NOTICE

**CERTAIN DATA
CONTAINED IN THIS
DOCUMENT MAY BE
DIFFICULT TO READ
IN MICROFICHE
PRODUCTS.**

Tank 241-A-105 Evaporation Estimate 1970 through 1978

Prepared for the U.S. Department of Energy
Assistant Secretary for Defense Programs

Westinghouse
Hanford Company Richland, Washington

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

Approved for Public Release

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

LEGAL DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This report has been reproduced from the best available copy.
Available in paper copy and microfiche.

Available to the U. S. Department of Energy
and its contractors from
Office of Scientific and Technical Information
P. O. Box 62
Oak Ridge, TN 37831
(615) 576-8401

Available to the public from the U. S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4650

Printed in the United States of America

DISCLM-1 CHP (1-91)

Tank 241-A-105 Evaporation Estimate 1970 through 1978

G. K. Allen

Date Published
September 1991

Prepared for the U.S. Department of Energy
Assistant Secretary for Defense Programs

**Westinghouse
Hanford Company**

P.O. Box 1970
Richland, Washington 99352

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Approved for Public Release

INFORMATION RELEASE REQUEST

References:
WHC-CM-3-4

Complete for all Types of Release	Purpose		New ID Number WHC-EP-0410	
	☐ Speech or Presentation ☐ Full Paper ☐ Summary ☐ Abstract ☐ Visual Aid ☐ Speakers Bureau ☐ Poster Session ☐ Videotape		☐ Reference ☒ Technical Report ☐ Thesis or Dissertation ☐ Manual ☐ Brochure/Flier ☐ Software/Database ☐ Controlled Document ☐ Other	
	(Check only one suffix)		Existing ID Number (include revision, volume, etc.)	
			If previously cleared, list ID number.	
			Date Release Required 09/30/91	
Complete for Speech or Presentation	Title TANK 241-A-105 EVAPORATION ESTIMATE 1970 THROUGH 1978		Unclassified Category UC- 721	
			Impact Level 2	
	Title of Journal		Group or Society Sponsoring	
	Date(s) of Conference or Meeting		City/State	
		Will proceedings be published? ☐ Yes ☐ No		
		Will material be handed out? ☐ Yes ☐ No		
		Title of Conference or Meeting		

CHECKLIST FOR SIGNATORIES

Review Required per WHC-CM-3-4	Yes	No	Reviewer Name (printed)	Signature	Date
Classification/Unclassified Controlled Nuclear Information	☐	☒			
Patent - General Counsel	☒	☒	S.W. Berglin	S.W. Berglin	2/25/91
Legal - General Counsel	☒	☐	Barbara Williamson	Barbara Williamson	2/25/91
Applied Technology/Export Controlled Information or International Program	☐	☒			
WHC Program	☐	☒			
Communications	☐	☒			
DOE-RL Program	☒	☐	J. Newson	J. Newson	9-23-91
Publications Services	☒	☐	L.A. Kemp	L.A. Kemp	9-27-91
Other Program	☐	☒			
References Available to Intended Audience	☒	☐	Lisa Kemp	L.A. Kemp	9-27-91
Transmit to DOE-HQ/Office of Scientific and Technical Information	☒	☐			

Information conforms to all applicable requirements. The above information is certified to be correct.

Author/Requestor (Printed/Signature) G. K. Allen <i>G. K. Allen</i>	Date 12 SEPT 91
Responsible Manager (Printed/Signature) WALTER L. KNECHT <i>W. L. Knecht</i>	Date 9/12/91
Intended Audience ☐ Internal ☐ Sponsor ☒ External	

INFORMATION RELEASE ADMINISTRATION APPROVAL STAMP

Stamp is required before release. Release is contingent upon resolution of mandatory comments

Date Received 9/12/91 *WB*

Document Title: Tank 241-A-105 Evaporation Estimate 1970 Through 1978

Prepared by:

G. K. Allen
Waste Characterization Analysis

27 Jun 91
Date

Reviewed by:

S. W. Claybrook
Numerical Applications, Inc.

11 Sep 91
Date

Approved by:

R. E. Raymond, Manager
Single-Shell Tank Technology

7-9-91
Date

Approved by:

W. L. Knecht, Manager
Waste Characterization Analysis

9/11/91
Date

This page intentionally left blank.

**TANK 241-A-105 EVAPORATION ESTIMATE
1970 THROUGH 1978**

G. K. Allen

ABSTRACT

Tank 241-A-105 was subjected to a severe steam explosion in January 1965 that caused the metal liner on the bottom to bulge upward approximately 8 feet above its concrete foundation. Shortly after this event, radiation was detected in drywells around the tank and it was declared a leaker. Sluicing operations to remove material from the tank began in August 1968 and continued through August 1970. After sluicing was completed, a significant amount of heat generating material still remained in the tank. To keep tank temperatures below operating limits, the water level in the tank was maintained at an approximate depth of 1.5 feet. This practice was continued until January 1979 when it was believed that the contents had decayed sufficiently to discontinue the water addition and put the tank on a portable exhaust system.

Recent concern has focused on what portion of this cooling water added to Tank 241-A-105 actually evaporated and how much leaked into the soil during the nine year time period. This report presents the results of a study that estimates the amount of water evaporated from Tank 241-A-105 between 1970 and 1979.

The problem was completed in two parts. The first part involved development of a three dimensional heat transfer model which was used to establish the tank heat load. The results of this model were validated against thermocouple data from Tank 241-A-105. The heat removed from the tank by the ventilation air was then used as input to a second computer code, which calculated the water evaporation. Based upon these two models, the amount of water evaporated from Tank 241-A-105, between 1970 and 1979, was between 378,000 and 410,000 gallons.

CONTENTS

1.0	INTRODUCTION	1
2.0	CODE AND MODEL DESCRIPTION	1
2.1	HEATING7 MODEL ASSUMPTIONS	2
2.2	FATHOMS MODEL ASSUMPTIONS	11
2.2.1	Volume Assumptions	11
2.2.2	Atmospheric Boundary Conditions	11
2.2.3	Heat Boundary Conditions	13
2.2.4	Additional Boundary Condition	13
3.0	HEAT TRANSFER RESULTS	13
4.0	EVAPORATION RESULTS	24
5.0	CONCLUSIONS	27
6.0	REFERENCES	28

APPENDICES

A	HEAT TRANSFER STUDY ON TANK 241-A-105	APP A-i
B	COMPOSITION AND DENSITY OF TANK 241-A-105 SOLIDS	APP B-i
C	TANK FARM 241-A STATUS REPORT	APP C-i
D	RESULTS COMPARISON WITH DRAFT EBASCO ENVIRONMENTAL STUDY . . .	APP D-i

FIGURES

1	Side View, Tank 241-A-105	3
2	Cylindrical Coordinate HEATING7 Model (radius-height orientation) .	4
3	Tank Bottom Contour	5
4	HEATING7 Model - Tank Bottom (radius-theta orientation)	6
5	Tank Lateral Thermocouple Probes	9
6	FATHOMS Model	12
7	Lateral Number 1 Temperature History	15
8	Lateral Number 2 Temperature History	16
9	Lateral Number 3 Temperature History	17
10	Lateral Number 4 Temperature History	18
11	Calculated Temperature Contour 2 ft Below Tank Bottom, 1968	19
12	Calculated Temperature Contour 2 ft Below Tank Bottom, 1978	20
13	Temperature Surface 2 ft Below Tank Bottom, 1968	21
14	Temperature Surface 2 ft Below Tank Bottom, 1978	22
15	Temperature 2 ft Below Tank After Portable Exhauster Failure	23
16	150 CFM Air Flow Rate	25
17	660 CFM Air Flow Rate	26

TABLES

1	Material Properties	7
2	Air Temperature Dependant Properties	8
3	Assumed Model Heat Generation Rates	10
4	Assumed Model Yearly Heat Generation Rates	10
5	Average Psychrometric Properties	11
6	Sludge Temperatures, Tank 241-A-105 1.5 ft from Tank Bottom	24
7	Water Evaporated from Tank 241-A-105	27

WHC-EP-0410

This page intentionally left blank.

