UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

July 18, 1994

MEMORANDUM FOR: G. Donald McPherson, Senior Thermal Hydraulics and Testing Expert

THRU: Ralph Caruso, Group Leader
Analytical Support Group

FROM: Walton L. Jensen, Senior Reactor Engineer
Analytical Support Group

SUBJECT: REPORT ON AP600 MATRIX TEST NO. 6 AT THE SPES-2 FACILITY AND INSPECTION OF VAPORE ADS TEST FACILITY

Matrix test #6 was performed at SPES-2 on June 10, 1994, at the SIET laboratories at Piacenza, Italy. Matrix test #6 simulated the full double ended guillotine break of the division-B DVI line with caused loss of 1/2 of ECCS capability. The division-A DVI line remained available and provided adequate core cooling throughout the test.

The most significant outcome was that no core heatup occurred. All core thermocouples began a downward trend from the beginning of the test that was not interrupted. We left the SIET facility with the impression that Matrix test #6 had been well done, that the data could be utilized to effectively benchmark analytical computer codes and that the results had not uncovered any new or unexpected phenomena. The inclosed attachment 1 describes our detailed observations.

SPES-2 is a full height, full pressure, 1/395 scale thermal-hydraulic model of the Westinghouse AP-600 standard nuclear power plant design with passive safeguards. The core for the reference plant is simulated in SPES-2 using 97 electrically heated rods with a nominal operating power of 4.9 MW. The primary circuit, the steam generators and the safety systems (CMT, IRWST, PRHR, ADS and accumulators) are included in the facility.

Preparations for test #6 and the test itself was monitored by K. Shembarger, D. McPherson, M. Ortiz (INEL) and W. Jensen on June 9 and June 10, 1994. On June 13, 1994, M. Ortiz and W. Jensen reviewed the test results in detail with Dr. Medich the SIET test manager and V. Merritt the Westinghouse on site engineer.

Enclosure 2 describes the visit of K. Shembarger, D. McPherson, W. Jensen and M. Ortiz at the ADS testing facility at Casaccia, Italy. The tests are being conducted for Westinghouse on the VAPORE test facility which is operated by ENEA. The facility simulates stages 1, 2 and 3 of ADS for AP600 in full scale. The phase A series which were scoping tests to examine the behavior of

Enclosure

the ADS sparger and IRWST pool under bounding steam flow conditions were completed in December 1992. The facility is currently being modified for the B1 series of tests which will investigate steam and water flow through the valves under expected plant conditions.

Please refer questions to M. Ortiz (208) 526-9488 or W. Jensen (301) 504-2856 who prepared this report.

Walton L. Jensen, Sr. Reactor Engineer
Analytical Support Group

Enclosures:
As stated

cc: M. Virgilio
R. Jones

AP600 SPES-2 TEST PROGRAM - MATRIX TEST #6 INSPECTION REPORT

Introduction

The SPES-2 facility is operated for Westinghouse by SIET. SIET is an Italian research company set up jointly by the Italian national utility (ENEL), and various government and industry groups. SIET operates laboratories inside the "Emilia" power station at Piacenza which contains the SPES-2 facility. SPES-2 is a full height, full pressure, 1/395 scale thermal-hydraulic model of the Westinghouse AP-600 standard nuclear power plant design with passive safeguards. The core for the reference plant is simulated in SPES-2 using 97 electrically heated rods with a nominal operating power of 4.9 MW. The primary circuit, the steam generators and the safety systems (CMT, IRWST, PRHR, ADS and accumulators) are included in the facility. See figure 1.

The test matrix is designed to explore the response of the reference plant to a series of piping breaks of various sizes and locations to provide data for thermal-hydraulic computer codes that will be used in AP600 licensing. Matrix test 6 which we witnessed is designed to put a severe challenge on the passive safety systems. The test simulates the full double ended guillotine break of the division-B DVI line which causes the loss 1/2 of ECCS capability. The A division remains available to provide core cooling.

