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Accession #: D196002436

Document #: SD-W211-ER-002

Title/Desc:
ENGINEERING REPORT INITIAL TANK RETRIEVAL SYSTEMS TANK 241SY102 WASTE COOLING EVALUATION PROJECT W-211

Pages: 48

Sta. 4 (3)

DEC 2 9 1995 **ENGINEERING DATA TRANSMITTAL**

Page 1 of 1

1. EDT № 611596

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) DST Retrieval Projects/7F520	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: Project W-211	6. Cog. Engr.: C. A. Rieck	7. Purchase Order No.: N/A
8. Originator Remarks: WHC-SD-W211-ER-002, Revision 0, "Engineering Report, Initial Tank Retrieval Systems, Tank 241-SY-102 Waste Cooling Evaluation, Project W-211" describes the results of an evaluation of thermal effects for Tank 241-SY-102 from the planned operation of two mixer pumps to mobilize the tank contents.		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: N/A
11. Receiver Remarks:		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date: N/A

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval-Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	WHC-SD-W211-ER-002	N/A	0	Engineering Report, Initial Tank Retrieval Systems, Tank 241-SY-102 Waste Cooling Evaluation, Project W-211	N/A	2	1	

16. KEY

Approval Designator (F)	Reason for Transmittal (G)		Disposition (H) & (I)	
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 2. Release 3. Information	4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment	4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.
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2	1	Cog. Mgr. J. E. Van Beek		12/29/95	S2-48	D. R. Nunamaker			T4-08	3	
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18. CA Rieck 12/28/95 Signature of EDT Originator / Date	19. N/A Authorized Representative for Receiving Organization / Date	20. JE Van Beek 12/29/95 Cognizant Manager / Date	21. DOE APPROVAL (if required) Ctrl. No. N/A [] Approved [] Approved w/comments [] Disapproved w/comments

BD-7400-172-2 (04/94) GEF097

BD-7400-172-1

Engineering Report, Initial Tank Retrieval Systems, Tank 241-SY-102 Waste Cooling Evaluation, Project W-211

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U.S. Department of Energy Contract DE-AC06-87RL10930

EDT/ECN: 611596 UC: 2030
Org Code: 8K520 Charge Code: D1110
B&R Code: 39EW31301 Total Pages: 46

Key Words: Mixer pumps, cooling, heating, thermal, Tank 241-SY-102, retrieval, tank waste

Abstract: This document provides preliminary results of an evaluation of thermal effects for Tank 241-SY-102 from the planned operation of a mixer pump retrieval system to be installed by Project W-211. The report evaluated four cases of mixer pump operation at varying tank waste levels. These are considered bounding cases for retrieval operations in Tank 241-SY-102.

The results of the analyses indicate that planned mixer pump operation will result in slow, controlled, and easily observed increases in waste temperature without compromising the tank operating specification limits.

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ENGINEERING REPORT

INITIAL TANK RETRIEVAL SYSTEMS TANK 241-SY-102 WASTE COOLING EVALUATION

PROJECT W-211

Prepared for

Westinghouse Hanford Company

December 1995

Subcontract WHC-380393

Prepared by

ICF Kaiser Hanford Company
Richland, Washington

W211ER3

W211ER3

ENGINEERING REPORT

FOR

INITIAL TANK RETRIEVAL SYSTEMS TANK 241-SY-102 WASTE COOLING EVALUATION

PROJECT W-211

ICF Kaiser Hanford Company (ICF KH)

Prepared By: Mark A Przybylski 12·28·95
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ENGINEERING REPORT

INITIAL TANK RETRIEVAL SYSTEMS TANK 241-SY-102 WASTE COOLING EVALUATION

PROJECT W-211

I. INTRODUCTION

This report describes the results of an ICF Kaiser Hanford Company (ICF KH) preliminary evaluation on the thermal effects (tank heat up) of using two mixer pumps to mobilize the waste in Tank 241-SY-102, a double-shell tank (DST). The thermal analysis predicts the estimated temperatures for the vapor space above the liquid waste, the waste contents, and the annulus, after the mixer pumps have been operated for a certain amount of time. The resulting temperatures from the thermal analysis are compared to the tank operating/ design limits and may be used to determine the best operating program for the mixer pumps.

The primary tank heat removal system for Tank 241-SY-102 consists of two parts: a primary tank vapor space ventilation system, and an annulus ventilation system. The primary system provides a substantial part of the tank's cooling capacity and includes a continuous flow of air through the vapor space above the liquid waste. This flow of air has multiple purposes. One use is to maintain a negative pressure in the dome space so that any vapors or aerosols derived from the waste are captured and then flow through a filter bank before they are released to the environment. Another purpose of this airflow is to remove sensible heat from the dome space if the temperature of the waste exceeds the mean inlet air temperature. The air flow will also remove potentially harmful (explosive or corrosive) vapors from the vapor space, and any water vapor evolved from the waste through evaporation will be swept out. The annulus ventilation system airflow provides both leak detection and sensible heat removal capabilities.

II. SUMMARY AND CONCLUSIONS

Four cases were investigated to evaluate the transient heat-up and cool-down of Tank 241-SY-102 with no changes to the current primary or annulus ventilation systems. The cases are described as follows:

- Case 1: Full tank, two mixer pumps at 100% flow (500 hp of heat input) for 15 days, followed by two mixer pumps at 50% flow (65 hp of heat input).

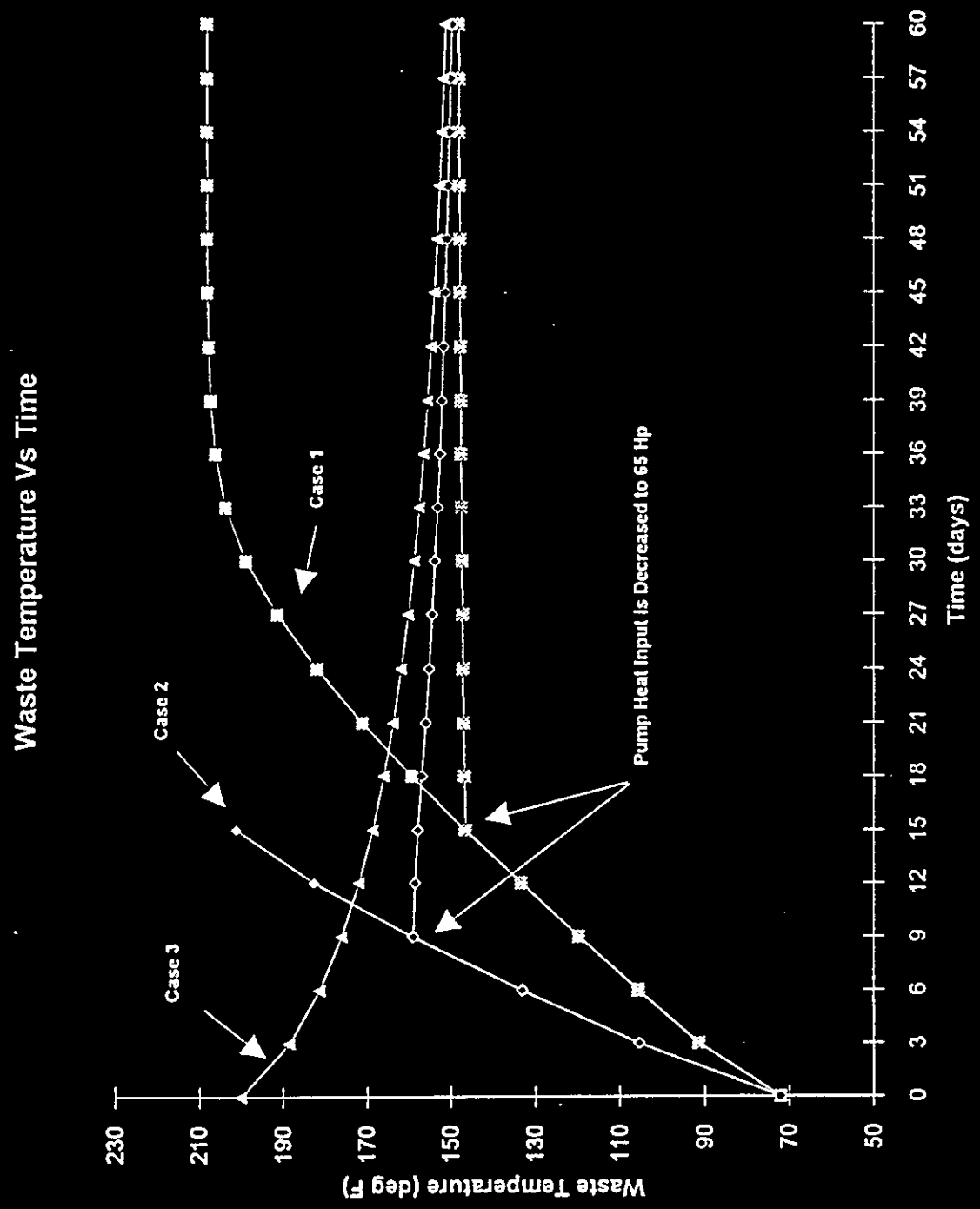
- Case 2: Half tank, two mixer pumps at 100% flow (500 hp of heat input) for 9 days, followed by two mixer pumps at 50% flow (65 hp of heat input).

