ATTACHMENT I
EDAC 175-130 02

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SEISMIC DESIGN BASES AND CRITERIA
FOR YANKEE ROWE GENERATING STATION

SYSTEMATIC EVALUATION PROGRAM

prepared for

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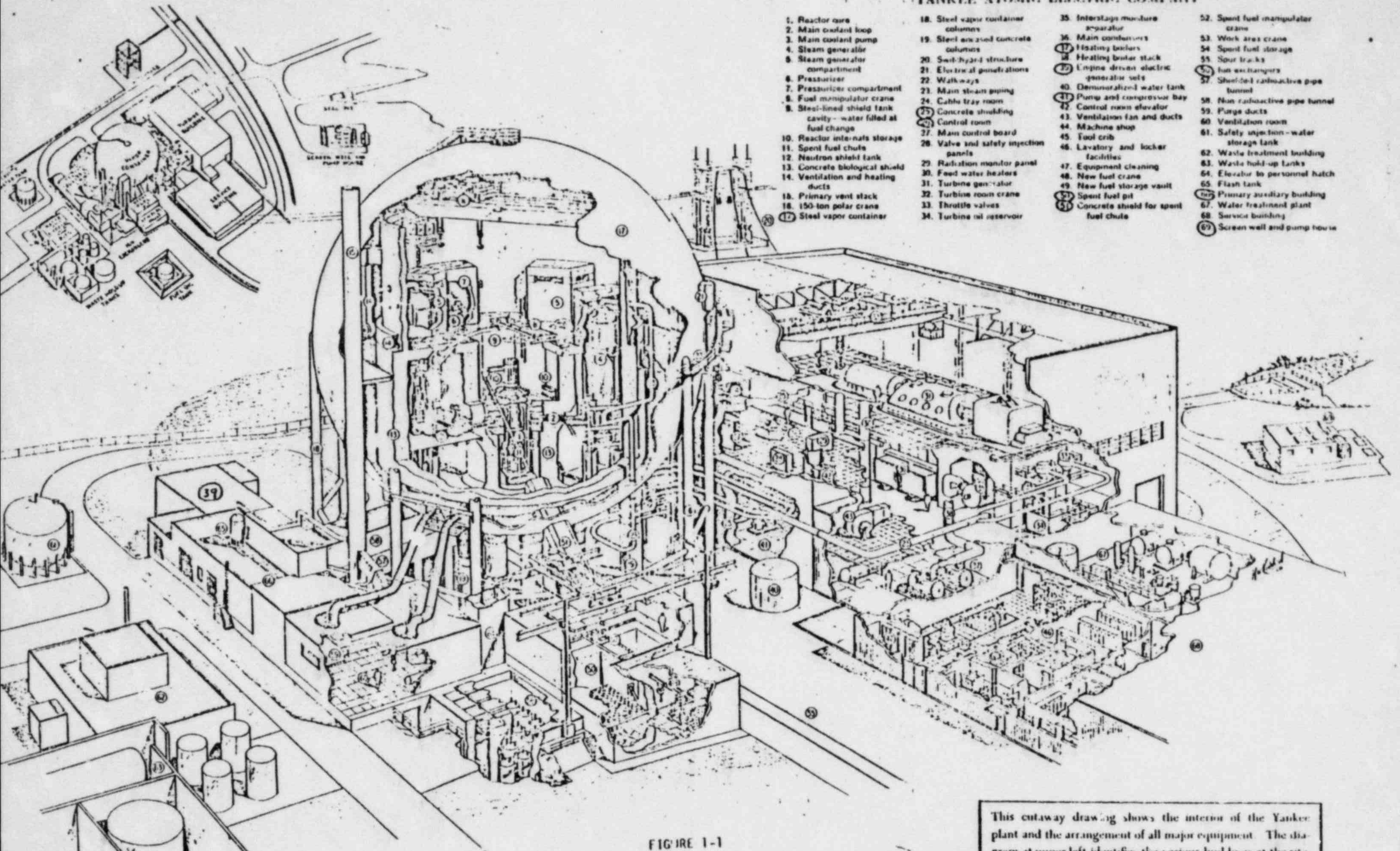
1. INTRODUCTION

This report is a presentation of the results of a study of the seismic design bases used in the design of the Yankee Rowe nuclear generating station. The plant is located at Rowe, Massachusetts, and is operated by Yankee Atomic Electric Company. The study was based upon a review of docket and other available literature. The Final Hazards Summary Report (Reference 1) and the Architect Engineer design requirements (Reference 2) were the principal sources of information with regard to design and analysis methods. The study did not perform a check of the design, but was focused on ascertaining the methodologies and codes used in the design.

