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ESTABLISH THE COOLING LIQUID AT A MINIMUM LEVEL

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7. Abstract

This report presents the computer simulations used to evaluate whether tank 241-C-106 can be operated at new lower operating liquid levels without significant reduction in the heat removal capability of the tank ventilation system. It is concluded that if the tank is operated with the liquid level between 72 and 74 in. the evaporation of the tank will be similar to what it is for the current operating level of 75 to 79 in. Analyses predict that for both operating limits voids will form during the summer months and disappear during the winter months. The waste temperatures for both operating limits will be close to the same. Installation of a chiller can maintain the highest waste temperatures below the saturation temperature (i.e., no voids will form) year round provided 67% of the original pool surface area is maintained for evaporation.

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**TANK 241-C-106 THERMAL HYDRAULIC ANALYSIS
TO ESTABLISH THE COOLING LIQUID AT A MINIMUM LEVEL**

EXECUTIVE SUMMARY

Tank 241-C-106 is a High-Heat Watch List tank. Until sufficient waste is retrieved from this tank, the waste must be cooled to prevent overheating that could damage the structural integrity of the tank. Currently, the waste is being cooled primarily by evaporation, with an operating liquid level nominally between 190 and 200 cm, in conjunction with forced ventilation. A process test was conducted in which additions of cooling water were stopped. The purpose of the test was to determine the minimum amount of water required for cooling and to define new, lower operating liquid levels in the tank in case of a leak. If the tank were to leak, the new safe operating envelope would minimize the environmental impact and establish a lower minimum operating level.

The process test was initiated on March 10, 1994. The test ended June 15, 1994, after approximately 18 cm of water on top of the waste was allowed to evaporate. The crust that is above the waste sludge, but normally covered with a liquid pool, was partially exposed. Water additions resumed on June 17, 1994, and subsequently the crust was covered with liquid. A process test report was issued (Bander 1995) that summarizes the data collected and the thermal analyses conducted to explain the results of the process test.

To evaluate whether the tank can be operated at new, lower operating liquid levels, additional computer analyses were conducted using the models developed for the process test analyses. The primary purpose of these

additional analyses, which are reported here, is to evaluate what liquid levels the tank can be operated at without a significant reduction in the heat removal capability of the tank ventilation system. The analyses also evaluate differences in waste temperatures and saturation zone sizes compared to the analyses performed when the crust was uncovered during the process test.

Tank 241-C-106 can be operated at the reduced liquid level range between 183 and 188 cm (72 and 74 in.) with little effect on the heat removal capacity of the ventilation system. Waste temperatures will remain close to those for the current operating liquid levels, and evaporation rates will be similar. Voids will continue to form in the bottom of the tank (in the saturation zone) during the summer and disappear in the winter, as is the case for the current operating liquid levels. This voided zone is estimated to be smaller than the voided region observed during the process test.

Installation of a chiller will maintain the highest waste temperature at the bottom of the tank to at least 2 to 3 °C (4 to 5 °F) below the local saturation temperature, provided that at least 67 percent of the original pool surface area is maintained for evaporation.

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LIST OF TERMS

FIC
GOTHIC

Food Instrument Corporation
Generation of Thermal-Hydraulic Information for
Containment

TC
TMACS
Tri-Party Agreement

Thermocouple
Tank Monitor and Control System
*Hanford Federal Facility Agreement and
Consent Order*

1.0 INTRODUCTION

Tank 241-C-106 is a High-Heat Watch List Tank. Until sufficient waste is retrieved from this tank, the waste must be cooled to prevent overheating that could damage the structural integrity of the tank. Currently, the waste is being cooled primarily by evaporation in conjunction with forced ventilation. Cooling by evaporation is accomplished through the addition of approximately 23,000 liters (L) (6,000 gallons [gal]) of water each month to maintain a layer of water above the waste surface.

Milestone M-40-05 of the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) (Ecology et al. 1994) specified that a safety alternative test was to be conducted in high-heat tank 241-C-106 in which additions of cooling water would be stopped. The purpose of the test was to determine the minimum amount of water required for cooling and to define new, lower operating liquid levels in the tank in case of a leak. If the tank were to leak, the new safe operating envelope would minimize the environmental impact and establish a lower minimum operating level.

