Tank 37H Salt Removal Batch Process and Salt Dissolution Mixing Study

by

K. C. Kwon

Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

M. R. Poirier

DOE Contract No. **DE-AC09-96SR18500**

This paper was prepared in connection with work done under the above contract number with the U. S. Department of Energy. By acceptance of this paper, the publisher and/or recipient acknowledges the U. S. Government's right to retain a nonexclusive, royalty-free license in and to any copyright covering this paper, along with the right to reproduce and to authorize others to reproduce all or part of the copyrighted paper.

This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-96SR18500 with the U.S. Department of Energy.

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, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness 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. 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 directly from the best available copy.

Available for sale to the public, in paper, from: U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, phone: (800) 553-6847, fax: (703) 605-6900, email: orders@ntis.fedworld.gov online ordering: http://www.ntis.gov/ordering.htm

Available electronically at http://www.doe.gov/bridge

Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from: U.S. Department of Energy, Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831-0062, phone: (865) 576-8401, fax: (865) 576-5728, email: reports@adonis.osti.gov

WSRC-TR-2001-00277
Rev. 0

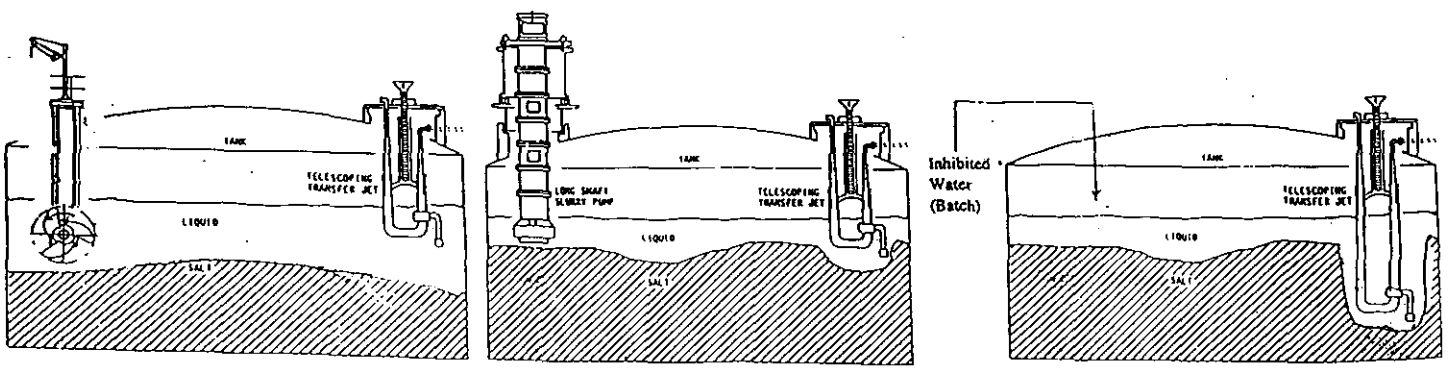
Keywords: Tank 37H, Salt
Dissolution, Heat Transfer

Tank 37H Salt Removal Batch Process and Salt Dissolution Mixing Study

Ki C. Kwon

Michael R. Poirier

July 17, 2001



APPROVAL

Authors:

K. C. Kwon, WHMP — Date: 7/18/01

M. R. Poirier, WHMP — Date: 7/18/01

Design Check

J. L. Siler, WHMP — Date: 7/18/01

Customer

R. C. Jolly, HLW-WRP — Date: 8/16/01

D. T. Conrad, Mgr., HLW-WRP — Date: 8/16/01

Management

W. B. Van Pelt, Mgr., WHMP — Date: 7-18-01

W. L. Tamosaitis, Mgr., WPTS — Date: 7/18/01

Table of Contents

Summary 3
Background 4
Approach 4
Slurry Pump Agitation 4
Flygt Mixer Agitation 5
Multiple Mixers 6
Modified Density Gradient 6
Molecular Diffusion 8
Dissolution Time Calculation 9
Heat Transfer Analysis 11
Assumptions 14
Conclusions 15
Path Forward 15
References 15
Appendix 1. Selected Sketches, Test Data and Example Calculations 17
Appendix 2. Dissolution Calculations 33
Appendix 3. Heat Transfer Calculations 66

Summary

SRS High Level Waste (HLW) wishes to use Tank 37H as the receipt tank for the 3H Evaporator concentrate. Prior to using Tank 37H as the 3H Evaporator concentrate receipt tank, HLW must remove 50 inches of salt cake from the tank. They requested SRTC to evaluate various salt removal methods for Tank 37H. These methods include slurry pumps, Flygt mixers, the modified density gradient (MDG) method, and molecular diffusion. The authors reviewed previous test and operating data as well as the technical literature to estimate the salt removal rate by each method. They considered 16 different combinations of agitation and inhibited water temperature, and calculated the dissolution time by each method. The results are shown below. They are based on the assumption of constant inhibited water temperature inside the tank during dissolution. In reality, the temperature of the supernate and salt cake will change during the process. The table shows the range of dissolution rates calculated, the dissolution rate used in the calculations, dissolution time, fraction of process time for dissolution, and total process time.

Dissolution Method	Dissolution Rate (gpm)	Dis. Rate used (gpm)	Dissolution Time (days)	Dissolution Time (% of Total)	Total Process Time (months)
1. No Agitation (25°C)	1.18 – 2.47	1.83	117	54	7.0
2. MDG (25°C)	1.25 – 5.84	3.55	74	46	5.3
3. MDG (50°C)	1.78 – 8.32	5.05	60	41	4.9
4. MDG (75°C)	2.33 –10.80	6.56	53	37	4.6
5. One Flygt Mixer (25°C)	2.0 – 4.0	3.0	82	46	5.9
6. Two Flygt Mixers (25°C)	2.8 – 5.7	4.2	67	41	5.4
7. One Flygt Mixer (50°C)	2.8 – 5.8	4.3	66	40	5.4
8. One Slurry Pump (25°C)	3.0 – 7.0	5.0	61	38	5.2
9. Three Flygt Mixers (25°C)	3.5 – 6.9	5.2	59	38	5.1
10. One Flygt mixer (75°C)	3.7 – 7.4	5.6	57	37	5.1
11. Two Flygt Mixers (50°C)	4.0 – 8.0	6.1	55	36	5.0
12. One Slurry Pump (50°C)	4.3 – 9.9	7.1	51	34	4.9
13. Three Flygt Mixers (50°C)	4.9 – 9.8	7.4	50	34	4.8
14. Two Flygt Mixers (75°C)	5.3 – 10.5	8.6	47	33	4.7
15. One Slurry Pump (75°C)	5.6 – 13.0	9.3	46	32	4.7
16. Three Flygt Mixers (75°C)	6.4 – 12.9	10.6	43	31	4.6

The conclusions from this work are the following:

- A single Flygt mixer with tank supernate temperature of 25° C should be sufficient to dissolve and remove 50 inches of salt cake within six months. Increasing the supernate temperature or adding additional Flygt mixers will decrease the time to dissolve the salt cake.
- A single slurry pump with tank supernate temperature of 25° C also should be sufficient to dissolve and remove 50 inches of salt cake within six months. Increasing supernate temperature or adding additional slurry pumps will decrease the time to dissolve the salt cake.
- Calculations predict that the modified density gradient method should be able to remove 50 inches of salt cake within six months, but uncertainty exists in predicting dissolution rates by this method (predicted dissolution rates varied between 1.25 gpm and 5.84 gpm at 25° C). HLW should exercise caution when making decisions using calculated dissolution rates for this method.
- Molecular diffusion is unlikely to remove 50 inches of salt cake in six months.

- If the inhibited water temperature is 25° C, the actual tank supernate temperature will be higher and the salt dissolution rate faster than predicted by this analysis.
- If the inhibited water temperature is 50 or 75° C, tank cooling will reduce the tank supernate temperature to 30 – 40° C, which increases the dissolution time and minimizes the benefit of adding heated water to the tank. Including this effect, the dissolution rate with one Flygt mixer is 3.15 gpm (rather than 4.3) for case 7 and 3.35 gpm (rather than 5.6) for case 10.

Background

Tank 30H is the receipt tank for concentrate from the 3H Evaporator. Tank 30H has had problems, such as cooling coil failure, which limit its ability to receive concentrate from the 3H Evaporator. SRS High Level Waste (HLW) wishes to use Tank 37H as the receipt tank for the 3H Evaporator concentrate. Prior to using Tank 37H as the 3H Evaporator concentrate receipt tank, HLW must remove 50 inches of salt cake from the tank. They requested SRTC to evaluate various salt removal methods for Tank 37H. These methods include slurry pumps, Flygt mixers, the modified density gradient method, and molecular diffusion.

Approach

Four approaches were evaluated for removing salt cake from Tank 37H:

- *Slurry pump agitation*
- Flygt mixer agitation
- Modified density gradient
- Molecular diffusion

The authors reviewed previous test and operating data as well as the technical literature to estimate the salt removal rate by each method.

Slurry Pump Agitation

SRS performed a salt removal demonstration in Tank 19F in 1980 and 1981 using long shaft vertical centrifugal pumps (i.e., slurry pumps).[1] During the first dissolution batch, 172,000 gallons of salt cake was dissolved with 236,000 gallons of inhibited water in 350 hours using a single slurry pump (8.2 gpm salt cake dissolution rate). During the dissolution, the supernate temperature was approximately 33° C. In another salt removal application, SRTC examined the effect of temperature on salt cake dissolution rate and estimated it to be approximately 1.7%/°C (using 200,000 gallons of dissolution water).[2] Correcting for temperature, the estimated dissolution rate at 25° C is 7.1 gpm. During the second dissolution batch, 281,000 gallons of salt cake was dissolved with 442,000 gallons of inhibited water in 930 hours using a single slurry pump (5.0 gpm salt cake dissolution rate). The supernate temperature during batch 2 was 45° C. Correcting for temperature, the estimated dissolution rate at 25° C is 3.3 gpm. Using this data, the estimated salt cake dissolution rate with a single slurry pump at 25° C is 3 – 7 gpm.

Tank 19F has no center column or cooling coils. Since Tank 37H has a center column and cooling coils, the actual dissolution rate will be less than in Tank 19F under the same conditions. Additionally, the volume of dissolution water in Tank 19F was greater than the volume of

dissolution water to be used in Tank 37H. Previous work showed increasing the dissolution water volume decreased the dissolution rate[2], so the smaller volume in Tank 37H would increase the dissolution rate over that observed in Tank 19F under the same conditions. These differences would affect the dissolution rate, but they are in opposite directions and should not change it dramatically.

The supernate density at the start of the Tank 19F salt dissolution demonstration was greater than 1.0. The reason is salt cake dissolution occurred prior to starting the slurry pumps. This dissolution was subtracted to calculate the overall dissolution rate in Tank 19F. Some dissolution will occur prior to starting mixing in Tank 37H, but the amount cannot be quantified.

A salt cake dissolution rate of 3 – 7 gpm at 25° C is probably a good estimate for a single standard slurry pump. The authors chose a dissolution rate of 5 gpm at 25° C for this analysis.

Flygt Mixer Agitation

No salt removal testing or demonstrations have been performed at SRS to date with Flygt mixers. Salt dissolution rates with Flygt mixer agitation can be predicted from salt dissolution data in slurry pump agitated tanks. Previous SRTC work on salt dissolution assumed the process to be mass transfer limited and the mass transfer coefficient to be described by equation [1]

$$K \propto \sqrt{\frac{\tau_w}{\rho}} Sc^{-0.7} \propto U_j D_j Sc^{-0.7} \qquad [1]$$

where K is the mass transfer coefficient, τ_w is the shear stress at the salt cake surface, Sc is the Schmidt number, U_j is the jet discharge velocity, and D_j is the jet nozzle diameter.[2,3] Since the Flygt mixer will behave as a turbulent jet, salt dissolution rates with Flygt mixers and slurry pumps can be compared by calculating the U_jD_j for each device.

A standard slurry pump has a flow rate of 600 gpm/nozzle, a nozzle diameter of 1.5 inches, and a nozzle velocity of 109 ft/s. The U_jD_j is 13.6 ft^2/s. Since the slurry pump has two opposing nozzles, the total U_jD_j is 27.2 ft^2/s.

A model # 4650 Flygt mixer has a flow rate of 10,700 gpm, a nozzle diameter of 22 inches, and a nozzle discharge velocity of 9 ft/s. The U_jD_j is 16.5 ft^2/s. The Flygt mixer has a single discharge. The salt dissolution rate using Flygt mixers can be estimated from equation [2]

$$R_{Flygt} = R_{pump} (16.5/27.2) = 0.6\ R_{pump} \qquad [2]$$

Using this approach, the estimated dissolution rate with a single Flygt mixer at 25 ° C is 2 – 4 gpm. The effect of the center column and smaller dissolution water volume would be similar to their effects with the slurry pump. Modeling the Flygt mixer as a turbulent jet is a good assumption. A salt cake dissolution rate of 2 – 4 gpm at 25° C is probably a good estimate for a single Flygt mixer. The authors chose a dissolution rate of 3 gpm at 25° C for this analysis.

Multiple Mixers

Using multiple Flygt mixers or slurry pumps will increase the dissolution rate. Two mixers will dissolve the salt cake faster than one mixer, but not necessarily twice as fast. Koh et. al. investigated the impact of the number of jets on jet mixing time.[4] They found the mixing time to be inversely proportional to the square root of the number of jets. Using that work, one assumes the salt cake dissolution rate is proportional to the square root of the number of mixers or pumps.

Modified Density Gradient

Another method for dissolving salt cake is the modified density gradient method. In this method, inhibited water is added to one side of a waste tank at the same time, or sometimes before, the concentrated supernate is removed from the other side of the tank with a transfer jet that is mined into the salt cake. The current plan in Tank 37 is to have a mined well depth of 155 inches from the tank bottom.

In 1979, SRS used a density gradient method to remove the salt from Tank 10 with a transfer jet that was mined into the salt to a depth of 36 inches from the tank bottom.[8,9,10,11,12]

SRTC investigated density driven salt dissolution techniques in 1996. They found the method could be applied to SRS waste tanks, but the key step to performing this technique was to "maintain the solution level just above the top of the saltcake".[6] This report includes a laboratory test result of a modified density gradient (MDG) method using 3" wide x 36" long x 15" high glass trough. The salt solution removal rate of MDG trough was 10 ml/min.[6] If one assumes the dissolution rate does not change during scale up, the corresponding salt dissolution rate of Type IIIa Tank 37H is described by equation [3]

$$\begin{aligned}\text{Dissolution Rate} &= (10\ \text{ml/min})\,(\text{Tank 37H surface area}) / (\text{Trough surface area}) / (2.4+1)\\ &= (10\ \text{mL/min}/\ 3786\ \text{mL/gal})\,(523.85\ \text{m}^2) / (0.0697\ \text{m}^2) / 3.4\\ &= 5.84\ \text{gpm}\end{aligned} \qquad [3]$$

SRTC investigated density gradient methods at the bench-scale in 1979. They found dissolution rate to be 1/4th the rate measured with mechanical agitation.[7,8] Assuming salt dissolution rate with the density gradient method at full-scale is 1/4th the slurry pump rate (or 5 gpm average) dividing by 4, one calculates a dissolution rate of 1.25 gpm for Tank 37H.

The references also show a laboratory test result of a density driven method using a 31 cm jar.[7,8] The salt cake dissolution rate of the jar is 11 ml/min. Assuming no change in the dissolution rate during scale up, the calculated salt dissolution rate of Tank 37H is calculated to be 6.13 gpm in equation [4].

$$\begin{aligned}\text{Dissolution Rate} &= (11\ \text{ml/min})\,(\text{Tank 37H surface area}) / (\text{Jar surface area}) / (2.4+1)\\ &= (11\ \text{mL/min}/\ 3786\ \text{mL/gal})\,(523.85\ \text{m}^2) / (0.0731\ \text{m}^2) / 3.4\\ &= 6.13\ \text{gpm}\end{aligned} \qquad [4]$$

SRS performed a demonstration of the modified density gradient dissolution method in Tank 10 in 1979.[8,9,10,11,12] Tank 10 is a Type I tank. It is 75 ft in diameter, 24.5 ft high, and has a capacity of 750,000 gallons. The tank contained a large salt mound (17 feet high) in one half of the tank. The other half also contained salt, but not at a uniform level. A level of 17 feet corresponds to 500,000 gallons. Since one half of the tank did not contain 17 feet of salt, the actual amount of salt cake in the tank was probably less than 500,000 gallons.

Supernate was observed between salt mounds in the tank. The supernate was probably saturated when the demonstration started. On two occasions, the tank received water from RBOF-RRF. The amount of water is not known. This water probably dissolved some of the salt cake in the tank and was near saturation when the demonstration started. Water was added to the tank to allow the transfer jet to be mined. The time this water was in the tank prior to the dissolution process beginning is not documented. The water would have dissolved some salt. Dissolution water was added batch wise to fill the tank to 206 inches (~ 17 feet) rather than continuously.[11] Some dissolution likely occurred as the water was added to the tank and while the water sat in the tank. The amount of dissolution is not known.

The teletype report of Tank 10 dated 4/30/79 stated that over 3 days of operation, the salt dissolution rate "appears to be about 0.01 ft/hr as was predicted by TNX test". This is equivalent to the salt dissolution rate of 5.42 gpm with a supernate density of 1.3 g/cc.[8] Equation [5] shows the calculation converting the change in salt cake elevation to salt cake dissolution rate. However, the statement "appears to be about 0.01 ft/hr" raises uncertainty about the rigor with which the dissolution rate was calculated.

Dissolution Rate = (0.01 ft/hr) (12 in/ft) (2710 gal/in) / (60 min/hr) = 5.42 gpm [5]

Another reference describes the dissolution rate to be 2.8 gpm.[13] Because the tank conditions prior to the demonstration are not described and other effects such as water being in the tank prior to the demonstration starting could have contributed to dissolution, there is a great deal of uncertainty in the salt dissolution rate by the modified density gradient method. The reference does not provide the tank temperature during the demonstration. High Level waste should exercise caution when using this estimate. Additionally, the test conclusion indicates that solution chemistry (i.e., corrosion inhibitors) was difficult to control without tank mixing.[12]

Tank 10 Salt Removal Demonstration Details & Teletype Data also provides additional dissolution test data from 4/25 through 5/2979.[11] The dissolution process was performed for 35 days. According to the data recorded, 140,046 gallons of salt cake was dissolved. Dividing the amount of salt dissolved by the demonstration time (35 days) yields a salt cake dissolution rate of 2.8 gpm.

Based on the data obtained for salt dissolution by density gradient methods, the authors decided to perform the analysis with a dissolution rate of 3.55 gpm (the mid-point of 1.25 and 5.84) at 25° C. This approach makes a number of assumptions and extrapolations, so High Level Waste should exercise caution when using calculated dissolution rates for the modified density gradient method.

Molecular Diffusion

Another method for salt dissolution is molecular diffusion. With this method, inhibited water is added to the tank, salt cake dissolves, and supernate mixing occurs by molecular diffusion. Since thermal gradients will exist in waste tanks, thermal diffusion must also be considered. The thermal gradients will cause density variations that will increase the mass transfer rate. The thermal convection mass transfer coefficient can be calculated by using an analogy with thermal convection heat transfer that is described by equation [6].[14]

$$\frac{kL}{D} = 0.13\left(\frac{gL^3\rho^2\Delta\rho}{\rho\mu^2}\right)^{1/3}\left(\frac{\mu}{\rho D}\right)^{1/3} \qquad [6]$$

In equation [3], k is the mass transfer coefficient, L is the liquid depth, D is diffusivity, g is the acceleration due to gravity, ρ is supernate density, and μ is the supernate viscosity. The temperature difference is assumed to be 1° C. Once the mass transfer coefficient is calculated, the mass transfer rate can be calculated with equation [7].

$$J = k\,A\,\Delta C \qquad [7]$$

In equation [4], A is the surface area and ΔC is the concentration gradient. Table 1 shows the input parameters for equations [6] and [7].

Using the input parameters from Table 1 and equations [6] - [7], the salt dissolution rate by thermal diffusion is calculated to be 2.47 gpm for 2.4:1 dissolution ratio (2.4 gal. water to 1 gal salt cake dissolved).

Table 1. Input Parameters for Thermal Diffusion Calculation

Parameter	Value
D (cm^2/s)	1.57×10^{-5}
L (in)	50
ρ (g/cc)	1.3919
μ (cp)	2.42
ν (cm^2/s)	0.0174
ΔT (°C)	1
$\Delta\rho$ (g/cc)	0.00038
g (cm/s^2)	980
ΔC (g/cc)	0.2
A (cm^2)	5.27×10^6

In 1981, SRTC conducted a horizontal plane dissolution test, which is similar to molecular diffusion, using a four liter beaker with 15 centimeter diameter.[8] The measured salt dissolution rate was 0.51 mL/min, which corresponds to a dissolution rate of 1.18 gpm in Tank 37H. The authors used 1.18 gpm, 2.47 gpm, and 1.83 gpm (the average) to calculate salt dissolution times by this method.

This approach makes a number of assumptions and extrapolations. It has not been experimentally validated. Therefore, SRS HLW should exercise caution when using this data to predict salt removal rates by molecular diffusion.

Dissolution Time Calculation

SRTC used the analysis described above to calculate the time to dissolve 50 inches of salt cake by various methods. Table 2 shows the methods considered. The table shows the range of dissolution rates calculated for each method, as well as the dissolution rate used to calculate he total dissolution process time. The dissolution rate used for the calculations with the slurry pumps and Flygt mixers was determined by using the average dissolution rate in Tank 19 at 25° C, modifying it if necessary to calculate the dissolution rate with a Flygt mixer, and correcting the rate for temperature and the number of mixers. The results of calculation for dissolution time with MDG and other methods are shown in Table 2.

To calculate the time to dissolve 50 inches of salt cake, one must also consider the time required to add inhibited water, the salt dissolution time, the time to transfer supernate from the tank, and sampling and preparation time. SRTC made the following assumptions to calculate the salt dissolution time. Tank 37H will contain 269.5 inches of crystallized salt cake and 81.69 inches of saturated supernate when the supernate is removed from the tank. This supernate will be saturated with salt. The ratio of dissolved salt cake to inhibited water in the supernate removed from the tank is 1:2.4. HLW can add a maximum of 40 inches of inhibited water to the tank for each dissolution batch. HLW can add 8000 gallons of inhibited water in a 12-hour shift (the addition rate is 11.1 gpm). Seven days was added to the dissolution time for each batch to be conservative. The jet transfer rate of non-MDG to TK 26 is 60 gpm. As shown in Table 2, the jet transfer rate of MDG to Tank 26 are 4.25 to 36.73 gpm. Sampling and preparation time is 240 hours per dissolution batch.

Table 3 shows a number of different techniques can be used to dissolve the salt cake in Tank 37H. The spreadsheets used to perform the calculations are included in Appendix 1. The modified density gradient method with a transfer jet in the deeply mined well could dissolve the salt cake faster than a single Flygt mixer and horizontal plane or molecular diffusion dissolution. Increasing the supernate temperature of all methods or increasing the number of mixers decreases the dissolution time. The table also shows the fraction of dissolution time required for mixing is 30 – 54% of the total dissolution time. HLW can improve the salt dissolution rate by reducing the time for other steps (e.g., water addition, supernate removal, and sampling). Some dissolution will occur while inhibited water is added to the tank, which will reduce the overall salt dissolution time. The exact reduction in dissolution time cannot be quantified.

The authors have more confidence in the predicted dissolution times with Flygt mixers and slurry pumps than they do in the predicted dissolution times with molecular diffusion (MD) and the modified density gradient (MDG) method. There are a number of uncertain thermal effects on MD and unknown salt cake internal structural porosity or moisture permeability and undefined drain passage pattern which could change with time, temperature, transfer jet suction condition, water-salt cake level and other MDG method parameters.

Table 2. Salt Cake Dissolution Methods

Method	Dissolution Rate Range (gpm)	Transfer Rate to TK 26 (gpm)	Total Process Time (Months)
No Agitation 25C Low	1.18	60	8.63
No Agitation 25C Mid.	1.83	60	7.03
No Agitation 25C High	2.47	60	6.27
MDG 25C Low	1.25	4.25	8.08
MDG 25C Mid-value	3.55	12.05	5.32
MDG 25C High	5.84	19.86	4.73
MDG 50C Low	1.78	6.05	6.81
MDG 50C Mid-value	5.05	17.17	4.87
MDG 50C High	8.32	28.29	4.45
MDG 75C Low	2.33	7.91	6.11
MDG 75C Mid-Value	6.56	23.32	4.63
MDG 75C High	10.8	36.73	4.31
1 Flygt Mixer 25C Low	2.0	60	6.78
1 Flygt Mixer 25C Mid.	3.0	60	5.89
1 Flygt Mixer 25C High	4.0	60	5.45
1 Flygt Mixer 50C (Mid)	2.8 – 5.7 (4.3)	60	5.4
1 Flygt Mixer 75C	3.7 – 7.4 (5.6)	60	5.1
2 Flygt Mixers 25C	2.8 – 5.7 (4.2)	60	5.4
2 Flygt Mixers 50C	4.0 – 8.0 (6.1)	60	5.0
2 Flygt Mixers 75C	5.3 – 10.5 (8.6)	60	4.7
3 Flygt Mixers 25C	3.5 – 6.9 (5.2)	60	5.1
3 Flygt Mixers 50C	4.9 – 9.8 (7.4)	60	4.8
3 Flygt Mixers 75C	6.4 – 12.9 (10.6)	60	4.6
1 Slurry Pump 25C	3.0 – 7.0 (5.0)	60	5.2
1 Slurry Pump 50C	4.3 – 9.9 (7.1)	60	4.9
1 Slurry Pump 75C	5.6 – 13.0 (9.3)	60	4.7

Using these assumptions, SRTC calculated the dissolution time by each method in Table 2. Table 3 shows the results.

Table 3. Tank 37H Salt Dissolution Time

Method of Dissolution	Water Temp. (°C)	Dissolution Rate (gpm)	Dissolution Time (days)	Dissolution Time (% of Total)	Total Process Time (months)
1. No Agitation	25	1.83	116.8	54.4	7.0
2. MDG	25	3.55	73.8	46.0	5.3
3. MDG	50	5.05	60.2	40.5	4.9
4. MDG	75	6.56	52.8	37.4	4.6
5. One Flygt Mixer	25	3.0	82.2	45.7	5.9
6. Two Flygt Mixers	25	4.2	66.7	40.5	5.4
7. One Flygt Mixer	50	4.3	65.8	40.0	5.4
8. One Slurry Pump	25	5.0	60.5	38.3	5.2
9. Three Flygt Mixers	25	5.2	59.3	37.8	5.1
10. One Flygt mixer	75	5.6	57.0	36.9	5.1
11. Two Flygt Mixers	50	6.1	54.6	35.9	5.0
12. One Slurry Pump	50	7.1	50.9	34.3	4.9
13. Three Flygt Mixers	50	7.4	50.0	33.9	4.8
14. Two Flygt Mixers	75	8.6	46.9	32.5	4.7
15. One Slurry Pump	75	9.3	45.5	31.8	4.7
16. Three Flygt Mixers	75	10.6	43.3	30.8	4.6

Heat Transfer Analysis

One of the authors has developed a heat transfer model which describes heating and cooling in SRS High Level Waste Tanks.[15,16,17,18] The model is described by equation [5]

$$c_p \rho V(dT/dt) = Q_{dec} + Q_{jpm} + Q_{pur} + Q_{coi} + Q_{ana} + Q_{uns} + Q_{vwl} + Q_{sen} + Q_{tsr} \qquad [5]$$

where c_p is the specific heat of the liquid or solid phase, ρ is the density of the liquid or solid phase, V is the liquid or solid phase volume, T is bulk temperature, t is time, Q_{dec} is radionuclide decay heat, Q_{jpm} is heat input from a steam jet or slurry pump, Q_{pur} is the heat removed by evaporation and purge gas, Q_{coi} is the heat removed by submerged and vapor space cooling coil water, Q_{ana} is the heat removed by annulus air passing through the tank bottom cooling slots, Q_{uns} is the heat removed by underground soil, Q_{vwl} is the heat flow through the vertical tank wall, Q_{sen} is the sensible liquid heat flow into or out of the tank, and Q_{tsr} is the heat absorbed by tank structures.

This model evaluates equation [5] in discrete time steps. It evaluates heat inputs and outputs on the right side of equation [5], and calculates the new heat balance and temperature at the end of the time step. This process is repeated for a time determined by the user. SRS HLWE has compared the model predictions with actual waste tank temperatures to validate the model. The model is applicable to all types of SRS Tank Farm waste tanks (Types I, II, III, IIIa, and IV). Figure 1 shows a schematic of how the model is applied to SRS Waste Tanks. It has been approved by SRS HLWM for calculating waste tank tempertures.[15]

The authors employed the model to calculate the supernate and salt cake temperature during the entire dissolution process. The initial waste tank supernate temperature is assumed to be 37° C. If the inhibited water added to the tank has a temperature of 25° C, the supernate temperature will decrease as the inhibited water is added. If the inhibited water added to the tank has a

temperature of 50° C or 75° C, the supernate temperature will increase as the inhibited water is added. Since salt dissolution is an endothermic process, the supernate temperature decreases during salt dissolution. Once salt dissolution is complete, radionuclide decay heat will increase the supernate temperature. The supernate temperature will, in most cases, rise slightly during transfer of supernate from Tank 37H. Table 4 shows the calculated tank supernate temperature following inhibited water addition, at the end of salt dissolution, at the end of mixing, and the peak supernate temperature during batch 1 and batch 4 for each dissolution method. The table shows that when the inhibited water temperature is 50° C or 75° C, the actual supernate temperature will be much lower. When the inhibited water temperature is 25° C, the tank supernate temperature will be higher.

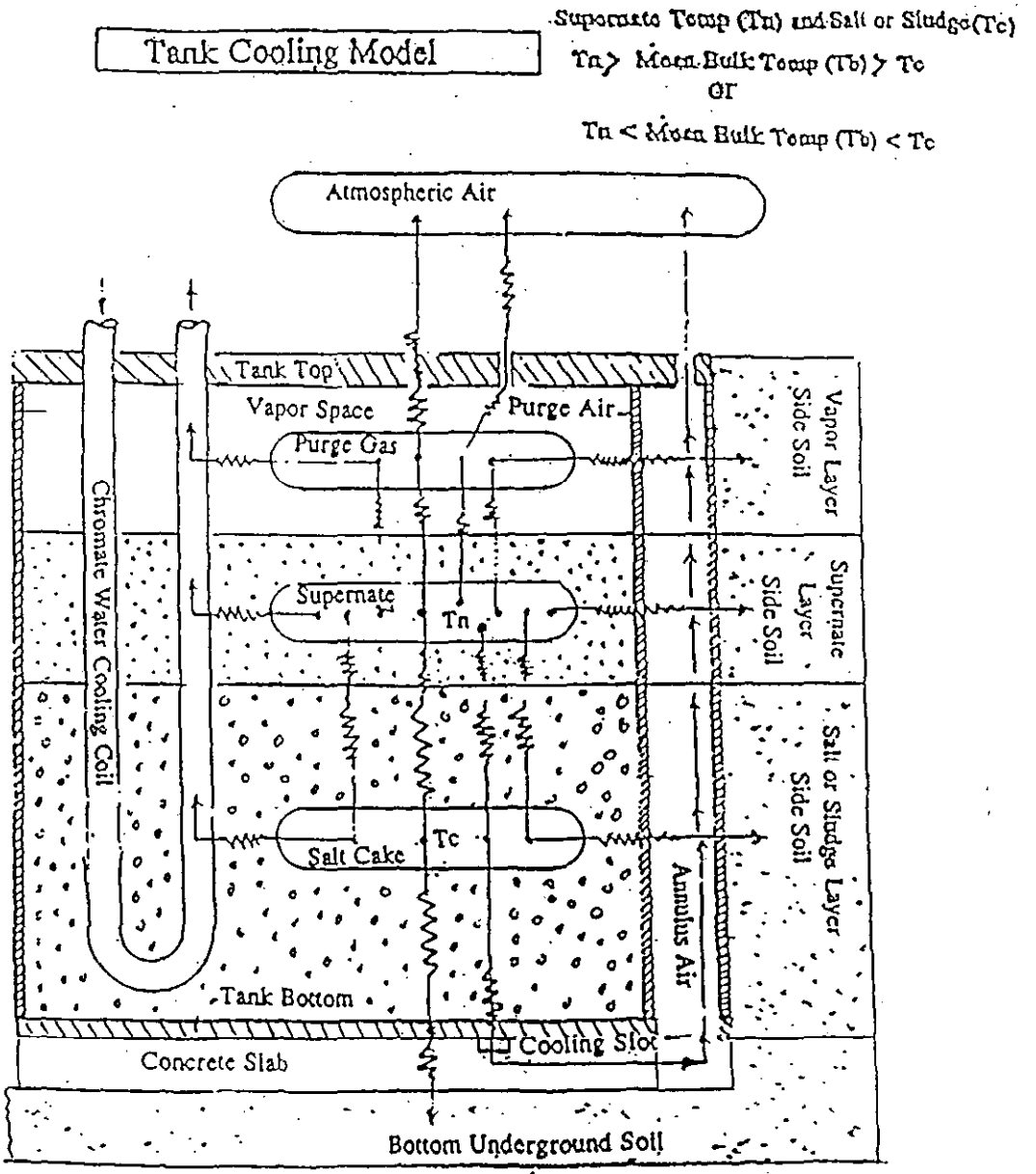


Figure 1. Schematic of Tank Cooling Model

When dissolving salt cake with one Flygt mixer and 25° C inhibited water, the supernate temperature will vary between 37° C and 27° C during the process. The supernate temperature at the end of the salt dissolution for the four batches was 34° C, 31.5° C, 29.5° C, and 28° C (31° C average). Since this temperature is higher than 25 ° C, the actual salt dissolution rate will be slightly higher than predicted by these calculations. Similar results are expected for other dissolution methods with 25 ° C inhibited water addition.

When dissolving salt cake with one Flygt mixer and 50° C inhibited water, the supernate temperature will vary between 38° C and 32° C during the process. The supernate temperature at the end of the salt dissolution for the four batches was 36° C, 34.5° C, 33.5° C, and 33° C (34° C average). Since this temperature is lower than 50 ° C, the actual salt dissolution rate will be less than predicted by these calculations. At a supernate temperature of 34° C, the calculated salt dissolution rate is 3.15 gpm. Similar results are expected for other dissolution methods with 50° C inhibited water addition.

Table 4. Tank 37H Supernate Temperature

Method of Dissolution	Water Temp. (°C)	End IW Addition Batch 1 / Batch 4	Peak Temp. Batch 1 / Batch 4	End Dissolution Batch 1 / Batch 4	End Mixing Batch 1 / Batch 4
1. No Agitation	25	36.0	37.0	33.6	34.3
		29.7	29.9	27.6	27.9
2. MDG	25	36.0	37.0	33.4	33.6
		29.1	29.1	26.5	27.0-
3. MDG	50	38.0	38.0	35.0	35.0
		34.0	34.0	30.6	30.8
4. MDG	75	40.1	40.1	37.3	37.0
		39.9	40.0	36.6	36.2
5. One Flygt Mixer	25	36.0	37.0	35.6	35.9
		29.8	30.0	27.5	27.7
6. Two Flygt Mixers	25	36.5	37.0	33.7	34.0
		30.0	30.2	27.6	28.2
7. One Flygt Mixer	50	38.0	38.0	35.5	35.7
		35.4	35.4	32.5	32.7
8. One Slurry Pump	25	36.0	38.6	36.1	38.6
		37.9	40.6	37.8	40.6
9. Three Flygt Mixers	25	36.0	37.0	33.8	34.3
		30.4	30.7	28.1	28.8
10. One Flygt mixer	75	40.0	40.0	37.5	37.5
		40.8	40.8	37.7	37.7
11. Two Flygt Mixers	50	38.1	38.1	35.6	35.9
		35.6	35.6	32.8	33.2
12. One Slurry Pump	50	38.0	39.7	37.3	39.7
		42.2	43.7	41.1	43.7
13. Three Flygt Mixers	50	38.1	38.1	35.8	36.2
		36.2	36.2	33.5	34.0
14. Two Flygt Mixers	75	40.2	40.2	37.5	37.7
		41.3	41.3	38.1	38.3
15. One Slurry Pump	75	40.1	41.2	38.9	41.2
		47.3	47.3	45.6	47.9
16. Three Flygt Mixers	75	40.2	40.2	37.8	38.2
		42.2	42.2	39.3	39.6

When dissolving salt cake with one Flygt mixer and 75° C inhibited water, the supernate temperature will vary between 41° C and 37° C during the process. The supernate temperature at the end of the salt dissolution for the four batches was 37.5° C, 37.7° C, 37.8° C, and 37.8° C (38° C average). Since this temperature is lower than 75° C, the actual salt dissolution rate will be less than predicted by these calculations. At a supernate temperature of 38° C, the calculated salt dissolution rate is 3.35 gpm. Similar results are expected for other dissolution methods with 75° C inhibited water addition.

The heat transfer calculation results are shown in Appendix 2.