The plant is located in Rowe, Massachusetts, adjacent to the Deerfield River alongside the pond formed by Sherman Dam. Yankee Rowe is a [redacted] four loop, pressurized water reactor (PWR) of 175 MWe capacity, which was put into commercial operation in June, 1961. The Nuclear Steam Supply System (NSSS) was supplied by Westinghouse, Inc., and the plant was designed and constructed by Stone & Webster (A/E).

Figure 1-1 shows the overall configuration of the plant. The NSSS is surrounded by a reinforced concrete cylinder, the bottom of which approximates a segment of a sphere. The wall thickness is 4.5 to 6 feet. This concrete structure, which supports the NSSS, attenuates the radiation from the main coolant loop and acts as a missile shield. The concrete structure is supported on 8 steel-encased concrete columns. These penetrate the outer spherical steel vapor container with expansion joints at the intersection of the sphere and the steel casings. Thus, the outer steel container and the concrete structures can tolerate small movements independent of each other due to thermal expansion.

The spherical steel vapor container envelopes the concrete structures and acts as a vapor container. The diameter of the sphere is 125 feet, and the minimum shell wall thickness is 7/8 inches. The turbine and auxiliary buildings are not structurally coupled to the reactor internal concrete on the steel sphere.



YANKEE ATOMIC ELECTRIC COMPANY

1. Reactor core
2. Main coolant loop
3. Main coolant pump
4. Steam generator
5. Steam generator compartment
6. Pressurizer
7. Pressurizer compartment
8. Fuel manipulator crane
9. Steel-lined shield tank cavity – water filled at fuel change
10. Reactor internals storage
11. Spent fuel chute
12. Neutron shield tank
13. Concrete biological shield
14. Ventilation and heating ducts
15. Primary vent stack
16. 150-ton polar crane

⑰ Steel vapor container

18. Steel vapor container columns
19. Steel encased concrete columns
20. Switchyard structure
21. Electrical penetrations
22. Walkways
23. Main steam piping
24. Cable tray room

㉕ Concrete shielding

㉖ Control room

27. Main control board
28. Valve and safety injection panels
29. Radiation monitor panel
30. Feed water heaters
31. Turbine generator
32. Turbine room crane
33. Throttle valves
34. Turbine oil reservoir
35. Interstage moisture separator
36. Main condensers

㊲ Heating boilers

38. Heating boiler stack

㊴ Engine driven electric generator sets

40. Demineralized water tank

㊶ Pump and compressor bay

42. Control room elevator
43. Ventilation fan and ducts
44. Machine shop
45. Tool crib
46. Lavatory and locker facilities
47. Equipment cleaning
48. New fuel crane
49. New fuel storage vault

㊿ Spent fuel pit

(51) Concrete shield for spent fuel chute

52. Spent fuel manipulator crane
53. Work area crane
54. Spent fuel storage
55. Spur tracks

(56) Ion exchangers

57. Shielded radioactive pipe tunnel
58. Non radioactive pipe tunnel
59. Purge ducts
60. Ventilation room
61. Safety injection – water storage tank
62. Waste treatment building
63. Waste hold-up tanks
64. Elevator to personnel hatch
65. Flash tank

(66) Primary auxiliary building

67. Water treatment plant
68. Service building

(69) Screen well and pump house

FIGURE 1-1

YANKEE ROWE NUCLEAR PLANT

This cutaway drawing shows the interior of the Yankee plant and the arrangement of all major equipment. The diagram at upper left identifies the various buildings at the site.

2. GEOTECHNICAL

2.1 GEOLOGY

The Yankee Rowe site lies in a small valley entering the Deerfield River Valley from the southeast approximately opposite the east end of Sherman Dam. This dam was constructed as a hydroelectric project by the New England Power Company in 1926 and has a maximum height of approximately 90 feet. Except for the Deerfield River Valley, the site is surrounded by the Berkshire Mountains, which rise to heights of about 1,000 feet above the site to either side and immediately behind it. The surface of the bedrock at the site is extremely irregular, solid ledge outcropping in a small hill along the northeast side and again in a large hill to the southeast. A seismic survey was made to check depths to bedrock. The seismic survey was run using the refraction technique, the depth of bedrock being determined at the end of each seismic survey line. This survey indicated that the surface of the rock generally slopes toward the Deerfield River.

The soils disclosed by the borings are primarily medium to fine sands with gravel, cobbles and boulders. They comprise a heterogeneous mass of soil dumped into place by the glacier and compacted by its weight. Some individual boulders are 10 to 12 feet in size. The borings indicated that the deeper lying soils were somewhat more compact and contain a slightly greater percentage of clay and silt size particles than the upper soils. The seismic survey also indicated the deeper lying soils to be somewhat more compact, as velocities were higher than in the surface materials. The bedrock is composed of Archean Metamorphics predominantly schists and gneiss. Although jointed, this is a strong, stable rock. Further data and discussions are available in the FHSR (Reference 1).