- Case 3: Half tank, two mixer pumps at 50% flow (65 hp of heat input), and an initial tank waste temperature of 200 °F.

- Case 4: Half tank, no mixer pumps, and an initial tank waste temperature of 200 °F.

The transient heat-up and cool-down data for Cases 1 through 3 are shown graphically in Figure 1. The graph for Case 4 was left out for clarity, but is shown in Appendix A. The computer input and output files are attached in Appendix A.

The results of these analyses must be considered preliminary and subject to change. The results are preliminary due to the uncertainty of the tank waste contents resulting from projected salt well pumping to Tank 241-SY-102, sludge and supernate volumes, and thermophysical properties at the time of mixing.


Waste Temperature Vs Time
Case 1
Case 2
Case 3
Pump Heat Input Is Decreased to 65 Hp
Waste Temperature (deg F)
230
210
190
170
150
130
110
90
70
50
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
51
54
57
60
Time (days)

The worst-case tank waste heat-up is for Case 2 which has two mixer pumps operating at 100% flow with 1/2 of a tank volume of waste. The results of the analysis for Case 2, with the mixer pumps operating continuously for 9 days (over 200 hours), indicate that the temperature of the mixed waste will become 160 °F. The outlet air temperatures in the primary (dome) ventilation system and in the annulus ventilation system are 140 °F and 160 °F, respectively. This result also shows the primary ventilation (dome) outlet water content to be 0.15 lbm H_2O/lbm air. These conditions are satisfactory because the primary ventilation system is designed for a maximum of 230 °F at saturated conditions (ref 9). For example, saturated air at 200 °F has a moisture ratio of approximately 2.3 lbm H_2O/lbm air. Further, the air flow from Tank 241-SY-102 is only 20% of the total flow in the SY-Farm ventilation train. Tank 241-SY-102 flow will be mixed with flow from the other two SY tanks, which have significantly lower temperature and moisture contents, before the flow enters the ventilation outlet train.

In Case 2, the rate of tank heat-up above a waste temperature of 125 °F is approximately 8.7 °F/day which is 44% of the allowable limit of 20 °F/day (ref 9). In the computer model, Tank 241-SY-102 is limited to a maximum waste temperature of 212 °F at the primary tank wall (ref 9). This temperature (212 °F) was reached after 16 days of simulated operations with two mixer pumps at 500 hp pump heat input.

The results for Case 1, which has two mixer pumps operating at 100% flow with a full tank (1,000,000 gal), indicate that for 9 days of continuous mixing, the mixed waste temperature is 120 °F. The corresponding primary and annulus ventilation outlet temperatures are 107 °F and 120 °F, respectively.

Cool-down results from Cases 1 and 2 assume two pumps operating at 50% flow (approximately 65 hp of pump heat input) to maintain the mobilized solids in suspension and allow tank waste contents to cool. For example, the mixer pumps for Case 2 are operated at 100% flow for 9 days, and then lowered to

50% flow thereafter. The waste will then cool from the 160 °F waste temperature reached to approximately 150 °F. The waste temperature will stabilize for two mixer pumps at 50% flow at approximately 150 °F (i.e., the tank waste will not cool beyond that temperature unless the pumps are turned off). Without the mixer pumps operating (Case 4), the tank waste cools at a rate of about 10 °F every 7 days.

Case 3 evaluated the tank cool-down when two mixer pumps are operating at 50% flow with the tank 1/2 full and an initial waste temperature of 200 °F. The temperature of the waste cools until it stabilizes at about 150 °F, after about 60 days of operation.

The duration of mixer pump operation required for waste mobilization is not precisely known, but is believed to be approximately 9 days (200 hours). These preliminary results indicate that the Tank 241-SY-102 mixed mean waste temperatures will increase in a slow, controlled, and easily observable manner, and will remain below tank operating specification limits for the time required to mobilize (mix) the waste. Therefore, it is concluded that tank cooling is not required if mixing operations are administratively controlled.

III. PURPOSE

The purpose of this report is to document the results of a preliminary analysis estimating that the tank waste temperature increase could occur when using two mixer pumps to mobilize the contents of Tank 241-SY-102.

IV. DESCRIPTION

A. THERMAL MODEL BACKGROUND

The thermal analysis used for Tank 241-SY-102 is a Simplified DST Thermal Program, developed by B. A. Crea from WHC Safety Fluid Mechanics (ref 2). The program was developed as a result of heat transfer

testing on a 12-ft diameter scale model for the Multi-Function Waste Tank Facility. This program is the same one that was used to develop the thermal analysis for Tank 241-AW-105. It has been benchmarked against two previous studies done with detailed finite element models, and is determined to be acceptable for use by WHC.

The thermal model provides a simple and easily used simulation of the thermal effects from using two mixer pumps to mobilize the waste in Tank 241-SY-102. The program (ref 2) uses the following four heat transfer paths:

- **Waste to the Primary (Dome) Air**
  Energy transport is from simple sensible heat transfer and mass transport caused by the evaporation of water from the waste into the primary airstream. The sensible heat is modeled with a constant specific heat for air. The heat transfer correlations used were taken from reference 5. The evaporative heat removal is based on the test data reported in reference 4.

- **Waste to the Annulus Air Flow**
  Energy transport is by forced convection between the tank bottom and the airstream, and turbulent natural convection between the tank walls and the air flowing through the annulus. The correlations used are taken from reference 3.

- **Soil to the Annulus Air Flow**
  Energy transport is by turbulent natural convection from the secondary liner to the air flowing through the annulus. The heat transfer correlation used is the same as that used for the tank walls.

- **Waste to the Soil**

  Radiant energy transport is modeled from the walls of the primary tank to the secondary liner, and from the waste surface to the dome.

There are two ultimate sinks: the atmosphere and the water table. Studies indicate that the majority of the heat that finds its way from the waste into the soil column is ultimately rejected to the soil surface and then into the atmosphere. This loss is modeled as a loss from the dirt at a constant temperature of 55 °F.

B. TANK 241-SY-102 MIXING OPERATIONS

The simplified DST thermal program (ref 2) was utilized to evaluate Tank 241-SY-102 transient heat-up and cool-down for the following four cases:

- Case 1: Full tank, two mixer pumps at 100% flow (500 hp of heat input), for 15 days, followed by two mixer pumps at 50% flow (65 hp of heat input).

- Case 2: Half tank, two mixer pumps at 100% flow (500 hp of heat input), for 9 days, followed by two mixer pumps at 50% flow (65 hp of heat input).

- Case 3: Tank cool-down, half tank, two mixer pumps at 50% flow (65 hp of heat input), and an initial tank waste temperature of 200 °F.

- Case 4: Tank cool-down, half tank, no mixer pumps, and an initial tank waste temperature of 200 °F.

C. DEVELOPMENT OF INPUT DATA

1. Tank 241-SY-102 Data

The Tank 241-SY-102 computer model input data are based on the core samples analyzed in the Tank 241-SY-102 characterization report (ref 1).

The following Tank 241-SY-102 waste volumes were obtained from reference 1:

Sludge	130 Kgal
Supernate	690 Kgal
Total	820 Kgal

The remaining tank volume was assumed to be filled with an additional 180 Kgal of non-complexed waste from S-Farm, with similar properties as supernate, for a total tank volume of 1,000 Kgal (ref 7).

Mixed Waste Density

A mixed waste density of 1.17 g/ml (73 lb/cu ft.) was determined conservatively by mixing 130 Kgal of Tank 241-SY-102 sludge at a density of 1.56 g/ml, 690 Kgal of Tank 241-SY-102 supernate at a density of 1.03 g/ml, and 180 Kgal of S-Farm (Tanks 241-S-110 and 241-S-103) non-complexed waste at the weighted mean density of 1.42 g/ml. A high density is conservative because it results in a higher pump heat generation.

