UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

May 1, 1979

TO: Dr. Andrew Bates

FROM: Ivan Catton

SUBJECT: MARK II OWNERS GROUP MEETING, MARCH 21-23, 1979, PALO ALTO, CALIFORNIA

COPIES TO: M. S. Plesset
R. Savio

Summary

A new series of 4T tests will be run. As usual the new tests have a narrow focus and in some respects seem to be poorly thought out. Minimal additional instrumentation could add a great deal. The experiments will answer questions about the vent acoustics and air/steam ratios effects on pool boundary loads. They do not, however, address vent lateral loading.

The CREARE multivent study appears to be much improved. The test matrix is satisfactory. Data interpretation, however, will be difficult. The CREARE multiple vent load reduction factor will probably be proposed for use on some future plants. This will have to be viewed with caut[illegible]

The approach taken to obtain plant pool boundary load[illegible]. The 4T data will be used to characterize a chug source for use [illegible]-D acoustic model of a plant pool. The plan is to use a worst case chu[illegible] only remaining hurdle is to determine how close to simultaneous chugging is one in a 80 vent Mark II pool.

The Caorso SRV data demonstrates that the Mark II DFFR is almost a factor of three too high in specifying SRV loads.

Apparently there is some lack of cooperation between various members of the owners group. WPPS is the only plant still using the rams head SR/V. All others will use T-Quenchers. Susquehana proceeded on its own by having KWU carry out studies of both T-Quenchers and Vents. Only recently have the members of the owners group bought into theKWU T-Quencher work. Susquehana is proceeding on its own with the Vent project with the help of both KWU and SRI. As a result the KWU T-Quencher work was available to all Owners Group members (but not GE) and the KWU Vent work was not available to GE nor the owners group.

The KWU T-Quencher study conducted for PP&L and the Mark II owners group shows that the condensation oscillation pressures are negligable and that the air clearing loads are about one-half those specified in the DFFR which are based on use of a rams head SRV.

The study of chugging being carried out for PP&L by KWU is very thorough. When the results become available they will set a standard for the industry.

Extended 4T Program

The earlier 4T test were conducted with the simulated drywell some distance away. A number of questions were raised about the effect of the vent length and how it couples the drywell to the pool (oscillations, etc.). Further, the NRC Staff did not feel that past test analysis and scaling arguments were sufficiently convincing to make plant specific conductions. A new series of experiments will be conducted with the drywell mounted on top of the 4T tank so that the vent length is the same as full size. All aspects of a LOCA will be modeled including air/steam mixtures. The major non-prototypic aspect is the symmetric arrangement of the 4T facility.

The primary purpose of the new program is to measure wall loads. As a result only vent mass flow, with grab samples to assess air content, tank wall pressure and selected temperatures will be measured. There will be "no" strain guages on the downcomers. This seems, on the surface, to be absurd. One should attempt to obtain as much information as possible from every test. The possibility of chugging and large lateral loads on the vents is not fully resolved in my mind as the various statistical approaches are based on a limited amount of data. The cost of a few strain guages is relatively small. Another similar question is about loads on obstacles beneath the vent. A rake of well placed hot wire anemometers would yield the information needed to validate, or invalidate, the ring vortex model being fostered for use in such load calculations.

Air effects on the steam injection process are to be a part of this new study. It is not clear how the test can be set up to properly simulate how the break flow will purge the drywell. GE has put the break at the top of the drywell to try and obtain the most rapid air purging. The steam mixture enters the drywell via a rams head. Circulation patterns could be set up that will delay air outflow. It would be better if the rams head were replaced with a diffuser or if some baffles were used. Until a definitive study of how the air is purged from the drywell is carried out, one must assume the worst combinations of air and steam. Some observations have shown that air content delays the bubble collapse but doesn't always alter how it collapses. It is therefore possible that certain combinations of air and steam can put one in the regime of large lateral loads.

Multivent Chugging Experiments

A multivent chugging experiment is being conducted by CREARE at scales ranging from 1/10 to 5/12. Up to seven vents will be used in their system. The basic plan looks very good. Test data shown were fairly repeatable. Air content was maintained to below 15 ppm.

A statistical analysis is planned where maximum and mean pressures are looked at. I believe that the work will miss the point unless the statistics are viewed in light of the several different types of physical processes occurring in the pool.

CREARE is attempting to develop a multi-vent multiplication factor. They note that as pool size increases for a given number of vents the load decreases. This is not surprising and has been observed by KWU as well as others. The reason is that each vent is a pressure or momentum source and the surface of a larger pool must feel a lower pressure than a small pool if the pool boundary integrated value is to be the same. The work is preliminary and, when viewed with the KWU proprietary data in mind, is headed in the right direction. The question will be how well the multiplication factor scales to full size complex geometries.