2.2 SEISMOLOGY

According to N. H. Heck's "Earthquake History of the United States" (Reference 3), only two earthquakes of sufficient intensity to be felt by any considerable number of people have epicentered within 50 miles of the site; one in 1875 near Canon Mountain, Connecticut, and one in 1884 in southern New Hampshire. Earthquakes epicentered in distant regions may have been felt slightly; one in 1925 epicentered in the St. Lawrence Valley was felt as far south as Virginia, but the damage done by it was limited to the St. Lawrence Valley, in areas of soft, unstable soils. Rev. Daniel Linehan, S.J., Director, Weston Observatory, in a memorandum dated April 29, 1955, indicates that this site is in one of the areas of least seismicity in the northeastern United States and that the risk of shock is very slight, but consideration should be given to the possibility of a weak or moderate earthquake. However, damage from earthquakes is greatest where there are soft, unstable soils of considerable depth. At this site, where the soil is firm and rests on bedrock at shallow to moderate depths, it was concluded that earthquakes of moderate intensity will not damage modern framed structures designed to withstand reasonable wind loads. Accordingly, no special provisions for seismic design were made (References 1 and 2).

3. SEISMIC CRITERIA

The Yankee Nuclear Power Station was not designed to the seismic criteria currently in effect. Neither structures nor equipment were classified into seismic categories such as Seismic Category I or equivalent, but instead were classified as Safety Related or Nonsafety Related. These systems were designed and analyzed in accordance with the design codes in effect in 1955 (References 4 through 8). For structures, the design of lateral load restraint systems was dictated by wind requirements. However, no lateral force provisions were made for internal structures or equipment. In general, an increase of one-third was allowed for short-term live loads.

Foundations are reinforced concrete, resting on soil consisting of fine sands and gravel, with many cobbles and boulders. The maximum bearing value on the soil allowed in the design is 4 tons per square foot, with some reduction for shallow or small footings. All the principal foundations rest on undisturbed soil. For general purpose building foundations, concrete with an ultimate strength of 2,500 psi has been used. For the foundations of the vapor container, reactor enclosure, turbine support, and other important structures, 3,000 psi concrete was used. Structural steel conforms to the Specifications for Structural Steel for Bridges (ASTM). The structural framing was designed, fabricated, and erected in accordance with the standard specifications and codes of the American Institute of Steel Construction and the American Welding Society. In general, the structural framing is shop riveted and was erected in the field with high strength bolts in lieu of rivets.

Safety related structures are discussed in three following sections. Included are the design procedures and codes used for (i) the vapor container, (ii) the internal structure, and (iii) the auxiliary structures (turbine building, primary auxiliary building and diesel generator building). Also included is a brief discussion of piping and equipment design considerations.

3.1 VAPOR CONTAINMENT

The vapor container is a steel sphere of 125 feet with a minimum thickness of 7/8 inch diameter (Figure 1-1). The center of the sphere is approximately 86' 6" from ground level. The container was designed, built and tested as per Section VIII of the ASME Boiler and Pressure Vessel Code (Reference 5) and Code Case No. 1226. The design pressure was 31.5 psi gage, which resulted in a corresponding membrane stress of 13.5 ksi, which was the design stress for fully radiographed welds.

The container is supported on 16 steel columns of 3' 6" diameter. The columns are braced with horizontal pipes of 2' 9" diameter. Additional bracing is provided by tie rod cross braces as shown in Figure 3-1. The structural design loads were based upon American Standard Building Code Requirements (ASBCR) of 1955 (Reference 7). The design snow and wind loads were 40 lb/ft^2 and 30 lb/ft^2, respectively, on the projected area. All penetrations of the sphere were reinforced to the full strength value of metal removed. All seams were completely radiographed. The concrete internals and their supports are independent of the sphere. All steel conformed to American Institute of Steel Construction (AISC) specifications.

3.2 INTERNAL STRUCTURES

The Nuclear Steam Supply System (NSSS) is housed in a cylindrical concrete structure with wall thicknesses of 4.5 to 6 feet (Figure 3-1) The wall thicknesses were selected based on shielding and missile penetration requirements. No seismic loads were considered in the design. Design loads were established from Reference 7 or from Stone & Webster Structural Division Standards (Reference 2), whichever was greater. The concrete was designed and poured in accordance with ACI 318-1956 (Reference 8). 3 ksi concrete of 150 lb/ft^3 was used for the most part.

The internal concrete structure is independent of the vapor container, and is supported on eight steel encased concrete columns. Two columns are 7' 6" diameter, and 6 columns are 7' diameter. There are no bracings between columns. The columns are located such that the horizontal stiffness in one direction is slightly different than the other.

Because the internal concrete structure is protected by the steel sphere from wind and snow, there was no lateral load specified. The foundation was designed to limit the bearing pressure to a maximum of 4 tons/ft^2 (References 1 and 2).

