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PROJECT TITLE: Severe Accident Sequence Analysis (SASA)

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Major work in progress during June includes completion of the final report for the fission product transport analysis of the Loss of Decay Heat Removal accident sequence and work to incorporate revisions in response to the peer review comments for the BWR pressure suppression pool thermal mixing study. Effort continues in the conversion of BWR-LACP to Fortran with preparation of a user's guide and toward the incorporation of modifications and improvements to MARCH-BWR in preparation for the degraded core calculations for the ATWS accident sequence. Preparations are also in progress for the fission product transport calculations for the ATWS sequence. 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 June 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.

Conversion of the CSMP-based BWR-LACP code to its Fortran version BWR-LTAS (Boiling Water Reactor — Long-Term Accident Simulation) is nearing completion. Fortran programs for most of the primary containment thermohydraulics were successfully tested during June. A standalone Fortran version of the reactor vessel thermohydraulics was compiled on the ORNL Fortran-77 compiler (the "V" compiler) and, after a debugging effort, successfully executed. All portions of converted coding are being compiled on the Fortran-77 compiler as they are completed.

Several additional chapters of the BWR-LTAS user's guide were completed during June and a preliminary draft was sent to Lanny Smith, who is responsible for the installation and operation of BWR-LTAS at Sandia. It is expected that a tape of the fully converted code (Version 1) will be forwarded to Sandia during July.

A 90-min training presentation concerning important aspects of BWR reactor plant construction and containment and the results of ORNL SASA Program BWR severe accident studies was delivered at three training seminars for personnel of the NRC Office of Inspection and Enforcement during June.

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 has been completed. Coding reflecting these model improvements has been implemented and test cases (primarily repeat calculations for the Loss of Decay Heat Removal accident sequence) have been run.

During testing it was discovered that very small time steps (<1 sec) were needed for numerical stability using the original MARCH solution technique, resulting in large computational time requirements. Consequently, a new solution technique (fully implicit) for the fuel, gap and cladding models was implemented. As a result, time steps and computational times for the new models are approximately the same as for the original models with the fuel and cladding treated as a lumped mass.

During testing of the models it became apparent that the metal/water reaction could accelerate the temperature rise of the cladding since the transfer of energy into the fuel (or to the coolant) was not sufficient to offset the energy generated by the metal/water reaction. The code (at this time) employs the reaction kinetics used in versions 1.0–1.7 of MARCH; therefore, it seems prudent to use the best available kinetics (available in MARCH 2.0). Efforts are underway to adapt Dr. Manahan's (BCL) ZRWATR routine for use by the improved BWR core models.

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 June, work has focused on the following subroutines: BOIL, AXIALC, BOILEX, BOILPR, and BOILP2. These are being replaced or modified as necessary to implement the ORNL-BWR models.

A package was sent on June 13 to Eric Haskin at SNL which included (1) a tape containing the MARCON code with ORNL properties and PRIMP modifications, (2) an input data deck, and (3) a sample output. This interim package provides improved analytical capability in the calculation of BWR severe accidents, particularly for depressurization transients. Upon completion of the incorporation of the remaining ORNL-BWR models, another package will be transmitted.

On June 22, ORNL received a pre-release stand-alone version of CORCON-MOD2. Effort has begun to make this code operational at ORNL.

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

1. MELRPI Code Development. Several modifications and improvements of the MELRPI modeling were implemented into the main program during June; others are still being developed:

(a) The new model for molten material relocation, previously implemented into the modified SLUG subroutine, has been extensively tested. In this new approach, the relocations of stainless steel and zircaloy are treated separately. Because the temperatures of individual zircaloy structures (cladding and channel walls) are very close to each other, it was decided to accelerate calculations by applying the slug model to the total amount of molten zirc released in any radial zone, with the nodal mass of refrozen zirc for each structure being calculated proportionally to the initial molten mass fractions. This new model calculates both the nodal distribution of solid crust formed on the surfaces of control rods, fuel elements and canisters, and the amount of molten material leaving the core region.

