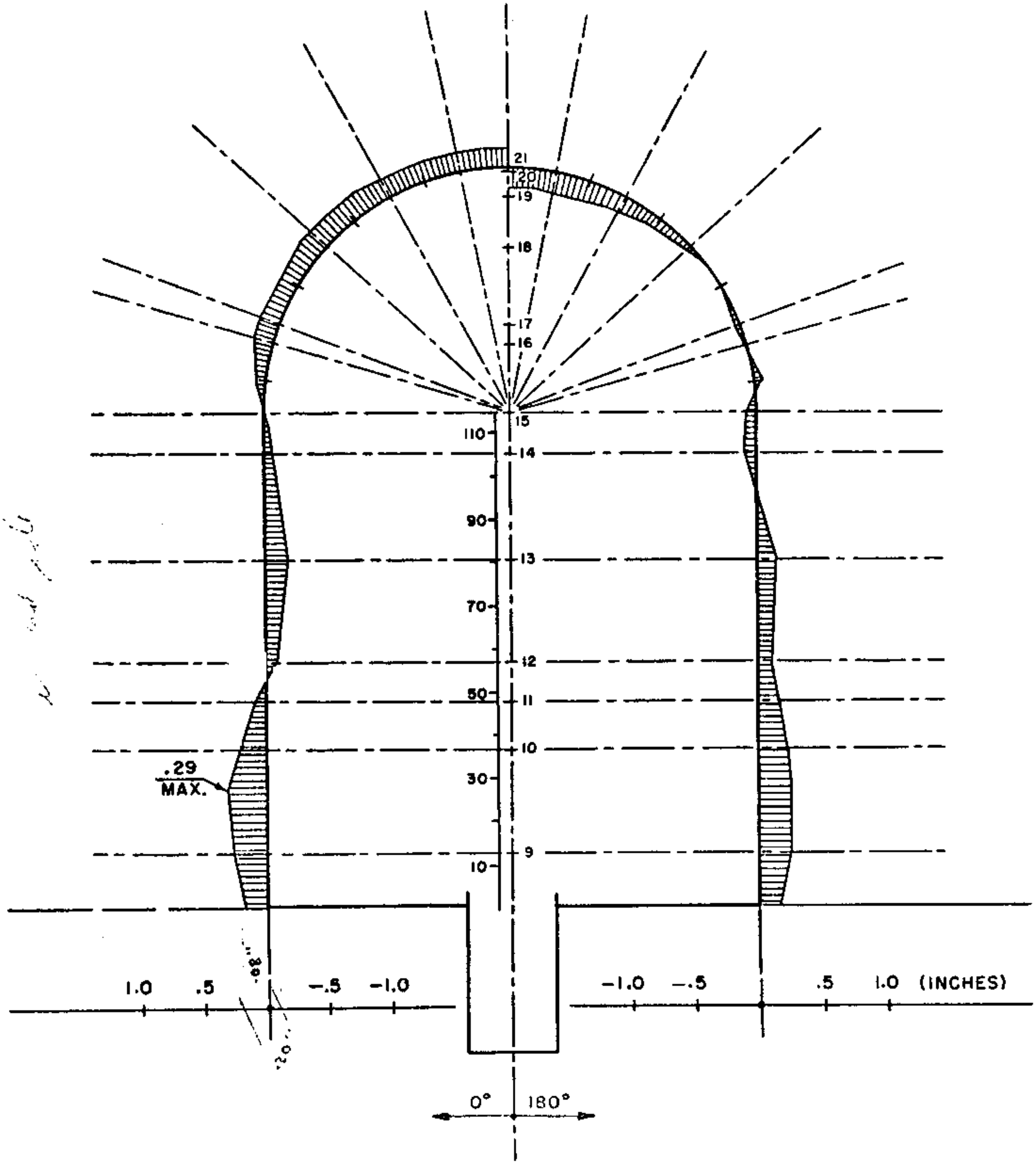


FIG. 5.2.2-42

July 1982

COOK NUCLEAR PLANT

SUPE 17A - CONCRETE THERMAL (NORMAL & ACCIDENT)
Q12 & Q13 (K/IN)

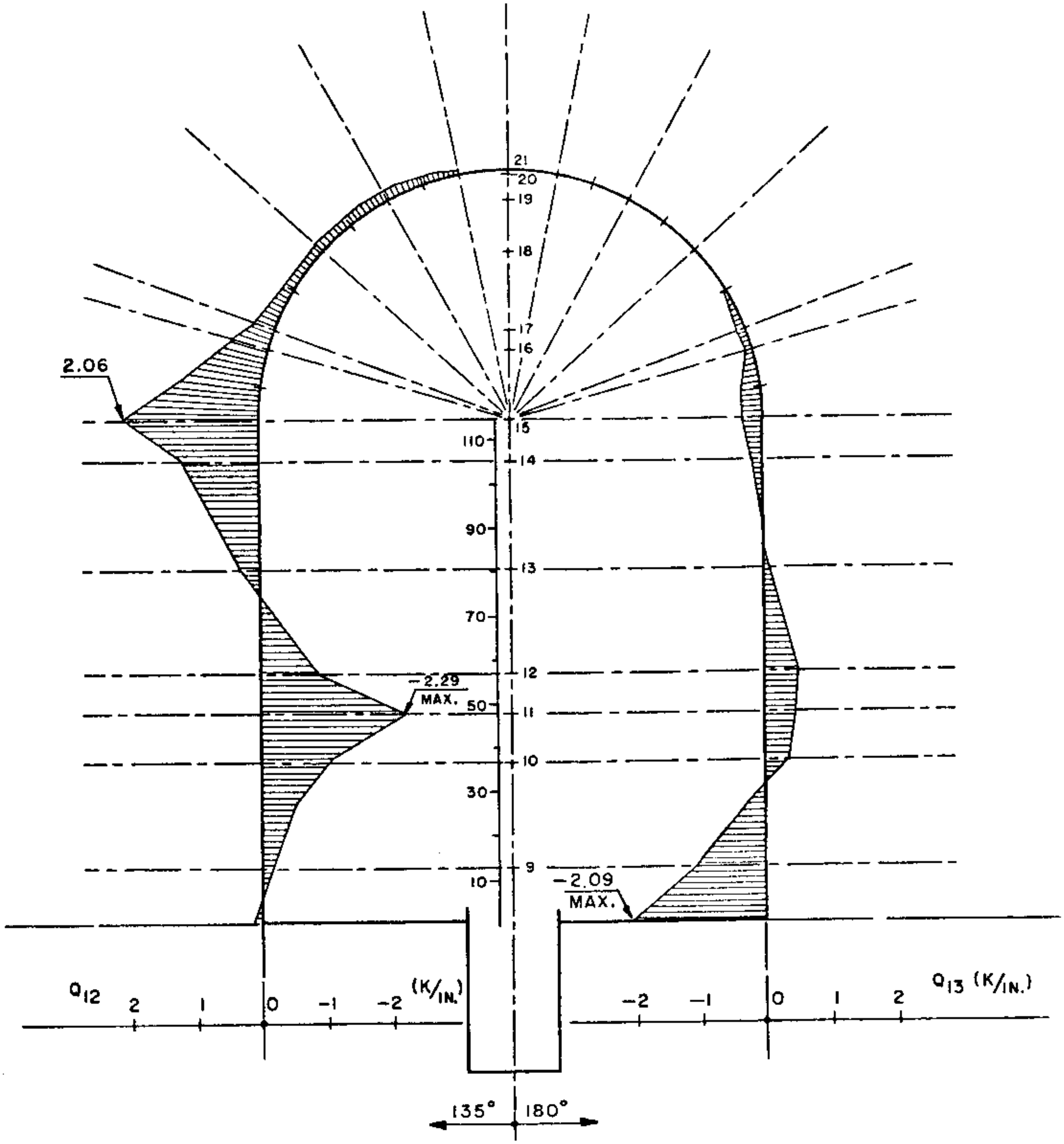


Fig. 5.2.2-43

July 1982

SUPE 2A|GNSLCOM0 & GNSLOOTO CONCRETE THERMAL
(NORMAL & ACCIDENT) MERIDIAN

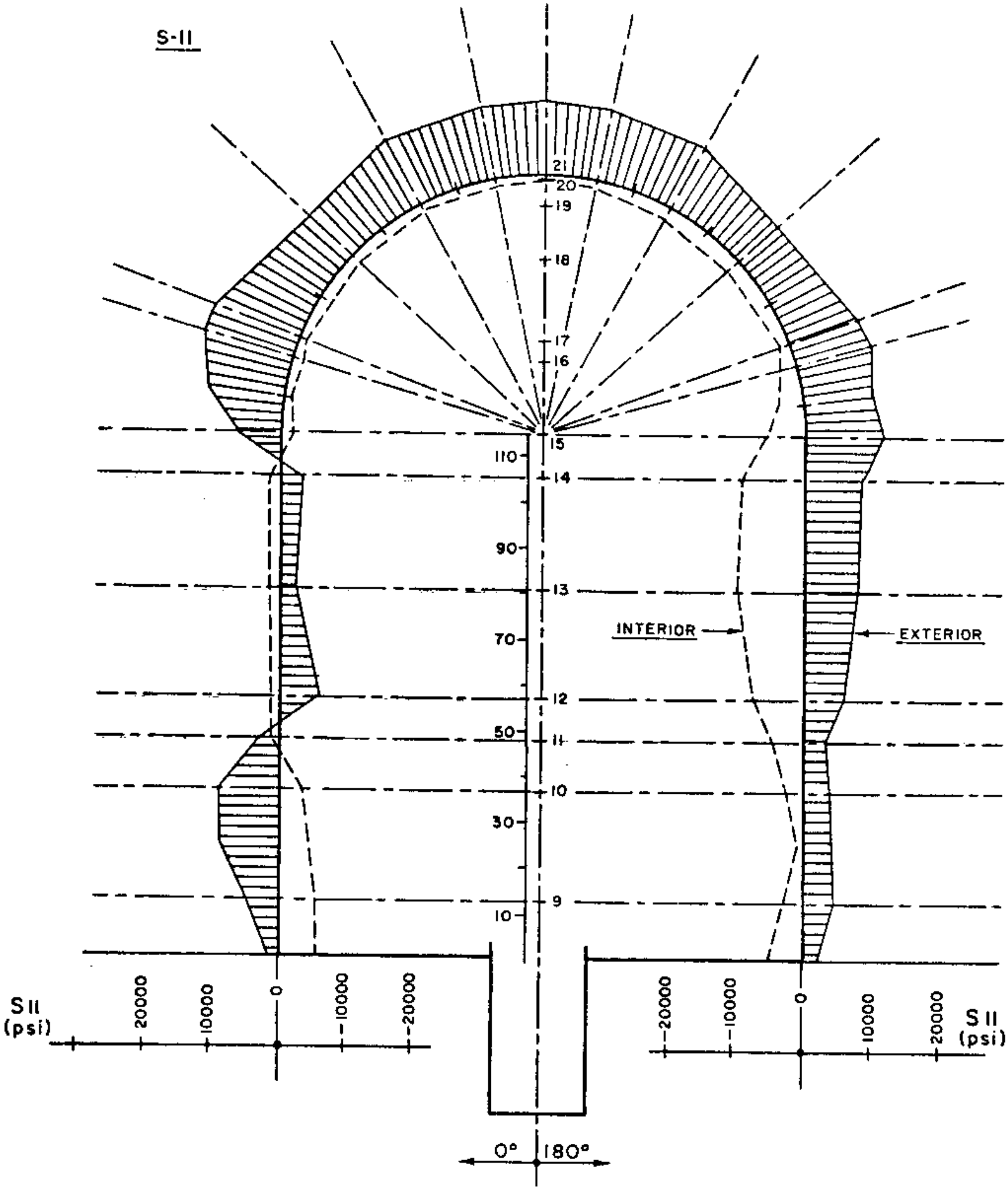


FIG. 5.2.2-44

July 1982

SUPE 2A|GNSLOOMO & GNSLOOTO CONCRETE THERMAL
(NORMAL & ACCIDENT) HOOP

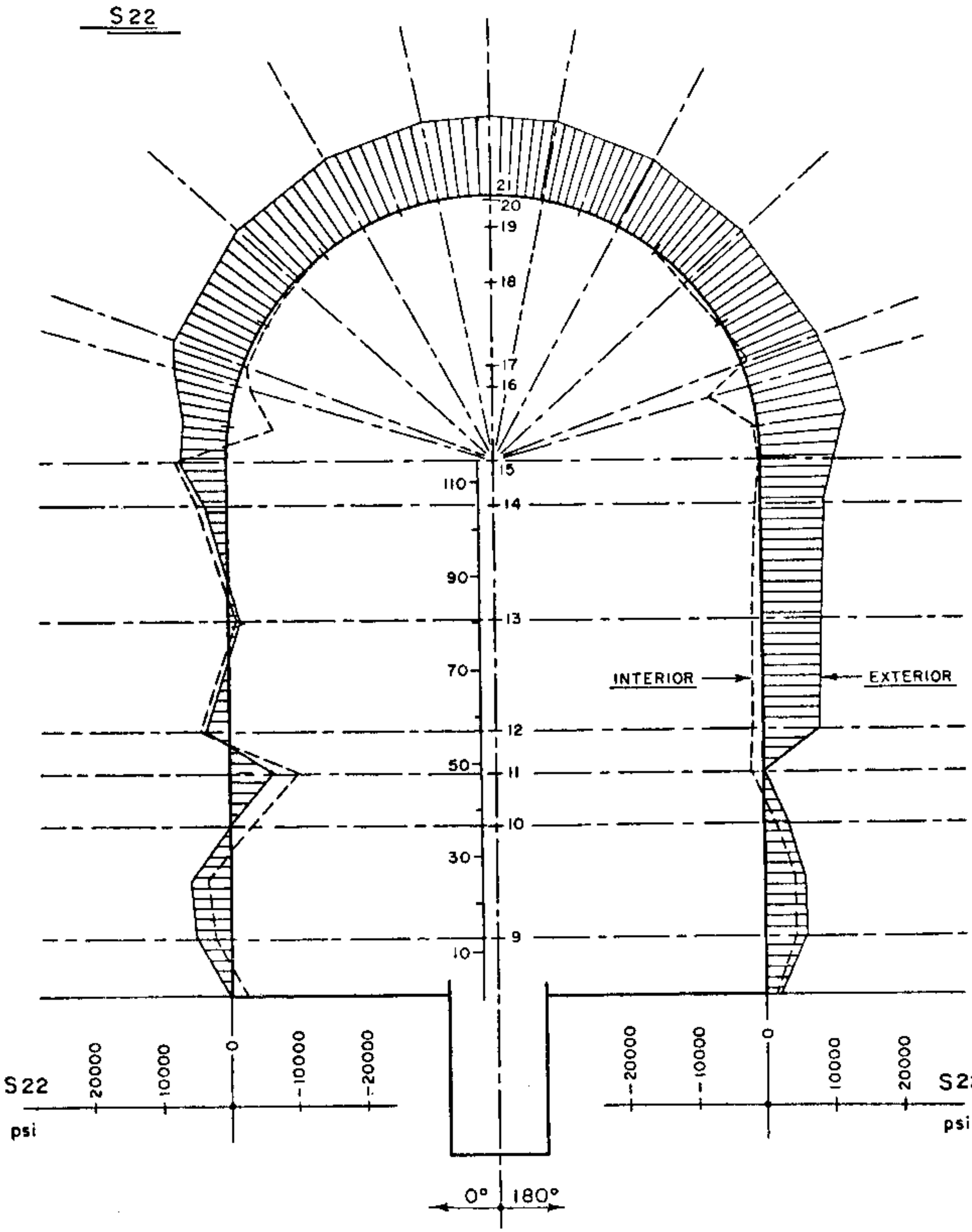


FIG. 5.2.2-45

July 1982

COOK NUCLEAR PLANT

SUPE 2A|GNSLOOTO & GNSLOOMO DESIGN BASIS EARTHQUAKE
FOR (0°): OPP. SIGN FOR 180°

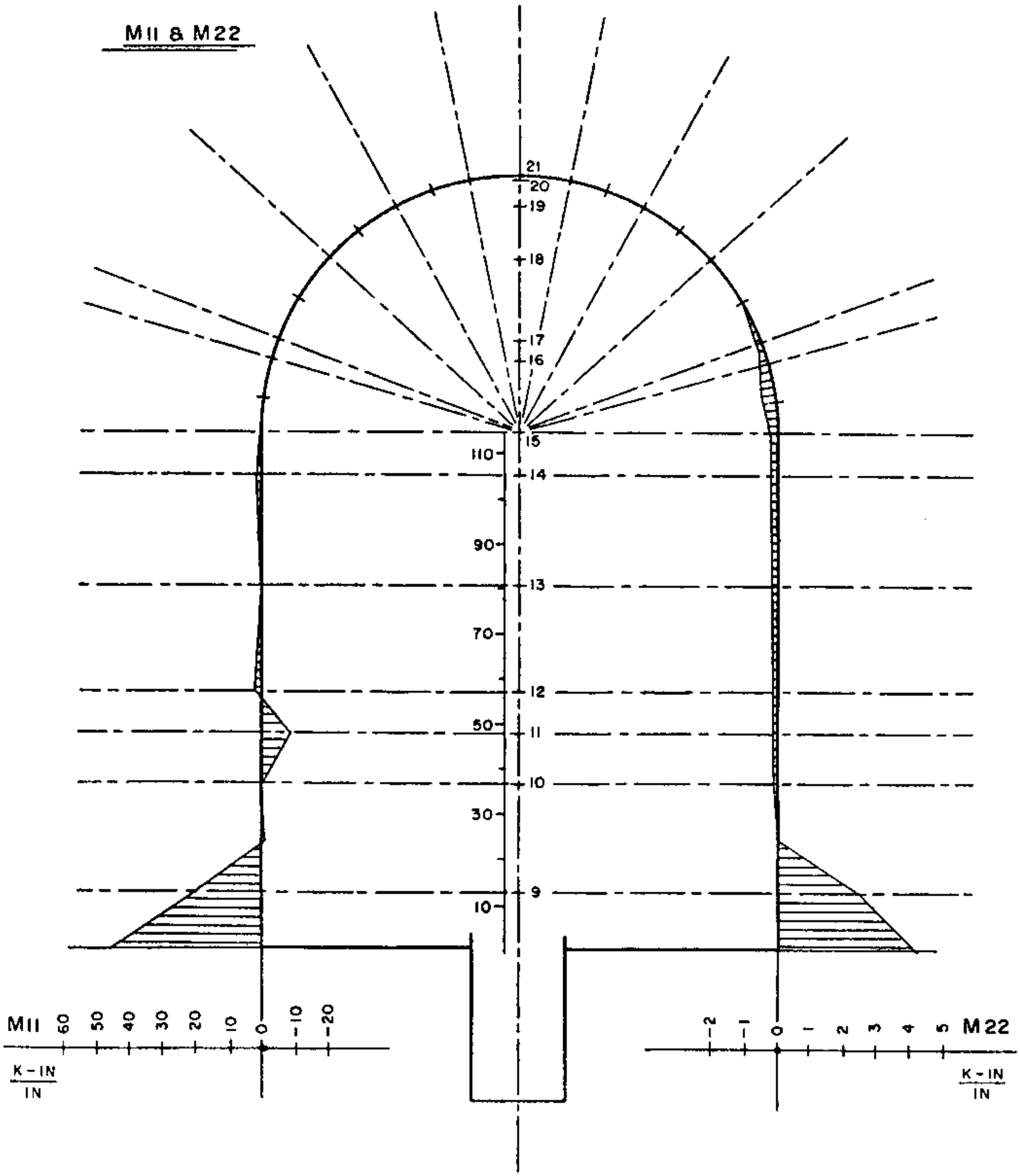


FIG. 5.2.2-46

July 1982

COOK NUCLEAR PLANT

SUPE 2A|GNSLOOTO & GNSLOOMO DESIGN BASIS EARTHQUAKE
FOR (0°): OPP. SIGN FOR (180°)

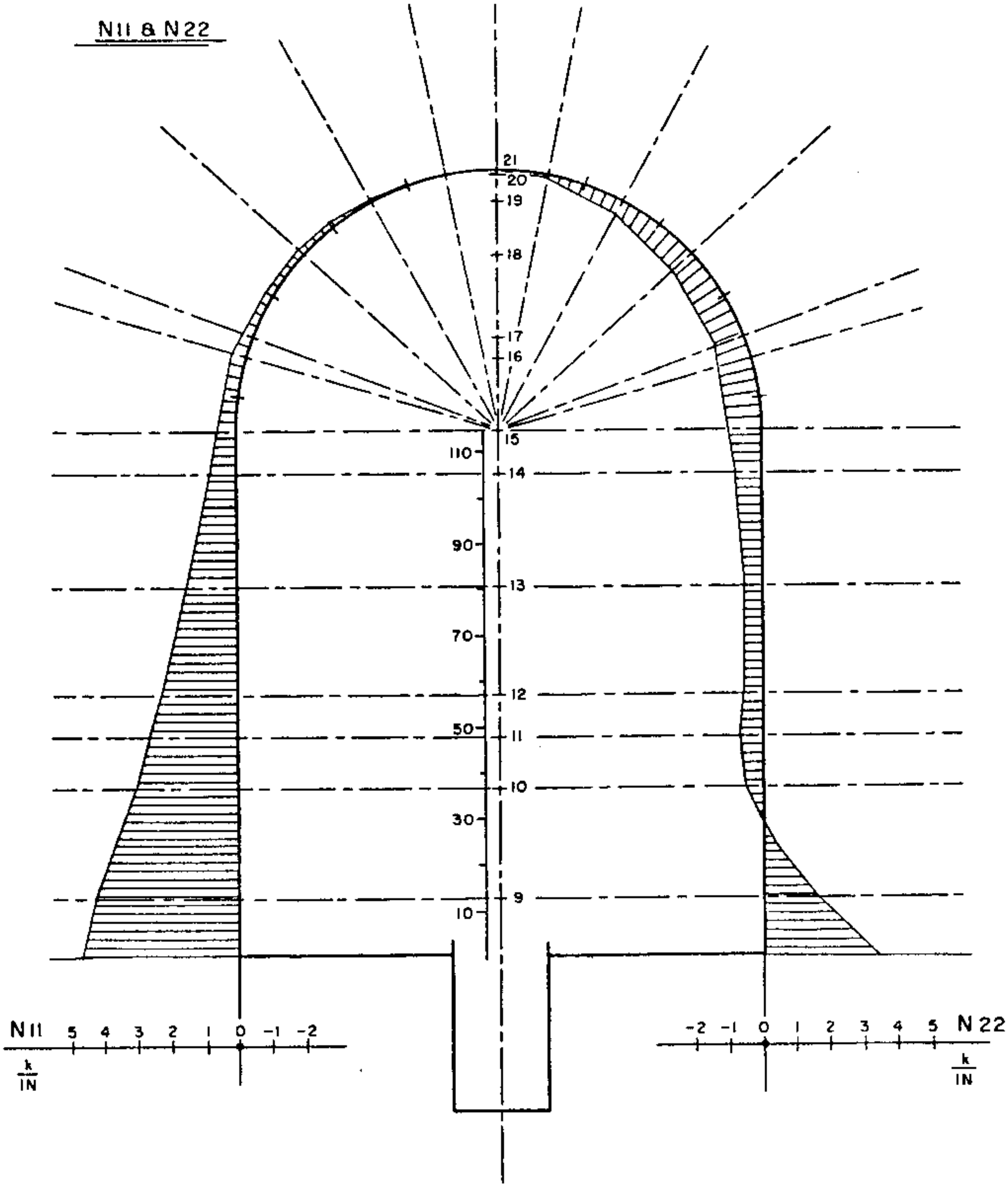


FIG. 5.2.2-47

July 1982

COOK NUCLEAR PLANT

SUPE 17A - DESIGN BASIS EARTHQUAKE
W. (DEFLECTION) - INCHES

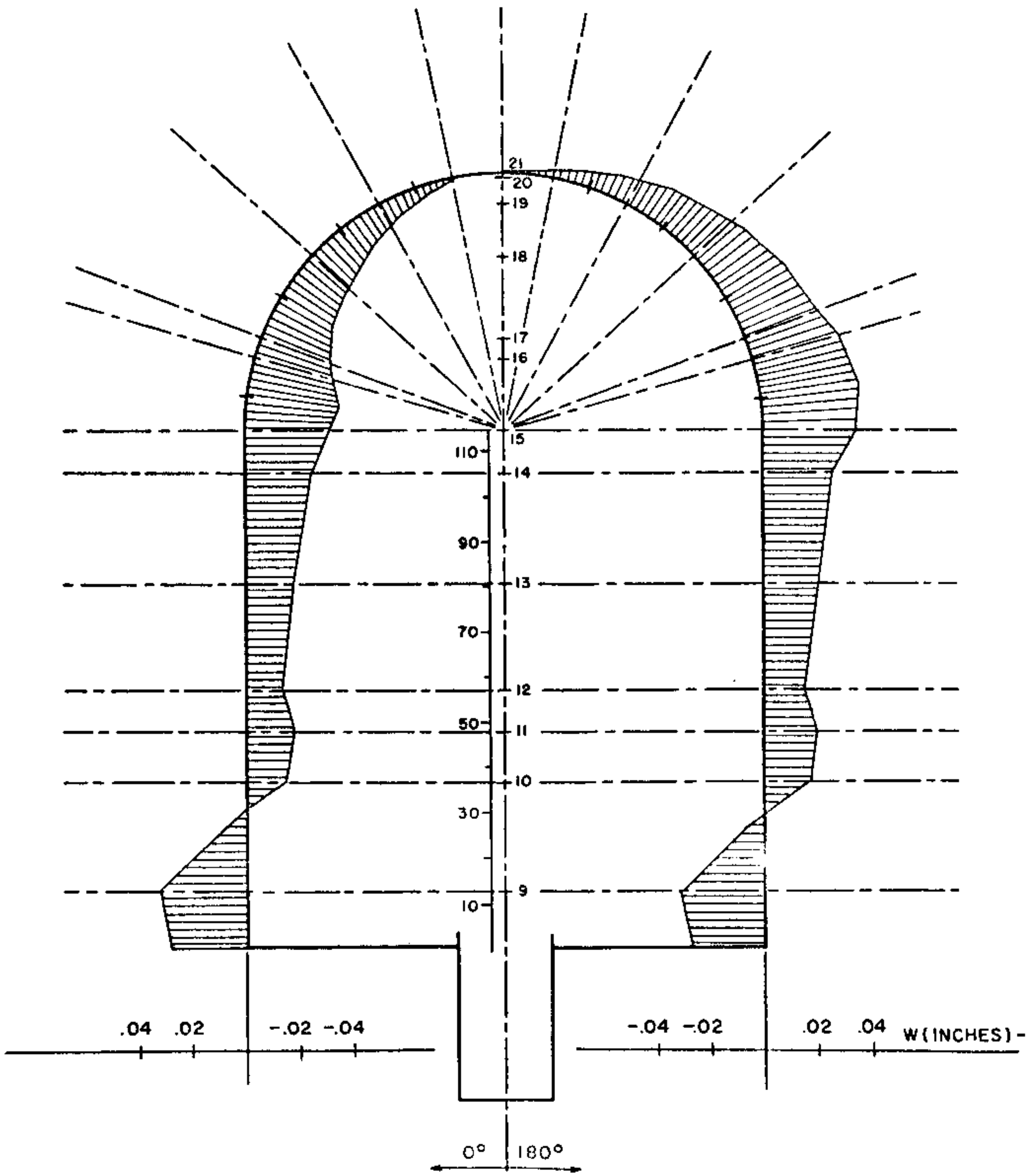


FIG. 5.2.2-48

July 1982

COOK NUCLEAR PLANT

SUPE 17/ - DESIGN BASIS EARTHQUAKE
Q12 & Q13 (KIPS/INCHES)