Mixed Waste Heat Capacity (C_p)

The specific heat for the liquid phase is 0.99 cal/g-°C. However, aqueous salt solutions and suspended solids (oxides or salts) will lower the heat capacity of a solution. A conservatively low mixed

waste heat capacity of 0.65 cal/g-°C (0.60 Btu/lb-°F) is used in the analysis. Using a mass weighted average (rho Cp Vol) of the tank contents results in a higher mixture Cp of approximately 0.70 cal/g-°C. A low heat capacity is conservative because it results in a faster heat-up.

Waste Decay Heat

The Tank 241-SY-102 characterization (ref 1) reports a total heat load of 7,100 Btu/hr for the 130 Kgal of sludge plus 690 Kgal of supernate. Reference 7, reports a total waste heat load of 4,083 Btu/hr for the 180 Kgal of non-complexed waste from S-Farm. The combined heat load of 11,183 Btu/hr converts to approximately 0.10 Btu/cu ft-hr for use in the program input.

Ventilation System Parameters

The Tank 241-SY-102 tank ventilation system air flow rates are as follows (ref 8):

	Actual	Maximum
Primary (Dome)	130 ACFM	200 ACFM
Annulus	336 ACFM	336 ACFM

The maximum ventilation flow rates were used for the program input. These flow rates are limited by the Tank 241-SY-101 safety limits for ventilation flow, maintaining a continuous negative pressure in Tank 241-SY-103, and a maximum exhaust rate for the primary ventilation system of 1,000 cfm for all three SY tanks.

Evaporation Data

The evaporation data consist of the inlet air ambient conditions into the ventilation systems, and the vapor pressure depression of the

mixed waste due to the contribution of dissolved salts in the aqueous solution.

The inlet air temperature of 77 °F was used in the program input. This ambient condition was specified for the MWTF design basis (ref 3) and is conservative in that it is the maximum 24-hour average temperature recorded during the hottest week on record. Implicit in the use of this figure is that the thermal mass of the tank and contents is so great that the diurnal variations in the air temperature will have insignificant effect on waste temperature.

The vapor pressure reduction factor consists of the ratio of the vapor pressures of the mixed waste solution to the vapor pressure of water at the same temperature. A conservative selection of the vapor pressure reduction for input into the program is 0.8.

Pump Heat Input

The pump heat input was based on the hydraulic data of the project W-151 mixer pumps (see attached pump curve). At 100% flow, the pump hydraulic characteristics are as follows:

Flow rate	10,400 gpm
Head	54 feet
Efficiency	74%

Using the above data and a mixed waste density of 1.2 g/ml results in a conservative heat input for two mixer pumps operating at 500 hp.

At 50% flow, the pump heat input into the waste is approximately 65 hp.

D. DOCUMENTATION OF COMPUTER INPUT FILES

The input and output data files for the four cases are included in Appendix A. These files contain the data described in the previous section. The cases are described as follows:

- Case 1: Full tank, two mixer pumps at 100% flow (500 hp of heat input) for 15 days, followed by two mixer pumps at 50% flow (65 hp of heat input).

- Case 2: Half tank, two mixer pumps at 100% flow (500 hp of heat input) for 9 days, followed by two mixer pumps at 50% flow (65 hp of heat input).

- Case 3: Tank cool-down, half tank, two mixer pumps at 50% flow (65 hp of heat input), and an initial tank waste temperature of 200 °F.

- Case 4: Tank cool-down, half tank, no mixer pumps, and an initial tank waste temperature of 200 °F.

E. THERMAL RESULTS

1. Case 1

The data for Case 1 show that for two mixer pumps operating at 100% flow with a full tank and an initial tank waste temperature of 72 °F, the mixed waste reaches a temperature of 119.68 °F in 9 days and 200 °F in about 31 days. The rate of tank heat-up (temperature change over time) for wastes above 125 °F is 4.4 °F/day which is 22% of the allowable limit of 20 °F/day. When both pumps are operated for 9 days, the air conditions relative to the ventilation systems are an annulus outlet temperature of 119.6 °F a dome outlet temperature of 107.54 °F, and a dome outlet water

content of 0.06 lbm H_2O/lbm air. The dome and annulus outlet temperatures are well below the ventilation system specification limits for air inlet temperature to the HEPA filter (230 °F maximum) (ref 9).

2. <u>Case 2</u>

The results of the analysis for Case 2, with the mixer pumps operating continuously for 9 days at 100% flow and the tank with 1/2 volume, indicate that the temperature of the mixed waste is 160 °F. The air temperatures from the primary (dome) ventilation system and from the annulus ventilation system are 140 °F and 160 °F, respectively. This result also shows the primary ventilation (dome) outlet water content to be 0.15 lbm H_2O/lbm air. These conditions are satisfactory because the primary ventilation system is designed for a maximum of 230 °F at saturated conditions (ref 9). For example, saturated air at 200 °F has a moisture ratio of approximately 2.3 lbm H_2O/lbm air. Further, the air flow from Tank 241-SY-102 is only 20% of the total flow in the ventilation train. The Tank 241-SY-102 flow will be mixed with flow from the other two SY tanks, which have significantly lower temperatures and moisture, before the flow enters the ventilation outlet train.

3. <u>Case 3</u>

Case 3 evaluated the transient tank cool-down when two mixer pumps are operating at 50% flow, with the tank half full and an initial waste temperature of 200 °F. The results show that the temperature of the waste cools at an initial rate of about 1.7 °F/day until a stabilized temperature of 150 °F is reached in about 60 days. The temperature of the waste will not cool further unless the pumps are turned off.

4. Case 4

Case 4 investigated the transient tank cool-down when no mixer pumps are operating, the tank is half full, and waste contents are at an initial mixed temperature of 200 °F. The tank waste temperature declines about 10 °F every 7 days.

V. UNCERTAINTIES AND RECOMMENDATIONS FOR FURTHER STUDY

As previously noted, the results of these analyses must be considered as preliminary and subject to change due to the uncertainty regarding tank waste contents, sludge and supernate volumes, and thermophysical properties at the time of mixing.

The two mixer pumps utilize a motor located external to the tank; therefore, the motor heat generation is not dissipated in the tank waste.

The duration of mixer pump operation for waste mobilization is approximately 9 days.

The hydraulic characteristics for the mixer pumps were obtained from the attached mixer pump curve (see Appendix B).

The primary tank ventilation system air flow rate from Tank 241-SY-102 is assumed to be 200 acfm. The annulus ventilation flow rate is 336 acfm. (These values were obtained from SY Tank Farm operations.)

The existing ventilation system will not be required to treat aerosols or increased condensate loads generated during operation of mixer pumps.

This analysis does not include heat generated from exothermic chemical reactions. If chemical reactions create a significant amount of heat, the final temperatures will be higher or the mixing time may be reduced.

VI. REFERENCES

1. Engineering Report, "Tank Characterization Report for Double-Shell Tank 241-SY-102," Document No. WHC-SD-WM-ER-336, Rev. 0, June 9, 1995.

2. Internal Memo from B. A. Crea (Safety Fluid Mechanics) to W. L. Knecht, Westinghouse Hanford Company, "Simplified DST Thermal Program," Document No. 74220-95-BAC-030, August 7, 1995.

3. Engineering Report, "Multi-Function Waste Tank Facility Thermal Hydraulic Analysis for Title II Design," Document No. WHC-SD-W236A-ER-010, Rev. 0, October 1994.

4. Engineering Report, "Results from Evaporation Test to Support the MWTF Heat Removal System Design," Document No. WHC-SD-W236A-ER-009, Rev. 0, November 23, 1994.

5. ASHRAE Handbook, Fundamentals, I-P Edition, 1993.

6. Report, "Waste Tank Summary Report for Month Ending August 31, 1995," prepared by Westinghouse Hanford Company, Document No. WHC-EP-0182-89.

7. Internal Memo from M. J. Sutey to S. H. Rifaey, Westinghouse Hanford Company, "Waste Compatibility Assessment of Tank 241-S-102, Tank 241-S-106, Tank 241-S-107, Tank 241-S-108, Tank 241-S-109, Tank 241-S-110 Waste with Tank 241-SY-102 Waste, Via DCRT 244-S," Document No. 77240-95-030 (draft).

8. Conversation Report, (electronic correspondence) from D. R. Nunamaker (Westinghouse Hanford Company) to M. A. Przybylski (ICF Kaiser Hanford Company), "SY-102 Ventilation Data: Actual and Maximum Ventilation System Flow Rates for SY-102," November 9, 1995.