3.3 AUXILIARY STRUCTURES

Turbine, primary auxiliary and diesel generator buildings were designed in accordance with References 7 and 8. The concrete was sized and poured as per ACI 318-1956.

The exterior walls of the upper part of Turbine Building are faced with insulated steel siding of "sandwich" construction, consisting of two layers of metal with fiberglas insulation between. The outer layer of steel siding consists of corrugated metal covered with asphalt-saturated asbestos sheets bonded to the steel with synthetic resin and protected by a plastic coating on the weather side. The inner faces are paneled with galvanized steel. The walls of the Control Room Area adjacent to the turbine room on the side facing the reactor are solid concrete 4 feet thick, constructed thus in order to serve both as building walls and as shielding in case unusual radioactivity should develop. The exterior walls of the lower part of the Turbine Building, Service Building, Auxiliary Equipment Building, Waste Disposal Building, Guardhouse, and Circulating Water Pump House are of hollow concrete block construction with a heavy exterior weather-protection coating of vinyl plastic. The small Office Building attached to the Turbine Building has exterior insulated steel paneled, porcelain enameled curtain walls. Window sash of all buildings is aluminum. Doors are industrial steel or rolling steel curtains. Interior partitions are all concrete blocks of the standard hollow type, but made solid where shielding is required. Solid block exterior walls are used in some parts of the Waste Disposal Building to provide shielding. All exterior building walls are designed for the wind loads established by the American Standard Building Code.

The storage vault for new fuel is constructed with a reinforced concrete frame, roof deck, and floor slab. The walls have no windows and are partly reinforced concrete and partly concrete masonry. The single large door is of the type known as "industrial steel" of heavy construction with tubular steel stiles and rails and sheet steel panels. There is a small access door in the large door.

Building floors in general are reinforced concrete, both when supported by structural framing and when laid on well-tamped earth fill. Steel decking is used throughout for roof construction, except over the control room where reinforced concrete 4 feet thick is used to provide shielding, and over the fuel vault where a solid reinforced concrete roof deck is installed. All roof decks are covered with 20-year bonded built-up tar and gravel roofing, flashed with lead-coated copper.

Building floors and roofs are designed for the following live loads:

Office areas - 2,000 lb. concentrated, or	100 psf
Stairways	100 psf
Control room - weight of installed equipment, or	50 psf
Turbine room - weight of dismantled pieces of equipment when laid down in designated areas; in all other areas	200 psf
Laboratories	100 psf
Toilet and locker room	100 psf
Work areas and special equipment areas	As required
Roof snow load	40 psf

3.4 SAFETY RELATED EQUIPMENT AND PIPING

Primary coolant loop, emergency core cooling system (ECCS), reactor vessel, steam generator and pump were designed for nuclear, thermodynamic and pressure requirements. NSSS uses 20" and 24" diameter 304 SS pipes, and was designed for 2300 psi at 550° F. ASME Section VIII (Reference 5) and ASA codes for piping were followed in the design of NSSS and pressure piping, but no provisions for seismic loads were made.

Electrical penetrations, control room systems, etc., were designed based upon nuclear, mechanical and functional criteria. Again, there were no special provisions for seismic or nonseismic, lateral loads.

