OCT 16 1985
BNL-NUREG-36986
CONF-860804--6

AN EVALUATION OF ATWS CORE DAMAGE FREQUENCY FOR AN EARLIER VINTAGE BWR/4*

K. K. Shiu, D. Ilberg, N. Hanan
Department of Nuclear Energy
Brookhaven National Laboratory
Upton, New York 11973

BNL-NUREG--36986
TI86 001190

This paper reports a study performed to evaluate the core damage frequency contribution from Anticipated Transient Without Scram (ATWS) in an earlier vintage BWR/4 plant. Discussions on improvements in the design and operation of BWR plants to reduce the likelihood of occurrence and core damage frequency of ATWS have continued for years. In November 1981, subsequent to the issuance of three alternate proposed ATWS rules, the Nuclear Regulatory Commission invited comments on these rules. In June, 1984, a final rule on the reduction of risk from ATWS[1] events was issued.

In the study, it is assumed that the BWR/4 reactor is of an earlier vintage. Therefore, only two of the modifications have been implemented in accordance with the final rule: a diverse scram system and automatic recirculation pump trip. It is further assumed in this study that the setpoint for Main Steam Isolation Valves (MSIVs) closure is at reactor pressure vessel (RPV) water level 1 and that the BWR emergency procedure guidelines[2] are implemented. The standby liquid control (SLC) system is a manually initiated system with a maximum injection capacity of 43 gallons per minute (GPM).

An event tree approach was adopted to analyze the progression and core damage frequency of different ATWS events. Five different types of transient initiators were assumed; they included turbine trip, MSIV closure and loss of condenser, loss of feedwater, loss of offsite power, and inadvertent open of relief valve. Five different functional event trees were developed. These trees evaluated functions such as feedwater runback, manual initiation of SLC and operator control of water level to minimize heat discharge into the suppression pool, and others. Unavailability values used to evaluate these trees are consistent with assumptions stated earlier.

*This work was done under the auspices of the U.S. Nuclear Regulatory Commission.
Views in this paper do not necessarily represent those of the U.S. Nuclear Regulatory Commission.

DISCLAIMER

The results of this analysis will be presented in the full paper. Contributions to core damage frequency for each initiator are evaluated; also for comparison, the ATWS task force results[1] using similar assumptions are included. In the ATWS task force assessment, only two groups of initiators were evaluated, namely, turbine trip and isolation. The total core damage frequency calculated by the Task Force was about 1.2×10^{-5} per year with a total initiator frequency of 4.3 per year. This study, using results obtained from a more detailed and refined assessment of the transient initiator frequency, 9.6 event per year[3], calculated the core damage frequency due to ATWS to be 5.9×10^{-5} per year. In both the ATWS task force analysis and this analysis, ARI is assumed to have been implemented. Although the numerical results differ by only about a factor of 5, there are a number of observations: 1) there is a two fold increase in the initiator frequency in the BNL evaluation; 2) for the isolation events, more realistic assumptions of operator actions on SLC initiation and reactor water level control is employed; 3) for turbine trip events, credit is allowed for the condenser to remove heat throughout the course of the transient; 4) contributions from the other three initiators not considered in the ATWS task force study contribute about 10% of the total.

In order to gain further insights from the results, the conditional core damage frequency was evaluated. It is found that even with the implementation of the ARI, the emergency procedure guidelines and automatic recirculation pump trip, the conditional core damage frequency given the onset of a transient is calculated to be 6.1×10^{-6} events per year. This value should be interpreted in light of the failure to scram probability of 1×10^{-5} events per year. In other words, given the occurrence of an ATWS, the likelihood of a core damage event is about 6 out of 10.

As a result of this study, the following areas were identified to contain large uncertainties which could have significant impacts on core damage frequency. The first area affects directly the true core damage frequency whereas the remaining two only affect the modeling analysis of the core damage frequency.

1) Control of Water Level

The BWR emergency procedure guidelines suggest that the reactor water level be lowered to the top of active fuel; this action reduces reactor power to a minimum level possible, thus slowing down the heatup of the suppression pool. Such an action also directly results in MSIV closure, and in the initiation of the automatic depressurization system unless inhibited by operator action; both system responses provide competing core damage risks.

2) Suppression Pool Temperature Limit

In this analysis, the suppression pool temperature limit is assumed to be 240°F. This is in part based on some analysis performed by the BWR owners group(4). A realistic assessment of the pool temperature limit would allow a more reasonable estimate of the time available to the operator to perform his functions.

3) Time Available for SLC Manual Actuation

Since the failure rate of an operator to perform any task is high during the initial time period of the ATWS event, failure to initiate SLC injection is dominated by human error. The determination of the length of time allowed for operator action, and hence human failure rate, is sensitive to the mixing time of boron in the lower plenum and to the time at which the suppression pool temperature exceeds its limits.

In summary, this study evaluated the total core damage contribution due to ATWS events for an earlier vintage BWR/4. A realistic calculation was performed for a plant with a particular ATWS prevention and mitigtion configuration and with some of the ATWS rule modifications implemented. Results are compared with the ATWS task force findings; three areas have been identified which could potentially have significant impact upon the ATWS core damage frequency contribution.

References

1. Federal Register, Vol. 49, No. 124, June 26, 1984.

2. Emergency Procedure Guidelines, BWR 1-6, NEDO-24939, Rev. 2, 1982.

3. Anavim, E. et al., "A Review of Transient Initiator Frequencies of a BWR PRA", Proceedings of International Meeting on Probabilistic Safety Methods and Applications, San Francisco, February 1985.

4. Knuth (KMC) to Graves (NRC), "Supplement ATWS Evaluations," letter dated December 2, 1982.