Assumptions

The authors made the following assumptions in performing the salt dissolution analysis:

- The effect of increasing tank supernate temperature on the dissolution rate is 1.7%/°C.
- The tank cooling coils have a small effect on the salt dissolution rate
- Using a smaller volume of dissolution water in Tank 37H than in Tank 19F has a small effect on the salt dissolution rate.
- The dissolution process is mass transfer limited.
- The discharge from a Flygt mixer behaves as a turbulent jet.
- The salt dissolution rate is proportional to the square root of the number of pumps or Flygt mixers.
- The ratio of dissolution fluid to salt cake is 2.4:1. This ratio is an average from the Tank 19 Salt Removal Demonstration.
- The ratio of the salt dissolution rate by the modified density gradient approach to the salt dissolution rate with mechanical agitation does not change during scale-up.
- The Colburn analogy can be used to describe thermal convection mass transfer.
- The thermal gradient in Tank 37H is 1° C. This assumption is based on the temperature difference between the salt cake and supernate obtained from the HLW morning report.
- The saturated supernate density is 1.39 g/cc, which is the density of a saturated sodium nitrate solution.
- The saturated supernate viscosity is 2.42 cp., which is the density of a saturated sodium nitrate solution.
- Tank 37H contains 269.5 inches of salt cake.
- Tank 37H contains 81.69 inches of saturated supernate.
- HLW can add a maximum of 40 inches of inhibited water to the tank a one time.
- HLW can add 8000 gallons of inhibited water to the tank in one 12 hour shift.
- Seven days is added to the dissolution time in each batch for conservatism.
- The jet transfer rate is 60 gpm for non-MDG dissolution cases.
- Sampling and preparation time is 240 hours for each dissolution batch.
- The initial waste tank supernate temperature is at 37° C

Conclusions

The conclusions from this work are the following:

- A single Flygt mixer with tank supernate temperature of 25° C should be sufficient to dissolve and remove 50 inches of salt cake within six months. Increasing the supernate temperature or adding additional Flygt mixers will decrease the time to dissolve the salt cake.
- A single slurry pump with tank supernate temperature of 25° C also should be sufficient to dissolve and remove 50 inches of salt cake within six months. Increasing supernate temperature or adding additional slurry pumps will decrease the time to dissolve the salt cake.
- Calculations predict that the modified density gradient method should be able to remove 50 inches of salt cake within six months, but uncertainty exists in predicting dissolution rates by this method (predicted dissolution rates varied between 1.25 gpm and 5.84 gpm at 25° C). HLW should exercise caution when making decisions using calculated dissolution rates for this method.
- Molecular diffusion is unlikely to remove 50 inches of salt cake in six months.
- If the inhibited water temperature is 25° C, the actual tank supernate temperature will be higher and the salt dissolution rate faster than predicted by this analysis.
- If the inhibited water temperature is 50 or 75° C, tank cooling will reduce the tank supernate temperature to 30 – 40° C, which increases the dissolution time and minimizes the benefit of adding heated water to the tank. Including this effect, the dissolution rate with one Flygt mixer is 3.15 gpm (rather than 4.3) for case 7 and 3.35 gpm (rather than 5.6) for case 10.

Path Forward

If HLW requires more rigorous estimates of the salt dissolution time, SRTC could reduce the uncertainty in the calculated dissolution time by performing the following work:

- Perform a more rigorous analysis of salt dissolution by the density gradient methods.
- Perform a more rigorous analysis of salt dissolution by molecular diffusion.
- Perform a more rigorous evaluation of changing supernate temperature in the tank when the inhibited water is heated prior to addition.

References

1. A. Q. Goslen, "Tank 19 Salt Removal", DPSP-84-17-7, August 1986.
2. M. R. Poirier, "Recommended Slurry Pump Operating parameters in Tank 25", WSRC-RP-95-00723, July 31, 1995.
3. M. R. Poirier, "Calculating Salt Dissolution Rates in Tank 41", X-CLC-H-00019, January 11, 1995.
4. S. T. Koh, S. K. Setsuro Y. Tada, T. Takahashi, T. Aragaki, and I. Yamada, "Jet Mixing of Liquids with a Rotating Nozzle around the Axis of a Cylindrical Vessel", J. Chem. Eng. Japan, 23, no. 4, 1990, pp. 463-467.
5. J. N. Brooke, "Report #GL-97-September 1997 from the Waterways Experiment Station of the US Army Cops of Engineers Titled: Interstitial Fluid Displacement (IFD) for Preferential Recover of Cesium from Saltcake", SRT-WHM-98-0017, February 5, 1998.

6. B. J. Wiersma, "An Investigation of Density Driven Salt Dissolution Techniques", WSRC-TR-96-0160, August 1996.
7. D. L. Kiser, "Bench-Scale Investigation of Different Concepts for Waste Tank Salt Dissolution", DPST-79-269, February 26, 1979.
8. D. L. Kiser, "Removal of Salt from High-Level Waste Tanks by Density-Driven Circulation or Mechanical Agitation", DP-1587, January 1981.
9. G. H. Street, "Salt Removal from Tank 10", TA 2-959A, April 9, 1979.
10. G. H. Street, "Salt Removal from Tank 10", TA 2-959, March 31, 1980.
11. J. C. Bailey, "Tank 10 Salt Removal Demonstration Details", DPSP-79-17-11, April 11, 1979.
12. C. J. Thomas, "Salt Removal from Tank 10", TC-2-959, September 14, 1983.
13. Bill Parish, "Reducing or Eliminating the Use of Slurry Pumps from High Level Waste Tanks", July 19, 1993.
14. R. H. Perry and C. H. Chilton, Chemical Engineer's Handbook, 5th Ed., New York: McGraw-Hill, 1973.
15. K. Kwon, "Heat Balance an Thermal Analysis of Tank 30 & Tank 29 as 3H Evaporator Concentrate Receipt Tanks", WSRC-TR-2001-00024, Rev. 0, March 2001.
16. K. C. Kwon, "Tank 48 and Tank 50 Liquid Phase Thermal Analysis for Cycle 1", WSRC-TR-95-0220, Rev. 0, September 14, 1995.
17. K. C. Kwon, "Tank 41 Content Temperature During Salt Removal Operations", WSRC-TR-95-0089, Rev. 0, March 9, 1995.
18. K. C. Kwon, "Tank 25F Mixed Waste Thermal Analysis During Salt Removal Batch Process With Cooling Coils Off", WSRC-TR-97-0067, Rev. 0, October 1, 1997.

Appendix 1

Selected Sketches, Test Data and Example Calculations

A) Molecular Diffusion (or Horizontal Plane) Dissolution

B) Modified Density Gradient Dissolution

C) Mixing by Flygt Mixer(s) and Dissolution

D) Mixing by Slurry Pump and Dissolution

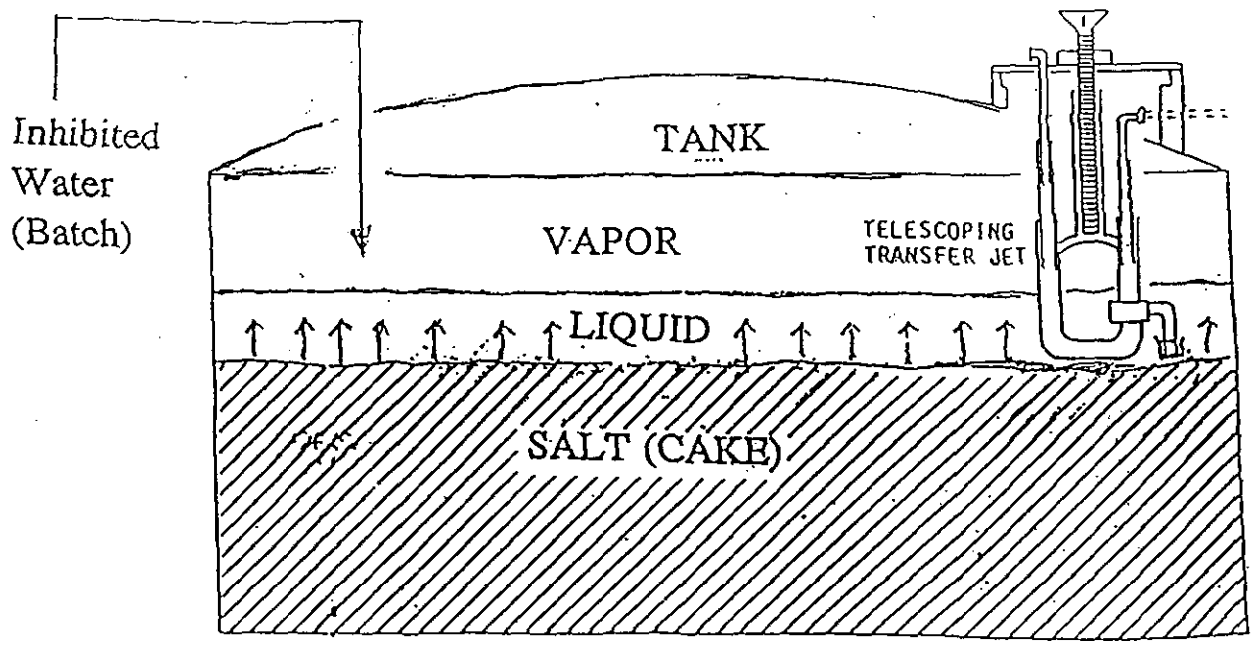
A) Molecular Diffusion Dissolution Without Agitation

Molecular Diffusion - 25C IW (Case 1)

Horizontal Plane Dissolution of Salt by
Molecular Diffusion and Thermal Diffusion

Highly Concentrated or Saturated Salt Solution
Near Salt Cake-Liquid Interface

Low Concentration or Less Saturated Salt Solution
Near Vapor-Liquid Interface



	used here	low	high	Horizontal plane dissol. lab test
salt dissolution rate (gpm)	1.83	1.18	2.47	1.18 and diffusion calc. value
total time (months)	7.03.	8.63	6.27	2.47 were shown as low & high

Reference (A) D. Kiser, Savannah River Laboratory (Jan/81), DP-1587, "Removal of Salt from High-Level Waste Tanks By Density Driven Circulation or Mechanical Agitation"

Horizontal Plane Dissolution

Items \ Case	Four Liter Beaker Test	Type IV Tank 22H	Type IIIa Tank 37H
Tank ID (D)	15 cm	85 ft	85 ft
D in meter	0 meter	26 meters	26 meters
Diameter Ratio	1	173.8791	173.8791
Area (A1)	0.0174 m2	527.1784 m2	527.1784 m2
ID Area Ratio	1	30233.97	30233.97
Center Cylinder OD	0 ft	0 ft	6.75 ft
	0 m	0 m	2.0574 m
Center Column Area (A2)	0 m2	0 m2	3.324507 m2
Net Area (A=A1-A2)	0.0174 m2	527.1784 m2	523.8539 m2
Equiv De=(4*Ae/pi)^0.5	0 meter	25.908 meters	25.82617 meters
Equiv. Dia. Ratio	1	173.8791	173.3300
Net Area Ratio	1	30233.97	30043.31
Cake Dissolution Rate	0.06 cm/hr		
	0.000010 m3/hr		
	0.002763 gal/hr		
	0.000046 gpm	1.39 gpm	1.38 gpm
salt dissolution ratio			
2.4	0.000039 gpm	1.19 gpm	1.18 gpm
2.3	0.000040 gpm	1.22 gpm	1.21 gpm
2.2	0.000041 gpm	1.26 gpm	1.25 gpm
2.1	0.000043 gpm	1.30 gpm	1.29 gpm
2.0	0.000044 gpm	1.34 gpm	1.34 gpm
1.9	0.000046 gpm	1.39 gpm	1.38 gpm
Salt Solution Removal(B)	0.505 ml/m	15.27 L/min	15.17 L/min
B in gpm	0.000133 gpm	4.03 gal/min	4.01 gal/min
Salt Dissolution Rate = B / (2.4+1)	0.000039 gpm	1.19 gpm	1.18 gpm

Molecular Diffusion Case

==========

diffusion time		16.4	days
dissolution rate		2.47	gpm
dissolution water added	=	40	inch
salt cake dissolved using 2.4 to 1 ratio	=	16.6667	inch
total supernate produced	H =	56.6667	inch
salt cake - supernate temperature diff	dT =	1	C
diff. supernate density between 26C & 25C	drh =	0.00038	g/cm3

liquid depth		L =	143.9333	cm
liquid gallon per inch depth of tank		=	3510	gal/inch
unit conversion from gallon to cm3		=	3785.4	cm3/gal
total volume of dissolved salt solution		V =	752916060	cm3
		Vgal =	198900	gal
surface area = A = V/L =	5.23E+06 =	A =	5231006	cm2
gravitational acceleration		g =	980	cm/sec2
absolute viscosity of salt solution		mu =	2.42	cp
kinematic viscosity of salt solution =		mu/rho=	1.7386	centistokes
	(mu/rho)/92903.4 =		0.00001871	ft2/sec
	(mu/rho)*(12*2.54)^2/92903.4 =	nu =	0.0174	cm2/sec

Grashof Number

Gr = (g)(L^3)(drh)/(rho*nu^2) = Gr = 2639213298

Schmidt Number

kinematic visco. / diffusivity = Sc = nu/Df = 1107.40

Sherwood number

Sh = 0.13 * Gr^(1/3) * Sc^(1/3) = Sh = 1858.68

Sh = (k) * L / Df

Mass Transfer Coeff = k = (Sh) * Df / L = k = 0.00020274 cm/sec

Mass Transfer Rate = J = k * A * dC J = 207.81 g/sec

total volume of dissolved salt solution	V =	752916060	cm3
differential density between water & salt solu. =		0.392	g/cm3
differential mass between water & salt solu = dM =		295067804	grams

total transfer time of differential mass

t = dM / J =	1419873	sec =	23665	min	=	394.41	hrs
					=	16.43	days

salt dissolved = (Vgal) * 1 / (1+2.4)					= Qsd =	58500	gals
dissolution rate =	58500	gals /	23665	min.	=	2.47	gpm

Modified Density Gradient (MDG) Dissolution

Low Density Inhibited Water or Supernate --- Upper Layer

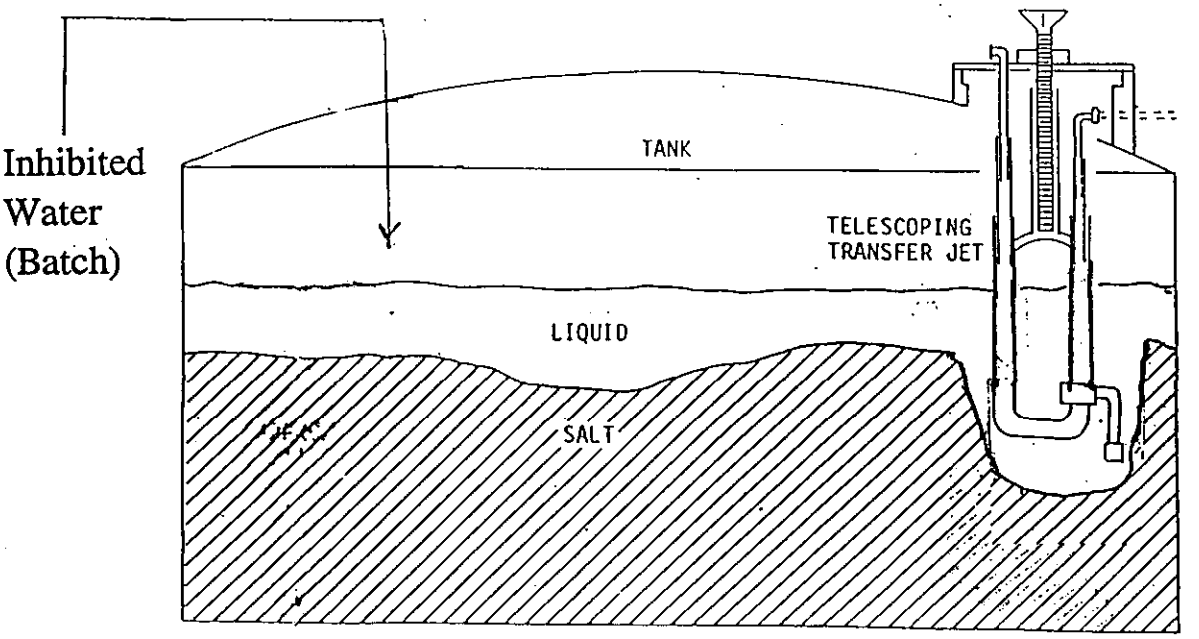
High Density Dissolved Salt Solution --- Lower Layer or Well

Dissolved Salt Solution To Be Transferred Out During Dissolution

MDG - 25C IW (Case 2)

MDG - 50C IW (Case 3)

MDG - 75C IW (Case 4)



Reference (A) D. Kiser, Savannah River Laboratory (Jan/81), DP-1587, "Removal of Salt from High-Level Waste Tanks By Density Driven Circulation or Mechanical Agitation"

Reference (B) B. Wiersma, SRTC (Aug/96), WSRC-TR-96-0160, "An Investigation of Density Driven Salt Dissolution Techniques"

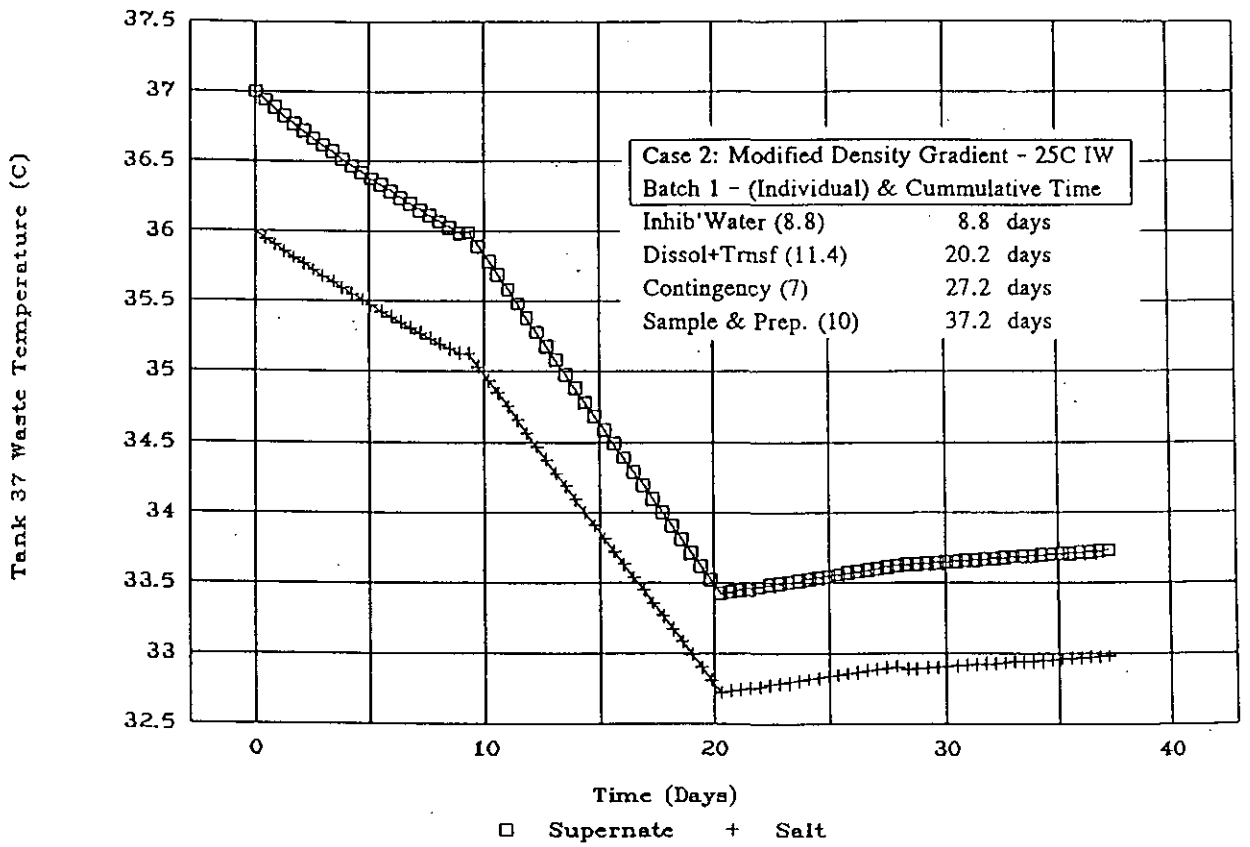
Density-Driven Circulation Test

Items \ Case	1981 Lab Jar Test (A)	1996 Trough Test (B)	Type IV Tank 22H		Type IIIa Tank 37H	
Trough Size or ID	31 cm	3"x36"x15"high	85 ft		85 ft	
Equiv circle ID in meter	0 meter	0.2979 m	26 meters		26 meters	
Equiv. Diameter Ratio	1	0.9766	84.94		84.94	
Area (A1)	0.0731 m2	0.0697 m2	527.1784 m2		527.18 m2	
Area Ratio	1	0.9537	7215.527		.7216	
Center Cylinder OD	0 ft	0 ft	0 ft		7 ft	
	0 m	0 m	0 m		2 m	
Center Column Area (A2)	0 m2	0 m2	0 m2		3.32 m2	
Net Area if A=(A1-A2)	0.0731 m2	0.0697 m2	527.1784 m2		523.85 m2	
Equiv De=(4*Ae/pi)^0.5	0 meter	0.2979 meter	25.908 meters		25.83 meters	
Equiv. Dia. Ratio	1	0.9766	84.94426		84.68	
Net Area Ratio	1	0.9537	7216		7170	
Cake Dissolution Rate	0.31 cm/h	0.25 cm/hr	Salt Cake Dissolution Rate (gpm) by using test data			
	0.00023 m3/hr	0.00018 m3/hr				
	0.05983 gal/hr	0.04662 gal/hr	(A)	(B)	(A)	(B)
	0.00100 gpm	0.00078 gpm				
salt dissolution ratio	SD Ratio=1.913	SD Ratio=2.4	7.20	5.88	7.15	5.84
2.4	0.00085 gpm	0.00078 gpm	6.17	5.88	6.13	5.84
2.3	0.00088 gpm	0.00080 gpm	6.35	6.06	6.31	6.02
2.2	0.00091 gpm	0.00083 gpm	6.55	6.25	6.51	6.21
2.1	0.00094 gpm	0.00085 gpm	6.76	6.45	6.72	6.41
2.0	0.00097 gpm	0.00088 gpm	6.99	6.66	6.95	6.62
1.913	0.00100 gpm	0.00091 gpm	7.20	6.86	7.15	6.82
Salt Solution Removal(B)	11 ml/min	10 ml/min				
B in gpm	0.00291 gpm	0.00264 gpm	20.97	19.99	20.84	19.86
Salt Dissolution Rate = B / (2.4+1)	0.00085 gpm	0.00078 gpm	6.17 gpm	5.88 gpm	6.13 gpm	5.84 gpm
			(salt dissol. ratio of 2.4 case)			

Modified Density Gradient with 25C Inhibited Water (Batch 1)

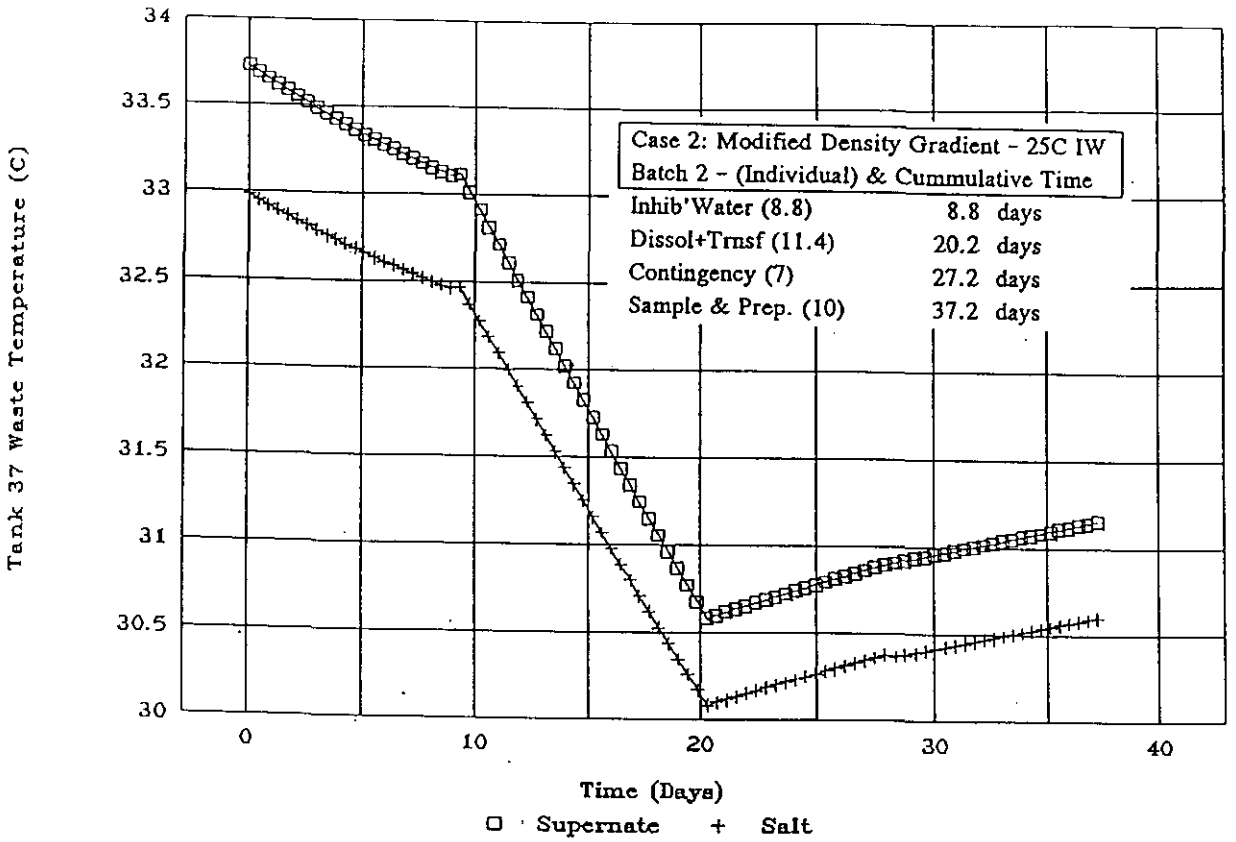
a) initial salt cake level (average of 262" & 277") ----------	269.50	inch
b) inhibited water batch = ~80% of 10 Kgal tank ----------	8000	gallons per batch
inhibited water pumping to TK 37 (80 to 120 gpm) ----------	100	gpm ; IWp=1.33 hrs
total time of 1 batch IW addition to TK 37 = IWt ----------	12	hrs
IW addition ---------- 1 batch per 12 hr shift &	2	batches per day
total IW add hr needed/net pumping hr = IWt/IWp = 12/1.33 -------	9	
equiv. continuous IW addition rate= IWt/IWp = 100 gpm/9 ----	11.11	gpm
batch water add hrs= (40in*3510gal/in)/(11.11gpm*60min/hr)=	210.6	hrs = 8.8 days
c) jet transfer TK 37->TK 30 (Existing Decant Before Batch)	60	gpm (not Batch Case)

d) salt dissolution rate (gpm)	3.55	1.25	5.84	Avg of 25% slurry pump rate
transfer to TK 26 (gpm)	12.05	4.25	19.86	and 1979 TK 10 data gives
total time (months)	5.32	8.08	4.73	(5*0.25+5.84)/2 = 3.55 gpm



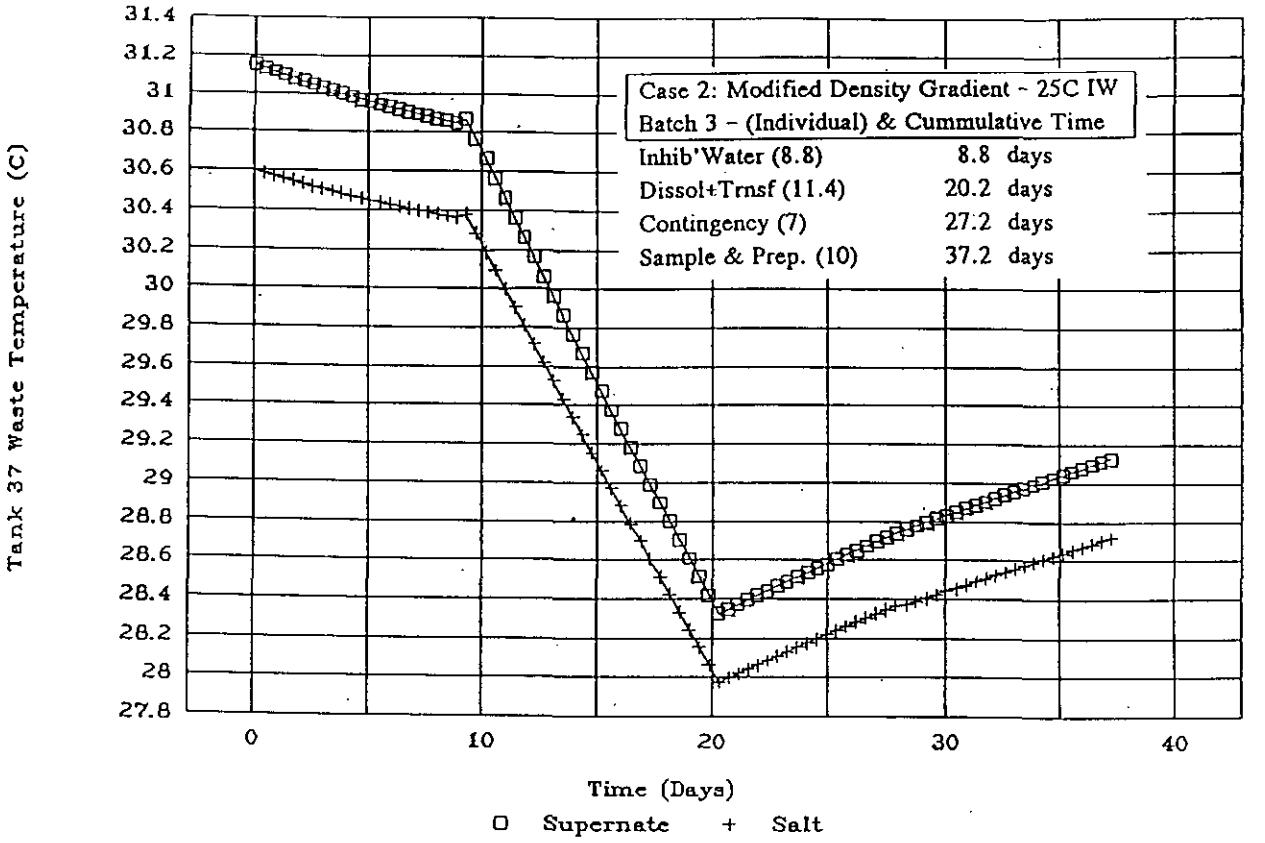
Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content		
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Inhib'Water	210.6
gallons	952965	140400	58500	205920	894465	1100385	Disso+Trnsf	275.0
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	Contingency	168.0
net hours		210.6	275.0	275.0	transfer		Sampl&Prep.	240.0
							batch total (days)	37.2

Modified Density Gradient with 25C Inhibited Water (Batch 2)



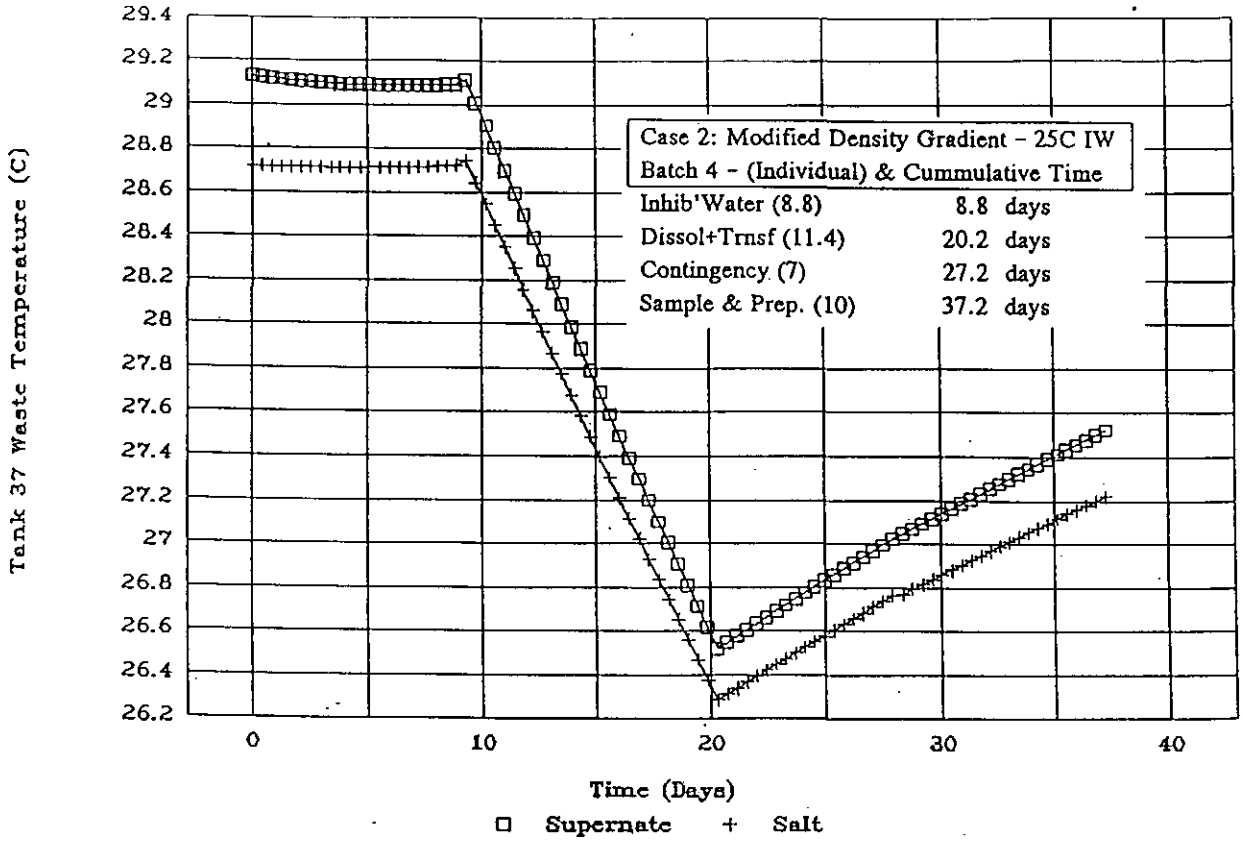
Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content		
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	Inhib'Water	210.6
gallons	901485	140400	58500	205920	842985	1048905	Disso+Trnsf	275.0
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	Contingency	168.0
net hours		210.6	275.0	275.0	transfer	batch total (days)	Sampl&Prep.	240.0
								37.2

Modified Density Gradient with 25C Inhibited Water (Batch 3)



Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
							Disso+Trnsf	275.0
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	Contingency	168.0
gallons	850005	140400	58500	205920	791505	997425		
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	Sampl&Prep.	240.0
net hours		210.6	275.0	275.0	transfer		batch total (days)	37.2

Modified Density Gradient with 25C Inhibited Water (Batch 4)



Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5
gallons	798525	140400	58500	205920	740025	945945
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%
net hours		210.6	275.0	275.0	transfer	batch total (days)

Step	Hours
Inhib'Water	210.6
Disso+Trnsf	275.0
Contingency	168.0
Sampl&Prep.	240.0
	37.2

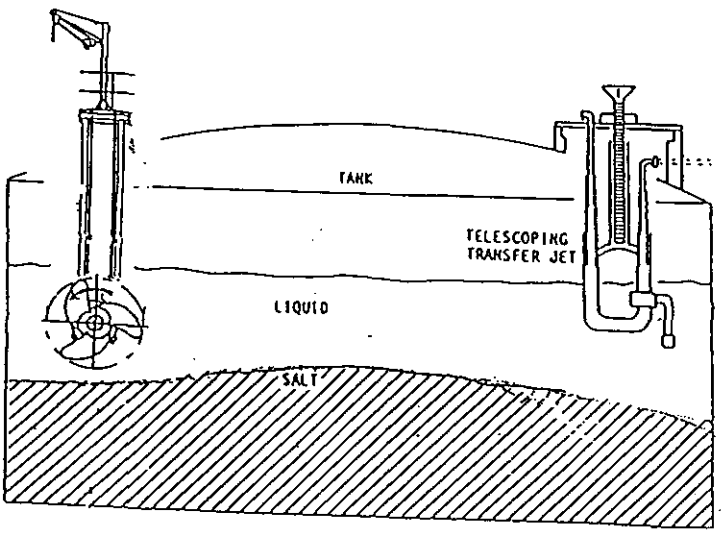
C) Mixing by Mechanical Agitation (Flygt Mixer)

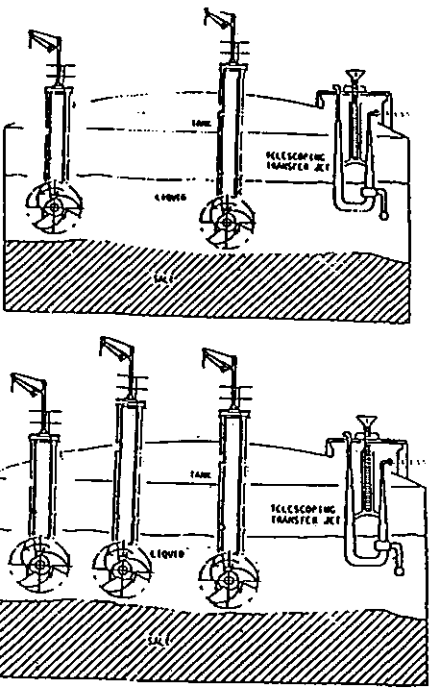
1 Mixer 25C IW (Case 5)
1 Mixer 50C IW (Case 7)
1 Mixer 75C IW (Case 10)

2 Mixers 25C IW (Case 6)
2 Mixers 50C IW (Case 11)
2 Mixers 75C IW (Case 14)

3 Mixers 25C IW (Case 9)
3 Mixers 50C IW (Case 13)

3 Mixers 75C IW (case 16)





ITT Flygt
Mixer 4650
7.5 HP

Vortex Suppressor
(VS)

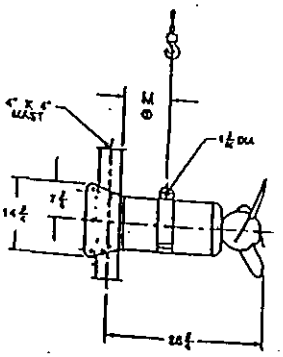
When used with VS
only 1 ft submergence
is needed.

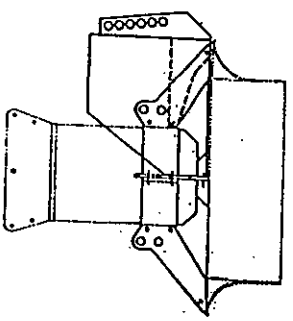
Minimum
Submergence

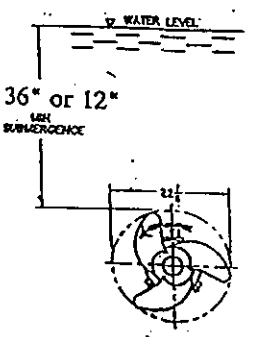
Minimum liquid depth
36" + 23" = 59" is
needed without VS.

Minimum liquid depth
12" + 23" = 35" is
needed with VS.