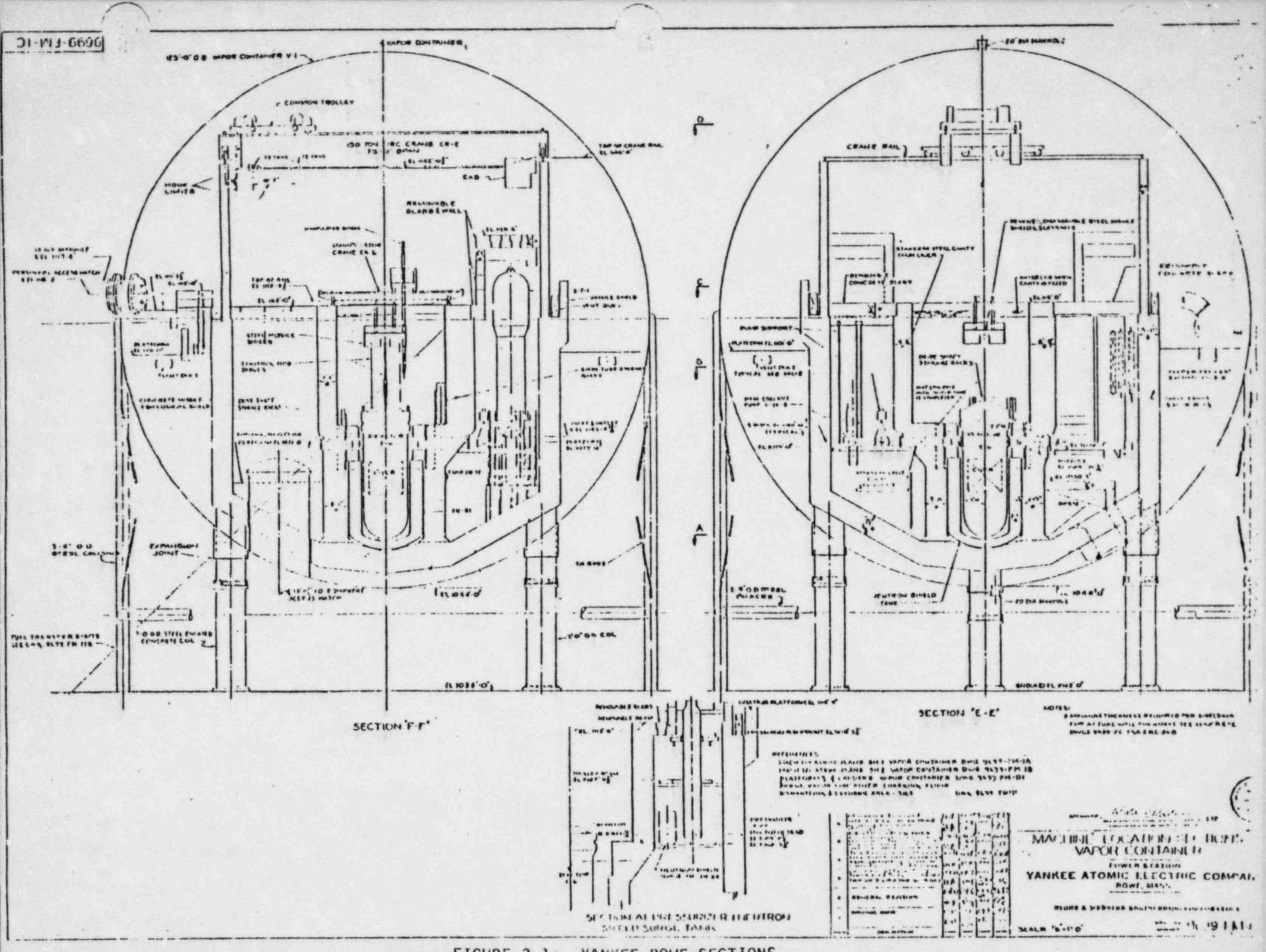


FIGURE 3-1: YANKEE ROWE SECTIONS

4. SUMMARY

As a part of the Systematic Evaluation Program, a review of the design methodologies, code requirements and specifications used in the design analysis of the Yankee Rowe atomic plant, was performed. The review was focused on ascertaining the seismic design methodologies and seismic requirements.

Based upon the review, it was concluded that (i) there were no special provisions for seismic criteria at the Yankee Rowe atomic plant, (ii) the structures were designed in accordance with American Standard Building Code Requirements of 1955 and American Concrete Institute (ACI) 318-1956, (iii) the NSSS and its equipment were designed to meet ASME Section VIII and ASA requirements, and (iv) electrical penetrations, control systems, etc., were designed based upon functional criterion. A summary of the design criteria used for the Yankee Rowe facility is contained in Table 4-1.

TABLE 4-1

YANKEE ROWE SEISMIC DESIGN INFORMATION

ITEM	YANKEE ROWE	CURRENT LICENSING CRITERIA
1. Type of Plant	PWR	---
2. Plant Capacity (MWe)	175	---
3. Architect/Engineer	Stone & Webster	---
4. Foundation	Shallow firm soil	---
5. Systems Important for Plant Safety (Equiv. Seismic Category I)	Not available	Systems necessary to: 1) Maintain Coolant System Pressure Boundary, 2) Shutdown Reactor & Maintain Safe Condition, 3) Prevent or Mitigate Offsite Exposure. Ref. USNRC Reg. Guide 1.29, and SRP 3.2.1
6. OBE (or Design E)	Not used	Ref. 10 CFR 100, Appendix A
7. SSE (or Max. E)	Not used	Ref. 10 CFR 100, Appendix A, SRP 3.7.1
8. Response Spectra	Not used	USNRC Reg. Guide 1.60 or Site Dependent Spectra, SRP 3.7.1
9. Type of Analysis	Eq. Static (wind)	Finite Element or Lumped Mass
10. Predominant Frequencies	Not determined	---
11. Material Damping	Not used	Ref: USNRC Reg. Guide 1.61, SRP 3.7.1
12. Modal Combinations	Not used	SRSS or Modification, USNRC Reg. Guide 1.92, SRP 3.7.2

TABLE 4-1 (continued)