The process test was initiated on March 10, 1994 in accordance with WHC-SD-WM-PTP-026, *Process Test Plan: Tank 241-C-106* (Sutey 1993) and Process Memo 94-018 (Alstad 1994). Water additions to the tank were temporarily discontinued to allow the liquid level to decrease through evaporation, at a rate of approximately 5 to 8 centimeters (cm) (2 to 3 inches [in.]) or 20,800 to 31,400 L (5,500 to 8,300 gal) per month. The test ended June 15, 1994, after approximately 18 cm (7 in.) of water on top of the waste was allowed to evaporate. The crust, which is above the waste sludge but normally covered with a liquid pool, was partially exposed. Water additions resumed on June 17, 1994, and subsequently the crust was covered with liquid.

During and following the process test, the thermocouples on the thermocouple tree in riser No. 14 began to indicate significantly higher temperatures in the sludge than the low temperatures typically observed at this location. The thermocouples on the thermocouple tree in riser No. 8, during this same time period, indicated temperature variations consistent with normal seasonal effects. The tank 241-C-106 process test report (Bander 1995) summarizes the analyses that were conducted to understand the phenomena causing the temperature history at riser No. 14.

To evaluate whether the tank can be operated at new lower operating liquid levels, computer analyses were conducted using the models developed for the process test analyses. The primary purpose of the analyses was to evaluate what liquid levels the tank can be operated at without a significant reduction in the heat removal capability of the tank ventilation system. The analyses also evaluated differences in waste temperatures and saturation zone sizes compared to the analyses performed when the crust was uncovered during the process test.

2.0 LIQUID SURFACE LEVEL MEASUREMENTS

Instrumentation for liquid surface level measurements consist of a Food Instrument Corporation (FIC) liquid-level gauge mounted in riser No. 1 and an ENRAF liquid-level gauge mounted in riser No. 7 (Figure 2-1). In 1994 all the liquid-level instruments were connected to the Tank Monitor and Control System (TMACS), which makes continuous monitoring possible. The FIC gauge has been recording data since 1981 and the more sensitive ENRAF gauge has been recording since October 1994. The ENRAF gauge has a manufacturer-reported accuracy of ± 0.10 cm (0.04 in.) under ideal conditions.

The FIC gauge has an accuracy of ± 0.25 cm (0.1 in.) under ideal conditions. Actual field experience indicates errors can be significantly higher due to riser elevation errors and the condition of the local FIC gauge. Waste buildup on the FIC probe can also adversely affect the accuracy of the liquid-level readings at any given point in time. A measurement precision of ± 0.63 cm (0.25 in.) was empirically established for the FIC with a specification limit of ± 1.3 cm (0.50 in.) (Schofield 1994).

The operating liquid level since 1981 has been nominally between 190 and 200 cm (75 and 79 in.), although on rare occasions the level has dropped to 189 cm (74.5 in.). Figure 2-2 shows the liquid surface level as measured by the FIC gauge from 1981 through 1988. The height reported is measured in inches from the knuckle of the tank which, due to the dished bottom of the tank, is 30.5 cm (12 in.) above the bottom center of the tank. The data were taken on a weekly basis during this time period. Figure 2-3 shows the liquid surface level as measured by the FIC and ENRAF gauges from 1989 through July 1995. These data were taken on a daily basis beginning the middle of 1989. The ventilation system was not operating towards the end of 1990 for about one month and at the beginning of 1992 for about 4 1/2 months. These outages (labeled in Figure 2-3) are reflected by surface level rises. The surface level during the process test is also labeled. Analyses of the surface level data (Crea and Bander 1994) show that the addition of water initially suppresses the evaporation rate to about half of the long-term rate for about 1 to 2 weeks. This can be observed in Figure 2-3 by the change in slope of the surface level data. There is also a seasonal effect (Barrington 1995) that shows more evaporation toward the end of summer and less evaporation toward the end of winter.

