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DCP/NRC1030
NSD-NRC-97-5320
Docket No.: STN-52-003

September 12, 1997

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: T. R. QUAY

SUBJECT: COMPLETE NON-PROPRIETARY VERSION OF ENCLOSURE 2 TO WESTINGHOUSE LETTER NSD-NRC-96-4872 (DCP/NRC0649)

REFERENCES:

1. Westinghouse Letter NSD-NRC-96-4872 (DCP/NRC0649).
2. Letter from Diane T. Jackson to Brian A. McIntyre, June 3, 1997, Request for Withholding Information (RAI) from Public Disclosure for Westinghouse AP600 Design Letter of October 30, 1996.

Dear Mr. Quay:

In a letter from Diane T. Jackson to Brian A. McIntyre, June 3, 1997, "Request for Withholding Information (RAI) from Public Disclosure for Westinghouse AP600 Design Letter of October 30, 1996" she indicated that the non-proprietary enclosure provided in reference 1 was incomplete. Non-proprietary versions of several figures and a table were inadvertently omitted. Enclosure 1 of this letter provides a revised copy of the non-proprietary submittal of October 30, 1996.

Please contact Ms. Susan V. Fanto (412)374-4028, if you have any questions concerning this material.

B. A. McIntyre

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

E004 1/1

jml

cc: W. C. Huffman, NRC
N. J. Liparulo, Westinghouse (w/o Attachment)

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ENCLOSURE 1 TO DCP/NRC1030

Question 470.30

Re: pH Control System

Provide the configuration of water volumes and water flow paths in the containment for dissolving and mixing the trisodium phosphate following an DBA.

Response:

The sources of water and boron that can be involved in post accident flooding of the containment include the following:

	Water Volume (max / min ft3)	Boron Concentration (max / min ppm)
RCS (without Pzr)	[ ]^{a,b}	2000 0
Pressurizer	1008 660	2000 0
Core Makeup Tank	2040 2000	3700 3400
Accumulator	1732 1667	2900 2600
IRWST	80000 74500	2900 2600
CVS Boric Acid Tank	8700 0	4375 na

Note that the CVS boric acid tank is a nonsafety-related component and as a result its minimum injected volume is zero. Two bounding combinations of these water sources are shown below. The minimum post accident pH occurs with the maximum amount of water and boron, as shown in the "Min pH" case. The maximum post accident pH occurs with the minimum amount of water and boron, as shown in the "Max pH" case.

	Max pH	Min pH	
Total amount water	5.39×10^6	6.37×10^6	lb
Boron concentration	2474	3007	ppm

The distribution of this water in the containment is described in section 4 of WCAP-1470, WGOTHIC Application to AP600. Note that the final post accident containment water flood level is about the 108' 2" elevation. Since the IRWST bottom is at the 103' elevation, some of the IRWST will not drain. The IRWST has a internal surface area of 2760 ft2; this results in about 14260 ft3 of water remaining in the IRWST.

In the event of a severe accident, the primary mixing mechanism is natural circulation driven by the hot reactor vessel containing the damaged fuel. Water and steam will flow up along the outside of the hot reactor vessel and into the loop compartments. The water carried into the loop compartments will flow through the corridor between the loop compartments past where the TSP baskets are located and down a vertical access tunnel to the reactor vessel compartment. This flow path promotes mixing of the TSP with the water inside the containment.

SSAR Revision: NONE

Question 480.346

Insufficient discussion is given concerning the LST analysis results to permit many conclusions to be drawn as to their significance. A better discussion in terms of the comparisons with experiment or comparisons between the two code versions is needed.

