DISTRIBUTION:
SUPPLEMENTAL
DRL READING
C&CTB READING
AD/RT READING

APR 19 1968

R. S. Boyd, Assistant Director
for Reactor Projects, DRL
THRU: S. Levine, Assistant Director
for Reactor Technology, DRL
R. C. DeYoung, Chief
Containment & Component Technology Branch, DRL

WISCONSIN PUBLIC SERVICE CORPORATION, KEWAUNEE NUCLEAR POWER PLANT, DOCKET NO. 50-305

DRL:C&CTB:NHD

The attached draft of the Containment Section for the DRL Report to the ACRS on Kewaunee is based on the review performed by A. L. Gluckmann and N. H. Davison.

cc: D. F. Knuth, DRL
R. G. Smith, DRL
E. G. Arndt, DRL
bcc: R. C. DeYoung, DRL
S. Levine, DRL
A. L. Gluckmann, DRL
N. H. Davison, DRL

OFFICE ▶	DRL:C&CTB	DRL:C&CTB	DRL:C&CTB	DRL:AD/RT		
SURNAME ▶	ALG ALGluckmann/sp	N.D. NHDavison	RCDeYoung	for SLevine		
DATE ▶	4/15/68	4/8/68	4/16/68	4/19/68		

Form AEC-318 (Rev. 9-53) U.S. GOVERNMENT PRINTING OFFICE : 1966—O-214-629

4.0 CONTAINMENT

The containment system for Kewaunee is identical to those employed in the Prairie Island Nuclear Generating Plants. Basically, it consists of a primary steel containment vessel enclosed within a reinforced concrete shield building. Equipment exterior to the shield building that is connected to equipment within the primary containment or is open to the containment atmosphere is enclosed within a special ventilation zone of the auxiliary building. This part of the auxiliary building is monolithic with the shield building and is considered to be an integral part of the containment system.

The primary containment is a vertical cylindrical steel vessel with hemispherical dome and ellipsoidal bottom. The inside diameter of the cylinder is 105 feet and the net free volume will be at least 1,320,000 cubic feet. The steel vessel will house the reactor vessel, the primary coolant loops, the accumulators of the safety injection system, the primary coolant pressurizer, and the pressurizer relief tank. The Class B vessel will be designed, fabricated, inspected, and tested in accordance with the ASME Boiler and Pressure Vessel Code, Section III and Section VIII.

The steel vessel will be designed for applicable combinations of dead loads, operating loads, vacuum load in the annulus, external pressure, seismic loads, and the pressure, temperature and jet force loads due to design basis loss of coolant accidents. The vessel will be designed for a maximum internal pressure of 46 psig coincident with a temperature of 268°F. The corresponding "design" internal pressure defined by the ASME Code is 41.4 psig at the same temperature. For the combination of dead loads, operating loads, accident loads, and the loads due to the design (smaller) earthquake the stresses will be limited to Code allowable values. When the loads due to the maximum hypothetical earthquake are substituted for those of the smaller earthquake, the primary stress intensities will be limited to 90% of the yield strength of the SA 516 grade 70 steel from which the vessel will be fabricated. The load combinations and stress limits established by the applicant are consistent with those used for similar structures we have reviewed. We concur with their use for this design.

The plate thickness of the cylindrical wall of the steel vessel will be approximately 1.5 inches. In order to eliminate the need for field stress relieving, the ellipsoidal bottom will be limited to a maximum thickness of 1.5 inches. Additional thickness near the knuckle is usually needed in ellipsoidal heads to take the compression in the hoop direction. To limit the thickness to the maximum allowable for this vessel horizontal circular stiffeners or internal concrete structure in areas where analysis indicates it is required will be provided to prohibit buckling. This arrangement is unusual for containment vessels. However, the applicant has agreed to perform additional studies to resolve areas of uncertainty. We believe that the problems involved are recognized, and that the studies being undertaken can result in an acceptable design.

After erection the steel vessel and the penetrations will be strength tested in accordance with the Code. The vessel will be leak tested to demonstrate that at a maximum internal pressure of 46 psig the mass leakage rate will not exceed 0.15% per day. The permissible leakage rate during subsequent in-service leakage tests will be based on a 0.5% mass leakage per day under accident conditions.

The shield building, which completely encloses the steel containment vessel, is a conventional reinforced concrete structure. The annular space between the steel and concrete structures with a volume of about 400,000 cubic feet ~~structures~~ is adequate to permit construction operations and periodic inspections of both structures. The concrete wall thickness (2.5 feet) and the dome thickness (2.0 feet) are based on shielding requirements and could be reduced if only structural requirements had to be considered.

