OAK RIDGE NATIONAL LABORATORY
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POST OFFICE BOX Y
OAK RIDGE, TENNESSEE 37831

October 15, 1984

Dr. Robert T. Curtis, Chief
Containment Systems Research Branch
U.S. Nuclear Regulatory Commission
7915 Eastern Avenue
Silver Spring, Maryland 20910

Dear Bob:

At the request of Jim Carter of NRR and with your concurrence, I attended two recent meetings at San Jose, California, concerning the efficacy of the MK III containment hydrogen control owners group (HCOG) BWR core heatup code, which is to be used to predict hydrogen release rates and timing in support of the forthcoming 1/4-scale BWR MK III containment experiments. The first meeting, on October 2, involved only NRC and NRC subcontractor personnel, with Mark Wigdor of NRR serving as chairman. The second meeting, on October 3 and the morning of October 4, was the principal meeting, also involving 17 representatives of the HCOG.

I am providing a summary of these meetings in the attachment. All costs associated with these meetings were borne by the ORNL SASA program. These are, approximately,

Travel and lodging.....	1800
Labor directly associated with meeting (3 1/2 days)...	1400
Labor in preparation for meeting (2 days).....	800
Total Cost	$4000

Please let me know if you desire additional information concerning this matter.

Sincerely,

Steve

S. A. Hodge
SASA Project Manager

SAH:jm

cc with attachment:

T. E. Cole
T. S. Kress
T. J. Walker, NRC
M. Wigdor, NRC

Attachment
S. A. Hodge Letter of
October, 15, 1984

SUMMARY OF MEETINGS ATTENDED

I. Meeting held at Howard Johnsons, San Jose, California, on October 2, 1984.

A. Participants

Mark Wigdor	NRR/RSB (Chairman)
Jim Han	RES/FSRB
Allen Notafrancesco	NRR/CSB
Fulvio Niotico	NRC (Visitor)
Peter Cybulskis	BCL
Steve Hodge	ORNL
J. W. Yang	BNL

B. Purpose. Because the two NRC members (one each from NRR and RES) most knowledgeable concerning the question of the effects of possible hydrogen burning in the BWR MK III containment system under severe accident conditions have recently been transferred to other duties, the purpose of this meeting was to provide detailed background and current status information to the new responsible person, Mark Wigdor of NRR.

C. Evaluation. There was effective information exchange during the meeting. Major points made were:

1. The BWR core contains approximately twice as much zirconium as the PWR core and therefore has the potential for much higher hydrogen production under severe accident conditions.

2. It is important that any BWR severe accident analysis code contain models that reflect the actual BWR in-vessel structure, which is totally different from the in-vessel structure of a PWR.

3. There are modeling errors in the HCOG BWR core heatup code that must be corrected.

4. An entirely new question involving the potential for reaction of the B_4C powder within the BWR control rods with steam under severe accident conditions must eventually be addressed.

II. Meetings held at the Hotel Le Baron, San Jose, California, on October 3 and the morning of October 4.

A. Participants

Mark Wigdor	NRR/RSB
Allen Notafrancesco	NRR/CSB
Fulvio Niotico	NRC (Visitor)
August Cronenberg	Eng. Science & Analysis
Peter Cybulskis	BCL
Steve Hodge	ORNL
J. W. Yang	BNL
James R. Haley	MP&L (HGOG Chairman)
Bob Evans	Enercon
Marvin Morris	Gulf States Utilities
Dennis B. Hacking	Enercon Services
G. M. Fuls	GMF Assoc.
Ben Beasley	Bechtel
Mike Manski	MP&L
Steve Green	Illinois Power Co.
John Richardson	TERA Corp.
Jim Healzer	S. Levy, Inc.
Jay Gillis	S. Levy, Inc.
Gerry Presby	Cleve. Elect. Illum. Co.
Robert E. Henry	FAI
John Hosler	EPRI
Gary Thomas	EPRI

B. Purpose. The purpose of the meeting was to attempt to resolve NRC concerns with regard to the efficacy of the HCOG BWR core heatup code in predicting hydrogen generation rates under potential severe accident conditions. Some of the NRC concerns involving the incorrect modeling of heat transfer from the fuel to the cladding identified by Steve Hodge at ORNL were resolved by correspondence with Gary Thomas prior to the meeting.

C. Evaluation. The NRC and NRC subcontractor representatives made the following points at the meeting:

1. The effects of hydrogen burning in the BWR MK III outer containment are only important if these and these alone have the potential to convert an otherwise recoverable severe accident into a total accident involving reactor vessel and containment failure.

2. The potential for hydrogen generation in the interstitial region of the BWR core is not adequately modeled in the BWR core heatup code. Specifically, there are no models in the code for steam generation in this region.

3. The sensitivity analyses reported by the HCOG showing that there is no effect on hydrogen generation of using four-nodal representation of the channel boxes and control blades vs. single-nodal representation is invalid due to item 2 above.