Videos were taken inside the tank during and after the process test. The first videos were taken on April 22, 1994, when the tank liquid level was 183.4 cm (72.2 in.). Two tank risers on opposite sides of the tank were used. This configuration allowed examination of the entire waste surface, the waste-tank wall interface, the FIC plummet, existing in-tank equipment, tank walls, and the underside of the dome. This set of videos showed that the layer of crust above the solid waste, formed from precipitation of minerals in the river water additions, was exposed all the way around the tank for about 60 cm (2 feet [ft]) away from the wall. The liquid pond extended over the remainder of the tank.

Figure 2-1. Riser Locations for Tank 241-C-106.

241-C Farm Layout

241-C-106

No.	Dia.	Elev.	Description and Comments
1	4"	646.15	FIC, BM
2	12"	646.18	Exhauster Riser
3	12"	647.24	Lead Covered WC
4	4"		Recirculating Dip Leg WC
5	4"		Recirculating Dip Leg WC
6	12"	646.01	Sluicing Access/Flange
7	12"	646.48	OBSV Port/Press. Gauge
8	4"	645.66	B-221 Temperature Probe
9	42"		Sludge Pump
13	26"		Distributor Jet WC
14	4"	645.5	Temperature Probe
15	12"		Air Inlet Filter

Legend:

- 3 1/2 in. circle is tank outline
- Risers
- 42"
- 12" in proportion to size
- 4
- 1, 2, 3, etc. Riser number - may not agree with field ID
- Various size rectangles are pits - may have label
- Double rectangle indicates weather covered pit unless otherwise identified.
- Calsson (USU 72" dia.) - covered
- A 42" manhole at dome top - no riser to surface
- or

29210056.5

Figure 2-2. Historical FIC Liquid Surface Level Data (1981 through 1988).

Figure 2-3. Historical FIC Liquid Surface Level Data (1989 through July 1995).

3.0 TEMPERATURE MEASUREMENTS

Temperature measurements are obtained from two thermocouple (TC) trees mounted in riser No. 8 (tree No. 1) and riser No. 14 (tree No. 2). In 1994 the temperature instruments were connected to the TMACS, which makes continuous monitoring possible. Figure 3-1 shows the TC data in riser No. 8 and No. 14 for TCs 1, 2, and 3, numbering from the bottom of the tree, for 1993 through July 1995. Data were collected weekly before April 1994 and subsequently on a daily basis. The water additions during this period are shown by plotting the surface level, scaled to fit on the figure. The periodic increases in temperatures in riser No. 14 are caused by the water additions as can be seen by comparing the level data curve with the TC curves for riser No. 14. A convective gap closure model (Thurgood et al. 1995) was developed for simulating the oscillating temperatures at the TC tree in riser No. 14.

Following the process test, TCs on the tree in riser No. 14, which is located midway between the center of the tank and the tank wall, began to indicate significantly higher temperatures in the waste sludge than the typically low temperatures observed at this location. This is illustrated in Figure 3-1. Temperatures increased at the bottom TC in riser No. 14 from about 51.7 to 102.8 °C (125 to 217 °F) following the process test. Temperatures at the TCs in riser No. 8, which is near the tank wall, became only slightly elevated during 1994, relative to seasonal norms as illustrated in Figure 3-1. This can be accounted for by the above-average summer temperatures in 1994.

Several liquid-filled potholes in the crust and around the TC trees were observed in the videos taken at the end of the process test. It is postulated that a convective cooling gap may exist between the TC tree in riser No. 14 and the surrounding sludge. This gap may have closed during the process test as a result of the expansion of the saturation zone in the center of the tank. This would result in the TCs measuring the temperature of the sludge that had previously been at some radial distance from the TC tree. The annular gap would not have to be as large as the potholes observed to provide cooling and could be on the order of 0.2 cm thick (Eyler 1995) or smaller.

Figure 3-1. Measured Temperatures in Tank 241-C-106,
Riser No. 8 and No. 14
(TCs 1, 2, and 3, January 1993 through July 1995).

4.0 SIMULATION OF PROCESS TEST

A two-dimensional (2-D) model of tank 241-C-106 was developed using the GOTH computer code (Thurgood et al. 1995). GOTH is based on the GOTHIC (Generation of Thermal-Hydraulic Information for Containment) computer code (Thurgood 1992 and George 1993). GOTHIC is a general-purpose thermal-hydraulics computer program for design, licensing, safety, and operating analysis of nuclear power plant containments and other confinement buildings.

