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PROJECT TITLE: Severe Accident Sequence Analysis (SASA)

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Major work in progress during April involves continuing modifications and improvements to MARCH-BWR in preparation for the degraded core calculations for the ATWS sequence, conversion of BWR-LACP to Fortran and preparation of a users' guide, preparation for the fission product transport calculations for the ATWS sequence, and work to incorporate revisions in response to the peer review comments into the ATWS accident sequence analysis report and the Loss of Decay Heat Removal fission product transport analysis report. Unit 1 of the Browns Ferry Nuclear Plant serves as the model plant for all studies.

The personnel contributing to the SASA effort at ORNL are divided into three working groups. The individual group reports for progress during April 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-LACP to study the plant response to operator actions.

Activities during April involved tasks necessary for the completion of the ATWS accident sequence investigation and for conversion of the BWR-LACP code from the presently employed CSMP simulation language into Fortran and preparation of a users' guide.

The primary containment modeling chapter of the BWR-LACP users' guide has been completed. Programming of a Fortran subroutine to calculate high pressure vessel makeup is in progress. The Fortran version of BWR-LACP will be named BWR-LTAS (Boiling Water Reactor—Long Term Accident Simulation) to avoid the connotation that the code is applicable only to loss of AC power accidents.

All anticipated peer review comments on the draft ATWS report have been received and revisions to the draft have been incorporated as appropriate. Several BWR-LACP runs were made to see what would happen if the only operator action following an MSIV closure-initiated ATWS were to initiate boration via the SLC system. The results, which show that reactor shutdown would preclude containment failure, are being incorporated into the ATWS report.

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 provide separate models for fuel, gap and cladding in the BWR core models is continuing.

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 underway to incorporate the ORNL-BWR models into an SNL version of MARCH 2.0. During April, an updated version of MARCH 2.0 was obtained from the Sandia National Laboratory. It has been successfully compiled and a debug sample input deck has been prepared. Efforts are underway to complete execution of the program. As stated last month, several existing subroutines have been identified which have deficiencies with regard to BWR applications. These subroutines will either be modified or replaced with ones developed at ORNL for the purpose of performing ATWS analysis.

Investigation of Radiant and Volumetric Heat Souces 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. There are two time periods of interest in developing scaling factors for the governing conservation equations: the flow transit time through the standpipe and the radioactive decay time of the entrained fission products. If the heat source strength of the fission products is significantly dependent upon the transit time as well as position in the standpipe, an additional convective term is introduced into the energy conservation equation. This heat source term must then be mathematically considered as nonlinear. However, if the heat source strength is relatively independent of the position or transit time of the flow in the standpipe, the heat source term will then be considered as nonhomogenious, as is commonly done for the energy conservation equation with volumetric heat sources. The heat source strengths and transit times of the Beta emitting fission products entrained in the flow through the steam separators and standpipes will identify the appropriate analysis considerations.

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

1. MELRPI Code Development (R. Taleyarkhan) The MELRPI code was recently modified to include a separate model for control blade melting and relocation. This includes a second moving grid, accounting for motion of various control blade sections upon relocation. The former/first grid tracks motion of the channel boxes and fuel, respectively. The efforts initiated in the past month to model the molten mass release from the channel box and fuel materials, using the slug model, have resulted in better modeling of this process. It should be recalled that previously these materials upon release from a debris node were assumed to fall directly into the lower structures. This gave rise to a lower

hydrogen production rate. Preliminary tests using the improved model indicate a higher hydrogen production rate. Work is currently underway to rigorously test the new model.

2. Implementation of the Lower Head Failure Model (R. Taleyarkhan) A mathematical model for propagation of debris material from the grid plate onto the control rod guide tubes, the subsequent thermal attack of various structures, and the ablation and ejection of molten debris from the reactor vessel has been formulated. A digital computer subroutine LPFRPI has been written for numerical implementation of the model. Implementation is being performed in three stages. In the first stage, which has been completed, along with preliminary test runs and debugging, LPFRPI evaluates relocation of molten debris along the guide tubes and the subsequent heatup/melting of these structures. In the second stage, calculations will be made to evaluate re-positioning of various sections of the guide tubes upon melting; work is now underway and preliminary debugging is being performed. Finally, in Stage 3, the evaluation of melt ejection and ablation of the openings in the reactor vessel bottom head will be calculated.

