
Item B-54: Ice Condenser Containments (Rev. 1)

DESCRIPTION

Historical Background

This NUREG-0471¹ item deals with two concerns regarding the ice condenser containment design. The first concern arises from an ACRS comment on the D. C. Cook Unit 1 review. The normal procedure used by the staff (CSB) to conclude on the adequacy of containment design entails performing a confirmatory analysis of the applicant's design basis accident and approving or disapproving the design on the basis of comparison

of the two analyses. CSB uses the CONTEMPT-LT² Code developed by INEL to perform independent containment analyses. The CONTEMPT-LT³ Code does not have the capability to analyze an ice condenser containment. The staff's review of the ice condenser design has, therefore, been conducted by rigorous review of the applicant's code, LOTIC (developed and used by Westinghouse as containment designer for applicants using the ice condenser containment design), and the full-scale ice condenser test program conducted by Westinghouse to prove their design. In their initial review of the D. C. Cook plant, the ACRS recommended that the staff develop a computer code with ice condenser capability in order to perform independent confirmatory calculations in the fashion normally utilized in containment design review.

The second part of this issue deals with technical specifications regarding the weighing of ice in the approximately 2,000 baskets in the ice condenser and the minimum acceptable ice weights and ice condenser inspection frequency. The concern has been spawned by the nonsymmetric ice losses by sublimation experienced at D. C. Cook and later at Sequoyah. Present technical specifications do not consider the patterns of ice loss experienced in the field and DOR was looking ahead anticipating requests for relief in the future.

Safety Significance

Both parts of the issue deal with the ice condenser capability to extract blowdown energy in the early phase (first hour) of a LOCA. After ice-melt, the containment pressure control is provided by containment spray systems for continued energy removal as in conventional dry containment designs. Failure of containment by overpressure due to inadequate ice inventory, inadequate ice condenser surveillance and maintenance, or faulty analysis would be the expected result. Two types of accidents could occur, each having a different expected frequency.

The first would be a large LOCA with early containment failure but with adequate core cooling. The second event would be a large LOCA again with early containment failure followed by loss of core cooling and core-melt.

Possible Solution

Should a perception be reached that the probability of containment failure due to LOCA overpressurization was too high, peak containment pressure could be reduced by increasing the containment spray system

¹ NUREG-0471, "Generic Task Problem Descriptions (Categories B, C, and D)," U.S. Nuclear Regulatory Commission, June 1978.

² NUREG/CR-0255, "CONTEMPT-LT/028: A Computer Code for Predicting Containment Pressure-Temperature Response to a Loss-of-Coolant Accident," U.S. Nuclear Regulatory Commission, March 1979.

³ NUREG/CR-0255, "CONTEMPT-LT/028: A Computer Code for Predicting Containment Pressure-Temperature Response to a Loss-of-Coolant Accident," U.S. Nuclear Regulatory Commission, March 1979.

capacity drastically. This would entail as much as a fivefold increase in the spray system flow capacity. It would probably require complete new redundant containment spray systems.

PRIORITY DETERMINATION

Frequency Estimate

The containment spray system in plants with ice condenser containment is conservatively sized to prevent containment pressure greater than design pressure after ice-melt for an assumed large-break LOCA. Ice-melt is calculated and predicted by the full-scale ice condenser test program to occur, at the earliest, about 1 hour after a large-break LOCA. Containment failure is not predicted until containment pressure exceeds at least twice the design pressure. Therefore, the containment spray systems could handle the energy releases to containment after about the first half-hour after a LOCA without containment failure. This means the ice condenser must be effective for the first half-hour after a LOCA. During this time period, effective core cooling must take place or the decay energy will not reach the containment. The first half-hour after a large-break LOCA coincides roughly with ECCS operation in the injection mode. From WASH-1400,⁴ the frequency of a large LOCA is $10^{-3}/\text{RY}$ to $10^{-4}/\text{RY}$.

The ice condenser containment could fail during the first half-hour of a large LOCA due to overpressure if there were an analytical error in design or an inadequacy of technical specifications governing ice condenser operations. The analytical model (LOTIC)⁵ has been checked and double-checked by Westinghouse, licensees, and the NRC. The same is true of the technical specifications. The probability of having errors of this type should be in the range of 10^{-2} to 10^{-3} .

From the study performed to evaluate the use of containment purge valves, we found the probability of long-term (recirculation) ECCS failure, given a loss of containment integrity, to be in the range of (2.5×10^{-1}) to 10^{-2} . For a PWR-3 accident, the frequency of a LOCA with ECCS cooling and loss of containment integrity using conservative values is $(10^{-3})(10^{-2})/\text{RY}$ or $10^{-5}/\text{RY}$. For a PWR-8 accident, the frequency of a LOCA with loss of ECCS cooling and loss of containment integrity using conservative values is $(10^{-5})(2.5 \times 10^{-1})/\text{RY}$ or $2.5 \times 10^{-6}/\text{RY}$.

Consequence Estimate

The source term for the case of containment failure with effective long-term core cooling is that of a WASH-1400⁶ PWR-8 event, LOCA with effective ECCS and loss of containment integrity from containment isolation failure. Without effective long-term core cooling following containment failure, the source term is that of a PWR-3 event, early containment failure and depressurization followed by ECCS failure in the recirculation mode. Consequences for PWR-3 and PWR-8 release categories are expressed in man-rem. The total whole-body man-rem dose is obtained by using the CRAC Code⁷ for a particular release category. The calculations assume a uniform population density of 340 people per square mile (which is average for U.S. domestic sites) and a typical (midwest plain) meteorology.