TANK 241-A-105 EVAPORATION ESTIMATE 1970 THROUGH 1978

1.0 INTRODUCTION

Tank 241-A-105 was subjected to what was postulated as a severe steam explosion (Beard et al. 1967) in January 1965, which caused the metal liner on the bottom to bulge upward approximately 8 ft above its concrete foundation. This bulge created tears in the metal liner around the perimeter of the tank where the bottom meets the side. Sluicing operations to remove as much material as possible from the tank began in August 1968 and continued through August 1970. At that time, there was still a considerable amount of heat generating material in or under the tank causing high tank temperatures. To maintain tank temperatures within operating limits, the water level in the tank was maintained at an approximate depth of 1.5 ft. The liquid level was monitored and when it fell below this level, water was added to bring the level back to 1.5 ft deep. This practice was continued until January 1979 when it was believed that the contents had decayed sufficiently to discontinue the water addition and put the tank on a portable exhaust system. A process test was conducted to test if this change of operation could be done without exceeding maximum tank temperature criteria (Carl 1978). The results of this test indicated that cooling water could be eliminated without exceeding maximum tank temperature limits. At this time water additions were discontinued and Tank 241-A-105 was placed on a portable exhaust system.

Recent concern has focused on how much of the cooling water added to Tank 241-A-105 actually evaporated and how much leaked into the soil during the nine year time period it was added. This report presents the results of a study estimating the amount of water that evaporated from Tank 241-A-105 when water was added for cooling purposes from 1970 through 1978.

2.0 CODE AND MODEL DESCRIPTION

Two computer codes were used in this study: HEATING7 and FATHOMS. The HEATING7 computer code is a multidimensional heat conduction code designed to solve steady-state and/or transient heat conduction problems (Childs 1991). The FATHOMS computer code is a multidimensional thermal hydraulics code that was originally designed to model multi-component, two-phase flows in nuclear reactor power plant containment and auxiliary buildings (Burke 1990). However, the FATHOMS computer code is applicable to a wide range of thermal-hydraulic problems.

Calculation of the evaporation rate in Tank 241-A-105 is broken into two parts. The first part involved using the HEATING7 computer code to establish the existing heat content of the tank. The HEATING7 model assumptions were adjusted until the model calculated the same conditions that were seen in thermocouples, located in laterals underneath the tank. Once the HEATING7 model matched the data, it was used to establish the amount of heat

that was removed from the tank through the air ventilation system. This heat value was then used as input for the FATHOMS model. The FATHOMS code calculated the evaporation rates inside the tank based upon assumed exhauster flow rates.

2.1 HEATING7 MODEL ASSUMPTIONS

A three-dimensional HEATING7 model was used to represent Tank 241-A-105. The three dimensional model is necessary because the sludge in the bottom of the tank is not uniformly distributed, but located in several piles on the tank floor. In addition, the tank bottom is bulged, which will affect how much of the tank floor is actually covered with cooling water.

A side view of the tank is shown in Figure 1. Tank dimensions shown were taken from Drawing H-2-55911 (WHC 1991). A HEATING7 model using cylindrical coordinates was used to model the tank. Results of converting the tank in Figure 1 to cylindrical coordinates are shown in Figure 2, which shows a radius-height (rz) view of Figure 1. A contour plot of the tank bottom, shown in Figure 3 (Carl 1978), gives the location of the sludge piles as well as the bulged liner. The sludge piles in Figure 3 are modeled as shown in Figure 4. This is a radius-theta (r θ) representation of the sludge contours shown in Figure 3. The slashed areas represent sludge piles, diamond hashed areas show water, and clear areas show the bulged tank bottom which sticks above the 1.5 ft of cooling water in the tank. The volume of sludge is estimated to be 2,365 cu ft (Appendix A). Using this volume and the tank bottom surface area covered with sludge, shown in Figure 4, gives an average sludge height of 1.357 ft.

The location of the boundary conditions are shown in Figure 2. Boundary condition (bc) 1 is a forced convective boundary condition with a forced convective heat transfer coefficient of 2 Btu/(h·ft²·°F) convecting to a 55 °F temperature. This bc approximates an average wind speed across the soil surface convecting to the yearly average air temperature. Boundary condition 2 is an adiabatic boundary that approximates a tank center-to-center spacing of 102 ft. By using this bc, the model is assuming an infinite array of tanks, which have a 102-ft center-to-center spacing. Boundary condition 3 is an isothermal bc of 55 °F located at the water table. Boundary condition 4 is an isothermal surface-to-boundary condition with the boundary temperature set to 130 °F. This bc was established by review of in tank temperature records taken in the 1968 through 1978 time period. Sludge temperatures during this period ranged from 115 °F to 130 °F, with more measurements in the 130 °F range than the 115 °F range. Boundary condition 5 is a surface-to-surface bc that models the radiation heat transfer between the tank bottom and dome and the natural convection inside the tank. The radiative heat transfer coefficient is 1.2×10^{-9} Btu/(h·ft²·°R⁴). This value was derived from Equation 1.

$$h_r = S \times s_b \quad (1)$$

Figure 1. Side View, Tank 241-A-105.

Figure 2. Cylindrical Coordinate HEATING7 Model
(radius-height orientation).

Figure 3. Tank Bottom Contour.

Figure 4. HEATING7 Model - Tank Bottom
(radius-theta orientation).

where

S = shape factor assumed to be 0.7

sb = Stefan-Boltzman constant which is 1.714×10^{-9} Btu/(h·ft²·°R⁴).

The natural convective heat transfer coefficient is $0.11\Delta t^{0.25}$. This heat transfer coefficient is based upon the general correlation shown in Equation 2.

$$h = C \times \left[\frac{\Delta T}{L} \right]^n \quad (2)$$

where

C = 0.27

L = characteristic length 37.5

n = 0.25.

These values are based upon a horizontal plate with the heated surface facing up (Welty et al. 1969).

Five materials are used in this model whose thermal properties are shown in Table 1.

Table 1. Material Properties.