Response:

The report, PCS-GSR-001 (Reference 480.346-1), was documentation of work in progress and was written to provide a status of WGOTHIC code development and a comparison of results between code versions. The LST comparisons shown in PCS-GSR-001 illustrate the differences between the predicted results from WGOTHIC 1.0 and 1.2; they do not validate WGOTHIC 1.2 by comparison to measured data. Because preliminary data were used in PCS-GSR-001 (Reference 480.346-1), comparisons in that report should only be made between the 2 codes and not to the measured data. In addition, the manner in which the convective liquid film thermal transport of the LST exterior water was modeled in WGOTHIC 1.0 skews the comparison between WGOTHIC 1.0 and WGOTHIC 1.2. However, if convective liquid film thermal transport is neglected (either because it is a dry test or by ignoring its affects on the wet tests), WGOTHIC 1.0 predicts a higher pressure than WGOTHIC 1.2.

Code validation for WGOTHIC 1.2 is documented in WCAP-14382 (Reference 480.346-2) and a discussion of deviations from data is discussed in WCAP-14382 and supplemented by the response to RAI 480.390. Phase 2 and 3 of the large scale test program were used to validate the code. Tests from these phases are a more comprehensive set of tests and possess more extensive instrumentation than the baseline tests. The evaluation model is a bounding approach (Reference 480.346-4) consistent with code validation results in WCAP-14382.

The LST comparisons documented in WCAP-13246 (Reference 480.346-3) between WGOTHIC 1.0 predictions and the data were based on preliminary measured data because the final data reduction was not complete. Since that time, the data has been finalized. However, in PCS-GSR-001 the preliminary data continued to be used as input to WGOTHIC 1.2 so that the initial and boundary conditions were identical to those used in WGOTHIC 1.0. This way there was no doubt that a change in the predicted results was due to differences between the two code versions, not due to differences between initial and boundary conditions.

Because the purpose was to do a sensitivity to the code version, the measured temperatures and pressures reported in PCS-GSR-001 are also preliminary data and the same as those reported in WCAP-13246. The preliminary and final data for some key parameters are shown in Table 1. In some cases a difference between the preliminary and final data exists. For this reason, comparison of the predicted results to the preliminary measured data in PCS-GSR-001 is not intended to support code validation. The following discussion provides additional detail on the comparison of code versions. Code validation for WGOTHIC 1.2 is documented in WCAP-14382. WCAP-14382 supersedes WCAP-13246 and PCS-GSR-001.

The vessel pressure predictions for WGOTHIC 1.0 are lower than for WGOTHIC 1.2 for 3 of the 4 tests shown in PCS-GSR-001. This is a result of the method used to account for convective liquid film thermal transport in WGOTHIC 1.0. These 3 tests are wet tests in which up to 50% of the total heat transfer from the vessel is due to subcooling (as discussed in Section 9.2.2 of WCAP-13246). One of the major improvements made to WGOTHIC 1.2 was the capability to model convective liquid film thermal transport of the PCS water. WGOTHIC 1.0 did not have this capability. However, as explained in WCAP-13246 and briefly below, the effect of convective liquid film thermal transport on the heat transfer in WGOTHIC 1.0 was simulated by user input.

In WGOTHIC 1.0 the convective liquid film thermal transport was modeled by using the Uchida correlation to model condensation on the inside of the vessel and by specifying the outer surface temperature of the vessel to be equal to the measured outer surface wall temperature. The inner surface temperature was forced to be equal to the measured inner surface temperature by multiplying the Uchida correlation by a constant, thus forcing the heat flux through the dome to match the measured wall temperature difference. This allowed assessment of the code's ability to predict other measured parameters indicative of important processes for containment heat removal. At the elevation on the vessel surface where convective liquid film thermal transport ended and evaporation began to dominate the external mass transfer, determined from the measured test results, the WGOTHIC mechanistic correlations were used to model the internal and external heat transfer.

In WGOTHIC 1.0 the temperature difference was forced to be the same as the measurements over the vessel dome where subcooling occurred. Obviously, this is not conservative and is the reason WGOTHIC 1.0 does not predict a higher pressure than WGOTHIC 1.2. For the dry test, R7, in which there is no external liquid film and no user input to force the temperature difference through the dome, WGOTHIC 1.0 predicts a higher pressure than WGOTHIC 1.2.