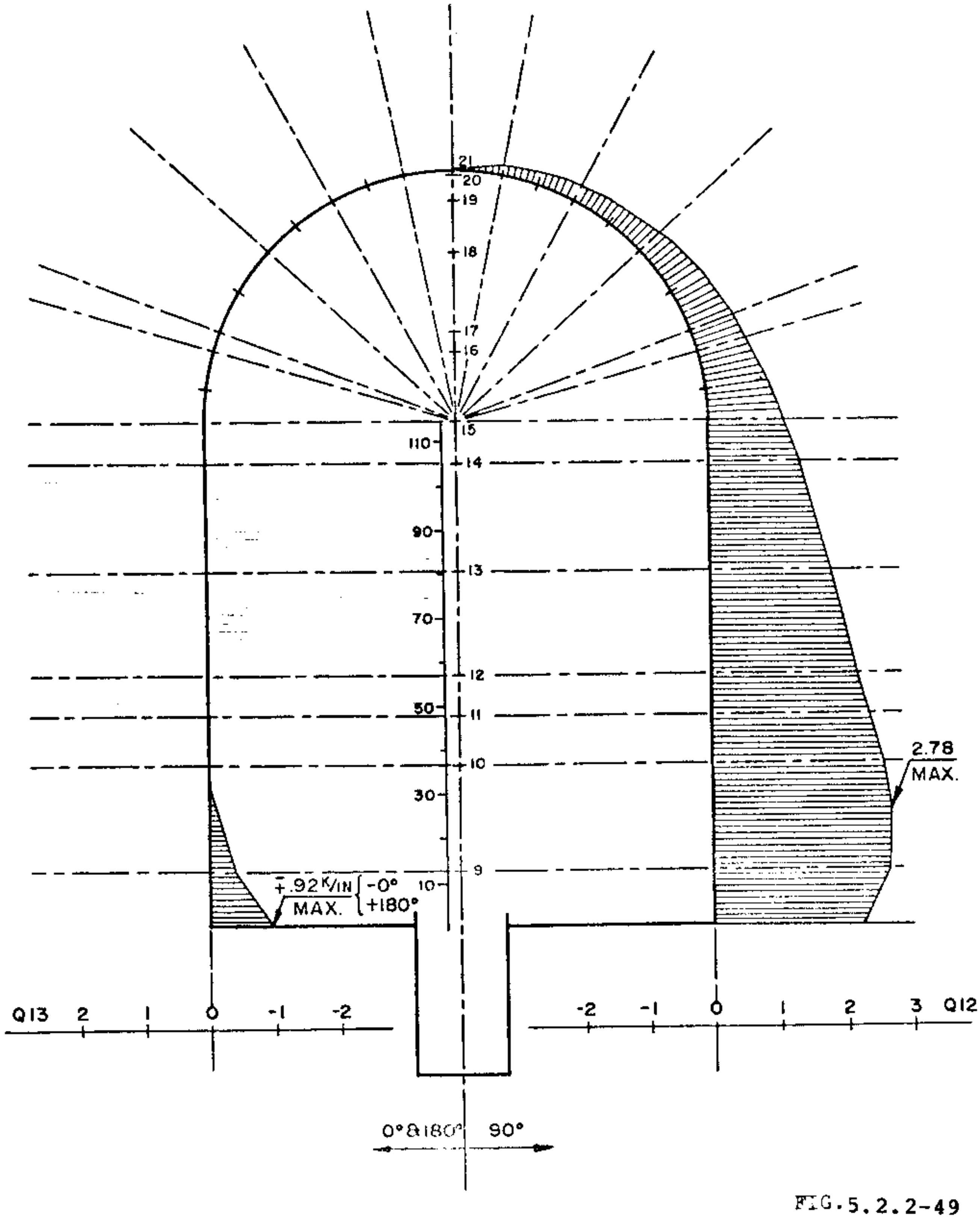


FIG. 5.2.2-49

July 1982

SUPE 2A|GNSLOOTO & GNSLOOMO DESIGN BASIS EARTHQUAKE
FOR (0°): OPP. SIGN FOR 180°

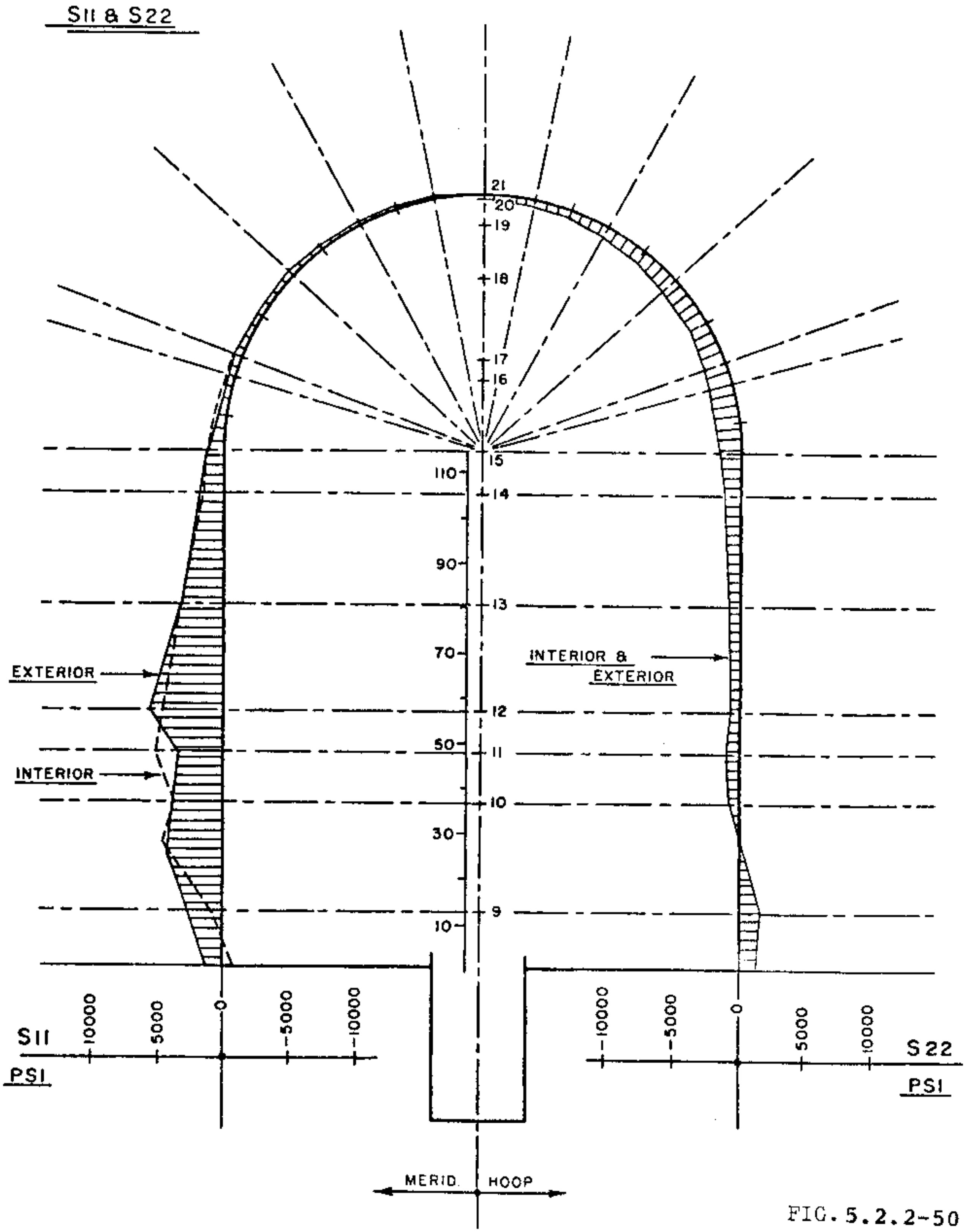


FIG. 5.2.2-50

July 1982

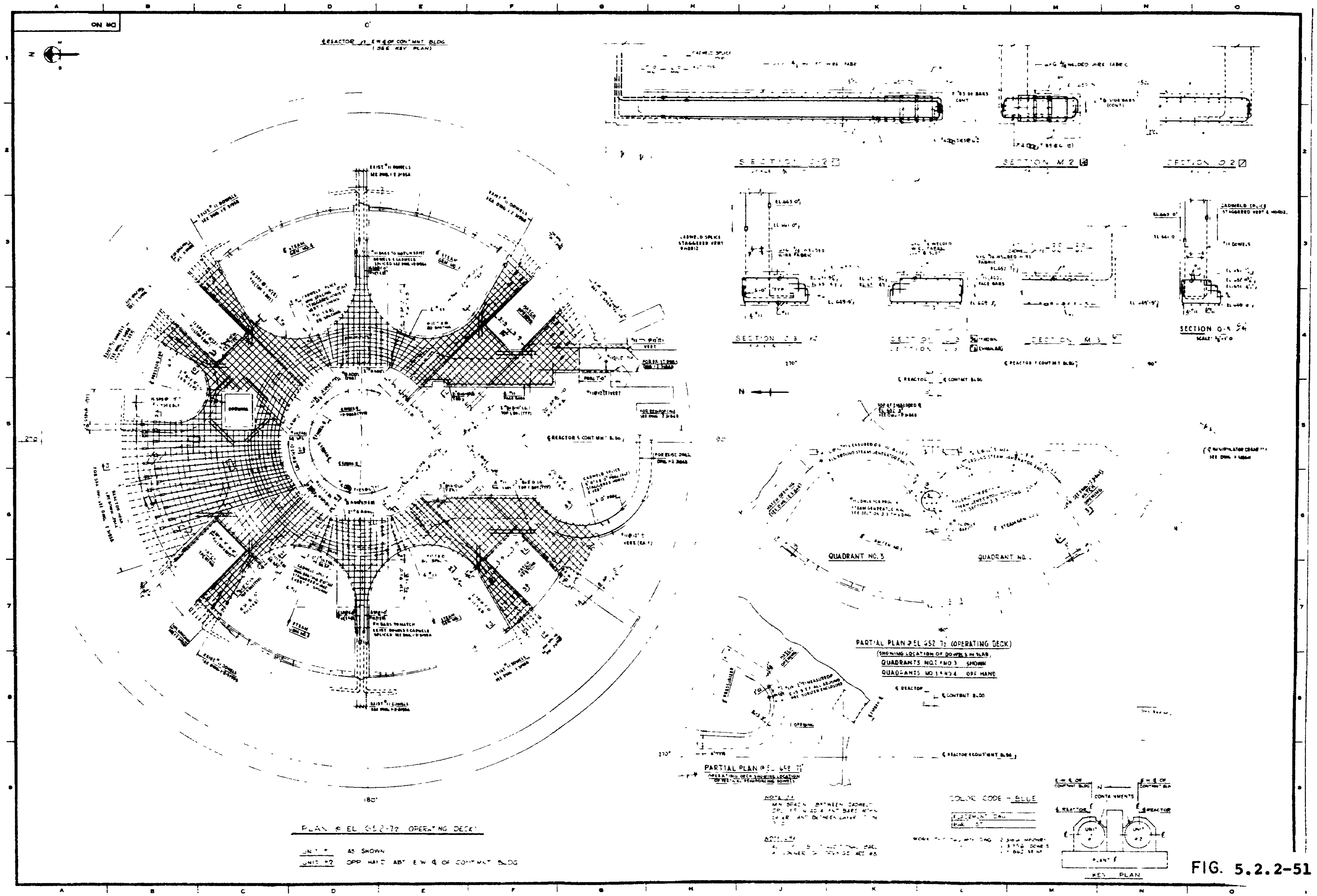


FIG. 5.2.2-51

July 1982

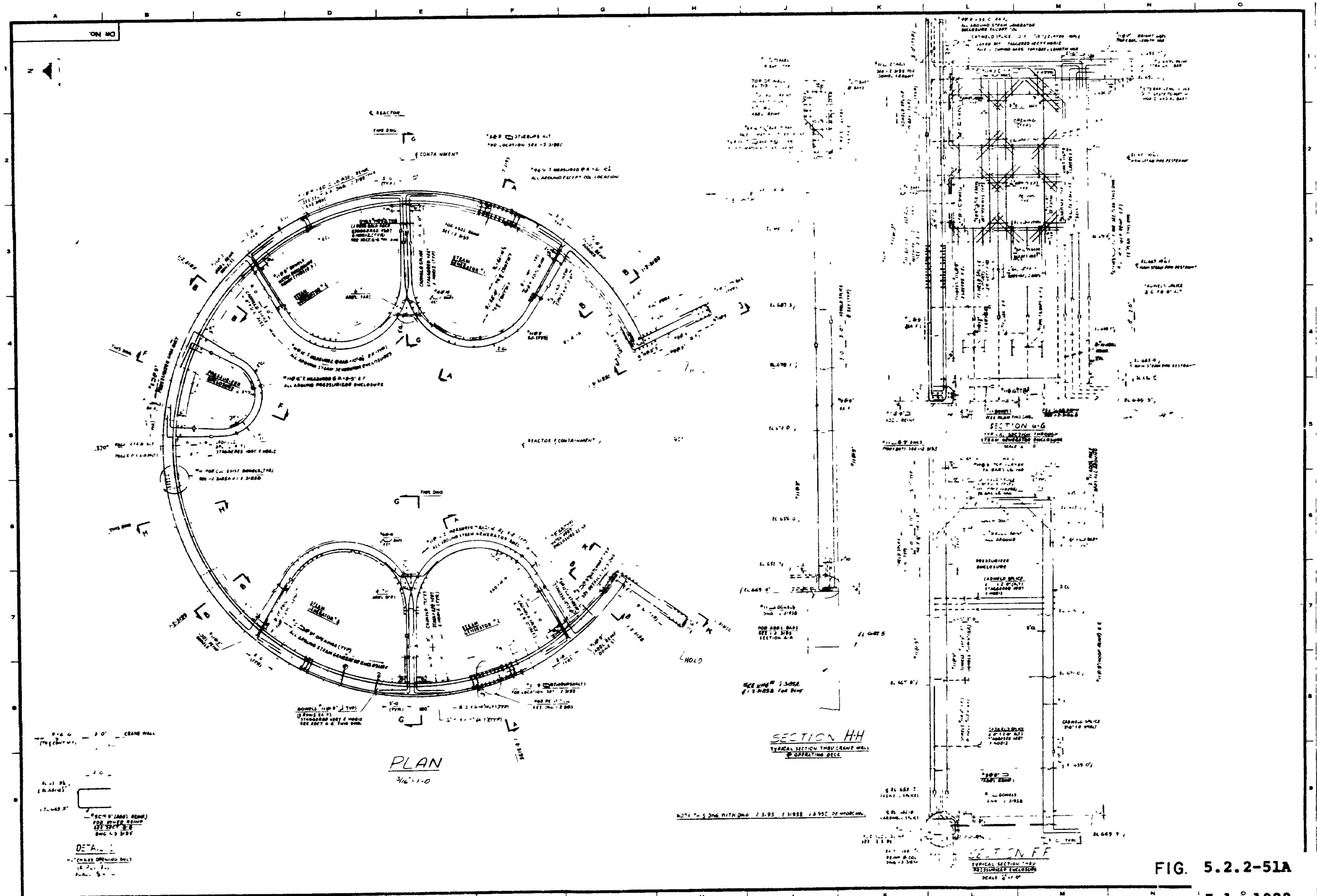


FIG. 5.2.2-51A

July 1982

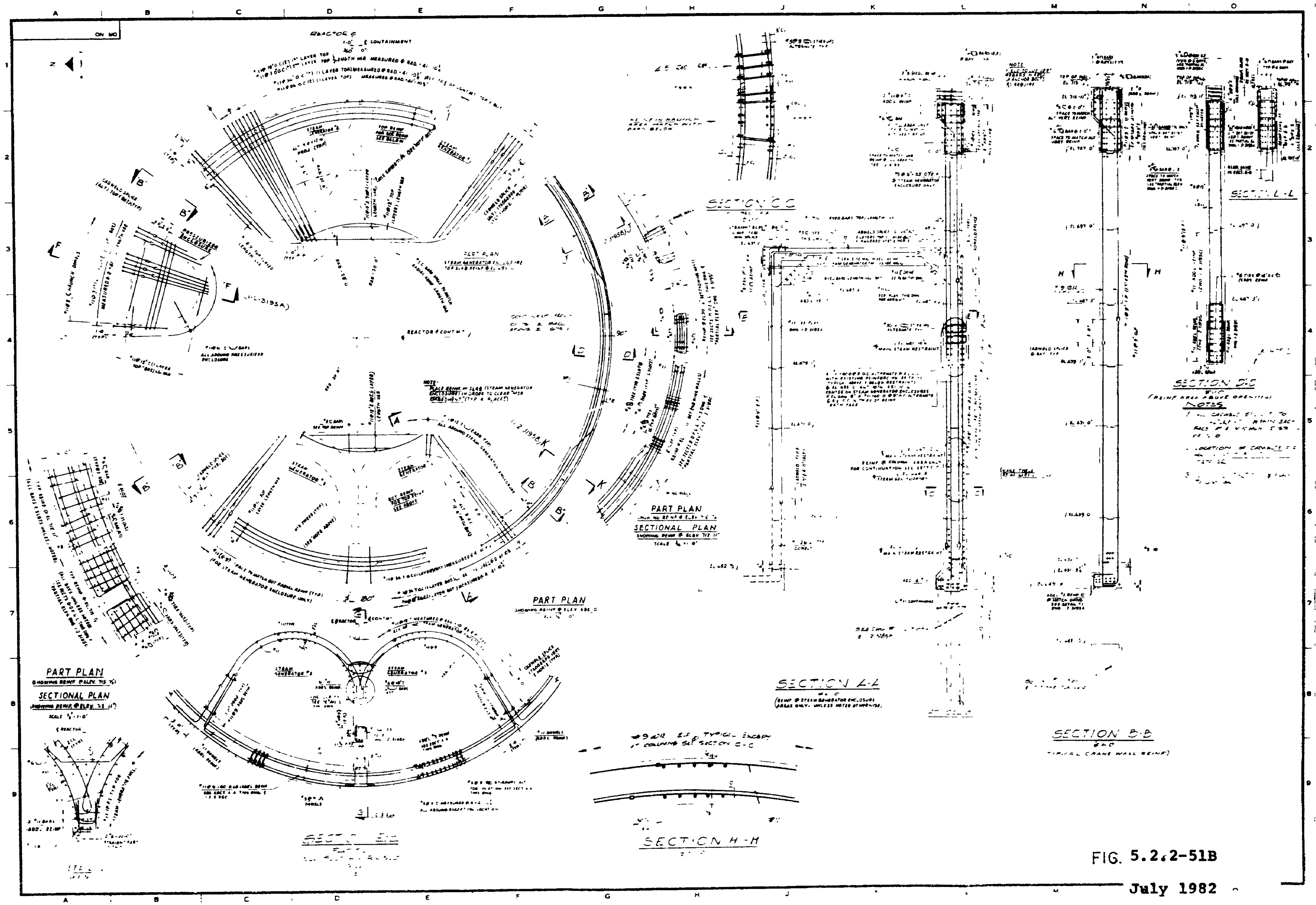
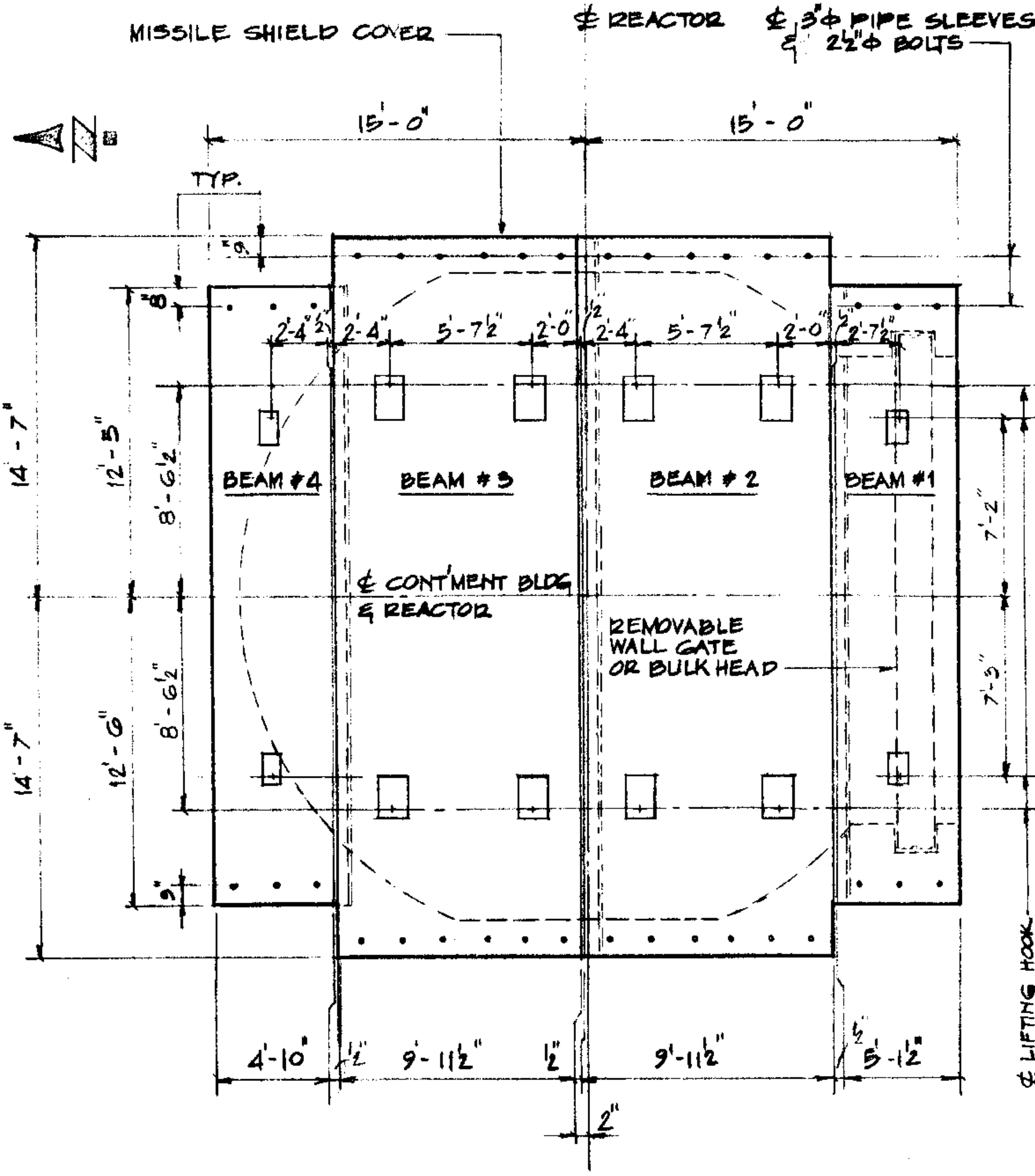


FIG. 5.2.2-51B

July 1982



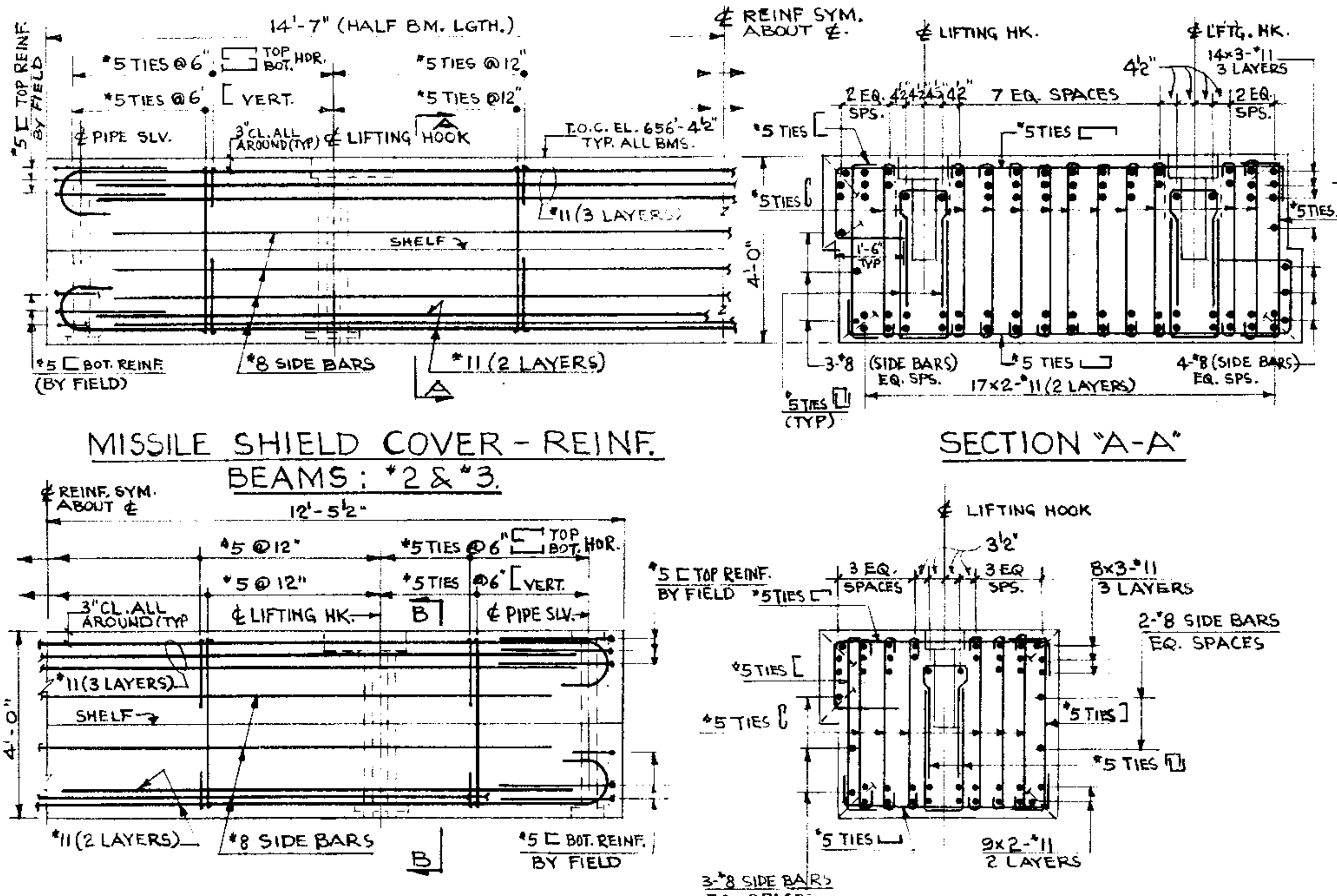
PLAN - MISSILE SHIELD COVER

ON TOP OF REACTOR CAVITY
REMOVABLE WALL
SCALE: 3/16" = 1'-0"

BY: FR

JULY 1982

FIG. 5.2.2-51C
July 1982



MISSILE SHIELD COVER - REINF.
BEAMS: #2 & #3.

SECTION "A-A"

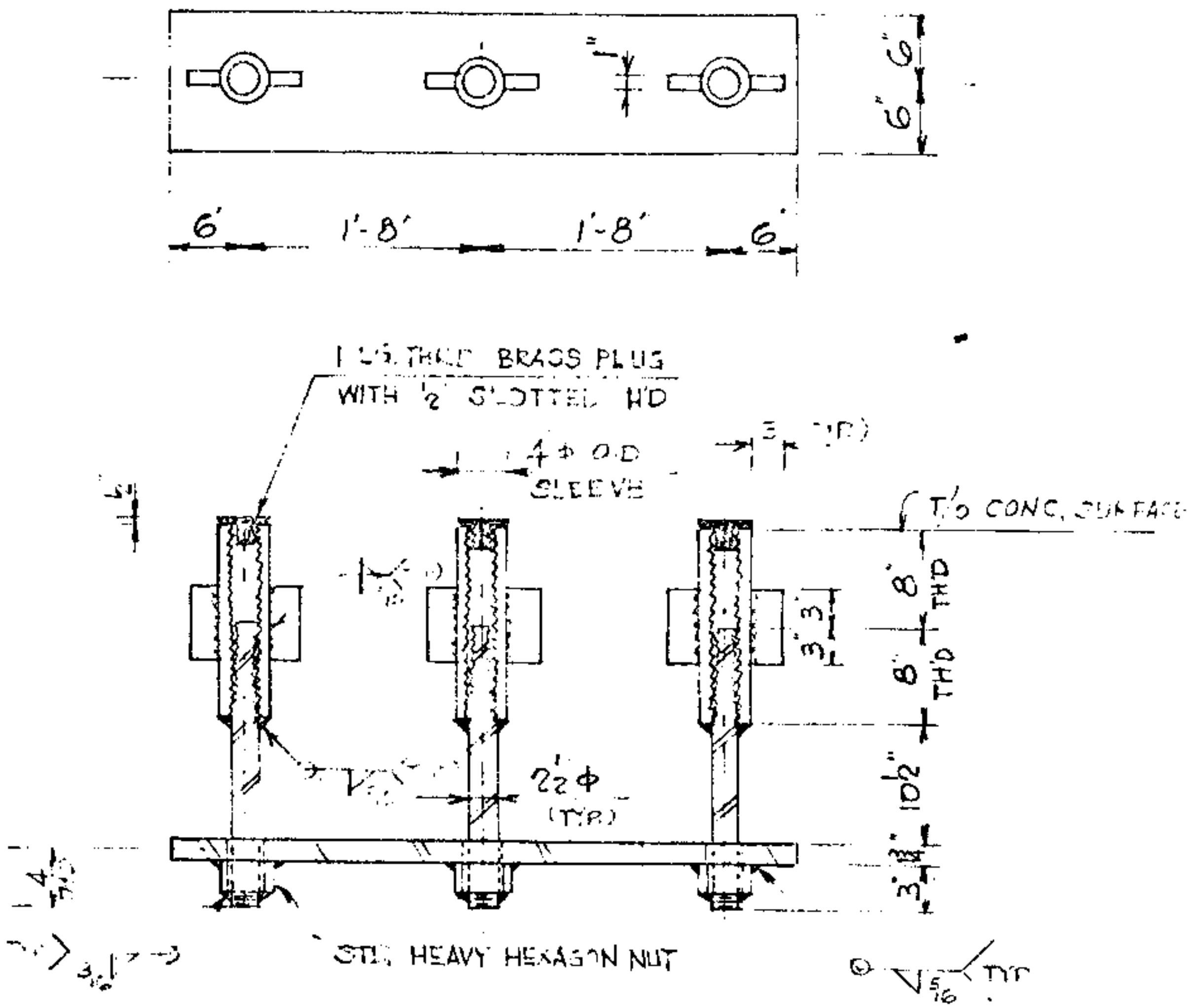
MISSILE SHIELD COVER - REINF.
BEAM: #1
BEAM #4 SIMILAR.

SECTION "B-B"

Fig. 5.2.2-51D

July 1982

BY F. CLARKE

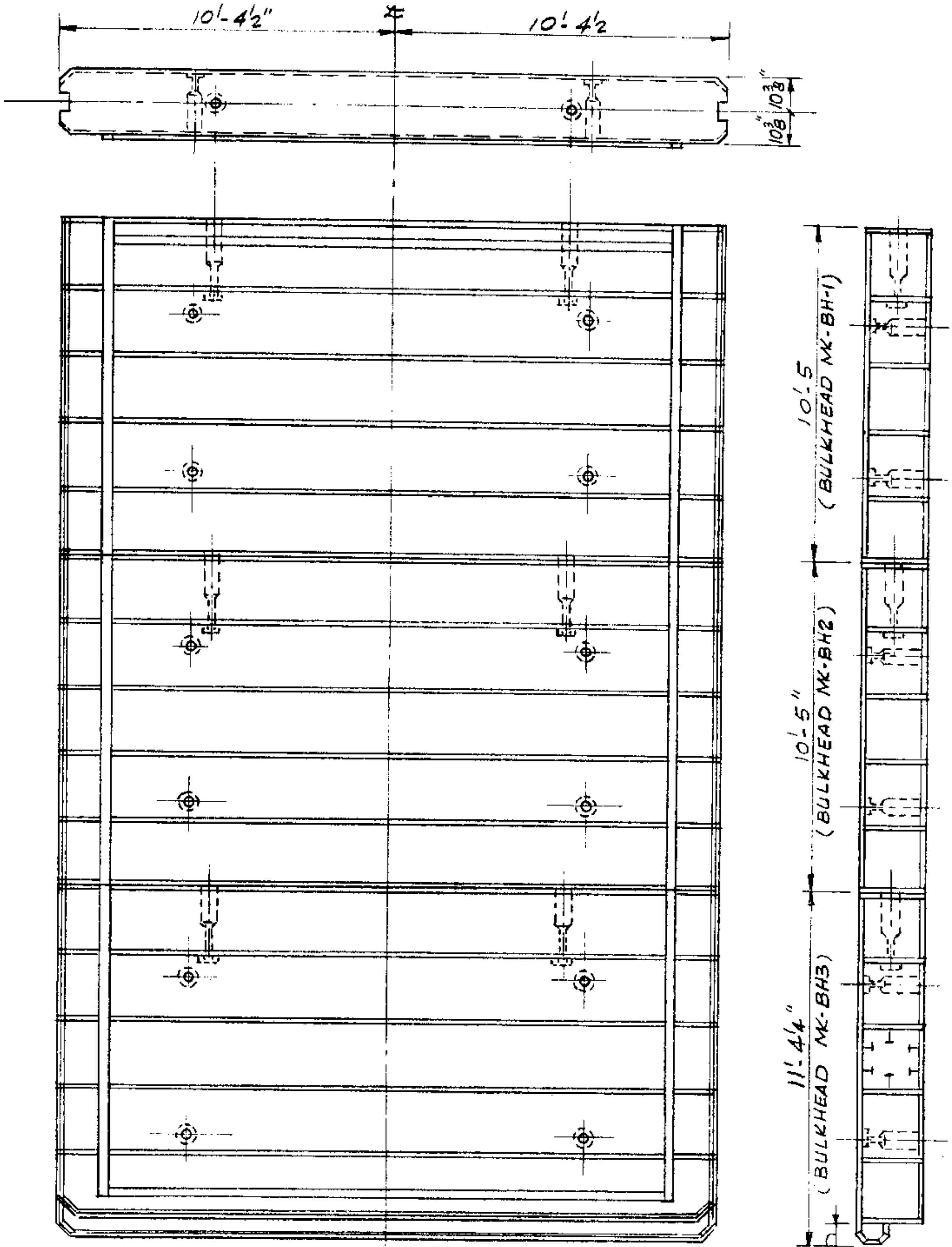


ANCHORAGE ASSEMBLY
OF MISSILE SHIELD COVER

MATERIAL: ASTM A-588-69

FIG. 5.2.2-51E
July 1982

BY JTL

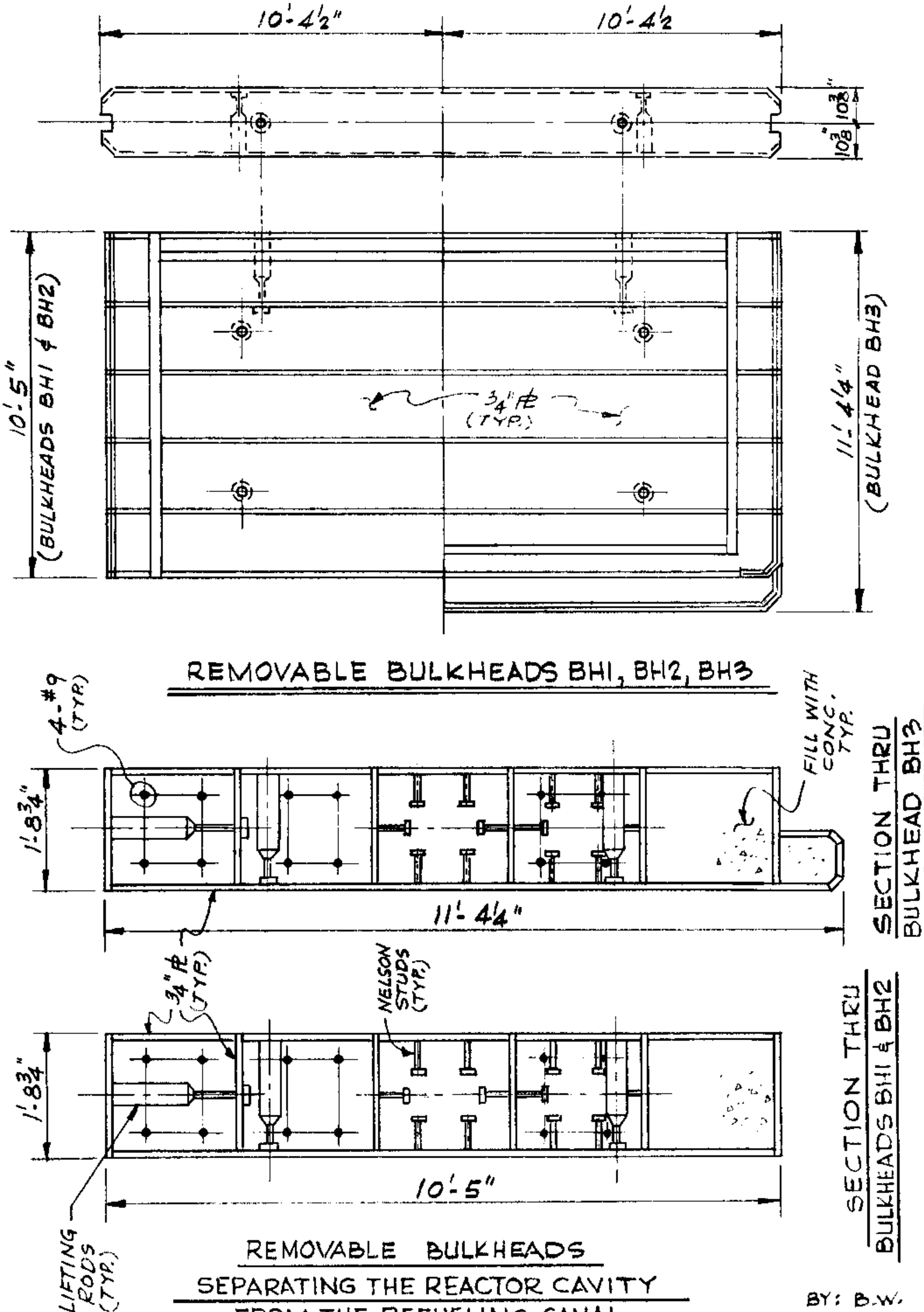


REMOVABLE BULKHEADS
SEPARATING THE REACTOR CAVITY
FROM THE REFUELING CANAL

BY: B.W.

July 1982

Fig. 5.2.2-52



REMOVABLE BULKHEADS
SEPARATING THE REACTOR CAVITY
FROM THE REFUELING CANAL

BY: B.W.

July 1982

Fig. 5.2.2-52A

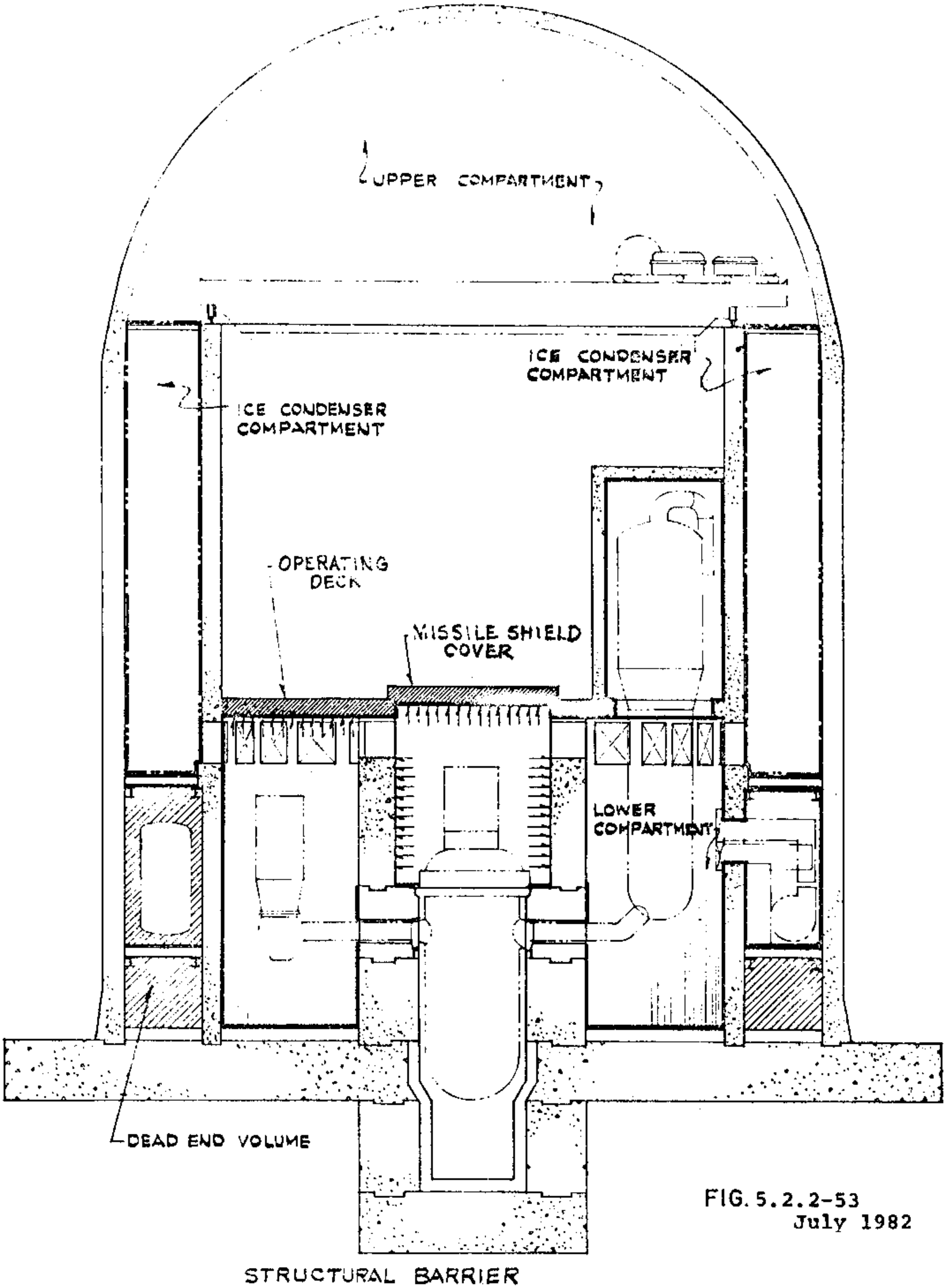
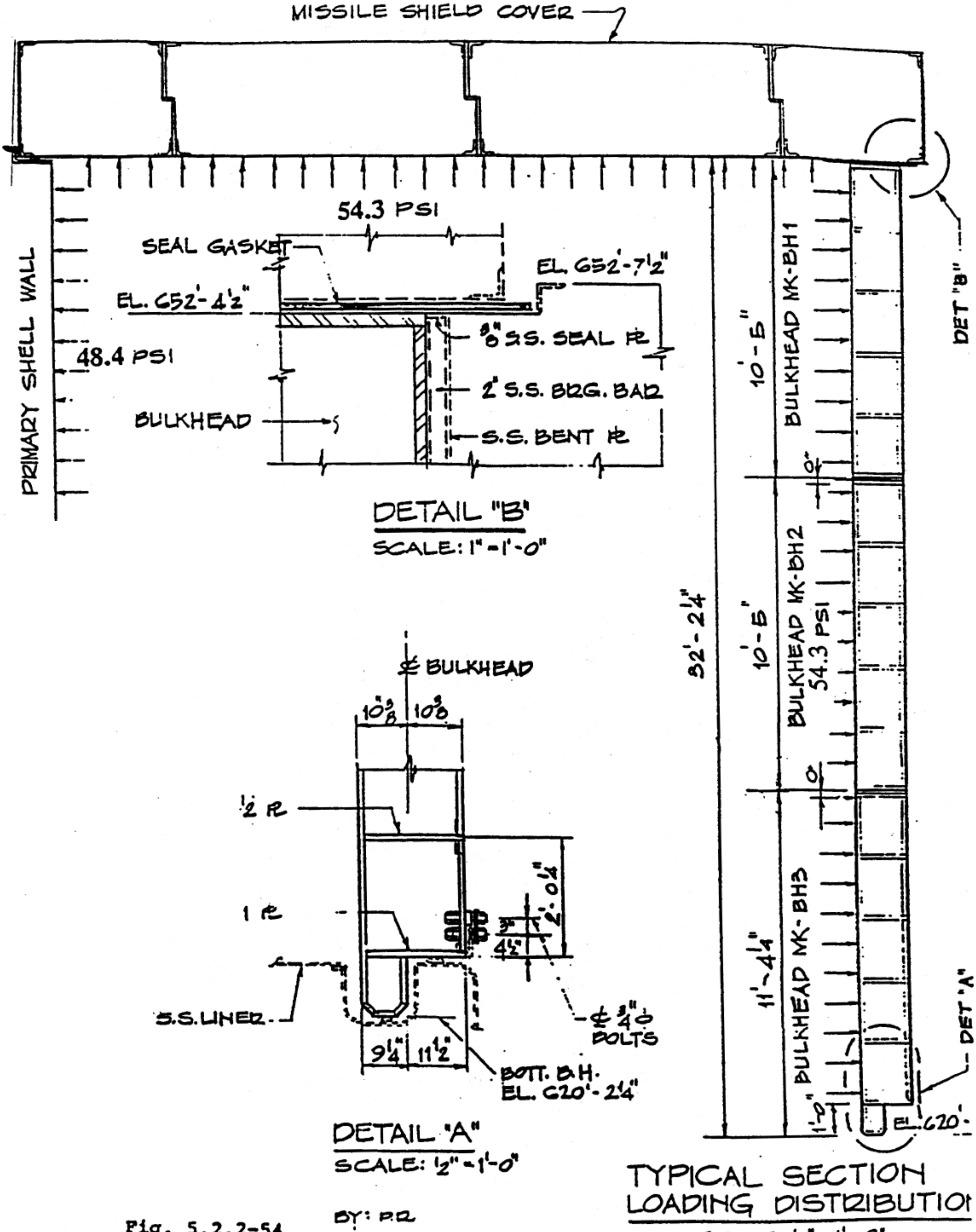


FIG. 5.2.2-53
July 1982



MISSILE SHIELD COVER
PRIMARY SHELL WALL
48.4 PSI
54.3 PSI
SEAL GASKET
EL. 652'-4½"
EL. 652'-7½"
⅜" S.S. SEAL PL
2" S.S. BRG. BAR
S.S. BENT PL
BULKHEAD
DETAIL "B"
SCALE: 1" = 1'-0"
DET "B"
BULKHEAD MK-BH1
BULKHEAD MK-BH2
54.3 PSI
BULKHEAD MK-BH3
10'-5"
10'-5"
11'-4¼"
32'-2¼"
1'-0"
EL. 620'-
DET "A"
℄ BULKHEAD
10⅜
10⅜
½ PL
1 PL
2'-0½"
3"
4½"
℄ ¾" ϕ BOLTS
S.S. LINER
9¼"
11½"
BOTT. B.H.
EL. 620'-2¼"
DETAIL "A"
SCALE: ½" = 1'-0"
TYPICAL SECTION
LOADING DISTRIBUTION
SCALE: ¼" = 1'-0"
BY: P.R.

