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Mario Fontana - May 16, 1996

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
SUBCOMMITTEE MEETING MINUTES
SEVERE ACCIDENTS
APRIL 8, 1996
ROCKVILLE, MARYLAND

INTRODUCTION

The ACRS Subcommittee on Severe Accidents met on April 8, 1996, at 11545 Rockville Pike, Rockville, Maryland, in Room T-2 B3. The purpose of the meeting was to gather information on the status of NRC severe accident codes. The entire meeting was open to public attendance. Mr. Noel Dudley was the cognizant ACRS staff engineer for this meeting. The meeting was convened at 8:30 a.m. and adjourned at 3:50 p.m.

ATTENDEES

ACRS

M. Fontana, Chairman
I. Catton, Member
T. Kress, Member
R. Seale, Member
N. Dudley, ACRS Staff

NRC STAFF

C. Ader, RES
S. Basu, RES
Y. Chen, RES
W. Hodges, RES
A. Malliakos, RES
A. Notafrancesco, RES
J. Ridgely, RES
A. Rubin, RES
J. Schaperow, RES
C. Tinkler, RES

There were no written comments or requests for time to make oral statements received from members of the public. An attendance list of other members of the NRC staff and public is available in the ACRS office files.

DISCUSSION OF AGENDA ITEMS

Dr. Mario Fontana, the Subcommittee Chairman, convened the meeting at 8:30 a.m., and noted that the staff would provide information regarding NRC severe accident codes.

Staff Presentation Concerning Severe Accident Codes

Mr. Charles Ader, RES, provided a brief overview of the NRC severe accident codes. He explained the objectives of the codes and the two-tier code strategy. The staff develops, validates, and maintains severe accident codes to support the NRC analytical capabilities to model plant accidents and transients.

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The Subcommittee members and the staff discussed the future of the severe accident codes including:

- codes becoming more detailed as computer capacity increases,
- detailed codes being subsumed into higher tier codes, and
- codes being used to support risk-informed judgment.

They discussed the peer reviews conducted as part of code development and the staff disposition of the peer review comments. Mr. Wayne Hodges, RES, noted that the staff and the Department of Energy are working together to identify joint interests in maintaining code expertise. He also noted that the staff has taken a top-down look at the codes to identify the major phenomena and the areas of large uncertainties that require modeling.

CONTAIN: Mr. Allen Notafrancesco, RES, presented the objectives and applications of the CONTAIN code. He summarized the technical approach, models, on-going activities, and future plans associated with the CONTAIN code. CONTAIN is an integrated thermal hydraulic code for analyzing severe accident conditions inside different types of containments. Sandia National Laboratories developed, validated, and maintains the code.

The Subcommittee members and the staff discussed the uncertainties associated with the CONTAIN code, NRR user need requests regarding certifying the code, and the potential use of the code in the regulatory process. They discussed the technical adequacy of the CONTAIN code, the ranking of severe accidents by the peer review group, and the potential for unidentified user-induced errors. The staff agreed to provide the Subcommittee with copies of the peer review group report, "CONTAIN Independent Peer Review," which includes a summary of the CONTAIN code PIRT on Table C-II.

A Subcommittee member stated that the NRC staff should be conscious, when it transitions to using the CONTAIN code for regulatory decisions, of the differences between a bounding code and a best estimate code. Another member offered the opinion that the peer review group did not include the right type of thermal-hydraulic reviewers and that the lump parameter model does not adequately address the atmospheric stratification in the containment.

SCDAP/RELAP5: Mr. Yi-Shung Chen, RES, presented the objective and applications of the SCDAP/RELAP5 code. He summarized the peer review group report, major core damage progression models, ongoing work, and future plans associated with the SCDAP/RELAP5 code. SCDAP/RELAP5 is a detailed mechanistic code used to analyze in-vessel severe accident progression. The code includes models for reactor vessel components, in-core phenomena, and lower plenum

phenomena. The staff is continuing to develop models based on the results of foreign research conducted by the member countries of the Cooperative Severe Accident Research Program (CSARP).