36" Without VS
12" With VS



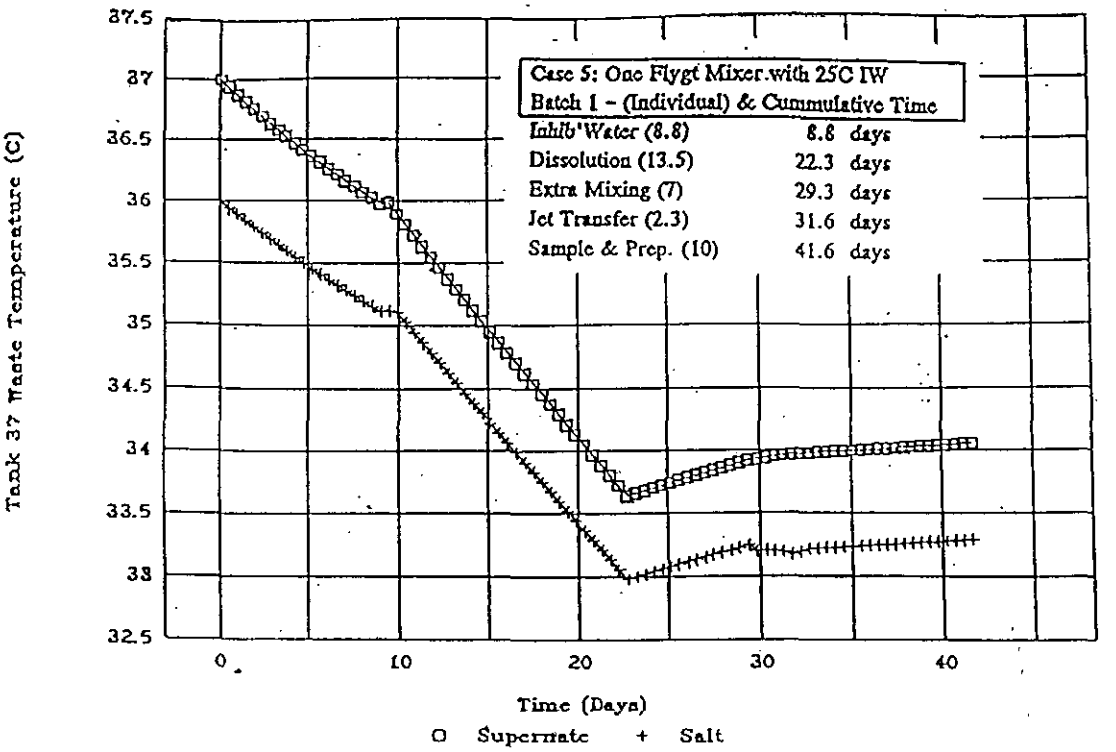




One Flygt Mixer with 25C Inhibited Water

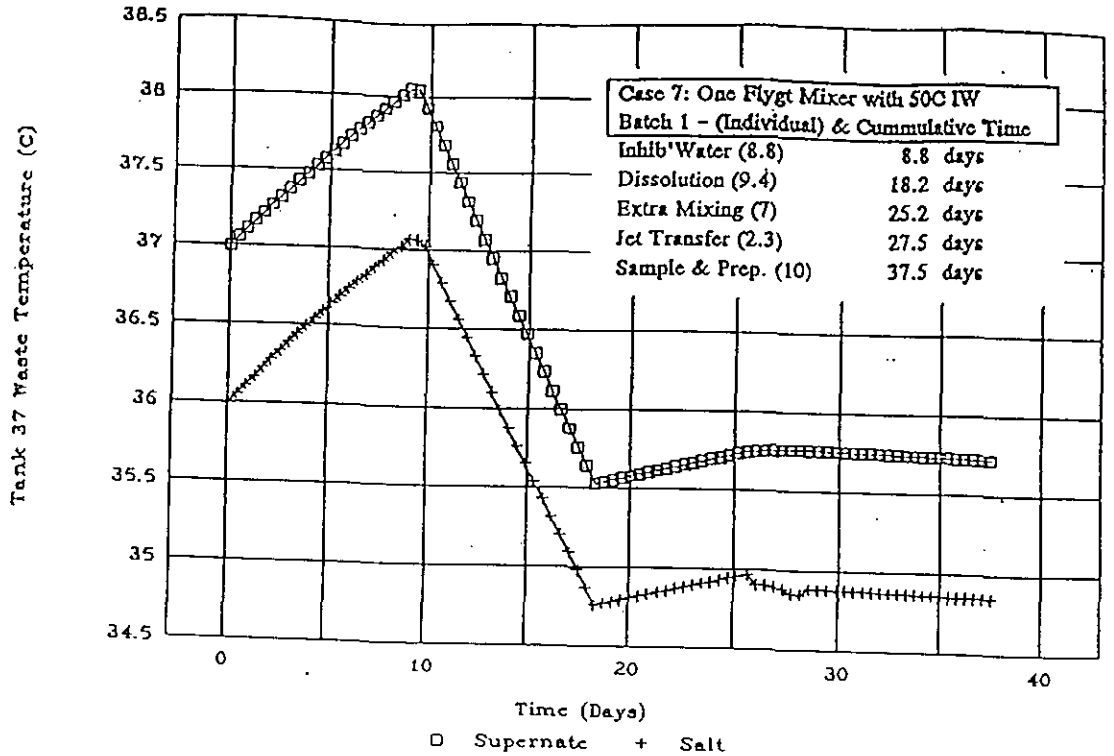
a) initial salt cake level (average of 262" & 277") ----------	269.50	inch
b) *inhibited water batch = ~80% of 10 Kgal tank* ----------	8000	*gallons per batch*
inhibited water pumping to TK 37 (80 to 120 gpm) ----------	100	gpm ; IWp=1.33 hrs
total time of 1 batch IW addition to TK 37 = IWt ----------	12	hrs
IW addition ---------- 1 batch per 12 hr shift &	2	batches per day
total IW add hr needed/net pumping hr = IWt/IWp = 12/1.33 -------	9	
equiv. continuous IW addition rate= IWt/IWp = 100 gpm/9 ----	11.11	gpm
batch water add hrs= (40in*3510gal/in)/(11.11gpm*60min/hr)=	210.6	hrs = 8.8 days
c) jet transfer TK 37->TK 30 and or TK 26	60	gpm

	used here	low	high
d) salt dissolution rate (gpm)	3.00	2.00	4.00
total time (months)	5.89	6.78	5.45

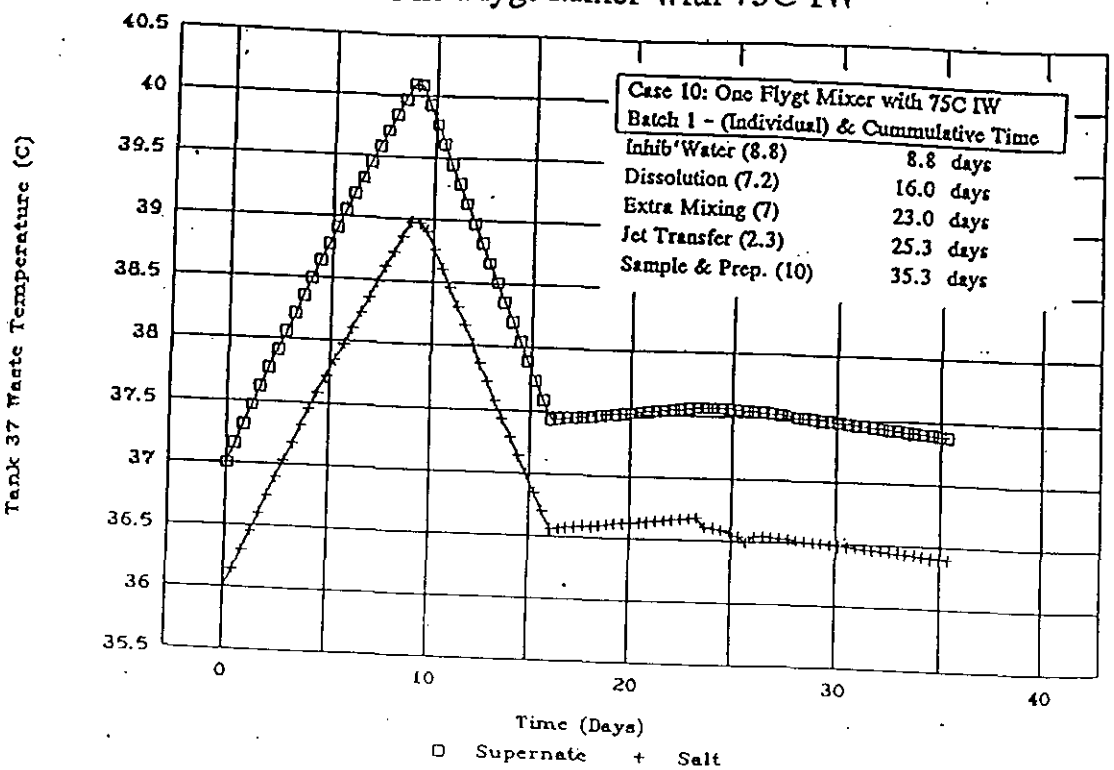


Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content		
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Inhib'Water	210.6
gallons	952965	140400	58500	205920	894465	1100385	Dissolution	325.0
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	Contingency	168.0
net hours		210.6	325.0	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
								41.6

Case 7: One Flygt Mixer with 50C IW



Case 10: One Flygt Mixer with 75C IW

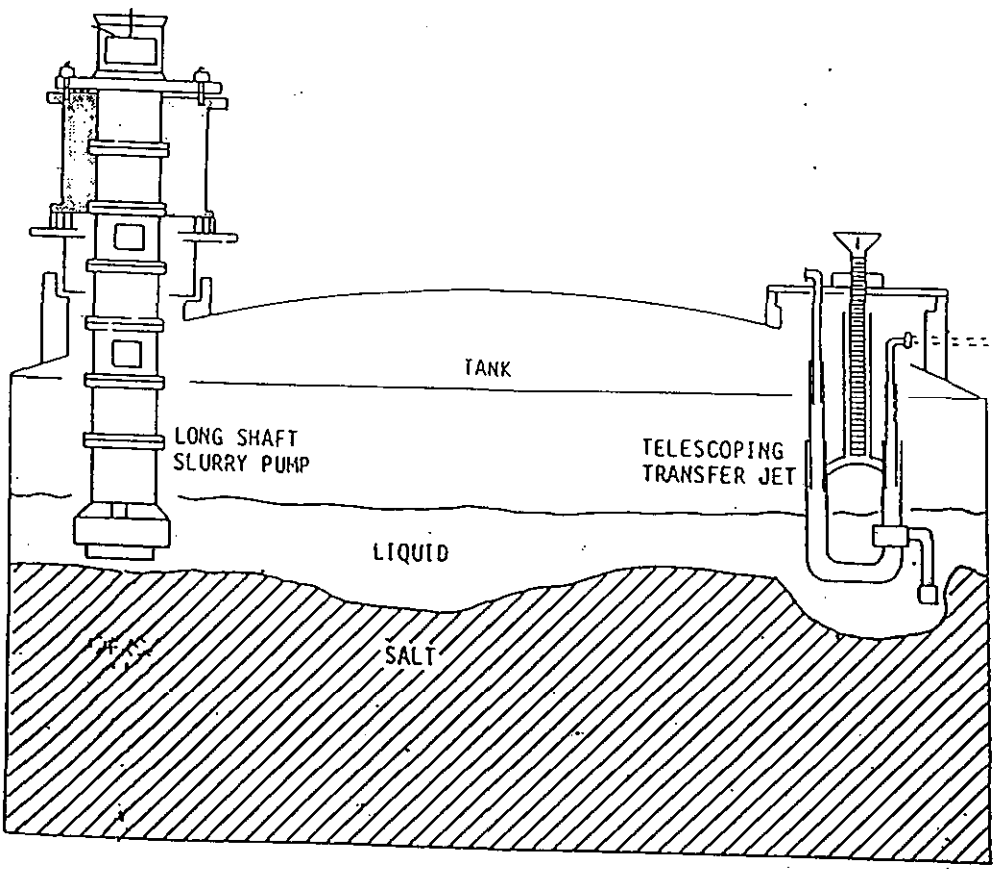


D) Mixing by Mechanical Agitation (Slurry Pump)

25C Inhibited Water (Case 8)

50C Inhibited Water (Case 12)

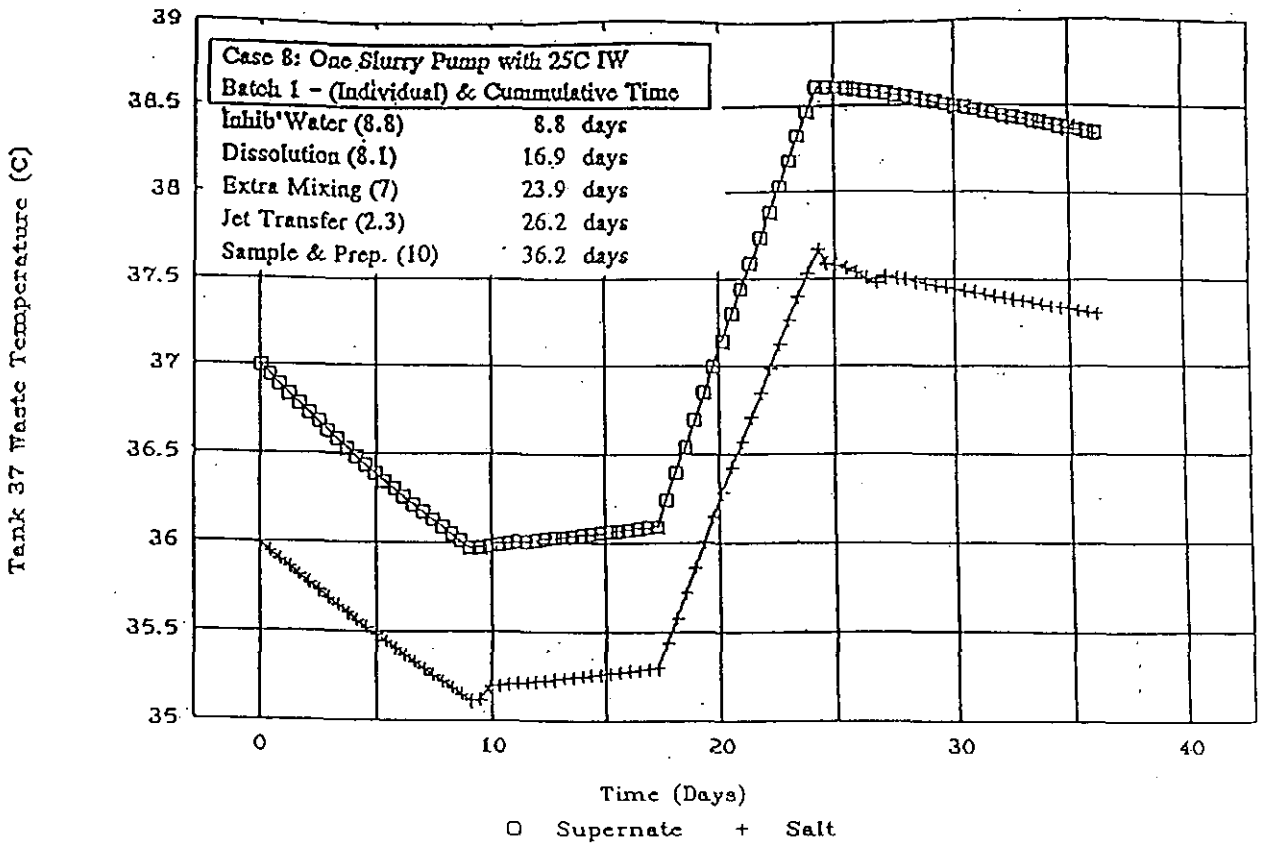
75C Inhibited Water (Case 15)



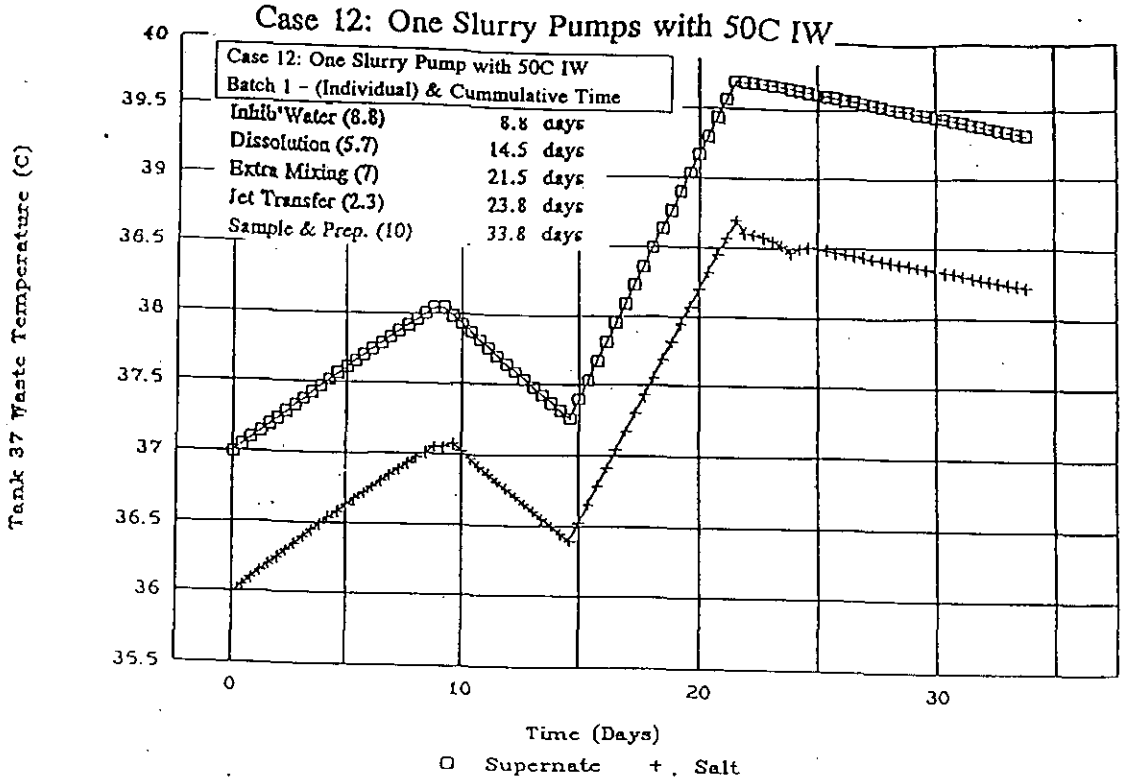
Minimum Submergence
16 inch above slurry pump bottom

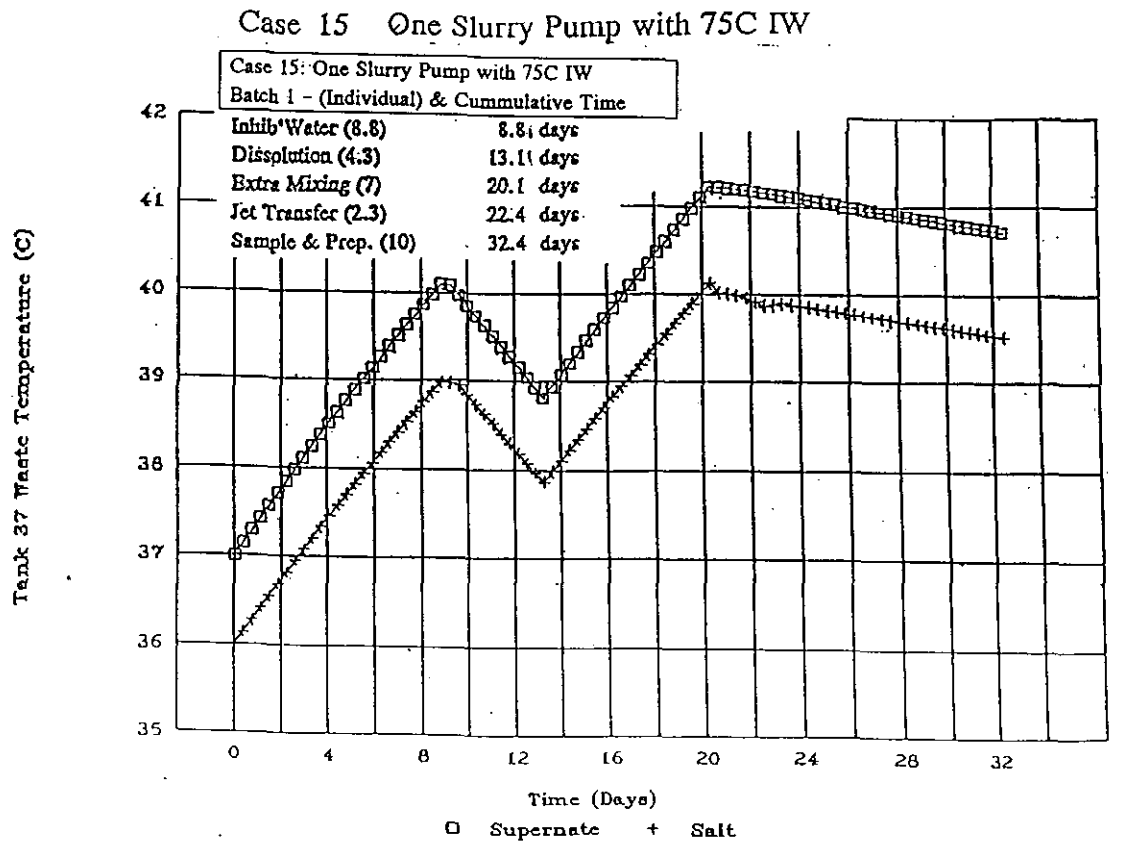
One Slurry Pump with 25C Ambient Inhibited Water

a) initial salt cake level (average of 262" & 277") =	269.50	inch
b) inhibited water batch = ~80% of 10 Kgal tank =	8000	gallons
inhibited water pumping to TK 37 (80 to 120 gpm) =	100	gpm
net pumping time of one batch IW to TK 37 = IWp =	1.3	hrs
number of IW batches per 12 hr-shift =	1	batch per shift
number of IW batches per day =	2	batches per day
total time of 1 batch IW addition to TK 37 = IWt =	12	hrs
total IW time needed/net pumping time = IWt/IWp =	9	
c) salt dissolution rate =	5	gpm
d) jet transfer rate from TK 37 to TK 30 or TK 26 = (60 to 100 gpm)	60	gpm



Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content		
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Inhib'Water	210.6
gallons	952965	140400	58500	205920	894465	1100385	Dissolution	195.0
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	ExtraMixing	168.0
net hours		210.6	195.0	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
								36.2


Case 12: One Slurry Pumps with 50C IW
Case 12: One Slurry Pump with 50C IW
Batch 1 - (Individual) & Cummulative Time
Inhib'Water (8.8) 8.8 days
Dissolution (5.7) 14.5 days
Extra Mixing (7) 21.5 days
Jet Transfer (2.3) 23.8 days
Sample & Prep. (10) 33.8 days
Tank 37 Waste Temperature (C)
40
39.5
39
36.5
38
37.5
37
36.5
36
35.5
0
10
20
30
Time (Days)
Supernate
Salt


Case 15 One Slurry Pump with 75C IW
Case 15: One Slurry Pump with 75C IW
Batch 1 - (Individual) & Cummulative Time
Inhib'Water (8.8) 8.8 days
Dissolution (4.3) 13.1 days
Extra Mixing (7) 20.1 days
Jet Transfer (2.3) 22.4 days
Sample & Prep. (10) 32.4 days
Tank 37 Waste Temperature (C)
42
41
40
39
38
37
36
35
0
4
8
12
16
20
24
28
32
Time (Days)
Supernate
Salt

Appendix 2
Dissolution Calculations

Dissolution Method	Dissolution Rate (gpm)	Dis. Rate used (gpm)	Dissolution Time (days)	Dissolution Time (% of Total)	Total Process Time (months)
1. No Agitation (25°C)	1.18 – 2.47	1.83	117	54	7.0
2. MDG (25°C)	1.25 – 5.84	3.55	74	46	5.3
3. MDG (50°C)	1.78 – 8.32	5.05	60	41	4.9
4. MDG (75°C)	2.33 –10.80	6.56	53	37	4.6
5. One Flygt Mixer (25°C)	2.0 – 4.0	3.0	82	46	5.9
6. Two Flygt Mixers (25°C)	2.8 – 5.7	4.2	67	41	5.4
7. One Flygt Mixer (50°C)	2.8 – 5.8	4.3	66	40	5.4
8. One Slurry Pump (25°C)	3.0 – 7.0	5.0	61	38	5.2
9. Three Flygt Mixers (25°C)	3.5 – 6.9	5.2	59	38	5.1
10. One Flygt mixer (75°C)	3.7 – 7.4	5.6	57	37	5.1
11. Two Flygt Mixers (50°C)	4.0 – 8.0	6.1	55	36	5.0
12. One Slurry Pump (50°C)	4.3 – 9.9	7.1	51	34	4.9
13. Three Flygt Mixers (50°C)	4.9 – 9.8	7.4	50	34	4.8
14. Two Flygt Mixers (75°C)	5.3 – 10.5	8.6	47	33	4.7
15. One Slurry Pump (75°C)	5.6 – 13.0	9.3	46	32	4.7
16. Three Flygt Mixers (75°C)	6.4 – 12.9	10.6	43	31	4.6

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 1) Molecular Diffusion with 25C Inhibited Water				% total time
Water to salt dissolution ratio =		2.4	to 1	
Molecular Diffusion with 25C IW:	7.03	months total		100%
1.83 gpm dissol. rate; dissol. and contingency =	116.8	days		54%

a) initial salt cake level (average of 262" & 277") ----------	269.50	inch
b) inhibited water batch = ~80% of 10 Kgal tank ----------	8000	gallons per batch
inhibited water pumping to TK 37 (80 to 120 gpm) ----------	100	gpm ; IWp=1.33 hrs
total time of 1 batch IW addition to TK 37 = IWt ----------	12	hrs
IW addition ---------- 1 batch per 12 hr shift &	2	batches per day
total IW add hr needed/net pumping hr = IWt/IWp = 12/1.33 -------	9	
equiv. continuous IW addition rate= IWt/IWp = 100 gpm/9 ----	11.11	gpm
batch water add hrs= (40in*3510gal/in)/(11.11gpm*60min/hr)=	210.6	hrs = 8.8 days
c) jet transfer TK 37->TK 30 and or TK 26	60	gpm

	used here	low	high	Horizontal plane dissol. lab test
d) salt dissolution rate (gpm)	1.83	1.18	2.47	1.18 and diffusion calc. value
total time (months)	7.03	8.63	6.27	2.47 were shown as low & high

Molecular Diffusion with 25C IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	Inhib'Water	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Dissolution	0.0
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	Contingency	0.0
net hours		0.0	0.0	77.7	transfer	batch total (days)	Jet Transfer	77.7
							Sampl&Prep.	240.0
								13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Dissolution	532.8
gallons	952965	140400	58500	205920	894465	1100385	Contingency	168.0
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	Jet Transfer	55.3
net hours		210.6	532.8	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								50.3

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	Dissolution	532.8
gallons	901485	140400	58500	205920	842985	1048905	Contingency	168.0
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	Jet Transfer	55.3
net hours		210.6	532.8	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								50.3

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	Dissolution	532.8
gallons	850005	140400	58500	205920	791505	997425	Contingency	168.0
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	Jet Transfer	55.3
net hours		210.6	532.8	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								50.3

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Dissolution	532.8
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	Contingency	168.0
gallons	798525	140400	58500	205920	740025	945945	Jet Transfer	55.3
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	Sampl&Prep.	240.0
net hours		210.6	532.8	55.3	transfer	batch total (days)		50.3

(Case 1) Molecular Diffusion with 25C Inhibited Water

Tank Level at the End of Batch 4 =		210.8	+ 2 =	212.8	" TK Lvl
Salt Cake Level Reduced =	269.5	-210.8	=	58.7	" TK Lvl
Total Inhibited Water Used=	561600	gallons	=	160.0	" TK Lvl
dissolution & transdfer time (a)	2131.1	hrs =		88.8	days
additional contingency time (b)	672.0	hrs		28.0	days
total dissolution, transf & contingency (a+b) =				116.8	days
inhibited water addition =	842.4	hrs =		35.1	days
initial TK decant transfer time =	298.7	hrs =		12.4	days
test sample & preparation=	1200.0	hrs =		50.0	days
total time =	5144.2	hrs =		214.3	days
			or	7.0	months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26, Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Dissolution	532.8
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	Contingency	168.0
gallons	747045	140400	58500	205920	688545	894465	Jet Transfer	55.3
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	Sampl&Prep.	240.0
net hours		210.6	532.8	55.3	transfer	batch total (days)		50.3

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 2) Modified Density Gradient with 25C Inhibited Water					% total time
Water to salt dissolution ratio =			2.4	to 1	
Modified Density Gradient with 25C IW:		5.32	months total		100%
3.55 gpm dissol. rate; dissol. and contingency =			73.8	days	46%

a) initial salt cake level (average of 262" & 277") ---------- 269.50 inch

b) inhibited water batch = ~80% of 10 Kgal tank ---------- 8000 gallons per batch

inhibited water pumping to TK 37 (80 to 120 gpm) ---------- 100 gpm ; IWp=1.33 hrs

total time of 1 batch IW addition to TK 37 = IWt ---------- 12 hrs

IW addition ---------- 1 batch per 12 hr shift & 2 batches per day

total IW add hr needed/net pumping hr = IWt/IWp = 12/1.33 ------- 9

equiv. continuous IW addition rate= IWt/IWp = 100 gpm/9 ----- 11.11 gpm

batch water add hrs= (40in*3510gal/in)/(11.11gpm*60min/hr)= 210.6 hrs = 8.8 days

c) jet transfer TK 37->TK 30 (Existing Decant Before Batch) 60 gpm (not Batch Case)

d) salt dissolution rate (gpm)	3.55	1.25	5.84	Avg of 25% slurry pump rate
transfer to TK 26 (gpm)	12.05	4.25	19.86	and 1979 TK 10 data gives
total time (months)	5.32	8.08	4.73	(5*0.25+5.84)/2 = 3.55 gpm

Modified Density Gradient with 25C IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	Inhib'Water	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Dissolution	0.0
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	Contingency	0.0
net hours		0.0	0.0	77.7	transfer	batch total (days)	Jet Transfer	77.7
							Sampl&Prep.	240.0
								13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Disso+Trnsf	275.0
gallons	952965	140400	58500	205920	894465	1100385	Contingency	168.0
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	Sampl&Prep.	240.0
net hours		210.6	275.0	275.0	transfer	batch total (days)		37.2

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	Disso+Trnsf	275.0
gallons	901485	140400	58500	205920	842985	1048905	Contingency	168.0
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	Sampl&Prep.	240.0
net hours		210.6	275.0	275.0	transfer	batch total (days)		37.2

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	Disso+Trnsf	275.0
gallons	850005	140400	58500	205920	791505	997425	Contingency	168.0
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	Sampl&Prep.	240.0
net hours		210.6	275.0	275.0	transfer	batch total (days)		37.2

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	Inhib'Water	210.6
gallons	798525	140400	58500	205920	740025	945945	Disso+Trnsf	275.0
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	Contingency	168.0
net hours		210.6	275.0	275.0	transfer	batch total (days)	Sampl&Prep.	240.0
								37.2

(Case 2) Modified Density Gradient with 25C Inhibited Water

Tank Level at the End of Batch 4 =		210.8	+ 2 =	212.8 " TK Lvl
Salt Cake Level Reduced =	269.5	-210.8	=	58.7 " TK Lvl
Total Inhibited Water Used=	561600 gallons		=	160.0 " TK Lvl
dissolution & transdfer time (a)	1100.1 hrs =			45.8 days
additional contingency time (b)	672.0 hrs			28.0 days
total dissolution, transf & contingency (a+b) =				73.8 days
inhibited water addition =	842.4 hrs =			35.1 days
initial TK decant transfer time =	77.7 hrs =			3.2 days
test sample & preparation=	1200.0 hrs =			50.0 days
total time =	3892.2 hrs =			162.2 days
			or	5.3 months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26,
Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level
of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	Inhib'Water	210.6
gallons	747045	140400	58500	205920	688545	894465	Disso+Trnsf	275.0
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	Contingency	168.0
net hours		210.6	275.0	275.0	transfer	batch total (days)	Sampl&Prep.	240.0
								37.2

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 3) Modified Density Gradient with 50C Inhibited Water					% total time
Water to salt dissolution ratio =			2.4	to 1	
Modified Density Gradient with 50C IW:	4.87	months total			100%
5.05 gpm dissol. rate; dissol. and contingency =			60.2	days	41%

a) initial salt cake level (average of 262" & 277") ---------- 269.50 inch

b) inhibited water batch = ~80% of 10 Kgal tank ---------- 8000 gallons per batch

inhibited water pumping to TK 37 (80 to 120 gpm) ---------- 100 gpm ; IWp=1.33 hrs

total time of 1 batch IW addition to TK 37 = IWt ---------- 12 hrs

IW addition ---------- 1 batch per 12 hr shift & 2 batches per day

total IW add hr needed/net pumping hr = IWt/IWp = 12/1.33 ------- 9

equiv. continuous IW addition rate= IWt/IWp = 100 gpm/9 ---- 11.11 gpm

batch water add hrs= (40in*3510gal/in)/(11.11gpm*60min/hr)= 210.6 hrs = 8.8 days

c) jet transfer TK 37->TK 30 (Existing Decant Before Batch) 60 gpm (not Batch Case)

d) salt dissolution rate (gpm)	5.05	1.78	8.32	Avg of 25% slurry pump rate,
transfer to TK 26 (gpm)	17.17	6.05	28.29	& TK10 test with 1.7% rise/°C
total time (months)	4.87	6.81	4.45	(7.1*0.25+8.32)/2 = 5.05 gpm

Modified Density Gradient with 50C IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	Inhib'Water	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Dissolution	0.0
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	Contingency	0.0
net hours		0.0	0.0	77.7	transfer	batch total (days)	Jet Transfer	77.7
							Sampl&Prep.	240.0
							batch total (days)	13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Disso+Trnsf	193.1
gallons	952965	140400	58500	205920	894465	1100385	Contingency	168.0
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	Sampl&Prep.	240.0
net hours		210.6	193.1	193.1	transfer	batch total (days)		33.8

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	Disso+Trnsf	193.1
gallons	901485	140400	58500	205920	842985	1048905	Contingency	168.0
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	Sampl&Prep.	240.0
net hours		210.6	193.1	193.1	transfer	batch total (days)		33.8

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	Disso+Trnsf	193.1
gallons	850005	140400	58500	205920	791505	997425	Contingency	168.0
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	Sampl&Prep.	240.0
net hours		210.6	193.1	193.1	transfer	batch total (days)		33.8

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Disso+Trnsf	193.1
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	Contingency	168.0
gallons	798525	140400	58500	205920	740025	945945		
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	Sampl&Prep.	240.0
net hours		210.6	193.1	193.1	transfer	batch total (days)		33.8

(Case 3) Modified Density Gradient with 50C Inhibited Water

Tank Level at the End of Batch 4 =		210.8	+ 2 =	212.8	" TK Lvl
Salt Cake Level Reduced =	269.5	-210.8	=	58.7	" TK Lvl
Total Inhibited Water Used=	561600	gallons	=	160.0	" TK Lvl
dissolution & transdfer time (a)	772.3	hrs =		32.2	days
additional contingency time (b)	672.0	hrs		28.0	days
total dissolution, transf & contingency (a+b) =				60.2	days
inhibited water addition =	842.4	hrs =		35.1	days
initial TK decant transfer time =	77.7	hrs =		3.2	days
test sample & preparation=	1200.0	hrs =		50.0	days
total time =	3564.4	hrs =		148.5	days
			or	4.9	months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26,
Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level
of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Disso+Trnsf	193.1
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	Contingency	168.0
gallons	747045	140400	58500	205920	688545	894465		
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	Sampl&Prep.	240.0
net hours		210.6	193.1	193.1	transfer	batch total (days)		33.8

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 4) Modified Density Gradient with 75C Inhibited Water					% total time
Water to salt dissolution ratio =			2.4	to 1	
Modified Density Gradient with 75C IW:	4.63	months total			100%
6.56 gpm dissol. rate; dissol. and contingency =			52.8	days	37%

a) initial salt cake level (average of 262" & 277") ---------- 269.50 inch

b) inhibited water batch = ~80% of 10 Kgal tank ---------- 8000 gallons per batch

inhibited water pumping to TK 37 (80 to 120 gpm) ---------- 100 gpm ; IWp=1.33 hrs

total time of 1 batch IW addition to TK 37 = IWt ---------- 12 hrs

IW addition ---------- 1 batch per 12 hr shift & 2 batches per day

total IW add hr needed/net pumping hr = IWt/IWp = 12/1.33 ------- 9

equiv. continuous IW addition *rate= IWt/IWp = 100* gpm/9 ---- 11.11 gpm

batch water add hrs= (40in*3510gal/in)/(11.11gpm*60min/hr)= 210.6 hrs = 8.8 days

c) jet transfer TK 37->TK 30 (Existing Decant Before Batch) 60 gpm (not Batch Case)

d) salt dissolution rate (gpm)	6.56	2.33	10.80	Avg of 25% slurry pump rate,
transfer to TK 26 (gpm)	22.32	7.91	36.73	& TK10 test with 1.7% rise/°C
total time (months)	4.63	6.11	4.31	(9.3/4+10.804)/2 = 6.56 gpm

Modified Density Gradient with 75C IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	Inhib'Water	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Dissolution	0.0
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	Contingency	0.0
net hours		0.0	0.0	77.7	transfer	batch total (days)	Jet Transfer	77.7
							Sampl&Prep.	240.0
								13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
							Disso+Trnsf	148.5
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Contingency	168.0
gallons	952965	140400	58500	205920	894465	1100385		
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	Sampl&Prep.	240.0
net hours		210.6	148.5	148.5	transfer	batch total (days)		32.0

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
							Disso+Trnsf	148.5
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	Contingency	168.0
gallons	901485	140400	58500	205920	842985	1048905		
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	Sampl&Prep.	240.0
net hours		210.6	148.5	148.5	transfer	batch total (days)		32.0

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
							Disso+Trnsf	148.5
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	Contingency	168.0
gallons	850005	140400	58500	205920	791505	997425		
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	Sampl&Prep.	240.0
net hours		210.6	148.5	148.5	transfer	batch total (days)		32.0

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Disso+Trnsf	148.5
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	Contingency	168.0
gallons	798525	140400	58500	205920	740025	945945		
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	Sampl&Prep.	240.0
net hours		210.6	148.5	148.5	transfer	batch total (days)		32.0