The GOTH 2-D model consists of the tank, the inlet and outlet ventilation gas flows, and the soil beneath, to the side, and above the tank. The soil surface temperature is assumed to be at, and varies with, the ambient air temperature. The groundwater temperature 61 m (200 ft) below grade is assumed to be fixed at 12.8 °C (55 °F). The nodalization used in the tank and soil is provided in Figures 4-1 and 4-2. The model uses the measured ventilation data and the water addition data as input. The model allows for the formation of voids when the temperature of the sludge reaches the saturation temperature, which is estimated to be 109 °C (228 °F) at the bottom of the tank (Bander and Crea 1994).

Figure 4-3 shows a comparison between the measured FIC and calculated liquid surface level when no voids are allowed to form. The measured water addition data were used as input for increasing the volume of liquid in the tank. The flat portion of the measured data at a level of 176.5 cm (69.5 in.) is due to the FIC plummet resting on some abandoned material, as observed in the video taken on June 15, 1994. The model simulates the liquid surface as it would decrease due to evaporation of liquid. Note there is a discrepancy of 5 to 7.5 cm (2 to 3 in.) at the end of the process test between measured and calculated liquid surface level. Also note that the discrepancy goes away in about five months, indicating that the steam in the sludge had condensed.

The discrepancy between measured and calculated liquid surface level can be accounted for if voids are allowed to form in the sludge where and when the saturation temperature is reached. Figure 4-4 shows the comparison when voids are allowed to form. During and following the process test, voids are calculated to be generated initially in the lower central region of the tank sludge. This saturation zone or void-bearing sludge region spreads toward the tank wall and a small amount vertically upward. This voidage causes movement of the sludge in both the horizontal and vertical directions. This phenomenon is important for explaining the temperature fluctuations that occurred at the riser No. 14 TC tree.

Figure 4-1. Two-Dimensional Model of Tank 241-C-106 with Soil Nodalization and Heat Conductors.

Figure 4-2. Two-Dimensional Model of Tank 241-C-106 and Tank Side Soil Nodalization with Heat Conductor Details.

Figure 4-3. Comparison of Measured FIC Data and GOTH Calculated Liquid Surface Level (with no formation of voids in the waste sludge).

Figure 4-4. Comparison of Measured FIC Data and GOTH Calculated Liquid Surface Level (with formation of voids in the waste sludge).

5.0 SIMULATION OF MODIFIED PROCESS TESTS

A simulation was conducted to predict what would have occurred if the process test had been stopped when the liquid surface level reached about 183 cm (72 in.), assuming that no sludge was uncovered. Water additions from January 1, 1994 through the last water addition prior to the start of the process test were carried out according to the tank water addition logs. After initiation of the process test, water was added to maintain the pool level between 183 and 193 cm (72 and 76 in.) through December 31, 1995. Processed water from the steam plant was assumed to be added at a temperature of 32 °C (90 °F) and at a rate of 2,300 L/hr (600 gal/hr). The estimated evaporation suppression due to water additions following the modified process test was included starting from the time of the initiation of the modified process test. The 1994 ambient air conditions have been assumed to be repeated for the 1995 calendar year. A two-year transient calculation was made to allow any short-term effects caused by the operating level change to damp out.

This simulation is shown in Figure 5-1 as the curve labeled "GOTH 72-76 in." Note that at about the middle of July the rate of surface level decrease is much lower for about one month, causing the water cycle in both years to be longer than average. This is due to the formation of voids in the waste sludge. This formation of voids occurs while the tank is reaching a new equilibrium level and adjusting to the hot summer temperatures. The following two water addition cycles are shorter than average, indicating the voids are condensing. This void formation may have caused some anomalous riser No. 14 temperature behavior, but not to the extent seen following the process test.

