Item B-68: Pump Overspeed During LOCA

DESCRIPTION

Historical Background

This NUREG-0471[1] item, as presently formulated, involves the conduct of analytical and experimental work to determine whether or not destructive overspeeds could be attained and to determine if corrective actions are necessary. A potential exists for BWR recirculation pumps or PWR primary coolant pumps to overspeed during a LOCA. The evaluation of this item includes the consideration of Item A-32.

Safety Significance

The potential consequences are from missile damage to systems necessary to mitigate the consequences of the existing LOCA.

Possible Solution

A possible solution would be to construct a missile barrier around each pump.

PRIORITY DETERMINATION

Assumptions

Assume that a LOCA exists in the form of a double-ended pipe break near the discharge of the pump. Assume that the most damaging pump-generated missile would be from fragmentation of the pump flywheel. This assumption implies that other possible missiles, such as motor winding, pump shaft, etc., have either a much lower probability of occurrence or a much lower mass than the pump flywheel, resulting in a much lower probability of damage. This assumption, then, limits the issue to PWRs.

Frequency Estimate

In Section 5.3.5 of WASH-1400,[2] Appendix IV, a detailed scenario for PWR primary coolant pump flywheel missile events is presented. The frequency estimates used here are those of WASH-1400[3] and are as follows:

(1) Frequency of a PWR large LOCA is 10^{-4}/RY (2) Fraction of vulnerable safety-related piping to total piping = 0.13 (3) Probability of pump overspeed is 1.0 (4) Probability of flywheel fracture at overspeed is 1.0 (5) Fraction of area around overspeeding pump where missile impact could lead to unacceptable damages = 0.1.

Therefore, the total frequency (F) of the above scenario is given by, $F = (10^{-4})(1.3 \times 10^{-1})(1.0)(1.0)(10^{-1})/RY = 1.3 \times 10^{-6}/RY$

Consequence Estimate

For the type of accident scenario postulated in the WASH-1400[4] report, the Probabilistic Analysis Staff

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[1] NUREG-0471, "Generic Task Problem Descriptions (Categories B, C, and D)," U.S. Nuclear Regulatory Commission, June 1978.
[2] 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.
[3] 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.
[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.

predicted a PWR Category 7 release.

Consequences for a PWR-7 release category are expressed in man-rem. The total whole-body man-rem dose is obtained by using the CRAC Code[5] for the 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-7 event, D = 2.3 x 10^3 man-rem.

Cost Estimate

Industry Cost: The cost of designing and installing missile barriers around pumps is $500,000/plant.

NRC Cost: Two staff-years will be required to review basic barrier design and inspect the construction of the barrier. This cost is estimated to be $160,000 and is negligible in comparison with the industry cost for implementing the change on more than 70 reactors.

Therefore, the total cost for the solution to this issue is $(70 x 0.5)M or $35M.

Value/Impact Assessment

Based on a total risk reduction of 6.3 man-rem for 70 PWRs, the value/impact score is given by:

$$S = \frac{6.3\,\text{man} - \text{rem}}{\$35\text{M}}$$

$$= 0.2\,\text{man} - \text{rem} / \$\text{M}$$

Uncertainties

There are uncertainties in the estimates of accident frequencies, consequences, and cost used in the value/ impact score equation. However, these uncertainties would have to be in error by more than 2 orders of magnitude before the above assessment is affected.

CONCLUSION

This issue is of such small safety significance and low risk reduction value relative to its potential cost that the priority ranking is low and, therefore, it should be DROPPED from further consideration.

[5] 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.