If no user input is used to simulate convective liquid film thermal transport for the wet tests, WGOTHIC 1.0 predicts a higher pressure than WGOTHIC 1.2. In WCAP-13246, the predicted vessel pressure and wall temperatures were shown for Test R11 using WGOTHIC 1.0 without accounting for convective liquid film thermal transport by user input. The results show that the vessel pressure predicted by WGOTHIC 1.0 was 57.8 psia. The vessel pressure predicted for test R11 by WGOTHIC 1.2 (PCS-GSR-001) was 46.20 psia.

References

480.346-1 PCS-GSR-001-R0, "AP600 PCCS Design Basis Analysis Models and Margin Assessment Report", June 30, 1994, Letter NTD-NRC-94-4174.

480.346-2 WCAP-14382, "WGOTHIC Code Description and Validation", May 1995.

480.346-3 WCAP-13246, Westinghouse-GOTHIC: A Computer Code for Analyses of Thermal Hydraulic Transients For Nuclear Plant Containments and Auxiliary Buildings, July 1992.

480.346-4 NTD-NRC-96-4816 (WCAP-14407), "WGOTHIC Application to AP600", September 1996, Tables 2-3 and 2-4.

SSAR Revision: NONE

AP600

a,b

Question 480.390

No discussions are provided in Ref. 3 to address differences between the test results and WGOTHIC results. For example, test 212.1 shows WGOTHIC predicting an increasing pressure while the test data appears fairly constant; and test 214.1 pressure predictions are less than the measured value. To what extent are differences attributed to the water coverage model? Discuss other problems with either the test data or the WGOTHIC analyses that explain the differences between the data and the analyses.

Reference:

3. "WGOTHIC Code Description and Validation," WCAP-14382, May 1995.

Response:

Discussion is provided to address differences between test results and WGOTHIC results throughout Section 8.0 of WCAP-14382 (Reference 480.390-1). Additional discussion follows.

The differences between the test results and the WGOTHIC results are not due to the water coverage model (Reference 480.390-2, Section 7) because the water coverage model is not used for the LST analyses. The measured steady state water coverage is used for the LST WGOTHIC calculations.

Some of the differences between the measured and predicted results are due to uncertainty in the measurements, as discussed below. Nominal, as measured, test boundary and initial conditions, material properties and vessel geometry were used as code input to the WGOTHIC model to isolate the effects of noding and momentum formulation. Noding has been assessed for the evaluation model (Reference 480.390-2, Section 13). The effects of noding and momentum formulation on mixing and stratification predictions was determined (Reference 480.390-2, Section 9). Sufficient data were taken to isolate and quantify competing effects as discussed in response to RAI 480.282.

After the impact of noding, momentum formulation, and competing effects is assessed, it can be determined that the differences between the measured and predicted results from both the distributed parameter and lumped parameter models can be attributed to one or a combination of the following items:

1. uncertainty in the measured steam flow rate at lower flow rates
2. effect of variability in the measured PCS water flow rate on the vessel water coverage
3. lack of measured data on the transient vessel water coverage
4. predicting continuous overmixing of noncondensibles in the vessel

The largest measurement uncertainty is the transient water coverage and transient steam flow rate. The LST water coverage was typically measured only during the start of the test and at steady states. The water coverage used in the code was based on these measurements. In reality, the water coverage varies in response to test and environmental conditions; however, it is simply modeled as a step change.

The Phase 2 and 3 priority large scale tests, defined in Section 7.0 of WCAP-14382, as well as non-priority tests were modelled with both a distributed parameter model and a lumped parameter model. The distributed parameter model more accurately predicts the test results than the conservatively biased lumped parameter model as discussed below and in Section 6.3.2 of Reference 480.390-1.

Distributed Parameter Model

The distributed parameter model discussed in Appendix A of WCAP-14382 established that detailed noding in the regions of the highest gradients results in good agreement between measured and predicted results, as shown for several local and global parameters in Appendix A. Noding studies were performed to the model in Appendix A and are discussed in Section 5 of WCAP-14382. The purpose of the noding studies was to develop a model with less nodes without distorting the flow field. Reducing the number of nodes reduces the run time and model set-up time. The noding for the resulting distributed parameter model is discussed in Section 6.0 of WCAP-14382. The test calculations for this model are compared to the measurements in Section 8.0 of WCAP-14382.