Material	Thermal conductivity Btu/h·ft·°F	Density lb/ft ³	Specific heat Btu/(lb·°F)
Sludge	100.0	500.0	0.1
Soil	0.3	111.1	0.2
Concrete	0.7	144.0	0.21
Air	Temperature dependant properties, see Table 2		
Water	0.364	62.1	0.999

The thermal properties of the sludge are artificially high to allow the heat to flow freely to the heat generation boundary. This assumption is used to simplify the computer code computations. The major resistance to heat transfer is the air inside the tank, so this simplifying assumption will have no impact on the overall heat transfer problem. In addition, the sludge temperatures were of no interest to this study. The temperature dependant air properties assumed are listed in Table 2.

Table 2. Air Temperature Dependant Properties.

Temperature	Thermal conductivity Btu/(h·ft·°F)	Density lb/ft ³	Specific heat Btu/(lb·°F)
60	0.0146	0.0764	0.240
80	0.0152	0.0735	0.240
100	0.0156	0.0710	0.240
150	0.0167	0.0651	0.241
200	0.0179	0.0602	0.241
250	0.0191	0.0559	0.242

Four lateral thermocouple probes, which measures soil temperature, are located 2 ft underneath the bottom of Tank 241-A-105, as shown in Figure 5. The tank heat generation rate was derived by adjusting its value so the calculated model temperatures matched the measured thermocouple readings of the soil temperatures in the laterals underneath the tank. Initially, all the heat was placed in the sludge inside the tank, but temperatures 2 ft underneath the tank were not high enough to match measured values from thermocouples inside the laterals. The only way the model would match measured lateral temperatures was to place a second smaller heat generation region underneath the tank. Lateral temperature data are available from 1968 to 1978. Two steady state runs were completed: one matched the 1968 lateral temperature measurements and a second matched the 1978 lateral temperature measurements. The heat generation rates for the two cases are shown in Table 3.

The major radionuclide in the sludge is strontium-90 (Appendix B) which has a half life of 28.6 years. Based upon this half life, the radioactive decay for the heat generation is shown in Equation 3.

$$q = q_0 e^{-0.024236 \times t} \quad (3)$$

where

q_0 = initial heat generation rate
 t = time in years.

The in-tank heat generation rate, assumed in Table 3, used this decay to decrease its heat generation between 1968 and 1978. Initially, this same assumption was used for the heat generation underneath the tank, but when a suitable heat generation rate for the 1968 time period was found and decayed to its 1978 value, temperatures were too high. Only when the heat generation rate underneath the tank was reduced, to that shown in Table 3, did the temperatures match. The yearly tank heat generation rates between 1968 and 1978 can now be calculated and are shown in Table 4.

Figure 5. Tank Lateral Thermocouple Probes.

Table 3. Assumed Model Heat Generation Rates.

Year	Volumetric heat generation rate Btu/(h·ft ³)		Total heat generation rate Btu/(h·ft ³)	
	In tank	Under tank	In tank	Under tank
1968	24.21	3.4	57,192.5	30,383.0
1978	19.0	1.6	44,884.6	14,297.9

Table 4. Assumed Model Yearly Heat Generation Rates.

Year	Volumetric heat generation rate Btu/(h·ft ³)		Heat removed from tank vapor space Btu/h
	In tank	Under tank	
1968	24.21	3.4	71,395.6
1969	23.63	3.2	68,330.9
1970	23.064	3.004	65,334.0
1971	22.512	2.814	62,421.1
1972	21.973	2.627	59,563.9
1973	21.447	2.446	56,788.5
1974	20.933	2.268	54,067.2
1975	20.432	2.095	51,418.3
1976	19.943	1.926	48,831.9
1977	19.465	1.971	46,307.2
1978	19.0	1.6	43,844.4

The in-tank heat generation rate in Table 4 was calculated based solely on Equation 3. The under tank heat had to be decreased faster than predicted by Equation 3 alone and an additional factor was used to decrease this rate. It is postulated that this additional factor required for the under tank heat generation rate is necessary because the leak plume is being washed deeper into the soil column by the cooling water leaking from the tank. These values were then input into a HEATING7 model that calculated the heat removed from the tank vapor space. This heat generation is used as input to the FATHOMS model, which is discussed in the following section.

After 1978, when the cooling water was discontinued, the heat generation rate for transient analyses used the decay functions of Equation 3 for both the in tank and under tank heat generation rate. This indicates that after the cooling water was discontinued, the heat generation underneath the tank remained stationary.

2.2 FATHOMS MODEL ASSUMPTIONS

The FATHOMS model is shown in Figure 6. The model consists of a tank containing a layer of water in the bottom. Air is pumped into the tank from the upper right side of the model and exits out the top left side. Heat is by the incoming air. Model assumptions are broken into atmospheric boundary conditions, heat boundary conditions, and model volume assumptions as discussed in the following paragraphs.

2.2.1 Volume Assumptions

The tank volume assumed for the FATHOMS model was 172,369 ft³. This value was calculated based upon the air volume above the sludge using the HEATING7 model configuration. The surface area for water evaporation was 4,417 ft², which was based upon the surface area of the tank.

2.2.2 Atmospheric Boundary Conditions

The air being pumped through the tank is assumed to be at seasonal ambient air conditions. The seasonal conditions used are shown in Table 5 which gives a monthly average between the years 1950 and 1970 [taken from Table 2.3-8 of WHC-EP-0240-1 (WHC 1978)].

Table 5. Average Psychrometric Properties.

Month	Dry bulb temperature, °F	Relative humidity	Saturated vapor pressure (psia)	Pressure ratio
Jan	30.3	76.0	0.0	0.0
Feb	37.5	69.7	0.1101	0.005348
Mar	44.0	55.0	0.1419	0.005439
Apr	52.5	46.4	0.1955	0.006322
May	61.8	41.8	0.2736	0.007974
Jun	69.9	39.4	0.3628	0.009963
Jul	77.5	31.5	0.4683	0.010281
Aug	75.3	34.9	0.4353	0.010588
Sep	67.0	39.9	0.3283	0.009130
Oct	53.2	57.7	0.2006	0.008067
Nov	40.1	72.6	0.1220	0.006173
Dec	33.4	80.8	0.0935	0.005265

psia = pounds per square-inch absolute (pressure).

Figure 6. FATHOMS Model.

The FATHOMS computer code uses a pressure ratio rather than relative humidity directly. The pressure ratio is defined by Equation 4.

$$\text{pressure ratio} = \text{relative humidity} \times \frac{P_{\text{sat}}}{P_{\text{tot}}} \quad (4)$$

The total pressure is 14.348 psia (Garfield 1975). In addition, the initial temperature of the vapor and liquid inside the tank was assumed to be 130 °F. The 130 °F temperature was selected because the heat transfer model used a 130 °F isothermal boundary condition at the surface of the liquid in the tank.

The exact air flowrate through Tank 241-A-105 is difficult to determine because all the tanks in A, AX, AY, and AZ Tank Farms are on a common exhaust system (Building 702-A), but Kazer and Veneziano (1978) has estimated this flow rate to be between 150 and 660 cubic feet per minute (CFM) with the more likely value closer to 150 CFM. Both the 150 and the 660 CFM flow rates were used to establish a problem bounding condition.