Pre-test Briefing

On June 9, 1994 (the day before the planned test) K. Shembarger, D. McPherson, M. Ortiz (INEL) and W. Jensen arrived at the test facility. We were briefed by Dr. Medich the director of the facility and Mr. S. Gandolfi the experiment manager on the status of the facility and the upcoming test. Mr. L. Conway the Westinghouse test engineer was present. The facility has experienced considerable difficulty with the thermocouples within the electrically heated simulated reactor core. Of the original array of 80 thermocouples only about a third remain operable. Only two operable thermocouples remain at the top of the heated section. The failure mechanism appears to be vibration during previous testing which caused cracking of the electrical insulation and shorting. Some of the thermocouple strings have been replaced with a design having a smaller wire size and thicker insulation. SIET feels that adequate data can be collected with the remaining operable thermocouples. SPES-2 has been modified to include the most recent changes by Westinghouse to AP600. These include the DVI line venturi, revised ADS logic and removal of the CMT pressure balance line from the pressurizer. In SPES-2 the hot leg pressure balance line has been isolated at each end. Three catch tanks are available to measure discharges from the test rig. One tank collects flow from stages 1, 2 and 3 of ADS. A second tank collects flow from the vessel end of the break which includes the DVI line venturi. The third tank collects flow from the CMT side of the break and the forth stage of ADS. We commented that having more than one source discharge into a single tank will make data separation difficult. The facility also includes turbine flow meters which have proved ineffective in measuring two phase flow rates. Gamma densitometers are also installed which could be used to derive flow from pressure drop data but the gamma densitometers have also proved ineffective.

We viewed pretest predictions of the upcoming test by ANSALDO using RELAP. Some core heatup was predicted but only about 50 deg-F above the starting temperature of about 640 deg-F at the surface of the heater rods. Dr. Ortiz (INEL) stated that he had begun a rough scoping analysis of the upcoming test which also showed core heatup. He did not have current values for orifice and venturi sizes when he set up the model. This information was provided by SIET for future analyses. The electric heater section of the test facility is interlocked to shut off power at a temperature of 600 deg-C to prevent equipment damage in the event excessive core heatup did occur.

An analysis of an earlier test by ANSALDO was presented by Dr. Medich. The predictions for accumulator flow and CMT flow overlay the test data almost exactly. The analysis deviated from the data for a brief time when the accumulators emptied. Discharge of nitrogen accumulator gas briefly caused pressure to increase in the DVI line temporary interrupting CMT flow. Nitrogen gas discharge from the accumulators was not modeled in the RELAP analysis so that the analysis did not show this effect. The time of CMT flow interruption was brief however and was not judged to have a significant effect on the overall prediction. We questioned Mr. Conway as to when SPES-2 data would be generally available. He stated that Westinghouse expected to release quick look reports on the first group of tests within a month. Computer tapes containing a detailed listing of the data will also be made available at that time.

During the briefing, operations staff reported trouble controlling the electric power supply. The problem was stated to be in the upper range above 4 MW. The upper range is used only to pre-heat the facility and in the first few seconds of the test. Power throughout the remainder of the test is controlled by a separate 4 MW power supply which was not experiencing the problem. Dr. Medich believed the problem would not significantly affect the upcoming test since upper level power would not need to be finely controlled but only switched on and off.

Facility tour

The simulated reactor vessel is composed of 41 segments held together with springs and bolts. Each segment is electrically insulated from the adjacent segments to prevent shorting of the heater elements. The segmented arrangement is designed to reduce thermal stresses during rapid temperature changes. Early in the test series failure of two insulation rings produced significant leaks. This problem appears to have been corrected. We were shown the major components, the location of the breaks and the drain lines which are operated locally during facility filling and heatup. Housekeeping appeared to be good. We noted unprotected instrument lines crossing walkways. Some sections of piping insulation appeared to be crushed by using them as a work platform.

A pre-test dry run is done as a matter of procedure. The crew was quite cooperative, for they had already finished the dry-run when we arrived at the control room and repeated it for our benefit. Procedural steps were signed off by the team leader as they were preformed. Operator action is minimized to simple actions such as turning of the pressurizer heaters and isolating steam lines. During the test operators primarily monitor a series of CRT screens giving arrays of data channels. They have two sets of CRT screens:

one in the control room and another in a smaller room aside (for observers like us to be out of the way of the operators). Each CRT can display a preselected array of data channels (digitally, not plots), and this can be changed on the spot by recalling a different pre-establish data display file. On some of the screens, one can actually display more than one window with each having a set of data channels displayed. The SIET operators appeared to be capable and well led.

We visited the PANTHERS SBWR test facility which is under construction in the same area. PANTHERS is a full scale model of two PCCS/ICC heat exchangers. A large view port has been cut in the cooling water tank to provide visual observation of boiling phenomena around the heat exchanger tubes during testing. Construction continued throughout our visit including the time when the SPES-2 Matrix test was underway.