Although the developed distributed parameter model (Section 6.0 of WCAP-14382) is not as detailed as the model in Appendix A, it provides a reasonably accurate and detailed resolution of the velocity and noncondensible distributions within the LST. The results from both models for tests 212.1 and 222.1 are given in Appendix A and Section 8.0 for comparison.

Test 212.1

The distributed parameter predictions and test data results show that the vessel pressure is steadily increasing. However, the vessel pressure predicted by the distributed parameter increases faster than the measured vessel pressure (but slower than the lumped parameter pressure prediction).

This trend in the prediction is due to continuous mixing of noncondensibles in the vessel resulting in less steam above the deck where the PCS heat removal is most effective. Both the code and the experiments show that the partial pressure of air below the deck decreases with time (Figures 8-20 through 8-22 in WCAP-14382). However, the distributed parameter model predicts the mixing to occur at a faster rate than the measured results. As the noncondensibles continuously increase in concentration above the deck, there is less heat and mass transfer and the predicted vessel pressure increases.

Test 214.1

For test 214.1A, the distributed parameter vessel pressure is underpredicted by 2%. As stated above, the distributed parameter model is a more accurate representation of the LST than the lumped parameter model. The distributed parameter model is not conservatively biased and is expected to slightly overpredict or underpredict the vessel pressure due to uncertainties.

Noncondensible measurements were not taken for this test. Therefore the effect overmixing may have on the predictions can not be determined. However, the code predictions show that the air pressure ratio below the operating deck continues to decrease with time as the vessel pressure in test 214.1B increases.

Test 216.1

The measured and predicted results are in agreement for the distributed parameter model.

Test 219.1

Beginning at 1400 seconds and continuing until approximately 3000 seconds, there is a noticeable increase in the predicted vessel pressure that is not evident in the measured pressure. This is due to the uncertainty source in the steam flow rate measured by the vortex meter.

Test 219.1 was a constant steam flow rate test that proceeded with no operator changes to the steam flow rate. In spite of this, at 1400 seconds the vortex meter indicates the steam flow rate increased by a factor of 4 (from 0.03 lb/s to 0.12 lb/s). However, the measured vessel pressure does not show an increase. The vortex meter is below its operating range for the first 1,400 seconds. There is uncertainty as to the magnitude of steam flow rate increase at 1,400 seconds. This anomaly in flow rate may be due to two phase flow during the initial steam measurments, with uncertainty reduced after 1400 seconds with superheated steam..

During 219.1B the predicted vessel pressure increases at a faster rate than the measurements. This is due to the WGOTHIC models continuously mixing and pushing more air above the operating deck resulting in heat and mass transfer that decrease with time and a vessel pressure that increases with time.

During 219.1C, the distributed parameter vessel pressure is overpredicted. This is attributed to a lack of measured data on the transient vessel water coverage. When water is injected onto the exterior vessel shell at 34,044 seconds, the measured water flow rate is highly oscillatory until approximately 36,000 seconds. During this oscillation the measured water flow rate varies from 0.14 lb/s to 0.64 lb/sec. Beyond 36,000 seconds the oscillations decrease and the water flow rate varies from 0.49 lb/s to 0.61 lb/s. The oscillations in the LST water flow rate can cause significant changes in the vessel water coverage. These changes in water coverage were not measured or accounted for in the WGOTHIC model. An evaluation of the oscillations and their effect on water coverage is discussed in Section 7.A.6 of Reference 480.390-2.

Test 222.1

The primary reason for the differences between the measured and predicted results is due to uncertainties in the vortex meter steam flow measurement while the flow meter is near its lower range. Differences between the measured and distributed parameter predicted results are discussed in detail on p. 8-2 and 8-3 of WCAP-14382.