2.2.3 Heat Boundary Conditions

The heat input boundary condition is applied to the water in the bottom of the tank. The actual value added is listed in Table 4. This heat is the amount calculated by the HEATING7 model, which was being removed through the boundary condition, and approximated the air flow rate through the tank.

2.2.4 Additional Boundary Condition

As shown in Figure 6, an inlet water flow rate was assumed. This boundary condition simply added water to the tank at a rate approximately equal to the evaporation rate so that a constant liquid level was maintained. The inlet temperature of this water was assumed to be 50 °F. Any heat removed from the tank, because of leaking cooling water, does not affect this assumption because the heat applied to the FATHOMS model is the heat calculated by the HEATING7 model, which was released to the ventilation.

3.0 HEAT TRANSFER RESULTS

Based upon the model assumptions previously described, the HEATING7 model was used to establish the amount of heat being removed from the tank by the ventilation air. The model validity was verified by checking the results with measured conditions in the tank.

Thermocouple readings from the laterals underneath the tank are shown in Figures 7 through 10. Each of these figures show the temperature-time history of the thermocouples located in each of the laterals. Two steady-state HEATING7 models were developed, one to match the 1968 conditions and the other to match the 1977 conditions. These model outputs were then compared to the actual temperature reading 2 ft underneath the tank shown in Figures 7 through 10. Figures 11 and 12 show temperature contour plots at the same depth as the laterals underneath the tank for the 1968 and 1978 HEATING7 models, respectively. This position of the laterals underneath the tank are superimposed on the contour plots for easier temperature comparison between the data in Figures 11 and 12 and the data in Figures 7 through 10. Comparison of temperatures and positions from the contour plots show good agreement with temperatures recorded in Figures 7 through 10.

The calculated contour plots show a local hot spot located roughly underneath the bulged liner. This hot spot is shown more effectively on the surface plots shown in Figures 13 and 14 for the 1968 and 1978 time period, respectively. This hot spot was previously thought to be caused by heat generating sludge that leaked into the void space underneath the bulge, but the HEATING7 model has no localized heat generation rate underneath the bulge. Based upon the HEATING7 model assumptions, it is felt that this hot spot exists because the bulged liner extends above the liquid level of the tank, and thus, it is cooled only by the tank ventilation air while the rest of the tank is covered with water and is cooled more effectively.

In 1979, it was felt that the heat content of Tank 241-A-105 had decayed enough to discontinue the cooling water additions and put the tank on a portable exhaustor air cooling system only. This portable exhaustor system operated until it was shut down on March 31, 1989. At that time, the temperatures in the laterals underneath the tank started to rise and kept rising until the exhaustor was restarted on March 17, 1990. This temperature rise, which was a direct result of the exhaustor failure, provided a good set of data for further verification of the heat transfer model.

The 1978 steady-state model output was used to start a transient calculation that modeled the portable exhaustor operation until it was shut down on March 31, 1989. At this point, the model boundary conditions were changed so no air entered the tank and the resulting temperatures were compared with measured lateral temperatures for that same time period. The model temperature rise predictions compared with the measured lateral temperature of thermocouple 28 are shown in Figure 15. This figure presents three curves. The solid line shows the temperature rise of thermocouple 28 in the lateral underneath the tank. The short dashed line is based on the initial assumed heat generation rate used by Everly and Bath (Appendix A) ($29.47 \text{ Btu/h}\cdot\text{ft}^3$). The long dashed line is based on a heat generation rate selected to best fit the temperature rise of thermocouple 28. The first heat generation value for this curve ($19 \text{ Btu/h}\cdot\text{ft}^3$) is in the tank and the second value ($1.6 \text{ Btu/h}\cdot\text{ft}^3$) is under the tank. As seen, the model predictions using the 19 and $1.6 \text{ Btu/h}\cdot\text{ft}^3$ volumetric heat generation rates in 1978 provide a reasonable fit to the measured temperature both in magnitude and rate of temperature increase. As noted in the assumption section, the 19 and $1.6 \text{ Btu/h}\cdot\text{ft}^3$ rates were the base case 1978 values. Actual transient heat generations were decayed using Equation 3 for both heat generation terms.

Figure 7. Lateral Number 1 Temperature History.

Figure 8. Lateral Number 2 Temperature History.

Figure 9. Lateral Number 3 Temperature History.

Figure 10. Lateral Number 4 Temperature History.

Figure 11. Calculated Temperature Contour
2 ft Below Tank Bottom, 1968.

Figure 12. Calculated Temperature Contour
2 ft Below Tank Bottom, 1978.

Figure 13. Temperature Surface 2 ft Below Tank Bottom, 1968.

Figure 14. Temperature Surface 2 ft Below Tank Bottom, 1978.

Figure 15. Temperature 2 ft Below Tank After Portable Exhauster Failure.

The agreement between the model predictions and actual measured temperatures for the 1968 and 1978 steady state runs, as well as for the transient runs when the portable exhaustor was down in 1989, provide a high degree of confidence that the assumed model heat generation rate is close to reality.

4.0 EVAPORATION RESULTS

Two bounding ventilation air flow rates were considered for the evaporation calculations: 150 and 660 CFM. Based upon the heat input and average atmospheric conditions discussed previously, the tank vapor space and liquid temperatures are shown in Figures 16 and 17 for the 150 and 660 CFM air flow rate, respectively. Each of these figures show the seasonal temperature variations of the vapor space and liquid inside the tank. As expected, the temperature variation for the 660 CFM case is wider than for the 150 CFM case. Sludge temperatures at the 1.5 ft level taken from "Tank Farm - 241-A - Status Report" records (Appendix C) are shown in Table 6.

These sludge temperatures correspond to the liquid temperature in the FATHOMS model and agree reasonably well with the 150 CFM case shown in Figure 16. As stated in Section 2.2.2, the 150 CFM case is considered more likely.

Table 6. Sludge Temperatures, Tank 241-A-105
1.5 ft from Tank Bottom.

Date	Temperature, °F
Oct 31, 1971	119
Nov 13, 1973	117
May 13, 1974	135

The water evaporated from the tank based upon the bounding ventilation air flow rates are shown in Table 7.

Examination of the data presented in Table 7 shows that there is a decreased total evaporation volume for the 660 CFM case. In addition, there is a significant drop in the evaporation rate between the first and second year for the 660 CFM case. The evaporation drop between the first and second year is caused by the initial temperature assumption of 130 °F at the beginning of the computer simulation. This causes a higher initial calculated evaporation rate than when the model brings the tank vapor temperatures down to the 80 °F temperature range predicted for the 660 CFM air flow rate. In both cases, the air exiting the tank is at, or very close to, saturated conditions. Because of the increased air flow for the 660 CFM case, the exiting air temperature is lower than for the 150 CFM case. This lower temperature causes a decrease in the total amount of water in the air at saturated conditions.

Figure 16. 150 CFM Air Flow Rate.

Figure 17. 660 CFM Air Flow Rate.