The Subcommittee members and the staff discussed peer review group recommendations, modeling of severe accidert phenomena, use of probabilistic risk analyses, and evaluation of the potential for steam generator tube failures during severe accidents. They discussed the lack of understanding of key physical phenomena, the inability of the code to accurately predict the behavior of core melt progression, and the need for a top-down review of the code to assure that modeling details provide a consistent level of validity for the calculational outputs. Also discussed was the involvement of foreign countries in using the code. A Subcommittee member suggested that a peer review be performed to determine whether the VICTORIA code could calculate fission product distributions during in-core melt events.

MELCOR. Mr. John N. Ridgely, RES, presented the objectives, applications, models, peer review group recommendations, and future plans associated with the MELCOR code. The code provides the capability to model key phenomena in order to understand severe accident progression from a probabilistic risk assessment perspective. The Subcommittee members and the staff discussed the relative speeds of the MELCOR and SCDAP/RELAP5 codes, and how the staff resolved the peer review group recommendations. The Subcommittee requested a copy of the peer review group report in order to understand what recommendations had been made.

VICTORIA: Mr. Jason Schaperow, RES, presented the objective, applications, models, peer review group recommendations, and future plans associated with the VICTORIA code. The objective of the VICTORIA code is to perform mechanistic best estimate analyses of fission product release and subsequent transport in the reactor coolant system. The Subcommittee members and the staff discussed whether the code modeled plate out and condensation of isotopes, and the fission product distribution in molten corium and steel. The staff agreed to provide the Subcommittee with an explanation of how the VICTORIA code treats beta emitters with respect to the location of heat generation.

HMS and COMMIX: Mr. Alan Rubin, RES, presented the objectives, applications, models, and ongoing work associated with the HMS and COMMIX codes. HMS is a three dimensional finite difference best estimate code for predicting transport, mixing, and combustion of gases in the containment. COMMIX is a three dimensional code that solves mass, momentum, and energy conservation equations as well as transport equations of turbulent parameters for predicting stratification and bulk circulation patterns in containment.

The Subcommittee members and the staff discussed differences between the HMS and COMMIX codes including the importance of selecting input parameters, the program algorithms, the heat transfer models, and problems associated with numerical diffusion. They discussed the process of conducting trials to select a single code and the possible use of existing codes that have undergone peer reviews.

Integrated Fuel Coolant Interaction (IFCI) Code: Mr. Rubin presented the objective, applications, models, and on-going work associated with the IFCI code. IFCI is an integrated fuel-coolant interactions code for modeling in-vessel and ex-vessel explosive and non-explosive phenomena. The Subcommittee members and the staff discussed heat transfer coefficients and the source of inputs to the code.

Subcommittee Discussions

During the afternoon discussion of issues associated with the Severe Accident Research Program, individual Subcommittee members expressed the following opinions, which do not necessarily represent the consensus of the Committee.

General Comments: The staff does not appear to be looking at severe accidents in an integrated way. The staff should review severe accident issues to determine what needs to be known, how much and how fast information is required, and the cost of developing the information. The staff should document the results of the reviews. Maintaining staff and contractor capabilities in the severe accident area, as budgets are reduced, is a concern.

Direct Containment Heating: Although residual issues exist, the staff has done enough to support the conclusion that direct containment heating is not a major risk contributor for large dry containment systems. The staff evaluation of Combustion Engineering containments is expected to conclude that direct containment heating is not a major risk contributor. The staff still needs to establish the ability of ice condenser and boiling water reactor containments to withstand the effects of direct containment heating.

Fuel-Coolant Interaction: The staff should develop an envelope curve, using all available data, and evaluate whether additional research is needed.

Debris Coolability: The staff knows enough to address whether or not a particle bed can be cooled. The staff should develop more information on how to predict particle size distributions under

different conditions. The largest uncertainty is whether or not the debris bed will dry out.

The MACE test progra[illegible] probably not provide much useful information concerning [illegible]xplosions, because the material used in the test does not h[illegible] same type of thermal diffusivity as molten core material. The abi[illegible]ity of overlaying water to penetrate the frozen crust of molten debris needs to be addressed before the coolability of a molten debris bed can be demonstrated.

Source Term: The staff does not have a database of fission product releases from high burn-up fuels and does not have a computer model to calculate releases.

Lower Head Integrity/Core Melt Progression: Some models perform far more detailed calculations than are warranted by the present knowledge of the physical configurations that occur during accidents. Improved models that require longer computational times may not do a better job in estimating risk. In-vessel core melt progression may be too complex to model in detail. Local bounding analysis may be more appropriate.