ITEM	YANKEE ROWE	CURRENT LICENSING CRITERIA
13. Directional Combinations	Not used	3-Direct. Concurrently (SRSS) Ref. USNRC Reg. Guide 1.92, SRP 3.7.2
14. Time History Analysis	None	SRP 3.7.1
15. Floor Response Spectra	None	Ref. USNRC Reg. Guide 1.122, SRP 3.7.2
16. Testing of Equipment	None	Ref. IEEE 344
17. Design Load Combinations	ASBCR	ASME B&PV Code Section III Div. 2 USNRC Reg. Guides 1.10, 1.15, 1.18, 1.19, 1.48, 1.55, SRP 3.8.1, 3.8.3, 3.8.4, 3.8.5
18. Simplified Design Methods	Not used	Floor Spectra Required. SRP 3.7.2 Peak of Floor Spectrum SRP 3.7.2, 3.7.3

REFERENCES

1. "Final Hazards Summary Report," Docket No. 50029-2, for Yankee Rowe Nuclear Generating Station.
2. Stone & Webster, "Summary of Structural Design Requirements, Yankee Atomic Electric Company," J.O. No. 9699, Oct. 1957.
3. N. H. Heck, "Earthquake History of the United States," Special Publication No. 149, U. S. Department of Commerce, Coast and Geodetic Survey.
4. Appendix A of 10 CFR 50, Design Basis for Nuclear Generating Stations.
5. ASME Boiler and Pressure Vessel Code, Section VIII, "Unfired Pressure Vessels," 1955.
6. ASTM specification for A300, Class A 201, Grade B, Firebox Quality.
7. American Standard Building Code Requirements, 1955.
8. American Concrete Institute, ACI 318-1956.
9. Docket 50029-395, "Effect of Failure of Noncategory I on Category I Equipment," letter from Mr. D. E. Vandenburgh, vice president of Yankee Atomic Electric Company, to USAEC, January 1975.

APPENDIX A

SUMMARY OF STONE & WEBSTER'S STRUCTURAL DESIGN REQUIREMENTS FOR YANKEE ROWE*

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*Reference: Stone & Webster J.O. No. 9699, October 17, 1957.

APPENDIX A

SUMMARY OF STRUCTURAL DESIGN REQUIREMENTS

YANKEE ATOMIC ELECTRIC PLANT

This summary has been prepared as a general guide to structural design consideration:

Site Conditions

The plant is situated on medium to fine sands with some clay and silt, cobbles and boulders. Existing excacations show that an almost vertical face can be obtained and maintained in open excavations and a one-to-one slope is considered a maximum batter for temporary work.

Pile driving is not considered practicable because of the number and size of the boulders.

All disturbed and loosened soils under structural foundations, such as may occur where a large boulder is removed, shall be excavated with side slopes not steeper than 45 degrees and the disturbed area backfilled to footing grade with leen concrete.

Foundations

All structures and equipment should be founded on spread footings. Where there is possibility of heaving due to frost action, footings should be carried to a minimum depth of 5' 0" below ground surface.

Generally a maximum bearing pressure of 6 tons per square foot is allowable for foundations with widths of 6' 0" and over. For shallow or narrow foundations, Appendix A should be consulted.

Wind Load on Foundations

The allowable soil pressure may in general be increased up to 33 1/3% under combined dead load, live load and wind load to whatever extent the excess over the basic allowable pressure is due to wind load.

Reference: ASA A56.1-1952.

Grade

General yard level around the Vapor Container will be at El. 1022. Building floor levels in the immediate vicinity are to be 8 inches above this, i.e., at El. 1022.67. Other floor levels are to suit design requirements.

Loads

Minimum design loads to comply with the American Standard Building Code A58.1-1955 and Stone & Webster Structural Division Standards, whichever is greater.

Floors

Supported reinforced concrete floors on structural steel framing should be designed for the following live loads:

Office area - 2,000 lb. concentrated, or	100 psf
Stairways	100 psf
Control Room - weight of equipment plus overall clear floor space	50 psf
Turbine Room - equipment weight (including weight in lay-down areas), or	150 psf

Roof Loading - See Snow Load.

Wind Load

Reference: American Standard Building Code Requirements, A58.1-1955.

Height	Pressure, Lb per Sq Ft
Less than 30'	20
30' - 49'	25
50' - 99'	30
100' - 499'	40

Snow Load

Reference: American Standard Building Code Requirements, A58.1-1955.

30 lb. per square foot on horizontal projected area.

Impact

Reference: AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.

Unit Stresses

Structural Steel: To AISC specification.

Concrete: To ACI building code. ACI 318-56.
General purpose concrete to be 2,500 psi at 28 days.

Vapor Container Supports: 3,000 psi at 28 days.

Vapor Container Interior Concrete: 3,000* psi at 28 days.
*(with a density not less than 150 lb. per cubic foot)

Reinforcement Steel: To ASTM specifications. Allowable stresses to ACI Building Code ACI 318-56.

Turbine Generator Foundations

General design to conform to General Electric recommendation given in the pamphlet GET-1749A, "Turbine Generator Foundations," and to Stone & Webster Reinforcing Standard for Turbine Supports, April 20, 1948.