Table 7. Water Evaporated from Tank 241-A-105.

Year	150 CFM air flow gallons	660 CFM air flow gallons
1	56,727	55,373
2	53,041	47,471
3	50,231	45,199
4	47,749	43,263
5	45,099	41,147
6	42,755	39,273
7	40,278	37,295
8	38,063	35,482
9	35,740	33,634
Total	409,683	378,137

During actual operating conditions, the 660 CFM air flow rate case might evaporate more liquid than the 150 CFM case. The heat input to the water in the FATHOMS model was based upon HEATING7 calculations which used a 130 °F boundary temperature. The boundary temperature matched the vapor space temperature calculated by FATHOMS for the 150 CFM flow rate case only. If the air flow rate was actually increased to 660 CFM, the tank vapor temperature would be lower, causing additional tank heat to be removed by the ventilation system. If a lower HEATING7 boundary temperature had been used, more heat would be removed by the air space and this additional heat would evaporate more water in the FATHOMS model.

5.0 CONCLUSIONS

This study calculated the amount of cooling water evaporated from Tank 241-A-105 from 1970 through 1978, when the tank was cooled by maintaining a minimum level of water in the tank. These calculations were completed by developing a heat transfer model and benchmarking the results with measured tank temperatures. Results from this benchmarked model were then used to calculate the amount of water evaporated.

In order for the heat transfer model to match measured data, a heat generation rate underneath the tank had to be added in addition to the heat inside the tank. During the 1970 through 1978 time period, this heat generation region underneath the tank had to be reduced faster than can be accounted for by radiolytic decay, which indicates that a leak plume is

underneath the tank and was washed deeper into the soil column during the time period when cooling water was added. The concentration of the heat generation region under the tank had to be reduced by 60% of its initial 1968 value by 1978. From 1978 to the present, the heat generation rates for transient analyses used the radioactive decay functions for both the in tank and under tank heat generation. This indicates that after the cooling water was discontinued, the heat generation migration under the tank stopped.

There is a localized hot spot underneath the tank that corresponds to the location of the bulge in the bottom. This hot spot has historically been attributed to sludge that leaked underneath the bulge. The model does not have a localized higher heat generation rate underneath the bulge, but still predicts the hot spot as measured in the tank. These results indicate the hot spot was caused because the bulge is extending into the air region and is only cooled by air while the rest of the tank bottom is cooled by the water. The hot spot in the middle of the tank still exists, even though the tank is now dry. Presently, this condition is attributed to the soil underneath the center of the tank, which is more effectively insulated by the tank than the soil underneath the perimeter of the tank.

The results of the heat transfer model was used as input to calculate the total amount of water evaporated from Tank 241-A-105 from 1970 through 1978. Based upon this heat transfer model, between 378,000 and 410,000 gallons of water were evaporated during this time period.

6.0 REFERENCES

- Beard, S. J., et al., 1967, *Purex TK-105-A Waste Storage Tank Liner Instability and its Implications on Waste Containment and Control*, ARH-78, Atlantic Richfield Company, Richland, Washington.
- Burke, T. M., 1990 *CAP/FATHOMS Code User's Manual*, WHC-SD-FM-ER-009, Westinghouse Hanford Company, Richland, Washington.
- Carl, B. P., 1978, *Elimination of Water Addition to Tank 105-A, 241-A Tank Farm Process Test Plan 781 (Part 1)*, RHO-CD-625, Rockwell Hanford Company, Richland, Washington.
- Childs, K. W., 1991, *Heating 7.1 User's Manual*, draft copy, K/CSD/TM-96, Martin Marietta, Oak Ridge, Tennessee.
- Garfield, J. S., 1975, *Anticipated Natural Air Breathing Rate for Underground Tanks*, ARH-CD-256, Atlantic Richfield Company, Richland, Washington.
- Kazer, J. D. and T. B. Veneziano, 1978, *Tank 105-A Stabilization Progress Report*, RHO-CD-255, Rockwell Hanford Company, Richland, Washington.
- Welty, J. R., C. E. Wicks, and R. G. Wilson, 1969. *Fundamentals of Momentum, Heat and Mass Transfer*, John Wiley and Sons, Inc., pp 341.

WHC-EP-0410

WHC, 1991, *Waste Storage Tank, Composite Section*. Drawing Number H-2-55911, Westinghouse Hanford Company, Richland, Washington.

WHC, 1989, *Nusar N Reactor Updated Safety Analysis Report - Amendment 20*, WHC-EP-0240-1, Westinghouse Hanford Company, Richland Washington.

This page intentionally left blank.

WHC-EP-0410

APPENDIX A

HEAT TRANSFER STUDY ON TANK 241-A-105

WHC-EP-0410

This page intentionally left blank.

Internal Letter

) Research International

JWB
8-14-78
FILE
105-A

August 10, 1978

60414-78-051

T. B. Veneziano
Tank Farm Process Engr'g
2750-E/200 EastD. W. Everly - S. S. Bath
Waste Processing Technology
2750-E/200 East
Ext. 240

Heat Transfer Study on Tank 105-A

Introduction

A steady state heat transfer study on Tank 105-A was performed using the computer program, HEATING 5. With data provided by Tank Farm Process Engineering (TFPE) and an assumed sludge material profile, a computer model was prepared. The program was run for variable amounts of total heat generation of sludge material to match a temperature profile two feet below the bottom surface of the tank provided as data by TFPE.

Summary

The results of the study show that a volume of 2365 ft³ of sludge material with a constant heat generation of 29.47 BTU/hr-ft³ and the assumed sludge material profile should have a maximum temperature of 215°F at a level two feet below the tank. With 1000 gallons per week of water added to Tank 105-A, a boundary condition of 130°F was used on the inner surfaces of the tank. If water is no longer added to the tank, the boundary condition on the tank surface is removed. The maximum steady state temperature in the tank under these conditions is over 500°F.

Data

Thermal conductivity of soil	0.25	BTU/hr-ft-°F
Thermal conductivity of sludge material	0.25	BTU/hr-ft-°F
Thermal conductivity of concrete	0.25	BTU/hr-ft-°F
Thickness of soil on tank	8.0	Feet
Heat generation of sludge material	29.47	BTU/hr-ft ³
Water addition to Tank 105-A	1000	Gallons/week
Temperature of inner tank surface	130°F	
Maximum temperature at a level two feet below Tank 105-A	215°F	

Assumptions

1. A constant temperature of 80°F was assumed for the soil surface boundary condition.
2. The temperature of the water table, a depth of 200 feet below the soil surface, was constant at 70°F.

T. B. Veneziano
Page 2
August 10, 1978

3. An insulated boundary was assumed between storage tanks.

Discussion

The computer model used for this heat transfer study is shown in Figures 1 and 2. This model was prepared from "An Estimate of Bottom Topography, Volume and Other Conditions in Tank 105-A, Hanford, Washington" by Woodward-Clyde Consultants and an estimate of sludge material under the bulge in the liner at the bottom of the tank by T. B. Veneziano of TFPE.