(Case 4) Modified Density Gradient with 75C Inhibited Water

Tank Level at the End of Batch 4 =		210.8	+ 2 =	212.8	" TK Lvl
Salt Cake Level Reduced =	269.5	-210.8	=	58.7	" TK Lvl
Total Inhibited Water Used=	561600	gallons	=	160.0	" TK Lvl
dissolution & transdfer time (a)	594.1	hrs =		24.8	days
additional contingency time (b)	672.0	hrs		28.0	days
total dissolution, transf & contingency (a+b) =				52.8	days
inhibited water addition =	842.4	hrs =		35.1	days
initial TK decant transfer time =	77.7	hrs =		3.2	days
test sample & preparation=	1200.0	hrs =		50.0	days
total time =	3386.2	hrs =		141.1	days
			or	4.6	months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26, Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Disso+Trnsf	148.5
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	Contingency	168.0
gallons	747045	140400	58500	205920	688545	894465		
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	Sampl&Prep.	240.0
net hours		210.6	148.5	148.5	transfer	batch total (days)		32.0

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 5) One Flygt Mixer with 25C Inhibited Water Water to salt dissolution ratio =	2.4 to 1	% total time
One Flygt Mixer with 25C IW:	5.89 months total	100%
3.00 gpm dissol. rate; dissol. and contingency =	82.2 days	46%

a) initial salt cake level (average of 262" & 277") ---------- 269.50 inch

b) inhibited water batch = ~80% of 10 Kgal tank ---------- 8000 gallons per batch

inhibited water pumping to TK 37 (80 to 120 gpm) ---------- 100 gpm ; IWp=1.33 hrs

total time of 1 batch IW addition to TK 37 = IWt ---------- 12 hrs

IW addition ---------- 1 batch per 12 hr shift & 2 batches per day

total IW add hr needed/net pumping hr = IWt/IWp = 12/1.33 ------- 9

equiv. continuous IW addition rate= IWt/IWp = 100 gpm/9 ---- 11.11 gpm

batch water add hrs= (40in*3510gal/in)/(11.11gpm*60min/hr)= 210.6 hrs = 8.8 days

c) jet transfer TK 37->TK 30 and or TK 26 60 gpm

d) salt dissolution rate (gpm)	used here 3.00	low 2.00	high 4.00
total time (months)	5.89	6.78	5.45

One Flygt Mixer with 25C IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	Inhib'Water	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Dissolution	0.0
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	Contingency	0.0
net hours		0.0	0.0	77.7	transfer	batch total (days)	Jet Transfer	77.7
							Sampl&Prep.	240.0
								13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Dissolution	325.0
gallons	952965	140400	58500	205920	894465	1100385	Contingency	168.0
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	Jet Transfer	55.3
net hours		210.6	325.0	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								41.6

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	Dissolution	325.0
gallons	901485	140400	58500	205920	842985	1048905	Contingency	168.0
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	Jet Transfer	55.3
net hours		210.6	325.0	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								41.6

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	Dissolution	325.0
gallons	850005	140400	58500	205920	791505	997425	Contingency	168.0
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	Jet Transfer	55.3
net hours		210.6	325.0	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								41.6

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Dissolution	325.0
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	Contingency	168.0
gallons	798525	140400	58500	205920	740025	945945	Jet Transfer	55.3
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	Sampl&Prep.	240.0
net hours		210.6	325.0	55.3	transfer	batch total (days)		41.6

(Case 5) One Flygt Mixer with 25C Inhibited Water

Tank Level at the End of Batch 4 =		210.8	+ 2 =	212.8	" TK Lvl
Salt Cake Level Reduced =	269.5	-210.8	=	58.7	" TK Lvl
Total Inhibited Water Used=	561600	gallons	=	160.0	" TK Lvl
dissolution & transdfer time (a)	1300.0	hrs =		54.2	days
additional contingency time (b)	672.0	hrs		28.0	days
total dissolution, transf & contingency (a+b) =				82.2	days
inhibited water addition =	842.4	hrs =		35.1	days
initial TK decant transfer time =	298.7	hrs =		12.4	days
test sample & preparation=	1200.0	hrs =		50.0	days
total time =	4313.1	hrs =		179.7	days
			or	5.9	months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26, Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Dissolution	325.0
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	Contingency	168.0
gallons	747045	140400	58500	205920	688545	894465	Jet Transfer	55.3
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	Sampl&Prep.	240.0
net hours		210.6	325.0	55.3	transfer	batch total (days)		41.6

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 6) Two Flygt Mixers with 25C Ambient Inhibited Water Water to salt dissolution ratio =	2.4 to 1	% total time
2 Flygt Mixers with 25C Ambient IW:	5.4 months total	100%
4.2 gpm dissolution rate; dissolution & mixing =	66.7 days	41%

a) initial salt cake level (average of 262" & 277") =	269.50	inch
b) inhibited water batch = ~80% of 10 Kgal tank =	8000	gallons
inhibited water pumping to TK 37 (80 to 120 gpm) =	100	gpm
net pumping time of one batch IW to TK 37 = IWp =	1.3	hrs
number of IW batches per 12 hr-shift =	1	batch per shift
number of IW batches per day =	2	batches per day
total time of 1 batch IW addition to TK 37 = IWt =	12	hrs
total IW time needed/net pumping time = IWt/IWp =	9	
c) salt dissolution rate =	4.2	gpm
d) jet transfer rate from TK 37 to TK 30 or TK 26 = (60 to 100 gpm)	60	gpm

2 Flygt Mixers with 25C Ambient IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	Inhib'Water	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Dissolution	0.0
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	ExtraMixing	0.0
net hours		0.0	0.0	77.7	transfer	batch total (days)	Jet Transfer	77.7
							Sampl&Prep.	240.0
								13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Inhib'Water	210.6
gallons	952965	140400	58500	205920	894465	1100385	Dissolution	232.1
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	ExtraMixing	168.0
net hours		210.6	232.1	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
								37.7

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	Inhib'Water	210.6
gallons	901485	140400	58500	205920	842985	1048905	Dissolution	232.1
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	ExtraMixing	168.0
net hours		210.6	232.1	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
								37.7

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	Inhib'Water	210.6
gallons	850005	140400	58500	205920	791505	997425	Dissolution	232.1
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	ExtraMixing	168.0
net hours		210.6	232.1	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
								37.7

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	Inhib'Water	210.6
gallons	798525	140400	58500	205920	740025	945945	Dissolution	232.1
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	ExtraMixing	168.0
net hours		210.6	232.1	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
								37.7

(Case 6) Two Flygt Mixers with 25C Ambient Inhibited Water

Tank Level at the End of Batch 4 =		210.8	+ 2 =	212.8	" TK Lvl
Salt Cake Level Reduced =	269.5	-210.8	=	58.7	" TK Lvl
Total Inhibited Water Used=	561600	gallons	=	160.0	" TK Lvl
dissolution with mixer (a) =	928.6	hrs =		38.7	days
extra mixing (b)	672.0	hrs		28.0	days
total mixer running time (a+b) =				66.7	days
inhibited water addition =	842.4	hrs =		35.1	days
jet transfer time =	298.7	hrs =		12.4	days
test sample & preparation=	1200.0	hrs =		50.0	days
total time =	3941.7	hrs =		164.2	days
			or	5.4	months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26, Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	Inhib'Water	210.6
gallons	747045	140400	58500	205920	688545	894465	Dissolution	232.1
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	ExtraMixing	168.0
net hours		210.6	232.1	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
								37.7

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 7) One Flygt Mixer with 50C Heated Inhibited Water Water to salt dissolution ratio =	2.4 to 1	% total time
1 Flygt Mixer with 50C Heated IW:	5.4 months total	100%
4.3 gpm dissolution rate; dissolution & mixing =	65.8 days	40%

a) initial salt cake level (average of 262" & 277") =	269.50	inch
b) inhibited water batch = ~80% of 10 Kgal tank =	8000	gallons
inhibited water pumping to TK 37 (80 to 120 gpm) =	100	gpm
net pumping time of one batch IW to TK 37 = IWp =	1.3	hrs
number of IW batches per 12 hr-shift =	1	batch per shift
number of IW batches per day =	2	batches per day
total time of 1 batch IW addition to TK 37 = IWt =	12	hrs
total IW time needed/net pumping time = IWt/IWp =	9	
c) salt dissolution rate =	4.3	gpm
d) jet transfer rate from TK 37 to TK 30 or TK 26 = (60 to 100 gpm)	60	gpm

1 Flygt Mixer with 50C Heated IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	0.0
							Dissolution	0.0
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	ExtraMixing	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Jet Transfer	77.7
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	Sampl&Prep.	240.0
net hours		0.0	0.0	77.7	transfer	batch total (days)		13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
							Dissolution	226.7
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	ExtraMixing	168.0
gallons	952965	140400	58500	205920	894465	1100385	Jet Transfer	55.3
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	Sampl&Prep.	240.0
net hours		210.6	226.7	55.3	transfer	batch total (days)		37.5

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
							Dissolution	226.7
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	ExtraMixing	168.0
gallons	901485	140400	58500	205920	842985	1048905	Jet Transfer	55.3
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	Sampl&Prep.	240.0
net hours		210.6	226.7	55.3	transfer	batch total (days)		37.5

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
							Dissolution	226.7
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	ExtraMixing	168.0
gallons	850005	140400	58500	205920	791505	997425	Jet Transfer	55.3
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	Sampl&Prep.	240.0
net hours		210.6	226.7	55.3	transfer	batch total (days)		37.5

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Dissolution	226.7
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	ExtraMixing	168.0
gallons	798525	140400	58500	205920	740025	945945	Jet Transfer	55.3
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	Sampl&Prep.	240.0
net hours		210.6	226.7	55.3	transfer	batch total (days)		37.5

(Case 7) One Flygt Mixer with 50C Heated Inhibited Water

Tank Level at the End of Batch 4 =		210.8	+ 2 =	212.8	" TK Lvl
Salt Cake Level Reduced =	269.5	-210.8	=	58.7	" TK Lvl
Total Inhibited Water Used=	561600	gallons	=	160.0	" TK Lvl
dissolution with mixer (a) =	907.0	hrs =		37.8	days
extra mixing (b)	672.0	hrs		28.0	days
total mixer running time (a+b) =				65.8	days
inhibited water addition =	842.4	hrs =		35.1	days
jet transfer time =	298.7	hrs =		12.4	days
test sample & preparation=	1200.0	hrs =		50.0	days
total time =	3920.1	hrs =		163.3	days
			or	5.4	months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26, Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Dissolution	226.7
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	ExtraMixing	168.0
gallons	747045	140400	58500	205920	688545	894465	Jet Transfer	55.3
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	Sampl&Prep.	240.0
net hours		210.6	226.7	55.3	transfer	batch total (days)		37.5

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 8) One Slurry Pump with 25C Ambient Inhibited Water Water to salt dissolution ratio =	2.4 to 1	% total time
1 Slurry Pump with 25C Ambient IW:	5.2 months total	100%
5 gpm dissolution rate; dissolution & mixing =	60.5 days	38.3%

a) initial salt cake level (average of 262" & 277") = 269.50 inch

b) inhibited water batch = ~80% of 10 Kgal tank = 8000 gallons
inhibited water pumping to TK 37 (80 to 120 gpm) = 100 gpm
net pumping time of one batch IW to TK 37 = IWp = 1.3 hrs
number of IW batches per 12 hr-shift = 1 batch per shift
number of IW batches per day = 2 batches per day
total time of 1 batch IW addition to TK 37 = IWt = 12 hrs
total IW time needed/net pumping time = IWt/IWp = 9

c) salt dissolution rate = 5 gpm

d) jet transfer rate from TK 37 to TK 30 or TK 26 = 60 gpm
(60 to 100 gpm)

1 Slurry Pump with 25C Ambient IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	Inhib'Water	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Dissolution	0.0
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	ExtraMixing	0.0
net hours		0.0	0.0	77.7	transfer	batch total (days)	Jet Transfer	77.7
							Sampl&Prep.	240.0
							batch total (days)	13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Inhib'Water	210.6
gallons	952965	140400	58500	205920	894465	1100385	Dissolution	195.0
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	ExtraMixing	168.0
net hours		210.6	195.0	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
							batch total (days)	36.2

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	Inhib'Water	210.6
gallons	901485	140400	58500	205920	842985	1048905	Dissolution	195.0
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	ExtraMixing	168.0
net hours		210.6	195.0	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
							batch total (days)	36.2

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	Inhib'Water	210.6
gallons	850005	140400	58500	205920	791505	997425	Dissolution	195.0
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	ExtraMixing	168.0
net hours		210.6	195.0	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
							batch total (days)	36.2

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Dissolution	195.0
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	ExtraMixing	168.0
gallons	798525	140400	58500	205920	740025	945945	Jet Transfer	55.3
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	Sampl&Prep.	240.0
net hours		210.6	195.0	55.3	transfer	batch total (days)		36.2

(Case 8) One Slurry Pump with 25C Ambient Inhibited Water

Tank Level at the End of Batch 4 =		210.8	+ 2 =	212.8	" TK Lvl
Salt Cake Level Reduced =	269.5	-210.8	=	58.7	" TK Lvl
Total Inhibited Water Used=	561600	gallons	=	160.0	" TK Lvl
dissolution with pump (a) =	780.0	hrs =		32.5	days
extra pump run mixing (b) =	672.0	hrs		28.0	days
total pump run mixing time (a+b) =				60.5	days
inhibited water addition =	842.4	hrs =		35.1	days
jet transfer time =	298.7	hrs =		12.4	days
test sample & preparation=	1200.0	hrs =		50.0	days
total time =	3793.1	hrs =		158.0	days
			or	5.2	months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26, Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Dissolution	195.0
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	ExtraMixing	168.0
gallons	747045	140400	58500	205920	688545	894465	Jet Transfer	55.3
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	Sampl&Prep.	240.0
net hours		210.6	195.0	55.3	transfer	batch total (days)		36.2

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 9) Three Flygt Mixers with 25C Ambient Temperature Inhibited Water					% total time
Water to salt dissolution ratio =			2.4	to 1	
3 Flygt Mixers with 25C Ambient IW:	5.1	months total			100%
5.2 gpm dissolution rate; dissolution & mixing =			59.3	days	37.8%

a) initial salt cake level (average of 262" & 277") =	269.50	inch
b) inhibited water batch = ~80% of 10 Kgal tank =	8000	gallons
inhibited water pumping to TK 37 (80 to 120 gpm) =	100	gpm
net pumping time of one batch IW to TK 37 = IWp =	1.3	hrs
number of IW batches per 12 hr-shift =	1	batch per shift
number of IW batches per day =	2	batches per day
total time of 1 batch IW addition to TK 37 = IWt =	12	hrs
total IW time needed/net pumping time = IWt/IWp =	9	
c) salt dissolution rate =	5.2	gpm
d) jet transfer rate from TK 37 to TK 30 or TK 26 = (60 to 100 gpm)	60	gpm

3 Flygt Mixers with 25C Ambient IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	0.0
							Dissolution	0.0
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	ExtraMixing	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Jet Transfer	77.7
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	Sampl&Prep.	240.0
net hours		0.0	0.0	77.7	transfer	batch total (days)		13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
							Dissolution	187.5
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	ExtraMixing	168.0
gallons	952965	140400	58500	205920	894465	1100385	Jet Transfer	55.3
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	Sampl&Prep.	240.0
net hours		210.6	187.5	55.3	transfer	batch total (days)		35.9

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
							Dissolution	187.5
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	ExtraMixing	168.0
gallons	901485	140400	58500	205920	842985	1048905	Jet Transfer	55.3
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	Sampl&Prep.	240.0
net hours		210.6	187.5	55.3	transfer	batch total (days)		35.9

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
							Dissolution	187.5
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	ExtraMixing	168.0
gallons	850005	140400	58500	205920	791505	997425	Jet Transfer	55.3
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	Sampl&Prep.	240.0
net hours		210.6	187.5	55.3	transfer	batch total (days)		35.9

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Dissolution	187.5
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	ExtraMixing	168.0
gallons	798525	140400	58500	205920	740025	945945	Jet Transfer	55.3
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	Sampl&Prep.	240.0
net hours		210.6	187.5	55.3	transfer	batch total (days)		35.9

(Case 9) Three Flygt Mixers with 25C Ambient Temperature Inhibited Wate

Tank Level at the End of Batch 4 =		210.8	+ 2 =	212.8 " TK Lvl
Salt Cake Level Reduced =	269.5	-210.8	=	58.7 " TK Lvl
Total Inhibited Water Used=	561600	*gallons*	=	160.0 " TK Lvl
dissolution with mixer (a) =	750.0	hrs =		31.3 days
extra mixing (b)	672.0	hrs		28.0 days
total mixer running time (a+b) =				59.3 days
inhibited water addition =	842.4	hrs =		35.1 days
jet transfer time =	298.7	hrs =		12.4 days
test sample & preparation=	1200.0	hrs =		50.0 days
total time =	3763.1	hrs =		156.8 days
			or	5.1 months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26, Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Dissolution	187.5
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	ExtraMixing	168.0
gallons	747045	140400	58500	205920	688545	894465	Jet Transfer	55.3
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	Sampl&Prep.	240.0
net hours		210.6	187.5	55.3	transfer	batch total (days)		35.9

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 10) One Flygt Mixer with 75C Heated Inhibited Water					% total time
Water to salt dissolution ratio =			2.4	to 1	
1 Flygt Mixer with 50C Heated IW:	5.1	months total			100%
5.6 gpm dissolution rate; dissolution & mixing =			57.0	days	37%

a) initial salt cake level (average of 262" & 277") = 269.50 inch

b) inhibited water batch = ~80% of 10 Kgal tank = 8000 gallons
inhibited water pumping to TK 37 (80 to 120 gpm) = 100 gpm
net pumping time of one batch IW to TK 37 = IWp = 1.3 hrs
number of IW batches per 12 hr-shift = 1 batch per shift
number of IW batches per day = 2 batches per day
total time of 1 batch IW addition to TK 37 = IWt = 12 hrs
total IW time needed/net pumping time = IWt/IWp = 9

c) salt dissolution rate = 5.6 gpm

d) jet transfer rate from TK 37 to TK 30 or TK 26 = 60 gpm
(60 to 100 gpm)

1 Flygt Mixer with 50C Heated IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	Inhib'Water	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Dissolution	0.0
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	ExtraMixing	0.0
net hours		0.0	0.0	77.7	transfer	batch total (days)	Jet Transfer	77.7
							Sampl&Prep.	240.0
								13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Dissolution	174.1
gallons	952965	140400	58500	205920	894465	1100385	ExtraMixing	168.0
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	Jet Transfer	55.3
net hours		210.6	174.1	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								35.3

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	Dissolution	174.1
gallons	901485	140400	58500	205920	842985	1048905	ExtraMixing	168.0
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	Jet Transfer	55.3
net hours		210.6	174.1	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								35.3

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	Dissolution	174.1
gallons	850005	140400	58500	205920	791505	997425	ExtraMixing	168.0
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	Jet Transfer	55.3
net hours		210.6	174.1	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								35.3

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Dissolution	174.1
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	ExtraMixing	168.0
gallons	798525	140400	58500	205920	740025	945945	Jet Transfer	55.3
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	Sampl&Prep.	240.0
net hours		210.6	174.1	55.3	transfer	batch total (days)		35.3

(Case 10) One Flygt Mixer with 75C Heated Inhibited Water

Tank Level at the End of Batch 4 =		210.8	+ 2 =	212.8	" TK Lvl
Salt Cake Level Reduced =	269.5	-210.8	=	58.7	" TK Lvl
Total Inhibited Water Used=	561600	gallons	=	160.0	" TK Lvl
dissolution with mixer (a) =	696.4	hrs =		29.0	days
extra mixing (b)	672.0	hrs		28.0	days
total mixer running time (a+b) =				57.0	days
inhibited water addition =	842.4	hrs =		35.1	days
jet transfer time =	298.7	hrs =		12.4	days
test sample & preparation=	1200.0	hrs =		50.0	days
total time =	3709.5	hrs =		154.6	days
			or	5.1	months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26, Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Dissolution	174.1
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	ExtraMixing	168.0
gallons	747045	140400	58500	205920	688545	894465	Jet Transfer	55.3
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	Sampl&Prep.	240.0
net hours		210.6	174.1	55.3	transfer	batch total (days)		35.3

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 11) Two Flygt Mixers with 50C Heated Inhibited Water Water to salt dissolution ratio =	2.4 to 1	% total time
2 Flygt Mixers with 50C Heated IW:	5.0 months total	100%
6.1 gpm dissolution rate; dissolution & mixing =	54.6 days	36%

a) initial salt cake level (average of 262" &.277") =	269.50	inch
b) inhibited water batch = ~80% of 10 Kgal tank =	8000	gallons
inhibited water pumping to TK 37 (80 to 120 gpm) =	100	gpm
net pumping time of one batch IW to TK 37 = IWp =	1.3	hrs
number of IW batches per 12 hr-shift =	1	batch per shift
number of IW batches per day =	2	batches per day
total time of 1 batch IW addition to TK 37 = IWt =	12	hrs
total IW time needed/net pumping time = IWt/IWp =	9	
c) salt dissolution rate =	6.1	gpm
d) jet transfer rate from TK 37 to TK 30 or TK 26 = (60 to 100 gpm)	60	gpm

2 Flygt Mixers with 50C Heated IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	0.0
							Dissolution	0.0
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	ExtraMixing	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Jet Transfer	77.7
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	Sampl&Prep.	240.0
net hours		0.0	0.0	77.7	transfer	batch total (days)		13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
							Dissolution	159.8
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	ExtraMixing	168.0
gallons	952965	140400	58500	205920	894465	1100385	Jet Transfer	55.3
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	Sampl&Prep.	240.0
net hours		210.6	159.8	55.3	transfer	batch total (days)		34.7

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
							Dissolution	159.8
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	ExtraMixing	168.0
gallons	901485	140400	58500	205920	842985	1048905	Jet Transfer	55.3
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	Sampl&Prep.	240.0
net hours		210.6	159.8	55.3	transfer	batch total (days)		34.7

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
							Dissolution	159.8
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	ExtraMixing	168.0
gallons	850005	140400	58500	205920	791505	997425	Jet Transfer	55.3
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	Sampl&Prep.	240.0
net hours		210.6	159.8	55.3	transfer	batch total (days)		34.7

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	Inhib'Water	210.6
gallons	798525	140400	58500	205920	740025	945945	Dissolution	159.8
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	ExtraMixing	168.0
net hours		210.6	159.8	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
								34.7

(Case 11) Two Flygt Mixers with 50C Heated Inhibited Water

Tank Level at the End of Batch 4 =		210.8	+ 2 =	212.8	" TK Lvl
Salt Cake Level Reduced =	269.5	-210.8	=	58.7	" TK Lvl
Total Inhibited Water Used=	561600	gallons	=	160.0	" TK Lvl
dissolution with mixer (a) =	639.3	hrs =		26.6	days
extra mixing (b)	672.0	hrs		28.0	days
total mixer running time (a+b) =				54.6	days
inhibited water addition =	842.4	hrs =		35.1	days
jet transfer time =	298.7	hrs =		12.4	days
test sample & preparation=	1200.0	hrs =		50.0	days
total time =	3652.4	hrs =		152.2	days
			or	5.0	months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26, Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	Inhib'Water	210.6
gallons	747045	140400	58500	205920	688545	894465	Dissolution	159.8
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	ExtraMixing	168.0
net hours		210.6	159.8	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
								34.7

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 12) One Slurry Pump with 50C Heated Inhibited Water Water to salt dissolution ratio =	2.4 to 1	% total time
1 Slurry Pump with 50C Heated IW:	4.9 months total	100%
7.1 gpm dissolution rate; dissolution & mixing =	50.9 days	34.3%

a) initial salt cake level (average of 262" & 277") =	269.50	inch
b) inhibited water batch = ~80% of 10 Kgal tank =	8000	gallons
inhibited water pumping to TK 37 (80 to 120 gpm) =	100	gpm
net pumping time of one batch IW to TK 37 = IWp =	1.3	hrs
number of IW batches per 12 hr-shift =	1	batch per shift
number of IW batches per day =	2	batches per day
total time of 1 batch IW addition to TK 37 = IWt =	12	hrs
total IW time needed/net pumping time = IWt/IWp =	9	
c) salt dissolution rate =	7.1	gpm
d) jet transfer rate from TK 37 to TK 30 or TK 26 = (60 to 100 gpm)	60	gpm

1 Slurry Pump with 50C Heated IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	Inhib'Water	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Dissolution	0.0
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	ExtraMixing	0.0
net hours		0.0	0.0	77.7	transfer	batch total (days)	Jet Transfer	77.7
							Sampl&Prep.	240.0
								13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Dissolution	137.3
gallons	952965	140400	58500	205920	894465	1100385	ExtraMixing	168.0
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	Jet Transfer	55.3
net hours		210.6	137.3	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								33.8

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	Dissolution	137.3
gallons	901485	140400	58500	205920	842985	1048905	ExtraMixing	168.0
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	Jet Transfer	55.3
net hours		210.6	137.3	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								33.8

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	Dissolution	137.3
gallons	850005	140400	58500	205920	791505	997425	ExtraMixing	168.0
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	Jet Transfer	55.3
net hours		210.6	137.3	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								33.8

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	Inhib'Water	210.6
gallons	798525	140400	58500	205920	740025	945945	Dissolution	137.3
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	ExtraMixing	168.0
net hours		210.6	137.3	55.3	transfer	batch total	Jet Transfer	55.3
						(days)	Sampl&Prep.	240.0
								33.8

(Case 12) One Slurry Pump with 50C Heated Inhibited Water

Tank Level at the End of Batch 4 =		210.8	+ 2 =	212.8	" TK Lvl
Salt Cake Level Reduced =	269.5	-210.8	=	58.7	" TK Lvl
Total Inhibited Water Used=	561600	gallons	=	160.0	" TK Lvl
dissolution with pump (a) =	549.3	hrs =		22.9	days
extra pump run mixing (b) =	672.0	hrs		28.0	days
total pump run mixing time (a+b) =				50.9	days
inhibited water addition =	842.4	hrs =		35.1	days
jet transfer time =	298.7	hrs =		12.4	days
test sample & preparation=	1200.0	hrs =		50.0	days
total time =	3562.4	hrs =		148.4	days
			or	4.9	months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26, Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	Inhib'Water	210.6
gallons	747045	140400	58500	205920	688545	894465	Dissolution	137.3
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	ExtraMixing	168.0
net hours		210.6	137.3	55.3	transfer	batch total	Jet Transfer	55.3
						(days)	Sampl&Prep.	240.0
								33.8

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 13) Three Flygt Mixers with 50C Heated Inhibited Water					% total time
Water to salt dissolution ratio =			2.4	to 1	
2 Flygt Mixers with 50C Heated IW:	4.8	months total			100%
7.4 gpm dissolution rate; dissolution & mixing =			50.0	days	33.9%

a) initial salt cake level (average of 262" & 277") = 269.50 inch

b) inhibited water batch = ~80% of 10 Kgal tank = 8000 gallons
inhibited water pumping to TK 37 (80 to 120 gpm) = 100 gpm
net pumping time of one batch IW to TK 37 = IWp = 1.3 hrs
number of IW batches per 12 hr-shift = 1 batch per shift
number of IW batches per day = 2 batches per day
total time of 1 batch IW addition to TK 37 = IWt = 12 hrs
total IW time needed/net pumping time = IWt/IWp = 9

c) salt dissolution rate = 7.4 gpm

d) jet transfer rate from TK 37 to TK 30 or TK 26 = 60 gpm
(60 to 100 gpm)

2 Flygt Mixers with 50C Heated IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	Inhib'Water	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Dissolution	0.0
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	ExtraMixing	0.0
net hours		0.0	0.0	77.7	transfer		Jet Transfer	77.7
						batch total (days)	Sampl&Prep.	240.0
								13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Inhib'Water	210.6
gallons	952965	140400	58500	205920	894465	1100385	Dissolution	131.8
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	ExtraMixing	168.0
net hours		210.6	131.8	55.3	transfer		Jet Transfer	55.3
						batch total (days)	Sampl&Prep.	240.0
								33.6

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	Inhib'Water	210.6
gallons	901485	140400	58500	205920	842985	1048905	Dissolution	131.8
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	ExtraMixing	168.0
net hours		210.6	131.8	55.3	transfer		Jet Transfer	55.3
						batch total (days)	Sampl&Prep.	240.0
								33.6

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	Inhib'Water	210.6
gallons	850005	140400	58500	205920	791505	997425	Dissolution	131.8
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	ExtraMixing	168.0
net hours		210.6	131.8	55.3	transfer		Jet Transfer	55.3
						batch total (days)	Sampl&Prep.	240.0
								33.6

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	Inhib'Water	210.6
gallons	798525	140400	58500	205920	740025	945945	Dissolution	131.8
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	ExtraMixing	168.0
net hours		210.6	131.8	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
								33.6

(Case 13) Three Flygt Mixers with 50C Heated Inhibited Water

Tank Level at the End of Batch 4 =	210.8	+ 2 =	212.8 " TK Lvl
Salt Cake Level Reduced =	269.5	-210.8 =	58.7 " TK Lvl
Total Inhibited Water Used=	561600 gallons	=	160.0 " TK Lvl
dissolution with mixer (a) =	527.0 hrs =		22.0 days
extra mixing (b)	672.0 hrs		28.0 days
total mixer running time (a+b) =			50.0 days
inhibited water addition =	842.4 hrs =		35.1 days
jet transfer time =	298.7 hrs =		12.4 days
test sample & preparation=	1200.0 hrs =		50.0 days
total time =	3540.1 hrs =		147.5 days
		or	4.8 months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26, Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	Inhib'Water	210.6
gallons	747045	140400	58500	205920	688545	894465	Dissolution	131.8
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	ExtraMixing	168.0
net hours		210.6	131.8	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
								33.6

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 14) Two Flygt Mixers with 75C Heated Inhibited Water Water to salt dissolution ratio =	2.4 to 1	% total time
2 Flygt Mixers with 75C Heated IW:	4.7 months total	100%
8.6 gpm dissolution rate; dissolution & mixing =	46.9 days	32.47%

a) initial salt cake level (average of 262" & 277") =	269.50	inch
b) inhibited water batch = ~80% of 10 Kgal tank =	8000	gallons
inhibited water pumping to TK 37 (80 to 120 gpm) =	100	gpm
net pumping time of one batch IW to TK 37 = IWp =	1.3	hrs
number of IW batches per 12 hr-shift =	1	batch per shift
number of IW batches per day =	2	batches per day
total time of 1 batch IW addition to TK 37 = IWt =	12	hrs
total IW time needed/net pumping time = IWt/IWp =	9	
c) salt dissolution rate =	8.6	gpm
d) jet transfer rate from TK 37 to TK 30 or TK 26 = (60 to 100 gpm)	60	gpm

2 Flygt Mixers with 75C Heated IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	Inhib'Water	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Dissolution	0.0
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	ExtraMixing	0.0
net hours		0.0	0.0	77.7	transfer	batch total (days)	Jet Transfer	77.7
							Sampl&Prep.	240.0
								13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Dissolution	113.4
gallons	952965	140400	58500	205920	894465	1100385	ExtraMixing	168.0
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	Jet Transfer	55.3
net hours		210.6	113.4	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								32.8

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	Dissolution	113.4
gallons	901485	140400	58500	205920	842985	1048905	ExtraMixing	168.0
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	Jet Transfer	55.3
net hours		210.6	113.4	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								32.8

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	Dissolution	113.4
gallons	850005	140400	58500	205920	791505	997425	ExtraMixing	168.0
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	Jet Transfer	55.3
net hours		210.6	113.4	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								32.8

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Dissolution	113.4
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	ExtraMixing	168.0
gallons	798525	140400	58500	205920	740025	945945	Jet Transfer	55.3
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	Sampl&Prep.	240.0
net hours		210.6	113.4	55.3	transfer	batch total (days)		32.8

(Case 14) Two Flygt Mixers with 75C Heated Inhibited Water

Tank Level at the End of Batch 4 =		210.8	+ 2 =	212.8	* TK Lvl
Salt Cake Level Reduced =	269.5	-210.8	=	58.7	* TK Lvl
Total Inhibited Water Used=	561600	gallons	=	160.0	* TK Lvl
dissolution with mixer (a) =	453.5	hrs =		18.9	days
extra mixing (b)	672.0	hrs		28.0	days
total mixer running time (a+b) =				46.9	days
inhibited water addition =	842.4	hrs =		35.1	days
jet transfer time =	298.7	hrs =		12.4	days
test sample & preparation=	1200.0	hrs =		50.0	days
total time =	3466.6	hrs =		144.4	days
			or	4.7	months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26, Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
							Inhib'Water	210.6
							Dissolution	113.4
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	ExtraMixing	168.0
gallons	747045	140400	58500	205920	688545	894465	Jet Transfer	55.3
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	Sampl&Prep.	240.0
net hours		210.6	113.4	55.3	transfer	batch total (days)		32.8

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 15) One Slurry Pump with 75C Heated Inhibited Water					% total time
Water to salt dissolution ratio =			2.4	to 1	
1 Slurry Pump with 75C Heated IW:	4.7	months total			100%
9.3 gpm dissolution rate; dissolution & mixing =			45.5	days	31.80%

a) initial salt cake level (average of 262" & 277") =	269.50	inch
b) inhibited water batch = ~80% of 10 Kgal tank =	8000	gallons
inhibited water pumping to TK 37 (80 to 120 gpm) =	100	gpm
net pumping time of one batch IW to TK 37 = IWp =	1.3	hrs
number of IW batches per 12 hr-shift =	1	batch per shift
number of IW batches per day =	2	batches per day
total time of 1 batch IW addition to TK 37 = IWt =	12	hrs
total IW time needed/net pumping time = IWt/IWp =	9	
c) salt dissolution rate =	9.3	gpm
d) jet transfer rate from TK 37 to TK 30 or TK 26 = (60 to 100 gpm)	60	gpm

1 Slurry Pump with 75C Heated IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	Inhib'Water	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Dissolution	0.0
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	ExtraMixing	0.0
net hours		0.0	0.0	77.7	transfer	batch total (days)	Jet Transfer	77.7
							Sampl&Prep.	240.0
								13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Dissolution	104.8
gallons	952965	140400	58500	205920	894465	1100385	ExtraMixing	168.0
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	Jet Transfer	55.3
net hours		210.6	104.8	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								32.4

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	Dissolution	104.8
gallons	901485	140400	58500	205920	842985	1048905	ExtraMixing	168.0
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	Jet Transfer	55.3
net hours		210.6	104.8	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								32.4

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	Dissolution	104.8
gallons	850005	140400	58500	205920	791505	997425	ExtraMixing	168.0
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	Jet Transfer	55.3
net hours		210.6	104.8	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
								32.4

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	Inhib'Water	210.6
gallons	798525	140400	58500	205920	740025	945945	Dissolution	104.8
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	ExtraMixing	168.0
net hours		210.6	104.8	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
								32.4

(Case 15) One Slurry Pump with 75C Heated Inhibited Water

Tank Level at the End of Batch 4 = 210.8 + 2 = 212.8 " TK Lvl

Salt Cake Level Reduced = 269.5 -210.8 = 58.7 " TK Lvl

Total Inhibited Water Used= 561600 gallons = 160.0 " TK Lvl

dissolution with pump (a) = 419.4 hrs = 17.5 days
extra pump run mixing (b) = 672.0 hrs 28.0 days
total pump run mixing time (a+b) = 45.5 days

inhibited water addition = 842.4 hrs = 35.1 days

jet transfer time = 298.7 hrs = 12.4 days

test sample & preparation= 1200.0 hrs = 50.0 days

total time = 3432.5 hrs = 143.0 days
or 4.7 months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26, Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	Inhib'Water	210.6
gallons	747045	140400	58500	205920	688545	894465	Dissolution	104.8
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	ExtraMixing	168.0
net hours		210.6	104.8	55.3	transfer	batch total (days)	Jet Transfer	55.3
							Sampl&Prep.	240.0
								32.4

TANK 37H DISSOLUTION CYCLE ANALYSIS

(Case 16) Three Flygt Mixers with 75C Heated Inhibited Water Water to salt dissolution ratio =	2.4 to 1	% total time
3 Flygt Mixers with 75C Heated IW:	4.6 months total	100%
10.6 gpm dissolution rate; dissolution & mixing =	43.3 days	30.8%

a) initial salt cake level (average of 262" & 277") =	269.50	inch
b) inhibited water batch = ~80% of 10 Kgal tank =	8000	gallons
inhibited water pumping to TK 37 (80 to 120 gpm) =	100	gpm
net pumping time of one batch IW to TK 37 = IWp =	1.3	hrs
number of IW batches per 12 hr-shift =	1	batch per shift
number of IW batches per day =	2	batches per day
total time of 1 batch IW addition to TK 37 = IWt =	12	hrs
total IW time needed/net pumping time = IWt/IWp =	9	
c) salt dissolution rate =	10.6	gpm
d) jet transfer rate from TK 37 to TK 30 or TK 26 = (60 to 100 gpm)	60	gpm

3 Flygt Mixers with 75C Heated IW:

Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content	Step	Hours
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0	Inhib'Water	0.0
gallons	1030278	202399	84333	286732	945945	1232010	Dissolution	0.0
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%	ExtraMixing	0.0
net hours		0.0	0.0	77.7	transfer	batch total (days)	Jet Transfer	77.7
							Sampl&Prep.	240.0
							batch total (days)	13.2

Batch #1	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	271.50	40.0	16.67	58.67	254.83	313.5	Dissolution	92.0
gallons	952965	140400	58500	205920	894465	1100385	ExtraMixing	168.0
%	86.6%	12.8%	5.3%	18.7%	81.3%	100.0%	Jet Transfer	55.3
net hours		210.6	92.0	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
							batch total (days)	31.9

Batch #2	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	256.83	40.0	16.67	58.67	240.17	298.8	Dissolution	92.0
gallons	901485	140400	58500	205920	842985	1048905	ExtraMixing	168.0
%	85.9%	13.4%	5.6%	19.6%	80.4%	100.0%	Jet Transfer	55.3
net hours		210.6	92.0	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
							batch total (days)	31.9

Batch #3	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Inhib'Water	210.6
depth (in)	242.17	40.0	16.67	58.67	225.50	284.2	Dissolution	92.0
gallons	850005	140400	58500	205920	791505	997425	ExtraMixing	168.0
%	85.2%	14.1%	5.9%	20.6%	79.4%	100.0%	Jet Transfer	55.3
net hours		210.6	92.0	55.3	transfer	batch total (days)	Sampl&Prep.	240.0
							batch total (days)	31.9

Batch #4	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	227.50	40.0	16.67	58.67	210.83	269.5	Inhib'Water	210.6
gallons	798525	140400	58500	205920	740025	945945	Dissolution	92.0
%	84.4%	14.8%	6.2%	21.8%	78.2%	100.0%	ExtraMixing	168.0
net hours		210.6	92.0	55.3	transfer	batch total	Jet Transfer	55.3
						(days)	Sampl&Prep.	240.0
								31.9

(Case 16) Three Flygt Mixers with 75C Heated Inhibited Water

Tank Level at the End of Batch 4 =		210.8	+ 2 =	212.8	" TK Lvl
Salt Cake Level Reduced =	269.5	-210.8	=	58.7	" TK Lvl
Total Inhibited Water Used=	561600	gallons	=	160.0	" TK Lvl
dissolution with mixer (a) =	367.9	hrs =		15.3	days
extra mixing (b)	672.0	hrs		28.0	days
total mixer running time (a+b) =				43.3	days
inhibited water addition =	842.4	hrs =		35.1	days
jet transfer time =	298.7	hrs =		12.4	days
test sample & preparation=	1200.0	hrs =		50.0	days
total time =	3381.0	hrs =		140.9	days
			or	4.6	months

After the existing supernate transfer to TK 30 and the above four batch transfer to TK 26, Tank 37 salt level of 212.8 inch will pass the project scope tank level of 227 inches.