Fig. 5.2.2-54

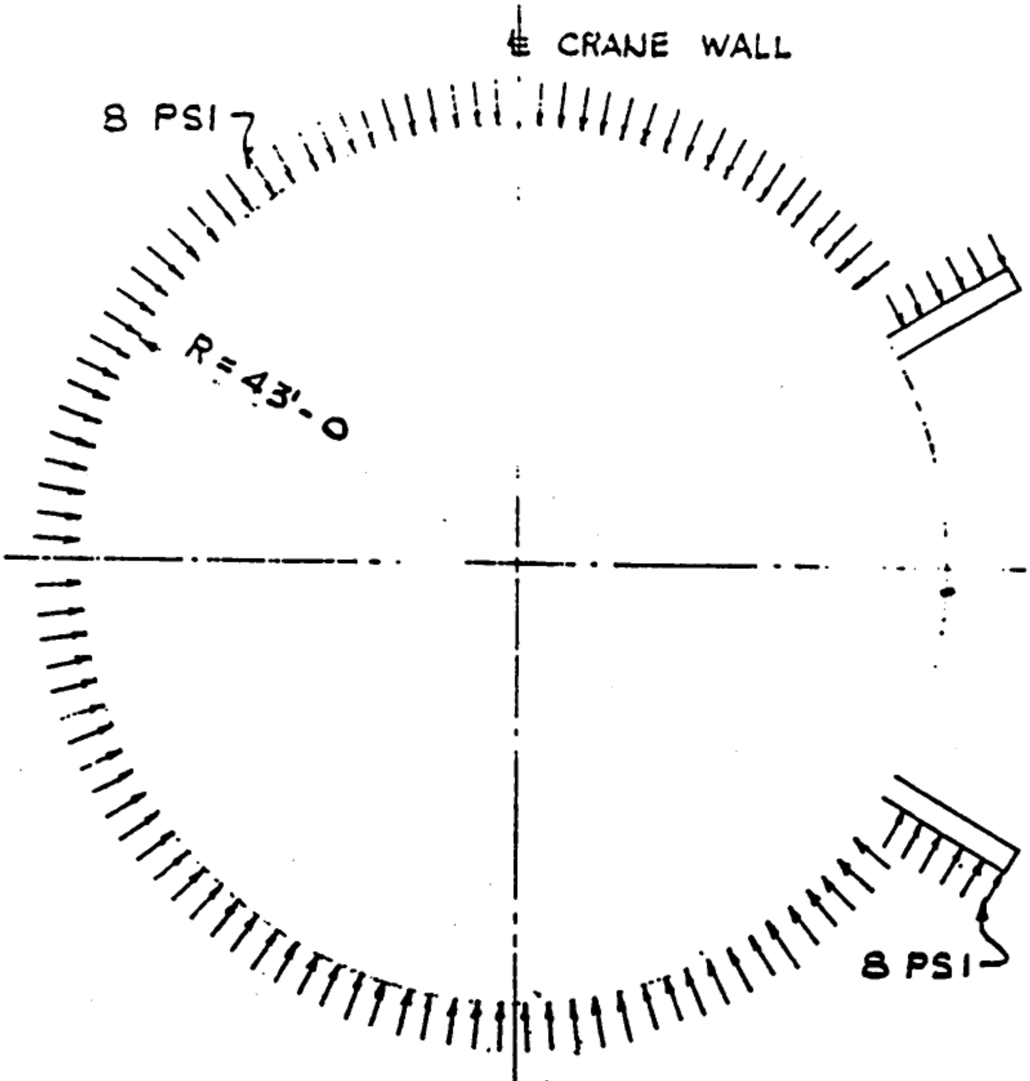


FIG 5. 26. 2-1 LOADING DIAGAM OF UPPER CRANE WALL

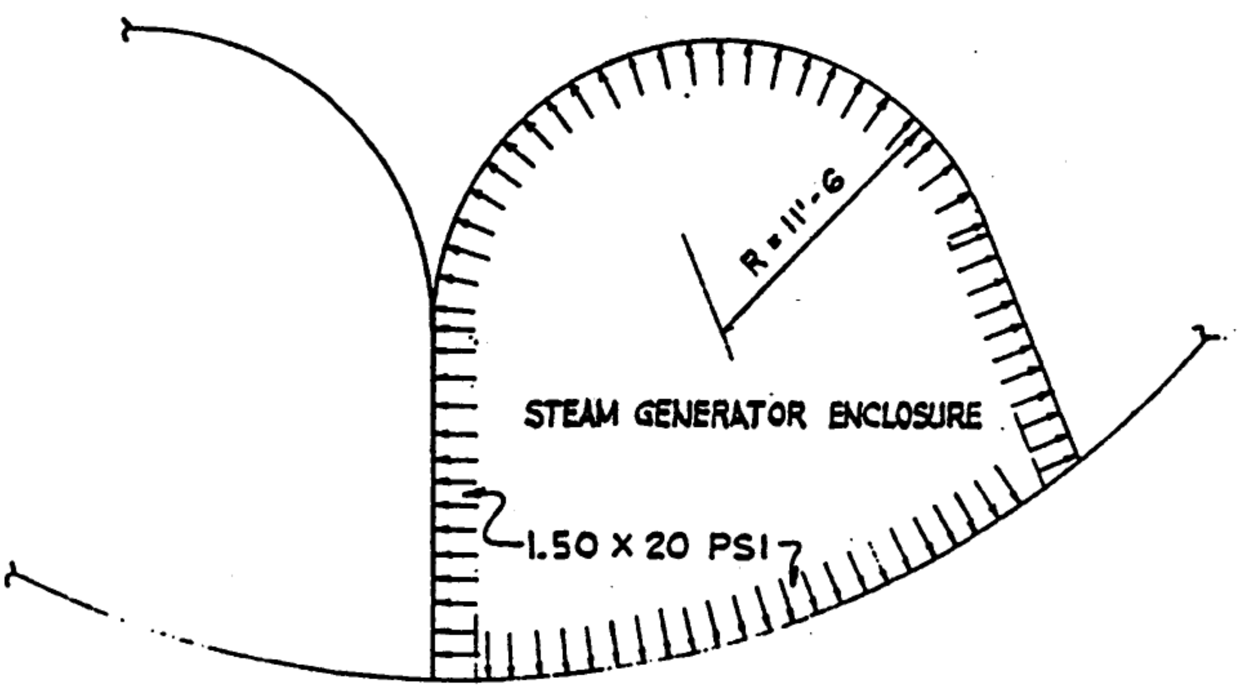


FIG. 5.2.2-54A, UNSYMMETRICAL INTERNAL PRESSURE LOADING DIAGRAM OF 30 PSI OF STEAM GENERATOR ENCLOSURE
July 1982

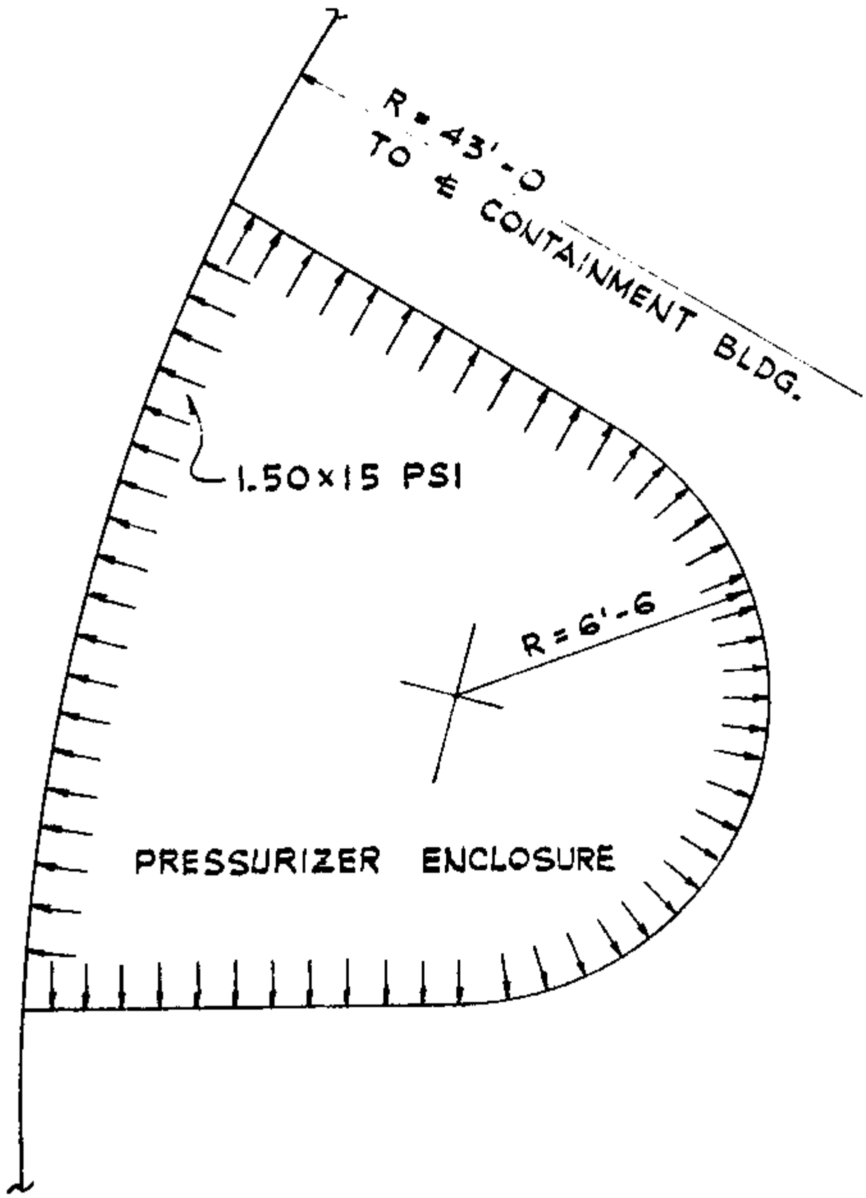
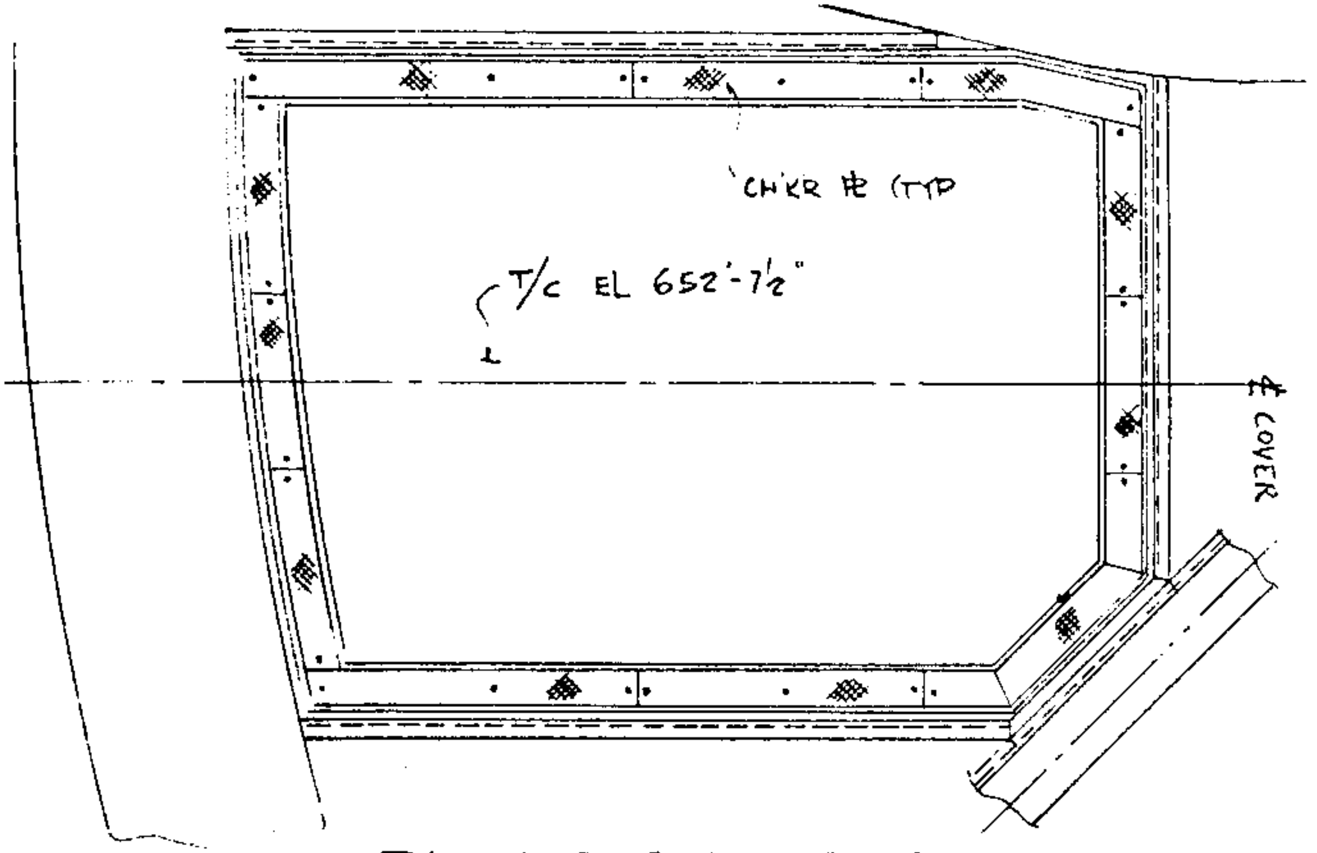
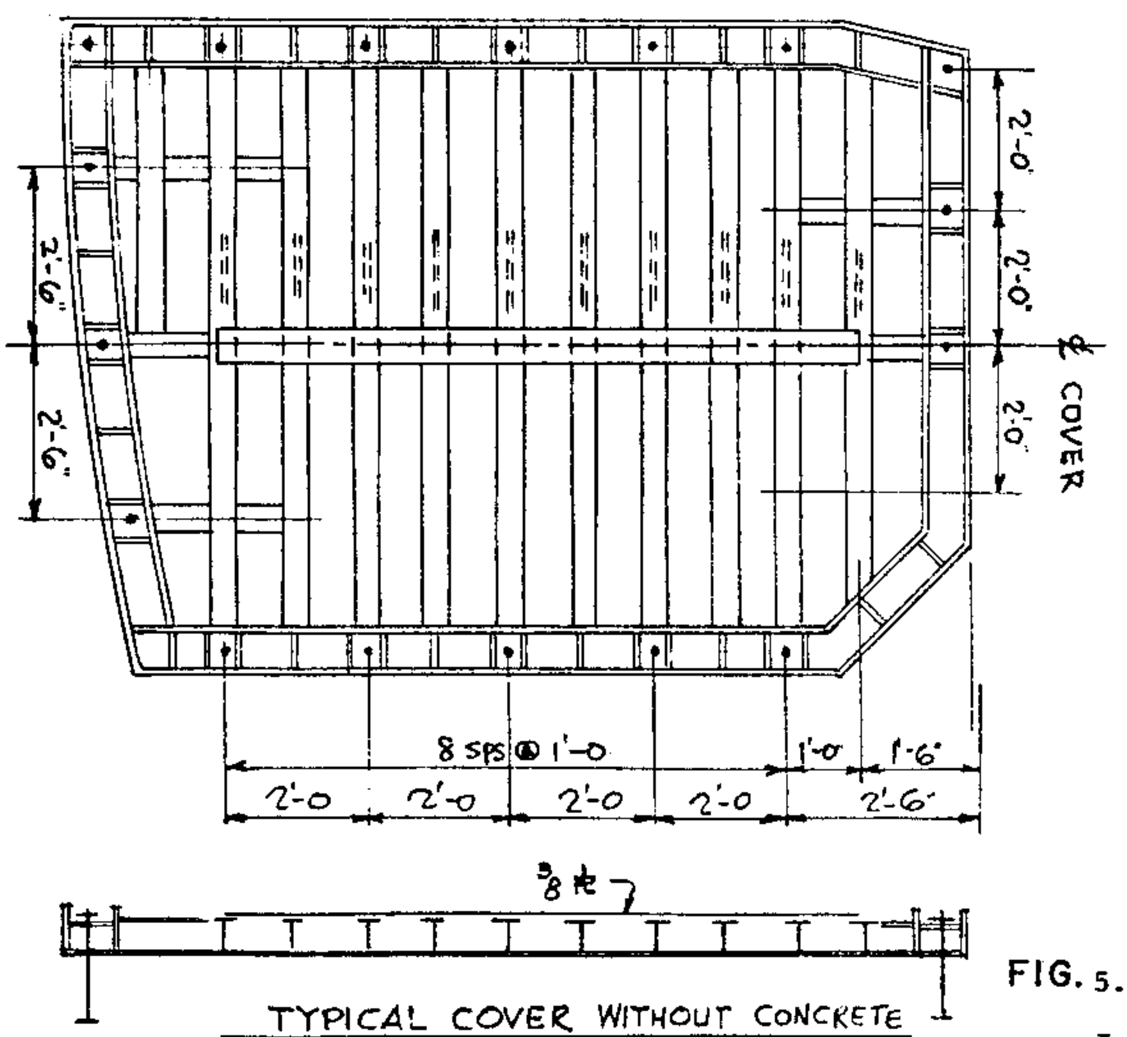


FIG 5.2.2-54B LOADING DIAGRAM OF 22.5 PSI OF PRESSURIZER ENCLOSURE

July 1982



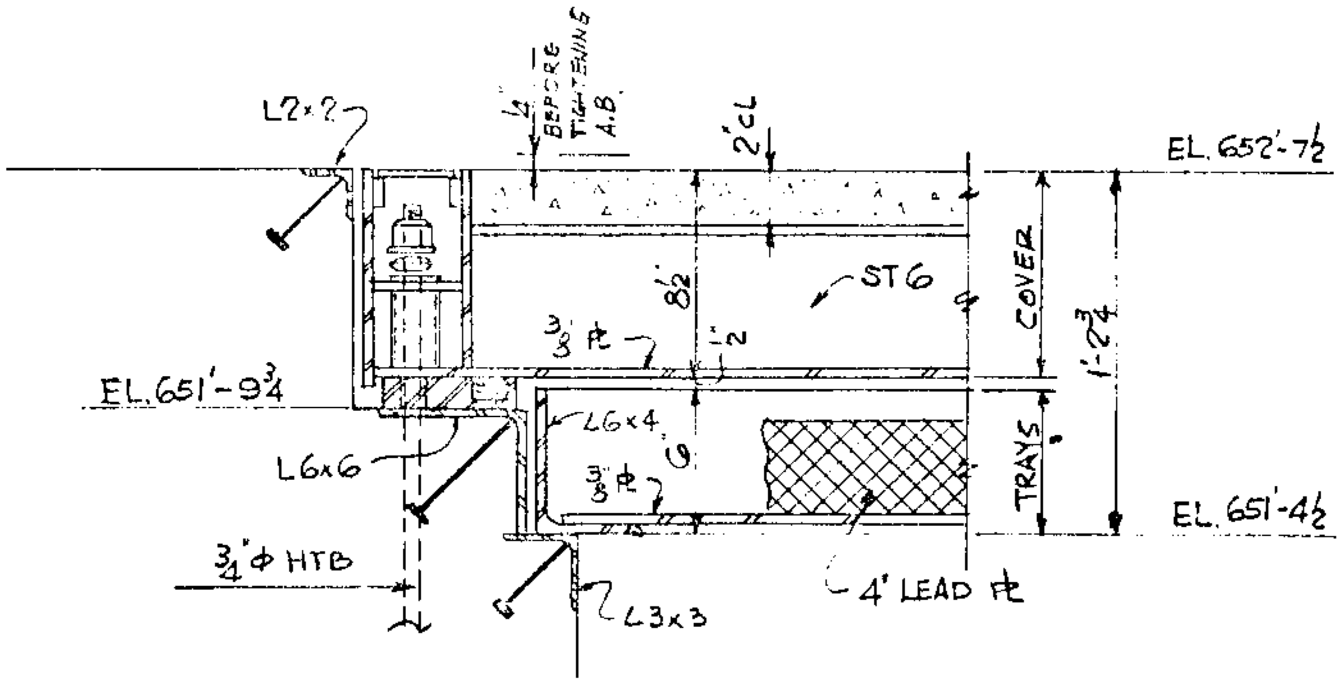
TYPICAL COVER WITH CONCRETE

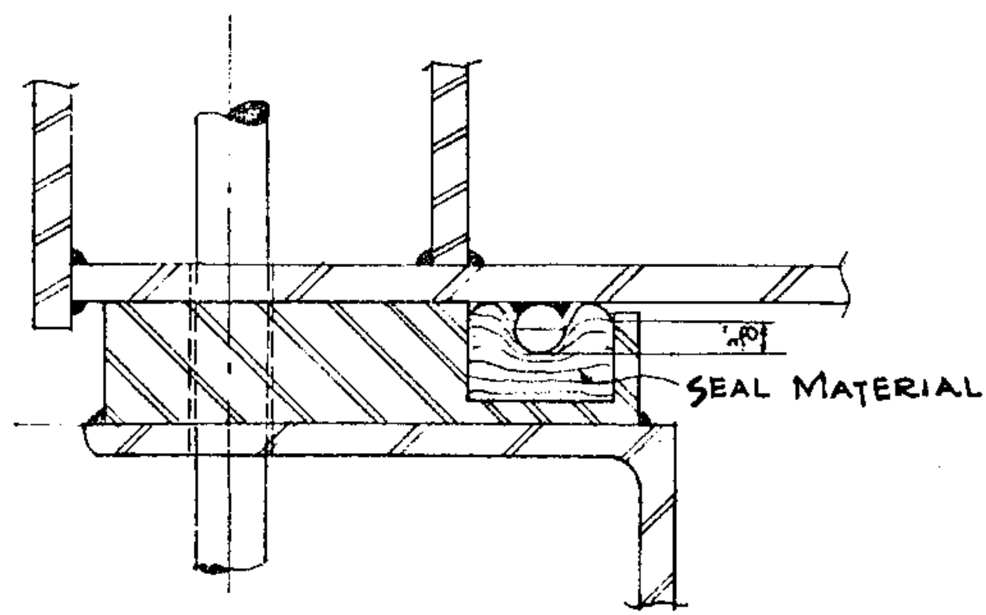


TYPICAL COVER WITHOUT CONCRETE

FIG. 5.2.2-55

July 1982



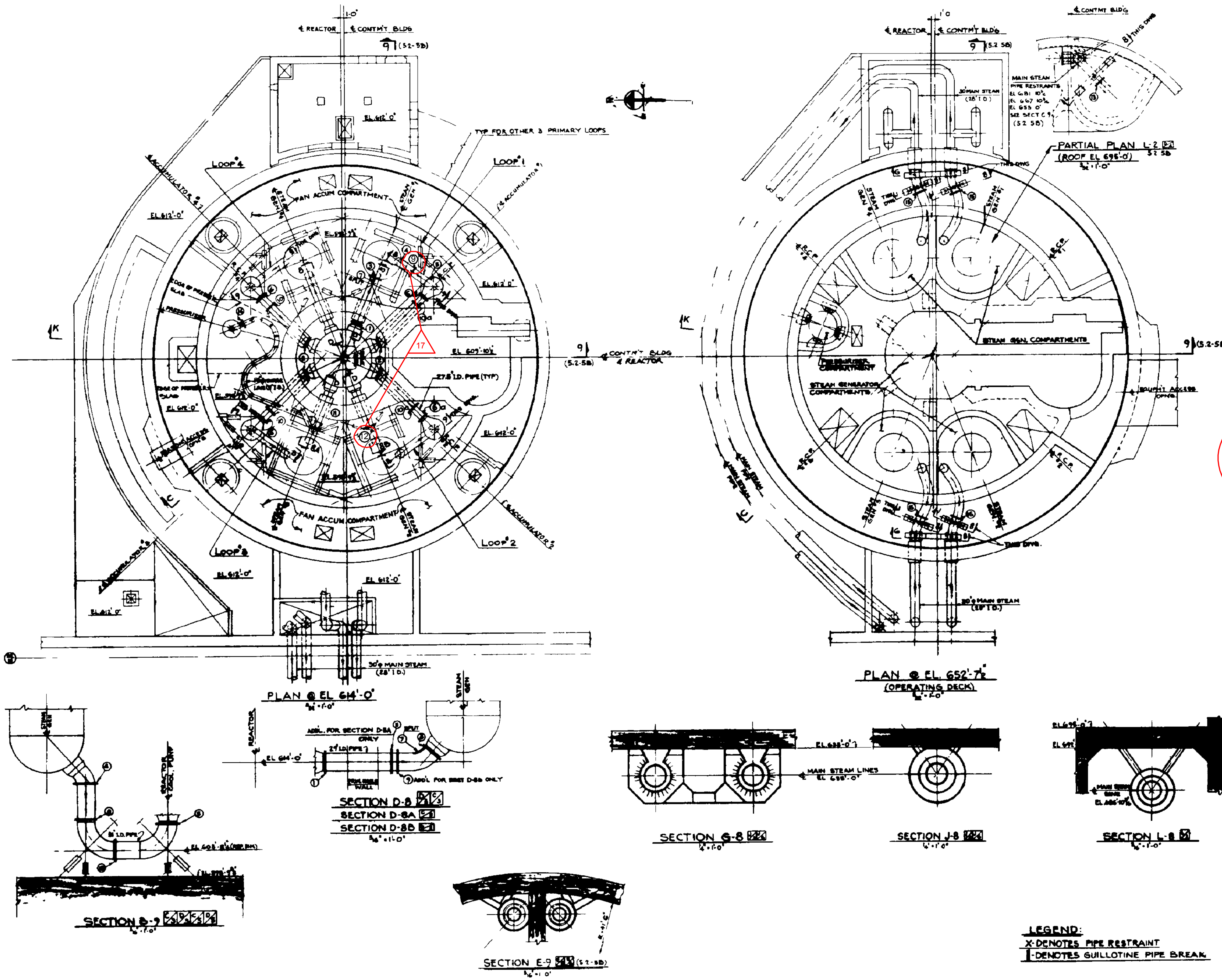


TYPICAL SECTION OF COVER

FIG. 5.2.2-55A

July 1982

DWG. NO. FSAR FIG.



NOTE:
BREAK LOCATIONS ARE BEING MAINTAINED FOR HISTORICAL PURPOSES. MAIN COOLANT LOOP AND UNITS PRESSURIZER SURGE LINE BREAKS HAVE BEEN ELIMINATED BY LEAK-BEFORE-BREAK METHODOLOGY.

LEGEND:
X - DENOTES PIPE RESTRAINT
I - DENOTES GUILLOTINE PIPE BREAK

DATE	NO.	DESCRIPTION	APPD.
	17	REVISED PER UCR 1565	

REVISIONS

INDIANA MICHIGAN POWER COMPANY

DONALD C. COOK

NUCLEAR PLANT

BRIDGMAN MICHIGAN

UNITS NO. 1 & 2
JET LOAD LOCATIONS
PLAN & SECT'S.

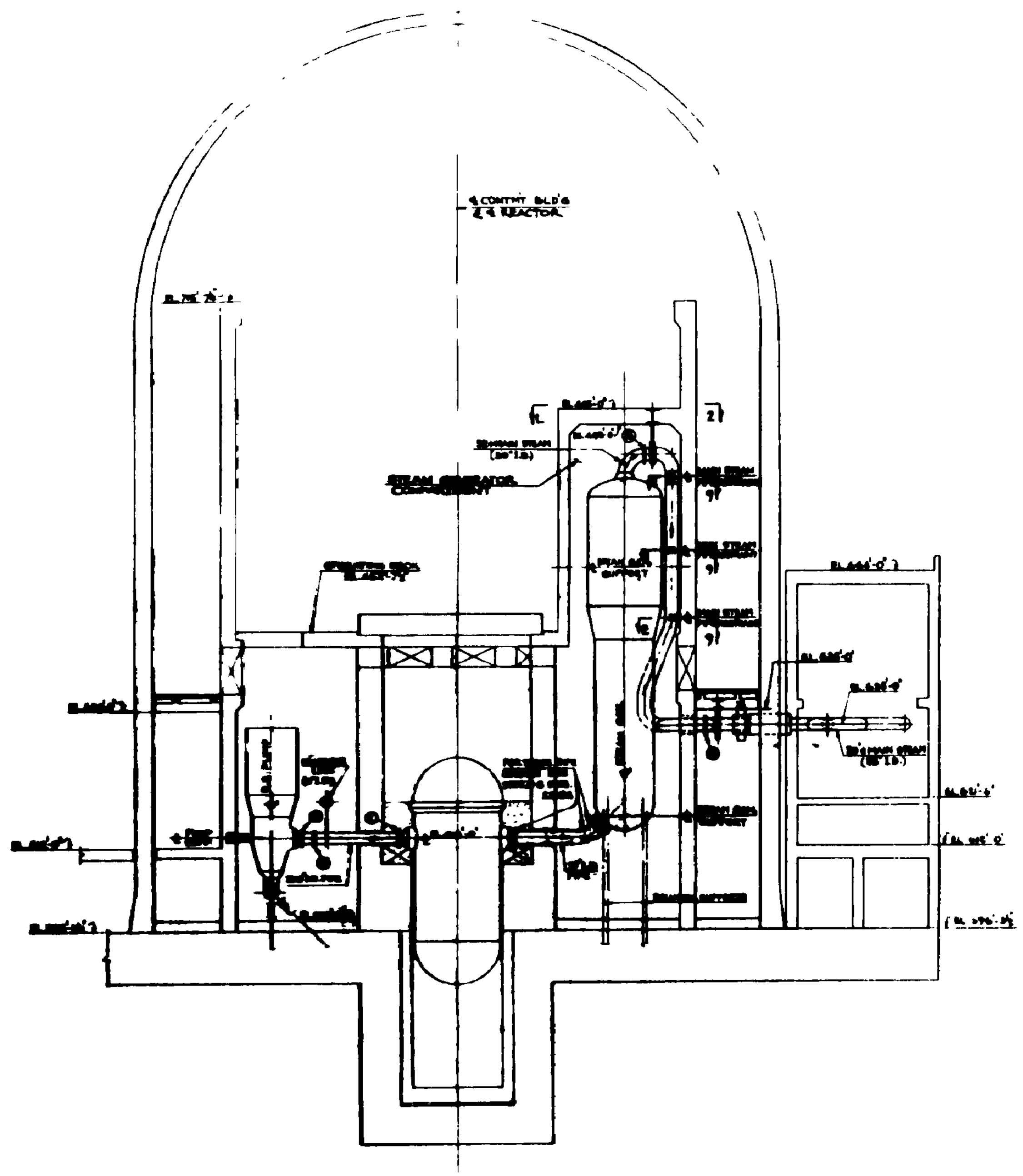
DWG. NO. FSAR FIG. 5.2.2-56

ARCH	ELEC	MECH	STR

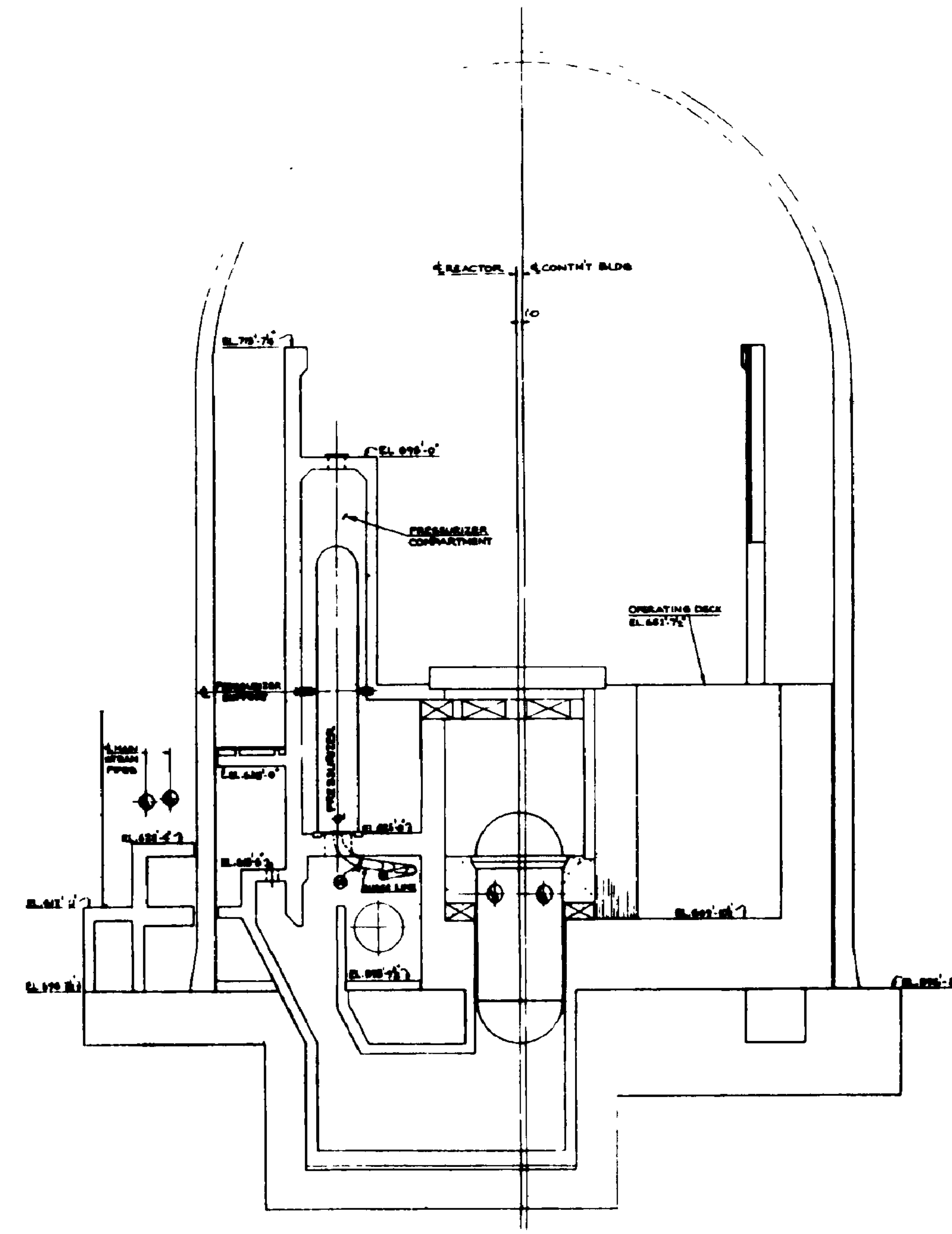
SCALE: DR:
DATE: CH:
DESIGN ENGINEERING DIVISION:

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

DWG. NO. FSAR FIG.



SECTION C-9



SECTION K-9

17

NOTE:
BREAK LOCATIONS ARE BEING MAINTAINED FOR HISTORICAL PURPOSES. MAIN COOLANT LOOP AND UNITS PRESSURIZER SURGE LINE BREAKS HAVE BEEN ELIMINATED BY LEAK-BEFORE-BREAK METHODOLOGY.