Additional data provided by TFPE was a heat generation rate of 29.47 BTU/hr-ft³ for the sludge material, a maximum temperature of 215°F at a level two feet below the tank, a temperature of 130°F on the inner surface of the tank, and the addition of 1000 gallons per week of water to Tank 105-A. Assuming a 130°F boundary condition inside the tank, a series of computer runs with a variable amount of total heat generation were made to estimate the volume of sludge material. In Figure 3, the maximum temperature two feet below the tank is plotted versus the volume of sludge material generating heat at a constant rate of 29.47 BTU/hr-ft³. Using the maximum temperature data, 2365 ft³ is the estimated volume of sludge material. The temperature profile at two feet below the tank bottom of a computer run made with the estimated sludge material volume is shown in Figure 4. If water were no longer added to Tank 105-A, the 130°F boundary condition is removed. Figure 5 shows the computed temperature profile at steady state for the bottom of the tank, the location of the maximum temperatures. For the estimated sludge material volume, the maximum temperature is above 500°F.

D. W. Everly

D. W. Everly
Waste Processing Technology

S. S. Bath

S. S. Bath
Waste Processing Technology

DWE/SSB/db
Att.

cc: w/att.
J. W. Bailey
S. S. Bath
G. D. Campbell
G. T. Dukelow
D. W. Everly
D. G. Harlow
C. O. Luchterhand
D. L. Merrick
L. A. Villalba
R. A. Zinsli
LB

TANK 105A - R₁ COORDINATES

FIGURE 1. COMPUTER MODEL

TANK 105 A

FIGURE 2. COMPUTER MODEL

VOLUME OF SLUDGE MATERIAL, ft³

* ASSUMING 29.47 BTU/hr-ft³
AS A CONSTANT HEAT
GENERATION RATE

FIGURE 3. VOLUME OF SLUDGE MATERIAL

TANK 105 A

2.0' BELOW TANK

130°F BOUNDARY CONDITION

2365 FT³ SLUDGE MATERIAL

FIGURE 4. TEMPERATURE PROFILE

TANK 105A

BOTTOM OF TANK
 2365 FT³ SLUDGE MATERIAL
 NO BOUNDARY CONDITION
 INSIDE TANK

FIGURE 5. TEMPERATURE PROFILE

This page intentionally left blank.

WHC-EP-0410

APPENDIX B

COMPOSITION AND DENSITY OF TANK 241-A-105 SOLIDS

This page intentionally left blank.

00198

Date: January 12, 1972

To: C. J. Francis
C. H. Walker

From: W. W. Schulz/C. W. McWhick

Subject: COMPOSITION AND DENSITY OF THE 105A
SOLIDS

Recent investigations have confirmed that there is a bulge in the bottom of the 105A tank. Plans for removing this tank from service are being formulated by the Waste Management Process Engineering Section. One attractive scheme involves removal of the residual liquid from the tank and indefinite storage of the remaining radioactive solids in the tank.

However, knowledge of the composition, volume, and heat generation properties of the solids in the 105A tank is necessary before proper decisions can be made about their indefinite storage in the tank. Work is currently under way in the Separations Chemistry Laboratory Section to determine these properties for two recent samples of the 105A tank solids. Reported here are composition and density data; heat generation data are being gathered by G. S. Barney of SCL and will be reported separately.

RESULTS

Composition and density data for the two samples of Tank 105A solids are listed in Table I. Solids identified as "Dry" solids were received in the form of hard, dry, brown lumps. The "Wet" solids were originally received as a wet slurry; water was allowed to evaporate from this slurry until air-dry solids were obtained. Portions of both the "Dry" and air-dried "Wet" solids were powdered for analytical purposes.

Save for sodium the "Wet" solids contained slightly more radioactive and inert material per unit weight than did the "Dry" material. The two samples were taken from different locations in the tank so the difference in composition probably reflects the inhomogeneous nature of the material in the tank. Duplicate analyses of the "Dry" solids were in good agreement for the inert constituents

00159

C. J. Francis
C. H. Walker
Page 2
January 12, 1972

but differed by about a factor of two for the radioactive elements.

TABLE I
COMPOSITION AND DENSITY OF 105A TANK SOLIDS

<u>Property</u>		<u>"Dry" Solids</u>	<u>"Wet" Solids</u>
Tap density, g/ml		1.54	1.43
Particle density, g/ml		1.22 (?)	2.04
		<i>Dry</i>	<i>Wet solids</i>
<u>Composition</u>	<u>Analysis 1^a</u>	<u>Analysis 2^b</u>	<u>Analysis 1^c</u>
Na, g/g	0.24	0.31	0.22
Fe, g/g	0.058	0.081	0.13
Al, g/g	0.032	0.038	0.046
Mn, g/g	0.0025	0.0026	0.0040
Si, g/g	0.013	0.022	0.028
Pu, g/g	2.3×10^{-5}	2.8×10^{-5}	7.9×10^{-5}
U, g/g	-	1.2×10^{-5}	-
⁹⁰ Sr, uCi/g	13,400	25,700	43,300
¹³⁴ Cs, uCi/g	610	2,000	2,900
¹³⁷ Cs, uCi/g	500	960	1,600
¹⁰⁶ Ru, uCi/g	420	-	1,400
¹²⁵ Sb, uCi/g	230	410	640
¹³⁴ Eu, uCi/g	85	160	220

a 1.203 g.
b 0.825 g
c 0.027 g.

Tap densities of the two solids (determined by the procedure described later) were about equal. The particle density (determined by HPM displacement) of the "Dry" solid was considerably less than that of the "Wet" material. Since particle densities of other sludges have been in the range 1.8 to 2.0 the 1.22 value for the "Dry" solids is suspect.

C. J. Francis
C. M. Walker
Page 3
January 12, 1972

00000

EXPERIMENTAL

Composition of the 103A tank solids was determined by fusing (9.75 hr at ~400 °C) approximately 0.5 to 1.2 grams of solids with 30 grams of KOH. The resulting melts were cooled to 25 °C and taken up in about 150 ml of water. The resulting slurry was heated to boiling and sufficient 12M HCl added to neutralize all residual KOH and make the final solution about 1M HCl. The acidified solution was boiled to concentrate its volume to about 150 ml, cooled to 25 °C, and diluted with water to exactly 200 ml.

Tap density of the solids was determined by evaporating water slurries of weighed amounts of "Dry" and air-dried "Wet" solids just to dryness in graduated vessels. Densities were calculated from the weight and volume of the final dried solids. Final and initial weights differed by only about 3 percent.

WWS:a

cc: GS Barney
JS Buckingham
MH Campbell
EC Rathvon
Process Aids (3)

This page intentionally left blank.

WHC-EP-0410

APPENDIX C

TANK FARM 241-A STATUS REPORT

.

.

.

.

This page intentionally left blank.

