AN OVERVIEW OF BWR SEVERE ACCIDENT SEQUENCE ANALYSES AT OAK RIDGE NATIONAL LABORATORY*

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ABSTRACT

Since its inception in October 1980, the Severe Accident Sequence Analysis (SASA) program at Oak Ridge National Laboratory (ORNL) has completed four studies including Station Blackout, Scram Discharge Volume Break, Loss of Decay Heat Removal, and Loss of Injection accident sequences for the Browns Ferry Nuclear Plant. The accident analyses incorporated in a SASA study provide much greater detail than that practically achievable in a Probabilistic Risk Assessment (PRA). When applied to the candidate dominant accident sequences identified by a PRA, the detailed SASA results determine if factors neglected by the PRA would have a significant effect on the order of dominant sequences. Ongoing SASA work at ORNL involves the analysis of Anticipated Transients Without Scram (ATWS) sequences for Browns Ferry.

SUMMARY

The objective of the Severe Accident Sequence Analysis (SASA) Program* at Oak Ridge National Laboratory (ORNL) is to perform detailed BWR accident analysis for candidate dominant sequences previously identified by the application of probabilistic risk assessment (PRA) methodology. The function of a PRA is to attempt to consider all possible accident sequences at a nuclear plant using event tree and fault tree techniques for the purpose of identifying the more probable, or dominant, sequences. The SASA approach, on the other hand, is to examine a particular category of accident sequences in much greater depth than would be possible in a PRA study.

The purpose of the ORNL SASA studies is to pre-determine the course of each of a series of severe accidents so as to establish the timing and the sequence of events; this information would be of use in the unlikely case that one of these accidents might actually occur. These studies also produce recommendations concerning the implementation of better system design and better emergency operating instructions and operator training to further decrease the probability of such an event. Each study includes an accident sequence analysis to determine the probable sequence of events and a fission product transport analysis.

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Almost all of the U.S. BWRs in operation today have containments of the General Electric Company (GE) Mark I design. Accordingly, all ORNL SASA studies to date have been performed on a representative plant of this design, specifically, Unit 1 of the Tennessee Valley Authority's Browns Ferry Nuclear Plant located near Athens, Alabama. The Tennessee Valley Authority has cooperated fully with these studies and has provided invaluable assistance.

The first accident study was Station Blackout at Browns Ferry with the accident sequence analysis (NUREG/CR-2182, Vol. 1) published in November 1981, and the fission product transport analysis (NUREG/CR-2182, Vol. 2) published in August 1982. This study demonstrated the importance of the condensate storage tank in BWR accident sequences and indicated that the small BWR Mark I containment might fail by overtemperature before overpressure in some accident sequences. The sequence analysis shows that a significant postponement of core uncovery can be gained by reactor vessel depressurization even though the high-pressure injection systems are used throughout the sequence. The existing plant was found to be viable under station blackout conditions for as long as battery power remained available (about six hours).

The second accident study concerns a postulated break in the scram discharge volume (SDV) immediately following a reactor scram which cannot be reset. This is in effect a small-break LOCA outside containment. The results of the accident sequence analysis (NUREG/CR-2672, Vol. 1) were published in November 1982 with the fission product transport analysis (NUREG/CR-2672, Vol. 2) following in July 1983. This potential accident was first identified by the NRC Office for Analysis

and Evaluation of Operational Data (AEOD) during their study of the partial failure-to-scram at Browns Ferry Unit 3 in July 1981. This accident sequence includes an almost total fission product release bypass of the pressure suppression pool.

The detailed SASA study of the SDV break accident sequence shows that ample protection against this accident is afforded by the existing plant design. There are certain actions that the operator should take to mitigate the effects of the accident which are identified in the study. One of the most significant findings was the effect that the Reactor Building fire protection system sprays would have in reducing the fission product release. These sprays are automatically initiated upon high temperature in the Reactor Building and have no automatic termination.

The third and fourth accident sequence studies completed at ORNL are the dominant Loss of Decay Heat Removal (TW) and Loss of Injection (TQUV) accident sequences identified by almost every BWR PRA. Individual papers concerning these studies are presented elsewhere at this conference.

Current SASA program efforts at ORNL are dedicated to the study of Anticipated Transients Without Scram (ATWS) at Browns Ferry. This is a cooperative effort between the SASA teams at ORNL and at the Idaho National Engineering Laboratory (INEL). The ORNL effort involves accident sequence analyses, human factors analyses, and fission product transport analyses and includes liaison with TVA and GE engineering personnel to ensure the adequacy of plant representation. The INEL

effort, with support from Brookhaven National Laboratory, provides state-of-the-art modeling of the response of the core to the changing water level and other conditions within the reactor vessel during the ATWS accident sequence.

Accident sequence analyses conducted by the SASA program at ORNL have provided detailed information concerning the progression of potential severe accidents for the BWR plant design most in use today. The SASA studies show that several plant systems not normally considered by PRAs in fact play an important role in determining the course of the accident. Additional studies are planned for the more modern plant designs.