DATE	NO.	DESCRIPTION	APP'D.
	17	REVISED PER UCR 1565	

REVISIONS

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INDIANA MICHIGAN POWER COMPANY

DONALD C. COOK

NUCLEAR PLANT

BRIDGMAN MICHIGAN

UNITS NO. 1 & 2
JET LOAD LOCATIONS
SECTIONS

DWG. NO. FSAR FIG. 5.2.2-56A

ARCH ELEC MECH STR

SCALE: DR:

DATE: CK:

DESIGN ENGINEERING DIVISION:

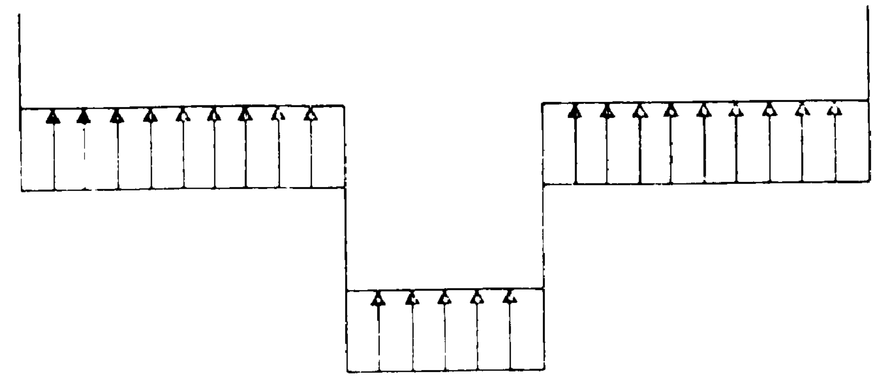
AEP AMERICAN ELECTRIC POWER

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

DISTRIBUTION OF SOIL REACTION BENEATH CONTAINMENT UNITS

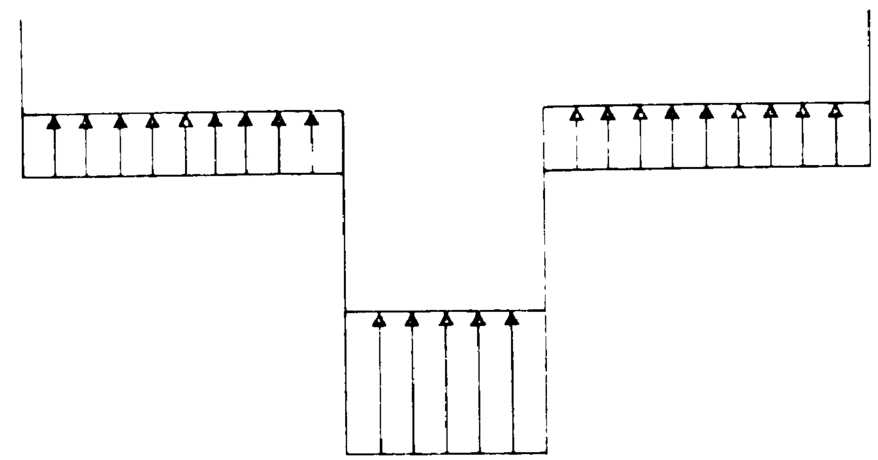
CASE I

UNIFORM PRESSURE DISTRIBUTION



CASE II

MAXIMUM PRESSURE UNDER REACTOR PIT



STATIC

CASE III

MAXIMUM PRESSURE AT FOUNDATION SLAB PERIMETER

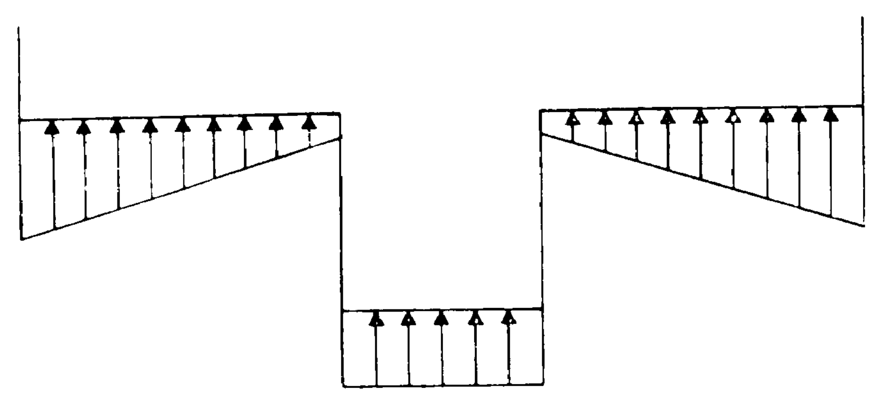


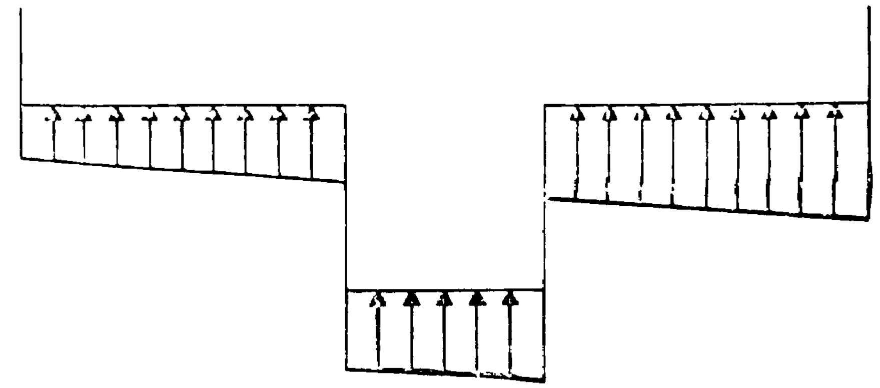
FIGURE 5.2.2-57

July 1982

DISTRIBUTION OF SOIL REACTION BENEATH CONTAINMENT UNITS

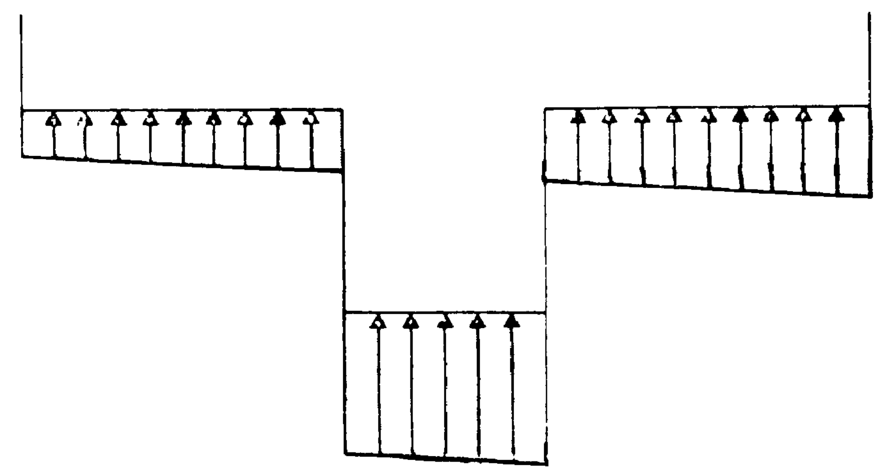
CASE I A

UNIFORM PRESSURE DISTRIBUTION



CASE II A

MAXIMUM PRESSURE UNDER REACTOR PIT



STATIC PLUS DYNAMIC

CASE III A

MAXIMUM PRESSURE AT FOUNDATION SLAB PERIMETER

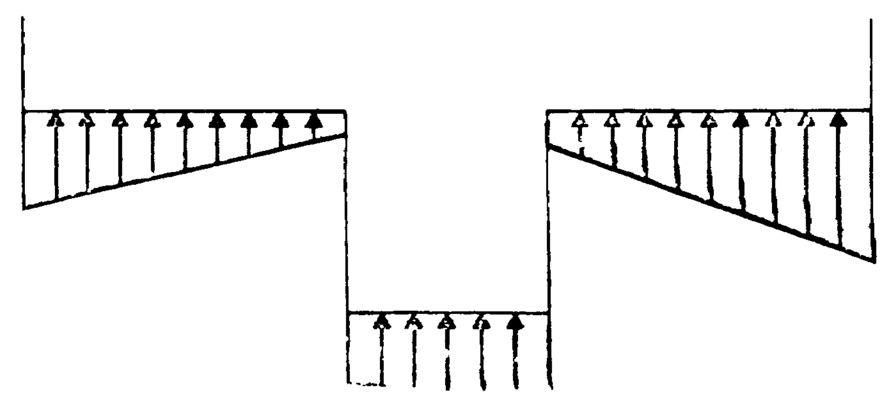


FIGURE 5.2.2-57A

July 1982

COOK NUCLEAR PLANT

GNSLOOM2/DEAD LOAD/HYPOT.EARTHQUAKE W x K = SOIL PRESSURE
UNIFORM SOIL PRESSURE (DEAD LOAD + DESIGN BASIS EARTHQUAKE)

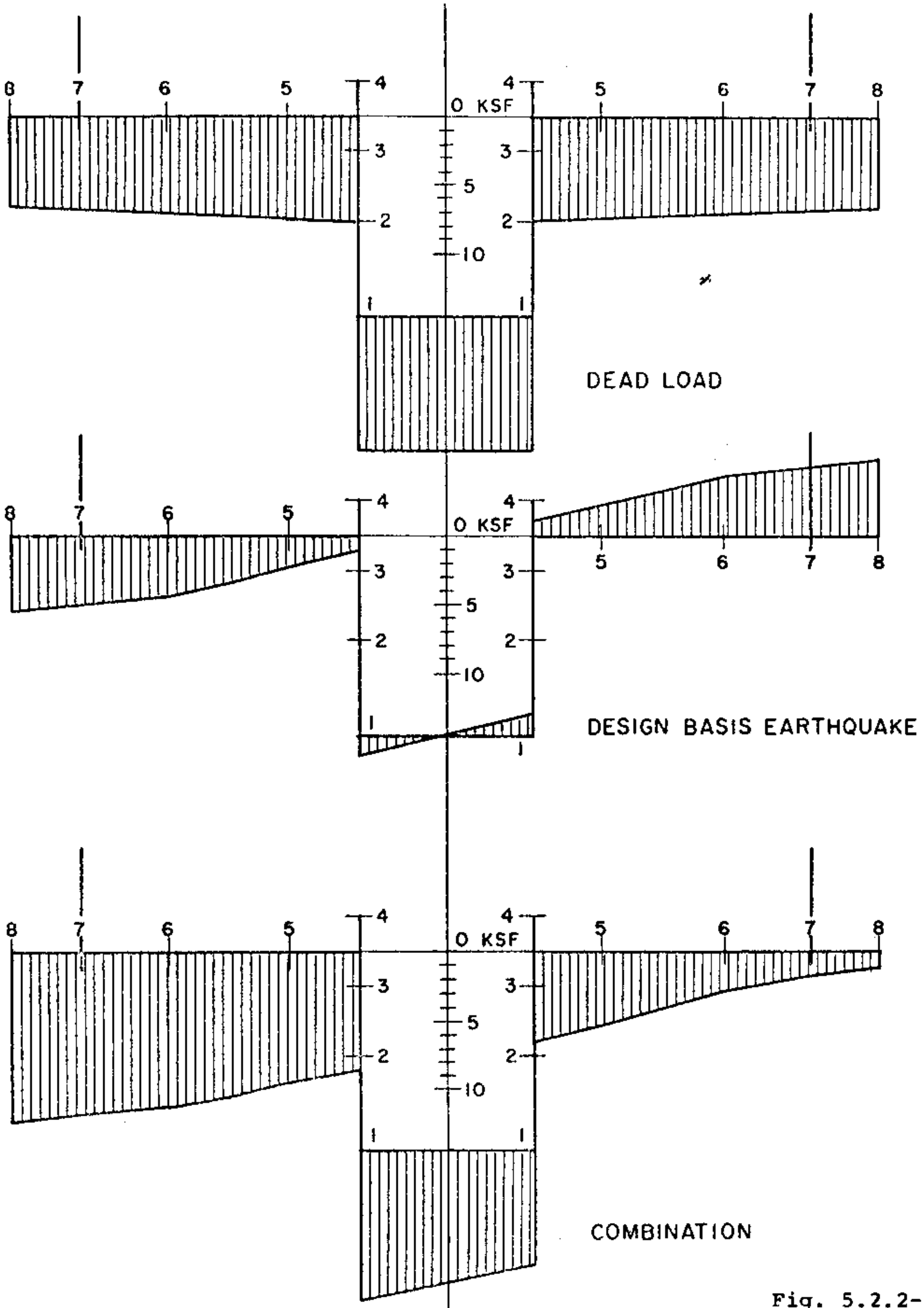


Fig. 5.2.2-58
July 1982

COOK NUCLEAR PLANT

GNSLOOMO/DEAD LOAD/HYPOT. EARTHQUAKE W x K = SOIL PRESSURE
NON UNIFORM SOIL PRESSURE (DEAD LOAD + DESIGN BASIS EARTHQUAKE)

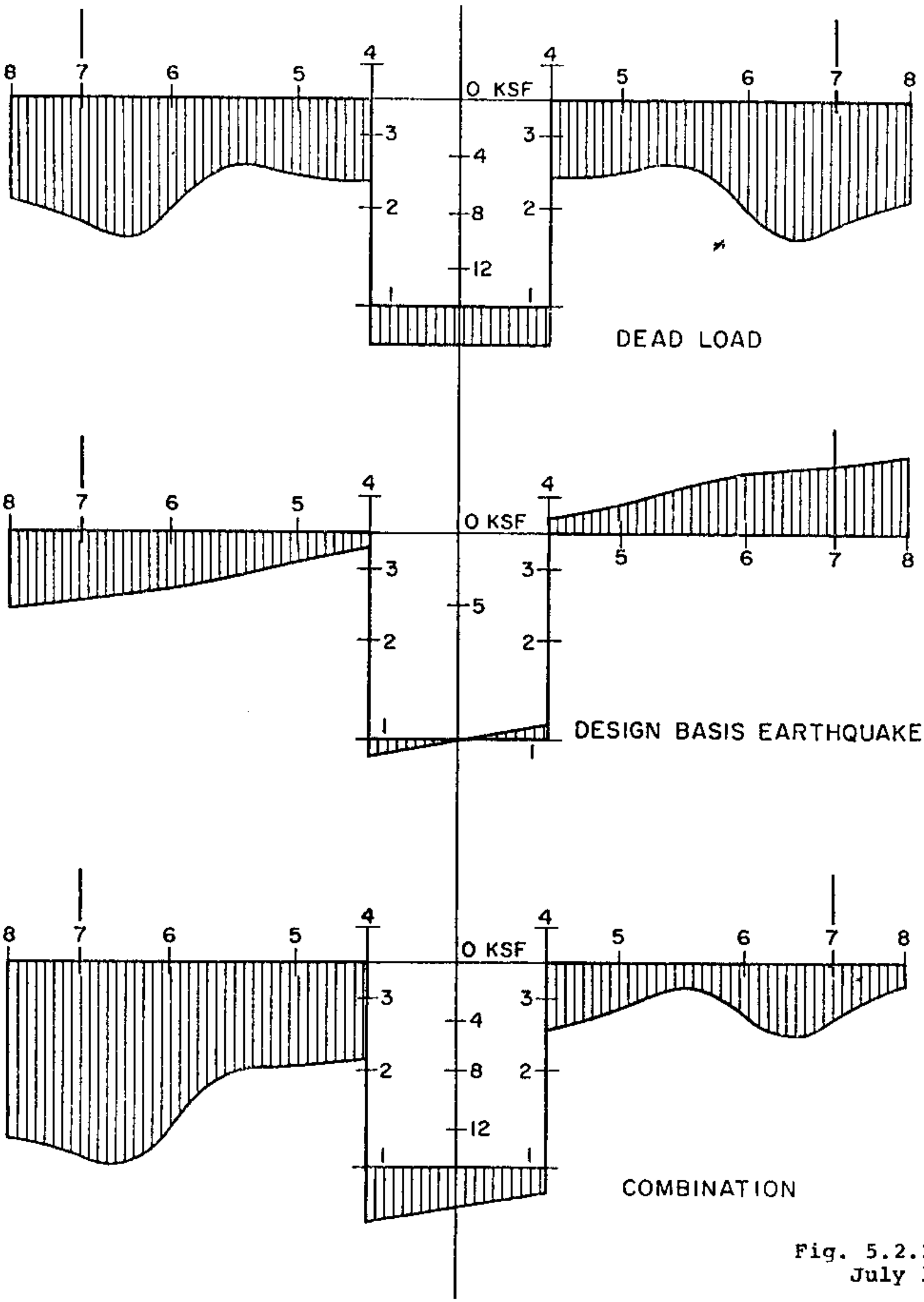


Fig. 5.2.2-58A
July 1982

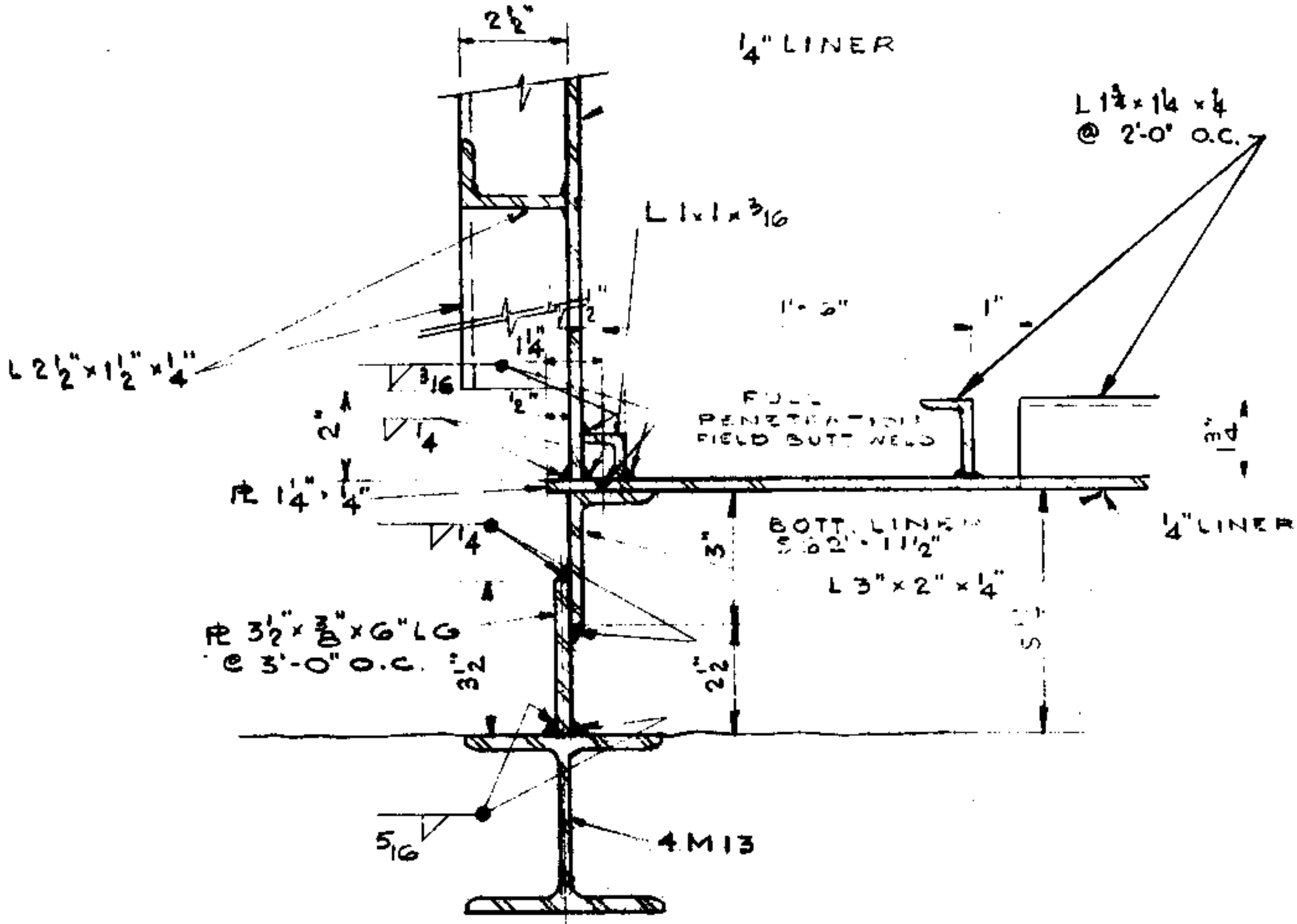


Fig. 5.2.2-59
LINER AT REACTOR POOL

July 1982

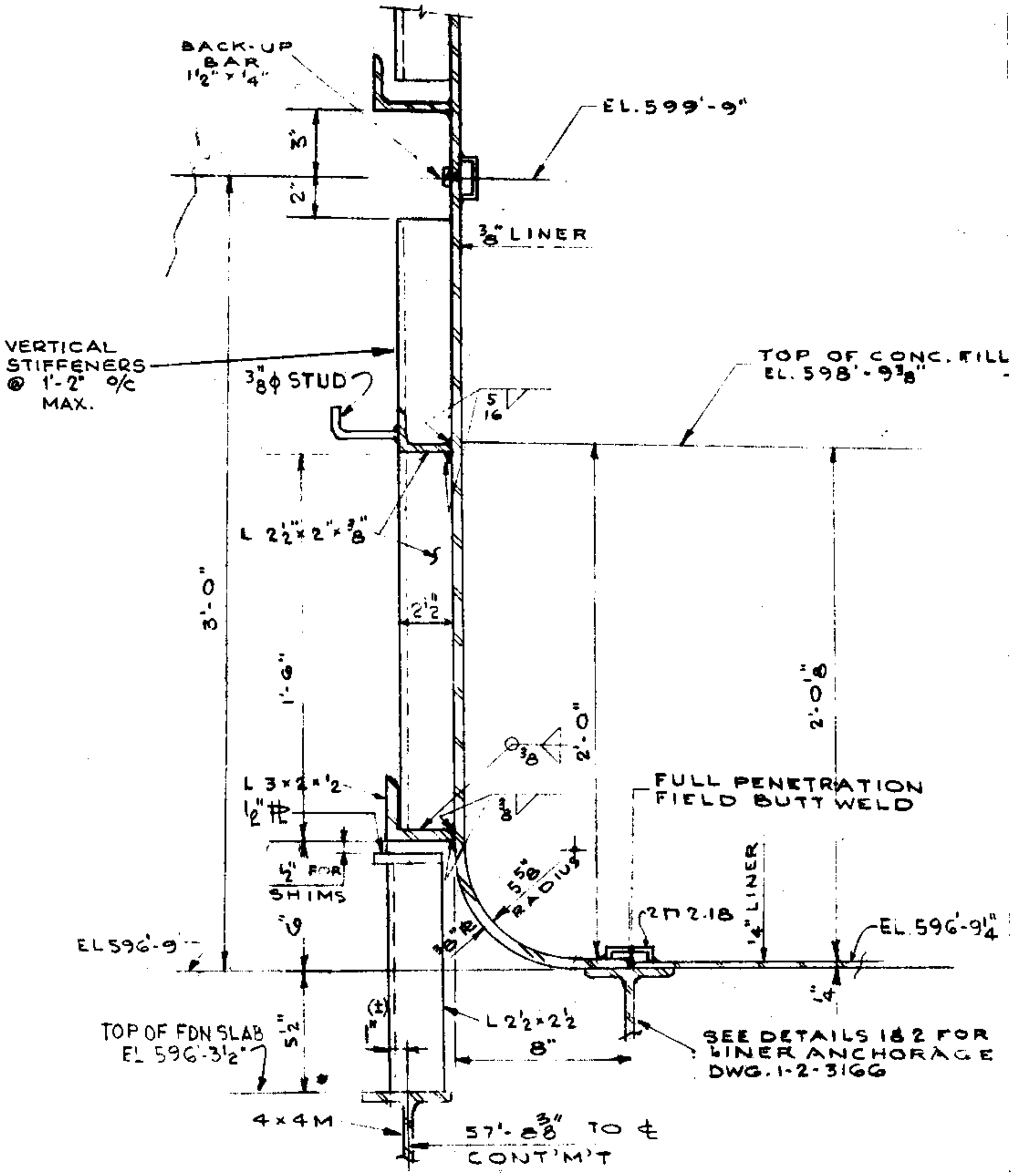
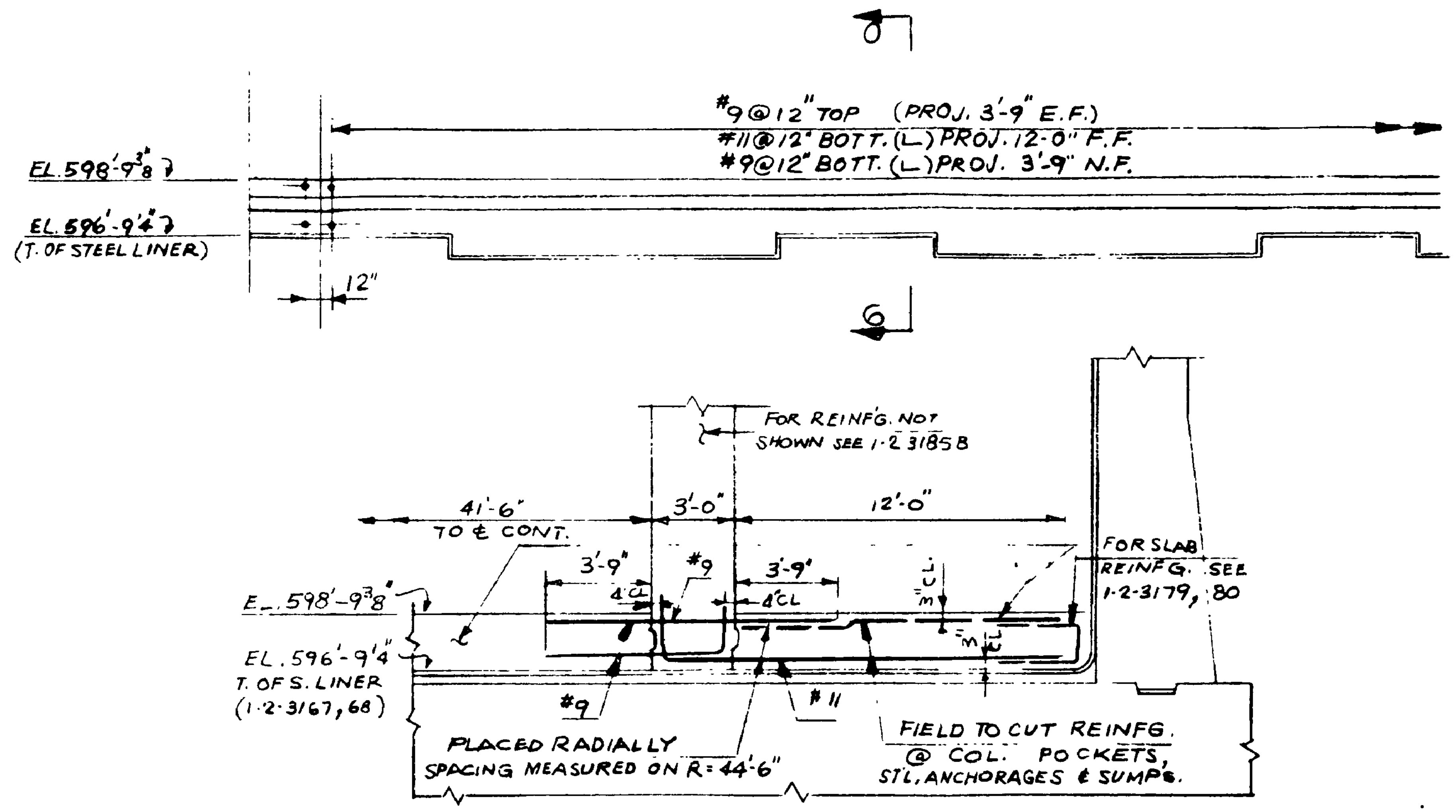


Fig. 5.2.2-59A

LINER JUNCTION - WALL AND FDN. SLAB

JULY 1982



SECTION 0-6 (TYP)

DEVELOPMENT OF CRANE WALL (INSIDE FACE)