Batch #5 is shown below even though it is not required to meet the original project scope level of 227 inches. The Tank 37 level after Batch 5 will be 198.2 inches if Batch 5 is processed.

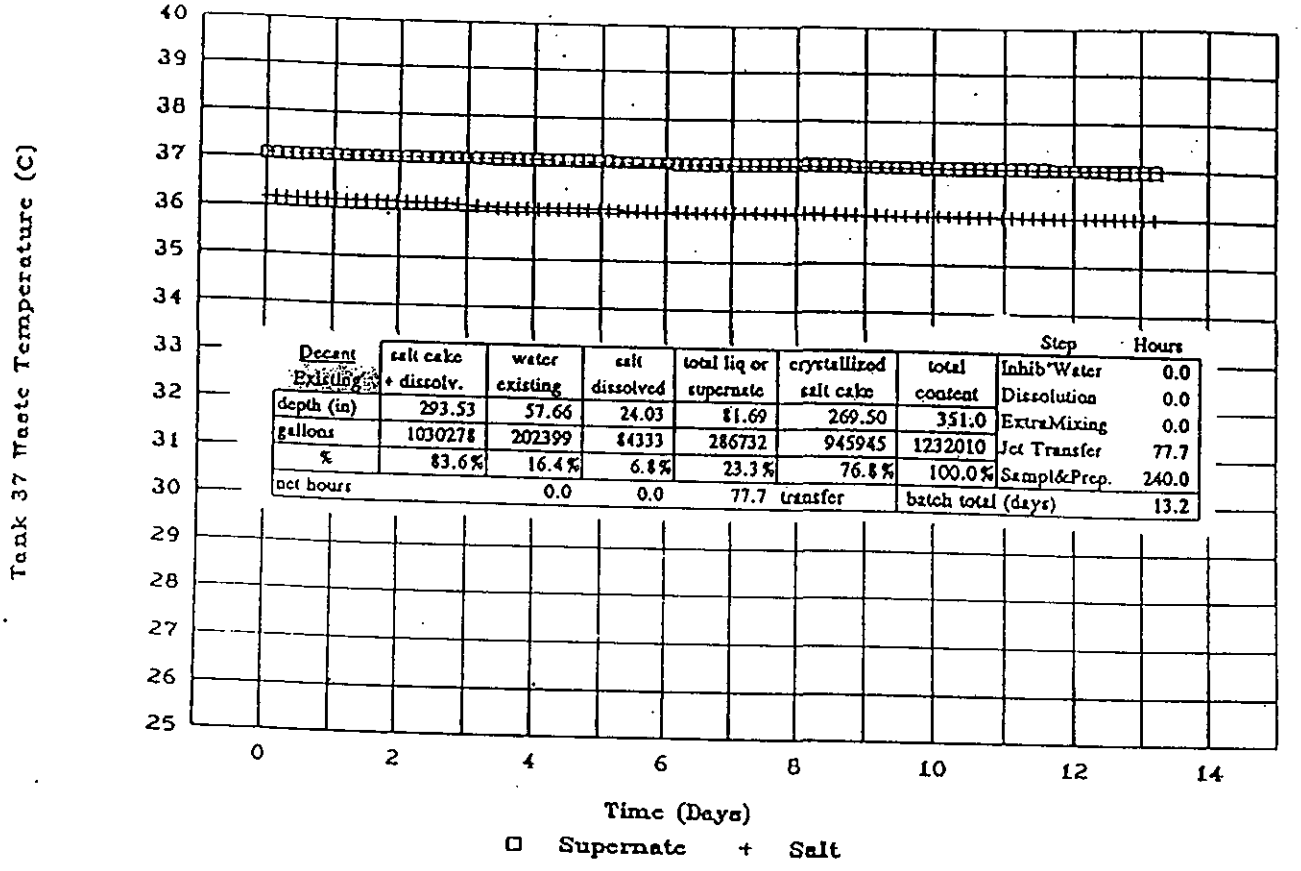
Batch #5	starting level	water added	salt dissolved	total supernate	crystallized salt cake	total content	Step	Hours
depth (in)	212.83	40.0	16.67	58.67	196.17	254.8	Inhib'Water	210.6
gallons	747045	140400	58500	205920	688545	894465	Dissolution	92.0
%	83.5%	15.7%	6.5%	23.0%	77.0%	100.0%	ExtraMixing	168.0
net hours		210.6	92.0	55.3	transfer	batch total	Jet Transfer	55.3
						(days)	Sampl&Prep.	240.0
								31.9

Appendix 3
Heat Transfer Calculations

Method of Dissolution	Water Temp. (°C)	End IW Addition Batch 1 Batch 4	Peak Temp. Batch 1 Batch 4	End Dissolution Batch 1 Batch 4	End Mixing Batch 1 Batch 4
1. No Agitation	25	36.0 29.7	37.0 29.9	33.6 27.6	34.3 27.9
2. MDG	25	36.0 29.1	37.0 29.1	33.4 26.5	33.6 27.0-
3. MDG	50	38.0 34.0	38.0 34.0	35.0 30.6	35.0 30.8
4. MDG	75	40.1 39.9	40.1 40.0	37.3 36.6	37.0 36.2
5. One Flygt Mixer	25	36.0 29.8	37.0 30.0	35.6 27.5	35.9 27.7
6. Two Flygt Mixers	25	36.5 30.0	37.0 30.2	33.7 27.6	34.0 28.2
7. One Flygt Mixer	50	38.0 35.4	38.0 35.4	35.5 32.5	35.7 32.7
8. One Slurry Pump	25	36.0 37.9	38.6 40.6	36.1 37.8	38.6 40.6
9. Three Flygt Mixers	25	36.0 30.4	37.0 30.7	33.8 28.1	34.3 28.8
10. One Flygt mixer	75	40.0 40.8	40.0 40.8	37.5 37.7	37.5 37.7
11. Two Flygt Mixers	50	38.1 35.6	38.1 35.6	35.6 32.8	35.9 33.2
12. One Slurry Pump	50	38.0 42.2	39.7 43.7	37.3 41.1	39.7 43.7
13. Three Flygt Mixers	50	38.1 36.2	38.1 36.2	35.8 33.5	36.2 34.0
14. Two Flygt Mixers	75	40.2 41.3	40.2 41.3	37.5 38.1	37.7 38.3
15. One Slurry Pump	75	40.1 47.3	41.2 47.3	38.9 45.6	41.2 47.9
16. Three Flygt Mixers	75	40.2 42.2	40.2 42.2	37.8 39.3	38.2 39.6

Decant

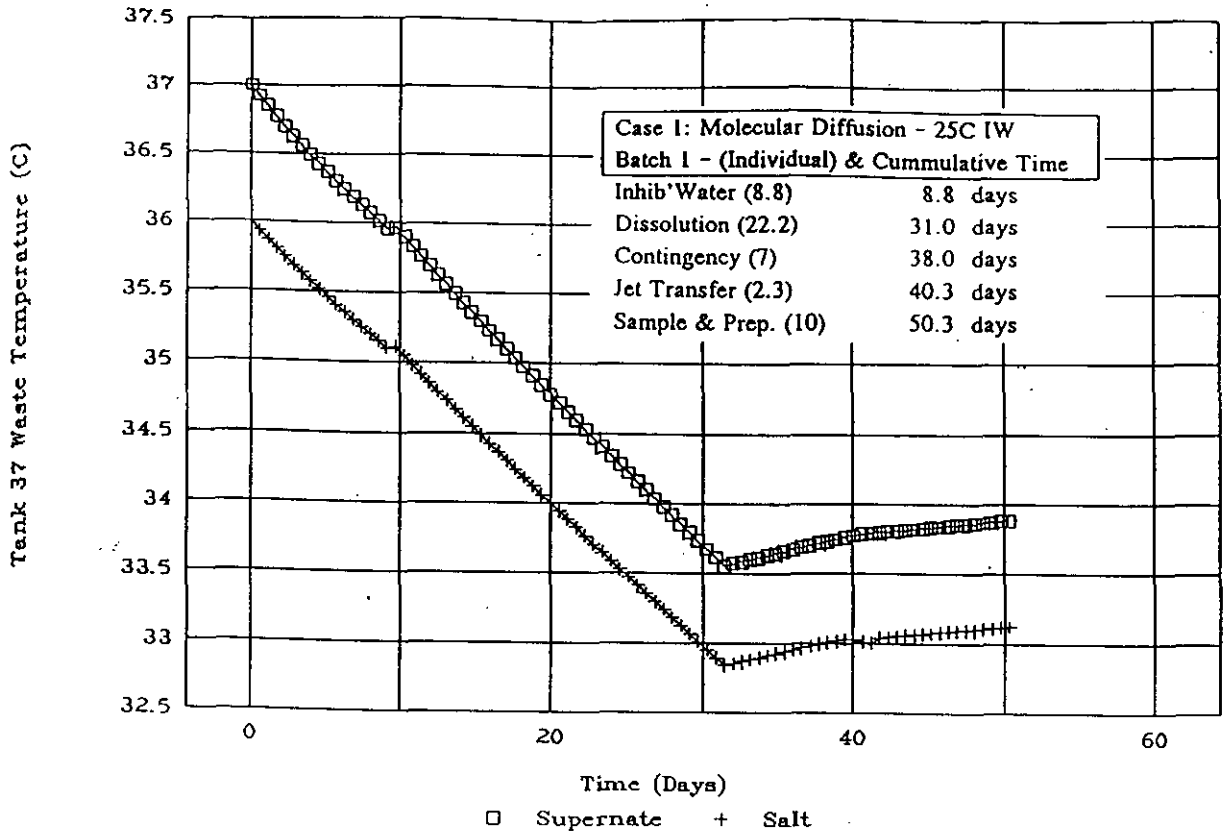
Decant of Existing Supernate from TK 37 to TK 30
Before Batch Dissolution Processses of Tank 37
(Salt Solution to be transferred to TK 26 Later)

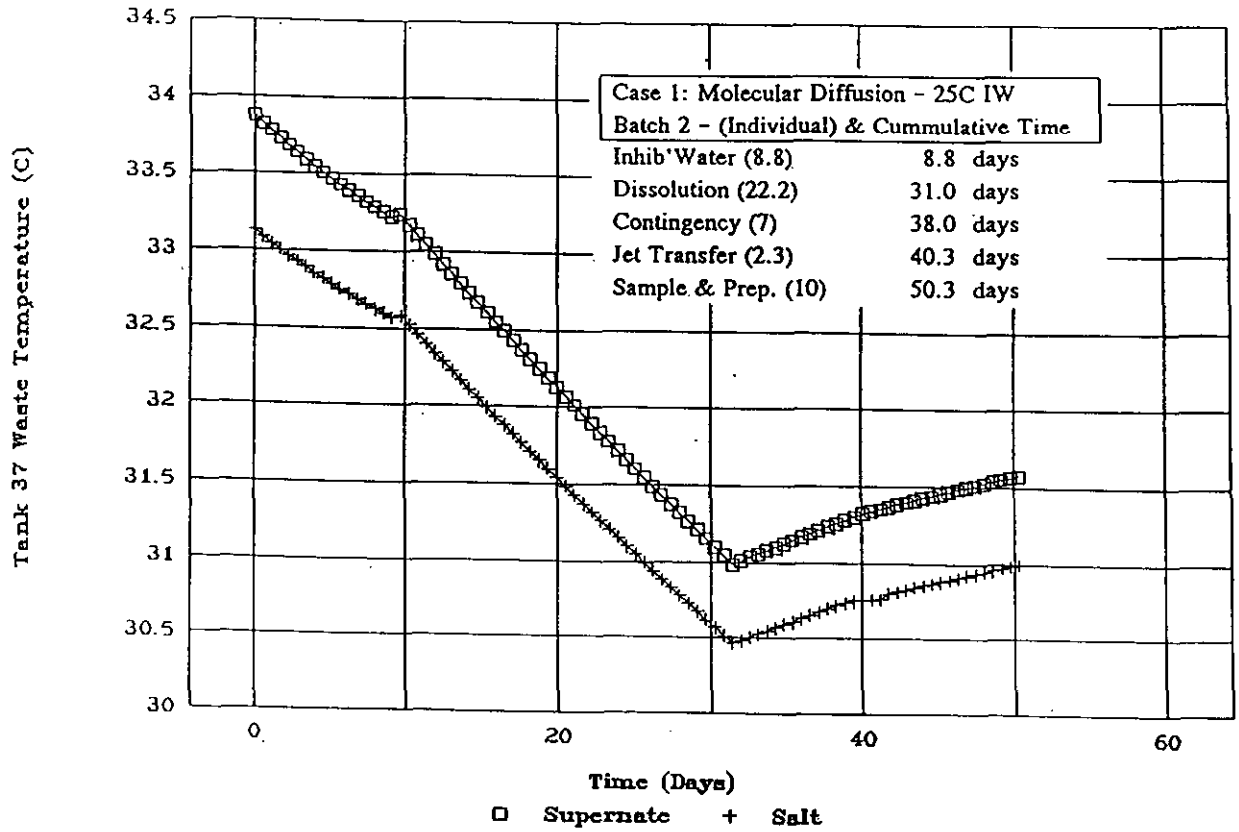


Decant Existing	salt cake + dissolv.	water existing	salt dissolved	total liq or supernate	crystallized salt cake	total content
depth (in)	293.53	57.66	24.03	81.69	269.50	351.0
gallons	1030278	202399	84333	286732	945945	1232010
%	83.6%	16.4%	6.8%	23.3%	76.8%	100.0%
net hours		0.0	0.0	77.7	transfer	batch total (days)

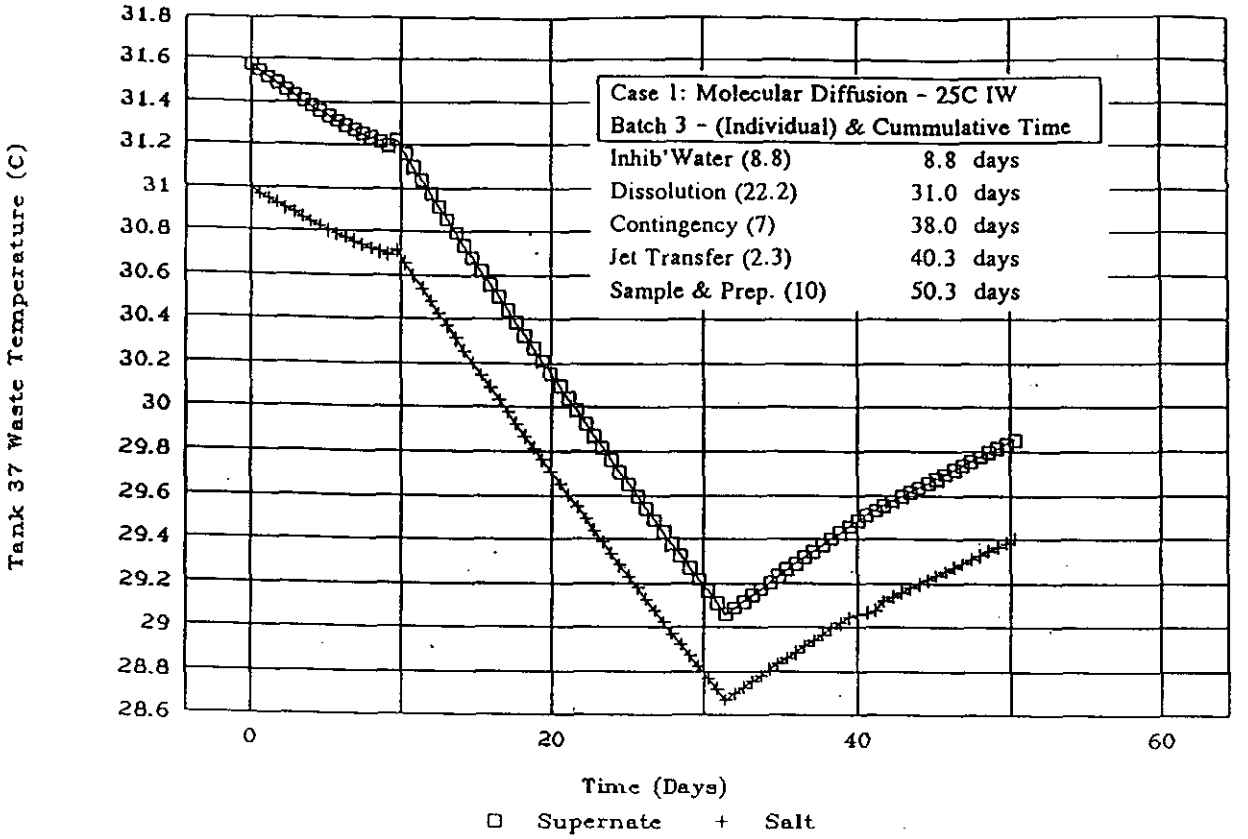
Step	Hours
Inhib'Water	0.0
Dissolution	0.0
ExtraMixing	0.0
Jet Transfer	77.7
Sampl&Prep.	240.0
	13.2

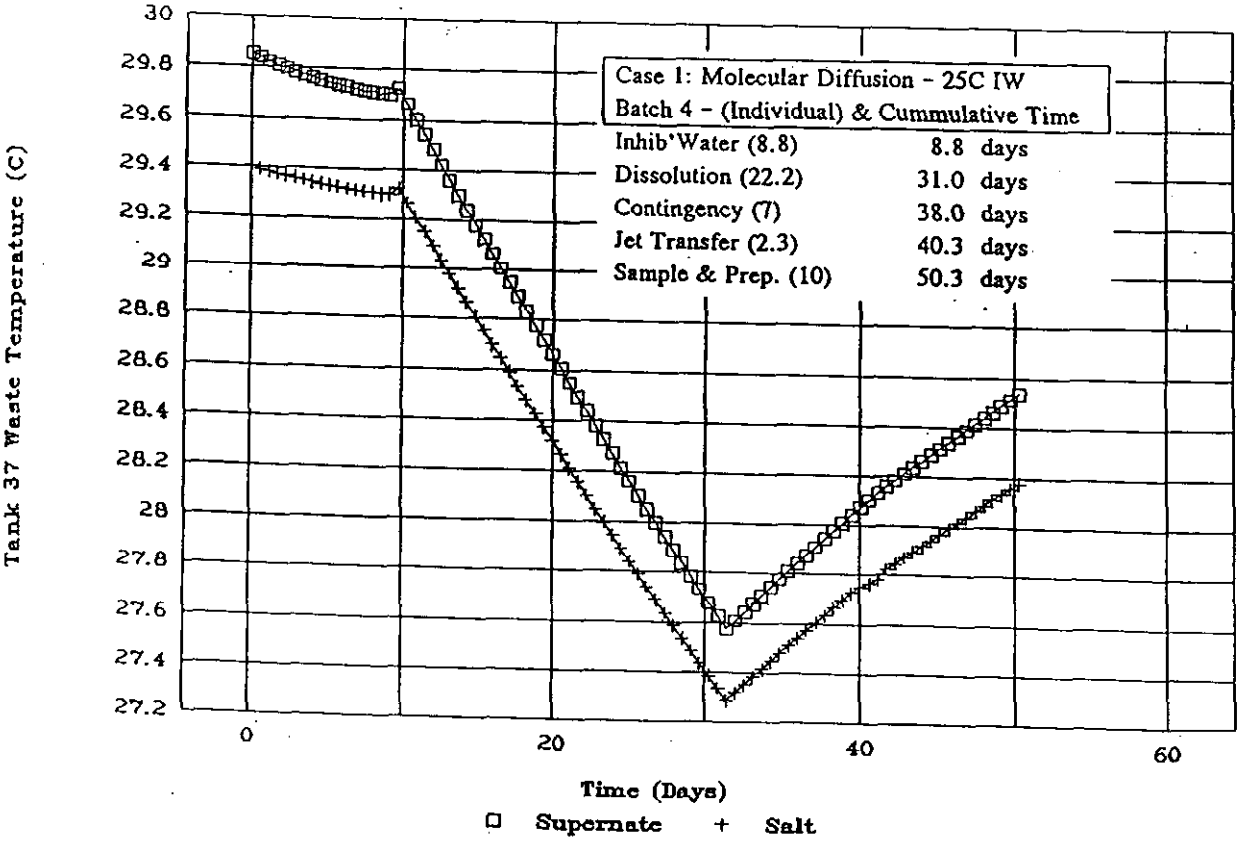
Case 1: No Agitation with 25C IW (Batch 1-2)



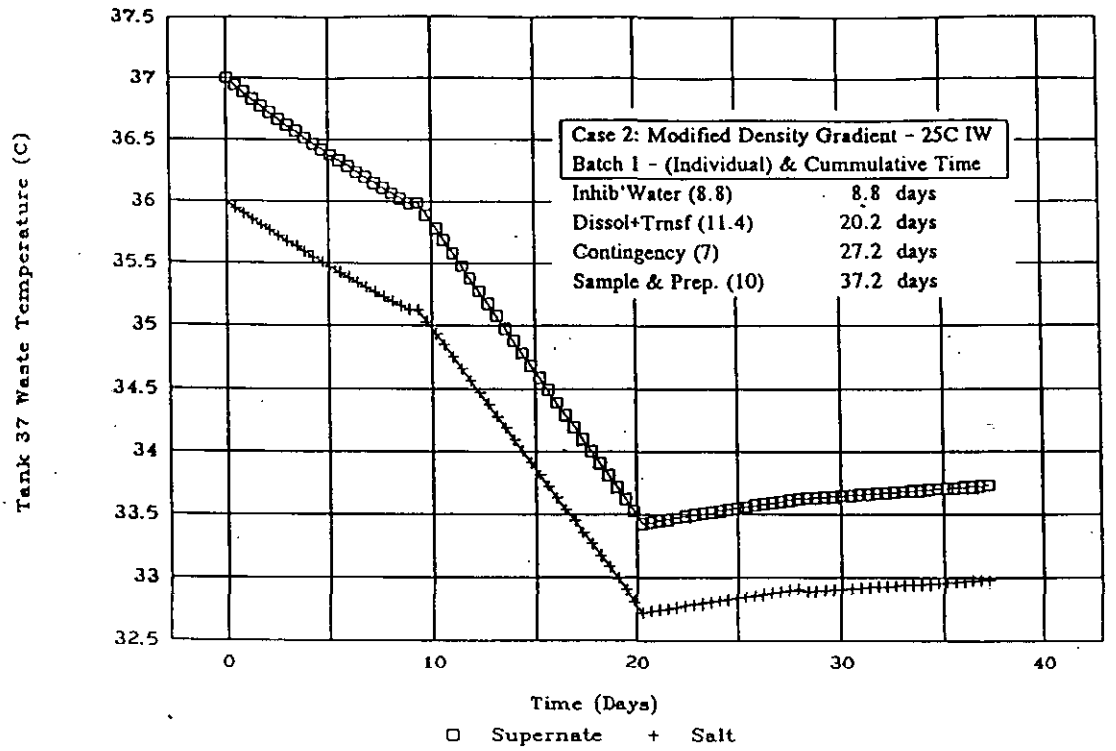


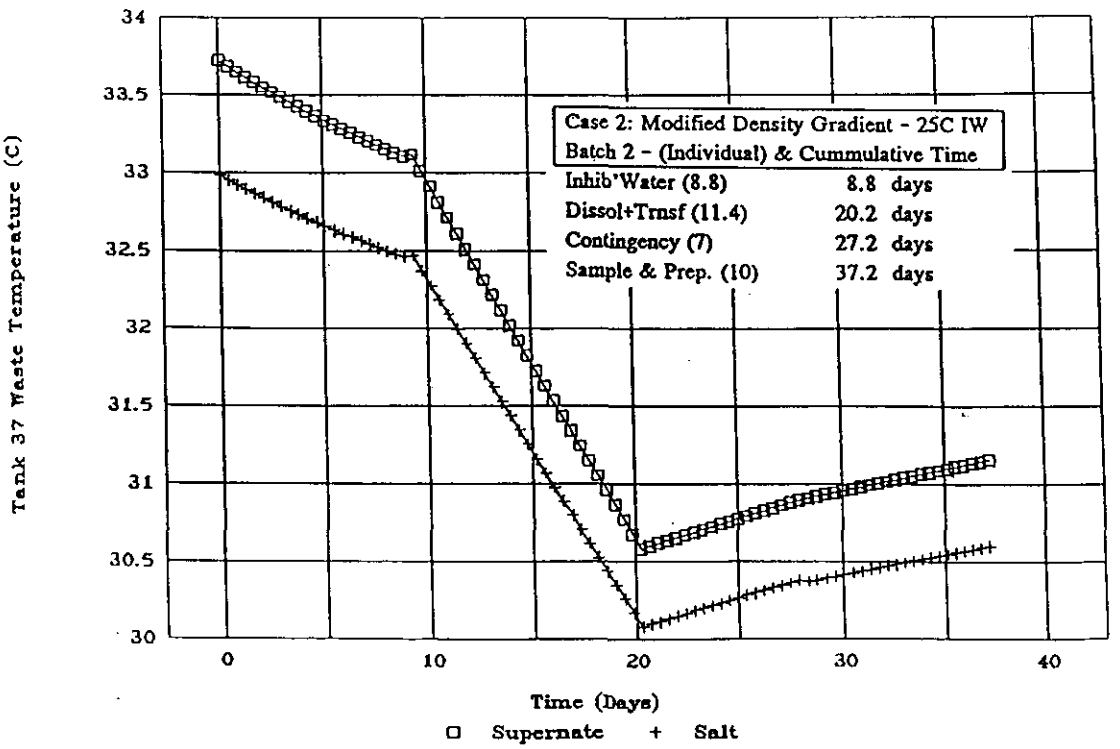
Case 1: No Agitation with 25C IW (Batch 3-4)



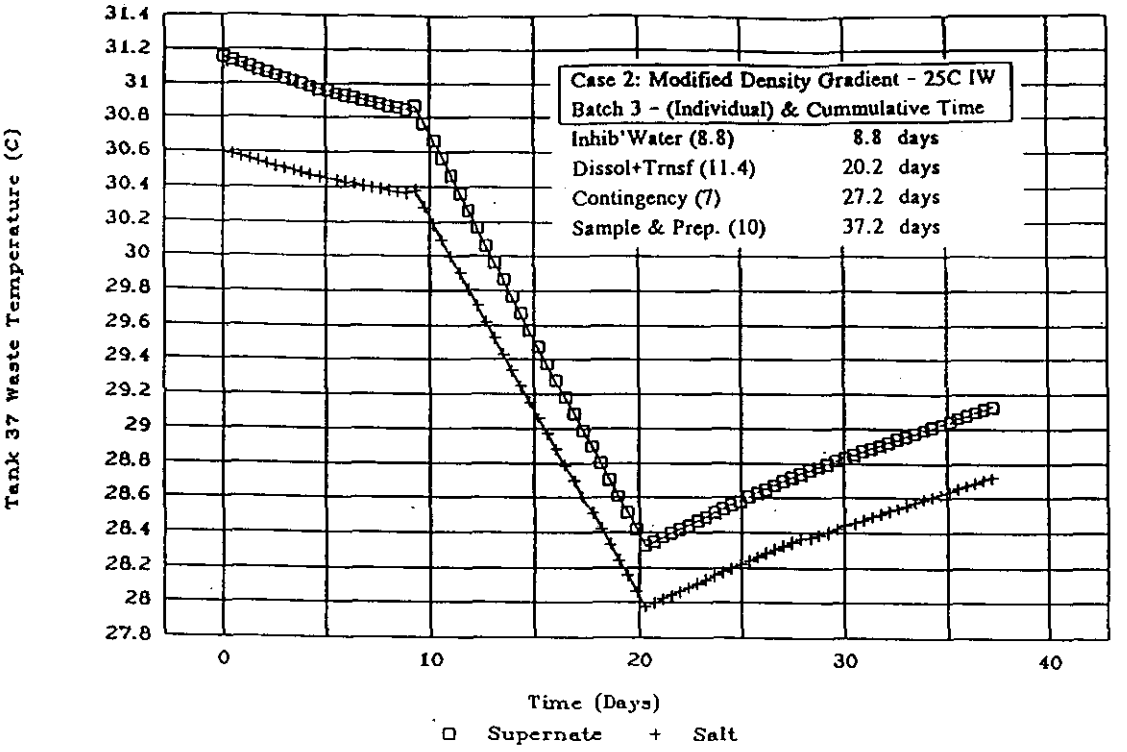


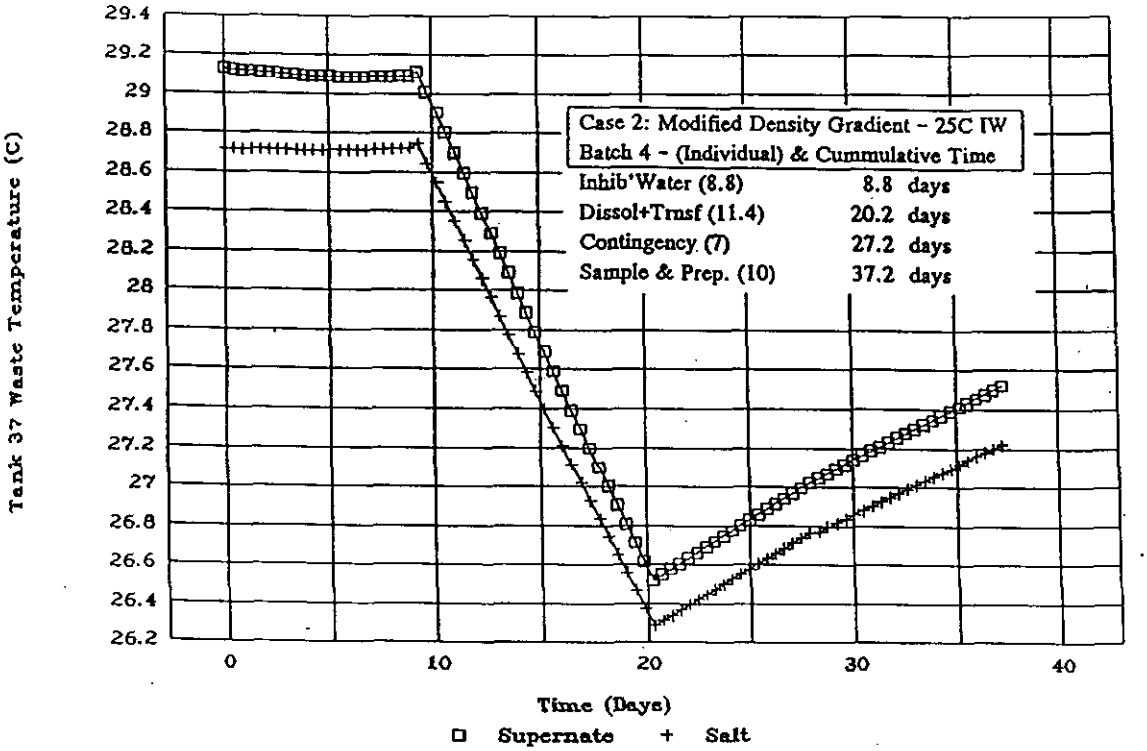
Case 2: Modified Density Gradient (Batch 1-2)



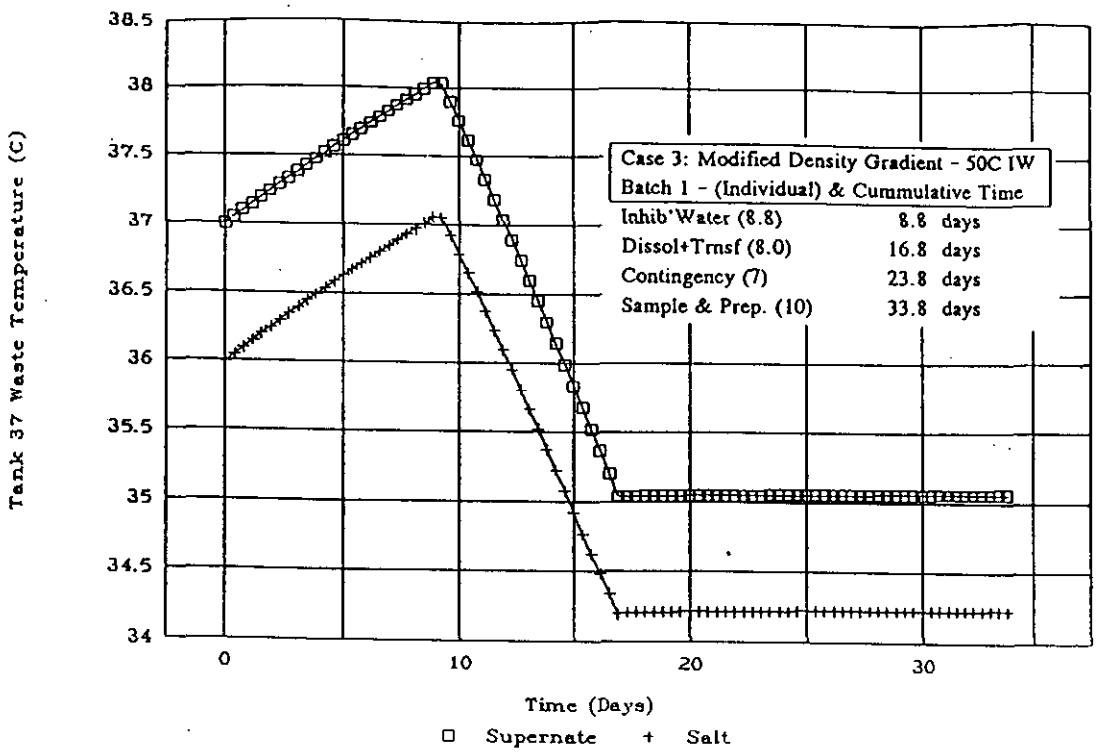


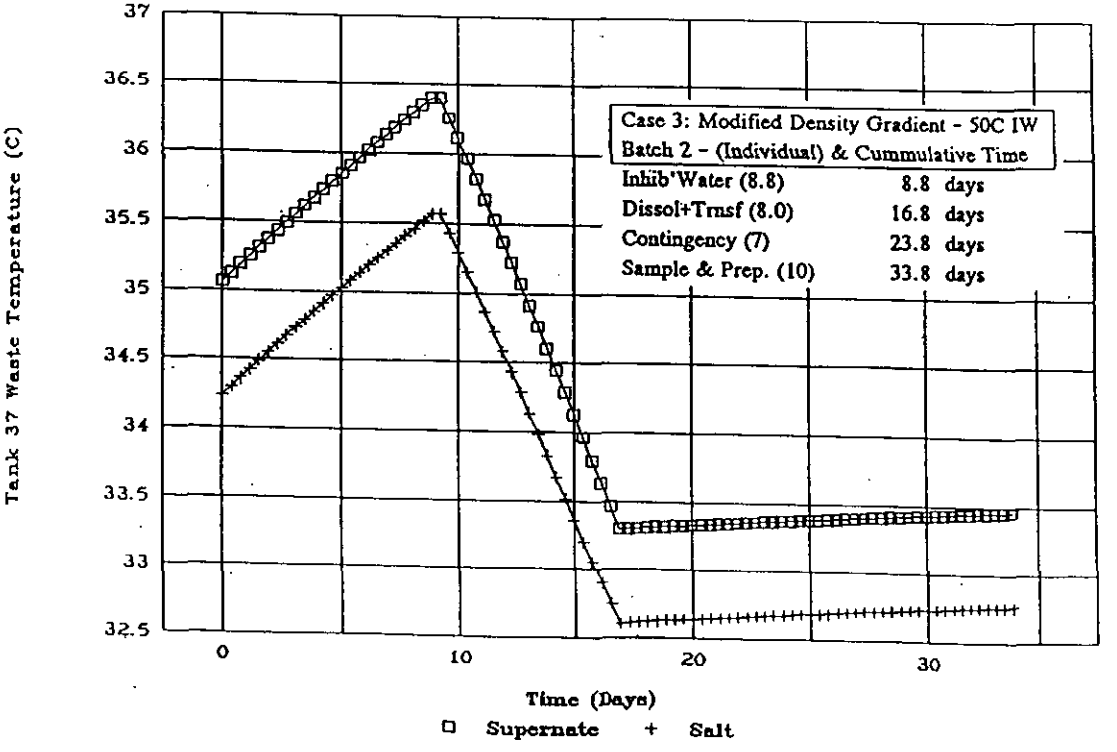
Case 2: Modified Density Gradient (Batch 3-4)