Lumped Parameter Model

Velocity and steam concentration are two dominant parameters in the mass transfer correlation and are competing effects in the lumped parameter model. The lumped parameter model overmixes noncondensibles from below the steam jet/plume, and the noncondensibles above the operating deck lead to underpredicted steam concentrations which penalize PCS heat removal. The overpredicted velocities enhance the PCS heat removal. These are compensating errors of about the same magnitude in the lumped parameter code calculation. Sufficient instrumentation has been used in the LST to quantify these competing effects (Reference response to RAI 480.282).

These results have been factored into the lumped parameter model (Section 5.3 and 6.3.2 of WCAP-14382) by using only the free convection correlation for heat transfer from containment to the inside vessel wall. The use of free convection in the lumped parameter model eliminates the effects of calculated velocities and results in a conservative pressure prediction.

Test 212.1

Although the magnitude of the differences between the measurements and the distributed model predictions, and between the measurements, and the lumped parameter model predictions may vary, the reasons for the differences are the same as discussed above for distributed parameter.

The lumped parameter results and test data results show that the vessel pressure is steadily increasing. However, the vessel pressure predicted by the lumped parameter model increases faster than the measured vessel pressure (and faster than the distributed model vessel pressure prediction).

This trend in the predictions is due to continuous mixing of noncondensibles in the vessel resulting in less steam above the deck where the PCS heat removal is most effective. Both the code and the experiments show that the partial pressure of air below the deck decreases with time. However, the lumped parameter model predicts the mixing to occur at a faster rate than the measured results. As the noncondensibles continuously increase in concentration above the deck, there is less heat and mass transfer and the predicted vessel pressure increases.

Test 214.1

The lumped parameter vessel pressure is overpredicted. The step change in predicted vessel pressure at 3,000 seconds (shown in Figure 8-73) is due to a step change in the water coverage input into the code. As stated earlier, the water coverage was only measured at steady-state portions of the test and the water coverage is modeled as a step change.

Noncondensible measurements were not taken for this test. Therefore the effect overmixing may have on the predictions can not be determined. However, the code predictions show that the air pressure ratio below the operating deck continues to decrease with time as the vessel pressure in test 214.1B increases.

Test 216.1

Overmixing occurs between the upper and lower compartments. The concentration of steam above the operating deck continuously decreases, resulting in the increasing pressure trend.

Test 219.1

Although the extent of the differences between the measurements and the distributed model predictions, and between the measurements and the lumped parameter model predictions may vary, the reasons for the differences are the same.

Beginning at 1400 seconds and continuing until approximately 3000 seconds, there is a noticeable increase in the predicted vessel pressure that is not evident in the measured pressure. This is due to the uncertainty source in the steam flow rate measured by the vortex meter during the initial vessel pressurization, as stated above in the distributed parameter model discussion.

During 219.1B the predicted vessel pressure is increasing at a faster rate than the measurements. This is due to the WGOTHIC model continuously mixing and pushing more air above the operating deck resulting in heat and mass transfer that decrease with time and a vessel pressure that increases with time.

The vessel pressure for test 219.1C is overpredicted by the lumped parameter model due to its conservative bias and the uncertainty in the water coverage due to fluctuations in the initial delivered flow as discussed above for the distributed parameter predictions.

Test 222.1

The primary reason for the differences between the measured and predicted results is due to uncertainties in the vortex meter steam flow measurement at lower steam flows. Differences between the measured and lumped parameter predicted results are discussed on p. 8-9 of WCAP-14382.

Test 222.4

Only the lumped parameter model was used to predict the results of test 222.4. As expected, the vessel pressure is overpredicted because the forced convection heat transfer along the inside vessel wall induced by the high velocity jet is neglected in the model. These results are discussed in more detail on p. 8-10 of WCAP-14382.

Measurement uncertainties and predictions of continuous overmixing of noncondensibles above the deck are the dominate contributors to the differences between the measured and predicted results. The distributed parameter model mixes the containment at a slower rate than the lumped parameter model, but at a faster rate than the measurements.