9. Specifications, "Operating Specifications for the 241-AN, AP, AW, AY, AZ & SY Tank Farms," Document No. OSD-T-151-007, January 29, 1992.

APPENDIX A

Thermal Analysis Program Input and Output

Case 1
Case 2
Case 3
Case 4

```
;       Input file for simple program to compute waste tank heatup as a result
; of mixer pump operation.  A semi colon acts as a comment designator so any
; data or comments that appear on a line following a semi-colon are ignored
; the first data record is the title of the run that this input file represents
;
 SY-102 TANK: Case 1: 2 mixers at 100% flow, full tank
;
;  The next input parameters are the waste specific properties for this tank
;
   73.0     ;The waste density in lbm/cubic ft
   0.65      ;The waste specific heat in Btu/lbm - deg F
   0.10      ;The waste decay heat in Btu/cubic ft - hr
   0.8     ;The waste vapor pressure as a fraction of that of water
   72.      ;The waste initial temperature for the start of the run
;
;  The next set of input parameters is the tank specific properties for this
;  analysis
;
   .0       ;The fraction of the tank's surface covered by crust.  It is assumed
;            that this area participates in exchange of sensible heat with the
;            primary air, but doesn't participate in the evaporative cooling of
;            the waste.
   200.0    ;The primary (dome space) ventilation system flow SCFM
   336.0    ;The annulus ventilation system flow
    77.0    ;Ambient inlet temperature
;
;  The next set of  analysis parameters are the transient analysis parameters
;
    1440.0 ;Number of hours for which to run the transient, since this program
;            has no restart capabilities it is assumed that all runs start at 0
    72.0    ;Printout interval for the output of the state variables.  This will
;            also be converted to days and printed out in the same file
   500.0     ;Max pump horsepower available to heat up the waste
   5        ;Number of data pairs that define the time vs normalized pump power
;            input data table.
```

```
  0.0       1.0
  215.0     1.0
  216.0     1.0
  700.0     1.0
 1440.0     1.0
;
   4       ;Number of data pairs that define the normalized tank level vs time
;           input data file.  The normalization factor is 1,000,000 gallons.
;           normalized values greater than 1.0 are permitted to allow for tanks
;           that have been filled beyond their nominal design limit.
   0.0       1.0
   200       1.0
   700       1.0
  5500       1.0
```

SY-102 TANK: Case 1: 2 mixers at 100% flow, full tank

WASTE DENSITY = 73.000 LBM/FT^3
WASTE SPECIFIC HEAT = 0.650 BTU/LBM -DEG F
DECAY HEAT = 0.100 BTU/FT^3 - HR
VAPOR PRESSURE WRT H20 = 0.800
FRACTION OF TANK COVERED BY CRUST = 0.000
DOME FLOW = 200.000 SCFM
ANNULUS FLOW = 336.000 SCFM
INLET AIR TEMP = 77.000 DEG F

TIME (HRS)	OUTLET M.R. (LBMH20/LBMAIR)	TEMP WASTE(deg-F)	PUMP POWER (HP)	LEVEL (FT)	OUTLET TEMP ANNULUS(deg-F)	OUTLET TEMP DOME(deg-F)
0.00	0.00	72.00	500.00	30.00	0.00	0.00
72.00	0.02	91.39	500.00	30.00	91.29	85.12
144.00	0.04	105.66	500.00	30.00	105.58	95.97
216.00	0.06	119.68	500.00	30.00	119.60	107.54
288.00	0.08	133.38	500.00	30.00	133.29	119.46
360.00	0.12	146.66	500.00	30.00	146.58	131.46
432.00	0.17	159.39	500.00	30.00	159.32	143.30
504.00	0.25	171.35	500.00	30.00	171.29	154.69
576.00	0.37	182.25	500.00	30.00	182.20	165.31
648.00	0.53	191.68	500.00	30.00	191.64	174.74
720.00	0.75	199.10	500.00	30.00	199.07	182.48
792.00	1.01	204.05	500.00	30.00	204.03	188.08
864.00	1.21	206.54	500.00	30.00	206.56	191.55
936.00	1.29	207.72	500.00	30.00	207.74	193.91
1008.00	1.33	208.29	500.00	30.00	208.30	195.47
1080.00	1.36	208.55	500.00	30.00	208.57	196.52
1152.00	1.36	208.67	500.00	30.00	208.70	197.26
1224.00	1.37	208.72	500.00	30.00	208.74	197.79
1296.00	1.37	208.74	500.00	30.00	208.76	198.19
1368.00	1.37	208.75	500.00	30.00	208.76	198.49
1440.00	1.37	208.75	500.00	30.00	208.76	198.72

CASE1

TOTAL HEAT BTU/HR	PUMP POWER (%)	ANNULUS LOSS (%)	LATENT HEAT (%)	SENSIBLE HEAT (%)	DIRT LOSS (%)	TIME (DAYS)
1284494.00	98.97	0.00	0.00	0.00	0.00	0.00
1284494.00	98.97	0.40	1.46	0.14	8.79	3.00
1284494.00	98.97	0.81	2.46	0.32	14.82	6.00
1284494.00	98.97	1.20	3.71	0.51	19.47	9.00
1284494.00	98.97	1.59	5.49	0.71	22.76	12.00
1284494.00	98.97	1.97	8.08	0.92	24.88	15.00
1284494.00	98.97	2.33	11.84	1.11	26.03	18.00
1284494.00	98.97	2.66	17.28	1.31	26.34	21.00
1284494.00	98.97	2.97	25.17	1.48	25.86	24.00
1284494.00	98.97	3.24	36.39	1.64	24.52	27.00
1284494.00	98.97	3.45	51.44	1.77	22.24	30.00
1284494.00	98.97	3.59	68.78	1.87	19.02	33.00
1284494.00	98.97	3.66	82.32	1.92	15.25	36.00
1284494.00	98.97	3.69	87.80	1.96	11.92	39.00
1284494.00	98.97	3.71	90.65	1.99	9.29	42.00
1284494.00	98.97	3.72	92.02	2.01	7.29	45.00
1284494.00	98.97	3.72	92.64	2.02	5.81	48.00
1284494.00	98.97	3.72	92.92	2.03	4.71	51.00
1284494.00	98.97	3.72	93.03	2.04	3.89	54.00
1284494.00	98.97	3.72	93.07	2.04	3.28	57.00
1284494.00	98.97	3.72	93.09	2.05	2.82	60.00

```
;       Input file for simple program to compute waste tank heatup as a result
; of mixer pump operation.  A semi colon acts as a comment designator so any
; data or comments that appear on a line following a semi-colon are ignored
; the first data record is the title of the run that this input file represents
;
 SY-102 TANK: Case 1: 2 mixers at 100% flow, full tank
;
;  The next input parameters are the waste specific properties for this tank
;
   73.0     ;The waste density in lbm/cubic ft
   0.65      ;The waste specific heat in Btu/lbm - deg F
   0.10      ;The waste decay heat in Btu/cubic ft - hr
   0.8     ;The waste vapor pressure as a fraction of that of water
   72.      ;The waste initial temperature for the start of the run
;
;  The next set of input parameters is the tank specific properties for this
;  analysis
;
   .0       ;The fraction of the tank's surface covered by crust.  It is assumed
;            that this area participates in exchange of sensible heat with the
;            primary air, but doesn't participate in the evaporative cooling of
;            the waste.
   200.0    ;The primary (dome space) ventilation system flow SCFM
   336.0    ;The annulus ventilation system flow
    77.0    ;Ambient inlet temperature
;
;  The next set of  analysis parameters are the transient analysis parameters
;
    1440.0 ;Number of hours for which to run the transient, since this program
;            has no restart capabilities it is assumed that all runs start at 0
    72.0    ;Printout interval for the output of the state variables.  This will
;            also be converted to days and printed out in the same file
   500.0     ;Max pump horsepower available to heat up the waste
   5        ;Number of data pairs that define the time vs normalized pump power
;            input data table.
```

```
  0.0       1.0
  359.0     1.0
  360.0     0.13
  700.0     0.13
 1440.0     0.13
   4        ;Number of data pairs that define the normalized tank level vs time
;            input data file.  The normalization factor is 1,000,000 gallons.
;            normalized values greater than 1.0 are permitted to allow for tanks
;            that have been filled beyond their nominal design limit.
   0.0       1.0
   200       1.0
   700       1.0
  5500       1.0
```