Improved Chugging Pool Boundary Load Definition

Use of the 4T data to define loads for a plant requires several steps. The 4T data contains in it the effect of boundary ring out as well as vent and pipe frequencies. The approach taken is to ask what pressure source at the vent exist gives certain measured response at the pool boundary. This uncouples the vent chugging from the pool response and yields a vent source term that can be used elsewhere.

A series of 4T "chugs" have been examined and the 137 with the highest peak pressures used to characterize a chug. The chug was uncoupled from the 4T pool using a K-FIX model of the pool and a finite element model of the pool boundaries. This characteristic chug source term will then be used with a 3-D acoustic model to obtain rigid wall loads for a Mark II containment. A structural FSI model with plant unique characteristics will then yield plant unique pool boundary loads. The statistics being generated by CREARE, with appropriate scaling factors, and chug timing (how are the vents behave relative to one another in time) will be needed to combine the characteristic chug into a multi-vent model.

The results of these experiences reduce the amount of work needed to confirm the SRV loads being used in the Susquehana design.

The Karlstein Test Facility is being modified to better simulate the Susquehana plant. A typical cell (geometric cross-sectional shape) associated with an SRV was constructed. The piping, valves, vacuum breakers, pipe supports, elbow, and the SR/V were simulated in full scale. Some compromise will result due to the solid boundaries. These are expected to be minimal and to fall within the experienced gained from earlier KWU work. The test facility is extremely well instrumented.

The Karlstein Tests clearly demonstrate that quenchers eliminated SRV steam discharge oscillation problems by significantly descreasing the pressure oscillation magnitude. SRI has looked at several aspects of the KWU work for Susquehana. Their contribution appears to be minimal.

Caorso SRV Experiments

The series of experiments conducted at Caorso show that the DFFR is conservative. An examination of maximum and minimum pressures measured at Caorso under a variety of conditions indicates that they are almost a factor of three under DFFR values. A great deal of discussion lead to no conclusions as to why.

T-Quencher Study

The T-Quencher study was originally initiated through a contract between PP&L (Susquehana) and KWU. The study support has since been augmented by the Mark II owners group. The owners group has not decided, at this time, whether they will use the results of the study to ask for a reduction in the DFFR loads.

The KWU group has been involved with SRV problems for quite some time and as a result made the decision to use quenchers over six years ago. To demonstrate that quenchers would solve problems such as those experienced at Wiergassen, a program was conducted that included full scale tests as well as two in-plant tests during startup. The results of their studies show that without a quencher, pool temperature must be limited to 45^{o}C and with a quencher allowable pool pressure must be the limiting factor (their design pressure). The results of the study apply directly only to a single SRV of the Susquehana design. Other owners will have to use analysis to account for plant differences if they choose to use the results of the study. The approach used to account for multiple SRV's will be to determine what should be used as a characteristic SRV source in a manner similar to that used to account for multiple vent chugging and with 3-D analysis determine the pool boundary loads. KWU generated a great deal of evidence to confirm the approach during the licensing of the 8 BWR's in Germany.

GKM Condensation Oscillation Test Program

Work is being done by KWU under contract to PP&L. Neither GE nor the owners group is involved and as a result is not privy to the program's results. The experimental study will only address pool boundary loads

and will be unique to Susquehana. PP&L plans a May 1980 fuel loading date for Susquehana and to meet the time requirements GKM will have completed testing by January 1, 1980. PP&L has SRI interfacing with KWU and there is somebody in residence in Mannheim.

The experimental facility will simulate a 30° sector in full scale. The test facility is in many respects similar to the GE 4T test facility. KWU went through the methodology needed to use the single vent data for plant calculations. In principle, it is similar to that being done for the owners group by Bechtel.

To confirm their multi-vent approach, a series of 1/8 scale experiments were run. They compared results from 10 vents, six vents, two vents and one vent. All were run in a concrete box with same vent to pool area ratio. They found the chugging load of a vent decreases when the pool area is larger. Further the maximum load was a factor of two higher than the average load and measurements all fell below calculations. It was concluded by KWU that measurements in a single cell can reasonably be corrected for use in a plant by accounting for area change. One can then reconstruct the total load by superposition. This can only be done rigorously for uniformly placed ducts. KWU will explore this by running several different tests.

There are still several concerns. The control of the steam/air mixture in the drywell seems to be arbitrary and as a result effects of air on chugging will have to be viewed with caution. Its not clear that the steam thermal content is high enough to drive the pool through the proper temeprature-time history. Finally, the pool boundaries will change the pool stratification (this is probably minor). The thoroughness of the KWU study is very encouraging. No documemtation is available at this time. PP&L has not decided to what degree they will take credit for the results of the study.