TECHNICAL
PRESS INFORMATION
N.S. SAVANNAH

COMPILED FOR THE
U.S. ATOMIC ENERGY COMMISSION
U.S. DEPARTMENT OF COMMERCE
MARITIME ADMINISTRATION

BY NEW YORK SHIPBUILDING CORPORATION, CAMDEN, NEW JERSEY

APPENDIX "A"

CONTAINMENT VESSEL DESIGN AND CONSTRUCTION

A containment vessel, 35 feet in diameter and 50.5 feet long, located in the reactor space, houses the SAVANNAH's entire reactor plant and primary cooling system. It is designed to contain all the water and steam released in the event of a mechanical failure of the pressurized water loops (maximum credible accident) and to support the lead ani polyethylene shielding covering the upper half of the containment vessel under a 30° roll.

The containment vessel consists of a center cylindrical section 35 feet in diameter, 16 feet long, of thicknesses varying from 2 3/8" to 3 3/4"; two hemispherical ends, 1.24 inch thick, attached to the cylindrical portion; and a cupola, 14-feet, 6 inches outside diameter, 16 feet high on top of the cylinder section. The shell steel is SA-212, Grade B. Four internal stiffening rings are provided in each hemispherical section. The half rings are made of a 1.25-inch thick web, and a 15 x 1.5-inch face plate. These connect to the top and bottom of two stiffening rings at the ends of the cylindrical section. The cylindrical section also contains two partial rings in the center portion of the same size as hemisphere rings. Each end ring of the cylindrical section is made of high tensile steel with a web of 1 1/4" thickness and a 15" face plate which varies in thickness from 1 1/2" to 3". The other rings are SA-212-Grade B. The vessel shell and rings weigh 275 long. tons and emcompass a volume of 41300 cu. ft. equivalent to 310,000 gallons.

(More)

The containment vessel is designed to withstand an internal pressure of 186 PSIG resulting from the maximum credible accident. In addition, it must support approximately 500 long tons of radiation shielding (lead and polyethylene) on the outer surface of the shell under a 30° roll. There are no generally accepted codes or specifications written to cover a structure intended for such a dual purpose. For this reason, the shell system and shielding support structure were designed separately. The shell and all its penetrations comply in all respects with the A.S.M.E. Code for Unfired Pressure Vessels. The supporting rings have been analyzed by the first principles of mechanics. Members have been selected which provide a safety factor of four for all loads except that of the maximum credible accident, and three for all loads including the maximum credible accident. These safety factors are valid when shielding necessary for a .5 r/year radiation exposure has been applied to the containment vessel and at a 30° roll of the ship.

Shell thicknesses were determined from the A.S.M.E. Code for Unfired Pressure Vessels and checked in accordance with shell membrane theory. Membrane stresses for the design pressure were under 17,500 PSI. Principal stresses in the hemisphere shell due to external loading were checked and were not considered critical.

A detailed investigation of discontinuity points was made according to classical plate and shell elastic-energy techniques. Penetration reinforcement and reinforcement around 13'-6" dia. opening were designed to meet the requirements of the Marine Eng. Reg., USCG CG-115, dated March 1, 1956. An investigation was made where the hemispherical shell and cylindrical shell meet and where the stiffening rings and shell meet, for a maximum credible accident.

(More)

The governing condition for design of the containment vessel was the shell weight plus weight of shielding superimposed upon shell pressure stresses due to a maximum credible accident. Dynamic load factors of pitch and roll were included in dead weight determination.

Moments, shears, and axial forces on each ring were determined by application of strain-energy equations. The ring loading is reacted by the supports and transmitted to the ship structure. Hemisphere rings were analyzed in the same manner with a saddle support at 45° to the vertical and restraint at top and invert of the end cylinder rings.

Preliminary investigation clearly indicated the critical design criteria for the containment vessel to be the dynamic 30° roll of ship in combination with a maximum credible accident and external shielding loads. The maximum stress was no greater than F_t = 26,000 psi and F_c= 22,800 psi for the combined loading analysis.

The containment vessel rests on 3 saddle-shaped longitudinal supports, port and starboard, welded to the tank top and one support under each hemisphere ring. Thirty-eight lubrite bearing plates 1/2" thick are provided to transmit loads to supports. The containment vessel is fastened to the ship structure only at the aft end of the cylindrical portion with 24-2 1/4" diameter high-strength bolts. This connection is designed to resist rotation and forward and aft motion, but allows the vessel to expand freely due to temperature changes. Supports at mid-height in way of collision mats prevent dislocation from rolling of the ship and the chocks at "B" Deck insure that the containment vessel is not dislocated by a 90° heel of the ship.

Foundations for nuclear components are provided inside the containment vessel designed to transmit the loadsthrough the shell to the external foundations in the ship structure.

The two hemispherical heads the cylindrical section and the cupola were fabricated separately. All welds in each section were preheated and the roots inspected by the magnetic particle method. After completion of welding all butts and seams were 100% radiographed. All fillets were inspected by the magnetic particle method. Each section was then stress relieved and assembled in place on the ship. A jacking arrangement was devised for handling the 275 ton assembled vessel so that the bearing pads and tapered liners could be fitted to suit the shell.

The vessel is provided with one 13 foot diameter opening at the top of the cupola, through which passes all the equipment to be fabricated and installed within the vessel. Two 42" I.D. access openings are provided on the vessel top, forward and aft of the cupola, with two standard manholes on the underside of the vessel. In addition, 76 other penetrations varying from one inch to 12 inch diameter are provided to accommodate piping and electrical wiring. The reinforcement for all penetrations was designed to comply with the A.S.M.E. Code for unfired pressure vessels and Marine Eng. Reg. U.S.C.G. CG-115. Penetrations for piping smaller than 2" consist of a nozzle through which the pipe passes. For piping larger than 2", a nozzle with a reinforcing doubler is used. Electrical penetrations are also made through appropriate nozzles. The seal for wiring is epoxy resin. This seal has been tested successfully at the pressure and temperature of the maximum credible accident.

(More)

The containment vessel, after assembly, with no internals in place, was hydrostatically tested to a pressure equivalent to the maximum credible accident. The hydrostatic test consisted of filling the vessel with steam heated water (approximately 130°F.) while venting all air pockets. When the vessel was full, the pressure was increased in ten increments to 173 P.S.I.G. (a later calculation of the pressure produced in the maximum credible accident) by a feed water pump, keeping the minimum shell temperature at approximately 100°F. to eliminate the possibility of brittle fracture.

In the event that the ship would sink, the two manholes in the bottom of the containment vessel have been arranged to open to prevent collapse of the containment vessel. The bolts securing the cover are necked down so as to break when the pressure outside corresponds to a water depth of 100 feet. When the pressure inside and out are equalized, a spring arrangement returns the cover to the closed position, thus preventing easy escape of the contained material.

The containment vessel is continuously air-conditioned to maintain a temperature of 120°F. and is ventilated only when the hatch is open and the plant shut down. Continuous radiation monitoring of exhaust air is provided.