SY-102 TANK: Case 1: 2 mixers at 100% flow, full tank

WASTE DENSITY = 73.000 LBM/FT^3
WASTE SPECIFIC HEAT = 0.650 BTU/LBM -DEG F
DECAY HEAT = 0.100 BTU/FT^3 - HR
VAPOR PRESSURE WRT H20 = 0.800
FRACTION OF TANK COVERED BY CRUST = 0.000
DOME FLOW = 200.000 SCFM
ANNULUS FLOW = 336.000 SCFM
INLET AIR TEMP = 77.000 DEG F

TIME (HRS)	OUTLET M.R. (LBMH20/LBMAIR)	TEMP WASTE (deg-F)	PUMP POWER (HP)	LEVEL (FT)	OUTLET TEMP ANNULUS (deg-F)	OUTLET TEMP DOME (deg-F)
0.00	0.00	72.00	500.00	30.00	0.00	0.00
72.00	0.02	91.39	500.00	30.00	91.29	85.12
144.00	0.04	105.66	500.00	30.00	105.58	95.97
216.00	0.06	119.68	500.00	30.00	119.60	107.54
288.00	0.08	133.38	500.00	30.00	133.29	119.46
360.00	0.12	146.53	65.00	30.00	146.54	131.43
432.00	0.13	146.84	65.00	30.00	146.86	133.87
504.00	0.13	147.06	65.00	30.00	147.07	135.56
576.00	0.14	147.22	65.00	30.00	147.23	136.89
648.00	0.14	147.36	65.00	30.00	147.37	137.93
720.00	0.14	147.49	65.00	30.00	147.50	138.73
792.00	0.14	147.61	65.00	30.00	147.62	139.36
864.00	0.14	147.72	65.00	30.00	147.74	139.87
936.00	0.14	147.82	65.00	30.00	147.84	140.28
1008.00	0.14	147.92	65.00	30.00	147.93	140.63
1080.00	0.14	148.01	65.00	30.00	148.02	140.91
1152.00	0.14	148.09	65.00	30.00	148.10	141.15
1224.00	0.14	148.17	65.00	30.00	148.18	141.36
1296.00	0.14	148.25	65.00	30.00	148.25	141.55
1368.00	0.14	148.32	65.00	30.00	148.33	141.70
1440.00	0.14	148.38	65.00	30.00	148.40	141.84

CASE1A

TOTAL HEAT BTU/HR	PUMP POWER (%)	ANNULUS LOSS (%)	LATENT HEAT (%)	SENSIBLE HEAT (%)	DIRT LOSS (%)	TIME (DAYS)
1284494.00	98.97	0.00	0.00	0.00	0.00	0.00
1284494.00	98.97	0.40	1.46	0.14	8.79	3.00
1284494.00	98.97	0.81	2.46	0.32	14.82	6.00
1284494.00	98.97	1.20	3.71	0.51	19.47	9.00
1284494.00	98.97	1.59	5.49	0.71	22.76	12.00
178515.19	92.58	14.13	58.09	6.58	178.78	15.00
178515.19	92.58	14.20	62.91	6.88	126.81	18.00
178515.19	92.58	14.24	66.21	7.08	92.67	21.00
178515.19	92.58	14.28	67.07	7.24	69.53	24.00
178515.19	92.58	14.30	67.37	7.37	53.53	27.00
178515.19	92.58	14.33	67.65	7.46	42.19	30.00
178515.19	92.58	14.35	67.90	7.54	33.97	33.00
178515.19	92.58	14.38	68.14	7.60	27.88	36.00
178515.19	92.58	14.40	68.35	7.65	23.32	39.00
178515.19	92.58	14.42	68.56	7.69	19.84	42.00
178515.19	92.58	14.44	68.75	7.73	17.16	45.00
178515.19	92.58	14.45	68.93	7.76	15.05	48.00
178515.19	92.58	14.47	69.10	7.78	13.39	51.00
178515.19	92.58	14.48	69.26	7.80	12.05	54.00
178515.19	92.58	14.50	69.41	7.82	10.97	57.00
178515.19	92.58	14.51	69.55	7.84	10.10	60.00

```
;       Input file for simple program to compute waste tank heatup as a result
; of mixer pump operation.  A semi colon acts as a comment designator so any
; data or comments that appear on a line following a semi-colon are ignored
; the first data record is the title of the run that this input file represents
;
 SY-102 TANK: Case 2: 2 mixers at 100% flow, 1/2 full
;
;  The next input parameters are the waste specific properties for this tank
;
   73.0     ;The waste density in lbm/cubic ft
   0.65      ;The waste specific heat in Btu/lbm - deg F
   0.10      ;The waste decay heat in Btu/cubic ft - hr
   0.8     ;The waste vapor pressure as a fraction of that of water
   72.      ;The waste initial temperature for the start of the run
;
;  The next set of input parameters is the tank specific properties for this
;  analysis
;
   .0       ;The fraction of the tank's surface covered by crust.  It is assumed
;            that this area participates in exchange of sensible heat with the
;            primary air, but doesn't participate in the evaporative cooling of
;            the waste.
   200.0    ;The primary (dome space) ventilation system flow SCFM
   336.0    ;The annulus ventilation system flow
    77.0    ;Ambient inlet temperature
;
;  The next set of  analysis parameters are the transient analysis parameters
;
    1440.0 ;Number of hours for which to run the transient, since this program
;            has no restart capabilities it is assumed that all runs start at 0
    72.0    ;Printout interval for the output of the state variables.  This will
;            also be converted to days and printed out in the same file
   500.0     ;Max pump horsepower available to heat up the waste
   5        ;Number of data pairs that define the time vs normalized pump power
;            input data table.
```

```
  0.0       1.0
  215.0     1.0
  216.0     1.0
  700.0     1.0
 1440.0     1.0
   4        ;Number of data pairs that define the normalized tank level vs time
;            input data file.  The normalization factor is 1,000,000 gallons.
;            normalized values greater than 1.0 are permitted to allow for tanks
;            that have been filled beyond their nominal design limit.
  0.0        0.5
  200        0.5
  700        0.5
 5500        0.5
```

SY-102 TANK: Case 2: 2 mixers at 100% flow, 1/2 full

WASTE DENSITY = 73.000 LBM/FT^3
WASTE SPECIFIC HEAT = 0.650 BTU/LBM -DEG F
DECAY HEAT = 0.100 BTU/FT^3 - HR
VAPOR PRESSURE WRT H20 = 0.800
FRACTION OF TANK COVERED BY CRUST = 0.000
DOME FLOW = 200.000 SCFM
ANNULUS FLOW = 336.000 SCFM
INLET AIR TEMP = 77.000 DEG F

TIME (HRS)	OUTLET M.R. (LBMH20/LBMAIR)	TEMP WASTE(deg-F)	PUMP POWER (HP)	LEVEL (FT)	OUTLET TEMP ANNULUS(deg-F)	OUTLET TEMP DOME(deg-F)
0.00	0.00	72.00	500.00	15.00	0.00	0.00
72.00	0.04	105.42	500.00	15.00	105.24	94.90
144.00	0.07	133.09	500.00	15.00	132.90	116.76
216.00	0.15	159.25	500.00	15.00	159.09	139.27
288.00	0.31	182.76	500.00	15.00	182.63	160.84
360.00	0.64	201.20	500.00	15.00	201.12	179.02

OUT OF RANGE TWASTE = 210.014

```
;       Input file for simple program to compute waste tank heatup as a result
; of mixer pump operation.  A semi colon acts as a comment designator so any
; data or comments that appear on a line following a semi-colon are ignored
; the first data record is the title of the run that this input file represents
;
 SY-102 TANK: Case 2: 2 mixers at 100% flow, 1/2 full
;
;  The next input parameters are the waste specific properties for this tank
;
   73.0     ;The waste density in lbm/cubic ft
   0.65      ;The waste specific heat in Btu/lbm - deg F
   0.10      ;The waste decay heat in Btu/cubic ft - hr
   0.8     ;The waste vapor pressure as a fraction of that of water
   72.      ;The waste initial temperature for the start of the run
;
;  The next set of input parameters is the tank specific properties for this
;  analysis
;
   .0       ;The fraction of the tank's surface covered by crust.  It is assumed
;            that this area participates in exchange of sensible heat with the
;            primary air, but doesn't participate in the evaporative cooling of
;            the waste.
   200.0    ;The primary (dome space) ventilation system flow SCFM
   336.0    ;The annulus ventilation system flow
    77.0    ;Ambient inlet temperature
;
;  The next set of  analysis parameters are the transient analysis parameters
;
    1440.0 ;Number of hours for which to run the transient, since this program
;            has no restart capabilities it is assumed that all runs start at 0
    72.0    ;Printout interval for the output of the state variables.  This will
;            also be converted to days and printed out in the same file
   500.0     ;Max pump horsepower available to heat up the waste
   5        ;Number of data pairs that define the time vs normalized pump power
;            input data table.
```

```
  0.0       1.0
  215.0     1.0
  216.0     0.13
  700.0     0.13
 1440.0     0.13
   4        ;Number of data pairs that define the normalized tank level vs time
;            input data file.  The normalization factor is 1,000,000 gallons.
;            normalized values greater than 1.0 are permitted to allow for tanks
;            that have been filled beyond their nominal design limit.
  0.0        0.5
  200        0.5
  700        0.5
 5500        0.5
```