4. The HCOG position that it is reasonable to begin calculations with the two-phase water level at 1/4 core height, the reactor vessel depressurized to two atmospheres, and all internal reactor vessel structures including the uncovered fuel at the corresponding saturation temperature (about 245°F) was not accepted. The HCOG argued that these non-physical assumptions concerning the initial conditions are in fact conservative since there is no preconditioning, i.e., initial buildup of an oxidized layer, upon the surface of the uncovered fuel before the calculation begins. The NRC position, however, is that it is necessary that each calculation begin with realistic initial conditions. The HCOG responded that this could be done without undue expense since the code does have restart capability.

5. NRC concurrence or non-concurrence with the HCOG position that only cases with the reactor vessel almost completely depressurized (pressure constant at two atmospheres) need be considered has been held in abeyance. The matter has importance beyond the effect of pressure upon steam generation and oxidation rates. With the vessel depressurized, the low pressure ECCS system injection rates would be so large that, were these systems operational, the core would be quickly recovered and the accident terminated; therefore, the effects of these systems need not be included in the hydrogen calculations. On the other hand, if consideration of cases in which the reactor vessel is only partially depressurized is included, then the pressure might hover near the shutoff head of the low pressure injection systems resulting in low injection rates and requiring that the special effects of these systems, particularly those of core spray, be considered.

   As it now stands, HCOG intends to only consider the case of an injection rate of 300 GPM. This corresponds to injection into the depressurized reactor vessel by two control rod drive hydraulic system (CRDHS) pumps. The case of injection by one CRDHS pump, although more likely, is not considered because it has been shown both in BWR core heatup code and previous SASA program analyses that the core is not recoverable under these conditions.

6. It was agreed that the effects of axial conduction in the fuel, cladding, channel boxes, and control blades are insignificant and need not be modeled unless the heat transfer provided by axial conduction were the only source of energy for steam production in the interstitial region. Actually, it is far more efficient to provide for steam production in the interstitial region by modeling the effect of gamma heating of the control blades and channel boxes.

7. It was agreed that questions concerning the effect of B_4C — steam reactions upon BWR hydrogen generation and control blade deformation would be held in abeyance until the results of calculations to be performed by the ORNL SASA program are available.

8. By far the most important NRC concern with the HCOG BWR core heatup code involves the use of a user-input temperature for permanent cutoff of the metal-water reaction. For the calculations discussed at the meeting, the generation of hydrogen in any core node was terminated when the nodal temperature reached 2400 K (3860 F); it is important to note that the termination is irreversible and therefore hydrogen generation from the affected node is not resumed if the nodal temperature subsequently decreases. The actual termination of oxidation is accomplished in accordance with an S-shaped function so that the oxidation rate begins to be reduced at 2350 K, decreases rapidly as the temperature passes through 2375 K, and then the final vestiges of the reaction are slowly reduced as the temperature approaches 2400 K.

   The HCOG representatives defend the use of the cutoff temperature based upon "upper limit interpretation of results from the Karlsruhe (Hagen) experiments and results to date from the Power Burst Facility Severe Fuel Damage (SFD) experiments. From a practical view, this experimentally-seen cutoff in oxidation is the apparent result of a drastic reduction in available oxidizing surface area as a result of slumping of the molten Zircaloy and probably molten Zr-U-O solutions. Since the cutoff is a result of physical restructuring, it is considered to be irreversible." On the other hand, NRC subcontractor representatives point out that continuous hydrogen production at very high temperatures has been reported in recent experiments at the Power Burst Facility and in the Annular Core Research Reactor at Sandia.

   It is obvious that some method for termination of hydrogen production when core nodes reach high temperatures

must be included in the BWR core heatup code. Otherwise, since there is no provision for recognition of core deformation and all nodes continue to stand in place even after fuel melting has occurred, there would simply be a continuous hydrogen generation at very high rates until 100% of the Zirconium had been reacted. The question is, what is a reasonable method and what is the appropriate cutoff temperature? The matter was not resolved at this meeting.

9. The HCOG representative believe that the amounts of hydrogen generated and the rates of hydrogen generation calculated by the BWR core heatup code should be considered to be conservative because they exclude consideration of (1) channel blockage effects that could produce steam starvation in the upper portions of blocked channels, and (2) the effect of hydrogen blanketing of the cladding. The NRC subcontractors commented that the experiments conducted to date do not confirm that channel blockage would be expected to occur and that because hydrogen blanketing is expected to be a real effect, there would be no objection to its use in the HCOG calculations. (Provisions for the calculation of the effect of hydrogen blanketing exist in the code.)

D. Future Plans. The HCOG is anxious to resolve the NRC concerns in regard to the BWR core heatup code that were identified at this meeting in a timely manner so that the code results can be used in support of the forthcoming 1/4-scale MK III containment experiments. To this end, a follow-on meeting with the NRC was tentatively scheduled for October 17. Unless otherwise directed, I have no plans to attend the follow-on meeting.

SAH:jm