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MEMORANDUM
25 October 1982

TO: Paul Boehnert
FROM: Ivan Catton
SUBJECT: Joint NRC/ANS Meeting on Basic Thermal Hydraulic Mechanisms in LWR Analysis, September 14-15, 1982, Bethesda

The meeting covered three topics: 1) Basic Scaling Principles for Two-Phase Flow, 2) Condensation Induced Instabilities and 3) Special Effects on Core Thermal Hydraulics. For the most part, the first topic was not adequately covered. Most of the speakers spent their alloted time explaining why they couldn't scale and how it really didn't matter. Of those that did address scaling, one clearly demonstrated the need for adjusting the timing of controlled events in LOFT to obtain better simulation. Speakers on the second topic discussed computer simulation as well as experimental results. The codes just can't handle condensation very well and experiments lead one to the conclusion that it is important if a number of rather complex processes are to be understood. The final topic dealt mainly with experimental studies of reflood. One was left with the feeling that we may know enough to make reasonable engineering predictions. More detailed discussions of some of the papers follows.

Topic 1. Scaling and Modeling

Paper No. 1. Basic Scaling Principles for simulation of BWR Behavior During Small LOCAS--D'Auria, Mazzini, and Vigni, Italy. Dimensional analysis was used to design an experimental loop for studies of natural circulation. It was nice to see dimensional analysis before the syste[illegible] [illegible]ilt even though it was concluded that one couldn't obtain similitude [illegible] [illegible]clusion that non-dimensionalization is insufficient and that one [illegible] obtain similitude was based on two shaky analysis. They show that [illegible] heat is important and that one would first have to refrigerate then heat to obtain similitude.

Paper No. 2. Scaling Basis for BWR Safety Experiments--Sutherland and Allison, GE. The basis for scaling the FIST facility was given. The paper in many respects is a rationalization for FIST as it is. Even though the arguments are convincing, I found the lack of any suggestions as to how a BWR simulation might be improved somewhat self serving. The paper clearly deserves reading. The scaling study brought out the importance of metal heat, CCFL at the top of the bypass, parallel channel effects and where compromises had to be made. The compromises were all reasonably rationalized. The use of a one-channel facility for simulation of a multichannel system is to be accomplished by analysis. Lingering doubts will be eliminated when the JAERI ROSA IV results become available. A full GE report will be available before the end of the year. It should be the subject of an ECCS SBCTF meeting as it will most likely be the basis for validation of future GE T/H codes.

Paper No. 3. Scaling of BWR Parallel Channel Effects--Conlon and Lahey, RPI. A case was made for complete steam binding. The scaling, however, was incomplete in that important thermal effects were not addressed. The experiments based on the scaling used Freon as a coolant. The experimental results may be useful for code verification but they have little relevance to BWR behavior because one cannot scale important thermal effects on condensation, CCFL as well as upper plenum flow patterns.

Paper No. 4. Influence of Scaling of the Batelle BWR Test Facility on the Analysis of Experimental Results--Wabba, Wolfert and Garsching, FRG. The purpose of the facility is assessment of DRUFAN 02, a code similar to RELAP5. The paper did not address scaling in a meaningful way. The facility is not nearly as well thought out as the FIST facility. Data from the facility may be questionable and the code has undergone a great deal of tuning. The paper is not worth reading.

Paper No. 5. Scaling of Thermally Driven Fluid Mixing and Heat Transfer Associated with Pressurized Thermal Shock of Reactor Vessels--Rothe and Wallis, Creare. A very meticulous scaling study was described. The paper is well worth reading as an example of how a problem should be approached. The need for both the heat transfer coefficient and fluid temperature and their time dependence is predicting thermal stress was clearly demonstrated. It was found that the CE system may see reverse flow and mixing in the SI piping.