SY-102 TANK: Case 2: 2 mixers at 100% flow, 1/2 full

WASTE DENSITY = 73.000 LBM/FT^3
WASTE SPECIFIC HEAT = 0.650 BTU/LBM -DEG F
DECAY HEAT = 0.100 BTU/FT^3 - HR
VAPOR PRESSURE WRT H20 = 0.800
FRACTION OF TANK COVERED BY CRUST = 0.000
DOME FLOW = 200.000 SCFM
ANNULUS FLOW = 336.000 SCFM
INLET AIR TEMP = 77.000 DEG F

TIME (HRS)	OUTLET M.R. (LBMH20/LBMAIR)	TEMP WASTE(deg-F)	PUMP POWER (HP)	LEVEL (FT)	OUTLET TEMP ANNULUS(deg-F)	OUTLET TEMP DOME(deg-F)
0.00	0.00	72.00	500.00	15.00	0.00	0.00
72.00	0.04	105.42	500.00	15.00	105.24	94.90
144.00	0.07	133.09	500.00	15.00	132.90	116.76
216.00	0.15	158.99	65.00	15.00	159.00	139.21
288.00	0.17	158.57	65.00	15.00	158.59	142.49
360.00	0.18	157.85	65.00	15.00	157.86	144.24
432.00	0.18	156.95	65.00	15.00	156.98	145.08
504.00	0.18	156.05	65.00	15.00	156.07	145.60
576.00	0.17	155.24	65.00	15.00	155.26	145.86
648.00	0.17	154.51	65.00	15.00	154.53	145.93
720.00	0.17	153.86	65.00	15.00	153.88	145.88
792.00	0.16	153.28	65.00	15.00	153.29	145.75
864.00	0.16	152.75	65.00	15.00	152.77	145.58
936.00	0.16	152.28	65.00	15.00	152.30	145.39
1008.00	0.16	151.86	65.00	15.00	151.87	145.19
1080.00	0.15	151.48	65.00	15.00	151.49	144.98
1152.00	0.15	151.14	65.00	15.00	151.16	144.78
1224.00	0.15	150.83	65.00	15.00	150.85	144.58
1296.00	0.15	150.55	65.00	15.00	150.57	144.39
1368.00	0.15	150.31	65.00	15.00	150.32	144.20
1440.00	0.15	150.08	65.00	15.00	150.09	144.03

CASE2A

TOTAL HEAT BTU/HR	PUMP POWER (%)	ANNULUS LOSS (%)	LATENT HEAT (%)	SENSIBLE HEAT (%)	DIRT LOSS (%)	TIME (DAYS)
1277867.00	99.48	0.00	0.00	0.00	0.00	0.00
1277867.00	99.48	0.80	2.40	0.30	17.28	3.00
1277867.00	99.48	1.59	5.05	0.67	30.91	6.00
171888.19	96.14	17.31	77.28	7.81	297.95	9.00
171888.19	96.14	17.22	86.15	8.22	197.57	12.00
171888.19	96.14	17.07	91.35	8.44	134.30	15.00
171888.19	96.14	16.88	93.63	8.55	93.00	18.00
171888.19	96.14	16.69	91.61	8.61	65.64	21.00
171888.19	96.14	16.52	89.32	8.65	47.31	24.00
171888.19	96.14	16.37	87.33	8.65	34.74	27.00
171888.19	96.14	16.23	85.58	8.65	25.99	30.00
171888.19	96.14	16.10	84.04	8.63	19.78	33.00
171888.19	96.14	15.99	82.69	8.61	15.31	36.00
171888.19	96.14	15.89	81.49	8.59	12.07	39.00
171888.19	96.14	15.81	80.43	8.56	9.70	42.00
171888.19	96.14	15.72	79.49	8.54	7.94	45.00
171888.19	96.14	15.65	78.65	8.51	6.63	48.00
171888.19	96.14	15.59	77.91	8.48	5.67	51.00
171888.19	96.14	15.53	77.25	8.46	4.97	54.00
171888.19	96.14	15.48	76.65	8.44	4.44	57.00
171888.19	96.14	15.43	76.13	8.42	4.07	60.00

```
;       Input file for simple program to compute waste tank heatup as a result

; of mixer pump operation.  A semi colon acts as a comment designator so any
; data or comments that appear on a line following a semi-colon are ignored
; the first data record is the title of the run that this input file represents
;
 SY-102 TANK: Case 3: Tank Cool Down, 2 mixers at 50% flow, tank 1/2 full
;
;  The next input parameters are the waste specific properties for this tank
;
   73.0     ;The waste density in lbm/cubic ft
   0.65      ;The waste specific heat in Btu/lbm - deg F
   0.10      ;The waste decay heat in Btu/cubic ft - hr
   0.8     ;The waste vapor pressure as a fraction of that of water
   200.      ;The waste initial temperature for the start of the run
;
;  The next set of input parameters is the tank specific properties for this
;  analysis
;
   .0       ;The fraction of the tank's surface covered by crust.  It is assumed
;            that this area participates in exchange of sensible heat with the
;            primary air, but doesn't participate in the evaporative cooling of
;            the waste.
   200.0    ;The primary (dome space) ventilation system flow SCFM
   336.0    ;The annulus ventilation system flow
    77.0    ;Ambient inlet temperature
;
;  The next set of  analysis parameters are the transient analysis parameters
;
    1440.0 ;Number of hours for which to run the transient, since this program
;            has no restart capabilities it is assumed that all runs start at 0
    72.0    ;Printout interval for the output of the state variables.  This will
;            also be converted to days and printed out in the same file
   65.0     ;Max pump horsepower available to heat up the waste
   5        ;Number of data pairs that define the time vs normalized pump power
;            input data table.
```

```
  0.0       1.0
  215.0     1.0
  216.0     1.0
  700.0     1.0
 1440.0     1.0
   4        ;Number of data pairs that define the normalized tank level vs time
;            input data file.  The normalization factor is 1,000,000 gallons.
;            normalized values greater than 1.0 are permitted to allow for tanks
;            that have been filled beyond their nominal design limit.
   0.0       0.5
   200       0.5
   700       0.5
  5500       0.5
```