Any additional studies in this area would more positively support the accident strategy of flooding the cavity to cool the lower head. The staff probably can do a reasonable job of evaluating heat flux for a single, uniform, molten pool. However, the staff has not addressed the question of what happens with separate layers of molten steel and molten corium. Multi-layer problems have not been addressed, and should not be that difficult to solve.

Hydrogen Combustion: The staff knows enough to calculate the impact of hydrogen detonation. The knowledge of the behavior of hydrogen in containment systems is adequate and additional research on hydrogen combustion is not needed. Tools exist to evaluate the important area of hydrogen stratification. However, computer codes that use lumped parameter models cannot adequately treat hydrogen stratification.

Use of Severe Accident Codes: The CONTAIN code and either the HMS or COMMIX code are good examples of the two-tier approach. The SCDAP code provides more detailed calculations than the MELCOR code for core melt progression, however the staff may not know enough to be sure that the results can be read properly. The staff should improve SCDAP/RELAP5 code or use the RELAP-5 code by itself for thermal hydraulic calculations.

After the discussion of individual Subcommittee member's opinions, Dr. Fontana adjourned the meeting at 3:50 p.m.

FUTURE ACTIVITIES

The Subcommittee expressed an interest in hearing additional information concerning the following subjects:

- the results from the SCDAP/RELAP5 code evaluation of the potential for a steam generator tube rupture during severe accidents,
- additional information on the activities being conducted at the Russian Research Center, Kurchatov Institute (RASPLAV), and
- the criteria the staff uses to terminate a severe accident research project or to close a severe accident issue.

SUBCOMMITTEE RECOMMENDATIONS

The Subcommittee recommended that the staff provide a presentation to the full Committee at the April 11-13, 1996 ACRS meeting and that the Subcommittee Chairman prepare a report to Chairman Jackson concerning the severe accident research program for consideration by the full Committee.

FOLLOWUP ACTIONS

During the meeting the staff agreed to provide the Subcommittee copies of the following documents:

Reports:

- CONTAIN Independent Peer Review [received 4-8-96]
- CONTAIN PIRT [see table C-II in CONTAIN Independent Peer Review]
- MELCOR Peer Review Report

Explanations:

- description of the status of SCDAP heat transfer coefficient [received 4-11-96]
- explanation of how the VICTORIA code treats Beta emitters
- description of internal differences between the HMS and COMMIX codes [received 4-11-96]

BACKGROUND MATERIAL PROVIDED TO THE SUBCOMMITTEE FOR THIS MEETING

1. Letter dated August 18, 1992, from David Ward, Chairman ACRS, to Ivan Selin, Chairman NRC, Subject: Severe Accident Research Program Plan

2. Slides dated March 1, 1996, by Charles Ader, RES, for the ACRS Severe Accident Subcommittee, Subject: Severe Accidents Codes

3. Report undated, by F. Cheung and K. Haddad, Pennsylvania State University, Subject: Steady State Observations and Theoretical Modeling of Critical Heat Flux Phenomena on a Downward Facing Hemispherical Surface

4. Report dated May 1995, by T. Chu, Sandia National Laboratories, Subject: Scaling and Design Report for Lower Head Failure Experiments

5. Report dated October 1995, by the Secretary-General of the OECD, Subject: Senior Group of Experts on Severe Accident Management (SESAM) Severe Accident Management Implementation

6. Draft Report dated November 1995, by the Secretary-General of the OECD, Subject: Areas Of Agreement, Areas For Further Action, Increasing Need For Collaboration

7. Proceedings of the Special Meeting On Severe Accident Management Implementation, held at Niantic, Connecticut, on June 12-14, 1995, by the Committee on the Safety of Nuclear Installations OECD Nuclear Energy Agency

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NOTE: Additional details of this meeting can be obtained from a transcript of this meeting available in the NRC Public Document Room, 2120 L Street, N.W., Washington, D.C. 20006, (202) 634-3274, or can be purchased from Neal R. Gross and Company Incorporated, Court Reporters and Transcribers, 1323 Rhode Island Avenue, N.W., Washington, D.C. 20005, (202) 234-4433.