QA briefing

We were briefed in facility QA procedures by A. Musa of SIET. QA operations appear to be thorough and complete and includes facility hardware, personnel qualification, procedures, maintenance and instrument calibration. QA reports are sent directly to the SIET general manager.

We requested to see the record files on instrumentation. Particularly, we picked two instruments (thermocouples) out of the P&ID and were able to locate the instrument documentation (calibration records and history). Each instrument seems to have two assigned tags: The SIET tag and the specific SPES-2 tag.

We also saw the design record files for previous tests. They contain, for each test, test procedures, instrumentation lists, steady state conditions prior to test, and a day of test report that notes deviations from procedures. We were also told that they follow ISO 9000 (international standard).

Test Conduct and Data Recording

Matrix test #6 was initiated at 2:48 pm on June 10, 1994. The following SIET personnel were responsible for operations:

Project Manager	M. Rigamonti
Experiment Manager	S. Gandolfi
SAED Manager	S. Gandolfi
Instrument Manager	A. Visconti
Plant Operator	A. Boiardi
System Facilities	S. Marchesini
"	A. Schiavi
Jolly (trainee)	M. Brigada
"	A. Martini

Additional Westinghouse personnel arrived to witness the test. These were E. Piplica (Test Engineering Manager), R. Nytes (Project Engineer), M. Mahiod (OSU Test Manager) and V. Merritt (Resident Engineer). The test was delayed approximately two hours by an indicated short in the upper range power supply. The short was determined to be in the steel jacketed water cooled bus bar.

Attempts to further locate the short were unsuccessful. Test preparation eventually proceeded anyway. As power was increased the indicated short cleared perhaps from dryout of equipment. As power was increased a small steam leak was observed in the line to the condenser. The CRT screens in the control room began to distort from the magnetic field produced by the high electric current flow. During warmup and pressurization of the test facility the operations staff monitored the required initial test conditions on the CRT screens. Those parameters out of the required range flashed. As the facility was heated and pressured most but not all of the flashed parameters were cleared before the command was given to start the test. With test initiation some steam noise and rumbling was heard in the control room.

One deviation from the expected procedure was a delay in the opening of ADS stage 1. It wasn't clear what caused the delay, but for this test it was estimated that the effect was not nonconservative and probably negligible (Most of the depressurization was happening through the break itself). Some of the required pre-test conditions are unattainable because they are out of the control of the plant: i.e.: the local weather determines the temperature in the CMT and the IRWST, the upper head has no flow from the core and can not be hotter than the cold leg fluid.

The gamma-densitometers output is affected greatly by the magnetic field from the power channel which also distorted the CRT screens in the control room. Discrimination between fluid density and pipe wall density requires accurate calibration of the gamma-densitometers. The output undergoes some processing to extract the magnetic field effect. We were not briefed on what the data processing involves but were told that the gamma-densitometer output is not relied upon.

Future tests

Matrix test #7 is scheduled for June 17. Test #8 which will be a blind test will be in two weeks. Test #10 which will be a SGTR with no operator action will be before the end of July. Test #9 will be later. Tests #11 and 12 will also be blind. Westinghouse suggested that personnel who will do the blind analysis not be present when the test is performed.

Post Test Data Examination

On June 13, 1994 M. Ortiz and W. Jensen met with Dr. Medich and A. Visconti of SIET and V. Merritt of Westinghouse to discuss the test results. The most significant outcome was that no core heatup occurred. All core thermocouples began a downward trend from the beginning of the test that was not interrupted. We compared test initial conditions with those previously established for the test. Most parameters were within specification. IRWST temperature was 27.149 deg-C instead of 25 deg-C max from the specification. One CMT was indicated to be 13.528 deg-C which was apparently caused by a faulty instrument. Upper head temperature was 271.11 deg-C which is below the minimum test specification of 291. deg-C. The following table compares the timing of events in the test with that which should have occurred for the reference plant using design delay times.