3. Development of the ECCRPI Subroutine As explained in the previous monthly report, ECCRPI has been implemented into MELRPI. Recently, some additional test runs have been made to verify the models used. A technical paper, presenting the ECCRPI modeling and sample results, has been accepted for publication in the ANS Proceedings on Nuclear Thermal-Hydraulics.

Presently, work is being finished to systematically document ECCRPI as part of the improved version of 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) Minor modifications to the fission product transport code have added greater accuracy to the calculations for (1) I transport and retention in containment volumes, and (2) noble gas solubility in water volumes. The actual inventories have changed only slightly from those reported in the draft report for the Loss of Decay Heat Removal accident sequence. Similar revisions are underway for calculations in the reactor vessel and for the release of nuclides from fuel.

Preparations have continued for obtaining new initial isotope inventories (using ORIGEN results) in anticipation of the ATWS sequence calculations. Actual ORIGEN calculations should begin in May and be completed by mid-June, pending the receipt of necessary input information from TVA.

Tellurium Transport Model (R. P. Wichner) The general features of Te behavior under LWR accident conditions were reviewed during April. Subsequently, a series of behavior models have been proposed to cover the following conditions: (1) release rate from fuel elements, (2) solubility in water, (3) dominant chemical forms in the reactor vessel and primary containment, (4) deposition rate and revaporization rate from steel surfaces, (5) interaction with aerosol particles, (6) release rate from drywell rubble, (7) deposition and revaporization from drywell surfaces, and (8) transport in the reactor building.

Chemical Change Effects (E. C. Beahm) The SOLGASMIX program modified at ORNL is now available to calculate equilibria involving reactions of cesium and iodine with material in the reactor vessel. Also, a model for iodine transport and chemistry developed in the Federal Republic of Germany is being tested to determine the sensitivity of the iodine chemical forms in containment to the ratios of CsI to I_2 leaving the reactor vessel.

Analysis of the Standby Gas Treatment System (SGTS) (S. D. Clinton) The Standby Gas Treatment System (SGTS) is of prime importance in severe accident sequences since the system is the final secondary containment barrier to the atmosphere. During the next reactor accident sequence study, the loading efficiencies and potential failure modes of the HEPA filters and charcoal bed will be critically examined in the projected reactor building environment.

Absorption of Gaseous Iodine by Water Droplets (M. F. Albert, Thesis Work) The spray model for the absorption of gaseous iodine by water droplets has been more extensively compared to experimental data. The assumptions for the spray model are: (1) well mixed drops, (2) the drops remain spherical, (3) all drops are the same size, (4) the drops always fall at their terminal velocity, (5) no interaction between drops, and (6) no heat transfer occurs.

The spray model has been compared against experimental data which reports the amount of iodine in the liquid phase. The spray model fairly consistently predicts a removal rate of liquid from the gas phase that is approximately one-third the observed rate. This is partially due to the simplicity of the model, which only predicts the removal of iodine by drops suspended in a gas and does not take into account the enhanced mass transfer which occurs during drop formation, the removal of iodine by the spray solution on the walls, or the removal by the pool of previously sprayed solution in the bottom of the containment. These other removal mechanisms are likely to be significant. Calculations are presently being done to account for the removal of iodine due to the spray solution on the walls of the vessel in order to improve the comparison of calculated results with test conditions.

MEETINGS AND TRIPS:

S. A. Hodge, R. P. Wichner, M. F. Albert, E. C. Beahm, S. D. Clinton, C. F. Weber, and A. L. Wright met with Bill Mims, Stan Chow, and Young In of TVA at ORNL on April 18 to discuss information exchange in support of the forthcoming SASA studies of fission product transport for accident sequences at Browns Ferry.

S. A. Hodge visited the University of Tennessee on April 23 to attend the dissertation defense presentation by D. H. Cook covering his SASA program pressure suppression pool modeling project.

REPORTS, PAPERS AND PUBLICATIONS:

None.

PROBLEM AREAS:

None.