MAY 25 1994

NOTE TO: Farouk Eltawila, Chief
Accident Evaluation Branch
Division of Systems Research
Office of Nuclear Regulatory Research

FROM: Sud Basu
Accident Evaluation Branch
Division of Systems Research
Office of Nuclear Regulatory Research

SUBJECT: SUMMARY OF THE MEETING BETWEEN THE NRC AND THE IBRAE (RAS) AND RRC HELD ON MAY 9-13, 1994

Participants: S. Basu, Y. Chen, R. Wright, R. Lee, N. Grossman, A. Rubin, F. Eltawila, USNRC, and V. Strizhov, IBRAE (RAS) and E. Bassanski (RRC)

Several informal meetings took place between various members of the AEB staff and Dr. V. Strizhov (RAS) and Dr. E. Bassanski (KI) during the week of May 9-13, 1994, following the CSARP meeting the previous week. The purpose of this note is to keep you informed of the topics discussed in the meeting, the status of various activities undertaken by the Russian Academy of Sciences (RAS) under Addenda 3 and 4 of the Implementing Arrangement on Severe Accident Research between NRC and Russian Research Center (RRC), and the proposed future work under the Arrangement.

In the area of model development/improvement for SCDAP/RELAP5, a draft design report entitled "Modeling of the Pellet/Cladding/Steam Interactions in the Framework of the Oxygen Transport Theory" was delivered to NRC by IBRAE (RAS) on May 9, 1994, as a partial fulfillment to Task 1.1 (see Attachment A). The draft report will be independently reviewed by the NRC staff and its contractors. Design reports on other tasks (identified as Tasks 1.2, 1.3, and 1.4 in Attachment A) will be delivered to NRC according to the following schedule:

Task 1.2: Improvement of Candling Model - September 30, 1994
Task 1.3: Improvement of the Failure Criteria for Cladding - September 30, 1994
Task 1.4: Improvement of the Porous Bed Heat Conductivity Model - December 31, 1994

The tentative schedule for implementation of new models into SCDAP/RELAP5/MOD3.1 is as follows:

Starting Date: Autumn of 1994
Expected Completion Date: April 1995

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To become more familiar with SCDAP/RELAP5, IBRAE requested that one resident engineer be sent to INEL for a few weeks. In the near future, NRC will send a copy of the SCDAP/RELAP5 programmers' guide to IBRAE.

Assessment of the new/improved models will be performed after completion of the implementation work. Estimated completion time for the assessment work is September 1995.

In the area of CORCON-Mod3 model development and validation, IBRAE finalized the NUREG/IA-129 report entitled "An Assessment of the CORCON-Mod3 Code," incorporating NRC comments on the draft report. Note that the report contains only the thermal-hydraulic calculations. IBRAE is working on a second report that will include fission product release calculations. Preparation of this second report was held up because of several deficiencies discovered by IBRAE in the VANESA module of CORCON-Mod3. These deficiencies, some of which were identified by SNL and ERI as well in their independent assessments, led to incorrect predictions of fission product releases. IBRAE has been working on correcting these deficiencies. In particular, IBRAE is developing an oxide layer chemistry model to determine the non-equilibrium oxygen potential of the oxide phase both in the presence and in the absence of metals in the melt. IBRAE is also working on an improved molybdenum and ruthenium chemistry model.

Note that since the release of CORCON-Mod3 in February 1993, SNL has made a number of code modifications (mostly minor bug fixes but one or two major modifications in particular, one dealing with the interlayer mixing model instability) in the process of integrating CORCON-Mod3 into MELCOR and CONTAIN. Therefore, it has been agreed upon that IBRAE will obtain the most recent version of CORCON-Mod3, will implement the VANESA modifications into this version, and will perform fission product release calculations for the same set of experiments used in NUREG/IA-129. At the end of this exercise, IBRAE will prepare a draft NUREG report. The estimated completion date for the assessment exercise and the draft NUREG report is October 31, 1994. Note that the modifications to be implemented into CORCON-Mod3 by IBRAE during this time period will also include a model to provide liquidus temperature calculations consistent with the recently generated ANL test data. After completion of the VANESA assessment work with improved chemistry models, a follow-on work plan will be prepared to improve VANESA, if required.

In addition to the above, IBRAE has also completed the development of a hydrodynamics-based melt spreading model, and prepared a model design/implementation report. The report was delivered to NRC on May 9, 1994. The report will be reviewed by the NRC staff and by independent external reviewers prior to implementation of the model into the MELCOR/CORCON code.

IBRAE (RAS) and RRC requested that two persons (one each from the two organizations) involved in the MELCOR activity be sent to the upcoming MELCOR workshop. NRC will make all necessary arrangements.

The RASPLAV project was discussed during the meetings, mainly with respect to the melt pool thermal hydraulics modelling and problems and challenges associated with such an activity. The currently used code has been extended to treat crust freezing and its effect on the pool heat transfer as described in the CSARP paper. Several codes are being developed including a 3D code for the modelling of a slice geometry. In addition, special investigations are being conducted to include the Lorentz force effect along with buoyancy forces.

