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Albuquerque, New Mexico 87115

July 10, 1979

Mr. Richard Sherry
U. S. Nuclear Regulatory Commission
Fuel Behavior Research Branch
Division of Reactor Safety Research
Mail Stop 1130 SS
Washington, D. C. 20555

Dear Rick,

Enclosed are status reports for the month of June for the core melt and separate effects programs.

I. STEAM EXPLOSIONS

The small-scale experiments are continuing in two areas. Characterization tests of the bridgewire trigger have indicated three areas of work that must be addressed before further theory-checking experiments begin (e.g., high ambient pressure tests): (1) the Lithium-Niobate pressure transducers will be recalibrated to assure minimum error in pressure measurements; (2) the peak pressures produced by the bridgewire show some scatter ($\pm$ 10%), thus some statistical range of expected peak pressures at various distances is planned; (3) other more well-defined trigger mechanisms are being investigated (e.g., magnetic flyer plate). Secondly, successful melting of pure ($\sim$ 1800 K) and ZrO_2 ($\sim$ 3500 K) using levitation and levitation-combustion melting techniques has been demonstrated. Attempts to trigger explosions with bridgewires have failed. The reason for this appears to be generation of noncondensible gases; hydrogen from oxidation of the iron, and hydrogen and oxygen due to water disassociation near the hot ZrO_2. The implication is that this is the reason for the observed explosion cut off at low oxygen concentrations.

The construction of the fully instrumented test facility is proceeding. Contracts have been placed for the interaction chamber and site modifications. Material for the

chamber has been ordered and site construction has begun. Experimental work has started on furnace optimization and melts of iron and iron-oxide are being prepared in preparation for melt-dropping experiments.

Analysis of Nelson's small-scale experiments is continuing. Rough calculations based on hydrogen production due to metal oxidation indicates that the volume of gas (possibly hydrogen) seen around the iron melt in the high speed movies corresponds well to that which would be evolved from iron oxidation. A simple model of the propagation of the explosion in Nelson's iron-oxide test indicates the whole heat transfer process would occur in a matter of 50 μs or less. The main fragmentation mechanism is due to local liquid-liquid contact and the coolant pressurization which is associated with it.

Containment failure analysis is continuing in the area of structural modeling of the coolant vapor expansion. A one-dimensional wave propagation model has been developed to observe the short-time behavior of pressure waves being transmitted through the steel vessel walls.

The HONDO code is expected to be used to extend the calculation and to aid in viewing the longer time impact of the water slug in the vessel heat.

II. CORE-CONCRETE INTERACTIONS

A. CORCON Development

Progress in the development of CORCON is reported herein for the five-week period from May 28 through June 30, 1979. Reference is made to "CORCON Development Schedule" from J. F. Muir's letter to Richard Sherry, FBRB, NRC, dated May 24, 1979. Progress is reported below for those items having estimated completion dates of 6/15 and 6/30/79. It is to be noted that not all of the tasks scheduled for completion by June 30th were completed. Furthermore, the bulk of efforts during the past week and next week have and will be devoted to preparation for the forthcoming trip to Germany, primarily for the NRC/FRG Information Exchange Meeting. It appears likely, therefore, that the estimated completion dates for the items listed on p. 3 of the referenced letter should be slipped by one or two weeks, i.e., from 7/31 and 8/31 to approximately 8/15 and 9/15,

respectively. The letter raises the possibility of a slippage of the milestone "Complete Initial Version of Improved INTER Model (CORCON)," No. 39300 in Buff Book, Level B, by one to two weeks.

Progress made during the report period is reported for the following items:

1. Restructuring of CASC model in CORCON: Programming has been completed and the resulting version of CORCON checked out on a sample problem.

2. Procedures for handling three melt layers plus a coolant layer: Separate subroutines for determining layer orientation within the molten pool; layer geometries (i.e., layer volumes and depths, and layer interface and pool surface locations, within the cavity); pressure as a function of vertical distance from the pool surface; and layer properties at each point on the pool periphery, from mixture properties to be provided (i.e., a property-switching procedure), have been coded, programmed and partially checked out. Unfortunately, these improvements necessitated fairly extensive modification of the logic in the melt-property subroutine, a routine for handling the properties of the metallic and oxidic mixtures within the melt, to properly account for layer formation, switching and combining (e.g., the combination of two oxidic layers into a single layer). This activity consumed time and effort originally scheduled for other tasks.