The lumped parameter model (with only free convection to model heat and mass transfer inside the vessel) is the basis for the evaluation model for the AP600 containment analysis. It is recognized that the lumped parameter model oversimplifies the calculation for entrainment into plumes or jets, and when detailed distributions within a volume exist. For heat and mass transferred primarily by the PCS, overmixing is conservative. For shorter times when the internals are significant heat sinks, heat sink input in the evaluation model is biased to ensure conservative pressure predictions (as discussed in Reference 480.390-2, Section 9). Methods by which the AP600 evaluation model is biased for mixing and stratification and other phenomena have been provided in Reference 480.390-2, Table 2-3 and 2-4.

References

480.390-1 WCAP-14382, "WGOTHIC Code Description and Validation", May 1995.

480.390-2 NSD-NRC-96-4816, WCAP-14407, "WGOTHIC Applications to AP600", September 1996.

SSAR Revision: NONE

Question 480.391

In Ref. 3, the results of the blind test are provided. The distributed parameter model under predicts the early pressure response. To what extent are differences attributed to the water coverage model? To what extent are differences attributed to not knowing the test boundary condition for the inlet steam? Since the blind test required that the test actual be run and resulting data be used to establish boundary conditions for the analysis, justify it's use as a blind test in the validation and verification of WGOTHIC. What would be the consequence of not having a blind test as part of the WGOTHIC validation and verification?

Reference:

3. "WGOTHIC Code Description and Validation", WCAP-14382, May 1995.

Response:

Question 480.391(a.)
Distributed Parameter under predicts early pressure response
Extent of differences due to water coverage model
Extent of differences due to not knowing the test boundary condition for the inlet steam

The distributed parameter model accurately predicts the initial pressure rise (Figure B.7 of Reference 480.391-2). It is not until the steam flow rate decreases, after the initial steam flow peak, that the differences between measured and predicted pressures emerge.

This underprediction of the vessel pressure is due to the ambiguity of the steam flow rate measurements. However, the extent of the underprediction due to steam flow rate can not be quantified. The underprediction of vessel pressure is not due to the water coverage model, which is used to predict coverage on the AP600, because the water coverage model (Reference 480.391-1) is not used for LST predictions. The measured water coverage is used for the LST calculations.

The water coverage was measured at three times during the test: at the start of the tests (100% coverage), ten minutes after the steam was introduced into the vessel (89% coverage), and at steady-state (85% coverage). The water coverage used in the code was based on these measurements. In reality, the water coverage varies in response to test and environmental conditions; however, it is simply modeled as a step change. Neglecting the transient change in water coverage has a smaller effect on the predicted results than the steam flow rate.

In the LST Final Data Report (Reference 480.391-3, p. 4-142), it was stated that the vortex steam meter was consistently reading 15% - 20% lower than the condensate flow measurements at steady-state. The reason for the difference, as discussed in Reference 480.391-3, is because the vortex flow meter is operating at the lower end of its range where the meter's inaccuracy is heightened. During thix steady-state period, the vortex meter was reading flow rates less than 0.7 lb/s.

The condensate flow measurements are considered more reliable. For this reason, the time-averaged condensate flow rate was used as code input during steady-state (i.e. after 6950 seconds).

Condensate flow measurements cannot be obtained during the initial transient (from 5741 seconds to 6950 seconds). However, after the initial 25 second steam blow down (from 5741 seconds to 5766 seconds), there are time periods between 5766 seconds and 6950 seconds when the steam flow rate drops to values below or near 0.7 lb/s. Therefore, it is reasonable to expect that the vortex meter may have been reading the same order of magnitude (15% - 20%) below the actual steam flow rate during the time interval of 5766 seconds to 6950 seconds.

Because there was no way to prove that the vortex meter was reading lower flow rates than actual steam flow rates, the steam flow rate from the vortex meter from 5766 seconds to 6950 seconds was not modified to account for the 15% - 20% bias except to set the steam flow rate to 0.45 lb/s (the minimum value in the vortex meter's operating range) when the vortex meter fell below its range (Reference 480.391-2, Section B.4). This occurred primarily between 5860 seconds and 5900 seconds and between 6400 seconds and 6600 seconds. But even with this modification, the steam flow rate input into the code is postulated to be too low and the cause for the underprediction in vessel pressure during the early part of the test.

