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A REVIEW OF THE TURBINE-BUILDING FLOODING STUDY OF THE OCONEE PRA**

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A peer review of the Oconee Probabilistic Risk Assessment[1,2] (OPRA) for Unit no. 3 was conducted at BNL for the NRC. This paper discusses the review of the OPRA turbine-building internal-flooding study, which is one of the dominant contributors, and was performed in great detail. This paper also includes a comparison with other flooding studies performed elsewhere.[3,4]

The flooding study of the OPRA is of importance because of the specific layout of the plant. Three iterations of the study were performed in the OPRA to obtain realistic results, and a fourth iteration was performed to include several plant modifications.

The study goes through ten different steps all of which were redone by BNL with modifications. The following list mentions some of the steps and the BNL treatment:

1. Identifying potential flood sources--the BNL review found that all important sources were accounted for and operating experience was appropriately employed to introduce additional failure modes.

2. Estimating flood initiator frequencies--the BNL review found the OPRA approach to be appropriate, i.e., to use plant detailed design and maintenance data for frequency estimation of flood initiators frequency, and validating the total flood frequency by an analysis of the nuclear power plants flooding experience (LERs). Some comments will be given in the paper on the data for valve ruptures. The piping rupture analyses and the maintenance contribution were found to be detailed and acceptable. The contribution from expansion joints is taken into account by considering two different modes of failure.

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3. Flooding rate for each initiator--BNL has redone this calculation, not only as an audit but also, because the OPRA provides these calculations for iteration 3 only and the results for iteration 4 are given in general terms. Only changes in unimportant initiators were found.

4. Grouping of the individual initiators--the grouping into flood categories that can exceed critical levels in which frontline and support systems are disabled was performed in the BNL review in more detail than in OPRA. The number of groups were increased to provide more detail on timing to reach critical flood levels. This increased detail by BNL had effects in both directions, i.e., to increase and decrease the core damage frequency.

   The grouping also included considerations of flood isolation potential considered in the long term cooling phase.

5. Quantification of flooding sequences--this included several steps such as definition of sequences, fault trees for systems, and fault trees for critical flood levels, considering possibilities of flood isolation before exceeding a critical flooding level in which various systems will fail. The latter were changed significantly by BNL as will be described in the paper.

   The sequences were rerun by BNL using the SETS code to obtain the minimal cut sets. They were compared with the OPRA cut sets.

6. Long term isolation of the flood and assuring long term heat sink--a special analysis was performed in the OPRA for this step which dominates the late core damage contribution. BNL reviewed this step and made some quantification changes.

The general results of the review are compared with OPRA results in Table 1. It is seen that an agreement was obtained despite several changes by BNL and the indepth review of all steps. The main finding is a binning assignment error in the OPRA results that in fact is on the conservative side--assigning 20% of the core damage frequency to early rather than to late core damage. There is some increase in the contribution of medium floods in the BNL review, and the contribution of maintenance errors to the BNL medium flood category is

somewhat larger. The more refined grouping performed by BNL has impact in both directions and this is apparent only when the detailed sequences are reviewed.(5)

The paper will refer to several other flooding studies and provide a comparison with the treatment of the ten steps of the flooding study discussed in the paper.

The paper concludes that the OPRA turbine building flooding study is a thorough and indepth analysis and achieved considerable realism, so that despite several additional details and modifications, BNL results agree with the OPRA findings.

Table 1 Summary of Relative Core Damage Frequencies for Turbine Building CCW Floods

Core Damage Bin	Flood Initiator	OPRA Results	BNL** Results
I: Early CD for LOCA Sequences	Very Large Flood	0.33	0.29
	Large Flood	0.03	0.04
	Medium Flood	0.007	0.007
	Total BIN I	0.36	0.34
II: Late CD for LOCA Sequences	Very Large Flood	ϵ	0.001
	Large Flood	0.009	0.003
	Medium Flood	0.009	0.004
	Total BIN II	0.018	0.008
III: Early CD for Transient Sequences	Very Large Flood	0.22*	0.003
	Large Flood	0.15	0.11
	Medium Flood	0.05	0.05
	Total BIN III	0.42	0.16
IV: Late CD for Transient Sequences	Very Large Flood	ϵ	0.18
	Large Flood	0.11	0.07
	Medium Flood	0.09	0.15
	Total BIN IV	0.20	0.40
TOTAL		1.00	0.91

*Binning error--should be in BIN IV.
**Relative to OPRA Total Core Damage Frequency for Turbine Building Flooding.

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