TANK FARM - 241-A - STATUS REPORT				DATE
OPERATOR: <u>G Y "B" 245</u>				<u>10-31-71</u>
DAY				SWING
A TANK FARM		G Y	DAY	SWING
1. VENT HDR. TEMPERATURE READING		<u>18</u>	<u>18</u>	<u>15</u>
2. OPI - 433 DE-ENTRAINER OP		<u>0</u>	<u>0</u>	<u>0</u>
3. PI - CONDENSER VENT HEADER		<u>2</u>	<u>2</u>	<u>2</u>
		LIQUID LEVEL	BULB TEMP.	TC IN BULB RISER
4. G Y:	101-A	<u>28' 5 3/4"</u>	<u>* 007 AR</u>	<u>181, 114, 115, 114</u>
	102-A	<u>1' 0 1/2"</u>		<u>67, 68, 69, 64</u>
	103-A	<u>10' 2"</u>		<u>206, 190, 132, 152</u>
	104-A	<u>27' 2"</u>		<u>218, 203, 171, 158</u>
	105-A	<u>1' 5 3/4"</u>		<u>119, 121, 120, 119, 115</u>
	106-A	<u>2' 2 1/2"</u>		<u>64, 64, 65, 60</u>
DAY:	101-A	<u>28' 6 3/4"</u>	<u>* 004 AR</u>	<u>181, 114, 115, 114</u>
	102-A	<u>1' 0"</u>		<u>67, 68, 69, 64</u>
	103-A	<u>10' 2 1/2"</u>		<u>206, 190, 132, 152</u>
	104-A	<u>27' 2 1/2"</u>		<u>218, 203, 171, 158</u>
	105-A	<u>1' 5 3/4"</u>		<u>119, 121, 120, 119, 115</u>
	106-A	<u>2' 2 1/2"</u>		<u>64, 64, 65, 60</u>
SWING:	101-A	<u>28' 6 1/2"</u>		<u>181, 114, 115, 114</u>
	102-A	<u>1' 0 1/2"</u>		<u>67, 68, 69, 64</u>
	103-A	<u>10' 2"</u>		<u>206, 190, 132, 152</u>
	104-A	<u>27' 2"</u>		<u>218, 203, 171, 158</u>
	105-A	<u>1' 4"</u>		<u>119, 121, 120, 119, 115</u>
	106-A	<u>2' 2 1/2"</u>		<u>64, 64, 65, 60</u>
5. MAIN SEAL POT LIQUID LEVEL (VALVE PIT INSTRUMENT SHACK) DAY		<u>17</u>		
6. 151 - A CATCH TANK LIQUID LEVEL		DAY		
7. 152 - A CATCH TANK LIQUID LEVEL		DAY <u>1' 11 3/4"</u>		
8. CONFIRM THAT ALL A-FARM CIRCULATORS ARE AS SPECIFIED.		G Y <u>✓</u>	DAY <u>✓</u>	SWING
9. FLUSH EACH CIRCULATOR ONCE PER DAY ON DAY SHIFT		CIRCULATORS FLUSHED <u>101A, 2, 3, 4, 5, 6</u>		
10. 105-A BULGE DETECTORS -		201-A <u>21'</u>		

TANK FARM - 241-A - STATUS REPORT				DATE <u>11-13-73</u>		
OPERATOR: <u>GY</u> <u>D</u>		DAY		SWING <u>B-10/14</u>		
A TANK FARM		GY		DAY		
1. VENT HOR. TEMPERATURE READING				<u>16</u>		
2. DPI - 433 DE-ENTRAINER DP				<u>0</u>		
3. PI - CONDENSER VENT HEADER				<u>7</u>		
		LIQUID LEVEL	BULB TEMP.	TO IN BULB RISER	NO. 1 TO	NO. 2 TO
4. GY:	101-A	<u>27'-10 1/2"</u>	<u>Rec'd NALCO</u>		<u>SPARKLED 105A</u>	
	102-A	<u>1'-0"</u>			<u>500 gal</u>	
	103-A	<u>1'-3"</u>				
	104-A	<u>27'-4 1/2"</u>	<u>- Turco Valve</u>			
	105-A	<u>1'-5 3/4"</u>				
	106-A	<u>2'-3"</u>				
DAY:	101-A	<u>27'-10 1/2"</u>			<u>121, 114, 115, 114</u>	
	102-A	<u>1'-0"</u>			<u>62, 62, 64, 58</u>	
	103-A	<u>10'-0"</u>			<u>209, 188, 130, 150</u>	
	104-A	<u>27'-4 1/2"</u>			<u>220, 201, 172, 158</u>	
	105-A	<u>1'-5 3/4"</u>			<u>115, 116, 114, 114, 112</u>	
	106-A	<u>2'-3"</u>			<u>61, 60, 58, 52</u>	
SWING:	101-A	<u>27'-10 1/2"</u>	1-176	12-350	1-142	
			2-310	13-350	2-150	
	102-A	<u>1'-0"</u>	3-229	14-343	3-158	
			4-237	15-317	4-168	
	103-A	<u>10'-0"</u>	5-235	16-216	5-185	
			6-218	17-216	6-200	
104-A	<u>27'-4 1/2"</u>	7-204	18-192	7-334		
		8-193	19-172	8-345		
	105-A	<u>1'-5 3/4"</u>	9-167	20-335	9-178	
		10-215	21-353	10-153		
	106-A	<u>2'-3"</u>	11-249	22-314		
			23-160			
				<u>24-164</u>		
5. MAIN SEAL POT LIQUID LEVEL (VALVE PIT INSTRUMENT SHACK) DAY <u>17</u>						
6. 151-A CATCH TANK LIQUID LEVEL DAY						
7. 152-A CATCH TANK LIQUID LEVEL DAY <u>2'-3 1/4"</u>						
8. CONFIRM THAT ALL A-FARM CIRCULATORS ARE AS SPECIFIED. GY <u>OK</u> DAY <u>✓</u> SWING <u>✓</u>						
9. FLUSH EACH CIRCULATOR ONCE PER DAY ON DAY SHIFT. CIRCULATORS FLUSHED <u>103-A</u>						
10. 103-A BULGE DETECTORS - 201-A <u>21</u>						

STATUS REPORT - 241-A TANK FARM				DATE 5-13-74	
OPERATOR:	GRAVEYARD	DAY	SWING	SUPERVISOR	
TANK FARM			GY	DAY	SWING
1. VENT HOR. TEMPERATURE READING			215	21	21
2. DPI - 433 DE-ENTRAINER OP			1	0	0
3. PI - CONDENSER VENT HEADER			2	2	2
LIQUID LEVEL			TEMPERATURE MONITOR OF		
4. GY:	101-A	27' 3 1/4"	SPE. WELD 1054		
	102-A	1' 8 1/4"	250 GAL. H ₂ O		
	103-A	2' 5 3/4"			
	104-A	23' 8 1/4"			
	105-A	1' 6 1/2"			
	106-A	10' 11 1/2"			
DAY:	101-A	29' 3 1/4"	12-	112	112
	102-A	1' 8 1/4"	63	70	63
	103-A	2' 5 1/2"	127	103	95
	104-A	24' 6"	229	220	193
	105-A	1' 6 1/4"	133	135	131
	106-A	11' 2"	88	87	80
SWING:	101-A	29' 3 1/4"	* No. 11 - from 4/19 TK.		
	102-A	1' 8 1/4"			
	103-A	2' 8 1/4"			
	104-A	24' 6"			
	105-A	1' 6 1/2"			
	106-A	11' 0 1/4"			
5. MAIN SEAL POT LIQUID LEVEL (VALVE PIT INSTRUMENT SHACK) DAY			16		
6. 151-A CATCH TANK LIQUID LEVEL DAY					
7. 152-A CATCH TANK LIQUID LEVEL DAY					
8. CONFIRM THAT ALL A-FARM CIRCULATORS ARE AS SPECIFIED. GY DAY SWING			OK OK		
9. FLUSH EACH CIRCULATOR ONCE PER DAY ON DAY SHIFT. CIRCULATORS FLUSHED			ALL		
10. 241-A COMP. ROOM (OK 2-4) H-12 OK			20' 8"		

sludge temps

LATE M. TEMPS.