Question 480.391(b.)

Since the blind test required that the test actual be run and resulting data be used to establish boundary conditions for the analysis, justify its use as a blind test in the validation and verification of WGOTHIC.

For a single-blind test, the test is run and the measured boundary and initial conditions are used for code input. These data are the independent test variables such as ambient conditions, PCS water flow rate and coverage, and steam flow rate into the vessel. All other measured data are withheld from the code analyst until the pretest code prediction is complete and the results are documented. These data are the dependent test variables such as vessel temperature and pressure. The blind LST is a single-blind test. To meet the blind test objective, the same parameters used as boundary and initial conditions for the priority tests are used to model the blind test.

The objective of the blind LST is to show that the models used in WGOTHIC are not adjusted for each specific test. The WGOTHIC input decks used for the blind test are the same decks used for the priority tests with only the initial and boundary conditions modified. The specific initial and boundary conditions required to define the model are listed in Section 6.1 of WCAP-14382.

Question 480.391(c.)

What would be the consequence of not having a blind test as part of the WGOTHIC validation and verification?

There would be no consequence of not having the blind test as part of the WGOTHIC validation and verification.

A set of priority tests for WGOTHIC validation was chosen, as discussed in Section 7.0 of WCAP-14382. These tests cover a range of parameters with special attention placed on the parameters that have the largest effect on vessel pressure. They also address the important phenomena as identified in the PIRT.

The blind test, test number 220.1, is not included in the priority tests and does not address any phenomena that is not already covered by one of the priority tests. The objective of the blind test is to show that the modeling approach does not require test specific tuning, not to further validate the code.

SSAR Revision: NONE

References

480.391-1 NSD-NRC-96-4816, "WGOTHIC Application to AP600", September 1996, Section 7.

480.391-2 WCAP-14382, "WGOTHIC Code Description and Validation", May 1995.

480.391-3 WCAP-14135, "Final Data Report for PCS Large Scale Tests, Phase 2 and 3", July 1994.

Question 480.392

If Ref. 3, air pressure ratios for test 212.1A, -B, and -C, 216.1A and -B, 219.1A, -B, and -C, and 221.1 are compared (test to predicted). For test 219.1B and -C, helium pressure ratios are also compared. These data are plotted as fixed points without uncertainty. Provide the uncertainty bands for the measured values. For the measured values, uncertainties relate to, in part, the uncertainty in pressure and temperature measurements of the captured gas samples, and taking multiple samples, as well as other uncertainties in analyzing the gas samples. For the predicted values, provide a discussion of how the plotted points are determined. If uncertainty is included in this determination (for example extrapolation of a test measurement for comparison) then include the appropriate uncertainty band on the predicted values as well. Once uncertainty is included, would any conclusions regarding non-condensible distributions, mixing or stratification be altered? Explain.

Reference:

3. "WGOTHIC Code Description and Validation," WCAP-14382, May 1995.

Response:

The uncertainty for the non-condensible measurement is calculated in Reference 480.392-1. It includes the uncertainty from the captured gas sample's pressure and temperature measurements. Taking multiple samples within a short time period increases the confidence in the measurements and does not contribute to the calculated uncertainty. Total sample volume removed from vessel has an insignificant effect on vessel inventory. The helium concentration in the non-condensible samples was determined via gas chromatography. The uncertainty associated with this analysis is minimal and is not included in the calculated uncertainty.

The uncertainty bands for the measured non-condensible values are shown in Figures 480.392-1 through 480.392-9.

For the predicted values, provide a discussion of how the plotted points are determined. If uncertainty is include in this determination (for example extrapolation of a test measurement for comparison) then include the appropriate uncertainty band on the predicted values as well.

The plotted predicted non-condensible pressure ratios are instantaneous values extracted from the WGOTHIC output at the same time that the measured non-condensible values were taken. The non-condensible prediction is taken from the node that corresponds to the measurement location. The predicted non-condensible pressure ratio is the predicted non-condensible partial pressure divided by the predicted total vessel pressure. No uncertainties have been determined for the predicted values.

