PROJECT TITLE: Severe Accident Sequence Analysis (SASA)

PROJECT MANAGER: S. A. Hodge

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Major work completed during July includes the final report for the BWR pressure suppression pool thermal mixing study and the conversion of BWR-LACP to its Fortran version BWR-LTAS with the provision of a tape of the initial version to SNL (SASA) for their checkout and use. Effort continues toward the completion of a user's guide and in the optimization of the input and output routines. Other work in progress involves the incorporation of final modifications to MARCH-BWR in preparation for the degraded core calculations for the ATWS accident sequence, preparation for the fission product transport calculations, and checkout and testing of the CORCON MOD 2 code.

The personnel contributing to the SASA effort at ORNL are divided into three working groups. The individual group reports for progress during July are presented below with a brief initial statement of the purpose of each group.

Group I: (R. M. Harrington) Determines and analyzes the events of the accident sequence that would occur prior to core uncovery, using the ORNL-developed simulation program BWR-LTAS to study the plant response to operator actions.

A significant milestone in the conversion of the CSMP-based BWR-LACP code to its Fortran version BWR-LTAS (Boiling Water Reactor — Long-Term Accident Simulation) has been completed. The first stand-alone Fortran version of the entire code was successfully compiled and executed during July using the ORNL Fortran-77 compiler and a tape of this initial version has been provided to the SASA program at Sandia. The remaining effort involves improvements to the BWR-LTAS input and output capability and the method of internal data manipulation.

Drafts of the previously unfinished chapters of the BWR-LTAS user's guide were completed during July and are being forwarded to SNL.

First steps have been taken toward beginning the sixth SASA study based on the Browns Ferry Nuclear Plant. The study will involve a total loss of plant control air with the initiating events based upon information assembled by TVA in the course of their ongoing probabilistic risk assessment (PRA).

Group II: (L. J. Ott) Determines and analyzes the events of the accident sequence that would occur following core uncovery, including core melt and containment failure.

MARCH Modifications for the In-Vessel Phase of the Browns Ferry ATWS Study (L. J. Ott) Action to adapt the ZRWATR routine (developed by Dr. Mike Manahan at BCL) for use with the improved BWR core models employed in MARCH-BWR has been completed. The ZRWATR routine is believed to be the best available calculational methodology for determination of the zirconium-water reaction rate under accident conditions.

An improved heat balance algorithm for calculation of the steam/hydrogen mixture temperature has been developed and incorporated into MARCH-BWR.

The mathematical development of separate models for the control blade stainless steel sheaths and the B_4C powder is in progress and coding of the models is underway.

Implementation of MARCH 2.0 at ORNL (C. R. Hyman, J. J. Robinson) Because not all of the ORNL-BWR models were included in MARCH 2.0, effort is continuing in the incorporation of these models into the SNL code MARCON (essentially MARCH 2.0 with the INTER package replaced by CORCON Mod 2). During July, work has been completed for the incorporation of ORNL models for BWR channel boxes and control blades into subroutine AXIALC. ORNL models for these features are similar to those extant in MARCH 2.0 with the important exceptions that (1) ORNL steam/hydrogen properties are used with AXIALC; (2) use is made of ORNL's heat transfer correlation package (HBOILX); and (3) metal/water reaction in the two-phase mixture region of the core is calculated if the fuel rod surfaces are determined to be undergoing film boiling.

Implementation of CORCON MOD 2 (C. R. Hyman, J. J. Robinson) Efforts to make the stand-alone version of CORCON MOD 2 operational at ORNL have been completed. A sample problem was successfully executed during July and the results compared to those provided by Randy Cole of SNL. As expected, the differences in precision between ORNL's IBM computer and SNL's computers cause the output quantities to not agree exactly, but the computed quantities are within tolerance when the calculations are performed at ORNL using double-precision.

Investigation of Radiant and Volumetric Heat Sources in the BWR Steam Separators and Standpipes (J. C. Conklin, Dissertation) Formulation and scaling of the governing conservation equations of mass, momentum, and energy have continued. The value of the heat source term in the energy equation is an important scaling parameter, as is the transit time for flow through the standpipe. Accordingly, a preliminary list of appropriate heat-generating fission products and a preliminary range of mass flows expected to be in the standpipe under certain severe conditions is being prepared. Additionally, computer coding for computation of the thermophysical properties of steam and hydrogen has been obtained.