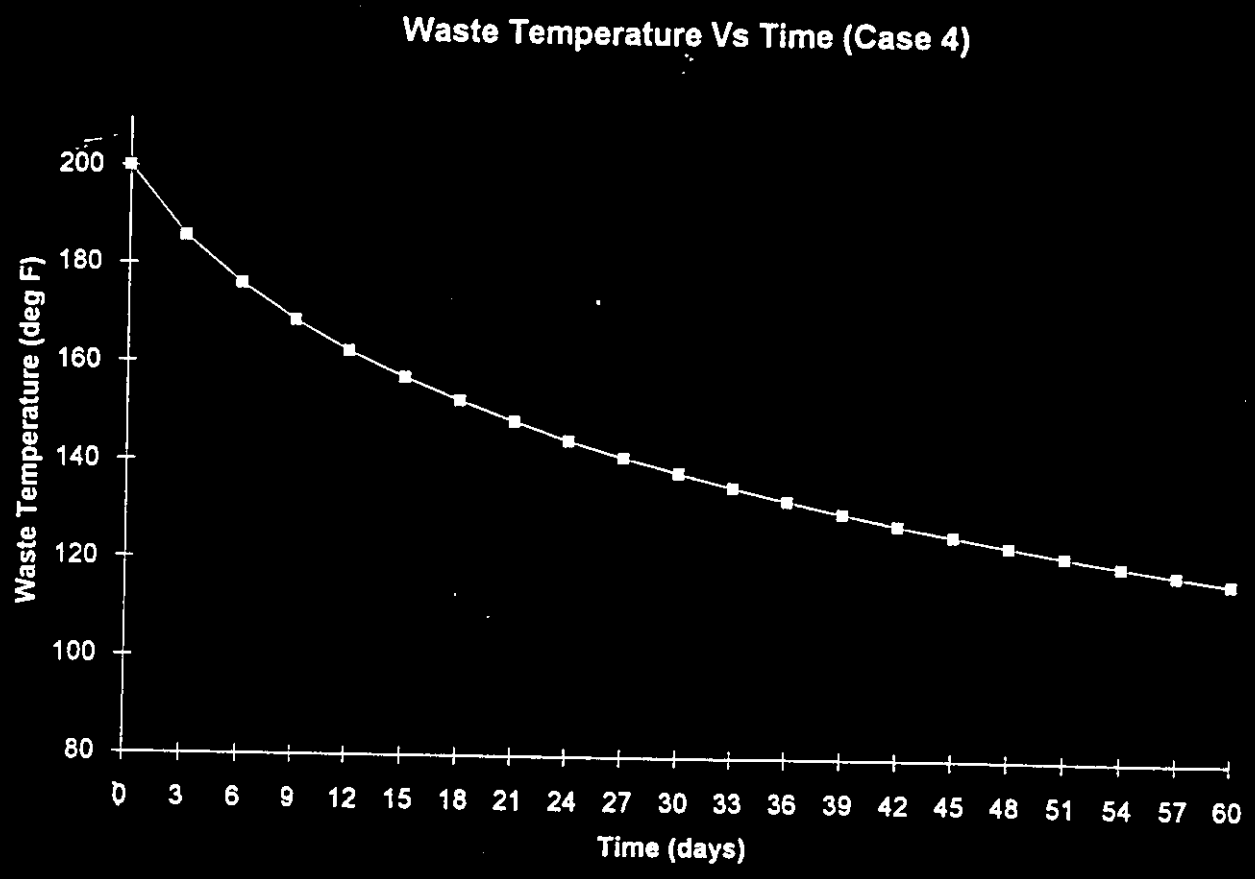
SY-102 TANK: Case : Tank Cool Down, 2 mixers at 50% flow, tank 1/2 f

WASTE DENSITY = 73.000 LBM/FT^3
WASTE SPECIFIC HEAT = 0.650 BTU/LBM -DEG F
DECAY HEAT = 0.100 BTU/FT^3 - HR
VAPOR PRESSURE WRT H20 = 0.800
FRACTION OF TANK COVERED BY CRUST = 0.000
DOME FLOW = 200.000 SCFM
ANNULUS FLOW = 336.000 SCFM
INLET AIR TEMP = 77.000 DEG F

TIME (HRS)	OUTLET M.R. (LBMH20/LBMAIR)	TEMP WASTE(deg-F)	PUMP POWER (HP)	LEVEL (FT)	OUTLET TEMP ANNULUS(deg-F)	OUTLET TEMP DOME(deg-F)
0.00	0.00	200.00	65.00	15.00	0.00	0.00
72.00	0.54	188.61	65.00	15.00	188.68	180.58
144.00	0.41	181.41	65.00	15.00	181.45	175.39
216.00	0.34	176.17	65.00	15.00	176.19	171.36
288.00	0.30	172.10	65.00	15.00	172.11	167.98
360.00	0.27	168.82	65.00	15.00	168.83	165.06
432.00	0.25	166.12	65.00	15.00	166.12	162.53
504.00	0.23	163.85	65.00	15.00	163.85	160.30
576.00	0.21	161.93	65.00	15.00	161.93	158.35
648.00	0.20	160.28	65.00	15.00	160.28	156.63
720.00	0.19	158.85	65.00	15.00	158.85	155.11
792.00	0.19	157.62	65.00	15.00	157.61	153.76
864.00	0.18	156.54	65.00	15.00	156.54	152.56
936.00	0.18	155.59	65.00	15.00	155.58	151.51
1008.00	0.17	154.76	65.00	15.00	154.75	150.56
1080.00	0.17	154.03	65.00	15.00	154.02	149.72
1152.00	0.16	153.38	65.00	15.00	153.37	148.97
1224.00	0.16	152.80	65.00	15.00	152.80	148.29
1296.00	0.16	152.29	65.00	15.00	152.29	147.70
1368.00	0.16	151.84	65.00	15.00	151.84	147.15
1440.00	0.15	151.44	65.00	15.00	151.42	146.67

CASE 3

TOTAL HEAT BTU/HR	PUMP POWER (%)	ANNULUS LOSS (%)	LATENT HEAT (%)	SENSIBLE HEAT (%)	DIRT LOSS (%)	TIME (DAYS)
171888.20	96.14	0.00	0.00	0.00	0.00	0.00
171888.20	96.14	23.58	276.29	13.01	4.57	3.00
171888.20	96.14	22.05	211.41	12.35	-11.07	6.00
171888.20	96.14	20.94	175.98	11.85	-24.14	9.00
171888.20	96.14	20.08	153.34	11.42	-31.47	12.00
171888.20	96.14	19.39	137.63	11.06	-34.51	15.00
171888.20	96.14	18.82	126.07	10.74	-34.81	18.00
171888.20	96.14	18.34	117.21	10.46	-33.49	21.00
171888.20	96.14	17.93	110.25	10.21	-31.29	24.00
171888.20	96.14	17.58	104.64	10.00	-28.69	27.00
171888.20	96.14	17.28	100.05	9.81	-25.95	30.00
171888.20	96.14	17.02	96.24	9.64	-23.26	33.00
171888.20	96.14	16.79	93.04	9.49	-20.69	36.00
171888.20	96.14	16.59	90.33	9.36	-18.28	39.00
171888.20	96.14	16.42	88.02	9.24	-16.09	42.00
171888.20	96.14	16.26	86.03	9.13	-14.10	45.00
171888.20	96.14	16.12	84.32	9.04	-12.30	48.00
171888.20	96.14	16.00	82.83	8.95	-10.68	51.00
171888.20	96.14	15.90	81.53	8.88	-9.22	54.00
171888.20	96.14	15.80	80.39	8.81	-7.90	57.00
171888.20	96.14	15.71	79.40	8.75	-6.72	60.00


Waste Temperature Vs Time (Case 4)
Waste Temperature (deg F)
200
180
160
140
120
100
80
0 3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48 51 54 57 60
Time (days)

```
;       Input file for simple program to compute waste tank heatup as a result

; of mixer pump operation.  A semi colon acts as a comment designator so any
; data or comments that appear on a line following a semi-colon are ignored
; the first data record is the title of the run that this input file represents
;
 SY-102 TANK: Case 4: Tank Cool Down, no mixers, tank 1/2 full
;
;  The next input parameters are the waste specific properties for this tank
;
   73.0     ;The waste density in lbm/cubic ft
   0.65      ;The waste specific heat in Btu/lbm - deg F
   0.10      ;The waste decay heat in Btu/cubic ft - hr
   0.8     ;The waste vapor pressure as a fraction of that of water
   200.      ;The waste initial temperature for the start of the run
;
;  The next set of input parameters is the tank specific properties for this
;  analysis
;
   .0       ;The fraction of the tank's surface covered by crust.  It is assumed
;            that this area participates in exchange of sensible heat with the
;            primary air, but doesn't participate in the evaporative cooling of
;            the waste.
   200.0    ;The primary (dome space) ventilation system flow SCFM
   336.0    ;The annulus ventilation system flow
    77.0    ;Ambient inlet temperature
;
;  The next set of  analysis parameters are the transient analysis parameters
;
    1440.0 ;Number of hours for which to run the transient, since this program
;            has no restart capabilities it is assumed that all runs start at 0
    72.0    ;Printout interval for the output of the state variables.  This will
;            also be converted to days and printed out in the same file
   0.0     ;Max pump horsepower available to heat up the waste
   5        ;Number of data pairs that define the time vs normalized pump power
;            input data table.
```

```
  0.0       1.0
  215.0     1.0
  216.0     0.13
  700.0     0.13
 1440.0     0.13
   4        ;Number of data pairs that define the normalized tank level vs time
;            input data file.  The normalization factor is 1,000,000 gallons.
;            normalized values greater than 1.0 are permitted to allow for tanks
;            that have been filled beyond their nominal design limit.
   0.0       0.5
   200       0.5
   700       0.5
  5500       0.5
```