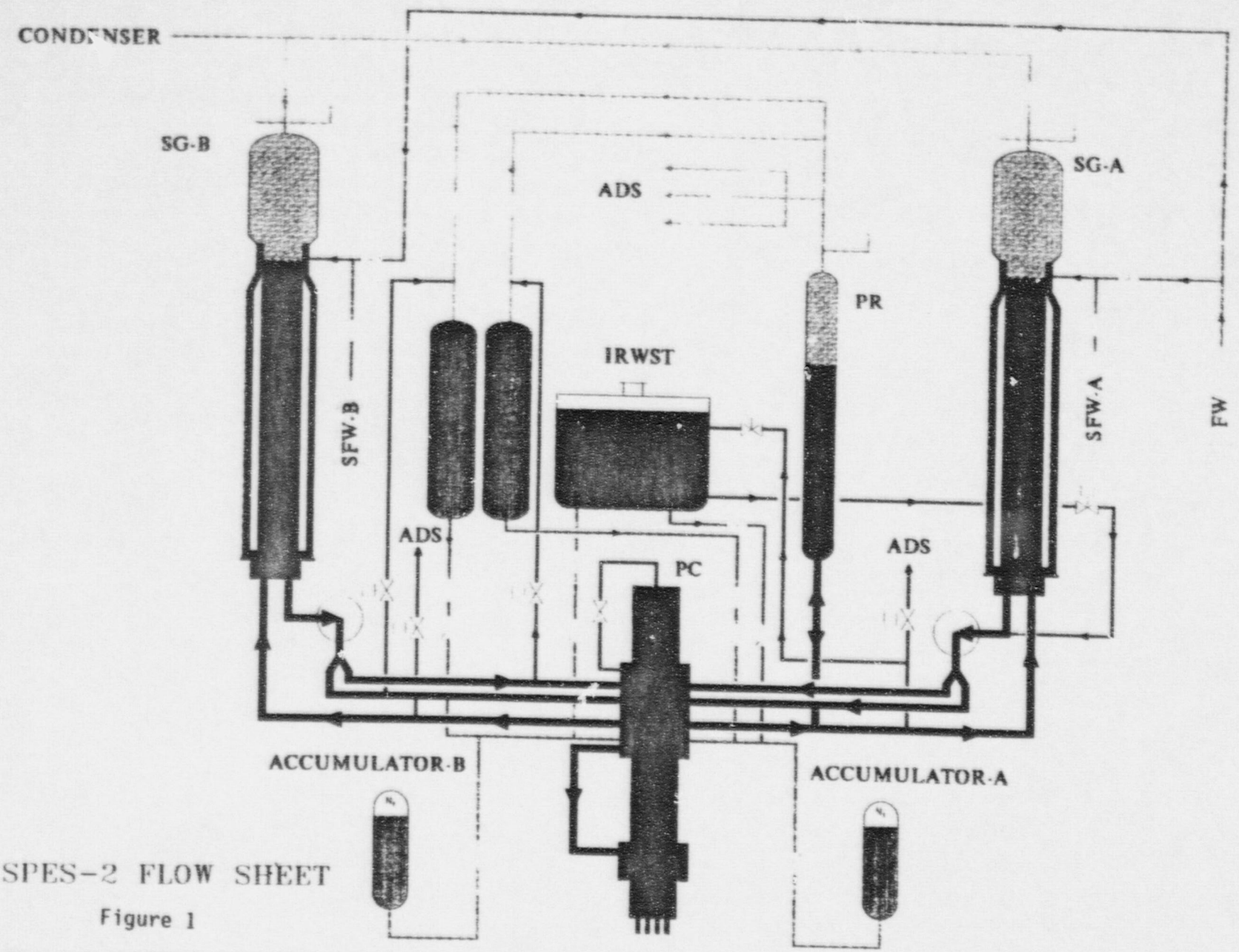
Event	Actual (s)	Reference (s)
Break	0	
RX trip signal	14	
S-signal	17	
Main steam isolation	17	16
MFW isolation	19	18
Scram	20	19.7
Open CMT discharge	20	19
Open PRHR	20	
Trip RCPs	37	33
67% CMT level B	129	
20% CMT level B	200	
ADS-1 open	200	159
ADS-2 open	265	254
ADS-3 open	386	374
ADS-4 open	504	489

SIET will fill out deviation sheets on each discrepancy. These should be investigated by Westinghouse to assess applicability of the test data to AP600.

We reviewed the QA plan specifically as it applied to matrix test #6 with M. Bacchiana of SIET. The plan appeared to be well documented and complete.

General Observations

We left the SIET facility with the impression that Matrix test #6 had been well done, that the data could be utilized to effectively benchmark analytical computer codes and that the results had not uncovered any new or unexpected phenomena. The most significant result appeared to be the absence of core heatup when core heatup had been predicted by RELAP.



SPES-2 FLOW SHEET

Figure 1