Paper No. 6. Scaling Criteria for LWRs under Single-Phase and Two-Phase Natural Circulation--Ishii and Kataoka, ANL. A very complete description of how one uses scaling most effectively was given. For two-phase natural circulation the scaling study was based on the drift flux equations. This resulted in 8 to 10 parameters. By neglecting certain aspects, similarity requirements for proper scaling of void fraction and quality were found. The need to adjust the timing of controlled events in LOFT for better simulation of a full scale PWR was brought cut very nicely.

Paper No. 7. Scaling Criteria and an Assessment of Semiscale Mod-3 Scaling for Small Break Loss-of-Coolant Transients--Larson, Anderson and Shimeck, INEL. The basis for the scaling is the same as that used for FIST. Compromises in the Semiscale Mod-3 scaling are described and for the most part rationalized by appealing to analysis with computer codes to bridge the gap. This is, in my opinion, an acceptable approach. It would be more comforting, however, if scaling analysis were done before rather than after so that they could influence the various integral facility designs. The effect of heat loss was noted.

Paper No. 8. Scaling Considerations for FLECHT-SEASET--Rosal, Hochreiter and Tome, Westinghouse. The paper describes the scaling basis chosen so that tests more typical of a high pressure small break LOCA or operational transient could be conducted at low pressure. To do this, they had to determine how pressure would effect their results. They found that steam velocities decreased by a factor of 16 when the pressure was increased to 120C psia. The big problem was how to get reflux boiling initiated. It was found that by draining liquid out of the boiler--the simulated core--they could do it. It seems to me that this is stretching too far in trying to milk the last drop of usefulness from an existing facility.

Paper No. 9. Scaling Considerations for Reduced-Scale Modeling of Steam Generators: The Westinghouse Model Boiler 2 Test Facility--Rod, Hopkins and Mendler, Westinghouse. The paper outlines the scaling principles underlying the original design of the Westinghouse Model Boiler 2 test facility for steady-state experiments and its proposed modification for transient tests for NRC, EPRI and W. The not-quite-full-height steam generator has full pressure primary and secondary side and like SCTF is a slice through the center of the SG that is 4 tubes columns wide and 13 tube rows long. The SG is fully instrumented. Its use for steady-state testing and code verification is well based. The scaling studies needed to justify its use as a transient test facility are not completed. On the surface, it looks like a good facility being run by competent people.

Paper No. 10. Scaling Effects in Degraded Core Coolability--Gorham-Bergeron and Lipinski, Sandia. The paper reviewed past efforts in this area and showed how well the Lipinski model addresses them all. A rationale for scaling from one fluid to another was not given. The paper brings together a large number of results and has some interesting discussion.

Paper No. 11. On the Hydrodynamic Characteristics of Two-Phase Flow through Porous Media--Dhir, Chu, Lee and Catton, UCLA. Experimental results are reported for two-phase flow in porous media composed of large particles ($d>1000\ \mu m$). Both homogeneous beds and heterogeneous beds were studied. A model based on the drift flux approach is shown to predict the void fraction reasonably well.

Topic 2. Condensation and Fluid Mixing

Paper No. 12. Effects of Condensation Modeling on Transient Behavior of Pressurized Water Reactors--DeMuth and Dobranich, LANL. TRAC condensation modeling was described. A number of calculations were made and it was found that condensation modeling can control a number of transients. For example, a PTS transient returns to natural circulation too soon if the condensation is too rapid. The modeling was nodalization sensitive which means the results may be nonsense. Some improvements have been made but the code still drives the physics. A number of safety issues are under investigation at LANL for NRR: PTS, recovery of Natural Circulation, Isolation of the steam generator following core damage. The results of these studies are to be used to assess operator guidelines. Symptom descriptions, alternate strategies and EOPs are under study. One cannot emphasize the need for understanding and modeling condensation enough.

Paper No. 13. Condensation Effects in Large Scale BWR Safety Experiments--Sutherland, GE. Results from the Lynn facility and condensation effects on Reflood Refill were discussed. The paper is one of the best at the meeting. The description of the upper plenum thermal hydraulic behavior following activation of the sprays explained a great deal of what was thought to be anomolous behavior. A very clear picture of the complex processes resulting from condensation was given. The importance of condensation was given. The importance of condensation on the reflood-refill process was clearly demonstrated.