BWR Severe Accident Model Development at RPI (M. Podowski et al)

1. MELRPI Code Development. The decay heat algorithm has been modified to include the decay of Actinides in accordance with ANSI/ANS standard 5.1 of 1979. The structure of the input file has been modified to eliminate the requirement for an intermediate step and the use of the restart option when problems involving the use of ECCS systems are calculated.

2. Modeling of Lower Plenum/Head Failure. The modeling of the basic components and phenomena is contained in subroutine LPFRPI, which is undergoing extensive testing. Results to date indicate that substantial modifications will have to be made before this subroutine can be merged with MELRPI.

Group III: (R. P. Wichner) Determines the magnitude and timing of fission product release from the fuel, establishes the various pathways for fission product release to the atmosphere, and performs the fission product transport calculations for each Severe Accident sequence analyzed.

Fission Product Transport Computation (C. F. Weber) ORIGEN2 calculations of nuclide inventories in the Browns Ferry Cycle 6 core, based upon information provided by TVA, have been completed. Work is now underway to fold data from the different fuel reloads to obtain a total core inventory for each nuclide. In addition, inventories in each of the 100 core nodes (10 axial levels, 10 radial regions) will be estimated using the axial and radial power factors supplied by TVA. Preliminary estimates based on the highest burnup fuel assemblies have indicated that several new nuclides should be included in the ATWS study (for which fission product releases occur within a shorter period after reactor shutdown than in any previous study). A more rigorous examination will be based on contributions to decay heat, since these are good indications of the total radiation (β^-, γ, etc.) produced by different nuclides. Current plans are to consider only those isotopes contributing at least 1% of the total decay heat of their elemental family.

Analysis of the Standby Gas Treatment System (SGTS) (S. D. Clinton) Three HEPA filters (MSA-462909) purchased from the Mine Safety Appliances Company have been delivered to the New Mexico State University filter plugging test facility. Filter loading tests at ambient temperature with water spray and latex aerosol will begin in August.

A Savannah River Laboratory document (DP-812) published in 1962 which describes tests of moisture separators and particulate filters in reactor containment was reviewed during July. The filtration system, which includes activated carbon, was designed to remove the radioactive fission products that might be released during a major reactor accident. In a system operation similar to that of the secondary containment at Browns Ferry, leakage from the reactor building is prevented by throttling the supply air and keeping the exhaust dampers wide open so that

the exhaust fans maintain a subatmospheric pressure in the building. Continuous operation of the exhaust fans during an accident is essential to prevent excessive filter temperatures due to the decay of fission products trapped on the filters (the report suggests a minimum flow rate of 300 scfm/filter). Emergency facilities are also provided to close the supply air dampers if the building internal pressure increases above atmospheric.

Absorption of Gaseous Iodine by Water Droplets (M. F. Albert, Thesis Work) A version of the model for predicting the absorption of gaseous iodine by a water spray has been revised to include the removal of iodine by the water which collects on the building walls. The removal is modeled as a wetted-wall column. The assumptions for this wall-spray model are the same as for the spray model with the addition of: (1) water enters the wall only at the top; (2) water exits the wall only at the bottom; (3) the flow rate of the water on the walls remains constant. The results of the wall-spray model (using an assumed 5% of the spray flow onto the walls) show that the increase in the removal rate of iodine is less than 5%.

A new numerical integration routine is being incorporated into all of the models (kinetic, drop, spray, wall-spray). This new routine is a systems library program, LSODE, which appears to be very efficient and more precise than the previously used numerical technique.

MEETINGS AND TRIPS:

L. J. Ott attended the SCDAP workshop meeting at INEL on July 23 and 24.

R. M. Harrington and S. A. Hodge visited TVA headquarters at Knoxville on July 25 to discuss the selection of the next Browns Ferry accident sequences to be studied by the ORNL SASA team.

REPORTS, PAPERS AND PUBLICATIONS:

The final report "ATWS at Browns Ferry Unit One — Accident Sequence Analysis," NUREG/CR-3470, ORNL/TM-8902, was distributed on July 27.

PROBLEM AREAS:

None.