Illinois Power Company

U-0679
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Docket No. 50-461

December 8, 1983

Director of Nuclear Reactor Regulation
Attention: Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Clinton Power Station Unit 1
SER Confirmatory Issue #6 (NUREG-0853)
Containment Ultimate Strength Analysis

Dear Mr. Schwencer:

Illinois Power Company letter U-0677 to A. Schwencer, dated November 3, 1983; documented the commitment to perform a local hydrogen detonation analysis for the Clinton Power Station (CPS) containment. We agreed to do the analysis using the methodology established by Mississippi Power & Light Company on the Grand Gulf station.

Attached are the CPS analyses which include the evaluations of the containment wall, the lower containment personnel air lock, the drywell personnel air lock, and the ultimate external static pressure capability of the drywell head.

We trust that this information will resolve SER Confirmatory Issue #6 for closeout in your future SER supplement. Please feel free to contact me if you have any further concerns you may want to discuss.

Sincerely yours,

R. M. Nelson
Director-Nuclear
Licensing & Configuration
Nuclear Station Engineering

GEW/lt

attachment

cc: G. A. Harrison, NRC Clinton Licensing Project Manager
NRC Resident Office
Illinois Department of Nuclear Safety
L. C. Ruth, NRC CSB
C. G. Tinkler, NRC CSB
A. Notafrancesco, NRC CSB

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Evaluation of Containment Wall, and Containment and Drywell Personnel Air Locks for Local Hydrogen Detonation

The Clinton containment wall, the lower containment personnel air lock (below the HCU floor level), and the drywell personnel air lock have been evaluated for structural adequacy regarding their ability to withstand a postulated local hydrogen detonation. The Impulsive Pressure-Time (IPT) curve associated with the local detonation is presented in Figure 1 in terms of absolute pressure. This impulse has been assumed to act on the containment wall in the region bounded by the suppression pool water level and the bottom of the HCU floor. Although the IPT curve in Figure 1 is shown abruptly truncated at fifteen milliseconds (msec), in reality, the curve does extend beyond 15 msec and will eventually attenuate to atmospheric pressure. This information has been accounted for in the present evaluation by extending the IPT curve in Figure 1 with a constant pressure line beyond 15 msec for an additional 1.5 msec and then attenuating the pressure to atmospheric at 19 msec.

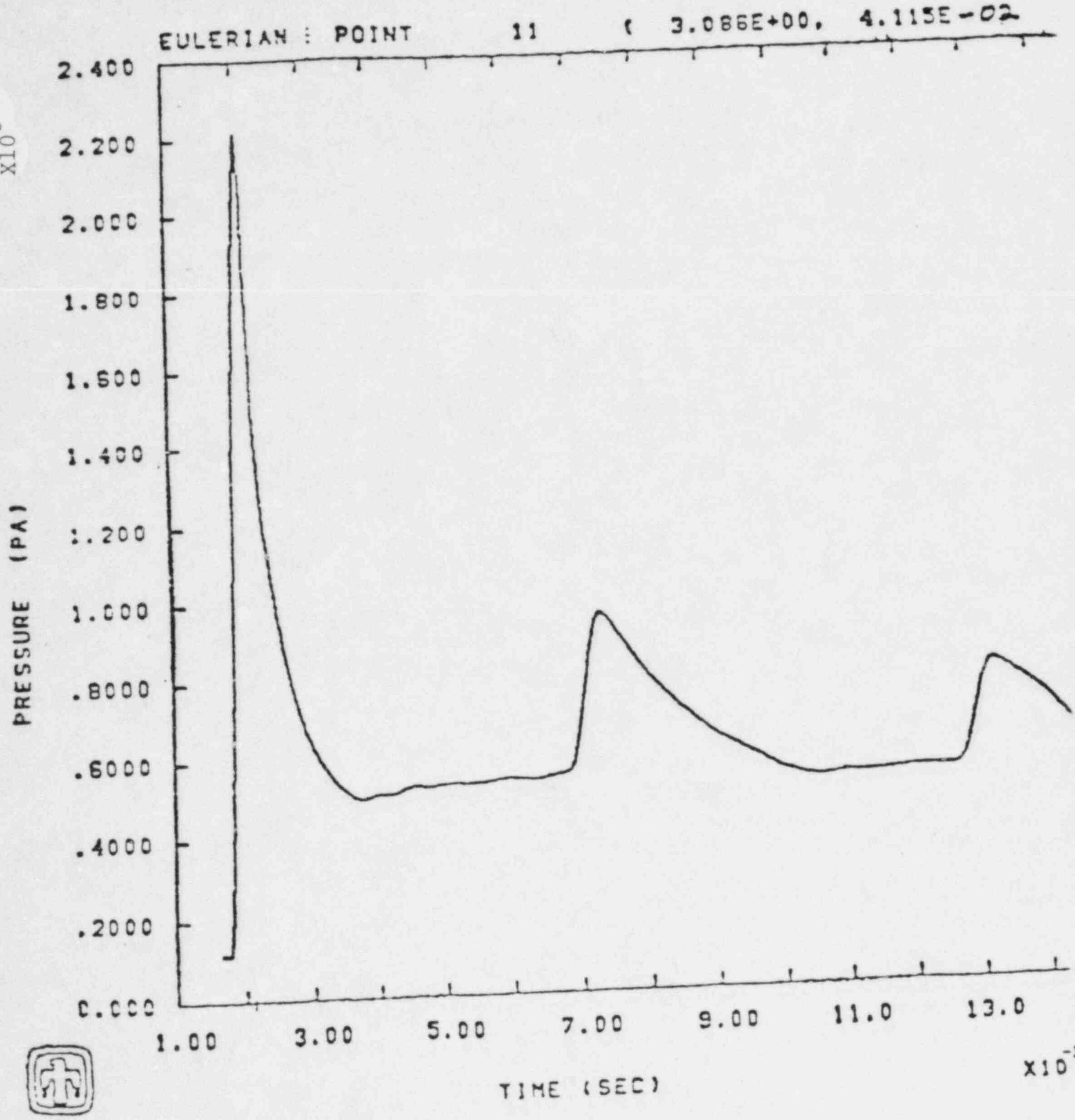
The response of the containment wall is evaluated by modelling it as an elasto-plastic, single Degree of Freedom (SDOF) dynamic system and subjecting it to the given IPT curve. The stiffness of the SDOF system is calculated based on the radial deformation of the shell assuming membrane action. The mass of the system is calculated by equating its frequency to the breathing mode frequency of the shell. The static pressure capacity of 75 psig (without considering liner as strength element), as reported in FSAR Section 3.8.1.4.8, is used to determine the yield resistance of the SDOF system.