A simulation similar to the one described in the previous paragraph was also conducted. In this case, after initiation of the process test, water was added to maintain the pool level between 185 and 190 cm (73 and 75 in.). This simulation is shown in Figure 5-1 as the curve labeled "GOTH 73-75 in." The time between water additions is longer in the winter and spring months and shorter during the summer and fall months. This is consistent with observed rates of change in liquid level in the tank during different times of the year. Small irregularities in some of the liquid level curves were caused by periods of vapor formation and collapse. The central lower region of the sludge reached the saturation temperature and steam voids formed during the summer months as in previous calculations. The maximum voidage in the summer of 1994 for this simulation occurred in August 1994 as shown in Figure 5-2. The voided region for this simulation was slightly smaller in radius and height than the saturation zone that occurred during the actual process test (Thurgood et al. 1995). These voids then collapse as the season moves into winter.

Figure 5-3 shows the TC 1 data for both riser No. 8 and No. 14 compared with the GOTH calculations for node locations close to the TC locations. The GOTH calculations are for the process test and the 185 to 190 cm (73 to 75 in.) modified process test. For the riser No. 8 curves, the calculated values are about 5.5 °C (10 °F) high. The riser No. 14 curves are widely different, except where the measured data approach the calculated values during the temperature excursion following the large water addition after the

process test. There are small differences between the GOTH calculations of the process test and the modified process test results.

The simulations for different operating liquid levels do not have the convective gap closure model in them. The convective gap closure model (Thurgood et al. 1995) can simulate the reduced temperatures and the oscillating temperatures at the TC tree in riser No. 14.

Because the GOTH model maintains some water above the entire sludge surface, the results for different minimum and maximum levels would be similar to those obtained above. If part of the crust were uncovered for periods of one week, there would be sufficient moisture in these areas to maintain the same evaporation rates. Thus, if the surface level is maintained between 183 and 188 cm (72 and 74 in.), the normal evaporation of the tank would be minimally affected.

One type of leak in a tank is a coast-line leak, which is caused by corrosion at the liquid surface-gas and tank wall interface. If such a leak develops on the wall of the tank within the current operating levels of 190 and 200 cm (75 to 79 in.), the tank can be operated between 183 and 188 cm (72 and 74 in.). A coast-line leak can be detected by observing the rate of change of the liquid surface and comparing this rate with its past history.

Figure 5-1. Simulation of Tank Liquid Surface Level.

Figure 5-2. Sludge Void Contours in August 1994.

protest2b-best estimate suppression.
Tue Aug 1 17:55:25 1995
GOTH Version 3.4 - April 1991

Figure 5-3. TC Data and GOTH Simulations of Process Test and Modified Test.

6.0 OTHER TECHNIQUES FOR CONTROLLING TANK TEMPERATURES

The previous analyses indicate that saturation conditions can be reached during the summer for normal tank operations. Because it is believed that no saturation zone exists in the tank during winter, a chiller in the ventilation system is expected to eliminate the saturation zone. Installation of a chiller that will provide inlet air at 4.5 °C (40 °F) and 100 percent relative humidity for a tank outlet ventilation flow of 65 cubic meters per minute (m^3/min) (2,300 cubic feet per minute [ft^3/min]) will maintain the highest waste temperature at the bottom of the tank to at least 2 to 3 °C (4 to 5 °F) below the local saturation temperature (Rensink 1995, Appendix I). Project W-320 at Westinghouse Hanford Company is currently beginning the installation of a ventilation system with a cooling coil in the recirculation loop. The chiller/ventilation system is expected to be operational in February 1996.

Several response actions have been planned to prevent or mitigate safety concerns associated with the high-heat waste in tank 241-C-106 (Rensink and Kriskovich 1995). One of these concerns is if a leak develops in the tank below the sludge surface. To prevent additional contamination to the soil beneath the tank, no more cooling water would be added to the tank. An analysis was done for the loss of evaporative cooling with operation of a chiller system (Rensink 1995, Appendix I). Also, it is assumed in this analysis that the waste sludge remains moist. This analysis shows that a saturation region is present continuously at the bottom of the tank. The size of this region will be larger than that which occurred during the process test but presumably smaller than that which occurred during the ventilation outage in 1992, because temperatures within the liquid layer during this ventilation outage reached 66 °C (150 °F) (Bander 1993) while those with chiller operation were calculated to be 38 °C (100 °F). It is unclear how the saturation region will behave as the tank dries out.