Preliminary studies were also performed with respect to the development of a scaling law to apply the experimental results to the reactor case. In addition, the initial investigation of one of the scenarios of core slump, with respect to jet interactions with the melt pool, was considered and presented at the CSARP meeting. Some future work was discussed, and the IBRAE proposals for 1995 work (Appendix A) were developed during the meeting.

Sud Basu
Accident Evaluation Branch
Division of Systems Research
Office of Nuclear Regulatory Research

Attachment:
As stated.

Distribution:
DSR Chron/AEB r/f
Basu/Basu r/f, Behbahani, Chen
Lee, Grossman, Wright, Rubin
Tinkler, Eltawila, King, Hodges

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OFFICE:	DSR/RES/AEB	AEB	AEB	AEB
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ATTACHMENT A

NSI Proposals for Extension of joint works with NRC

1. Improvement of fuel rod liquefaction, flow and solidification models for SCDAP/RELAP5 code.

Summary. This work is addressed to improve existing SCDAP/RELAP5 models dealing with the fuel rod liquefaction, flow, and solidification according to the Peer Review Committee's Recommendations. It is assumed that existing models which were developed at NSI will be used as a basic models for incorporation into SCDAP/RELAP5 code system.

Objectives

The specific objectives of the current work statement are as follows:

Provide code improvements by changing of the existing models for

(1) UO2/Zr/steam interaction
(2) Fuel rod liquefaction, flow and solidification in course interactions;
(3) Mechanical behavior of the cladding and
(4) Effective thermal conductivity in the porous bed.

Assess improved models against limited number of test data to demonstrate predictive capabilities of new models.

Before implementation procedure design report should be provided. The report shall contain: (1) objective of new model implementation, (2) detailed description of the model including phenomenological processes, main assumptions, (3) mathematical formalism, (4) justification for the models used, (5) data base supporting the model, (6) range of applicability and (7) proposed implementation plan.

1.1 Model of UO2/Zr/steam interaction

It is proposed that oxygen diffusion model will be used to calculate UO2/Zr/steam interactions. Usage of the diffusion equation allows to take into account different effects regarding to the phase transitions which could not be accounted in the frames of correlation approach. Proposed mathematical procedure leads to a great simplification of calculations, which become comparable (in computation time and memory consumption) with empirical correlation approach, used currently in the SCDAP code. The accuracy of these calculations is rather high a and comparable with more sophisticated and time consuming methods (i.e.PECLOX code).

Proposed working plan include:

(1) Development of the requirements to the implementation procedure (Interfaces, Connections and switches).

(2) Implementation of oxidation module and its testing in the frames of whole code;

Estimated Completion Date:
Estimated Level of Efforts:

1.2 Improvement of candling model

The basic simplified equations obtained from the set of hydrodynamics equations are assumed to be used to describe the droplet and rivulet flow of molten fractions including velocity and temperature regimes determination instead of gravity-driven annular ring relocation model currently used in the SCDAP/RELAP5 model.

Working Plan:

(1) Modifications of the existing models for SCDAP/RELAP5 code. Design Report will be provided.

(2) Incorporation of the candling model into SCDAP/RELAP5 code;

Estimated Completion Date:
Estimated Level of Efforts:

1.3 Improvement of the failure criteria of cladding

Proposed model treat mechanical behavior of the cladding including: (1) Ballooning (burst) of the cladding; (2) Breach formation by "flowering " mechanism due to the radial and azimuthal temperature gradients, observed in CORA-tests. Implementation of this model in the SCDAP/RELAP5 will allow to avoid the use of the parametric fuel rod oxide failure criteria that is user specified parameter.

Working Plan:

(1) Preparation of the Design Report will be provided.

(2) Incorporation of model into SCDAP/RELAP5 code.

Estimated Completion Date:
Estimated Level of Efforts:

1.4 Improvement of heat conductivity model in the porous bed

Current model of effective debris bed thermal conductivity does not treat selfconsistently properties if the porous bed in the lower head. Proposed model for calculations of the material properties includes different mechanisms of heat transfer (conduction, radiation) taking into account the presence of coolant in the porous bed;

Working Plan.

(1) Development of the model for debris properties.

(2) Incorporation of model into SCDAP/RELAP5 code.

Estimated Completion Date:
Estimated Level of Efforts:

1.5 Assessment of the models

Limited assessment of the implemented models and their predictions against test data (CORA-13,CORA-W1), comparison of the results predicted by old and new models.

Estimated Completion Date:
Estimated Level of Efforts:

1.6 Implementation of the model of UO2 dissolution by molten Zry.

Working plan on this specific item will be completed later.

Estimated Completion Date:
Estimated Level of Efforts:

2. CORCON-Mod3 models development and validation.

Objectives. This work is addressed to the improvement of the existing thermal hydraulic and FP release models and assessment of the modifications against limited test data. It is assumed also that comparison to the predictions by the old model will be provided.