Unit Stresses

Concrete, compression	350 psi
Concrete, bending	400 psi
Reinforcing steel, tension	10,000 psi
compression	4,000 psi

NOTE: The turbine is tandem compound double flow design 1,800 rpm.

APPENDIX B

YANKEE ROWE VAPOR CONTAINMENT AND INTERNALS DESCRIPTION*

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*Reference: Final Hazards Summary Report, Docket 50029-2, Section 231, September 15, 1959, and January 10, 1960.

APPENDIX B

VAPOR CONTAINMENT

General

The vapor container is a steel envelope which surrounds the main coolant equipment loops and encloses all pressurized parts of the main coolant system. It prevents the release of radioactivity to the atmosphere in the unlikely event of an accident resulting from a rupture and release of fluid from the main coolant system within the containment vessel.

When the reactor is critical or when the main coolant system is pressurized with nuclear fuel in place, the vapor container is closed and pressure-tight. Under these conditions access openings are closed with gasketed doors, pipelines not required for operation are closed with tight shutoff valves, and the fuel chute is blanked off with a bolted and gasketed closure.

The vapor container, when closed, is maintained at a pressure level slightly higher than atmospheric for continuous leakage indication.

The vapor container is a steel spherical shell, 125 feet in diameter and with a minimum wall thickness of 7/8 inches. The spherical shape is selected since it uses a minimum of material for a given volume and internal pressure. The spherical shape permits the most accurate determination of secondary stress and facilitates the design of the necessary penetrations.

The spherical vessel is supported on braced steel columns.

Piping Penetrations and Access Openings

Pipelines penetrating the vapor container, which are used only when the plant is not in operation, are provided with valves located outside the vapor container. These valves are closed whenever the reactor is critical or when the main coolant system is pressurized with nuclear fuel in place. Incoming pipelines, used for operation of the plant, are provided with two check valves, one inside and one outside the vapor container. The external check valve is, in some cases, located at an item of equipment or a closed auxiliary vessel. Outgoing lines, used for operation of the plant, are each provided with a closure trip valve arranged to close automatically on pressure rise in the container of 5 psi.

The personnel access opening is at the charging floor level just above the vessel equator. The opening consists of tubular shell penetration with 6' 8" head room and with a steel plate door at each end, one inside and one outside the vessel. This arrangement permits entrance to and egress from the vessel with the primary plant at pressure without ever completely opening the vessel to atmosphere. Door closures are hydraulically operated with provision for manual jacking. A small auxiliary bolted and gasketed manhole cover may be removed to provide access to the interior of the vessel if the normal door closures should fail to function. This auxiliary manhole is not opened unless the primary plant has been depressurized.

The personnel access opening is reached by a 4,000 lb. combined passenger and freight elevator and by a flight of stairs.

An additional bolted and gasketed manhole is provided in the lower part of the vapor container below the concrete bowl section. This allows access to the space between the concrete bowl and the vapor container shell primarily for construction purposes. No operational use of this manhole is planned.

A 13-foot 11½-inch ID equipment access opening is located in the lower part of the vessel for handling large items of equipment. The equipment hatch is opened only occasionally after initial leak tests and only when the primary plant is depressurized. The opening is provided with a flanged, bolted and gasketed cover which is removed from within by the overhead crane.

All large, heavy equipment, valves and pipe and many of the smaller components are handled by a polar crane inside the vessel. Rotation, traverse and the two 75-ton hoists are motorized.

Electrical Penetrations

Electrical power and control leads through the steel vapor container from the primary plant to the control bay of the secondary plant are provided with gas-tight fittings. Electrical penetrations are made through steel pipe penetrations welded into the vapor container with bolted and gasketed flanged ends. An electrical penetration cartridge with matching flange is drilled and tapped to receive sealing fittings for one or several conductors.

For 2,400 v conductors, a solid copper rod with 5 kv Buna insulation is used for the conductor through the penetration. The solid copper rod serves to stop any leakage through the cable stranding. A Sonolastic (pourable synthetic rubber sealing) compound is used in the seal in addition to the high temperature rubber seal furnished with the gland seal. After completion of the cartridge assembly by shop bench methods, the assembly is cured and tested.

Mineral insulated cable (MI) is used for power and control penetrations under 600 v except for coaxial cables.

A cartridge of similar construction to the 2,400 v cartridge is used, except the gland seal closely fitting the cable is potted with Sonolastic sealing compound.

Coaxial cables pass through vapor container penetrations in a cartridge similar to those used for power and control cables, except a solid connector is inserted in the coaxial strands to prevent air passage.

Thermocouple cables are magnesium oxide insulated with an overall cold drawn steel sheath. A gland seal with metallic seal ring and potting compound around the cable is tapped into the end flanges of the electrical cartridge similar to the 600 v type of fitting.

Internal Structure

Associated with the outer steel vapor container is an inner reinforced concrete structure which supports the main coolant loop equipment, attenuates radiation from the main coolant loop to a tolerable level outside the vapor container, and acts as a stop for objects possessing kinetic energy.