Once uncertainty is included, would any conclusions regarding non-condensible distribution, mixing or stratification be altered? Explain.

The conclusions regarding mixing or stratification are not altered due to uncertainties. As shown in Figures 480.392-1 through 480.392-9, the uncertainties do not change the relationship between the measured and predicted values.

Reference

480.392-1 WCAP-14135, "Final Data Report for PCS Large-Scale Tests, Phase 2 and 3", Appendix B, Section B.7.

SSAR Revision: NONE

The following figures contain proprietary test data and have been removed from this document:

Figure 480.392-1	Measured and Distributed Parameter Predicted Air Pressure Ratios for Test 212.1A
Figure 480.392-2	Measured and Distributed Parameter Predicted Air Pressure Ratios for Test 212.1B
Figure 480.392-3	Measured and Distributed Parameter Predicted Air Pressure Ratios for Test 212.1C
Figure 480.392-4	Measured and Distributed Parameter Predicted Air Pressure Ratios for Test 216.1A
Figure 480.392-5	Measured and Distributed Parameter Predicted Air Pressure Ratios for Test 216.1B
Figure 480.392-6	Measured and Distributed Parameter Predicted Non-Condensible Pressure Ratios for Test 219.1A
Figure 480.392-7	Measured and Distributed Parameter Predicted Non-Condensible Pressure Ratios for Test 219.1B
Figure 480.392-8	Measured and Distributed Parameter Predicted Non-Condensible Pressure Ratios for Test 219.1C
Figure 480.392-9	Measured and Distributed Parameter Predicted Air Pressure Ratios for Test 221.1

Question 480.394

For the blind test, two analyses are presented. One for the distributed parameter model and one for the lumped parameter model. Explain the difference between the two results for the initial pressure response. Why does the lumped parameter model perform better than the distributed parameter model during the early part of the analyses? Why do both analyses underpredict the initial pressure rise?

Reference:

3. "WGOTHIC Code Description and Validation," WCAP-14382, May 1995.

Response:

The initial pressure response for measured, distributed parameter, and lumped parameter are shown in Figure 480.394-1. Both models accurately predict the measured vessel pressure during the initial pressure rise. It is not until the steam flow rate decreases, after the initial steam flow peak, that differences between the three cases emerge. The initial pressurization is dependent on the vessel volume; it is not impacted by noding or momentum formulation.

As discussed in response to RAI 480.391, there is evidence that the vortex meter may be reading 15% - 20% below the actual steam flow rate between 5766 seconds and 6950 seconds. This causes the distributed parameter model to start underpredicting the vessel pressure after the initial steam blow down.

Comparisons between the lumped parameter model and pressure predictions from the Phase 2 and 3 LST show that the lumped parameter model consistently overpredicts vessel pressure (see Figure 480.394-2). This is due to conservatisms factored into the lumped parameter model, as discussed in Section 6.3.2 of WCAP-14382 and response to RAI 480.282.

Since the lumped parameter model over-predicts the vessel pressure when an accurate steam flow rate is used (Figure 480.394-2), when a low steam flow rate is used, as is the case in the blind test between 5766 seconds and 6950 seconds, the vessel pressure matches the measured pressure.

Comparisons between the distributed parameter model and pressure predictions from Phase 2 and 3 LST show that the distributed parameter model consistently predicts more nominal pressures (Figure 480.394-3). Therefore, when a low steam flow rate is used for the blind test between 5766 seconds and 6950 seconds, the predicted steam flow rate is lower than the measured steam flow rate.

SSAR Revision: NONE

The following figures contain proprietary test data and have been removed from this document:

Figure 480.394-1	Measured, Lumped Parameter and Distributed Parameter Vessel Pressure
Figure 480.394-2	LST Lumped Parameter Predicted Versus Measured Steady-State Vessel Pressure
Figure 480.394-3	LST Distributed Parameter Predicted Versus Measured Steady-State Vessel Pressure