For a PWR-3 event, $D = 5.4 \times 10^6$ man-rem For a PWR-8 event, $D = 7.5 \times 10^4$ man-rem.

Cost Estimate

In approximating the cost, the following must be considered: (1) the cost to complete the generic issue,

⁴ WASH-1400 (NUREG-75/014), "Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," U.S. Atomic Energy Commission, October 1975.

⁵ Federal Register Notice 44 FR 68307, "Decommissioning and Site Reclamation of Uranium and Thorium Mills," November 28, 1979.

⁶ WASH-1400 (NUREG-75/014), "Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," U.S. Atomic Energy Commission, October 1975.

⁷ NUREG/CR-2800, "Guidelines for Nuclear Power Plant Safety Issue Prioritization Information Development," U.S. Nuclear Regulatory Commission, February 1983, (Supplement 1) May 1983, (Supplement 2) December 1983, (Supplement 3) September 1985, (Supplement 4) July 1986, (Supplement 5) July 1996.

and (2) assuming an error is detected, the cost to correct the error at the operating ice condenser plants. There are 10 ice condenser plants, 4 currently operating and 6 in the OL review stage.

Industry Cost: Assuming an error is detected, the solution would require either a major design change to the ice condenser or addition of a new redundant large-capacity containment heat removal system. In either event, large plant downtimes would be incurred at the 4 operating plants with ice condenser containments. The cost of replacement power is assumed to be \$300,000/day. We have assumed a minimum effective downtime of 90 days for corrective actions.

The cost of redundant heat removal systems would be on the order of millions of dollars. We will assume the cost to be \$10M (including the cost of licensing review). The cost to each of the 4 operating plants would be (90) (\$300,000) + \$10M. Therefore, the total cost for all 4 operating plants is \$148M. The cost to the 6 unlicensed plants with ice condenser containments would be \$(6 x 10)M or \$60M.

NRC Cost: The cost to complete the generic issue was estimated to be 3 man-years of NRC and INEL (CSB consultant) personnel time. The code work was scheduled to be done in 1983. Therefore, the NRC cost would be about an additional \$300,000 to find a human error if present. The NRC cost to complete the evaluation of the issue for all 10 ice-condenser reactors would be about \$30,000/ reactor. This cost is negligible in comparison with industry cost.

Therefore, the total cost associated with the solution to this issue is \$(148 + 60)M or \$208M.

Value/Impact Assessment

It is assumed that the average life is 35 years for the 10 reactors (4 operating and 6 under construction).

- (1) For a PWR-3 event, the public risk reduction is 4.7×10^3 man-rem. Therefore,

$$S = \frac{4.7 \times 10^3 \text{ man - rem}}{\$208\text{M}}$$

$$= 23 \text{ man - rem} / \$\text{M}$$

- (2) For a PWR-8 event, the public risk reduction is 2.6×10^2 man-rem. Therefore,

$$S = \frac{2.6 \times 10^2 \text{ man - rem}}{\$208\text{M}}$$

$$= 1.2 \text{ man - rem} / \$\text{M}$$

Uncertainties

The uncertainty of each of the constituents in the value/impact score equation is about a half order of magnitude. Therefore, the uncertainty of the calculations should also be about a half order of magnitude to an order of magnitude. Even if the value/impact score were an order of magnitude or more greater, it would not be large by comparison to scores for recognized high risk events ($S > 10^3$).

Additional Considerations

Work on developing an independent analytical model for ice condenser containment analysis has been pursued for about the last 5 years. The containment features necessary for the analysis of conventional dry containments have been checked out and accepted. The ice condenser model is operational and checkout is partially complete. CSB expects to have an accepted code with users manual by March 1982.

Costs to date have probably exceeded \$1M. Costs to complete the code should be small in comparison to the funds already expended.

In addition, the person utilized by INEL in the CONTEMPT-4 development and checkout effort will be needed to conduct the continuing code maintenance and CSB technical assistance functions. The CONTEMPT Codes are the CSB licensing evaluation tools and must be maintained. Past experience has shown that termination of code work or alterations in the scope of the INEL contract has resulted in the individual assigned to the CONTEMPT code leaving INEL and thereby causing a severe disruption in CSB consultant capability.

CONCLUSION

The low value/impact score arrived at above indicates that this issue should be dropped as a generic issue. However, if significant errors exist in the computer code, the containment could fail during an accident and one level of the "defense-in-depth" protection could be lost. Furthermore, the maintenance of consultant capability at INEL is essential to performing the CSB licensing reviews. Based on the above analysis, it was recommended that the CONTEMPT-4 Code development be completed with a medium priority. Any future application analysis performed by INEL or CSB should be addressed to individual plant reviews and charged as case work.

MOD 4 and MOD 5 to the COMPEMPT 4 User's Manual were published as NUREG/CR-3716⁸ and NUREG/ CR-4001,⁹ respectively. No change to the SRP¹⁰ was required since it already included a provision for the staff to perform confirmatory analyses.¹¹ Thus, this issue was RESOLVED and no new requirements were established.

⁸ NUREG/CR-3716, "CONTEMPT 4/MOD 4," U.S. Nuclear Regulatory Commission, March 1984.

⁹ NUREG/CR-4001, "CONTEMPT 4/MOD 5," U.S. Nuclear Regulatory Commission, September 1984.

¹⁰ NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, (1st Ed.) November 1975, (2nd Ed.) March 1980, (3rd Ed.) July 1981.

¹¹ Memorandum for T. Speis from H. Denton, "Closeout of Generic Issue B-54, 'Ice Condenser Containments,'" October 22, 1984. [8411050142]