The structure, including the bottom slab, will be designed essentially in accordance with the ACI Code 318-63 for concrete structures, and AISC Specifications for structural steel elements. The working stress method of design will be used. The loads considered will include dead loads, live loads, accident loads, wind loads, tornado loads, snow loads, bouyancy loads, seismic loads, and missile loads. We have reviewed the combinations of loads selected by the applicant for design purposes as well as the stress limits to be imposed on the various load combinations. The stresses allowed for combined dead, live, and wind loads will be in accordance with ACI and AISC Codes except that the stress increase of 33% permitted by the codes will not be used. The stresses for combined dead, live, accident, and design earthquake loads will be limited to code allowable stresses. When the loads due to the maximum hypothetical earthquake are substituted for the design earthquake loads the stress limits are raised to 1.5 the code allowable values. For combined dead, live, and tornado loads, stresses in concrete will be limited to 85% of ultimate and to 90% of yield in reinforcing and structural steel. We concur with the load combinations and stress limits selected by the applicant.

Concrete will have a minimum compressive strength of 4000 psi at 28 days. Reinforcing steel will be in accordance with ASTM Specifications A-15, A-408, and A-432. Cadweld splices will generally be used. If fusion welding of reinforcing bars is required, it will be performed by qualified welders in accordance with the AWS Code. Our seismic design consultant has advised against fusion welding of A-432 bars. However, the applicant has stated that fusion welding will be used only where it is necessary because of geometry restrictions and that in these instances particular quality control measures will be taken to ensure acceptable chemical compositions of the bars and adequate controlled welding procedures. We and our consultant consider this approach to be acceptable.

The shield building in-leakage rate is assumed, for accident analyses purposes, to be 10%/day at a pressure of 0.25 inches of water. Planned initial and subsequent periodic tests are expected to demonstrate rates well below the assumed value.

That part of the auxiliary building that will serve as part of the containment system will be designed to the same Class I standards used for the shield building. The poured concrete walls and floors will have sealed joints, and doors will be equipped with conventional door closers and limit switches to signal an open door to the reactor operator in the control room. Penetrations through the walls will be sealed. The special ventilation zone will be designed to have an in-leakage rate of less than 100% per day at -0.25 inches of water. The auxiliary building ventilation system will maintain the negative pressure and will filter the effluent prior to exhaust to the atmosphere.

The modal seismic analysis of the entire containment will be performed using earthquake response spectra based on comparison of local conditions to those associated with the locations of the Taft and El Centro earthquakes. We and our seismic design consultants have ~~received~~ reviewed the analytical methods to be used, and assumptions made relating to the vertical component of motion, the damping factors, and the manner of combining loads directly and linearly. We and our consultants believe the methods and assumptions provide an acceptable bases for design.

The maximum relative movement of a hot penetration, during a post-accident condition, is expected to be about 1.4 inches axially and 1.0 inch laterally. The piping configuration and the supports on both sides of the penetrations will be designed to prevent overstressing of the vessel under any circumstances.

All hot process lines penetrating the annulus will be designed with a guard pipe to direct steam flow back to the primary containment in the event of a rupture of the process pipe wall in the annulus region. The applicant will design the penetrations and guard pipe so that there will be considerable margin between the pipe code allowable stress values and the maximum stress in the pipe for all load combinations (including combined pressure, thermal, seismic, and hydraulic jet forces for the assumed rupture). We believe that hot process line penetrations can be designed on this basis so they will not discharge steam into the annulus. We have recommended to the applicant that the guard pipes and the process pipes in hot process piping penetrations be included in periodic inspections of the containment.

A concrete primary shield wall and concrete floors enclose the reactor coolant loops and will prevent missiles from these locations from striking the containment steel wall. Local protection of the steel vessel will be provided against other potential missiles. The shield and auxiliary buildings will be designed for the impact of postulated external missiles including tornado driven missiles and turbine generated missiles. Reinforcement will be provided to control cracking in concrete at potential points of impact. We believe the applicant's approach to providing protection against missiles will result in an acceptable design.

The shield building introduces the potential for overpressurizing the annulus and collapsing the steel primary containment vessel. It is essential that the pressure differential between the outside and inside of the steel shell be less than 0.8 psi to prevent buckling of the shell. The vacuum relief valves for the steel containment will be sized to accommodate the maximum rate of cooling of the containment with the four finned coolers and two internal sprays in operation combined with maximum barometric changes. We note also that the vacuum relief system will be designed as a Class I system. We believe that the vacuum relief system designed in the proposed manner will provide protection against overpressurization of the annulus.

We have concluded that the proposed design of the containment system is acceptable from a structural viewpoint.