FIG. 5.2.2-59 B

JULY 1982

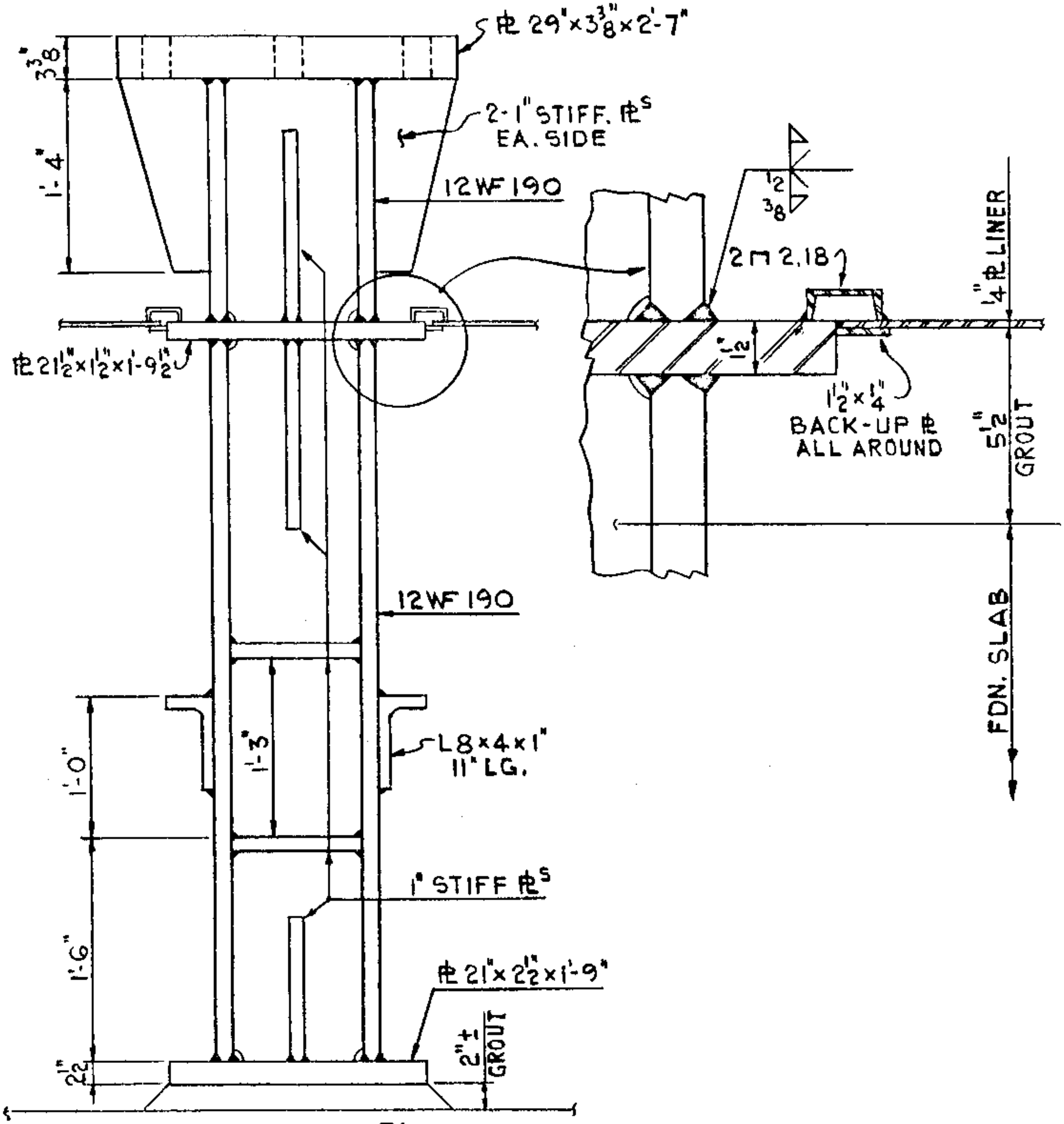


Fig. 5.2.2-59c

CONTAINMENT BUILDING

EMBEDDED ANCHOR FOR STEAM GENERATORS AND COOLANT PUMPS

D.C. COOK NUCLEAR POWER PLANT

BRIDGMAN MICHIGA

JULY 1982

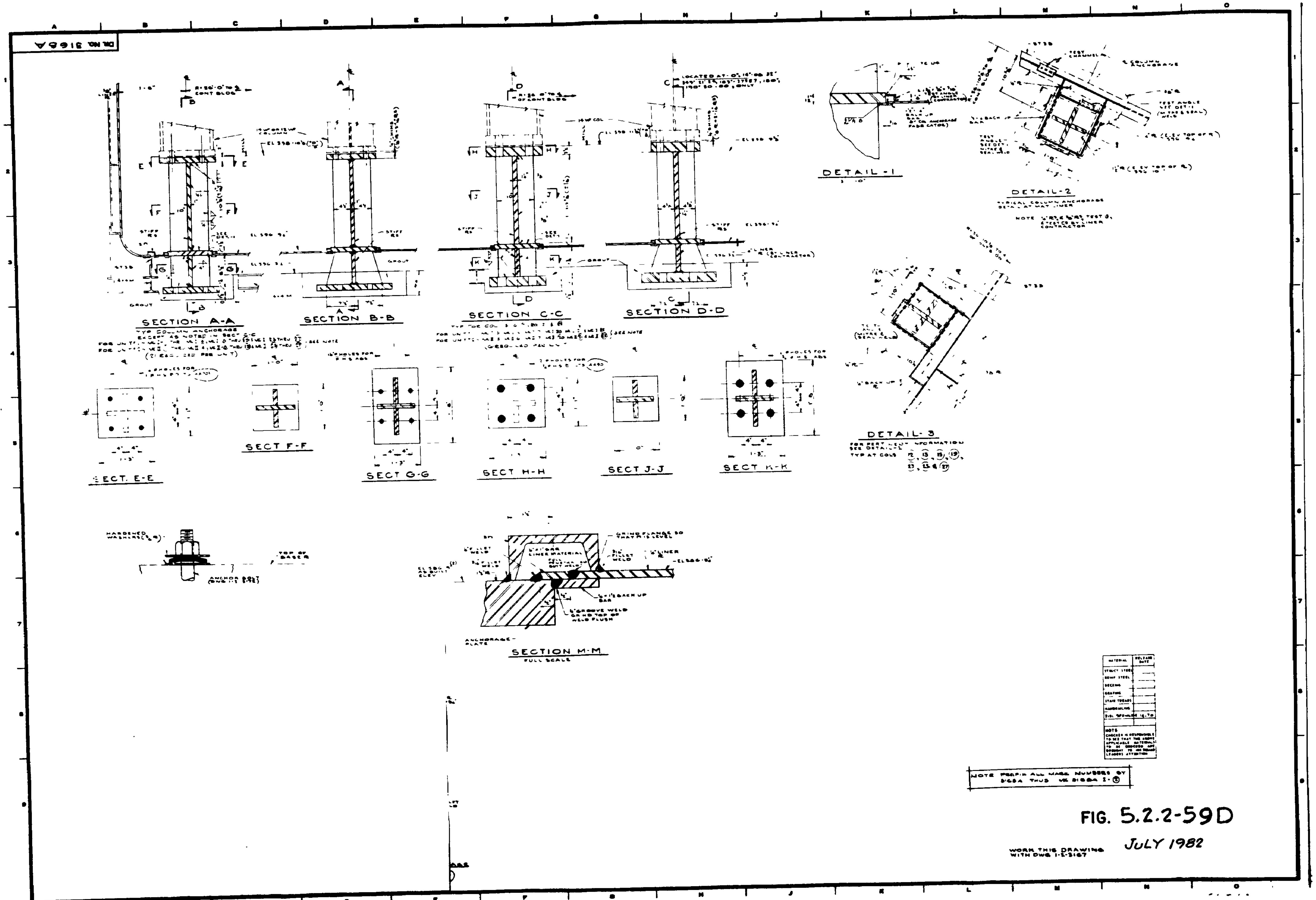


FIG. 5.2.2-59D

JULY 1982

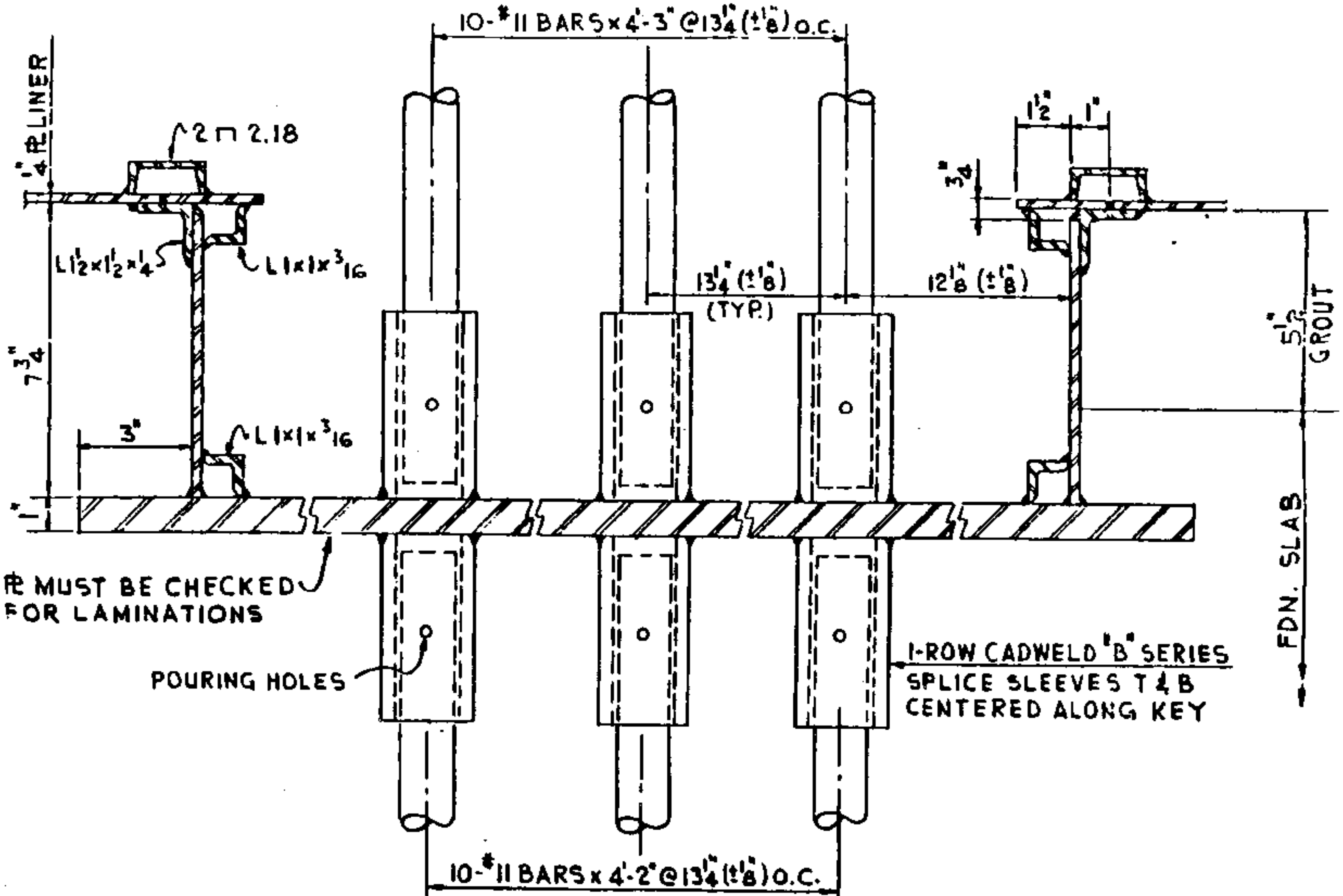


Fig. 5.2.2-59E

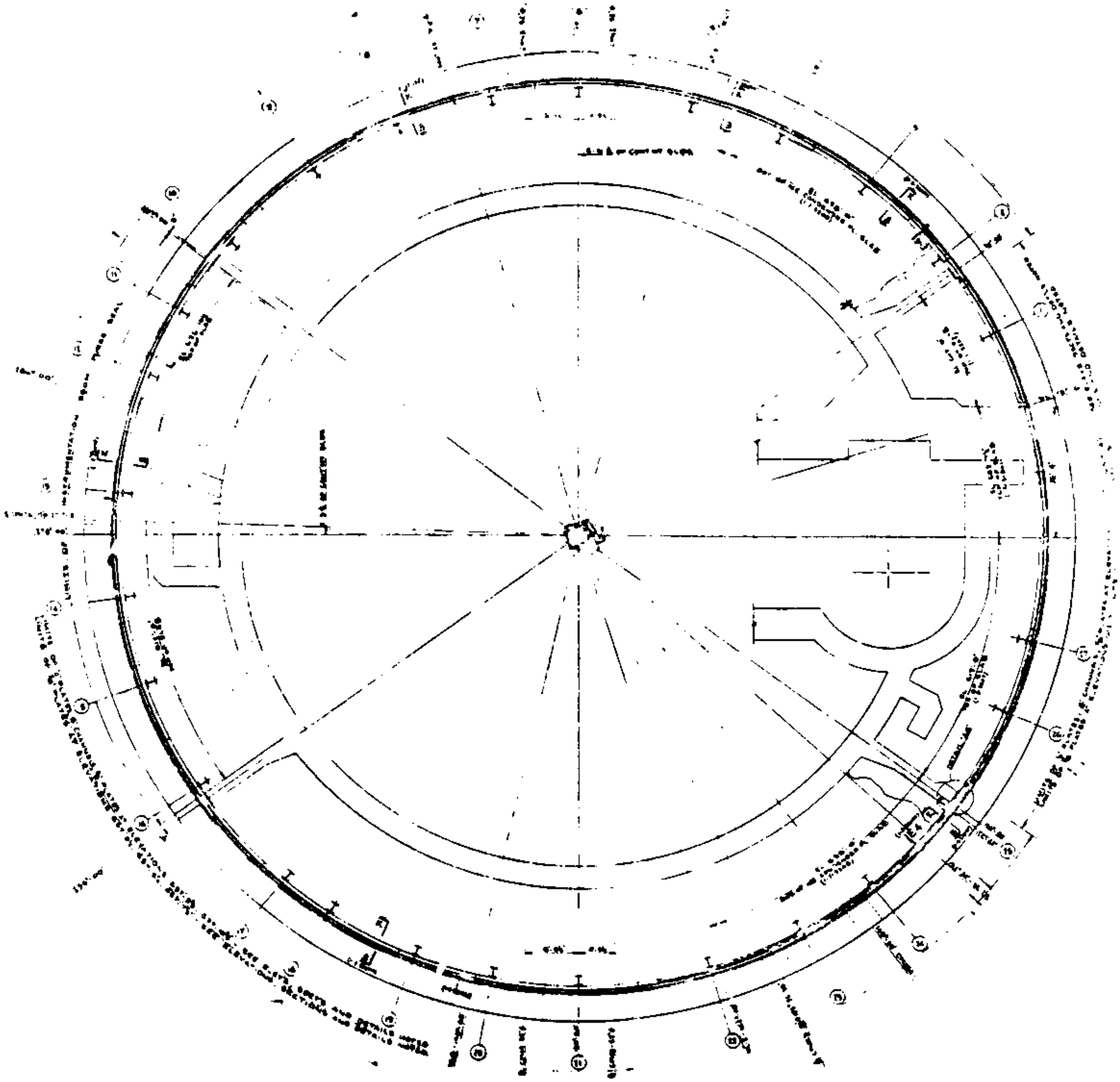
CONTAINMENT BUILDING

SHEAR RECESS & UPLIFT ANCHOR OF CRANE WALL

D.C. COOK NUCLEAR POWER PLANT

BRIDGMAN MICHIGAN

JULY 1982



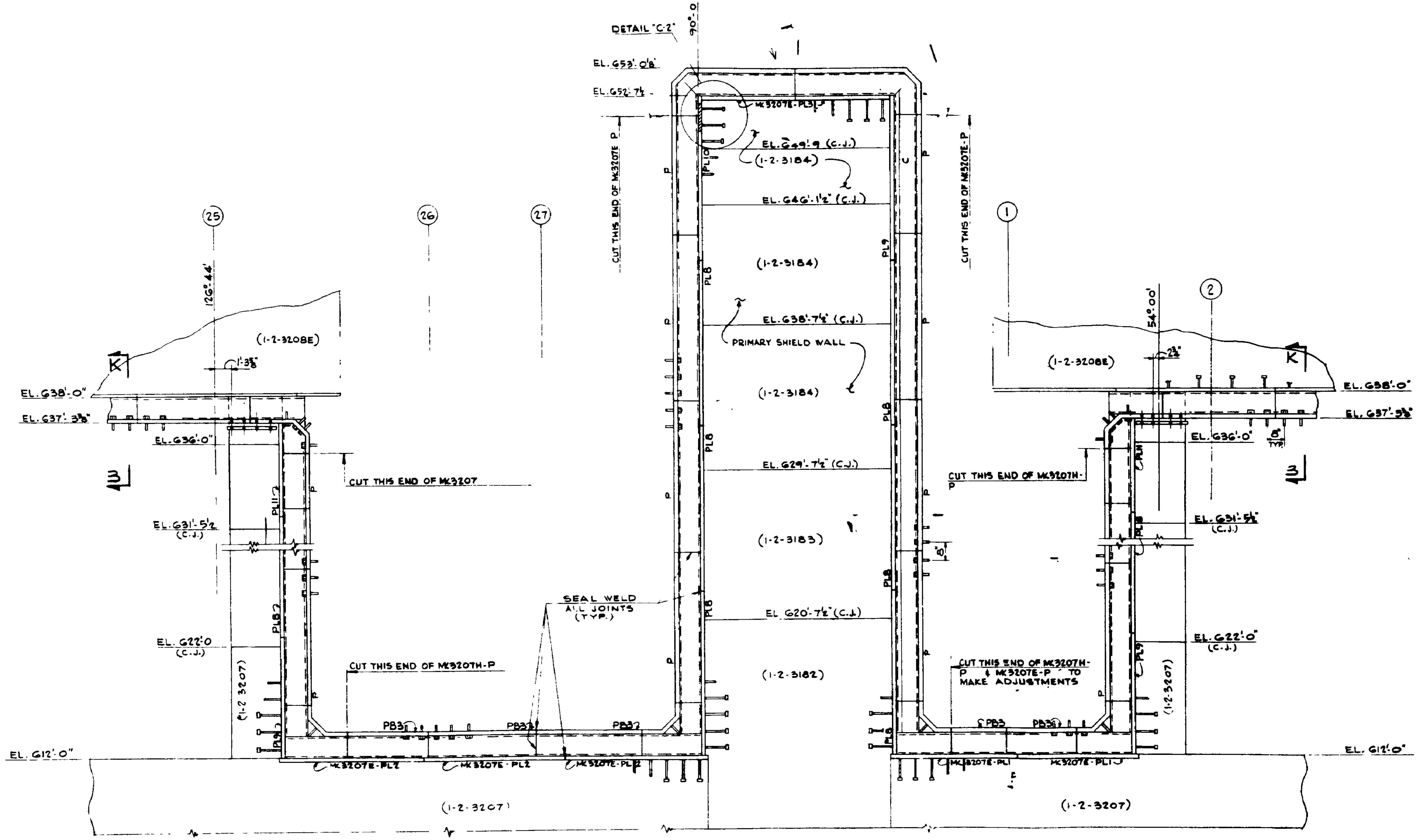
SEALING ARR'GT PLAN AT ELEV'S 611'-0, 658'-0, 692'-7½

UNIT #1 - AS SHOWN

UNIT #2 - OPP. HAND ABT E-W ℄ OF CONT'MT BLDG

FIG. 5.2.2-60B

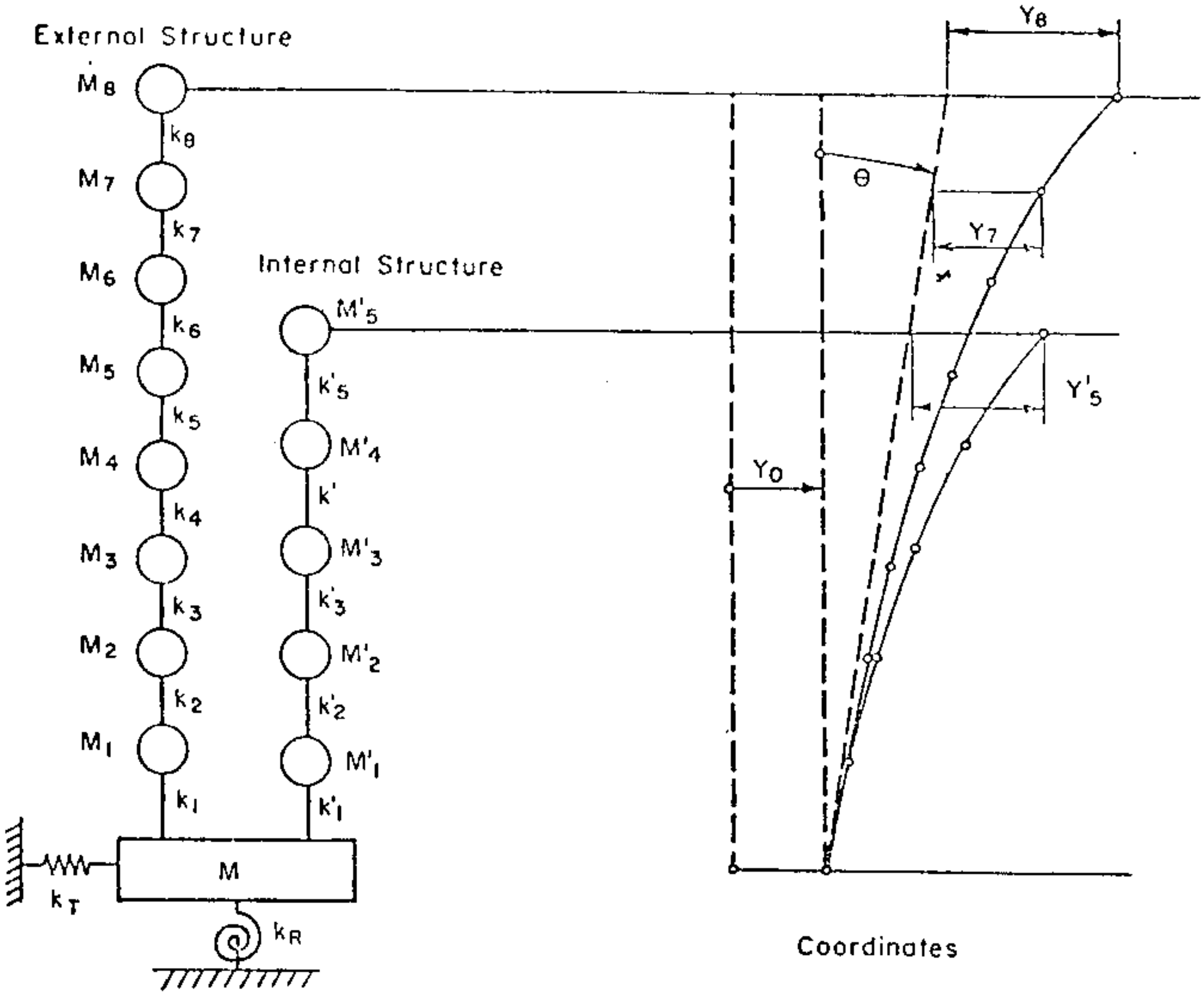
JULY 1982



ELEVATION "E-4" LOOKING NORTH
(NO SCALE)

FIG. 5.2.2-60C

JULY 1982

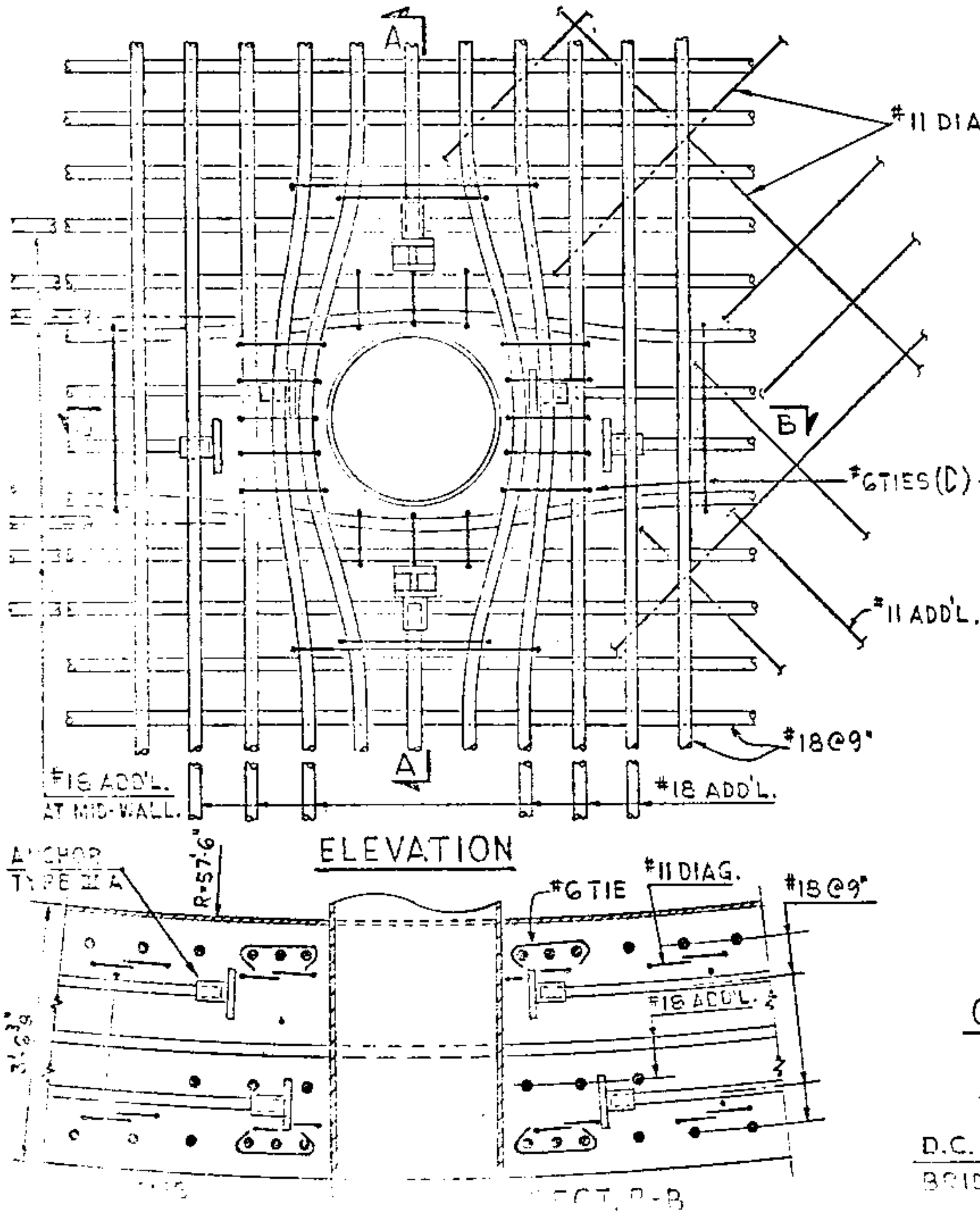


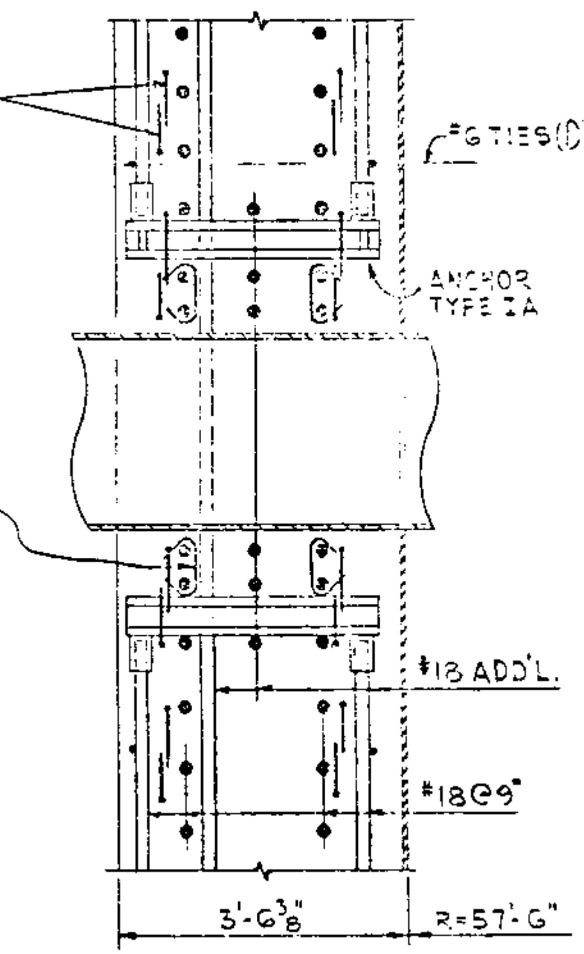
Dynamic Model

LEGENDS:

M = MASS
K = SPRING CONSTANT
Θ = ROTATION
Y = HORIZONTAL TRANSLATION
K_R, K_T = SOIL MODULUS SPRING CONSTANT (ROTATIONAL & TRANSLATIONAL)

Fig. 5.2.2-61





SECTION A-A

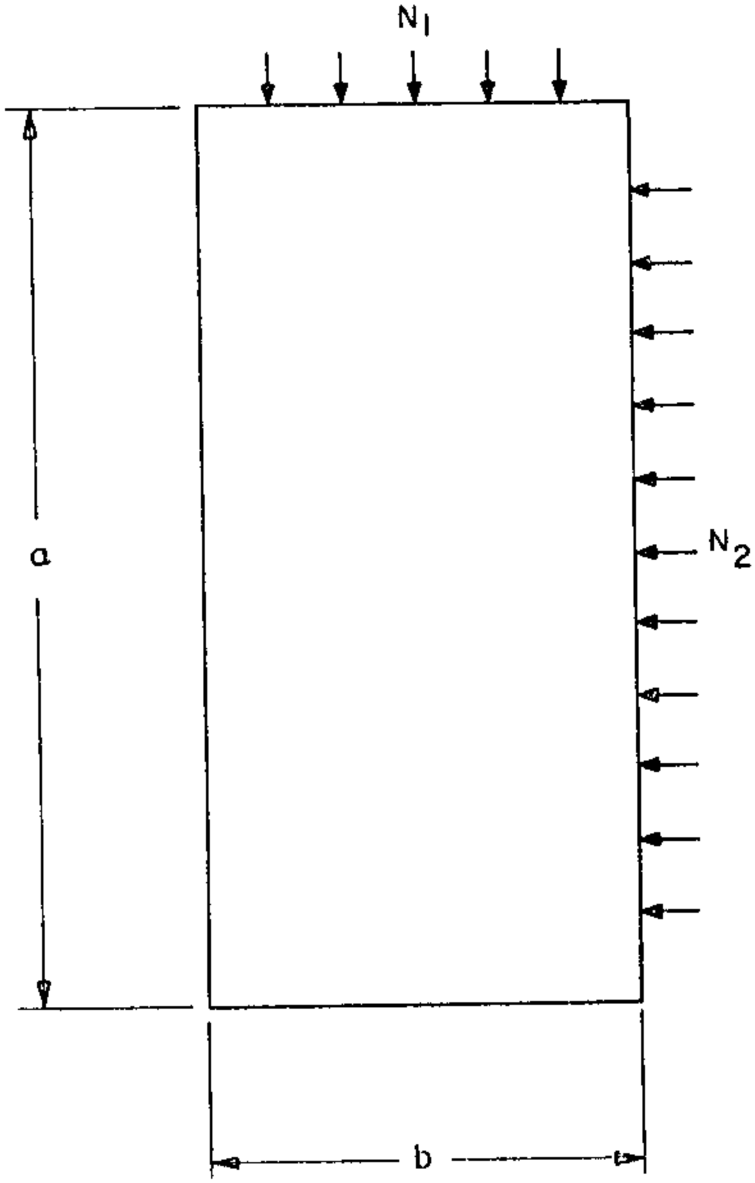
Fig. 5.2.2-63

CONTAINMENT BUILDING

TYP. RE-BAR ARRANGEMENT
AT PENETRATION < 5'-0"⌀

D.C. COOK NUCLEAR POWER PLANT
BRIDGMAN MICHIGAN

JULY 1982


N1
N2
a
b

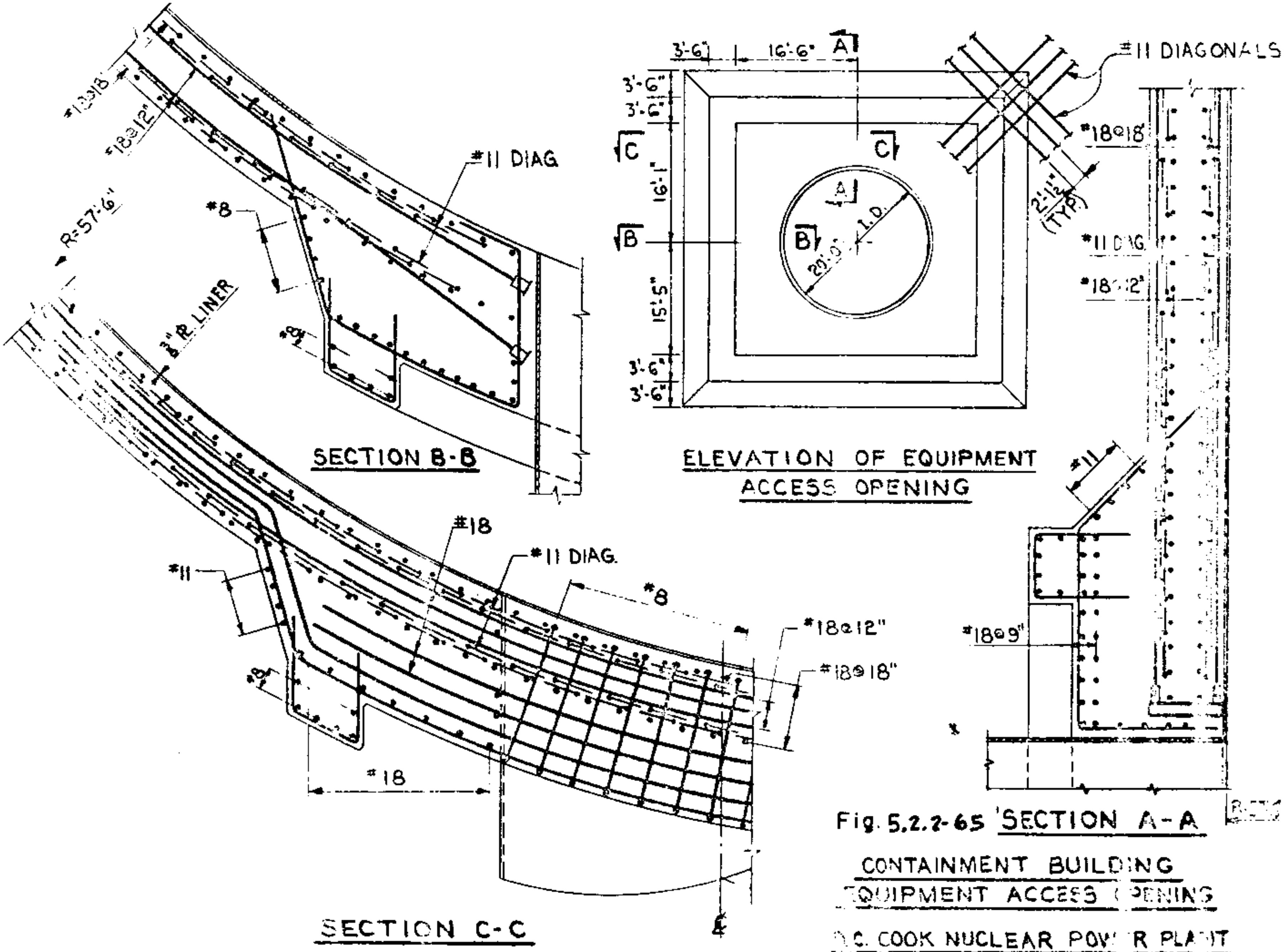
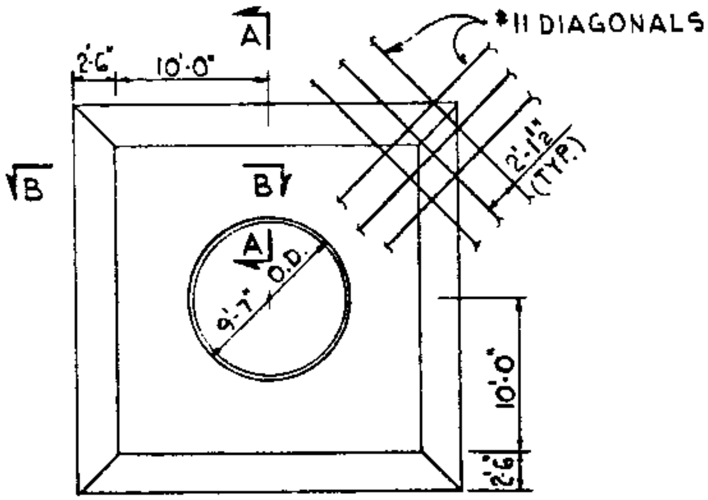


Fig. 5.2.2-65 SECTION A-A

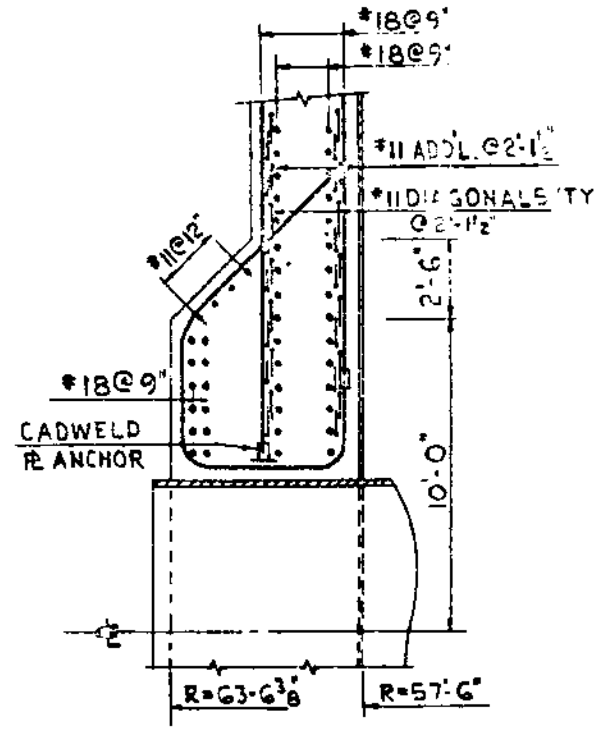
CONTAINMENT BUILDING EQUIPMENT ACCESS OPENING

D.C. COOK NUCLEAR POWER PLANT

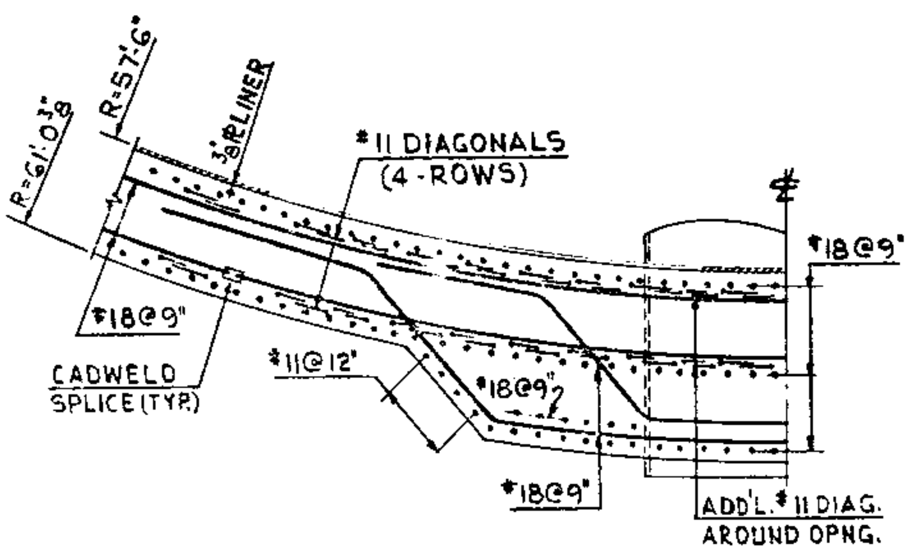
JULY 1982



ELEVATION OF PERSONNEL ACCESS OPENING



SECTION A-A



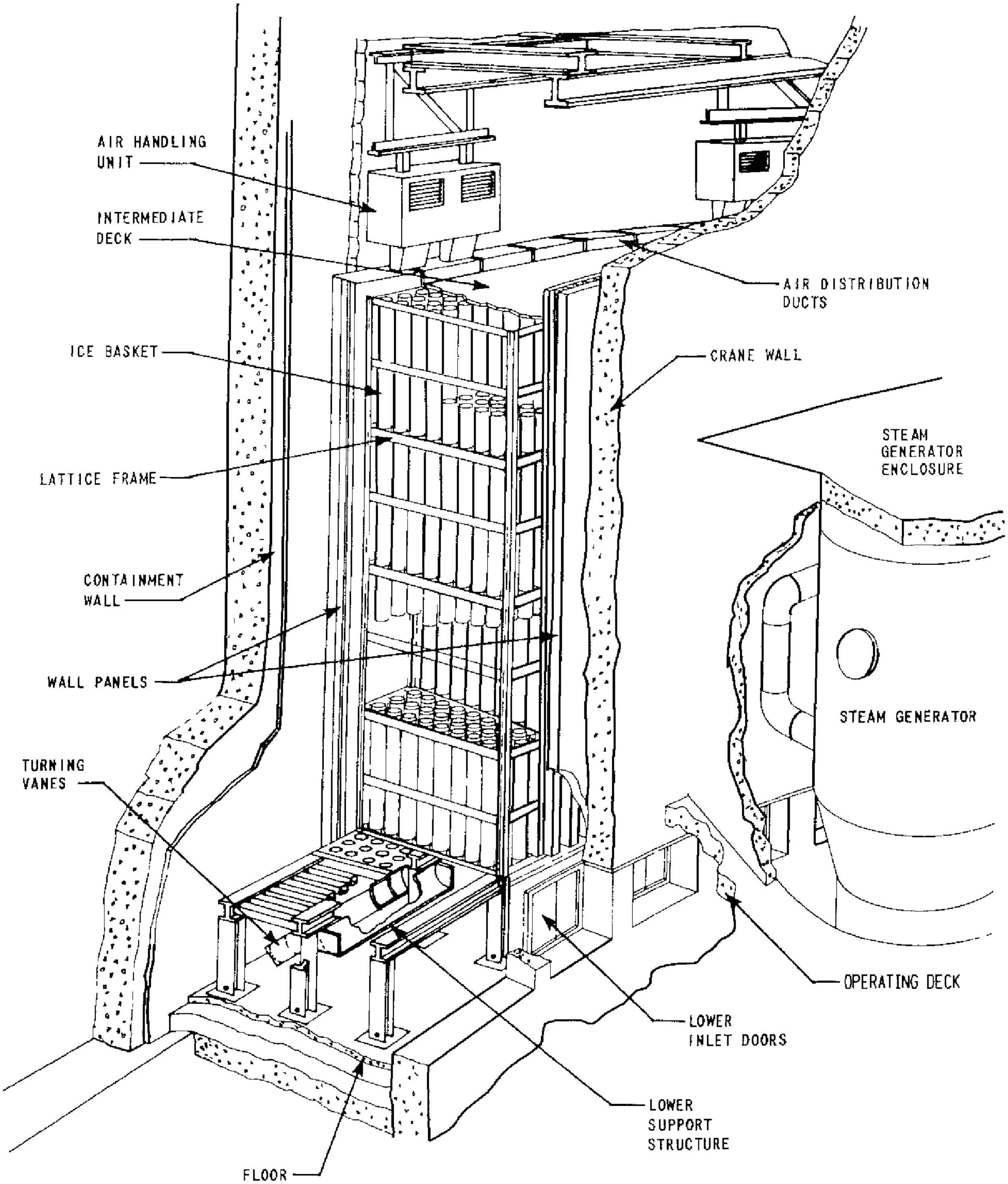
SECTION B-B

Fig. 5.2.2-65A

CONTAINMENT BUILDING
PERSONNEL ACCESS OPENING

D.C. COOK NUCLEAR POWER PLANT
BRIDGMAN MICHIGAN

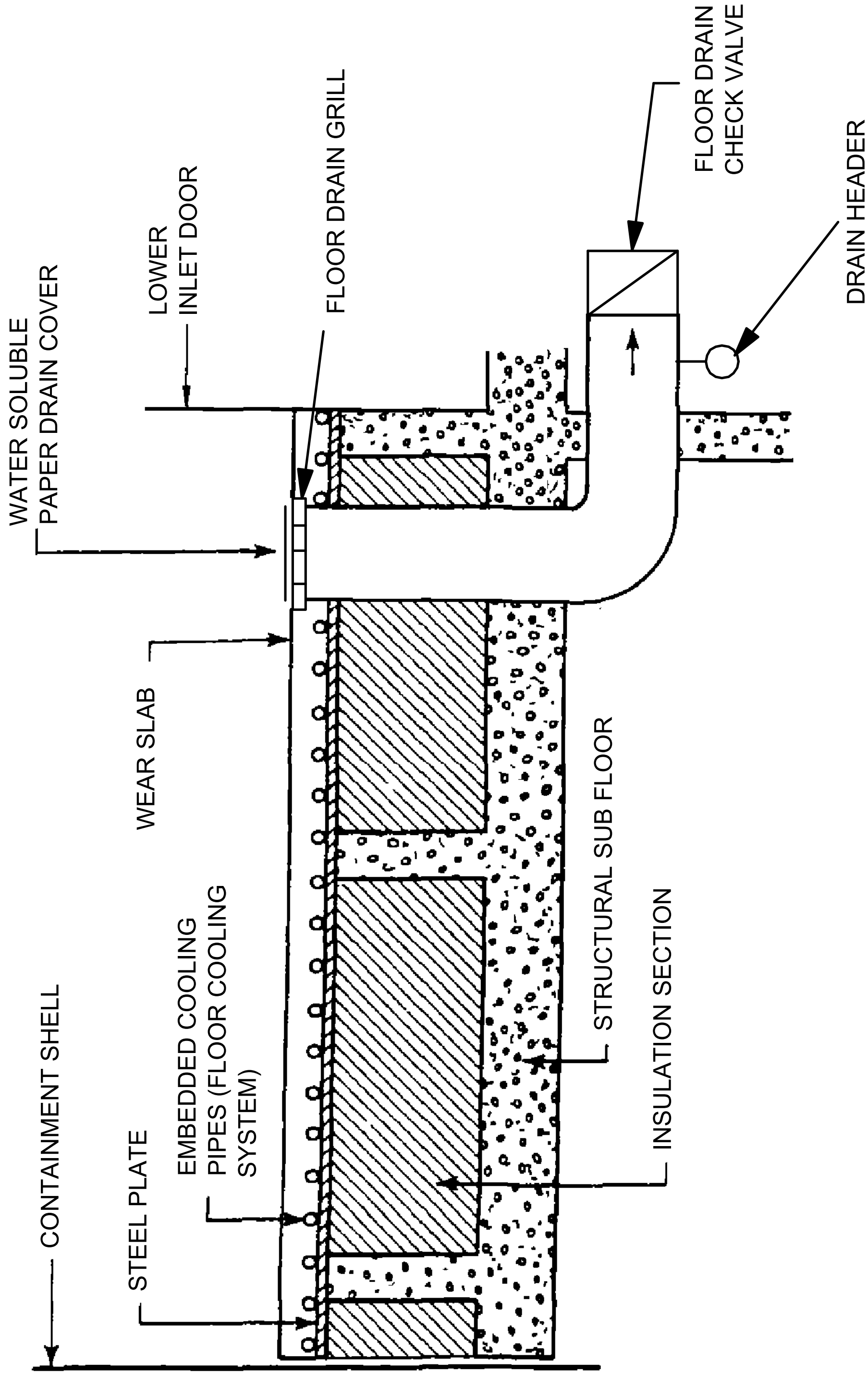
JULY 1982



16.3	REVISED PER 98-UFSAR-115
REV. NO.	**DESCRIPTION**

REVISIONS

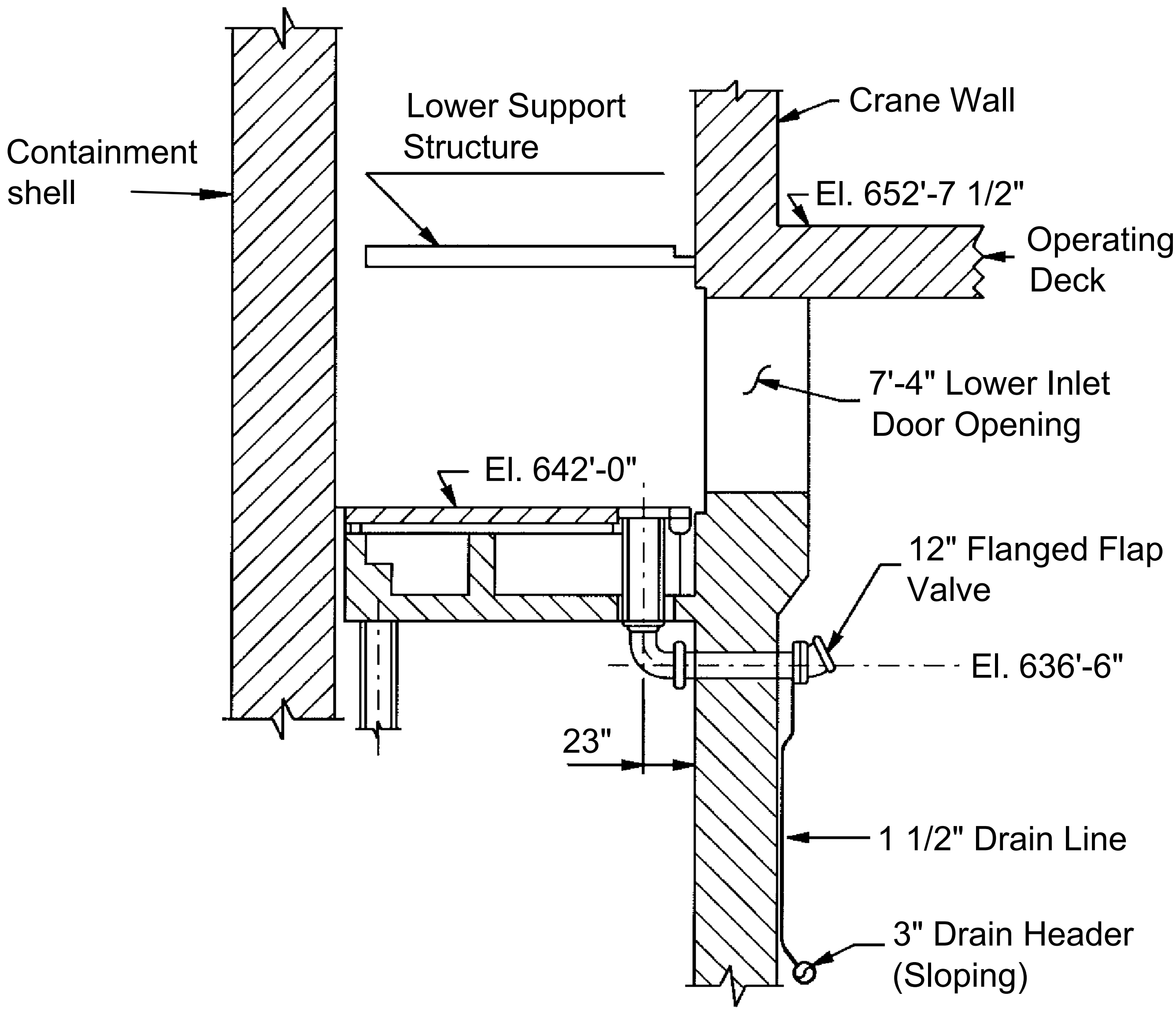
AMERICAN ELECTRIC POWER **COOK NUCLEAR PLANT** **NUCLEAR GENERATION GROUP** **BRIDGMAN, MICHIGAN**	TITLE **ISOMETRIC OF ICE CONDENSER**
	DWG. NO. **FSAR FIG. 5.3.2-1** — SH 1 of 1