SY-102 TANK: Case 4: Tank Cool Down, no mixers, tank 1/2 full

WASTE DENSITY = 73.000 LBM/FT^3
WASTE SPECIFIC HEAT = 0.650 BTU/LBM -DEG F
DECAY HEAT = 0.100 BTU/FT^3 - HR
VAPOR PRESSURE WRT H20 = 0.800
FRACTION OF TANK COVERED BY CRUST = 0.000
DOME FLOW = 200.000 SCFM
ANNULUS FLOW = 336.000 SCFM
INLET AIR TEMP = 77.000 DEG F

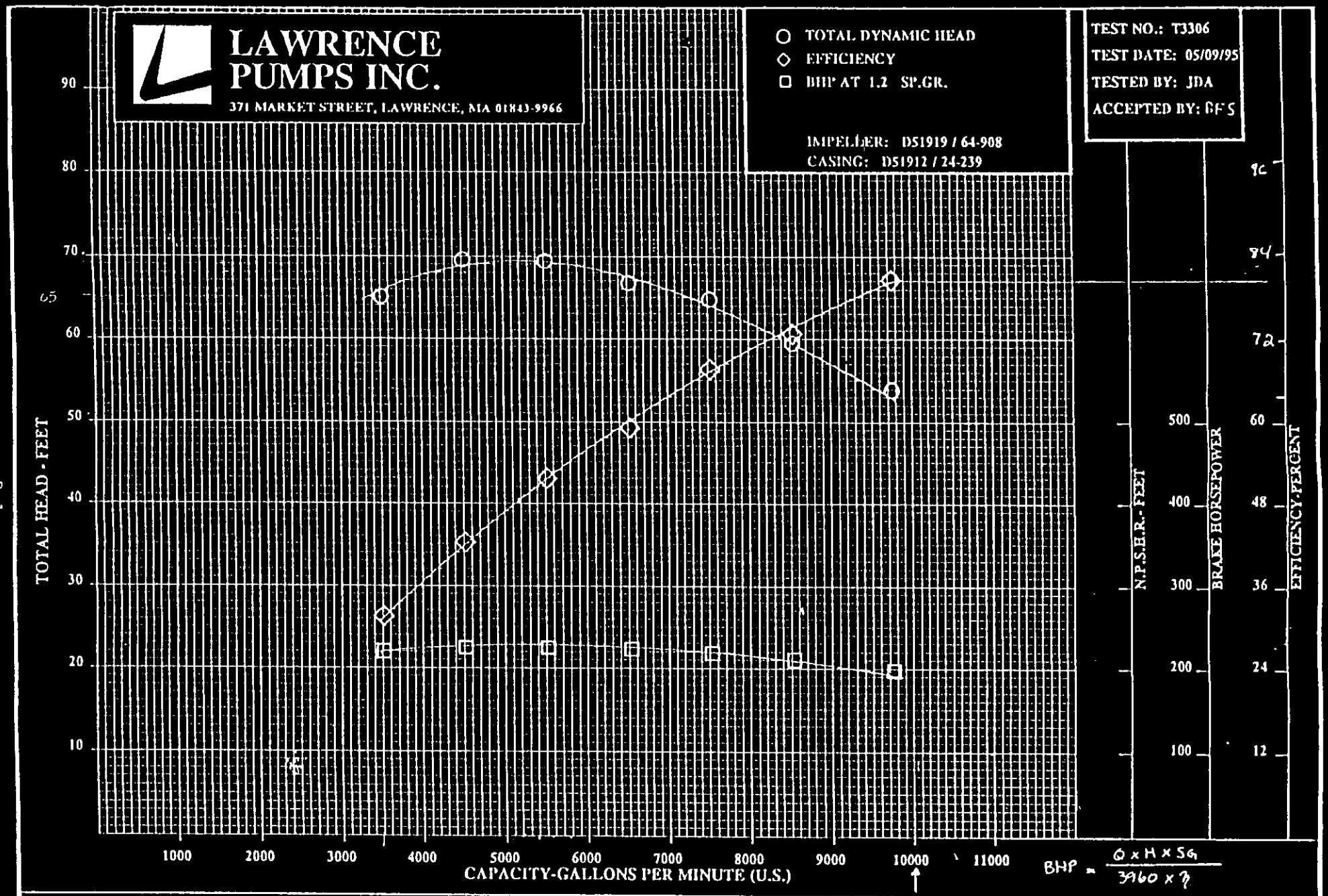
TIME (HRS)	OUTLET M.R. (LBMH20/LBMAIR)	TEMP WASTE(deg-F)	PUMP POWER (HP)	LEVEL (FT)	OUTLET TEMP ANNULUS(deg-F)	OUTLET TEMP DOME(deg-F)
0.00	0.00	200.00	0.00	15.00	0.00	0.00
72.00	0.48	185.61	0.00	15.00	185.68	178.43
144.00	0.34	176.00	0.00	15.00	176.05	171.42
216.00	0.27	168.55	0.00	15.00	168.58	165.55
288.00	0.22	162.40	0.00	15.00	162.43	160.35
360.00	0.18	157.14	0.00	15.00	157.16	155.65
432.00	0.16	152.52	0.00	15.00	152.54	151.36
504.00	0.14	148.42	0.00	15.00	148.43	147.43
576.00	0.13	144.71	0.00	15.00	144.73	143.82
648.00	0.11	141.35	0.00	15.00	141.36	140.48
720.00	0.10	138.26	0.00	15.00	138.27	137.40
792.00	0.10	135.41	0.00	15.00	135.42	134.53
864.00	0.09	132.76	0.00	15.00	132.77	131.87
936.00	0.08	130.30	0.00	15.00	130.31	129.38
1008.00	0.08	128.00	0.00	15.00	128.01	127.06
1080.00	0.07	125.84	0.00	15.00	125.85	124.88
1152.00	0.07	123.81	0.00	15.00	123.82	122.83
1224.00	0.06	121.89	0.00	15.00	121.90	120.90
1296.00	0.06	120.08	0.00	15.00	120.08	119.07
1368.00	0.06	118.37	0.00	15.00	118.37	117.35
1440.00	0.05	116.74	0.00	15.00	116.74	115.72

CASE4

TOTAL HEAT BTU/HR	PUMP POWER (%)	ANNULUS LOSS (%)	LATENT HEAT (%)	SENSIBLE HEAT (%)	DIRT LOSS (%)	TIME (DAYS)
6627.00	0.00	0.00	0.00	0.00	0.00	0.00
6627.00	0.00	595.13	6399.45	330.35	-19.21	3.00
6627.00	0.00	542.39	4542.14	307.52	-706.64	6.00
6627.00	0.00	501.52	3541.60	288.39	-1214.63	9.00
6627.00	0.00	467.83	2905.60	271.46	-1497.89	12.00
6627.00	0.00	438.97	2461.34	256.13	-1622.37	15.00
6627.00	0.00	413.69	2132.07	242.17	-1647.72	18.00
6627.00	0.00	391.18	1877.68	229.36	-1614.79	21.00
6627.00	0.00	370.90	1675.03	217.61	-1549.96	24.00
6627.00	0.00	352.44	1509.75	206.74	-1469.50	27.00
6627.00	0.00	335.52	1372.38	196.70	-1383.26	30.00
6627.00	0.00	319.91	1256.43	187.36	-1296.90	33.00
6627.00	0.00	305.43	1157.31	178.69	-1213.59	36.00
6627.00	0.00	291.95	1071.64	170.60	-1134.95	39.00
6627.00	0.00	279.34	996.91	163.03	-1061.71	42.00
6627.00	0.00	267.51	931.19	155.93	-994.01	45.00
6627.00	0.00	256.38	872.98	149.26	-931.73	48.00
6627.00	0.00	245.89	821.10	142.97	-874.56	51.00
6627.00	0.00	235.94	774.60	137.03	-821.72	54.00
6627.00	0.00	226.54	732.71	131.42	-773.72	57.00
6627.00	0.00	217.63	694.80	126.11	-729.63	60.00

APPENDIX B

Pump Curve



CUSTOMER: WESTINGHOUSE HANFORD CO.	SERIAL NUMBER: 90908-1	IMPELLER TESTED (IN): 15.50	SPEED (RPM): 960
USER NAME:	PUMP TYPE: 6" VERTICAL	IMPELLER PLOTTED (IN): 15.50	IMP DIA. MIN (IN): 15.50
P.O. NUMBER: MDW-SXV-327408	PUMP SIZE: 6	RATED FLOW (GPM): 10,400	IMP DIA. MAX (IN): 15.50
ITEM NUMBER:	SERVICE: WASTE MOBILIZATION MIXER	RATED HEAD (FT):	IMP EYE AREA (IN^2):