3. Mass fluxes entering and leaving melt: A procedure for computing the total flow (quantity per unit time) of either species, total mass, or energy across the melt/concrete interface has been developed. Fluxes of a given parameter (quantity per unit area per unit time) provided at each pool periphery point are integrated numerically over the periphery surface area, beginning at the centerline point at the pool bottom, to yield the total flow into or out of the pool up to each periphery point. Coding of this procedure has been initiated.

4. Void fraction/level swell model: Methods have been developed for determining bubble size (as a function of gas injection rate), bubble velocity (as a function of bubble size and fluid properties), local void fraction (as a function of vertical distance) and the level swell of each pool layer, and the entire pool, due to the presence of the gas phase. Coding of these models has been intiated.

5. Melt/gas chemical reaction model: A preliminary working version of this model, programmed in HP language, was received from D. Powers on June 15, 1979, along with results for sample problem calculations. The program has been translated into standard Fortran and brought up on the CDC 7600. It has been checked out on one of the sample problems provided, modified to reduce central processor time by about a factor of two, and rewritten into subroutine format. The code models the chemical reactions using a first-order, steepest descent free energy minimization technique. It provides product composition, heat of reaction and gas phase density and heat capacity.

6. Mass trasport and conservation procedures: No progress other than that described in Item 3 above.

B. Experimental Progress

A chemical equilibrium subroutine for the computer model, CORCON, was developed during the report period. This subroutine treats chemical reactions of gases with constituents of the molten core materials. It yields both equilibrium chemical compositions and heat effects associated with attaining these compositions. The subroutine has been tested by computing the literature problems:

(1) Gas phase pyrolysis of propane at 2200 K and 40 atmospheres.

(2) Carbon reduction of iron oxide in the presence of limestone.

In all cases, results from the subroutine were in very close agreement with published results.

Details of the model and test results will be published in the forthcoming quarterly report.

Two tests in the BURN series were completed during the report period. These tests, BURN 5 and BURN 6, exposed concrete to core debris heated inductively at a rate about one-half that used in tests BURN 2 and BURN 3. Results of the tests will be used to compile power vs. erosion rate curves for both basaltic and limestone concretes. Data reduction for the large-scale melt/concrete interactions tests is largely complete. Other

activities have delayed assembly of the data into a comprehensible format. These delays are not now expected to impact release of the data report in September 1979.

A crucible for the standard COIL test to be used along with a German test to compare computer models of melt/concrete interactions has been fabricated. The crucible has a 45 point thermocouple array for temperature and erosion rate measurements and a 3-station moisture migration sensor. The crucible will be used in a test in September 1979. Data necessary for model predictions of test results will be made available at that time.

Activities planned for July are: (1) test the chemical equilibrium subroutine with core meltdown problems, (2) conclude the BURN series tests, and (3) assemble data from previous experiments into report formats.

III. SEPARATE EFFECTS TESTS FOR TRAP CODE DEVELOPMENT

A series of meetings involving the principal investigators at Sandia Laboratories was held to initiate activities on the program. The advantages of a static system versus a flowing system for steam/vapor phase interaction experiments were identified, and a "quasi-static" system incorporating the best features of each was sketched out. The relative advantages of laser spectroscopy over mass spectroscopy for real-time identification of fission product compounds were also identified, and the means for incorporting laser spectroscopy into the experimental setup were discussed.

A literature search was begun for purposes of gathering data relative to the thermodynamic properties of the fission product compounds, the characteristic Raman spectra (as well as infrared and vibrational spectra), and any pertinent data relevant to vapor pressures and chemical kinetics. Use of existing computer codes to predict the equilibrium concentrations of fission product compounds in steam was explored.

A proposal was received from the New Mexico Institute of Mining and Technology for studies of the vapor pressure of CsOH using transpiration and effusion cell techniques. Contractural arrangements are being pursued.

Activities in July will include: (1) continuation of the literature search and use of analytical methods, (2) parameter estimation and preliminary design of the apparatus to be constructed at Sandia Laboratories, (3) completion of contractual arrangements with New Mexico Tech, and (4) preparation of a program plan.

Sincerely,

Marshall

Marshall Berman, Supervisor
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