REV. NO.	DESCRIPTION
16.3	REVISED PER 98-UFSAR-115

REVISIONS

AMERICAN ELECTRIC POWER **COOK NUCLEAR PLANT** **NUCLEAR GENERATION GROUP** **BRIDGMAN, MICHIGAN**	**TITLE FLOOR STRUCTURE**	
	DWG. NO. FSAR FIG. 5.3.5.1-1	SH 1 of 1



REV. NO.	DESCRIPTION
16.3	REVISED PER 98-UFSAR-452

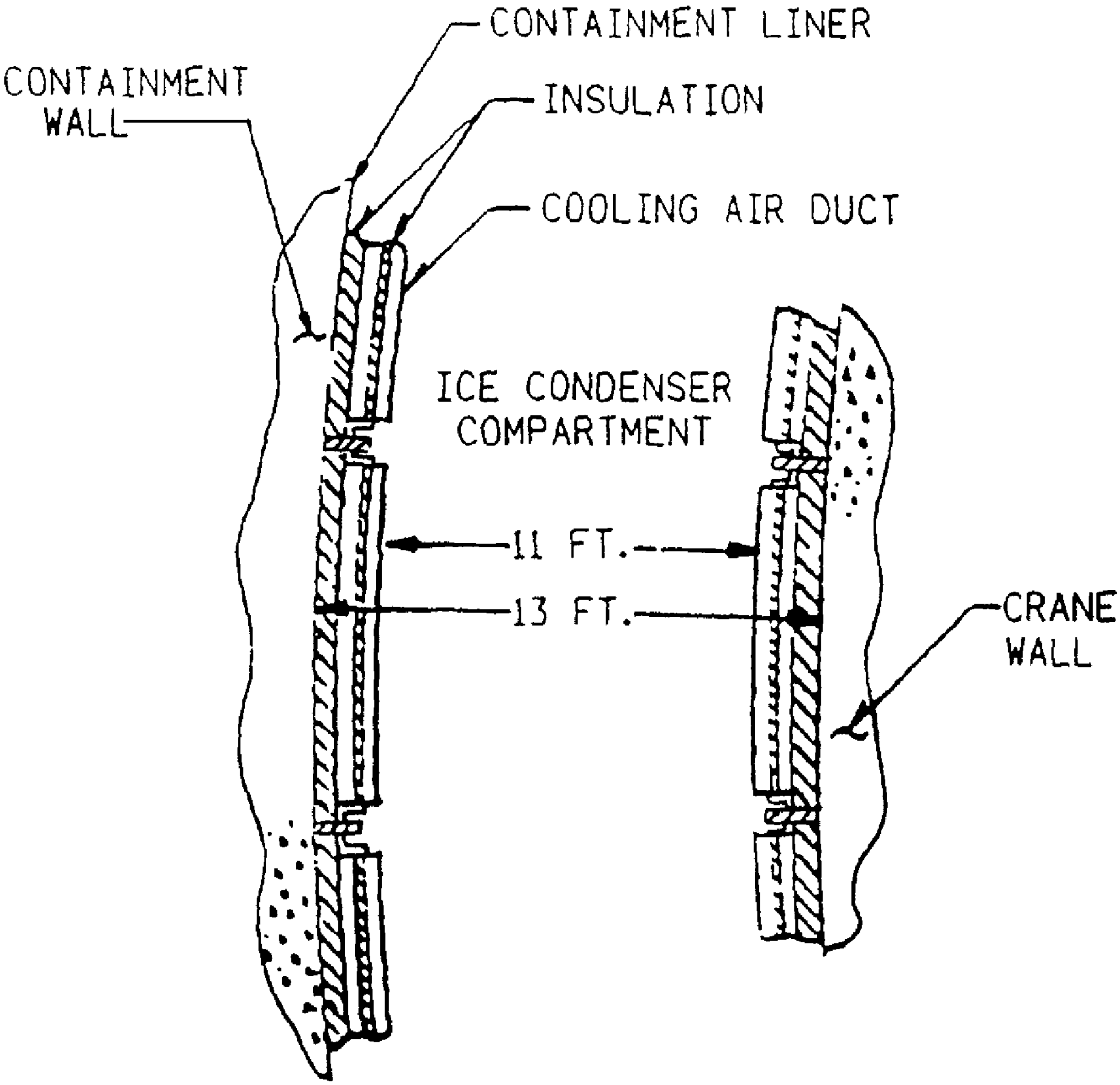
REVISIONS

AMERICAN ELECTRIC POWER
COOK NUCLEAR PLANT
NUCLEAR GENERATION GROUP
BRIDGMAN, MICHIGAN

TITLE **ICE CONDENSER INLET REGION DRAIN ARRANGEMENT**

DWG. NO. **FSAR FIG. 5.3.5.1-2**

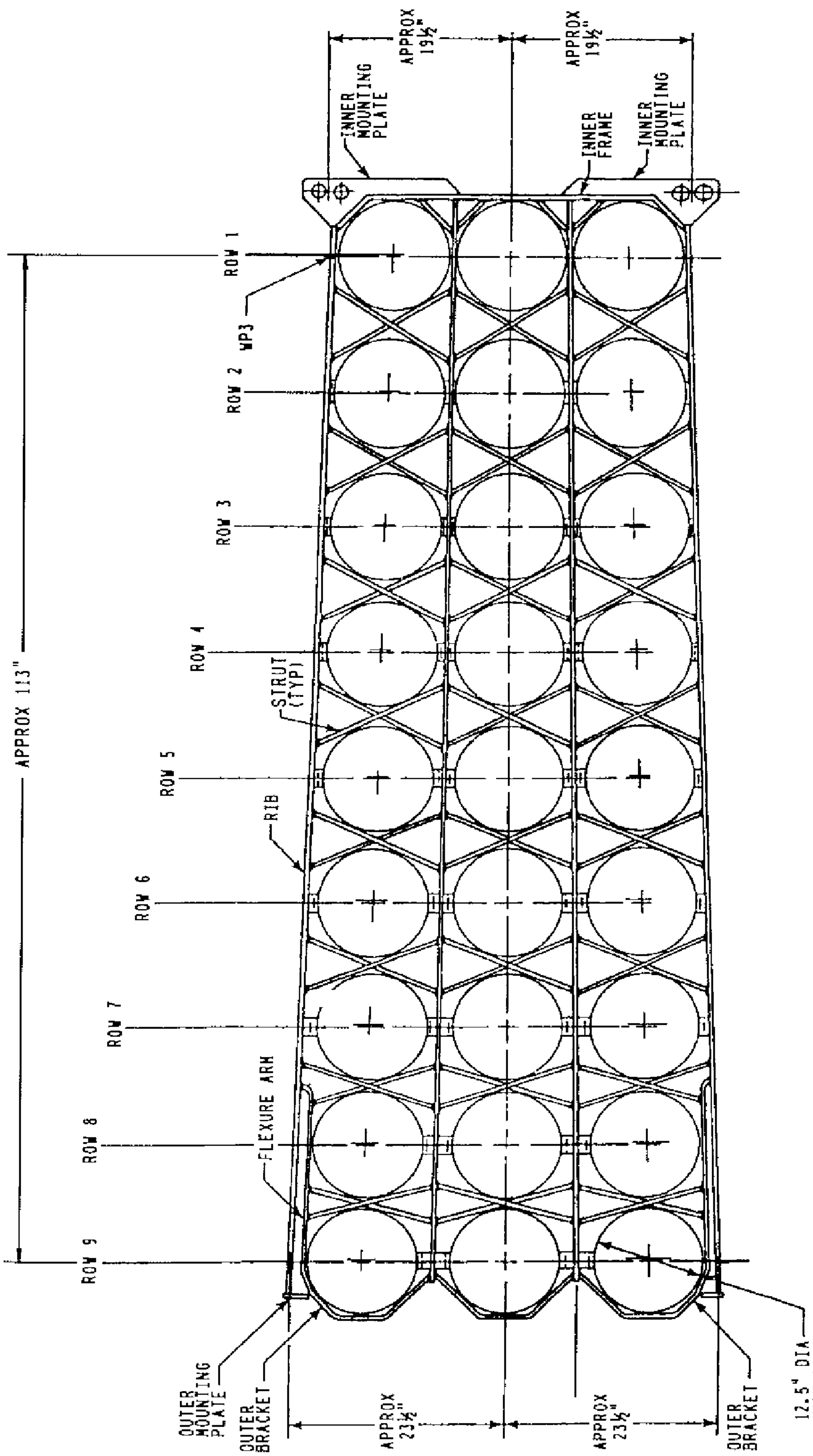
SH 1 of 1



16.3	REVISED PER 98-UFSAR-115
REV. NO.	**DESCRIPTION**

REVISIONS

AMERICAN ELECTRIC POWER **COOK NUCLEAR PLANT** **NUCLEAR GENERATION GROUP** **BRIDGMAN, MICHIGAN**	**TITLE** **ICE CONDENSER WALL PANELS**	
	DWG. NO. **FSAR FIG. 5.3.5.2-1**	SH 1 of 1



NOTE:
ROW NUMBERING REFLECTS WESTINGHOUSE NUMBERING SCHEME AND DIFFERS FROM AEP DESIGNATIONS

16.3	REVISED PER 98-UFSAR-115
REV. NO.	**DESCRIPTION**

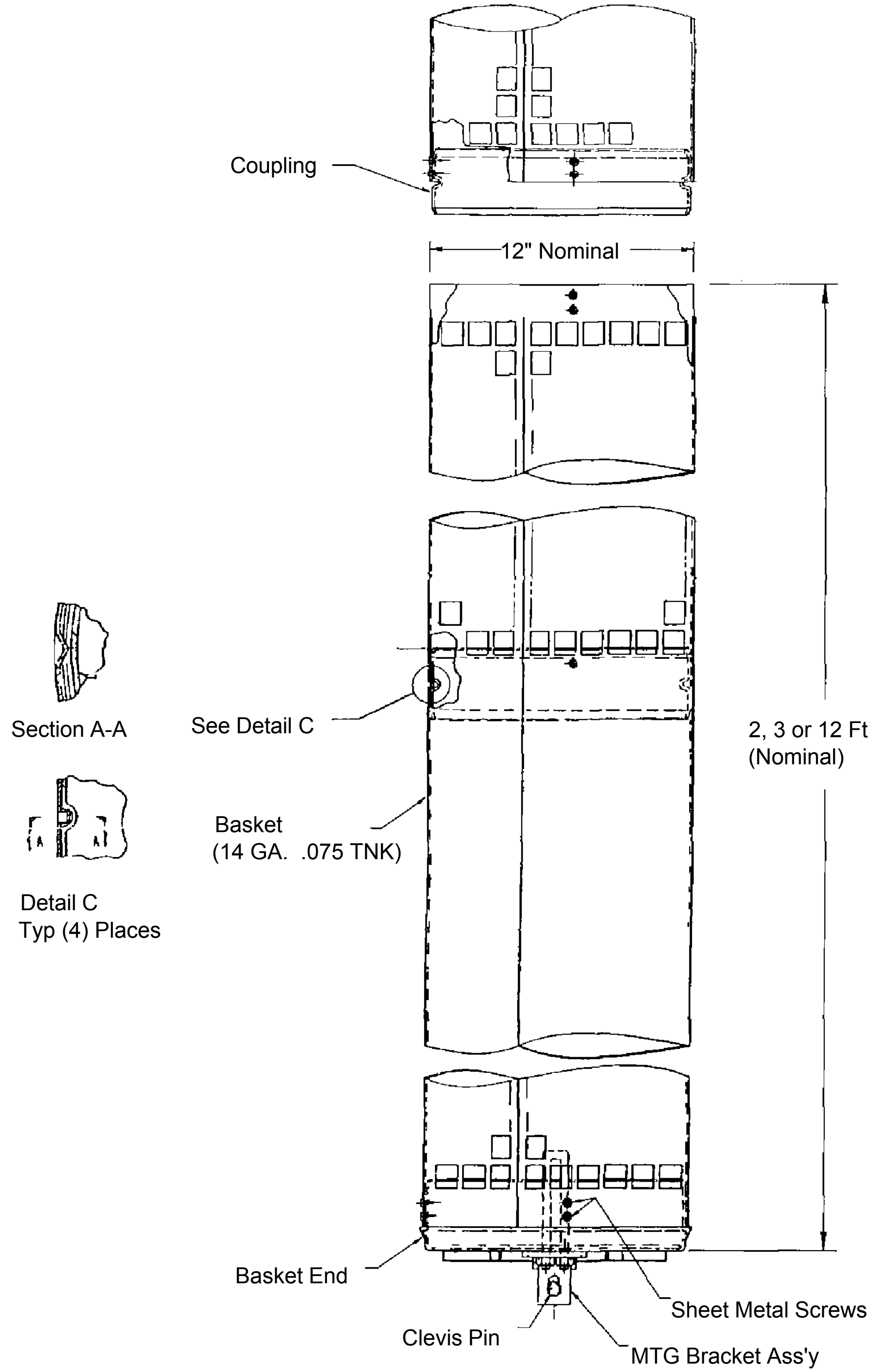
REVISIONS

AMERICAN ELECTRIC POWER
COOK NUCLEAR PLANT
NUCLEAR GENERATION GROUP
BRIDGMAN, MICHIGAN

TITLE TYPICAL LATTICE FRAME

DWG. NO. FSAR FIG. 5.3.5.3-1

SH 1 of 1



REV. NO.	DESCRIPTION
16.3	REVISED PER 98-UFSAR-115

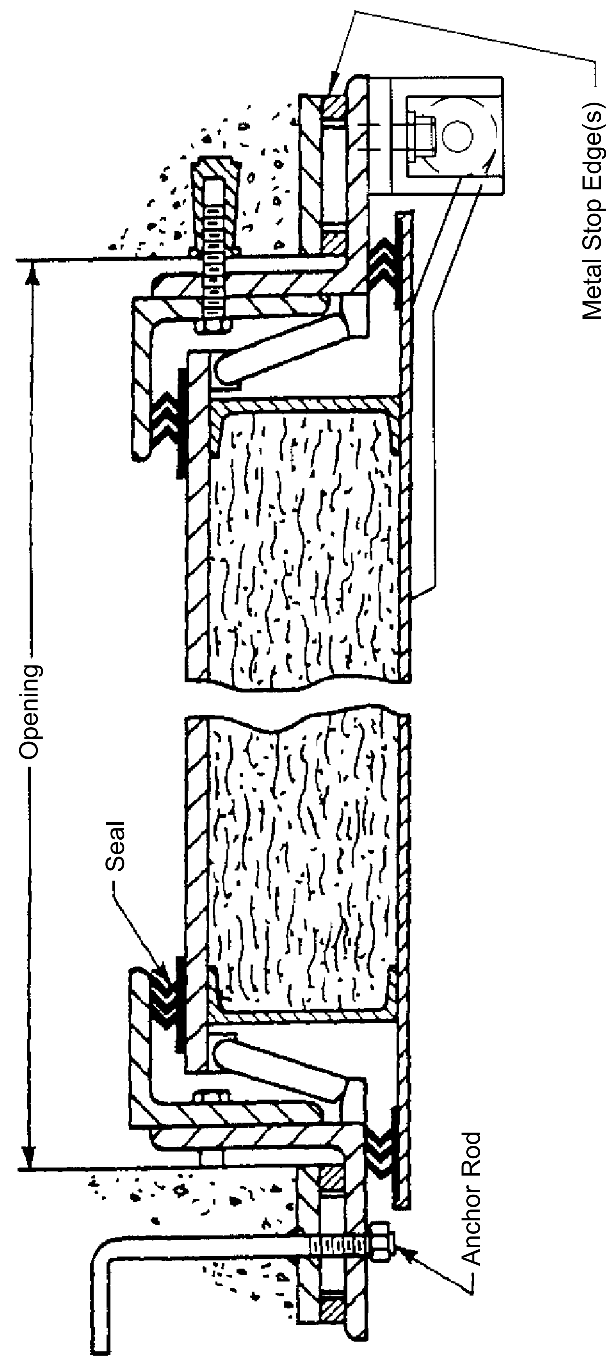
REVISIONS

AMERICAN ELECTRIC POWER
COOK NUCLEAR PLANT
NUCLEAR GENERATION GROUP
BRIDGMAN, MICHIGAN

TITLE **TYPICAL ICE BASKET ASSEMBLY**

DWG. NO. **FSAR FIG. 5.3.5.4-1**

SH 1 of 1



REV. NO.	DESCRIPTION
16.3	Revised Per 98-UFSAR-115

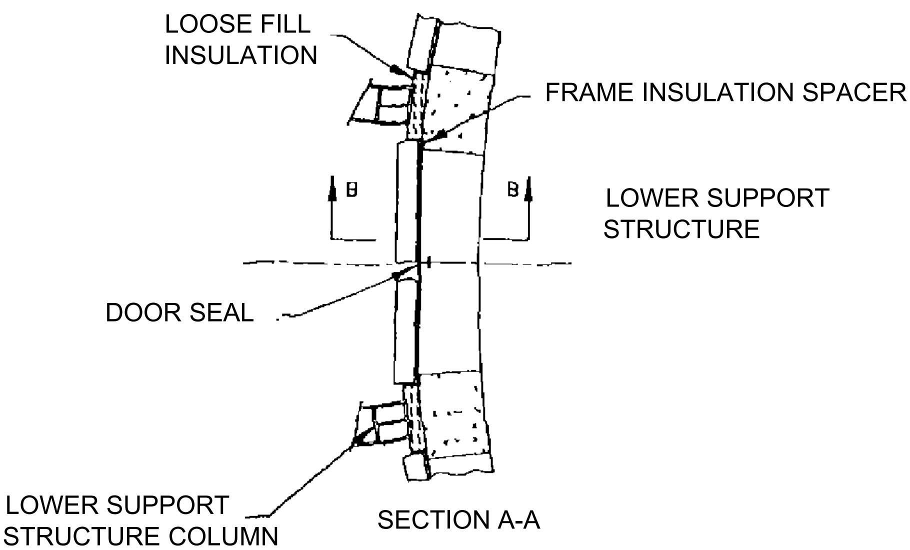
REVISIONS

AMERICAN ELECTRIC POWER
COOK NUCLEAR PLANT
NUCLEAR GENERATION GROUP
BRIDGMAN, MICHIGAN

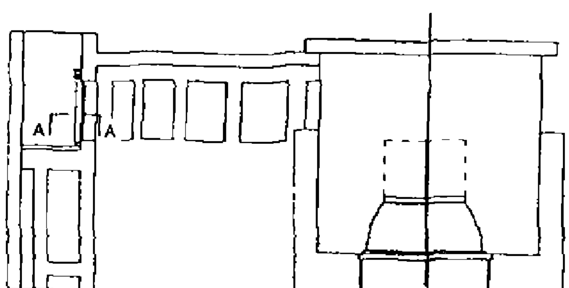
TITLE **HORIZONTAL THROUGH SECTION OF LOWER PERSONNEL ACCESS DOOR**

DWG. NO. **FSAR FIG. 5.3.5.8-1**

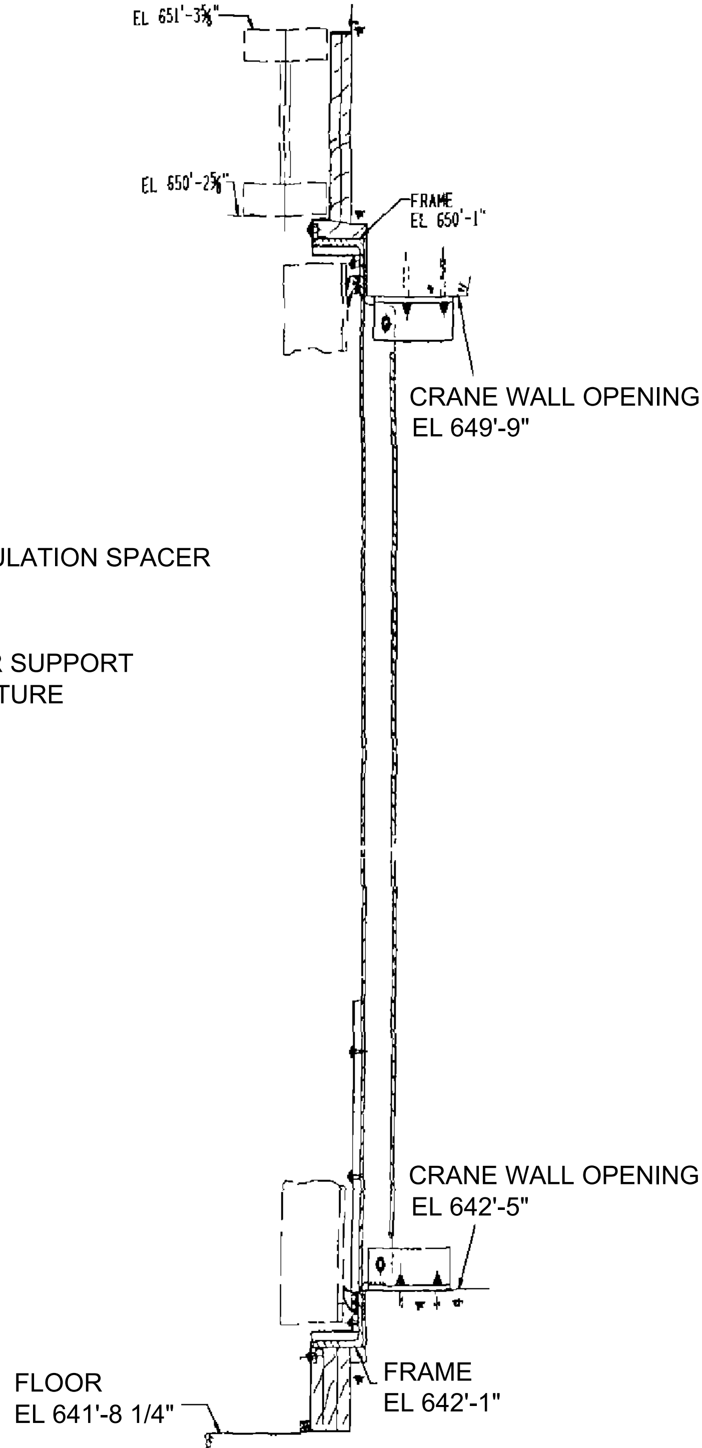
SH 1 of 1



SECTION A-A



PLANT ELEVATION SECTION

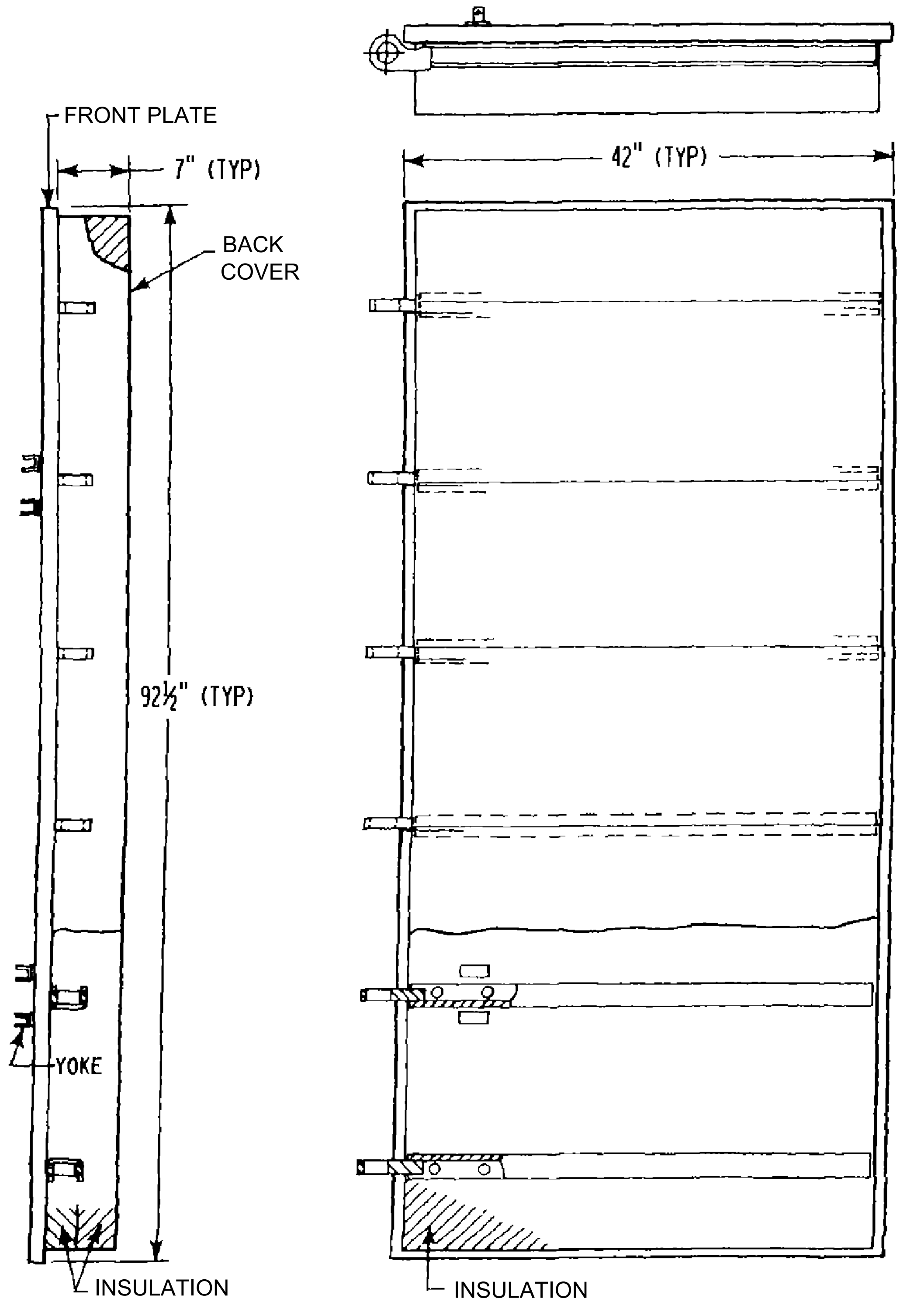


SECTION B-B

REV. NO.	DESCRIPTION
16.3	REVISED PER 98-UFSAR-115

REVISIONS

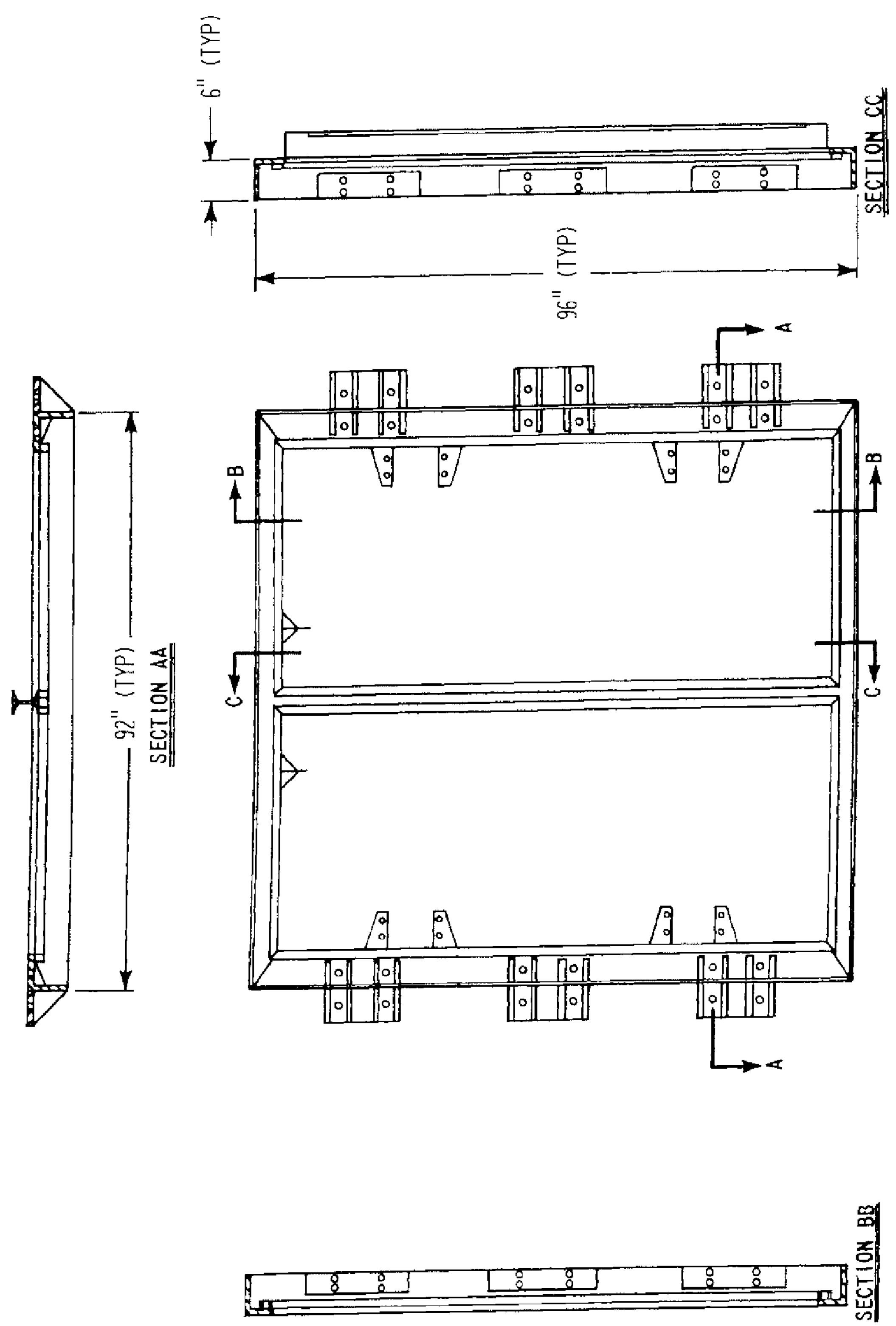
AMERICAN ELECTRIC POWER **COOK NUCLEAR PLANT** **NUCLEAR GENERATION GROUP** **BRIDGMAN, MICHIGAN**	**TITLE** **Typical Ice Condenser Door Frame Section**
	DWG. NO. FSAR FIG. 5.3.5.9-1 — SH 1 of 1



REV. NO.	DESCRIPTION
16.3	REVISED PER 98-UFSAR-115

REVISIONS

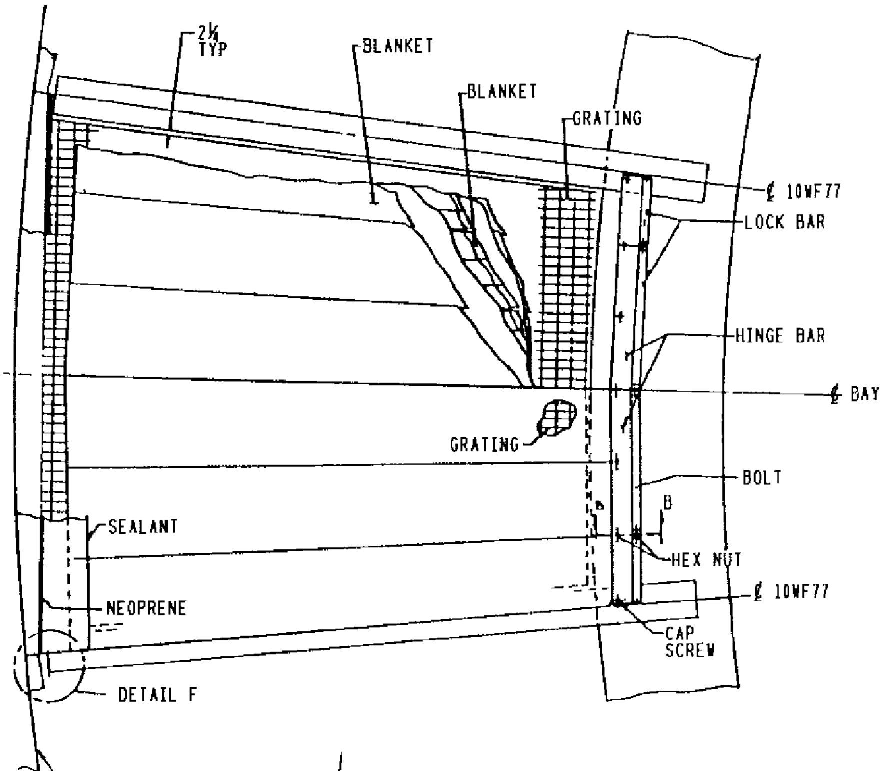
AMERICAN ELECTRIC POWER COOK NUCLEAR PLANT NUCLEAR GENERATION GROUP BRIDGMAN, MICHIGAN	TITLE **INLET DOOR PANEL ASSEMBLY**	
	DWG. NO. **FSAR FIG. 5.3.5.9-2**	SH 1 of 1