To maintain evaporative cooling after a leak develops in the tank below the sludge surface, it has been proposed that a sprinkler system be installed to keep the surface of the waste sludge moist (Rensink and Kriskovich 1995). A delay of 60 days in the installation of a chiller and water system to restore evaporative cooling following a leak will result in the formation of some steam in the bottom of the tank similar to the amount formed during the process test. Subsequent operation of the chiller will reduce temperatures at the bottom of the tank to values below the local saturation temperature provided that at least 67 percent of the original pool surface area is maintained for evaporation (Rensink 1995, Appendix I).

7.0 CONCLUSIONS

The conclusions from these analyses while maintaining the tank liquid level between 183 and 188 cm (72 and 74 in.) are as follows:

1. Evaporation from the tank will be normal
2. Waste temperatures will result that are close to those for the current operating liquid levels
3. Voids will form in the bottom of the tank during the summer but this voided zone is estimated to be smaller than the voided region that occurred during the process test
4. The voids in the tank disappear in the winter.

Thus, the tank can be operated between these new levels with little effect on the removal of heat from the tank.

Installation of a chiller will maintain the highest waste temperature at the bottom of the tank to at least 2 to 3 °C (4 to 5 °F) below the local saturation temperature, provided that at least 67 percent of the original pool surface area is maintained for evaporation.

8.0 REFERENCES

- Alstad A. T., 1994, *Temporary Water Addition Termination, Tank 241-C-106*, (Process Memo No. 94-108 from East Systems Engineering, March 2), Westinghouse Hanford Company, Richland, Washington.
- Bander, T. J., 1993, *Revised Thermal History of Tank 241-C-106*, WHC-SD-WM-ER-200, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Bander, T. J., 1995, *Tank 241-C-106 Process Test Report*, WHC-SD-WM-ER-427, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Bander, T. J., and B. A. Crea, 1994, *An Assessment of the Potential for a Steam Bump in Hanford Waste Tank 241-C-106*, WHC-SD-WM-ER-379, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Barrington, C. A., 1995, *Analysis of C-106 Evaporation Data*, (internal memo 71120-95-CAB-007 to D. M. Ogden, February 17), Westinghouse Hanford Company, Richland, Washington.
- Crea, B. A., and T. J. Bander, 1994, *Assessment of Hanford Waste Tank 241-C-106 Historical Water Additional and Evaporation Data*, (attachment to letter 9455642 from T. B. McCall to H. K. Fauske et al., "Assessment of C-106 Water Addition and Evaporation Data," August 18), Westinghouse Hanford Company, Richland, Washington.
- Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, Amendment 4, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.
- Eyler, L. L., 1995, *Assessment of Tank 241-C-106 Temperature Response Indications*, PNL-10514, Pacific Northwest Laboratory, Richland, Washington.
- George, T. L., 1993, *GOTHIC Containment Analysis Package User Manual*, NAI-8907-02, Rev. 4, Numerical Applications, Inc., Richland, Washington.
- Rensink, G. E., 1995, *Contingency Chiller System Design Report for Tank 241-C-106*, WHC-SD-WM-RPT-162, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Rensink, G. E., and J. R. Kriskovich, 1995, *Waste Tank 241-C-106 Comprehensive Cooling Design Summary Report*, WHC-SD-WM-RPT-104, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Schofield, J. S., 1994, *Technical Basis for the Leak Detection Surveillance of Waste Storage Tanks*, WHC-SD-WM-TI-573, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Sutey, M. J., 1993, *Process Test Plan: Tank 241-C-106*, WHC-SD-WM-PTP-026, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Thurgood, M. J., 1992, *Simulation of Gas Release in Tank 101-SY Using GOTH Computer Program*, NAI-9101-1, Numerical Applications, Inc., Richland, Washington.

Thurgood, M. J., B. C. Fryer, D. M. Ogden, and K. Sathyanarayana, 1995, *GOTH Tank C-106 Thermal Hydraulics Analysis Related to the 1994 Process Test*, NAI-940708-3, Numerical Applications, Inc., Richland, Washington.