Design Report concerning improvement of the currently used model will be provided. This report shall contain: (1) objective of new model implementation, (2) detailed description of the model including phenomenological processes, main assumptions, (3) mathematical formalism; (4) justification for the models used, (5) data base supporting the model, (6) range of arplicability and (7) proposed implementation plan.

Working Plan:

(1) Development of the model to provide liquidus temperature calculations consistent with test data for three default concretes currently used in the CORCON-Mod3;

(2) Understanding of ruthenium an molybdenum chemistry and development of the proper data and chemical species that may influence the release of these species;

(3) Development of the of oxide layer chemistry model to determine non equilibrium oxygen potential of oxide phase both in the presence and disappearance of metal layer;

(4) Implementation of new models in the frozen version of CORCON-Mod3 code and limited assessment and validation of the code against test data;

(5) Implementation of the non ideal oxide chemistry model.

Estimated Completion Date:
Estimated Level of Efforts:

3. Mechanistic Melt Spreading Model

Objectives. This work is planned to provide necessary data for CORCON-Mod3 melt spreading model (Time Dependent Melt Radius) and to improve current understanding of the related phenomena. RASPLAV/SPREAD code is assumed to be used for analysis. Implementation of model and corresponding recommendations to user will be developed. This model is based on the solution technique of the set of hydrodynamics equations in the creeping flow approximation with moving boundaries.

Working Plan:

Implementation of the melt spreading model in the dry and wet cavity.

Estimated Completion Date: 31/03/94

Appendix A

IBRAE (Russian Academy of Sciences) Proposals for joint works with NRC (1995)

Part 1. Continuation of current activity (Addendum 4).

Three ongoing tasks described in the Attachment A will be continued in 1995.

Task 1. Improvement of core degradation models.

The following tasks will be completed in 1995.

A) After design reports on items 1.1 - 1.3 will be completed and reviewed, implementation of new models in the SCDAP/RELAP code will be performed.

Estimated Completion Date: June 1995

B) Design report on item 1.6 (Implementation of UO_2 dissolution model) will be delivered to NRC before April 1995.

C) After implementation is completed, assessment of new models is foreseen in the frames of SCDAP/RELAP5 code (Item 1.5).

Estimated Completion Date: October 1995

Task 2. CORCON models development and validation.

After completion of VANESA models modification and assessment, working plan for 1995 will be proposed.

Task 3. Mechanistic melt spreading model.

After reviewing of the spreading model implemented into CORCON-Mod3, the following work may be foreseen:

A) Assessment of spreading model against available test data;

B) Feasibility studies of spreading model usage for a specific containment designs specified by NRC (like MARK-1 containment design).

Part 2. Proposals for extension of work in 1995.

1. SCDAP/RELAP models improvement.

1.1 Improvement of FP release model;

A new model for the description of intragranular fission gas release was developed. The same simplification as in FASTGRASS code is used (i.e. bimodal gas bubble size distribution), but discrepancies of this code (such as nonconservation of gas atoms in the course of coagulation processes) are eliminated.

Comparison with exact (without these simplifications) numerical calculations demonstrate in some important cases an improvement of FASTGRASS results by two orders of magnitude (in the integral value of FP release). Along with validating the new bimodal model for accident conditions, characterized by a very wide bubble size distribution function (up to 10#6 atoms in a bubble), a new numerical algorithm for bubble size grouping (ADAPTIVE SPARSE GRIDS) was developed. Benchmarks calculations demonstrate a very good agreement of proposed bimodal model with this advanced algorithm in the conditions of high temperature transients (severe accidents).

1.2 Implementation of material interaction models (B4C-SS, B4C-Zry, SS-Zry, etc.);

1.3 Implementation of lower head behavior model including simulation of natural circulation in a molten pool, heat transfer through the steel vessel, outside cooling of the vessel and mechanical response of the vessel steel.

1.4 Development of correlations for transient heat transfer due to natural convection.

2. MELCOR models.

2.1 Development of a simplified model for mechanical response of cladding.

2.2 Implementation of the slag heat transfer model into CORCON. Developed model treats formation of a slag due to mechanical destruction of a concrete layer adjacent to the melt and gas behavior at the interface boundaries.

2.3 Development and implementation of a consistent crust freezing and melting model for CORCON-Mod3 code.

2.4 Simplification and adaptation of models developed to the SCDAP/RELAP code for use in the framework of the MELCOR code.

3. Other models and codes.

3.1 Development of a mechanistic 3D spreading code;

3.2 Fragmentation of a jet and heat transfer to the water pool due to fragmentation (without steam explosion);

4. Other possible areas.

4.1 Determination of the dynamic loads (vessel and containment structures) due to external and internal impacts including hydrogen detonation and steam explosion;

4.2 Applications of US NRC codes to VVER nuclear power plants;

4.3 Assessment of codes against existing test data;

4.4 Analysis and improvement of the mathematical technique for the numerical solution of different equations describing phenomena in course of accident: heat conduction, convection, chemical kinetic processes when characteristic times differ several orders of magnitude, etc.