Paper No. 14. Behavior of Water Spray Injected into Air/Stream Environments--Lee and Tankin, Northwestern University. A detailed analysis was described that on the surface looked a bit unphysical. The experimental data were very carefully taken. It appears to me that the study may have more relevance to fuel injector design than nuclear safety. Future work where the water sheet portion of the jet is turbulent will be of more use.

Paper No. 15. Initiation of Water Hammer in Horizontal and Nearly Horizontal Pipes Containing Steam and Subcooled Water, Bjorge and Griffith, MIT. A particular configuration was studied; counter flow in a horizontal pipe. Results obtained allow water hammer to be avoided by proper water flow control. This is only one of many configurations of interest. Others should be studied. The work is a nice combination of analysis and the computer.

Paper No. 16. Condensation Induced Instability in a Reactor Coolant Loop with Combined Injection--Capiello, LANL. The paper reports the results of a TRAC study of KWU hot leg injection condensation oscillations. The usefulness of the study is not clear because the multi-dimensional character of the injection--hot leg flow interaction is modeled as one-dimensional. Further, if condensation is important and TRAC modeling is questionable, how can the results be acceptable?

Paper No. 17. Not given.

Topic 3. Thermal Hydraulics in Core During Reflood

Paper No. 18. Experimental Investigation of Reflood Heat Transfer in the Wake of Spacer Grids--Ihle, Rust and Lee, KFK. Some interesting data were discussed and an analysis was shown to yield a poor prediction of the peak clad temperature. This was used to conclude that there was a need for further study. I would conclude that they don't understand the problem. They noted that mist cooling was important and that grids shatter drops so that $d \sim 200\ \mu$.

Paper No. 19. Spacer Grid Heat Transfer Effects During Reflood--Chiou, Hochreiter, Utter and Young, Westinghouse. Drop Break-up is caused by the grids as noted in the previous paper. Further, wetting of the grid leads to a higher rate of steam production and cooler steam. Both processes lead to better cooling downstream of the grid. A model for drops break-up and grid wetting was proposed.

Paper No. 20. Re-entrainment of Droplets from Grid Spacers in Mist Flow Portion of LOCA Reflood of PWRs--Lee, Cho, Sheen and Aghili, SUNY--Stony Brook. Drop sizes and velocities were measured downstream of grid spacers. Some of the results looked strange. The air speed was 16 m/sec and the very small drops had velocities 1-2 m/sec. This work is a long way from being useful.

Paper No. 21. Hydraulics of Blocked Tube Bundles--Yao, Loftus, and Hockreiter, Westinghouse. An experimental program was conducted to obtain single-phase pressure drop data for flow through rod bundles with various blockages. Correlations were developed from the data.

Paper No. 22. Flow Blockage Heat Transfer Effects in the FLECHT-SEASET 21 Rod Bundle Test--Loftus and Hochreiter, Westinghouse. Heat transfer measurements for flow through blockage were made. Heat transfer improvement as seen to occur for single and two-phase flows in and downstream of simulated blockages. The largest heat transfer improvement is immediately downstream of the blockage and is seen to diminish with distance downstream of the blockage. The effects were not very dramatic.

Paper No. 23. A Study of Two-Phase Flow Thermal-Hydraulics During Bottom Reflood of Nuclear Reactor Cores--Ghiaasiaan, Catton and Duffey, UCLA. An empirical relationship for void fraction above the quench front is developed and used to correct some standard boiling heat transfer correlations. The UCLA multi-channel reflood model is then shown to yield very good comparison with experimental data from SCTF, FLECHT-SEASET and a small scale 1692 pin facility. Simple methods for treatment of the improtant phenomena are shown to adequately predict reflood phenomena.