BC-8500-020 (2-74)

This page intentionally left blank.

WHC-EP-0410

APPENDIX D

RESULTS COMPARISON WITH DRAFT EBASCO ENVIRONMENTAL STUDY

This page intentionally left blank.

RESULTS COMPARISON WITH DRAFT EBASCO ENVIRONMENTAL STUDY

In a parallel effort with this report, Ebasco Environmental completed an engineering study "Draft Tank 241-A-105 Leak Assessment" (May 24, 1991), which estimates that approximately 610,000 gallons of cooling water were added to this tank and concludes that there was sufficient heat generated in the tank to evaporate "most, and perhaps nearly all of this water." The report, WHC-EP-0410, calculates the amount of water evaporated to be between 378,000 and 410,000 gallons. This appendix examines the Ebasco report and identifies the assumptions that produces the difference in calculated water evaporated.

The calculational approach of the Ebasco document was to use historical operating records and existing documentation to calculate a heat balance around the tank. The Ebasco approach calculates a total heat balance around the tank as shown in Equation 1.

$$\begin{aligned} \text{Tank heat generation rate} = & \text{evaporation loss} + \\ & \text{conduction loss to soil surface} + \\ & \text{conduction loss to water table} + \\ & \text{latent heat increase of tank ventilation air. (1)} \end{aligned}$$

A value for each of these terms was calculated based upon a review of historical information.

An accurate value of the tank heat generation rate must be determined because it affects every term in Equation 1. The Ebasco study examines three sludge samples taken in 1972 and a third sample taken in 1965. The heat generation rates of the samples taken in 1972 varied by a factor of 3.6. The heat generation rate of the sample taken in 1965 fell between two of the 1972 samples and was chosen as the assumed value. This volumetric generation rate was then multiplied by an estimated sludge volume to get a calculated tank heat content.

As seen by the variability of the 1972 analyses, the volumetric heat generation rate is not known to a high degree of accuracy. Estimates of the total sludge volume are also questionable. Multiplication of these two numbers can produce cumulative tank heat generation errors of a very high magnitude. The Ebasco study used this heat generation as the basis for its calculations. Instead WHC-EP-0410 used a heat transfer model and compared calculated model temperatures with measured tank temperatures and adjusted the heat generation rate until the model temperatures matched the measured temperatures. It is believed that these measured tank temperatures are the most accurate information that exists which can be used to estimate the actual tank heat generation rate.

The Ebasco document assumes a constant conductive heat loss of 2,140 Btu/hr to the water table and 6,960 Btu/hr to the soil surface. Actual values will be a function of the tank heat content. The greater the total heat content, the larger the conductive losses will be. Based upon a total tank heat content of 75,000 Btu/hr, WHC-EP-0410 calculates conductive losses to the water table as 2,400 Btu/hr and conductive losses to the soil surface as 13,400 Btu/hr. The value for the heat conducted to the water table is close to the value in the Ebasco document, but soil surface heat loss is twice as high as their assumption. Over the 9 year period in question, this amounts

to almost 61,000 gallons less water evaporated or approximately 10% of the total amount of water added as tabulated in the Ebasco document.

The major difference between the Ebasco study and this document appears to be the assumed tank heat generation rate as shown in Table 1.

Table 1. Total Heat Generation Rate

Year	Ebasco document	WHC-EP-0410
	----- Btu/hr -----	
1971	102,600	81,330
1972	94,900	78,328
1973	90,200	75,383
1974	86,900	72,507
1975	84,300	69,718
1976	82,000	66,989
1977	79,900	64,323
1978	77,900	53,596
1979	75,900	59,183

Assuming the difference between the two heat generation rates in Table 1 all went to evaporation of water and based upon an enthalpy change of 1,150.4 Btu/lb for the evaporation of water, the extra heat assumed by the Ebasco document will evaporate an additional 130,673 gallons of water. Adding this number to the 410,000 gallons reported in this document gives a total of 540,673 gallons. This value can be directly compared to the Ebasco number by subtracting the 61,000 gallons as noted previously from the 610,000 gallons number to give 549,000 gallons. This value compares very favorably with the 540,673 gallons shown above.

In conclusion, the Ebasco document and WHC-EP-0410 used two different engineering approaches: the Ebasco approach predicting 610,000 gallons evaporated and the WHC-EP-0410 approach predicting 410,000 gallons evaporated. Based upon the magnitude of possible errors in engineering assumptions, these numbers are the same. As discussed above, the difference in the amount of water evaporated can be attributed to the difference in the assumed heat generation rate. It is believed that the evaporation calculations in WHC-EP-0410 are closer to actual rates because temperatures in the model were benchmarked against actual measured tank temperatures and found to give close temperature agreement.

DISTRIBUTION

Number of CopiesOnsite

11	<u>U.S. Department of Energy- Richland Operations Office</u>	
	G. J. Bracken	R4-04
	P. Hamric	A7-32
	R. D. Hildebrand	A5-55
	R. E. Gerton	A4-02
	J. Newson (5)	R4-04
	W. A. Rutherford	A4-02
	Public Reading Room	A1-65
1	<u>Pacific Northwest Laboratory</u>	
	B. Johnson	K1-78
33	<u>Westinghouse Hanford Company</u>	
	G. K. Allen (3)	H0-34
	D. V. Arbogast	L6-86
	M. L. Bell	H4-23
	R. V. Berg	L6-29
	D. C. Board	S1-57
	E. J. Campbell	B3-30
	J. I. Dearnig	H5-58
	C. Defigh-Price	H4-23
	J. L. Deichman	H4-23
	G. T. Dukelow	R2-97
	D. J. Green	S5-75
	C. S. Haller	R1-51
	H. Harmon	R2-52
	M. N. Islam	R3-08
	W. L. Knecht	H0-33
	A. J. Knepp	H4-56
	S. Marchetti	R2-50
	R. L. Miller	H0-34
	D. M. Ogden	H0-34
	J. G. Propson	R2-18
	T. E. Rainey	R1-49
	R. E. Raymond	R1-80
	L. E. Thomas	R3-08
	J. D. Thomson	R1-30
	R. K. Welby	R1-80
	Central Files	L8-04
	EDMC	H4-22
	Information Release	
	Administration (3)	L8-04
	Tank Farm Information Center	R2-95

END

**DATE
FILMED**

01/106/192