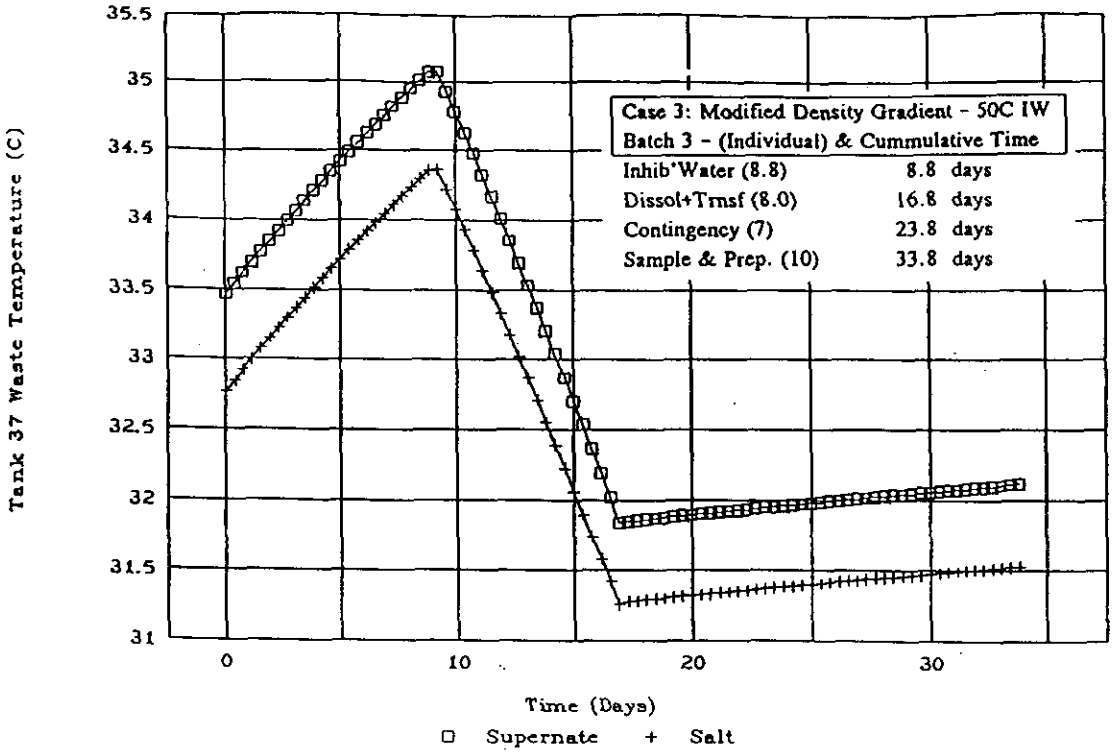


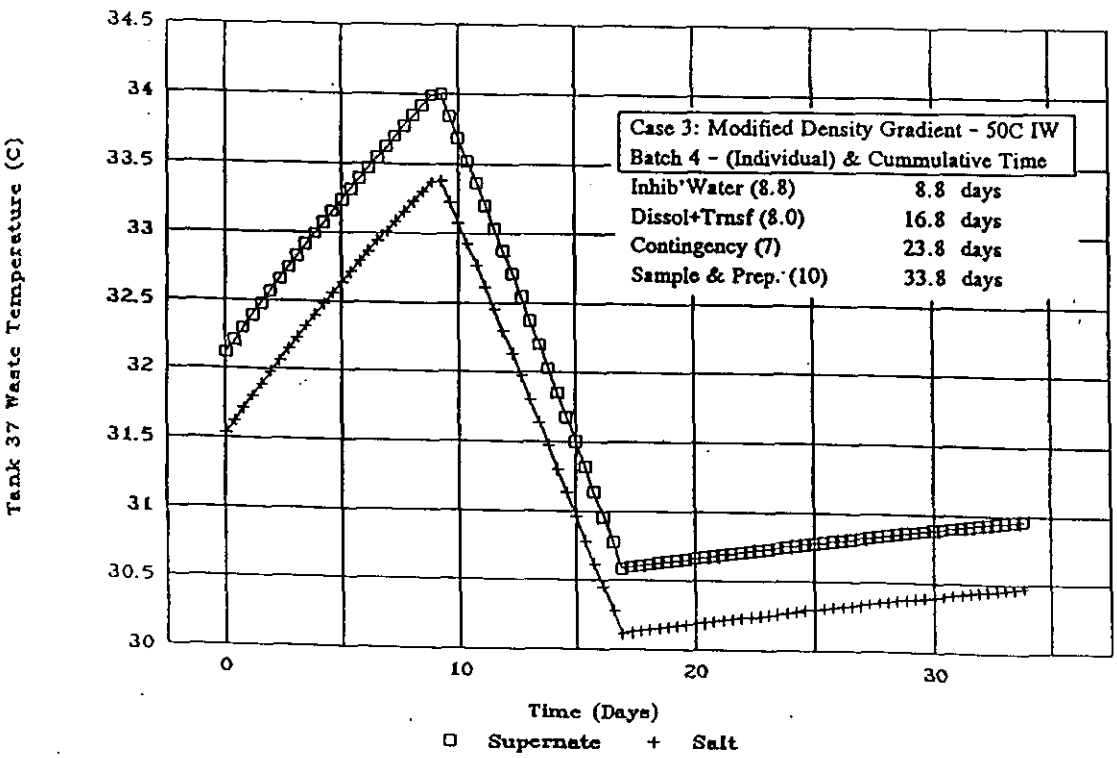
Case 3: Modified Density Gradient-50C IW (Batch 1-2)



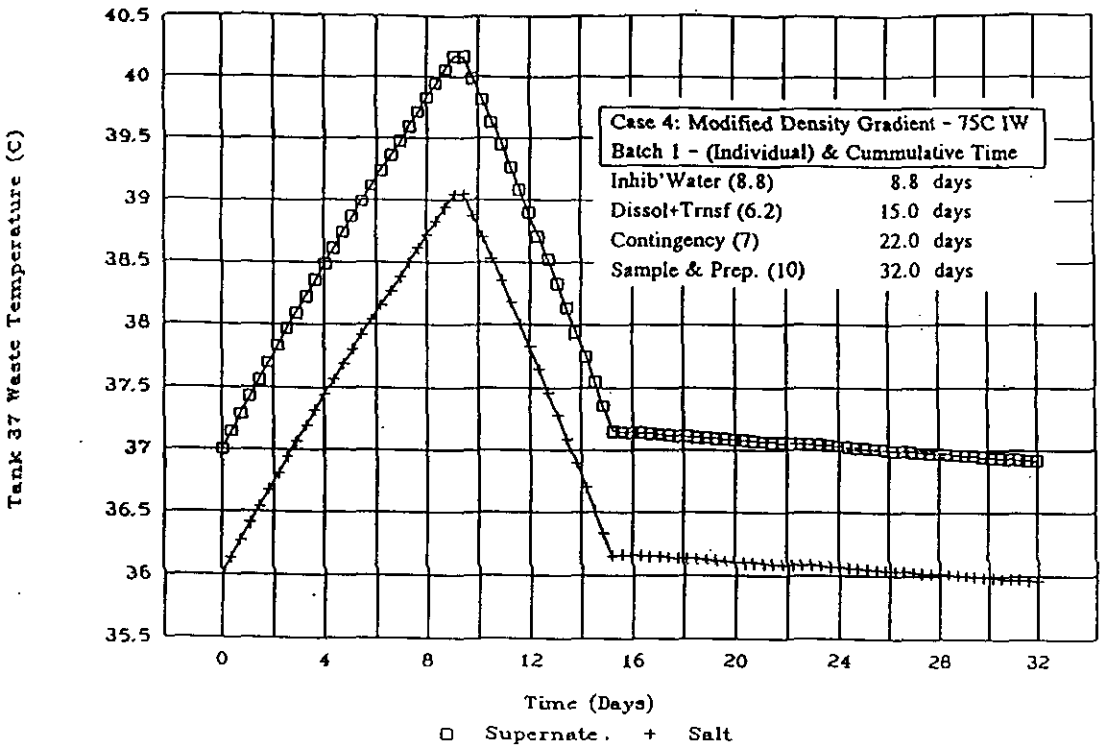


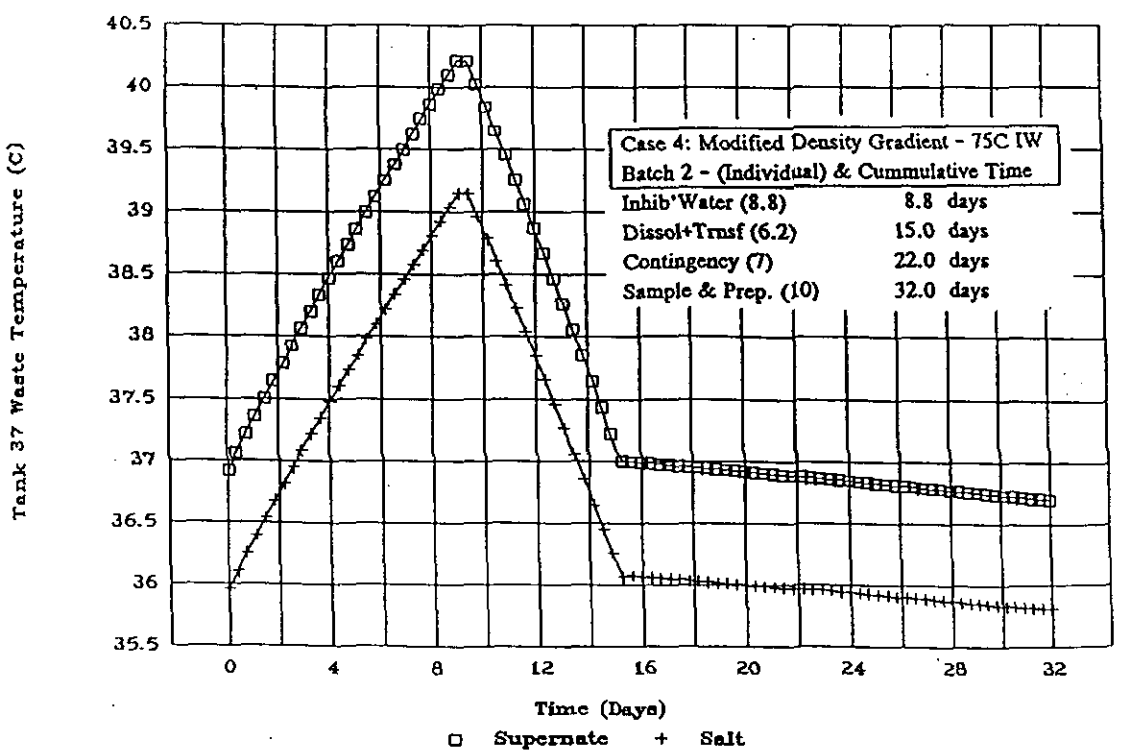
Case 3: Modified Density Gradient-50C IW (Batch 3-4)



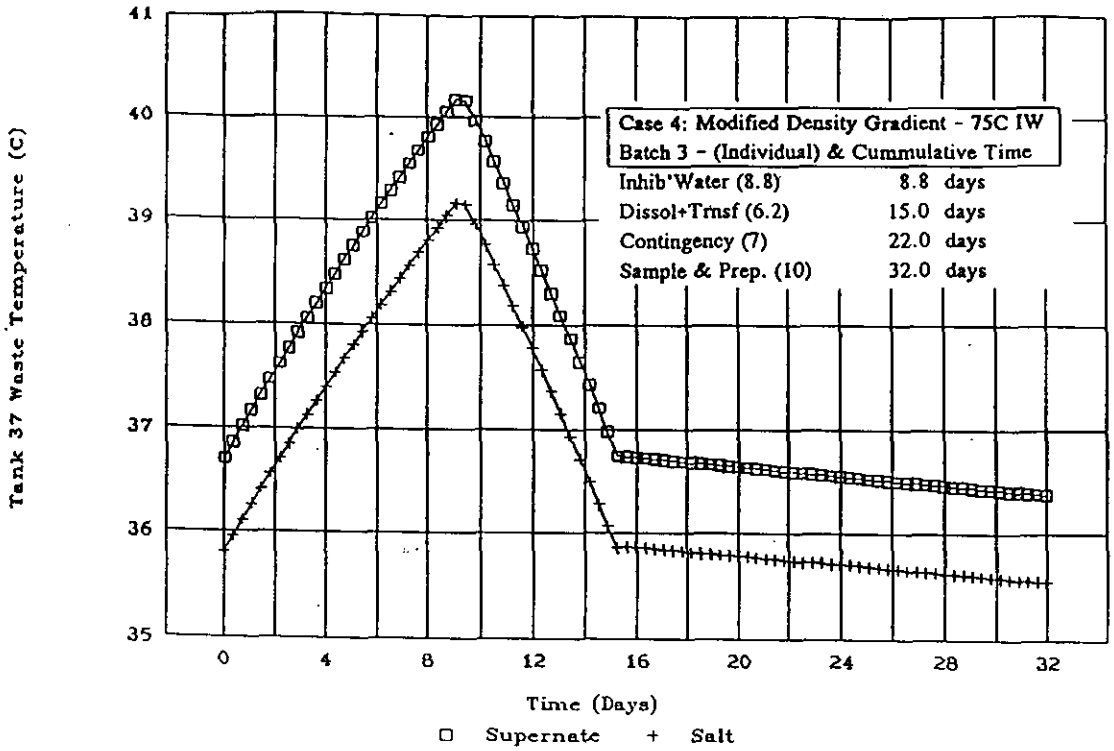


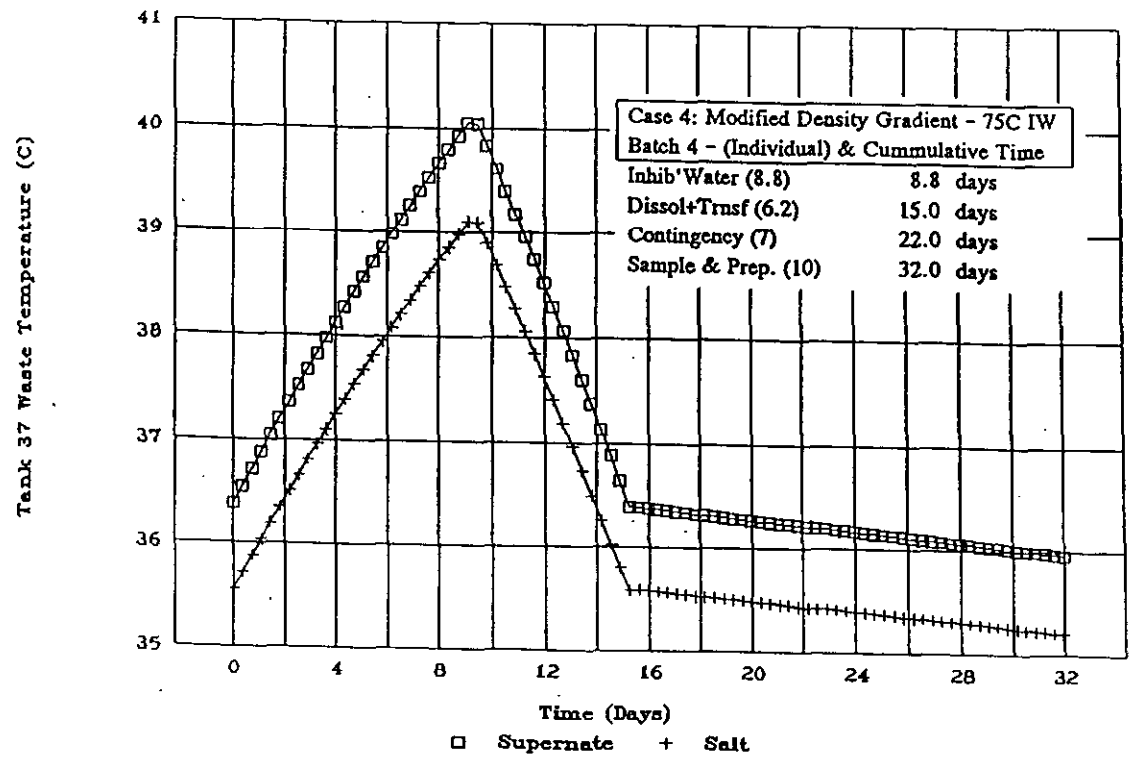
Case 4: Modified Density Gradient-75C IW (Batch 1-2)



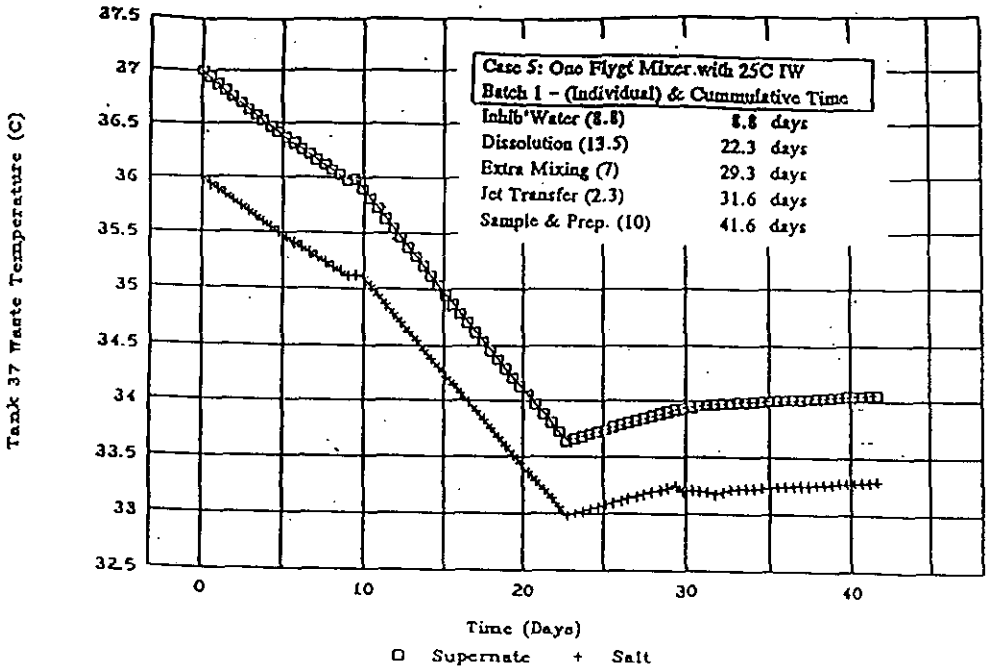


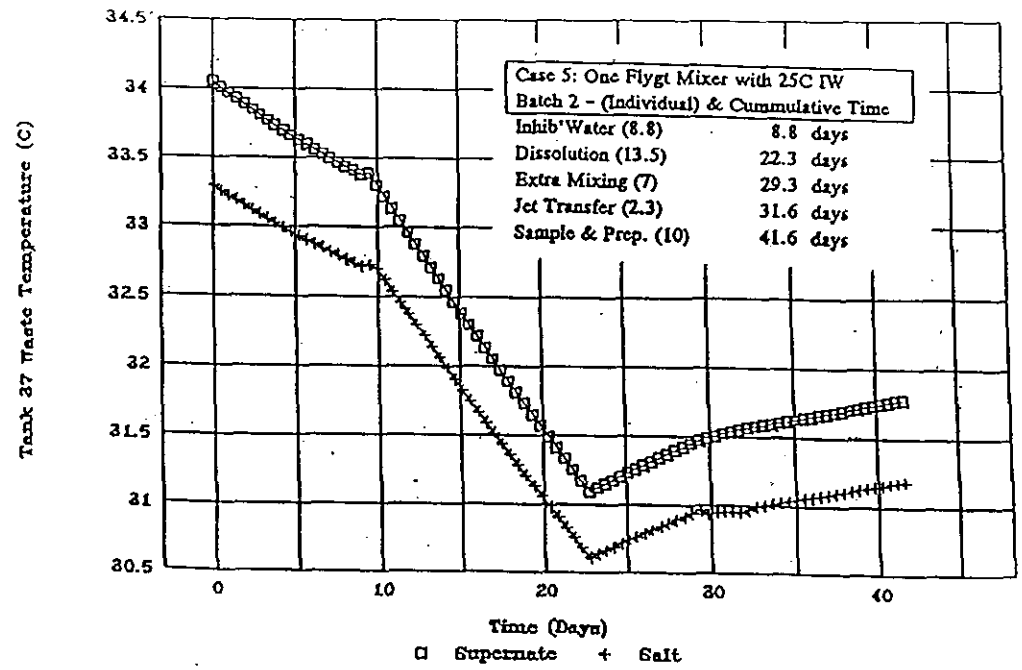
Case 4: Modified Density Gradient-75C IW (Batch 3-4)



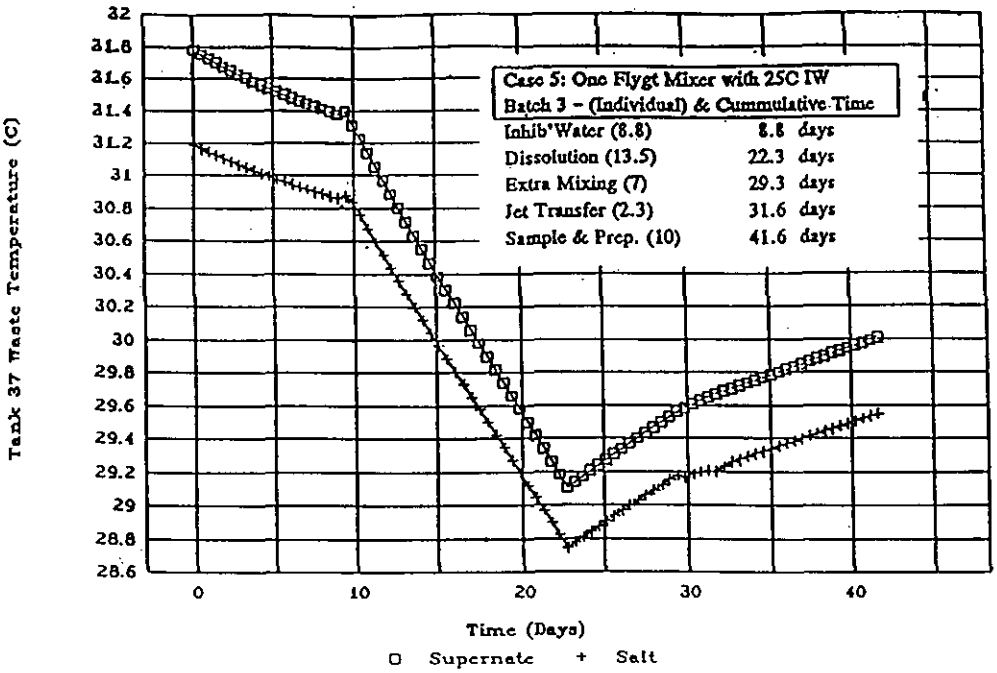


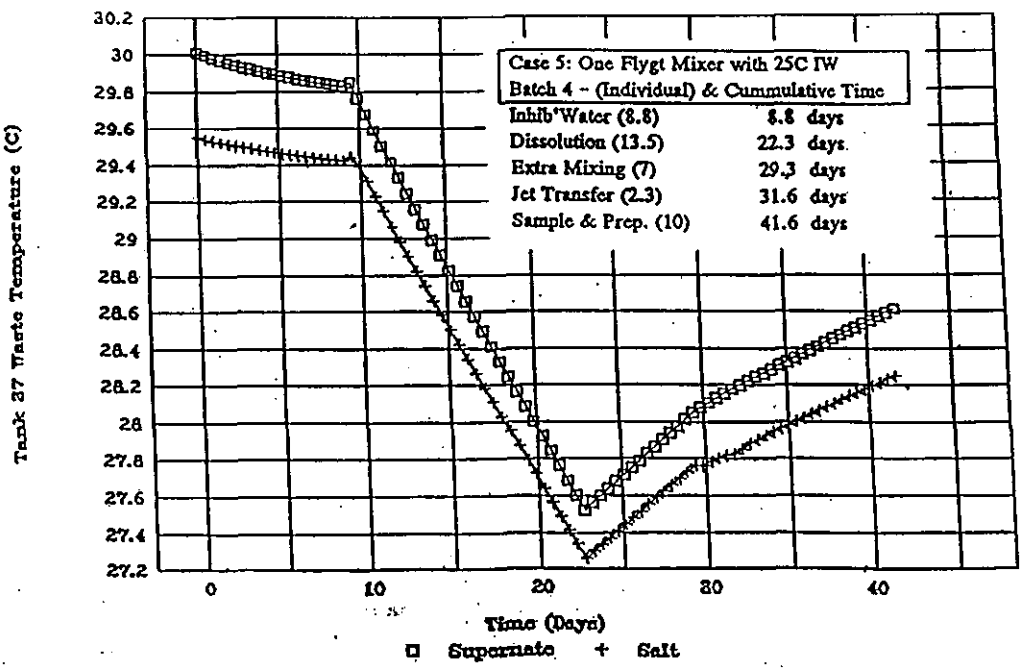
Case 5: One Flygt Mixer with 25C IW (Batch 1-2)



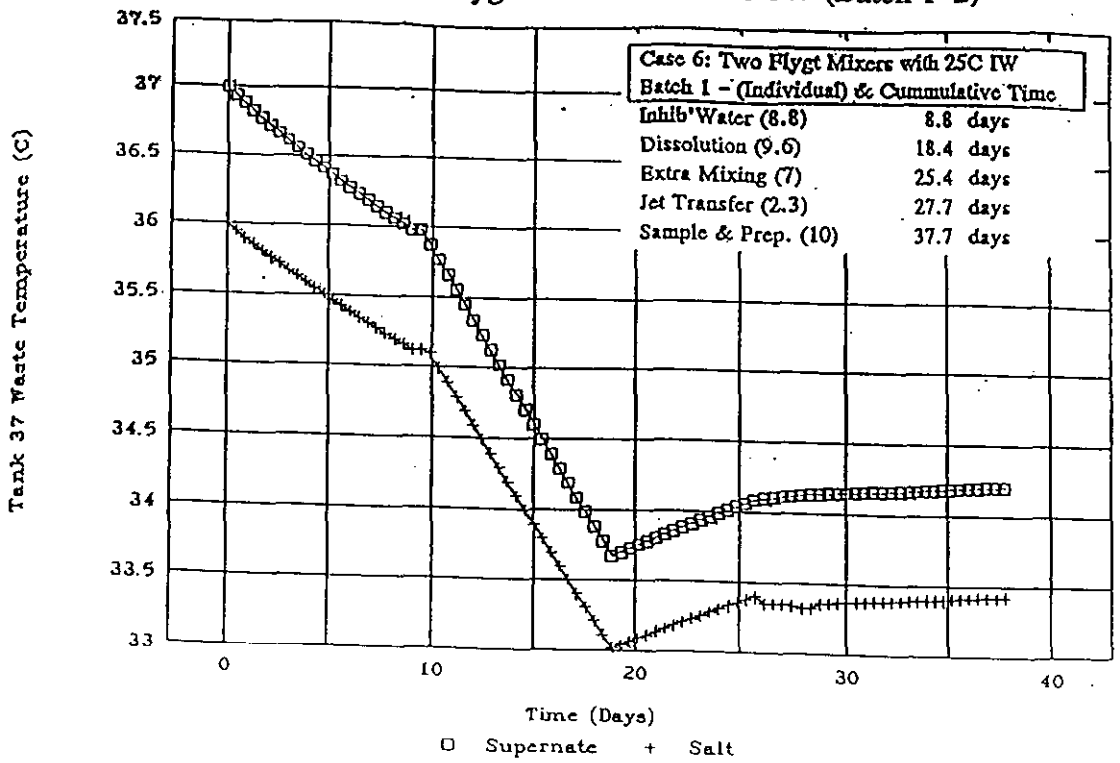


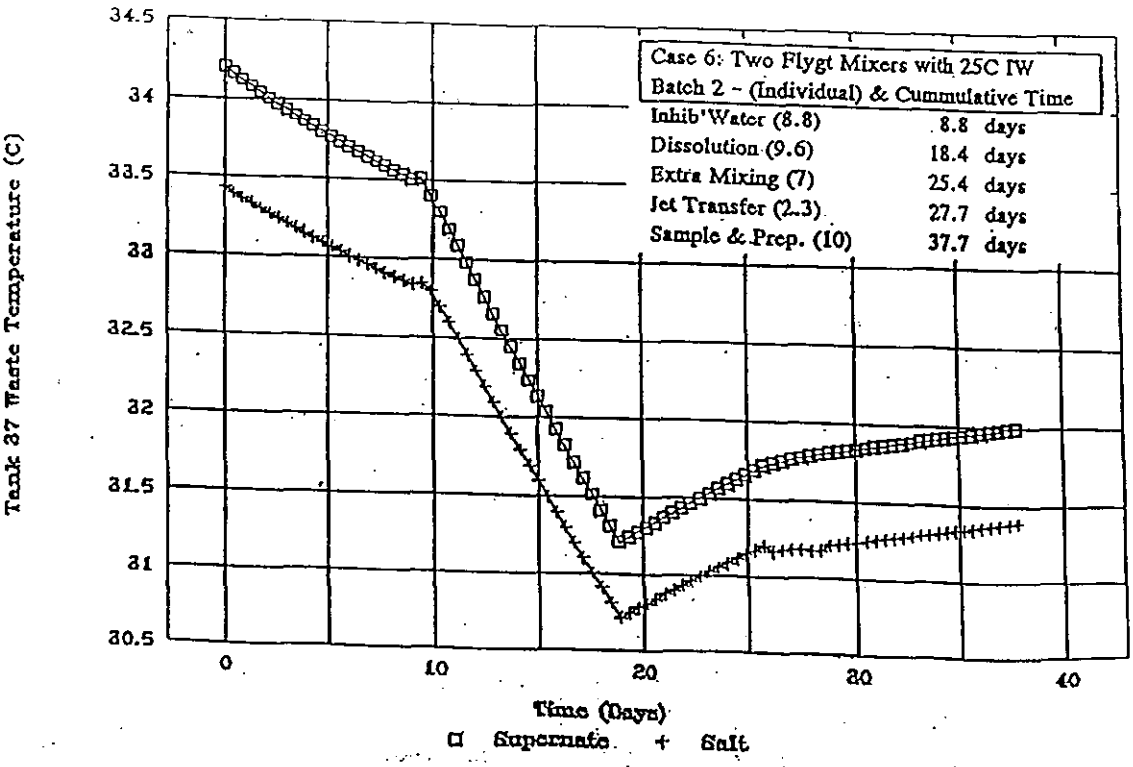
Case 5: One Flygt Mixer with 25C IW (BATCH 3-4)



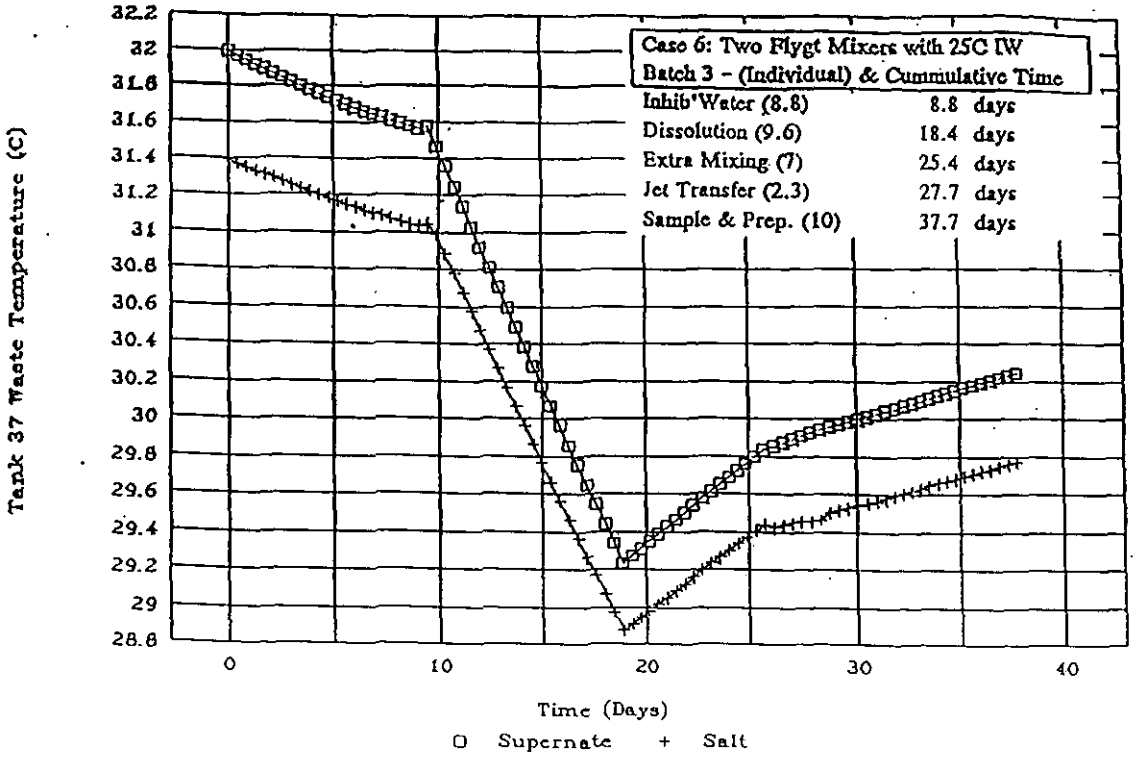


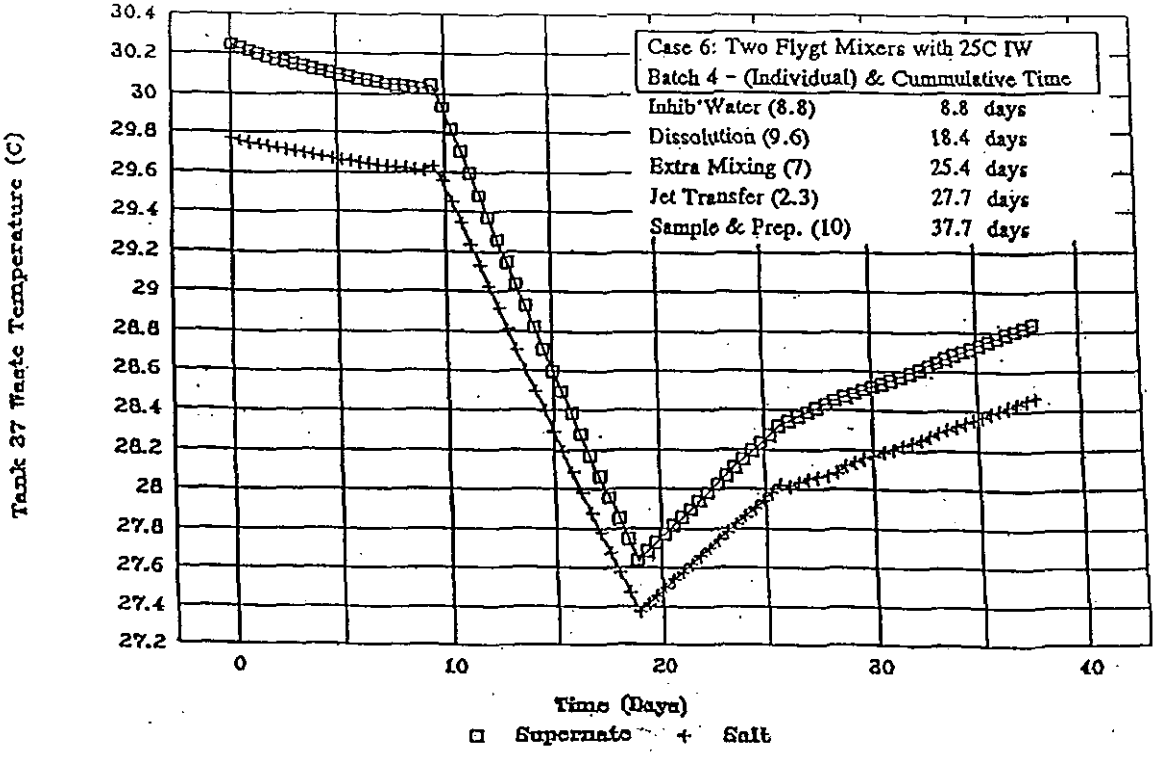
Case 6: Two Flygt Mixers with 25C IW (Batch 1-2)



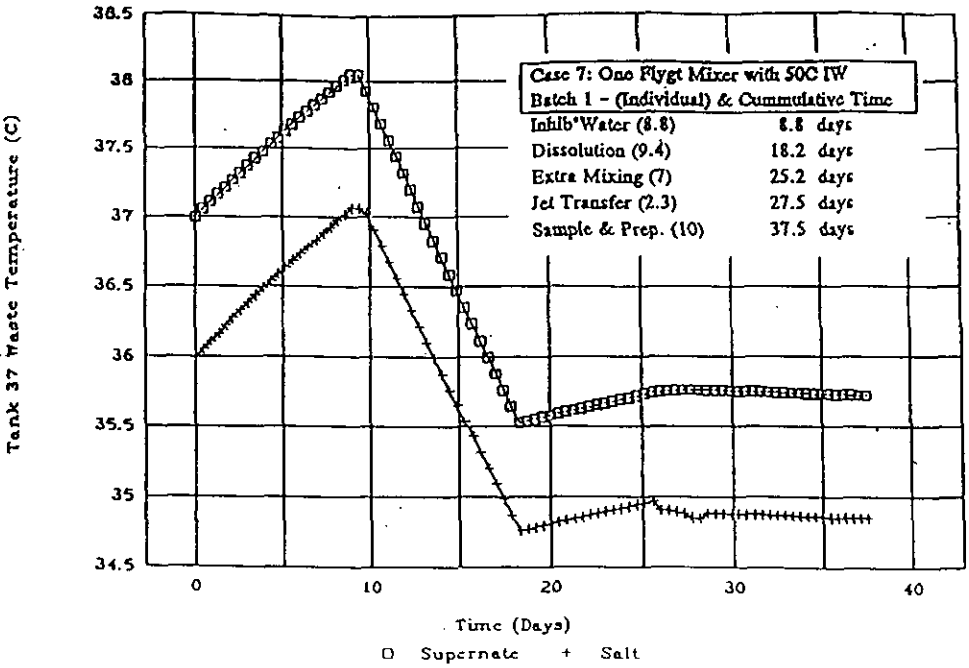


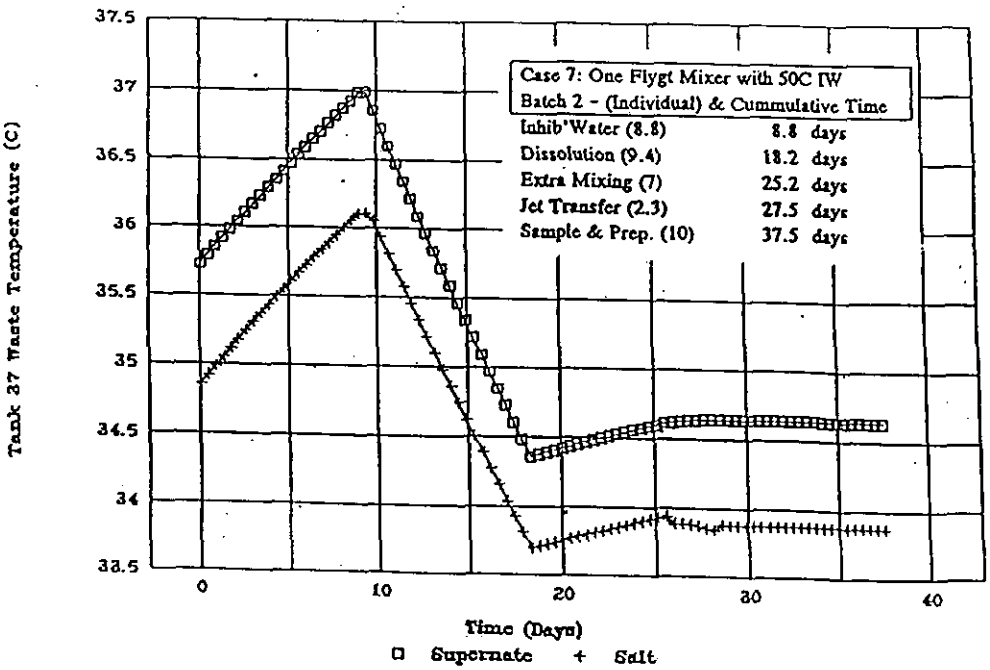
Case 6: Two Flygt Mixers with 25C IW (Batch 3-4)