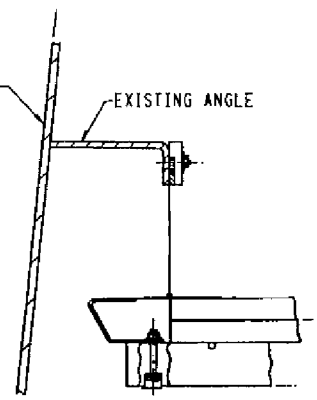


REV. NO.	DESCRIPTION
16.3	REVISED PER 98-UFSAR-115

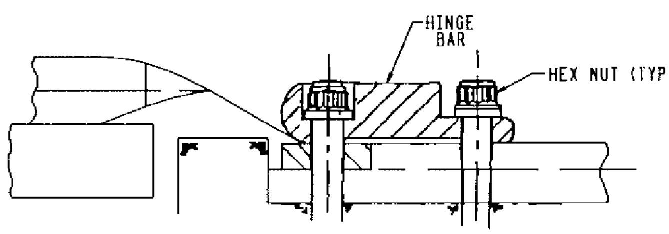
REVISIONS

AMERICAN ELECTRIC POWER COOK NUCLEAR PLANT NUCLEAR GENERATION GROUP BRIDGMAN, MICHIGAN	TITLE **INLET DOOR FRAME ASSEMBLY**
	DWG. NO. **FSAR FIG. 5.3.5.9-3** — SH 1 of 1





DETAIL F

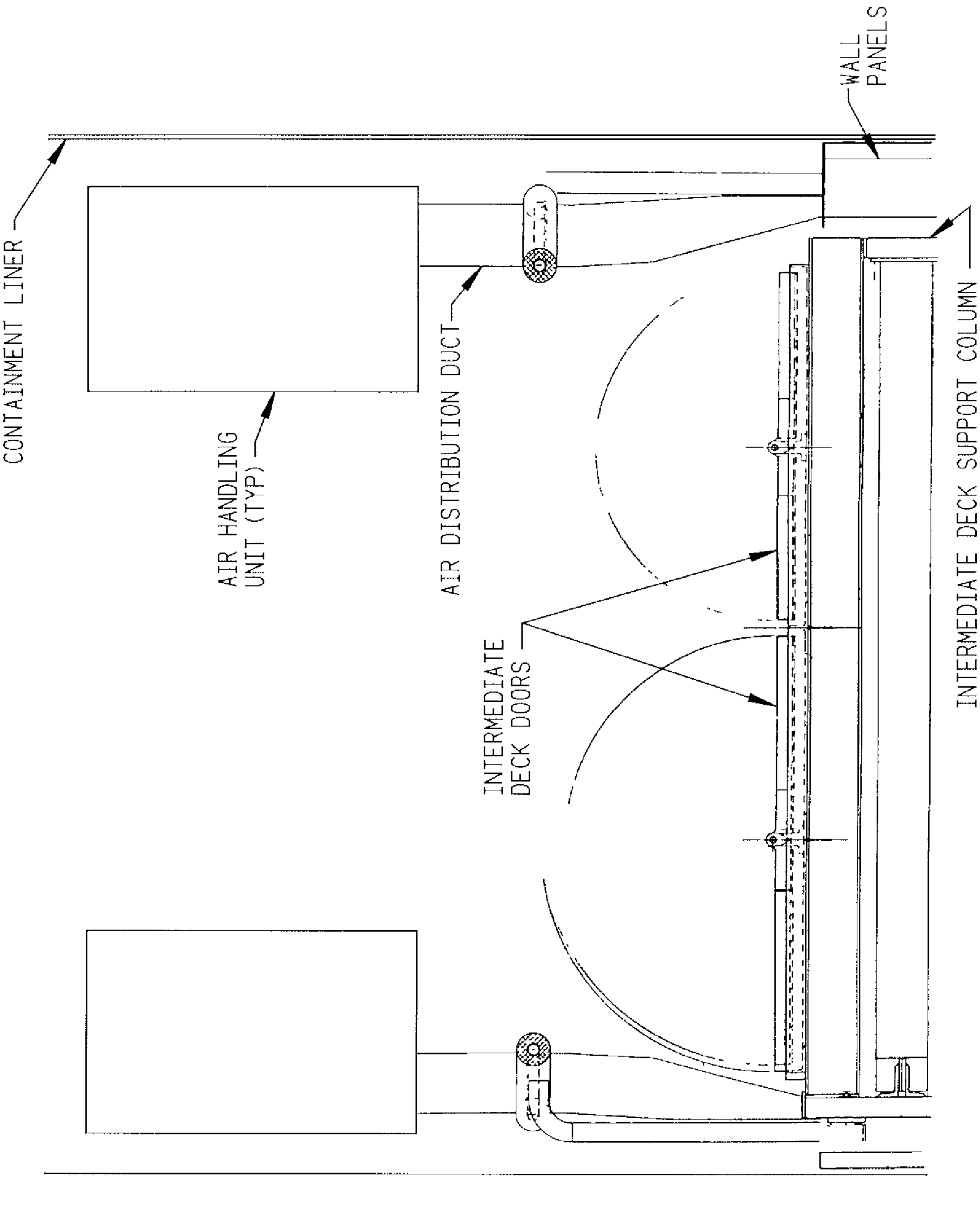


SECTION B-B

16.3	REVISED PER 98-UFSAR-115
REV. NO.	DESCRIPTION

REVISIONS

AMERICAN ELECTRIC POWER **COOK NUCLEAR PLANT** **NUCLEAR GENERATION GROUP** **BRIDGMAN, MICHIGAN**	TITLE **TOP DECK DOOR ASSEMBLY**
	DWG. NO. **FSAR FIG. 5.3.5.10-1** — SH 1 of 1



REV. NO.	DESCRIPTION
16.3	REVISED PER 98-UFSAR-115

REVISIONS

AMERICAN ELECTRIC POWER **COOK NUCLEAR PLANT** **NUCLEAR GENERATION GROUP** **BRIDGMAN, MICHIGAN**	**TITLE** **INTERMEDIATE DECK DOOR ASSEMBLY**
	DWG. NO. **FSAR FIG. 5.3.5.10 - 2** SH 1 of 1

...\fsar-fig-5.3.5.12-1_26.dgn 2/4/2015 6:50:58 AM

DWG. NO. FSAR FIG.5.3.5.12-1A
(30) Fan Cooler Units in Plenum located around Containment
Expansion Tank
VLA
VLA
VFX
FLEX HOSE
BACKDRAFT DAMPERS
VTI
VTI
ELECTRIC DEFROST HEATER
DEFROST CONDENSATE DRAIN (HEAT TRACED)
INTERNAL SOLID BAFFLE
DRAIN HEADER
FAN COOLER INTAKE FROM ICE BED EXHAUST PLENUM
FAN COOLER UNIT
FAN COOLER INTAKE FROM ICE BED EXHAUST PLENUM.
AIR DISTRIBUTION HDR TO DUCTS LOCATED AROUND ICE CONDENSER
AIR DISTRIBUTION HEADER TO DUCTS LOCATED AROUND ICE CONDENSER
NEGATIVE SYSTEM RETURN HDR
BLIND FLANGES TO BE INSTALLED AFTER ICE LOADING
POSITIVE SYSTEM SUPPLY HEADER FOR ICE BASKETS.
INSIDE REACTOR CONTAINMENT
OUTSIDE REACTOR CONTAINMENT
TO & FROM FLOOR COOLING SYSTEM SEE FIG. 5.3.5.12-1
L.O.
L.O.
F.C.
F.C
26.0
VFI
VFI
GLYCOL SUPPLY & RETURN. SEE FIG.5.3.5.12-1
℄ REACTOR CONTAINMENT
INSIDE MISSILE BARRIER
OUTSIDE MISSILE BARRIER
VTR
(96) TEMPERATURE SENSORS LOCATED THROUGHOUT ICE CONDENSER
ICE CONDENSER INLET DOOR
GENERAL NOTES
LEGEND
GLYCOL
REFERENCES:
OP-1(2)-5146A
OP-1(2)-5146B
OP-12-5146E
OP-12-5146F
ICE MACHINE SYSTEM
NESW SUPPLY
NESW RETURN
ICE TO UNIT 1 CONDENSER
ICE TO UNIT 2 CONDENSER
26.0 REVISED PER UCR-2062
DATE NO. DESCRIPTION APPD.
REVISIONS
REFER TO DRAWING MICROFILM OR MASTER INDEX FOR APPROVAL DATES AND SIGNATURES. (CADD-RASTER)
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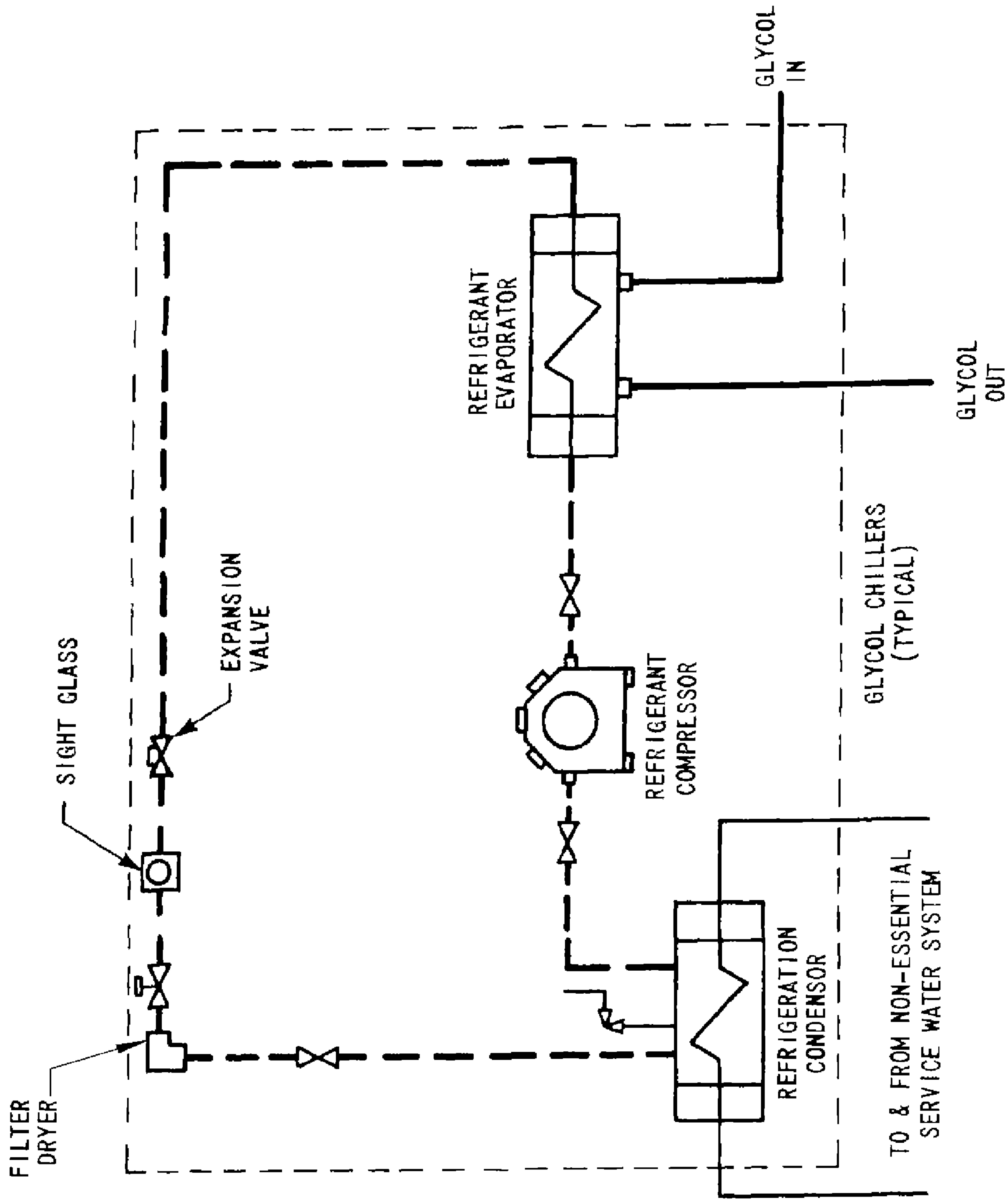
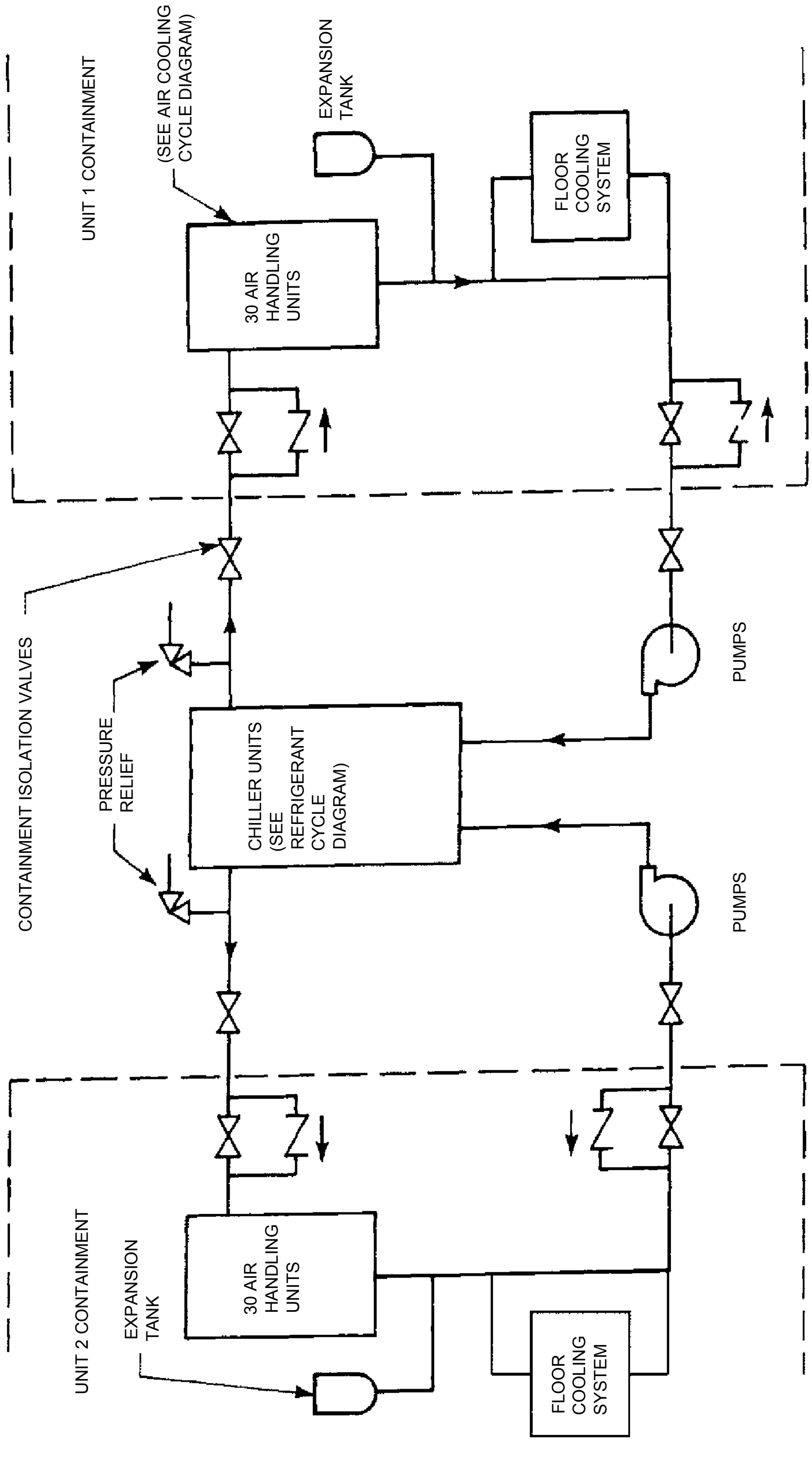
INDIANA MICHIGAN POWER COMPANY
DONALD C. COOK
NUCLEAR PLANT
BRIDGMAN MICHIGAN
ICE CONDENSER REFRIGERATION UNITS NO. 1 OR 2 SHEET 2 OF 2
DWG. NO. FSAR FIG. 5.3.5.12-1A
ARCH ELEC MECH STR
SCALE: DR:
DATE: CH:
DESIGN ENGINEERING DIVISION
AMERICAN ELECTRIC POWER
AEP SERVICE CORP. 1 RIVERSIDE PLAZA COLUMBUS, OH 43215



REV. NO.	DESCRIPTION
16.3	REVISED PER 98-UFSAR-115

REVISIONS

AMERICAN ELECTRIC POWER **COOK NUCLEAR PLANT** **NUCLEAR GENERATION GROUP** **BRIDGMAN, MICHIGAN**	**TITLE** **REFRIGERANT CYCLE DIAGRAM**
	DWG. NO. **FSAR FIG. 5.3.5.12 - 2** — SH 1 of 1



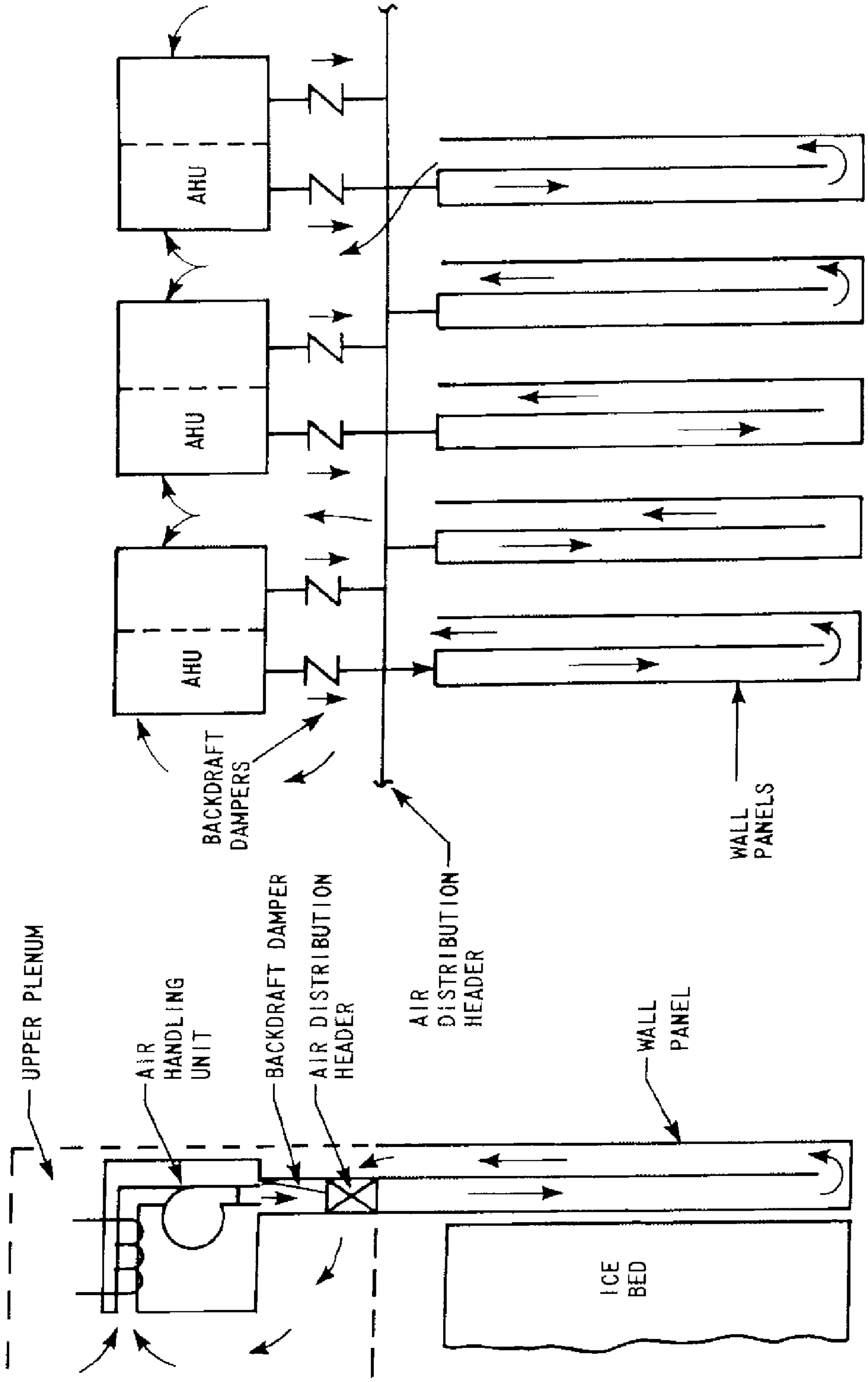
REV. NO.	DESCRIPTION
16.3	REVISED PER 98-UFSAR-115

REVISIONS

AMERICAN ELECTRIC POWER
COOK NUCLEAR PLANT
NUCLEAR GENERATION GROUP
BRIDGMAN, MICHIGAN

TITLE **GLYCOL CYCLE TO EACH CONTAINMENT**

DWG. NO. **FSAR FIG. 5.3.5.12-3** SH 1 of 1



REV. NO.	DESCRIPTION
16.3	REVISED PER 98-UFSAR-115

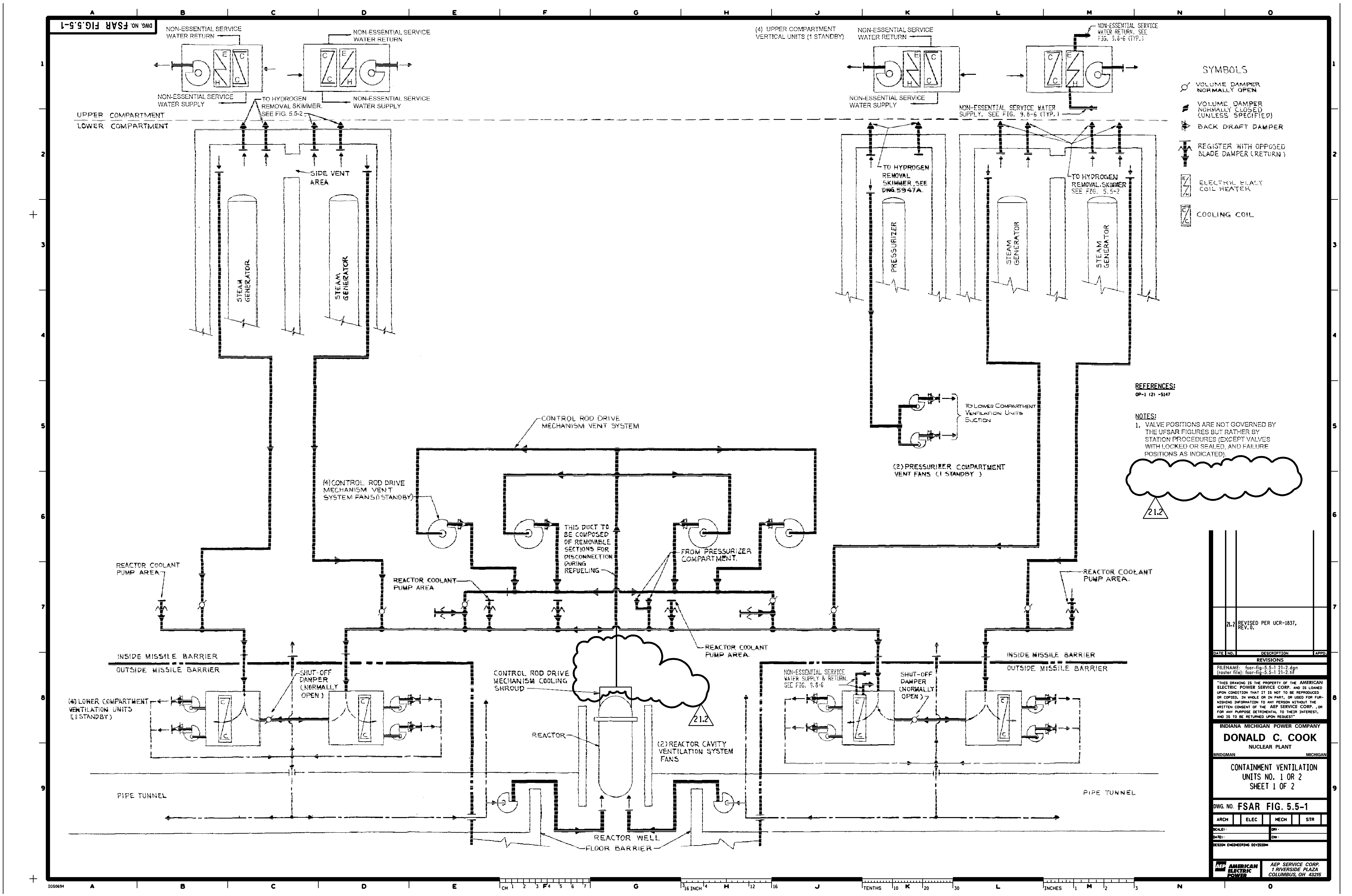
REVISIONS

AMERICAN ELECTRIC POWER
COOK NUCLEAR PLANT
NUCLEAR GENERATION GROUP
BRIDGMAN, MICHIGAN

TITLE **SCHEMATIC FLOW DIAGRAM OF AIR COOLING CYCLE**

DWG. NO. **FSAR FIG. 5.3.5.12 - 4**

SH 1 of 1



DWG. NO. FSAR FIG.5.5-1
NON-ESSENTIAL SERVICE WATER RETURN
NON-ESSENTIAL SERVICE WATER SUPPLY
TO HYDROGEN REMOVAL SKIMMER. SEE FIG. 5.5-2
(4) UPPER COMPARTMENT VERTICAL UNITS (1 STANDBY)
NON-ESSENTIAL SERVICE WATER RETURN, SEE FIG. 9.8-6 (TYP.)
NON-ESSENTIAL SERVICE WATER SUPPLY, SEE FIG. 9.8-6 (TYP.)
UPPER COMPARTMENT
LOWER COMPARTMENT
SIDE VENT AREA
STEAM GENERATOR
PRESSURIZER
TO HYDROGEN REMOVAL SKIMMER, SEE DWG.5947A.
TO HYDROGEN REMOVAL SKIMMER SEE FIG. 5.5-2
SYMBOLS
VOLUME DAMPER NORMALLY OPEN
VOLUME DAMPER NORMALLY CLOSED (UNLESS SPECIFIED)
BACK DRAFT DAMPER
REGISTER WITH OPPOSED BLADE DAMPER (RETURN)
ELECTRIC HEAT COIL HEATER
COOLING COIL
TO LOWER COMPARTMENT VENTILATION UNITS SUCTION
(2) PRESSURIZER COMPARTMENT VENT FANS (1 STANDBY)
REFERENCES:
OP-1 (2) -5147
NOTES:
1. VALVE POSITIONS ARE NOT GOVERNED BY THE UFSAR FIGURES BUT RATHER BY STATION PROCEDURES (EXCEPT VALVES WITH LOCKED OR SEALED, AND FAILURE POSITIONS AS INDICATED).
21.2
CONTROL ROD DRIVE MECHANISM VENT SYSTEM
(4) CONTROL ROD DRIVE MECHANISM VENT SYSTEM FANS (1 STANDBY)
THIS DUCT TO BE COMPOSED OF REMOVABLE SECTIONS FOR DISCONNECTION DURING REFUELING
FROM PRESSURIZER COMPARTMENT.
REACTOR COOLANT PUMP AREA
INSIDE MISSILE BARRIER
OUTSIDE MISSILE BARRIER
SHUT-OFF DAMPER (NORMALLY OPEN)
(4) LOWER COMPARTMENT VENTILATION UNITS (1 STANDBY)
CONTROL ROD DRIVE MECHANISM COOLING SHROUD
REACTOR
(2) REACTOR CAVITY VENTILATION SYSTEM FANS
NON-ESSENTIAL SERVICE WATER SUPPLY & RETURN. SEE FIG. 9.8-6
PIPE TUNNEL
REACTOR WELL
FLOOR BARRIER
21.2 REVISED PER UCR-1837, REV.0.
DATE NO. DESCRIPTION APPD.
REVISIONS
FILENAME: fsar-fig-5.5-1 21-2.dgn
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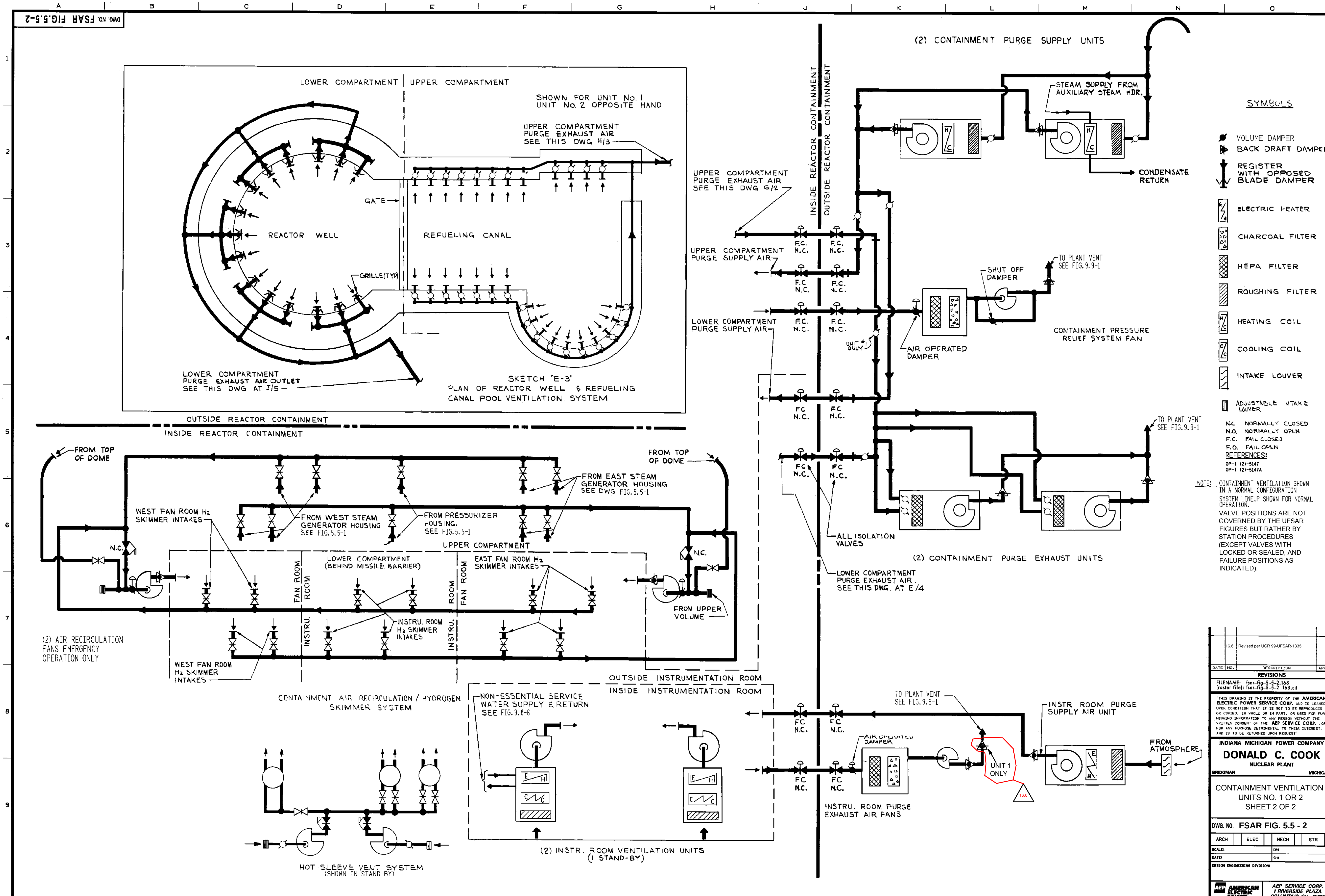
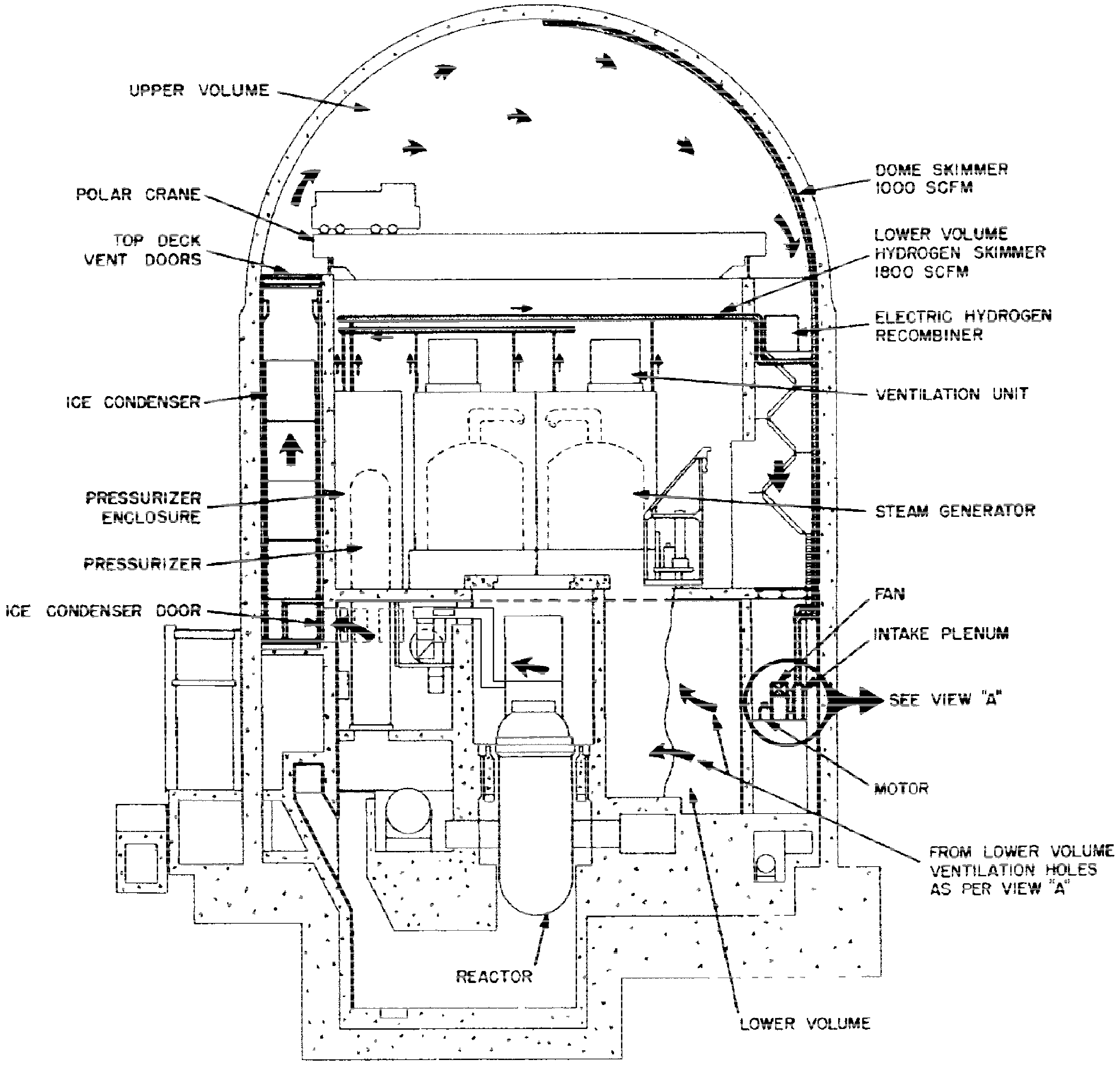
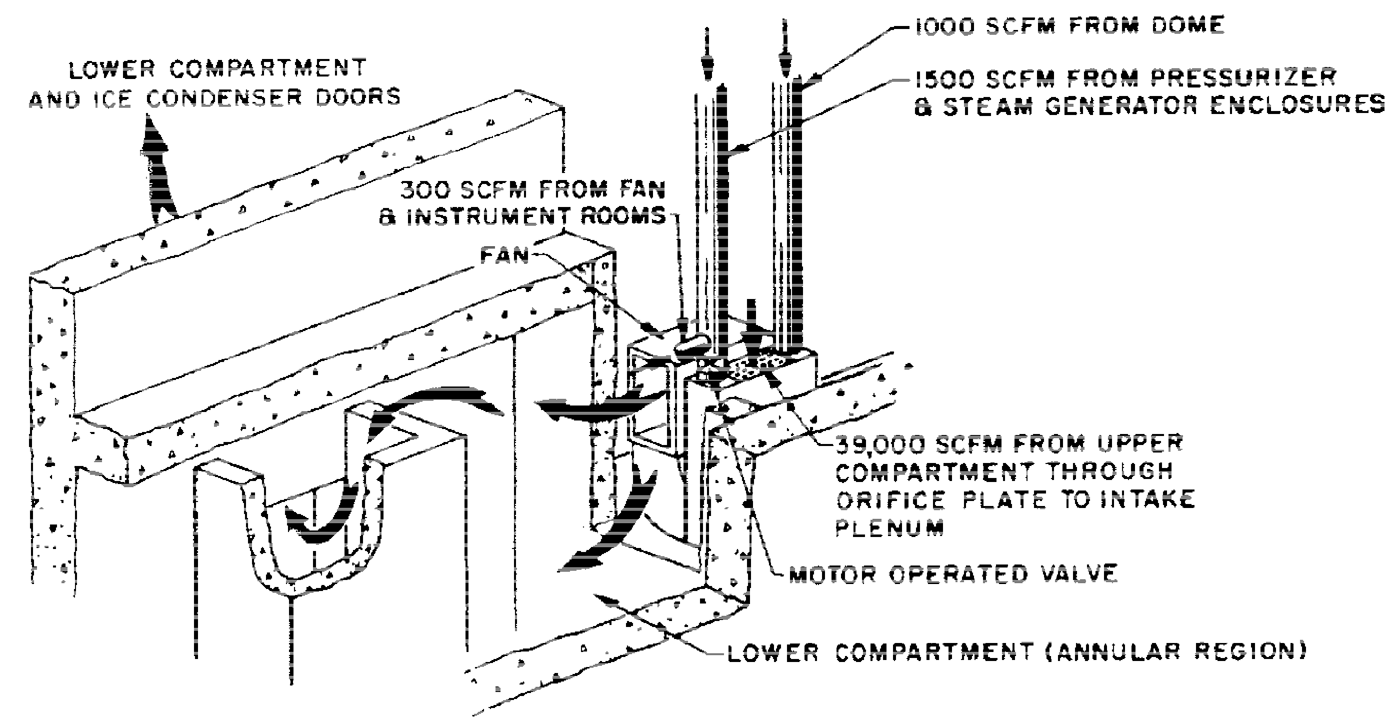
INDIANA MICHIGAN POWER COMPANY
DONALD C. COOK
NUCLEAR PLANT
BRIDGMAN MICHIGAN
CONTAINMENT VENTILATION
UNITS NO. 1 OR 2
SHEET 1 OF 2
DWG. NO. FSAR FIG. 5.5-1
ARCH ELEC MECH STR
AMERICAN ELECTRIC POWER
AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215