The pressurized equipment within the vapor container is surrounded by a reinforced concrete cylinder, the bottom of which approximates a segment of a sphere. Concrete wall thickness is 4.5 to 6 feet. Ordinary concrete is used having a density of 150 lb. per cubic foot, except for a small area around the fuel discharge chute where concrete having a density of 225 lb. per cubic foot is required because of the limited space available.

The concrete structure is supported on eight steel encased concrete columns which penetrate the spherical container. These penetrations are sealed with stainless steel expansion joints. The joints are welded and completely sealed to the steel shells of the concrete column. The column shells are seal-welded to the column base plates. They were built and tested as parts of the steel shell of the vapor container before being filled with concrete. This construction permits the spherical vessel and the internal concrete structure to make small movements independent of each other when temperature changes occur.

The concrete cylinder is separated into compartments by concrete walls, one for each loop and one for the pressurizer, to facilitate access to individual units at times of high activity level, as well as to minimize the extent of a disturbance. The access opening is segregated by battered concrete walls.

The operating compartments are covered by a 3 foot thick charging floor, with removable slab covers to provide crane access to equipment in the main coolant loops below. Spiral stairs provide the principal access from the charging to the operating level and minor stairs and ladders give access to other levels.

Design Features

The vapor container is designed, built and tested in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII (Unfired Pressure Vessels), and Code Case No. 1226, and the code stamp is applied. The vapor container is not provided with a relief valve, in accordance with special ruling, Case No. 1235, which states:

> "It is the opinion of the Committee that, since it is intended that these vessels be designed and built to safely contain all the lethal radioactive substances that may be released in case of a maximum credible accident affecting the reactor vessel or primary coolant circuit or both, and because of the hazardous character of the materials, which might be released, pressure relief devices are not required."

The stress permitted by the Code in the specified plate is 15,000 psi. The Code further specifies that the design stress shall be reduced by a factor of 0.9 when employing welded seams with 100% radiographic inspection. The resulting design stress is 13,500 psi.

The design pressure of the vapor container is 31.5 psi gage, corresponding to a membrane stress of 13,500 psi in a 125 foot diameter sphere with a minimum plate thickness of 7/8 inch.

The calculated internal pressure in the event of a major loss of water accident is 33.8 psi gage, which is called 34.5 psi gage for design purposes. This latter pressure includes the 10% overpressure permitted by the Code under paragraph UG-125(c), which states, "All unfired pressure vessels other than unfired steam boilers shall be protected by pressure relieving devices that will prevent the pressure from rising more than 10% above the maximum allowable working pressure, except when the excess pressure is caused by exposure to fire or other unexpected source of heat." A 10% increase in the design pressure of 31.5 psi gage results in an allowable pressure of 34.5 psi gage which corresponds to the internal pressure developed in a major loss of water accident.

The plate material is ASTM Specification A-300, Class A-201, Grade B, firebox quality, a carbon-silicon steel of suitable quality for forming and welding in pressure vessel service. The tensile strength is 60,000-72,000 psi with a minimum yield point of 32,000 psi. The atmospheric temperature outside the uninsulated sphere occasionally approaches -25° F., so that the shell metal temperatures may be close to the freezing point during operation. Specification A-300 material is employed for its superior impact value at low temperature, equivalent to 15 ft/lb at -50° F.

All penetrations of the sphere are reinforced to the full strength value of the metal removed. All shell seams are completely radiographed, as well as all welds in the penetrations, wherever possible. All welds not amenable to radiographic examination are subjected to a magnetic particle inspection at every pass.

All high temperature piping entering or leaving the spherical shell is isolated from the shell by means of a steel thermal sleeve which connects the pipe and shell. The space between the pipe and sleeve is filled with heat insulation. These expansion joints eliminate the necessity of heavily reinforcing the spherical shell to contain the forces and moments resulting from pipe expansions.

The internal concrete structure consists of two concentric cylinders of 3,000 psi compressive strength reinforced concrete. These cylinders are tied together with six reinforced concrete radial walls so located as to provide an isolation compartment for each main coolant loop, for the pressurizer, and for an access way from the equipment hatch into the structure. The compartment radial concrete walls have several ports to limit the differential pressure across the concrete walls to a value of 6 psi at the time of a major loss of coolant accident. The battered concrete walls at the equipment access opening are designated for 8 psi.

The inner concrete wall serves as the support for the reactor vessel, the water-filled neutron shield tank surrounding the reactor vessel, and as a shield tank cavity above the vessel. The shield tank cavity, which is water-filled when handling fuel, is lined with a stainless steel membrane to assure complete watertightness.

When not otherwise metal covered, the surface of the concrete is protected with a smooth, hard finish paint to prevent absorption of contaminated vapor and to assist in decontamination.