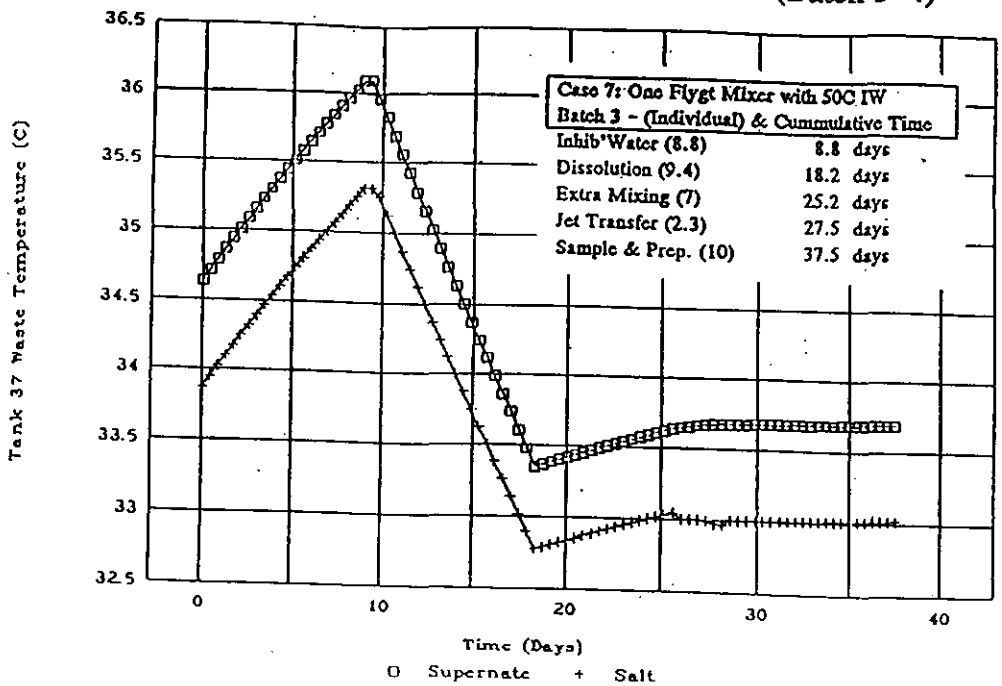


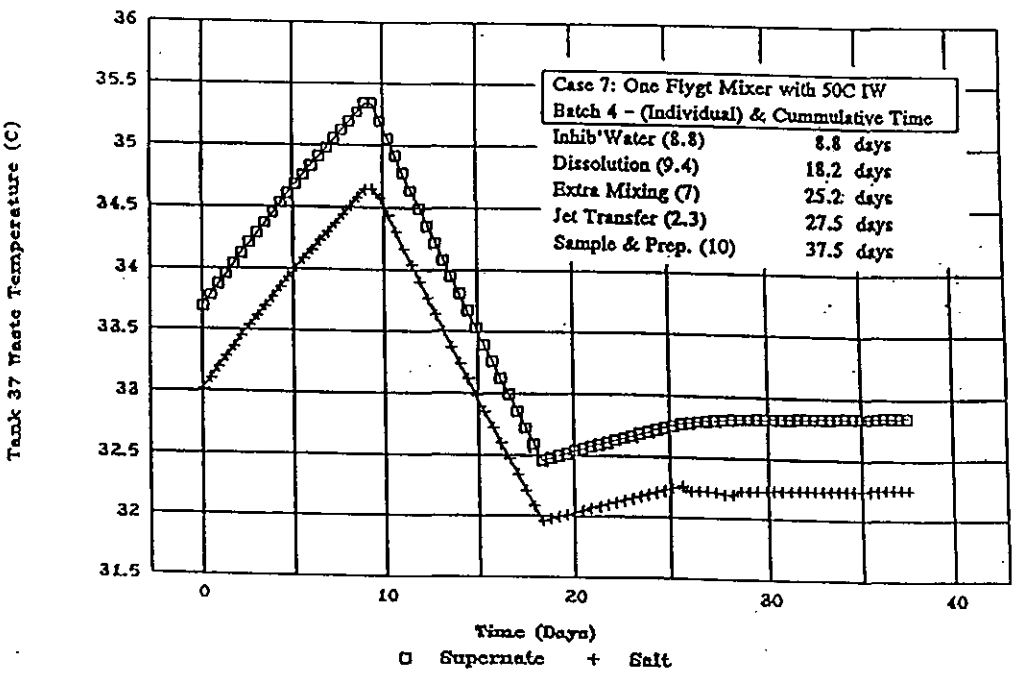
Case 7: One Flygt Mixer with 50C IW (Batch 1-2)



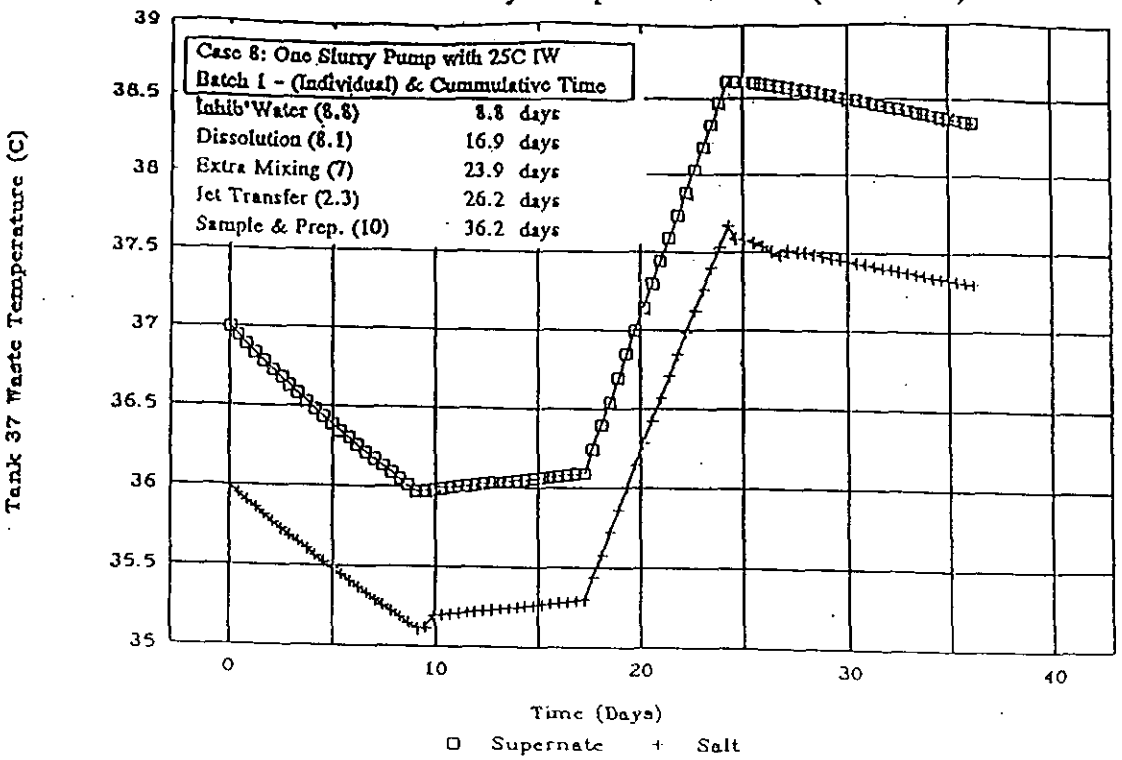


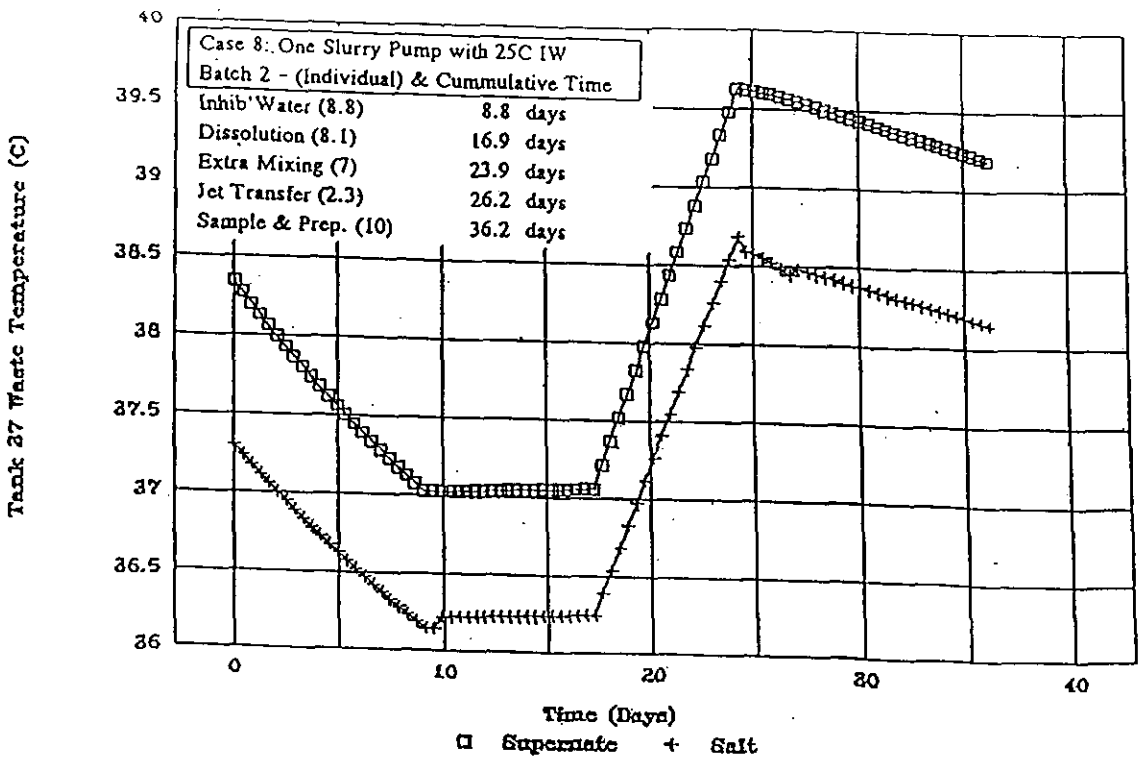
Case 7: One Flygt Mixer with 50C IW (Batch 3-4)



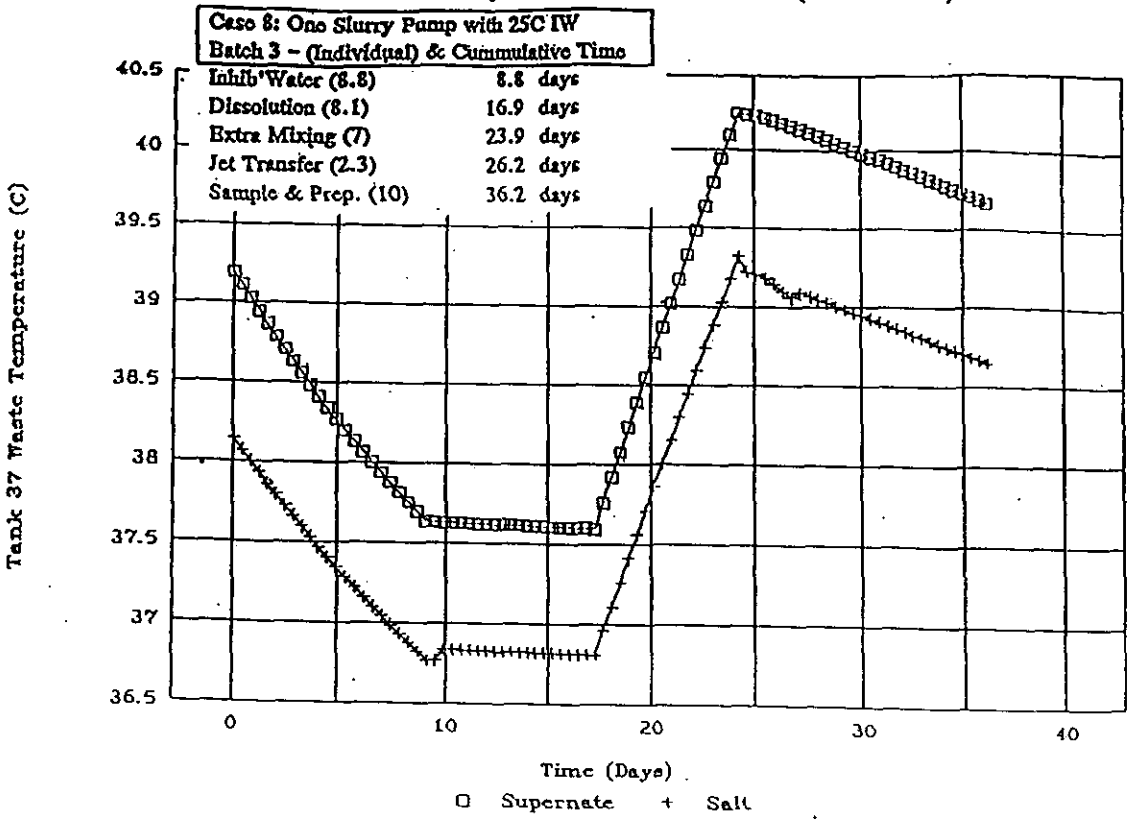


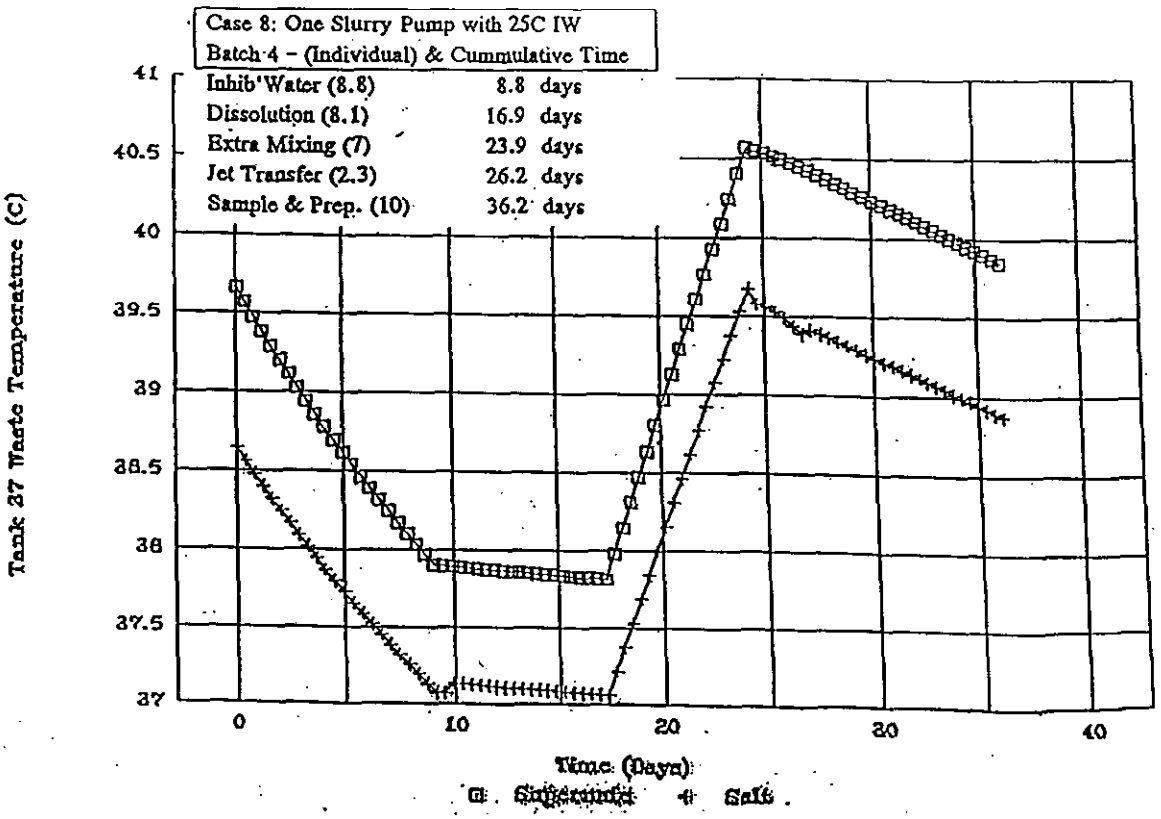
Case 8: One Slurry Pump with 25C IW (Batch 1-2)



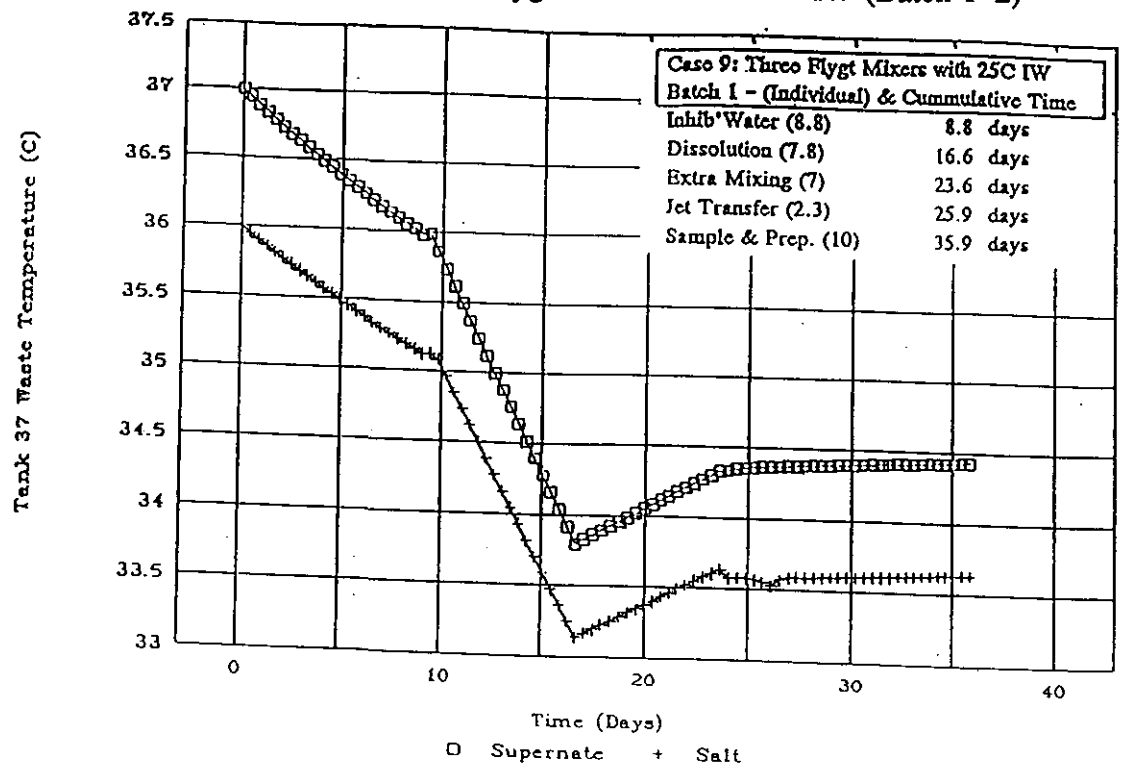


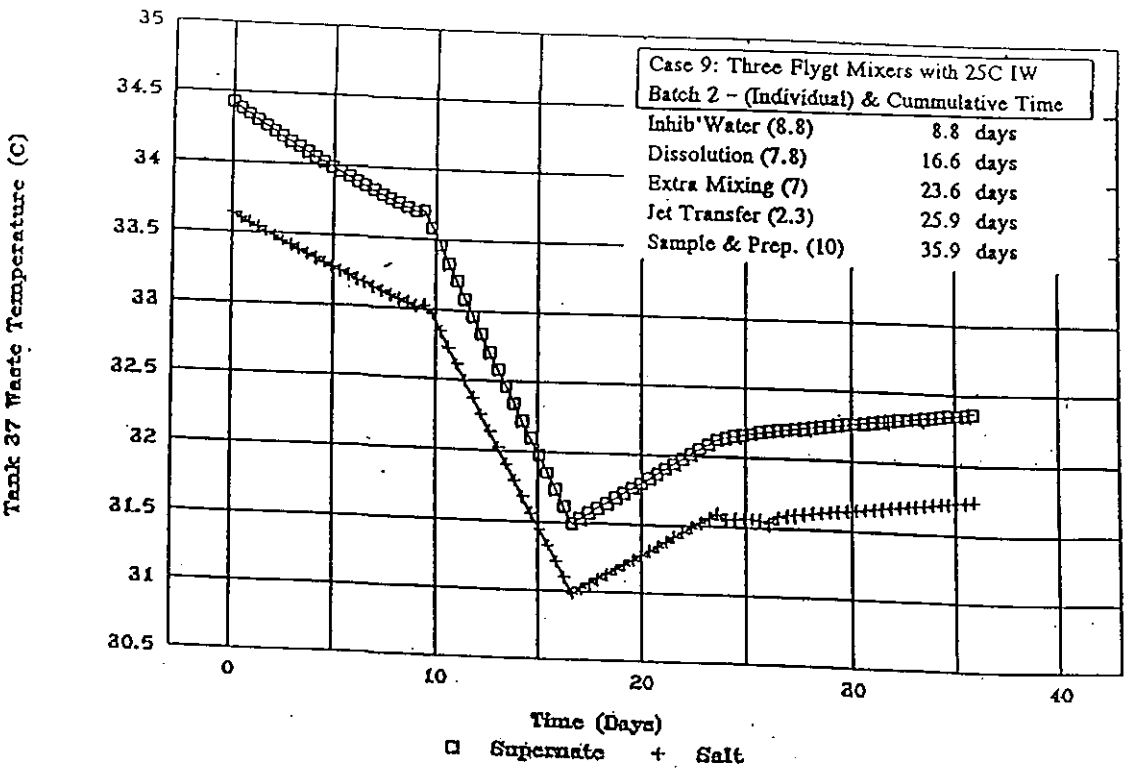
Case 8: One Slurry Pump with 25C IW (Batch 3-4)



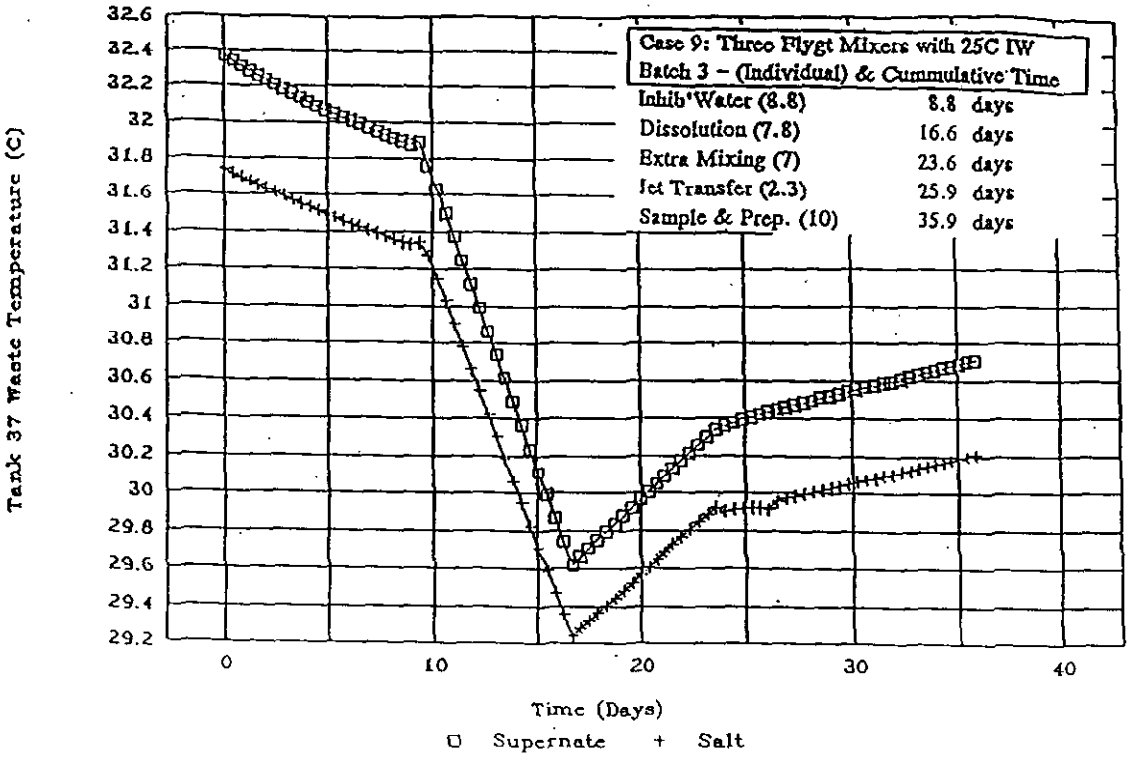


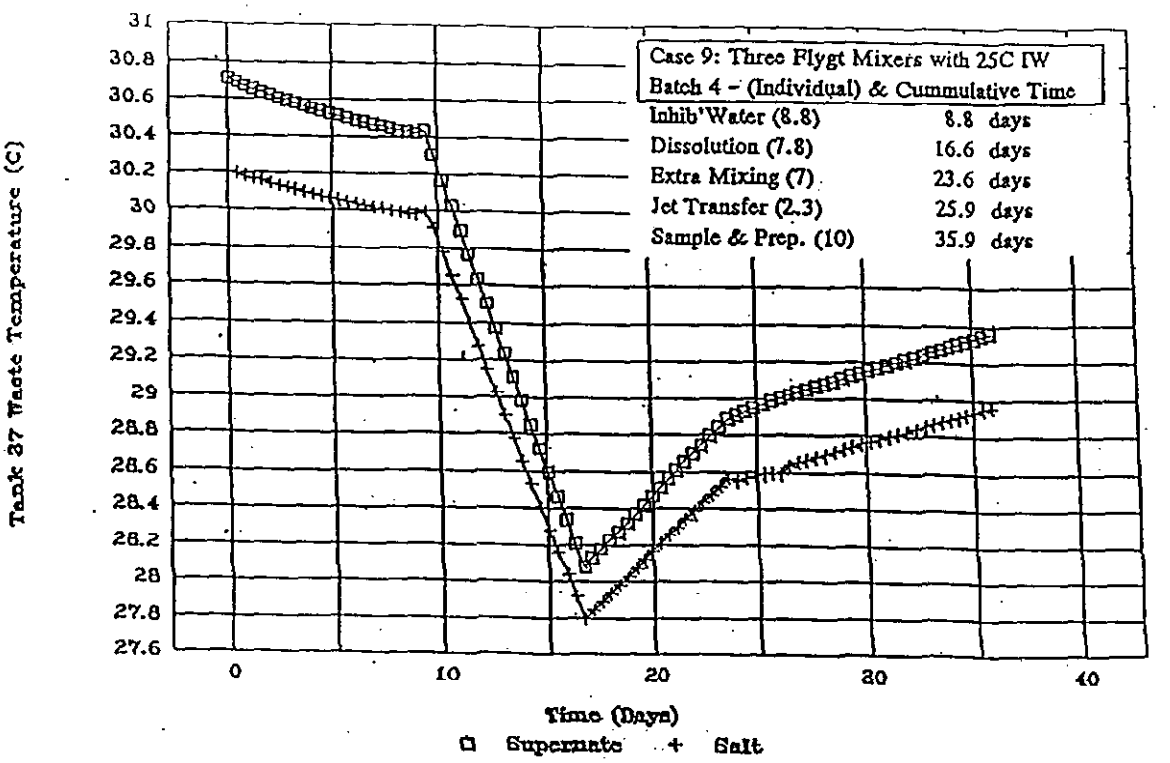
Case 9: Three Flygt Mixers with 25C IW (Batch 1-2)



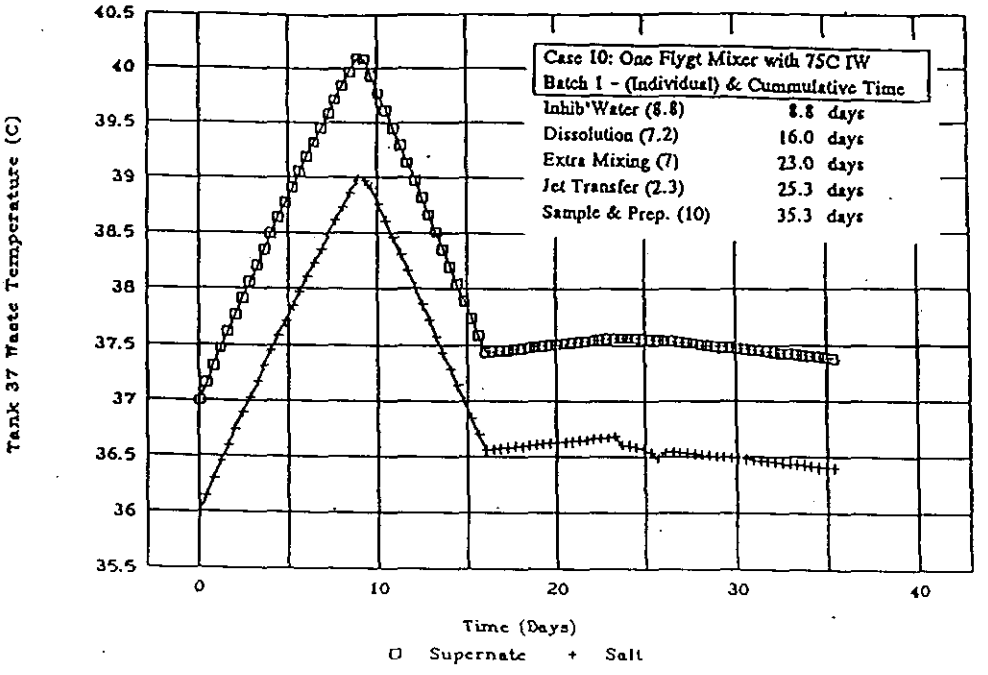


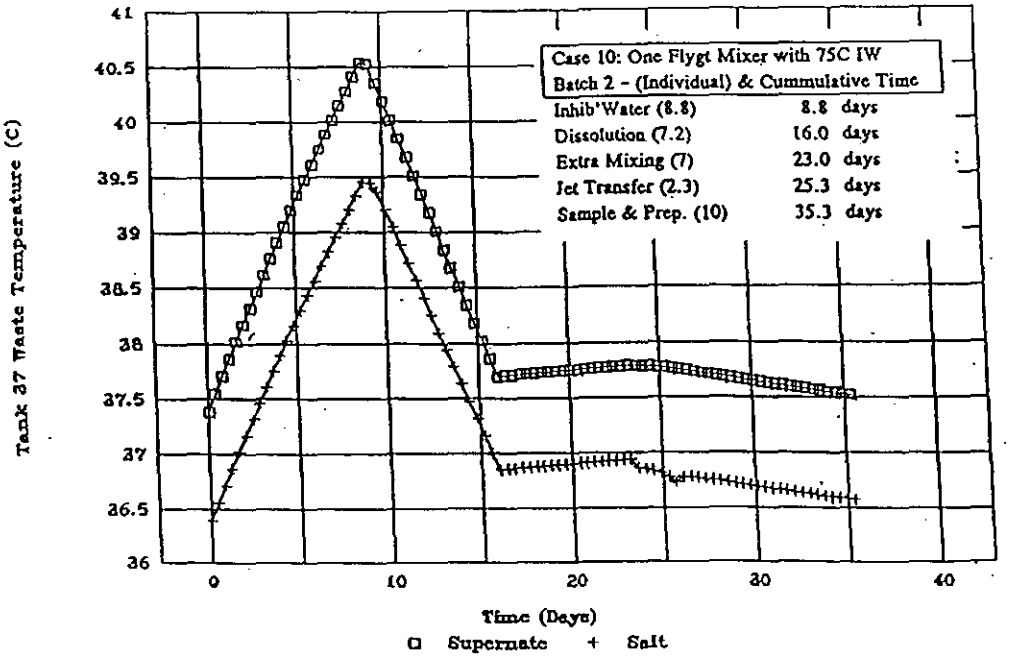
Case 9: Three Flygt Mixers with 25C IW (Batch 3-4)



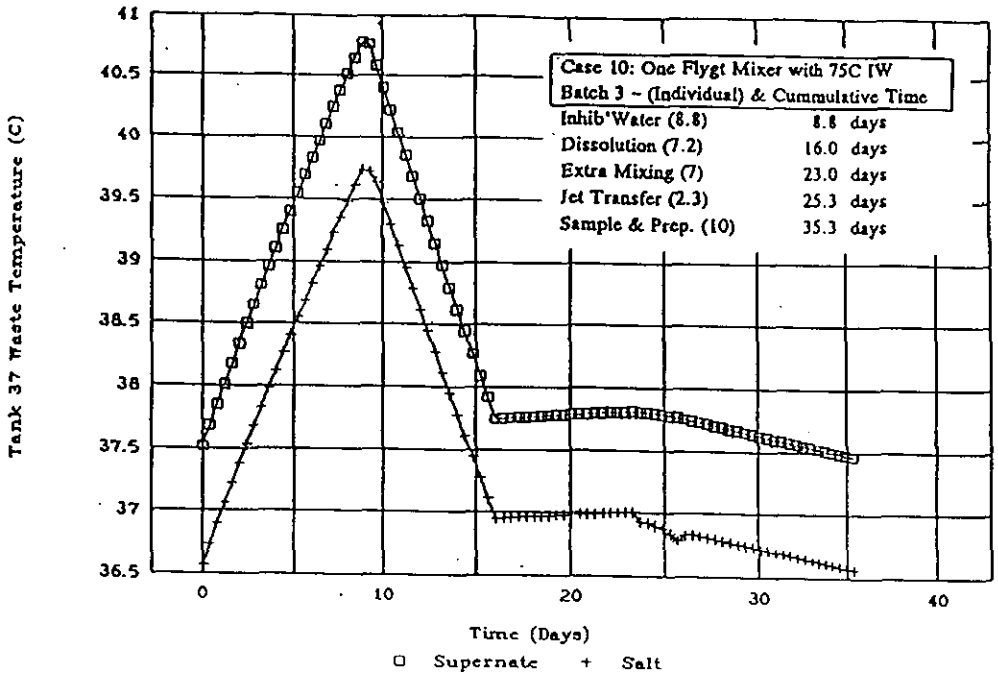


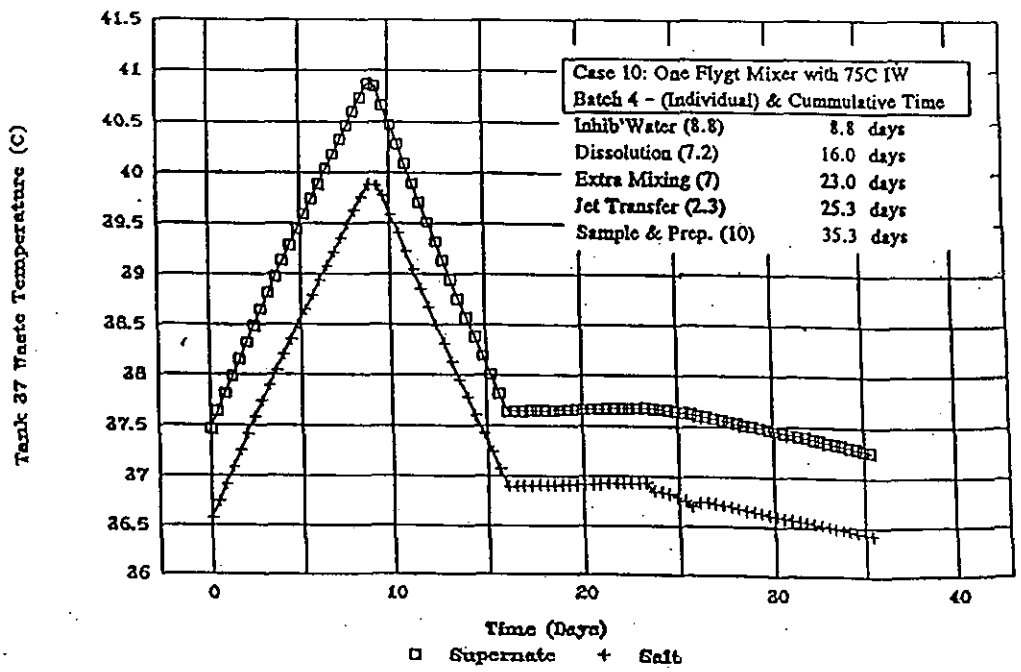
Case 10: One Flygt Mixer with 75C IW (Batch 1-2)