DWG. NO. FSAR FIG.5.5-2
LOWER COMPARTMENT
UPPER COMPARTMENT
SHOWN FOR UNIT No. 1
UNIT No. 2 OPPOSITE HAND
UPPER COMPARTMENT PURGE EXHAUST AIR SEE THIS DWG H/3
GATE
REACTOR WELL
REFUELING CANAL
GRILLE(TYP)
LOWER COMPARTMENT PURGE EXHAUST AIR OUTLET SEE THIS DWG AT J/5
SKETCH "E-3"
PLAN OF REACTOR WELL & REFUELING CANAL POOL VENTILATION SYSTEM
OUTSIDE REACTOR CONTAINMENT
INSIDE REACTOR CONTAINMENT
FROM TOP OF DOME
FROM EAST STEAM GENERATOR HOUSING SEE DWG FIG.5.5-1
WEST FAN ROOM H₂ SKIMMER INTAKES
FROM WEST STEAM GENERATOR HOUSING SEE FIG.5.5-1
FROM PRESSURIZER HOUSING. SEE FIG.5.5-1
UPPER COMPARTMENT
N.C.
LOWER COMPARTMENT (BEHIND MISSILE BARRIER)
EAST FAN ROOM H₂ SKIMMER INTAKES
FAN ROOM
INSTRU. ROOM
INSTRU. ROOM H₂ SKIMMER INTAKES
FROM UPPER VOLUME
(2) AIR RECIRCULATION FANS EMERGENCY OPERATION ONLY
WEST FAN ROOM H₂ SKIMMER INTAKES
CONTAINMENT AIR RECIRCULATION / HYDROGEN SKIMMER SYSTEM
OUTSIDE INSTRUMENTATION ROOM
INSIDE INSTRUMENTATION ROOM
NON-ESSENTIAL SERVICE WATER SUPPLY & RETURN SEE FIG. 9.8-6
HOT SLEEVE VENT SYSTEM (SHOWN IN STAND-BY)
(2) INSTR. ROOM VENTILATION UNITS (1 STAND-BY)
INSIDE REACTOR CONTAINMENT
OUTSIDE REACTOR CONTAINMENT
(2) CONTAINMENT PURGE SUPPLY UNITS
STEAM SUPPLY FROM AUXILIARY STEAM HDR.
CONDENSATE RETURN
UPPER COMPARTMENT PURGE EXHAUST AIR SEE THIS DWG G/2
UPPER COMPARTMENT PURGE SUPPLY AIR
LOWER COMPARTMENT PURGE SUPPLY AIR
F.C. N.C.
UNIT 1 ONLY
SHUT OFF DAMPER
TO PLANT VENT SEE FIG. 9.9-1
AIR OPERATED DAMPER
CONTAINMENT PRESSURE RELIEF SYSTEM FAN
ALL ISOLATION VALVES
LOWER COMPARTMENT PURGE EXHAUST AIR. SEE THIS DWG. AT E/4
(2) CONTAINMENT PURGE EXHAUST UNITS
TO PLANT VENT SEE FIG. 9.9-1
INSTR ROOM PURGE SUPPLY AIR UNIT
FROM ATMOSPHERE
AIR OPERATED DAMPER
UNIT 1 ONLY
INSTRU. ROOM PURGE EXHAUST AIR FANS
SYMBOLS
VOLUME DAMPER
BACK DRAFT DAMPER
REGISTER WITH OPPOSED BLADE DAMPER
ELECTRIC HEATER
CHARCOAL FILTER
HEPA FILTER
ROUGHING FILTER
HEATING COIL
COOLING COIL
INTAKE LOUVER
ADJUSTABLE INTAKE LOUVER
N.C. NORMALLY CLOSED
N.O. NORMALLY OPEN
F.C. FAIL CLOSED
F.O. FAIL OPEN
REFERENCES:
OP-1 (2)-5147
OP-1 (2)-5147A
NOTE: CONTAINMENT VENTILATION SHOWN IN A NORMAL CONFIGURATION
SYSTEM LINEUP SHOWN FOR NORMAL OPERATION.
VALVE POSITIONS ARE NOT GOVERNED BY THE UFSAR FIGURES BUT RATHER BY STATION PROCEDURES (EXCEPT VALVES WITH LOCKED OR SEALED, AND FAILURE POSITIONS AS INDICATED).
16.6 Revised per UCR 99-UFSAR-1335
REVISIONS
FILENAME: fsar-fig-5-5-2.163
(raster file): fsar-fig-5-5-2 163.cit
INDIANA MICHIGAN POWER COMPANY
DONALD C. COOK
NUCLEAR PLANT
BRIDGMAN MICHIGAN
CONTAINMENT VENTILATION
UNITS NO. 1 OR 2
SHEET 2 OF 2
DWG. NO. FSAR FIG. 5.5 - 2
DESIGN ENGINEERING DIVISION
AMERICAN ELECTRIC POWER
AEP SERVICE CORP. 1 RIVERSIDE PLAZA COLUMBUS, OH 43215

DWG. NO. FSAR FIG.5.5-3





NOTE: ACCUMULATOR NOT SHOWN FOR CLARITY

VIEW "A"

NOTES:

1. REVISED PER 2-MOD-55002.

21.2

DATE	NO.	DESCRIPTION	APPD.
	21.2	REVISED PER UCR-1837, REV.0.	

REVISIONS

FILENAME: fsar-fig-5.5-3 21-2.dgn
(raster file): fsar-fig-5.5-3 21-2.tif

INDIANA MICHIGAN POWER COMPANY

DONALD C. COOK

NUCLEAR PLANT

BRIDGMAN MICHIGAN

FLOW PATH OF THE CONTAINMENT AIR RECIRCULATION / HYDROGEN SKIMMER SYSTEM
UNIT NO. 1 OR 2

21.2

DWG. NO. **FSAR FIG. 5.5-3**

ARCH | ELEC | MECH | STR

SCALE: · DR: ·
DATE: · CH: ·

DESIGN ENGINEERING DIVISION:

AEP AMERICAN ELECTRIC POWER

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

IGS0694

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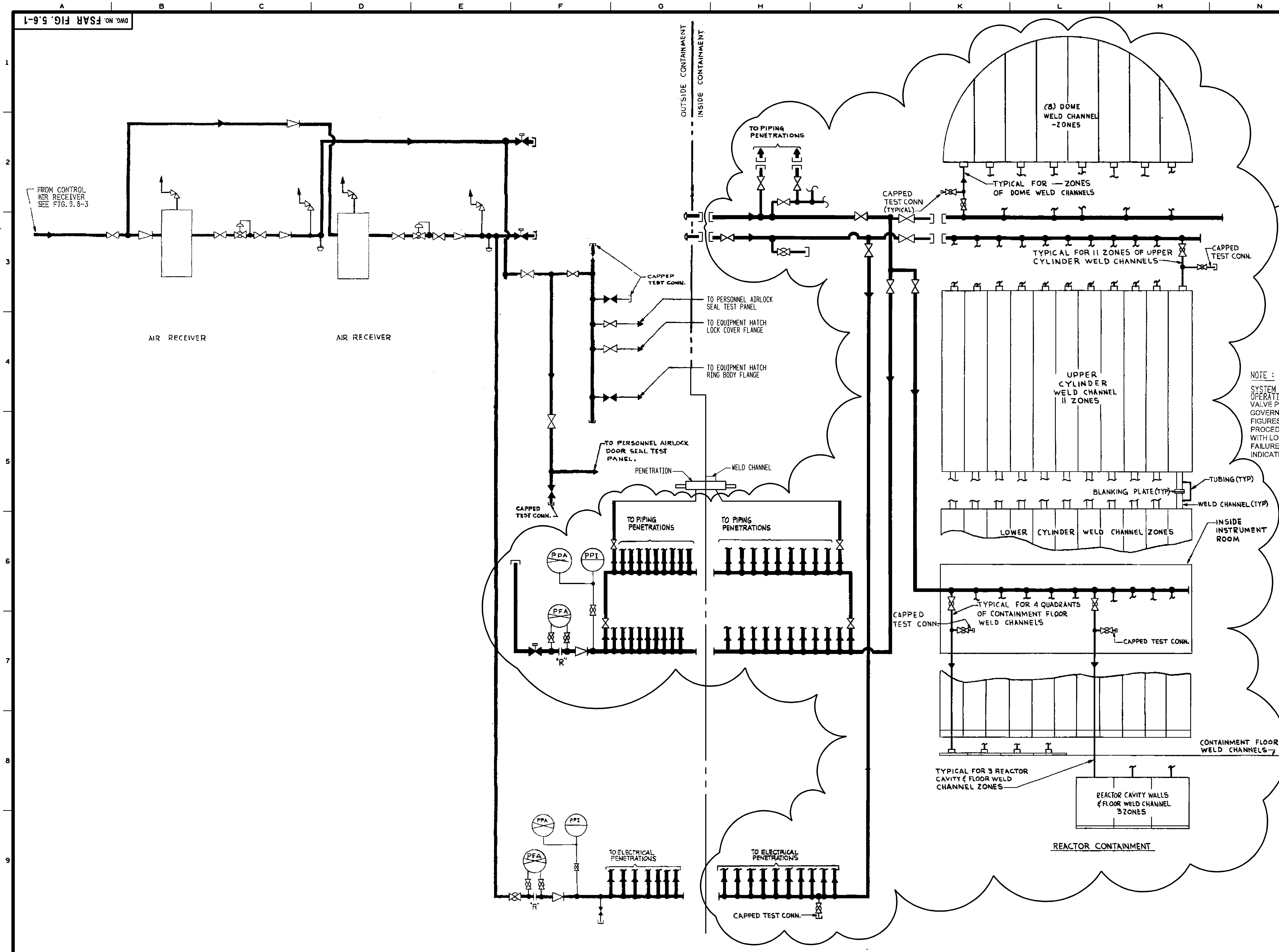


NOTE :

SYSTEM LINEUP SHOWN FOR NORMAL OPERATION.
VALVE POSITIONS ARE NOT GOVERNED BY THE UFSAR FIGURES BUT RATHER BY STATION PROCEDURES (EXCEPT VALVES WITH LOCKED OR SEALED, AND FAILURE POSITIONS AS INDICATED).

REFERENCES:
OP-1 (2) -5145

DATE	NO.	DESCRIPTION	APPD.
	21	REVISED PER UCR-1810, UCR-1811.	

REVISIONS

FILENAME: fsar-fig-5.6-1 21.dgn
(raster file): fsar-fig-5.6-1 21.tif

INDIANA MICHIGAN POWER COMPANY

DONALD C. COOK
NUCLEAR PLANT
BRIDGMAN MICHIGAN

CONTAINMENT PENETRATION
& WELD CHANNEL
PRESSURIZATION
UNIT NO. 1 OR 2

DWG. NO. FSAR FIG. 5.6-1

ARCH | ELEC | MECH | STR
SCALE: · DR: ·
DATE: · CH: ·
DESIGN ENGINEERING DIVISION:

AEP AMERICAN ELECTRIC POWER
AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

COOK NUCLEAR PLANT

COMPUTED STRAINS

TESRUN 21 - COMB. 10E11, E22 (STRAIN)

STRAIN DIAGRAMS DUE TO TESTING PRESSURE

1.34P (16.1PSI) MERIDIAN DIRECTION-E22 HOOP DIRECTION

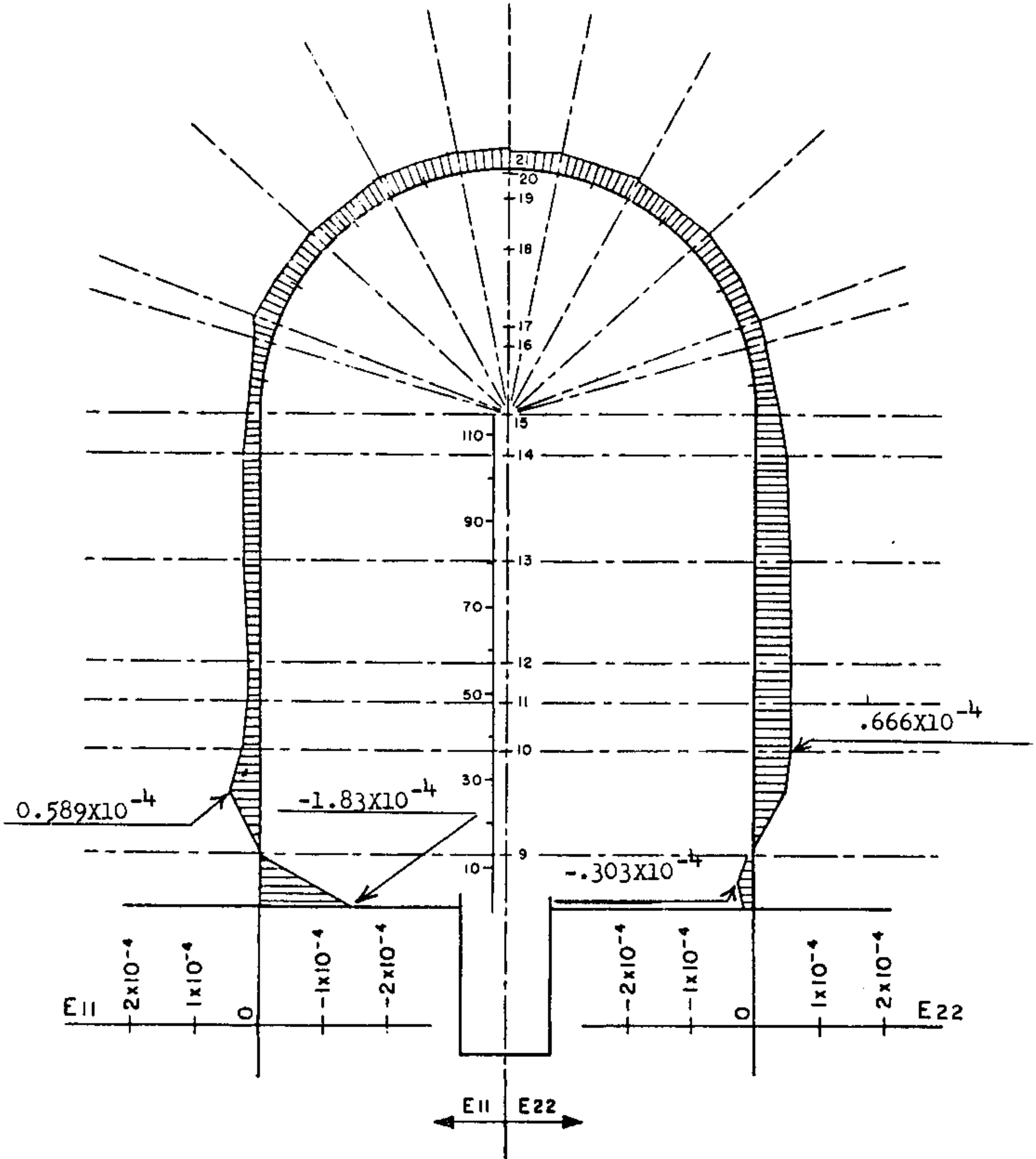


FIG. 5.7-1

July, 1982

COOK NUCLEAR PLANT
COMPUTED DISPLACEMENT

TESRUN 21 _COMB.10 _(W & U)
DEFORMATION DIAGRAMS DUE TO TESTING PRESSURE
1.34P (16.1 PSI)
W HORIZONTAL DEFORMATION-U VERTICAL DEFORMATION

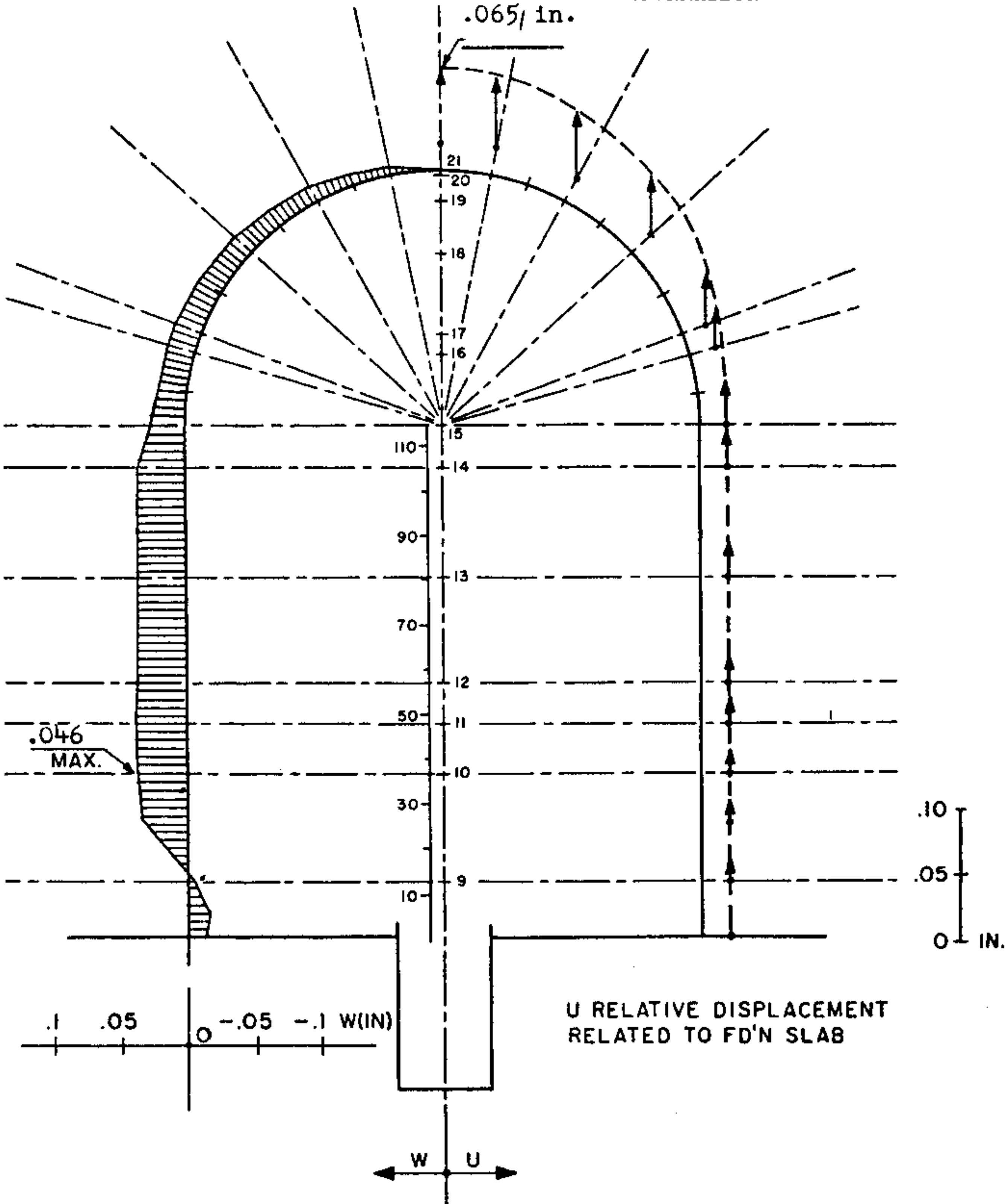
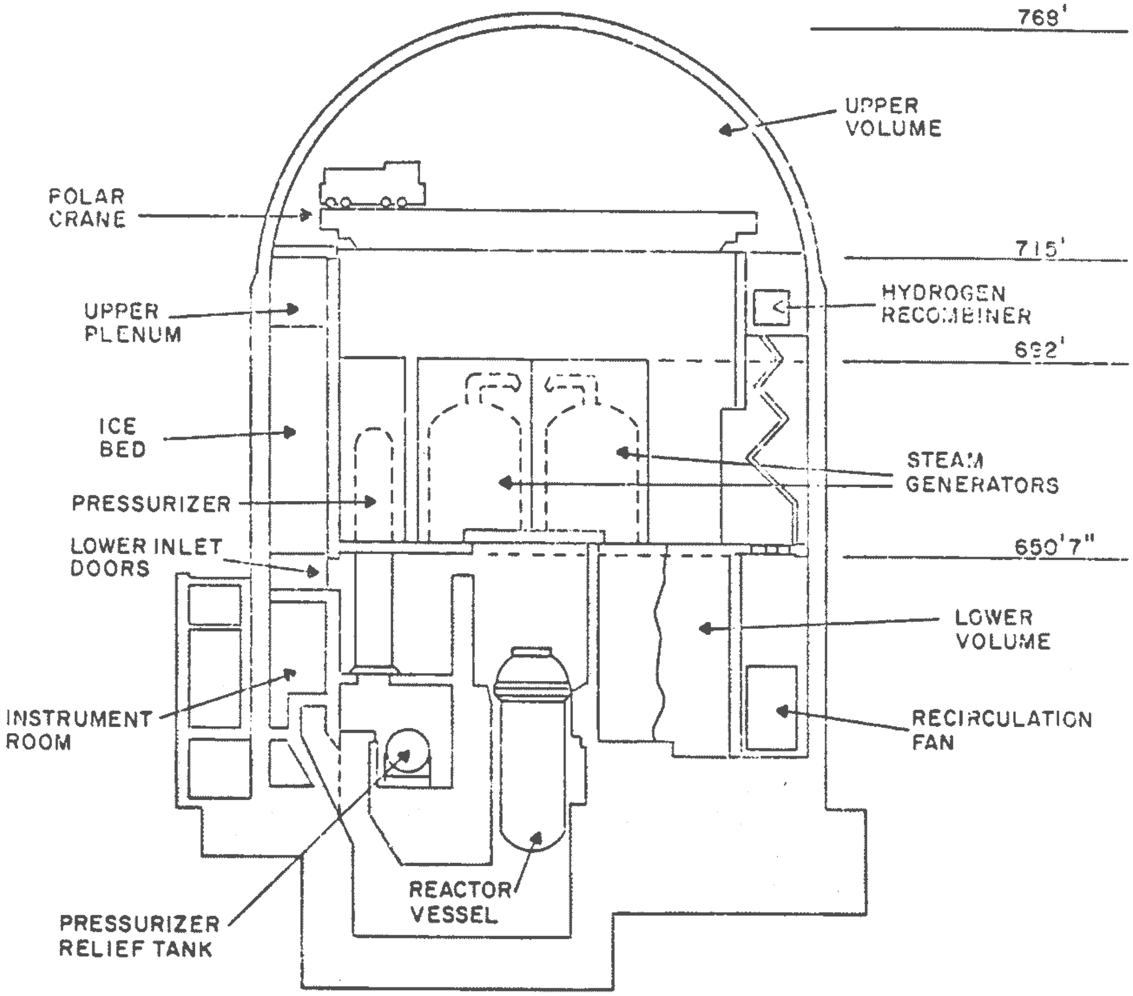


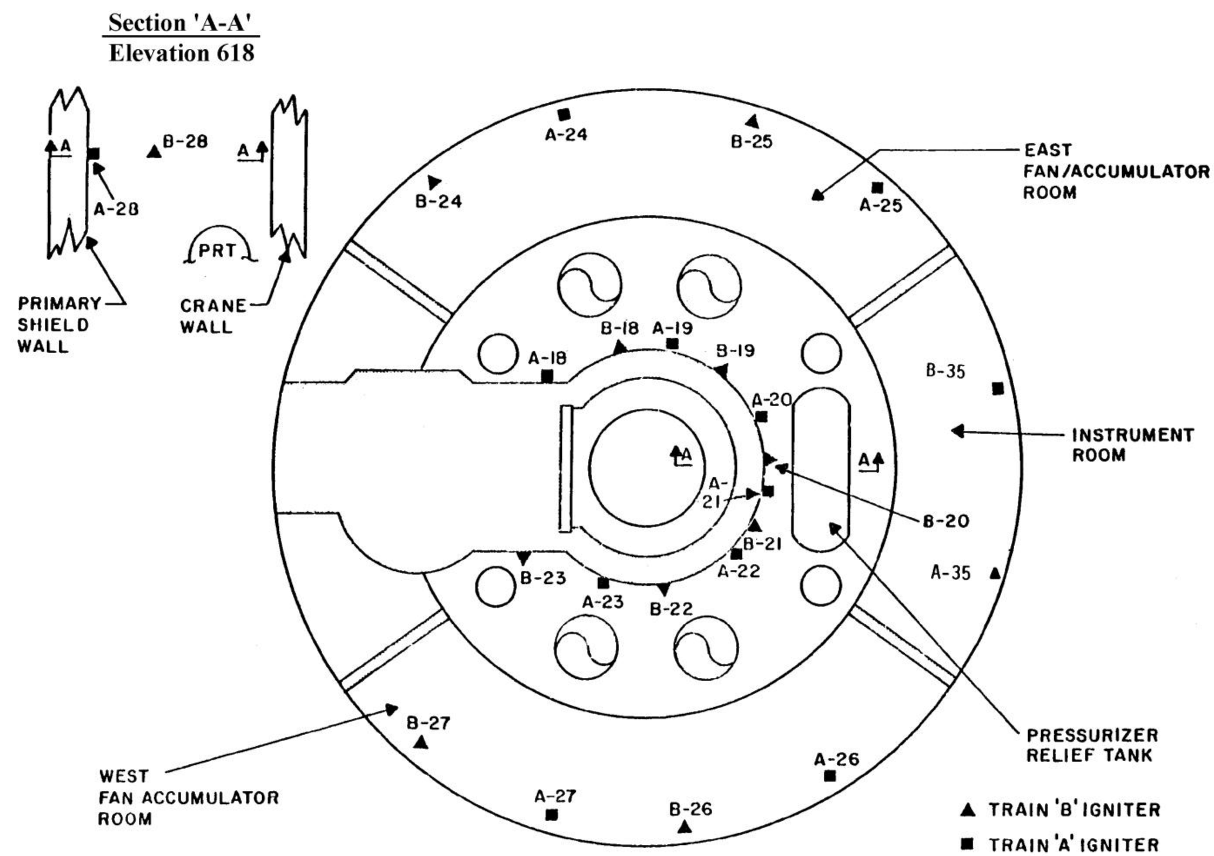
FIG. 5.7-2

July, 1982



Revision: **24.0**	Change Description: **UCR-1997, Rev. 0**

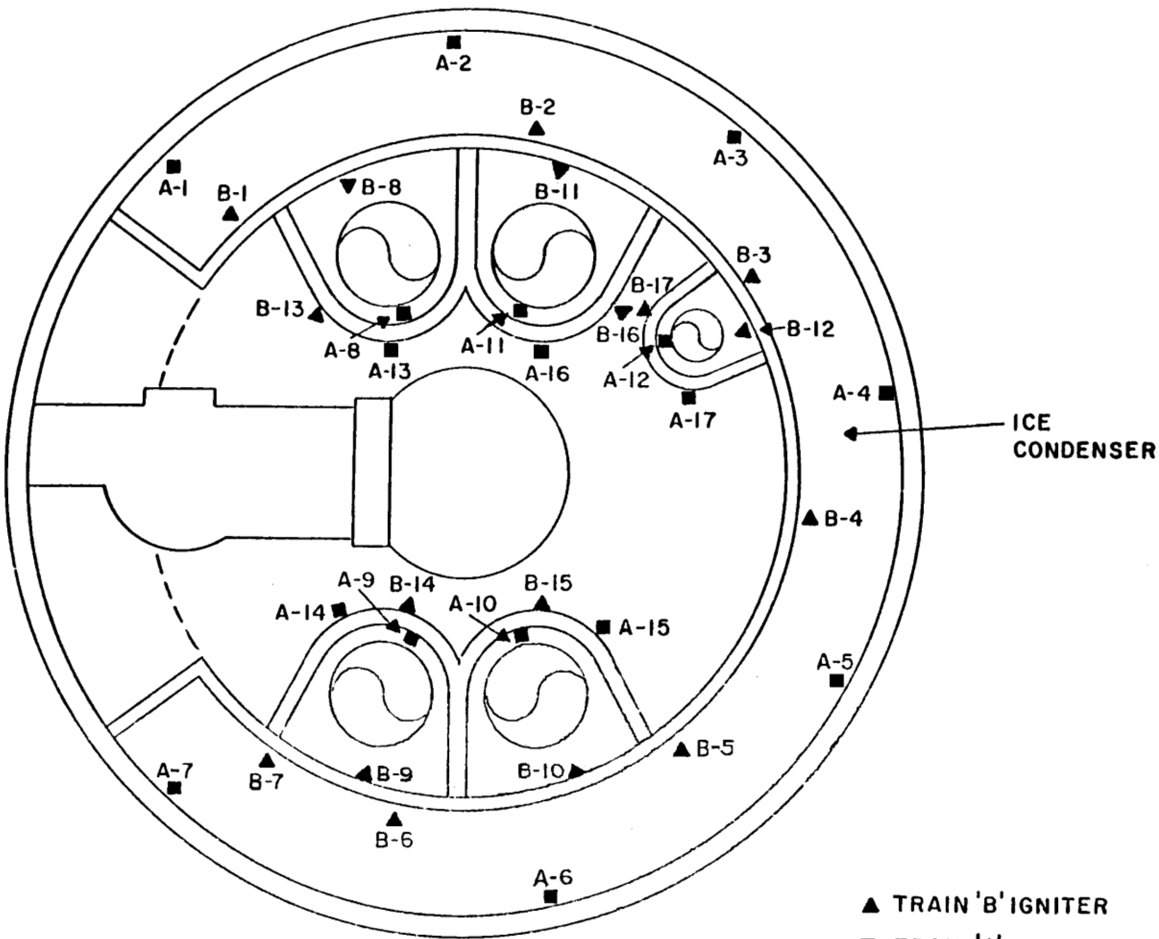
AMERICAN ELECTRIC POWER **COOK NUCLEAR PLANT** **NUCLEAR GENERATION GROUP** **BRIDGMAN, MICHIGAN**	Title: **UNIT 1 - GENERAL VIEW OF CONTAINMENT STRUCTURE**	
	UFSAR Figure: **5.8-1**	Sheet 1 of 1



For similar locations, in some cases the igniter assembly identification numbers are different, between Unit 1 and Unit 2.

Revision: **24.0**	Change Description: **UCR-1997, Rev. 0**

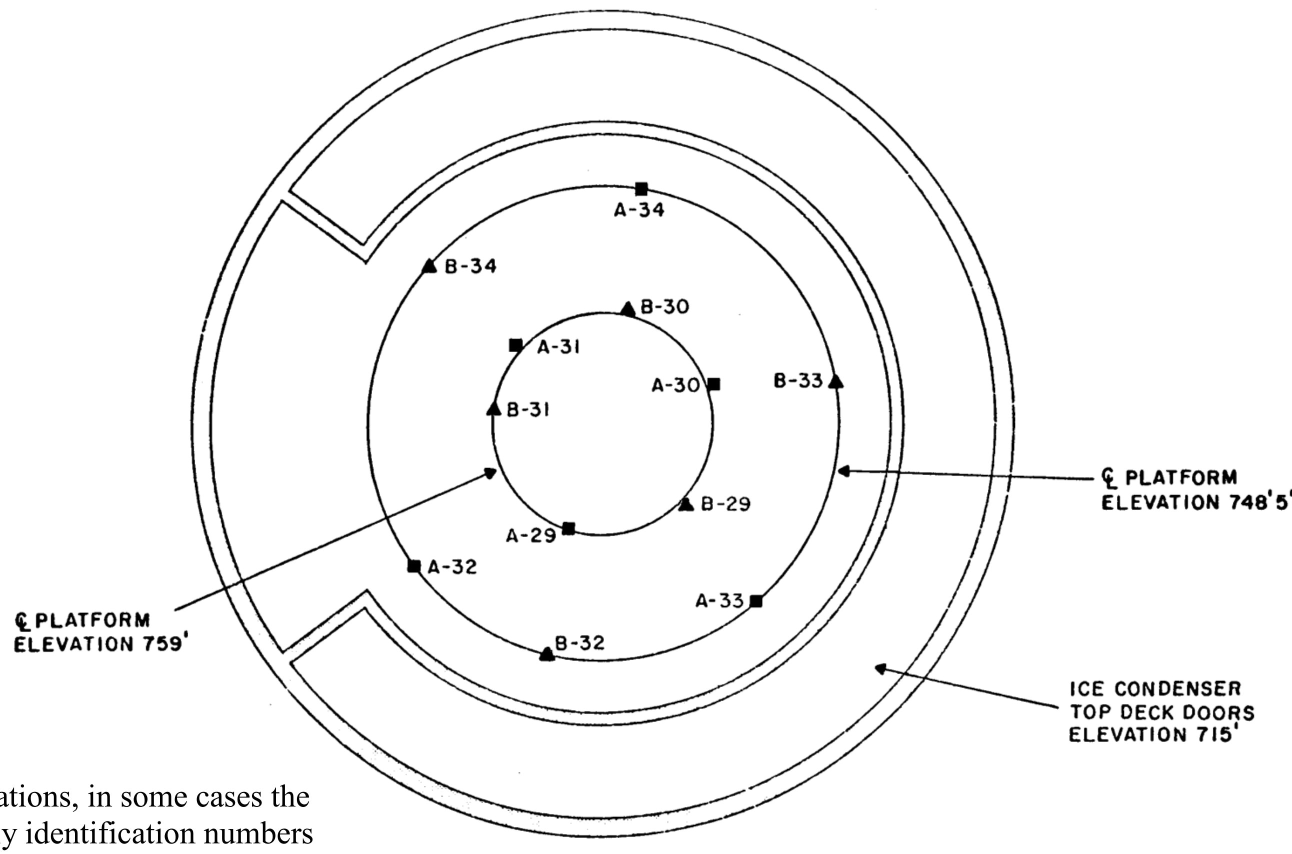
AMERICAN ELECTRIC POWER COOK NUCLAR PLANT NUCLEAR GENERATION GROUP BRIDGMAN, MICHIGAN	Title: **D. C. COOK UNIT NO. 2 CONTAINMENT PLAN BELOW ELEVATION 652' 7"**	
	UFSAR Figure: **5.8-2**	Sheet 1 of 1



For similar locations, in some cases the igniter assembly identification numbers are different, between Unit 1 and Unit 2.

Revision: **24.0**	Change Description: **UCR-1997, Rev. 0**

AMERICAN ELECTRIC POWER **COOK NUCLAR PLANT** **NUCLEAR GENERATION GROUP** **BRIDGMAN, MICHIGAN**	Title: **D. C. COOK UNIT NO.2 CONTAINMENT PLAN ABOVE ELEVATION 652' 7"**	
	UFSAR Figure: **5.8-3**	Sheet 1 of 1



For similar locations, in some cases the igniter assembly identification numbers are different, between Unit 1 and Unit 2.

Revision: **24.0**	Change Description: **UCR-1997, Rev. 0**

AMERICAN ELECTRIC POWER **COOK NUCLAR PLANT** **NUCLEAR GENERATION GROUP** **BRIDGMAN, MICHIGAN**	Title: **D. C. COOK UNIT NO. 2 CONTAINMENT PLAN ABOVE ELEVATION 715'**	
	UFSAR Figure: **5.8-4**	Sheet 1 of 1