The SDOF system described above was analyzed for the IPT curve utilizing a non-linear computer program which employs step-by-step numerical integration technique to solve the equation of dynamic equilibrium. The results of the analysis indicate that the containment shell is capable of withstanding the pressure impulse resulting from a local hydrogen detonation by mobilizing its yield resistance corresponding to the 75 psig static pressure capacity. The resulting ductility ratio is calculated to be less than three, which conforms to the guidance provided in ACI 349-80, "Code Requirement for Nuclear Safety-Related Concrete Structures", Appendix C. Considering 95 psig static pressure capacity, the containment wall remains within elastic range.

The response of lower containment personnel air lock and drywell personnel air lock has been evaluated by modelling various components of the locks (such as door panel and bulkhead plate) as an elasto-plastic, Single Degree of Freedom (SDOF) dynamic system and subjecting it to the given IPT curve. The SDOF system is based on equivalent mass and spring properties calculated in accordance with the method outlined in "Introduction to Structural Dynamics" by J. M. Biggs, McGraw Hill Book Company. The static pressure at which section yielding is initiated in the components is conservatively taken as the yield resistance of the SDOF system.

The SDOF system of the lock components described above was analyzed in the same manner as the containment wall. The results of the analysis indicate that the components of the locks are capable of withstanding the pressure impulse resulting from a local hydrogen detonation by mobilizing their yield resistance. The resulting ductility ratios are calculated to be less than ten.

In order to evaluate potential of any significant leakage through the lower containment personnel air lock, it should be considered that the maximum deformation of the door panel on the air lock will be small, although with a ductility ratio of less than 2.0. For mid panel deformation of this magnitude, the performance of the seals at the periphery of the door will not be affected. Considering the very short duration of the pressure pulse, it can be concluded that there would be no leakage out of the containment when both doors on the air lock are in the closed position.



GRAND GULF, 0.28 HZ-DRY AIR

FIGURE 1

Capacity of the Drywell Head Under External Pressure

The buckling capacity of the drywell head, which is comprised of an elliptical shell and a circular cylinder, has been evaluated using a conservative formulation developed at the David Taylor Model Basin (DTMB).

The critical external pressure for the head was calculated using the method given in the DTMB Report 1757, "The Effect of Initial Imperfections on the Collapse Strength of Deep Spherical Shells." This method employs nominal dimensions and worst case deviations from nominal dimensions to determine the critical pressure. When the calculations were performed for a conservative out-of-roundness based on the out-of-roundness tolerance permitted by the ASME code, the minimum differential pressure capacity of the elliptical head was calculated to be 107 psi.

The critical external pressure for the cylinder was determined using the method given in the DTMB Report 1639, "Structural Analysis and Design Considerations for Cylindrical Pressure Hulls." This method also employs nominal dimensions and worst case deviations from nominal dimensions to determine the critical pressure. When the calculations were performed for a conservative out-of-roundness based on the out-of-roundness tolerance permitted by the ASME code, the minimum differential pressure capability of the cylinder was calculated to be 97 psi.

In summary, the buckling capacity of the drywell head has been evaluated using a formulation taking into account the effect of initial imperfections. The lower bound estimate of 97 psi for the buckling capacity of the drywell head is based on a conservative assumption regarding such initial imperfections.