(b) An improved rubble bed model has been developed in which rubble bed formation criteria and propagation phenomena are treated separately for the control blades and canisters. The approach is based on two independent moving grids, the old grid used for fuel, cladding and channel walls, and the new grid, developed for tracking the relocation of control blades. Implementation and testing of the new rubble bed model are underway.

2. Modeling of Lower Plenum/Head Failure. The modeling of all the basic components/phenomena has been completed. The overall lower plenum/head model has been coded as a computer subroutine, LPFRPI. The debugging and initial testing of LPFRPI is underway. Because of the complexity of the accident phenomena, and due to a high level of uncertainty involved in their modeling, extensive testing and model verification will be required before LPFRPI can be combined 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) During June three significant steps have been taken in the development of the fission product transport (FPT) code:

1. Data from TVA has been assembled to calculate (using the ORIGEN2 code) initial nuclide inventories for the cycle six core. Personnel from Chemical Technology Division are now working on actual running of ORIGEN2; and the base case setup should be nearly complete by the end of the month.

2. Preliminary steps have been taken to include the basic computational features of the SOLGASMIX code as a subroutine in the FPT code which would calculate the I-Cs species distribution in the primary system.

3. Models have been included for the transport and retention of tellurium in containment and reactor building control volumes.

Chemical Change Effects (E. C. Beahm) The SOLGASMIX computer program is being modified to permit rapid calculation of equilibria between fission products, steam, hydrogen, and reactor vessel materials. The system employs 26 chemical species representing forms of cesium, iodine, boron, carbon, hydrogen, and oxygen expected under accident conditions. Free energies of formation for these species have been fitted from 600 to 1800 K to an equation of the type:

$$\Delta G_f = a + bT$$

where

ΔG_f = free energy of formation,

T = temperature, K.

Analysis of the Standby Gas Treatment System (SGTS) (S. D. Clinton) Three HEPA filters (MSA-462909) have been purchased from the Mine Safety Appliances Company for testing and evaluation at the New Mexico State University filter plugging test facility. These filters, manufactured in accordance with the requirements of Military Specification MIL-F-51068E, have cold-rolled steel frames (cadmium plated) and aluminum separators. Ambient temperature tests sponsored by the SASA program to determine the aerosol loading capacity and potential failure mode of the filter media should be initiated during July. Proposed tests at 180 and 220 F will require procurement and installation of a gas-fired heater (by NRR-sponsored testing programs) and will be delayed until additional funding (about $10,000) can be approved. A funding decision may be reached at the 18th Air Cleaning Conference scheduled for Baltimore, Maryland, on August 13–16, 1984.

MEETINGS AND TRIPS:

S. A. Hodge attended the 2nd Workshop on Containment Integrity at Washington, DC on June 13, 14, and 15 and served as co-chairman for one of the sessions.

S. A. Hodge delivered training lectures concerning BWR plant response under severe accident conditions to NRC Office of Inspection and Enforcement personnel at Bethesda, Maryland, on June 19 and 21. R. M. Harrington delivered the same lecture to I&E personnel at Richland, Washington, on June 26.

R. M. Harrington, S. A. Hodge, C. R. Hyman, L. J. Ott, and R. P. Wichner attended the SASA program review meeting at Silver Spring, Maryland on June 19 (PM) and June 20 (AM). Presentations were made by L. J. Ott and R. P. Wichner.

REPORTS, PAPERS AND PUBLICATIONS:

The final version of the report "Noble Gas, Iodine, and Cesium Transport in a Postulated Loss of Decay Heat Removal Accident at Browns Ferry," NUREG/CR-3617, was submitted for makeup, reproduction, and distribution on June 26.

The subcontractor report "The Modeling of BWR Core Meltdown Accidents — For Application in the MELPRI.MOD 2 Computer Code" by B. R. Koh, S. H. Kim, R. P. Taleyarkhan, M. Z. Podowski, and R. T. Lahey, Jr., at RPI, was distributed for peer review on June 27. Comments are requested by August 10.

PROBLEM AREAS:

None.