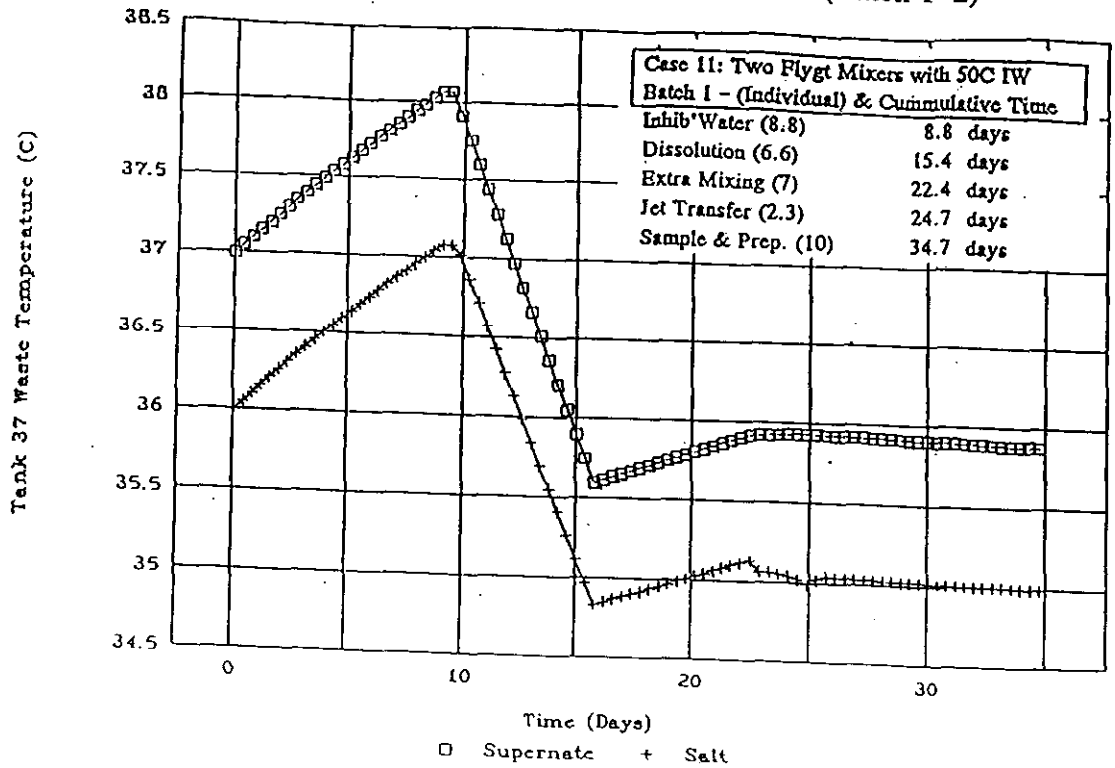


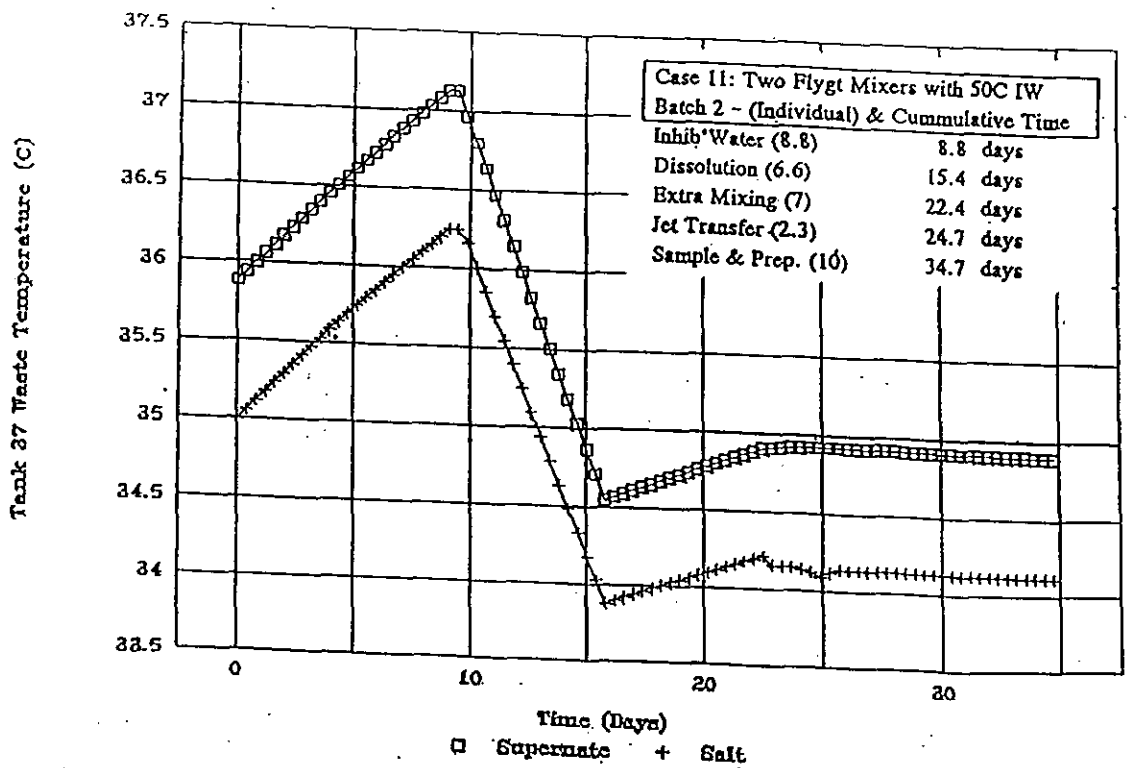
Case 10 One Flygt Mixer with 75C IW (Batch 3-4)



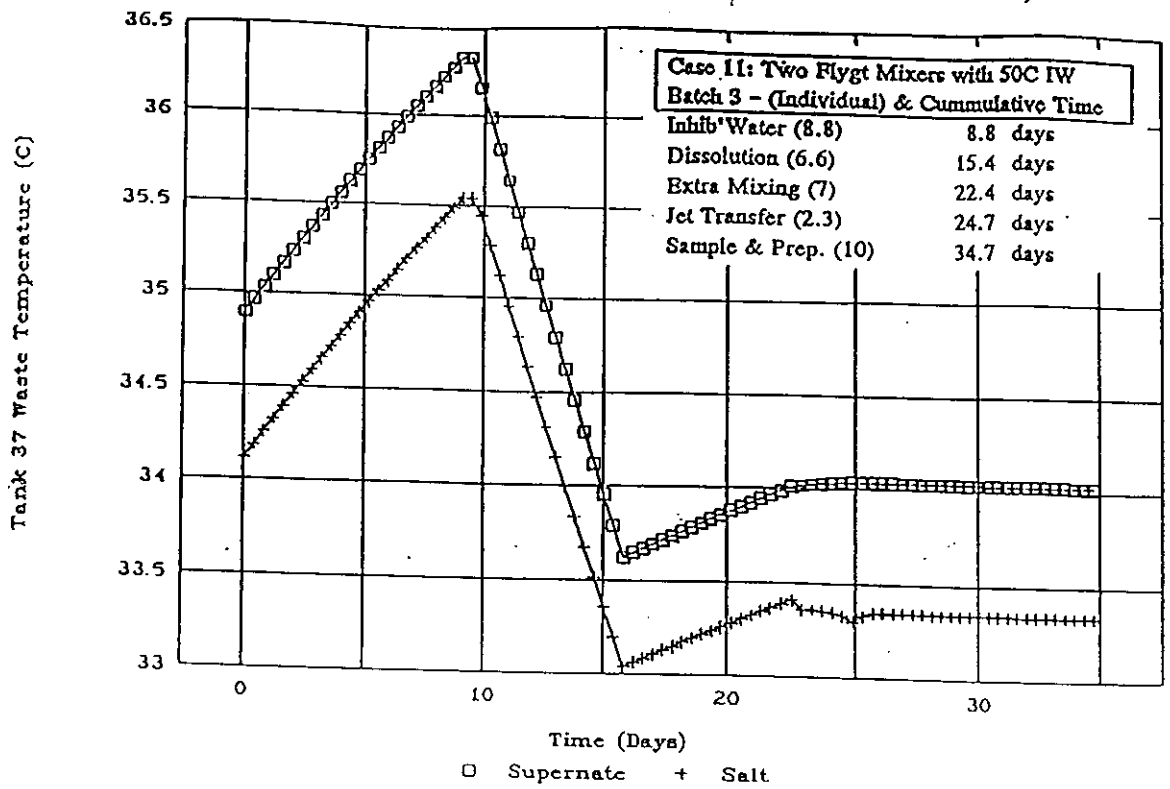


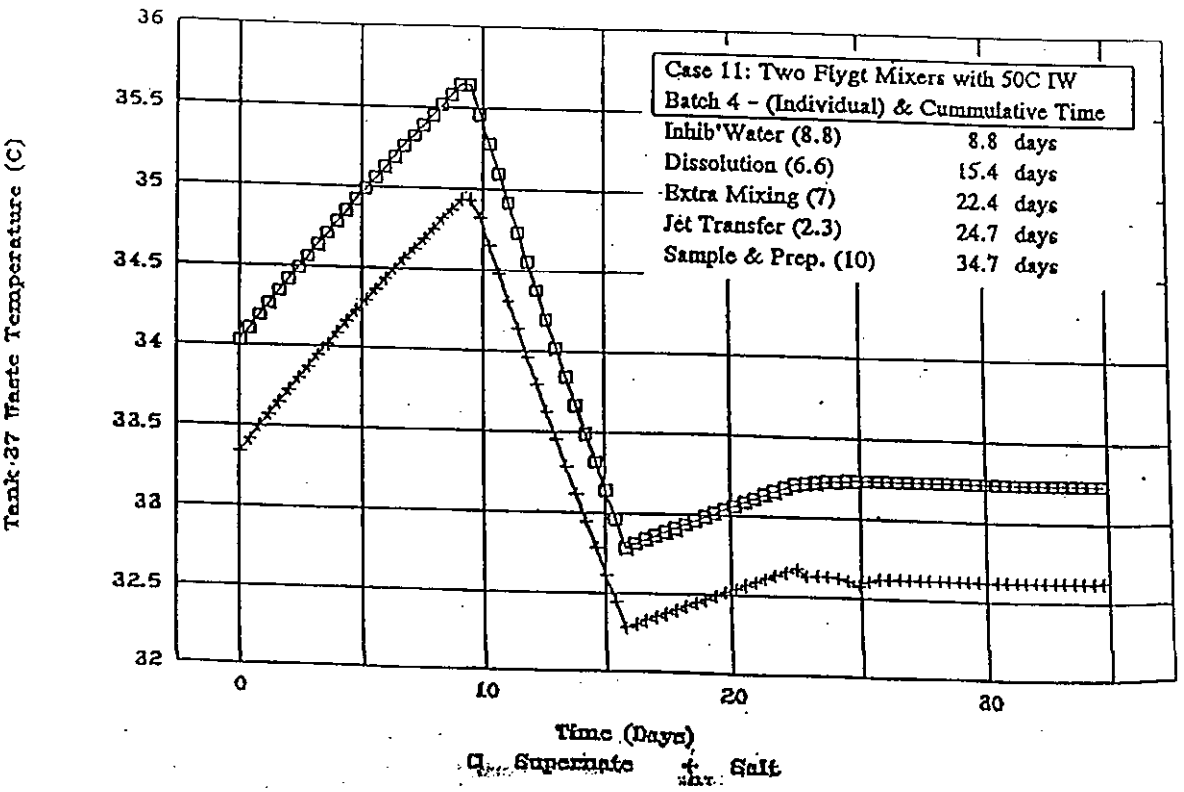
Case 11: Two Flygt Mixers with 50C IW (Batch 1-2)



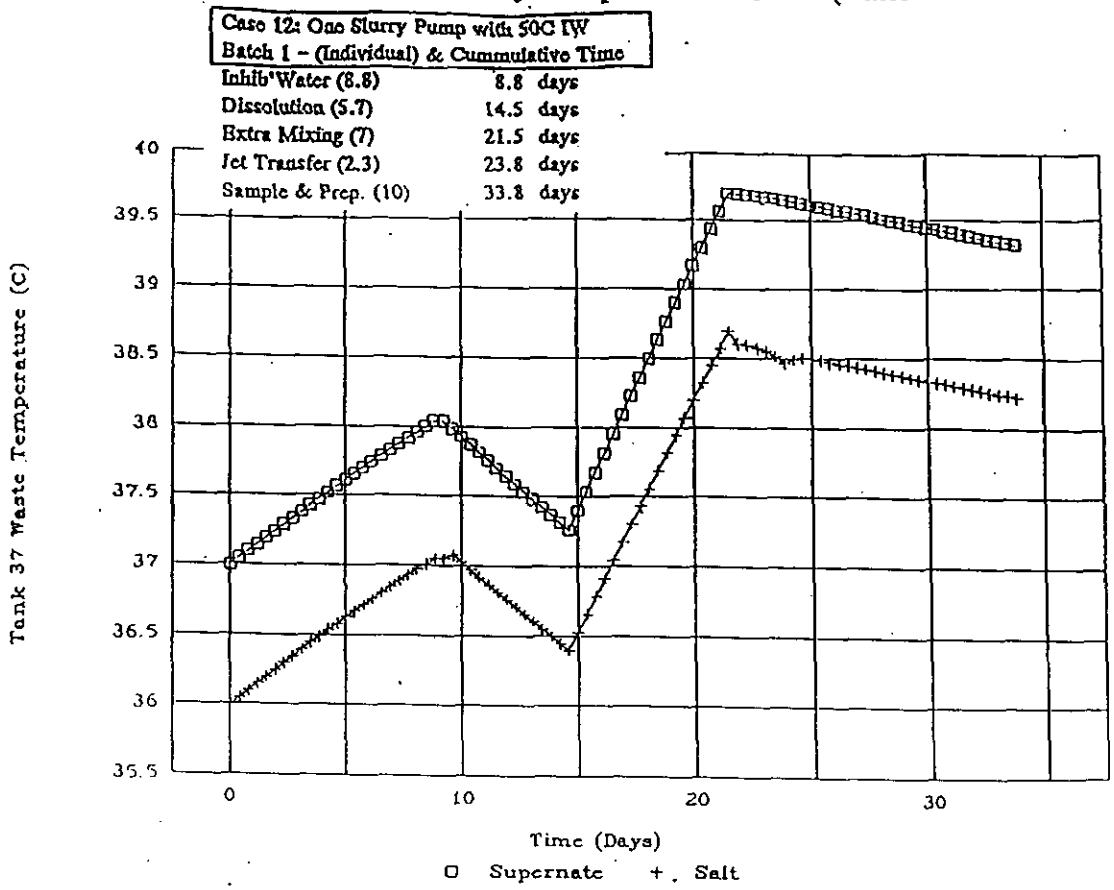


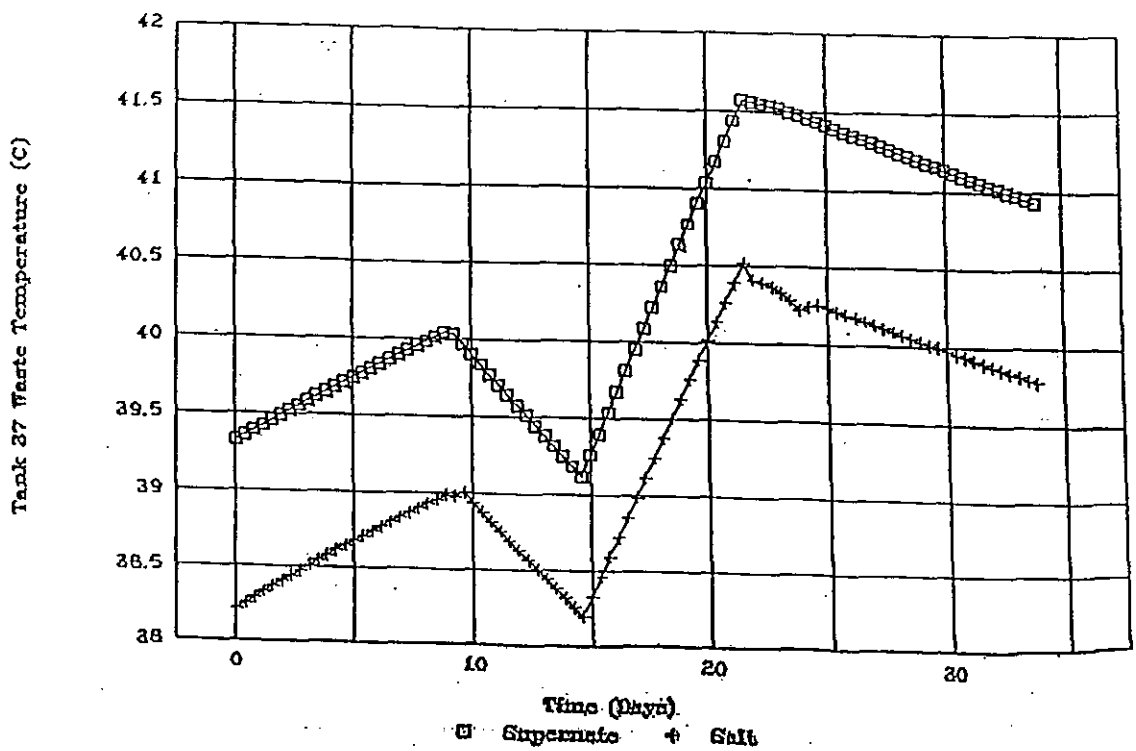
Case 11 Two Flygt Mixers with 50C IW (Batch 3-4)



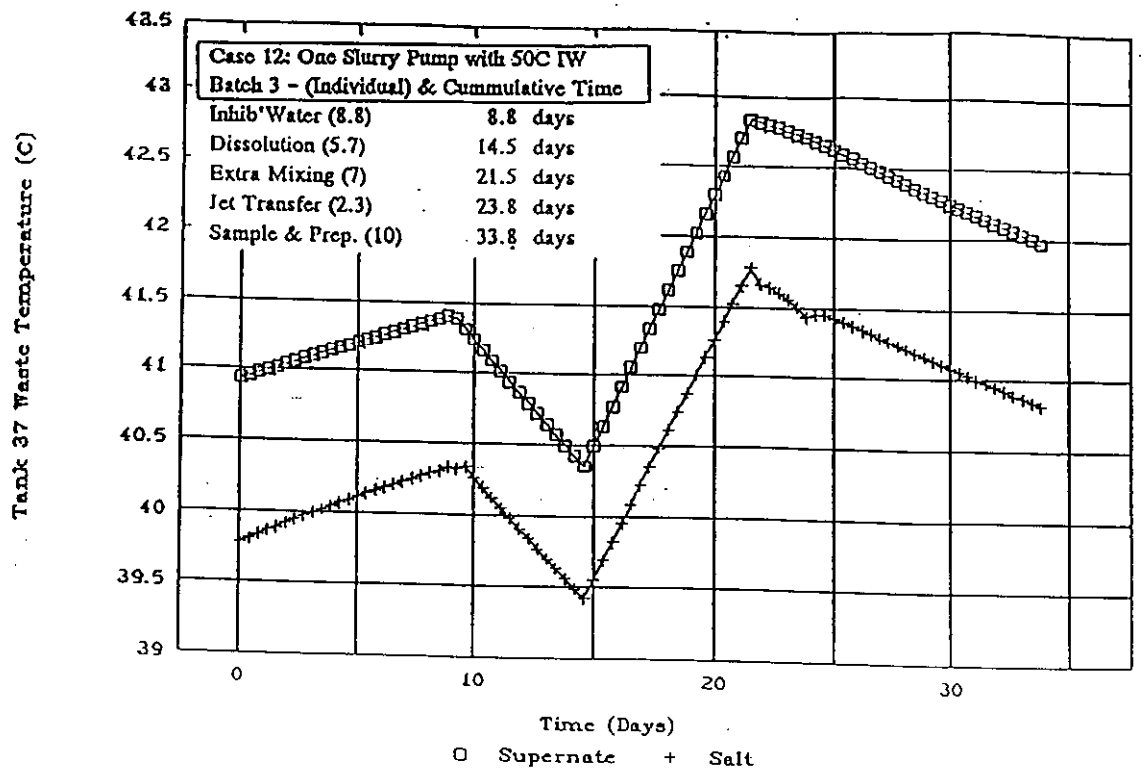


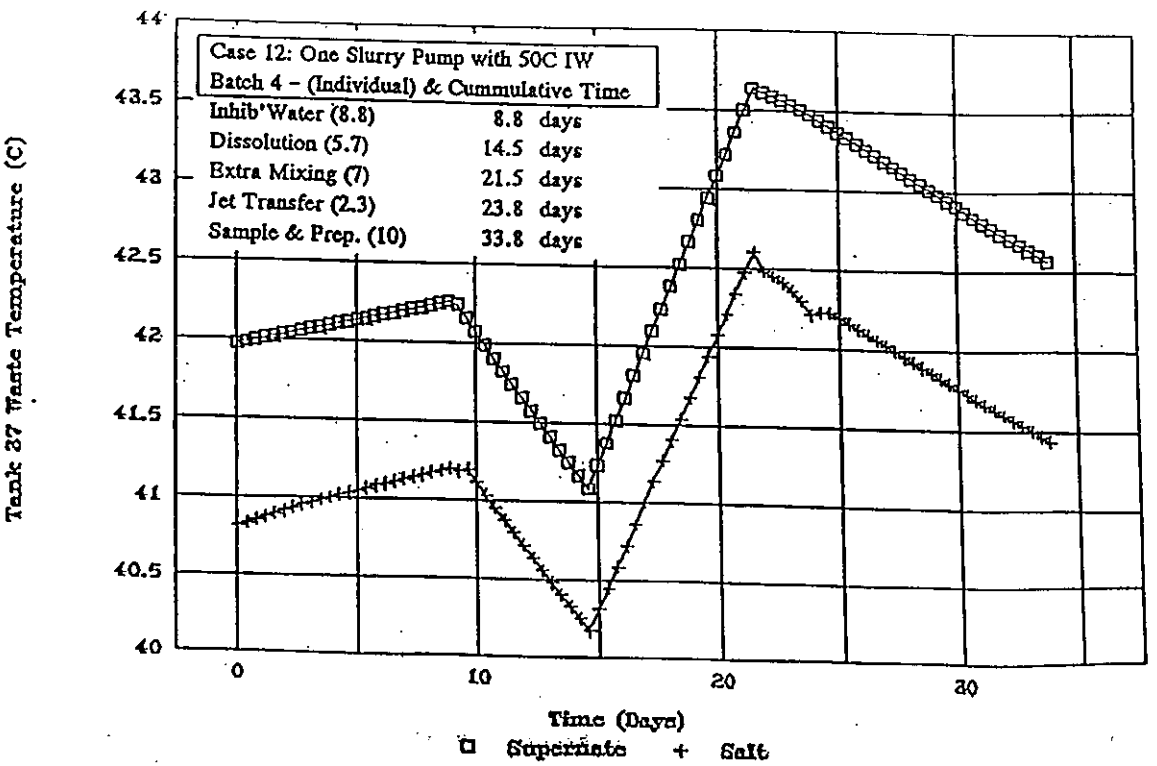
Case 12: One Slurry Pumps with 50C IW (Batch 1-2)



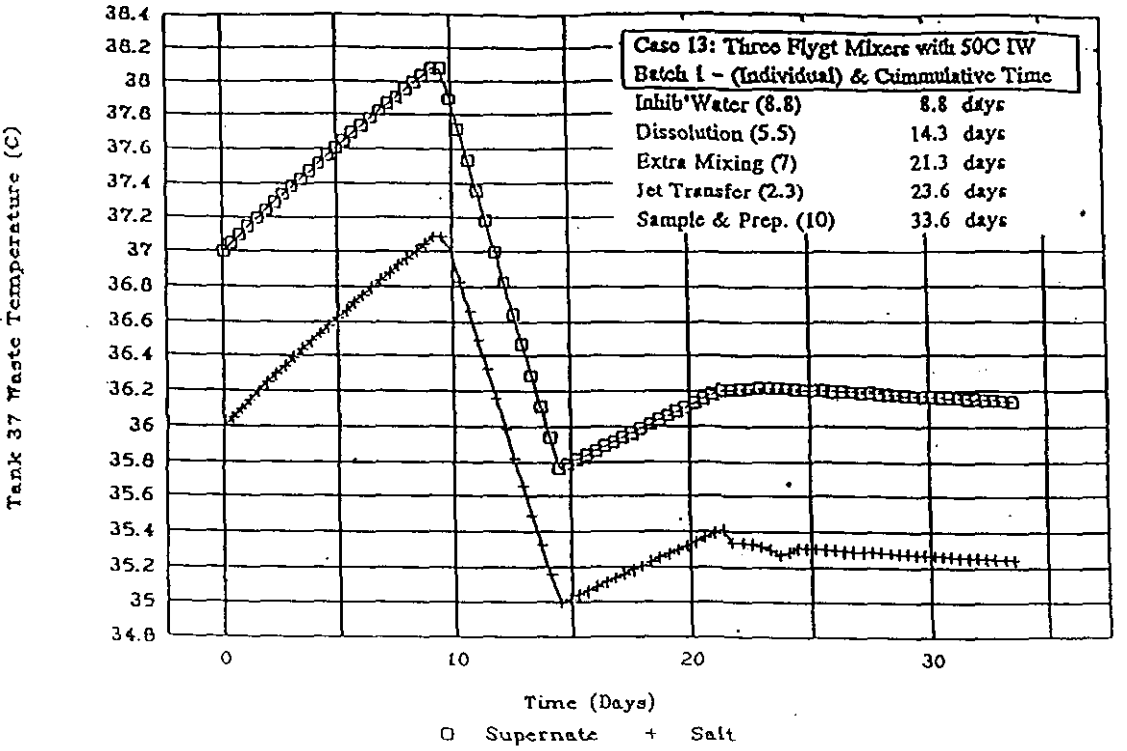


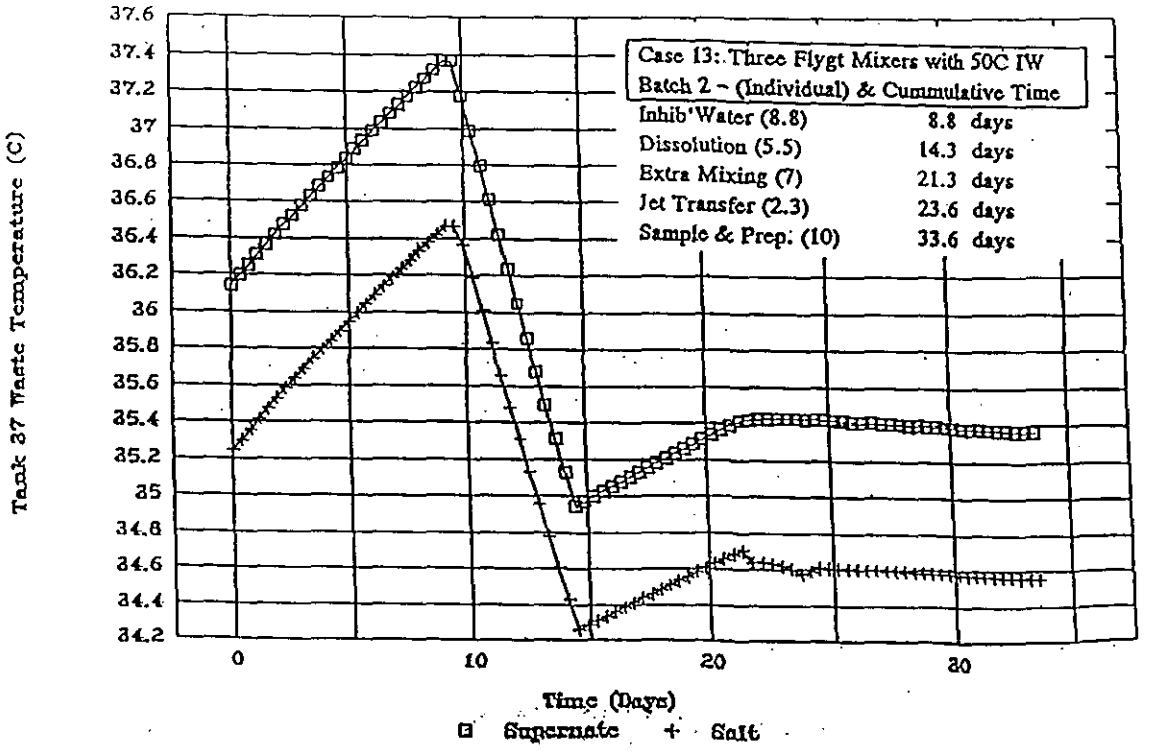
Case 12 One Slurry Pumps with 50C IW (Batch 3-4)



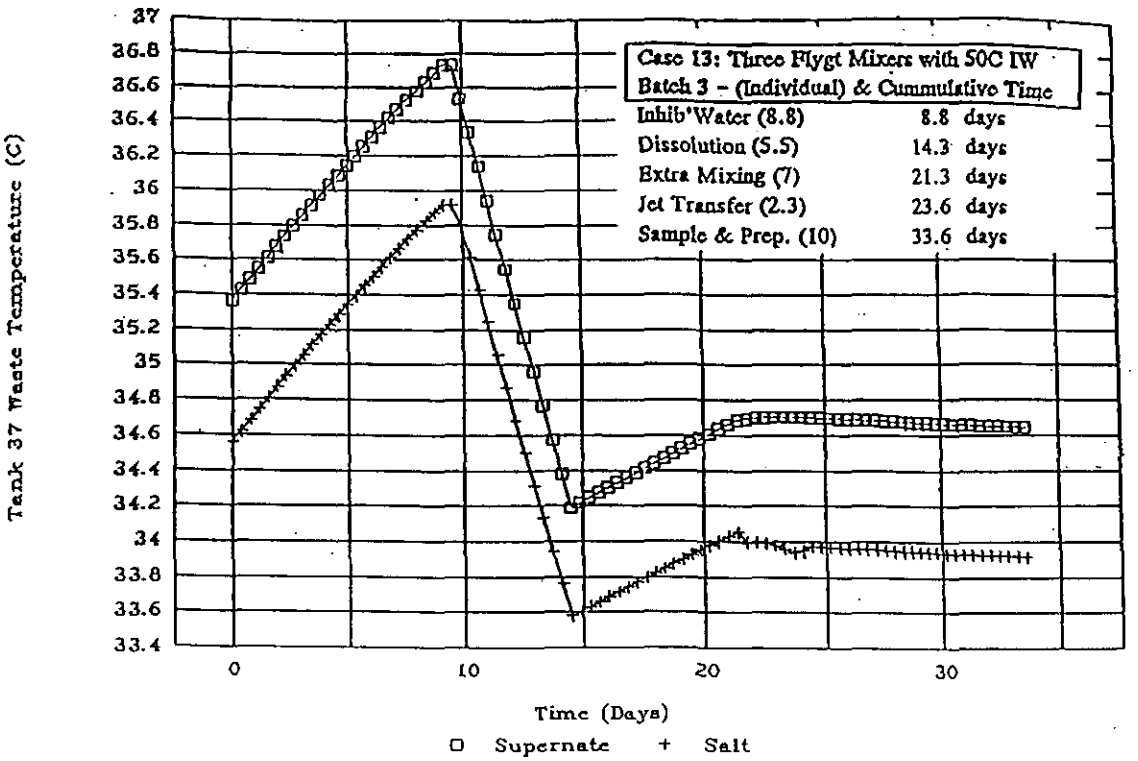


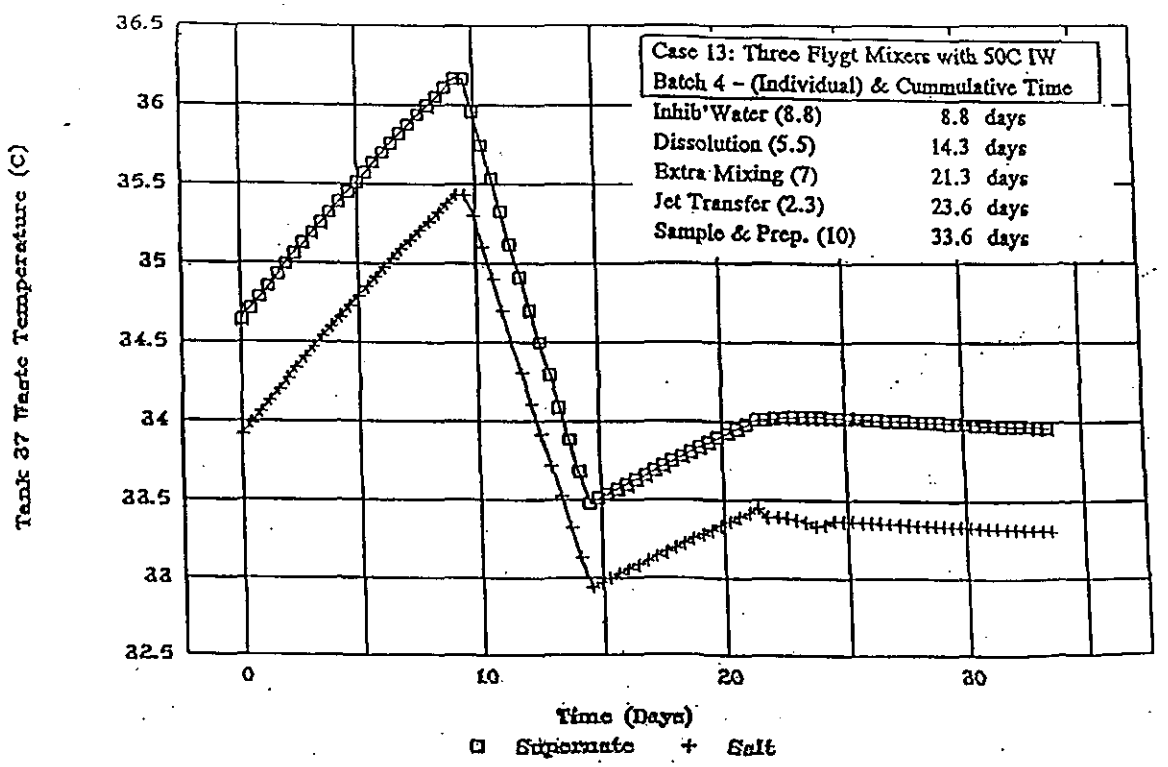
Case 13: Three Flygt Mixers with 50C IW (Batch 1-2)



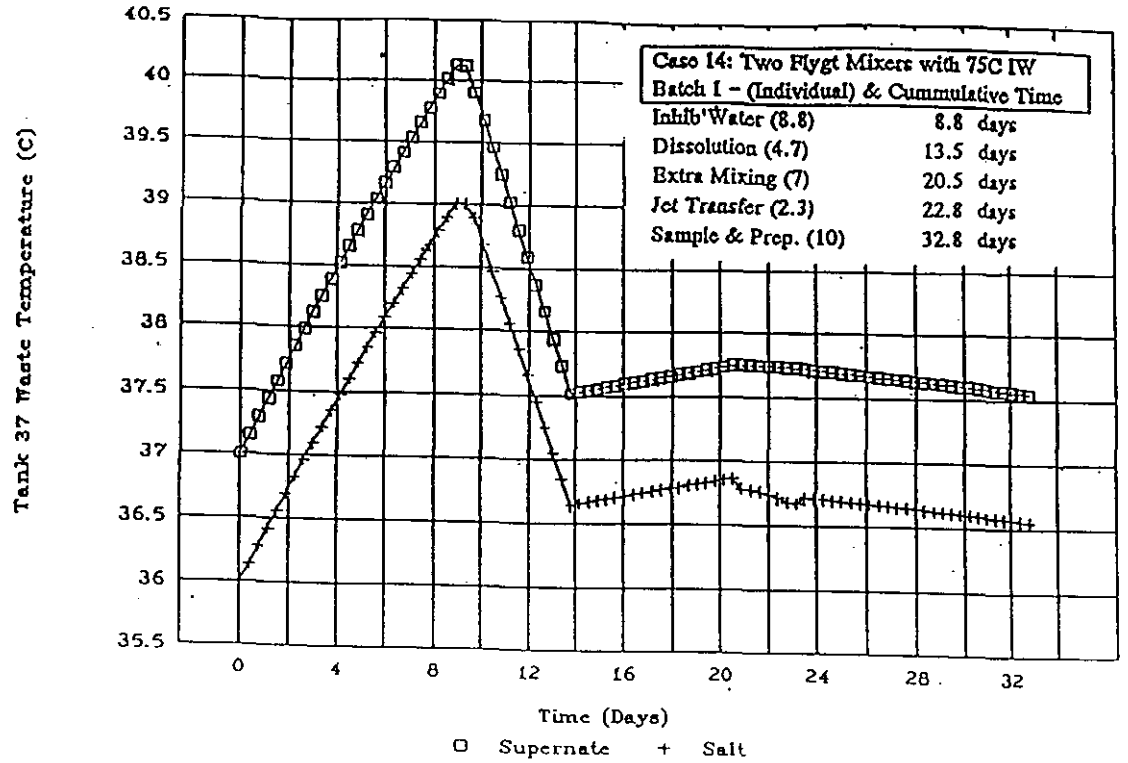


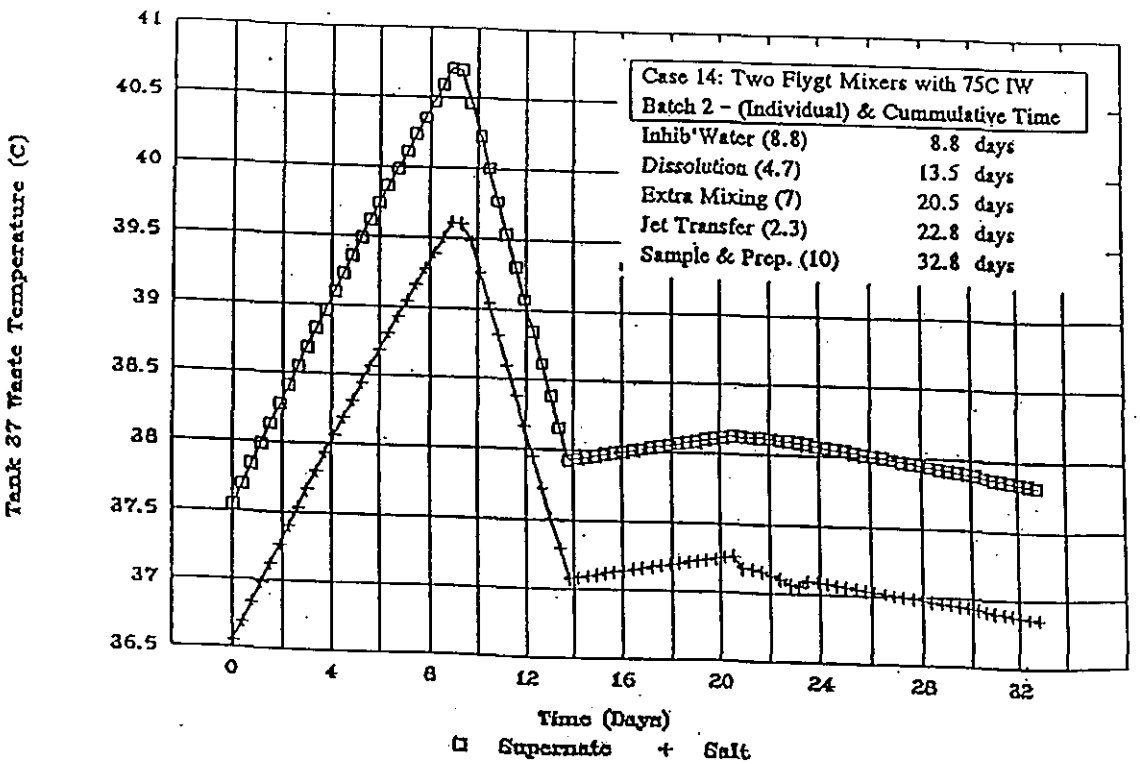
Case 13 Three Flygt Mixers with 50C IW (Batch 3-4)



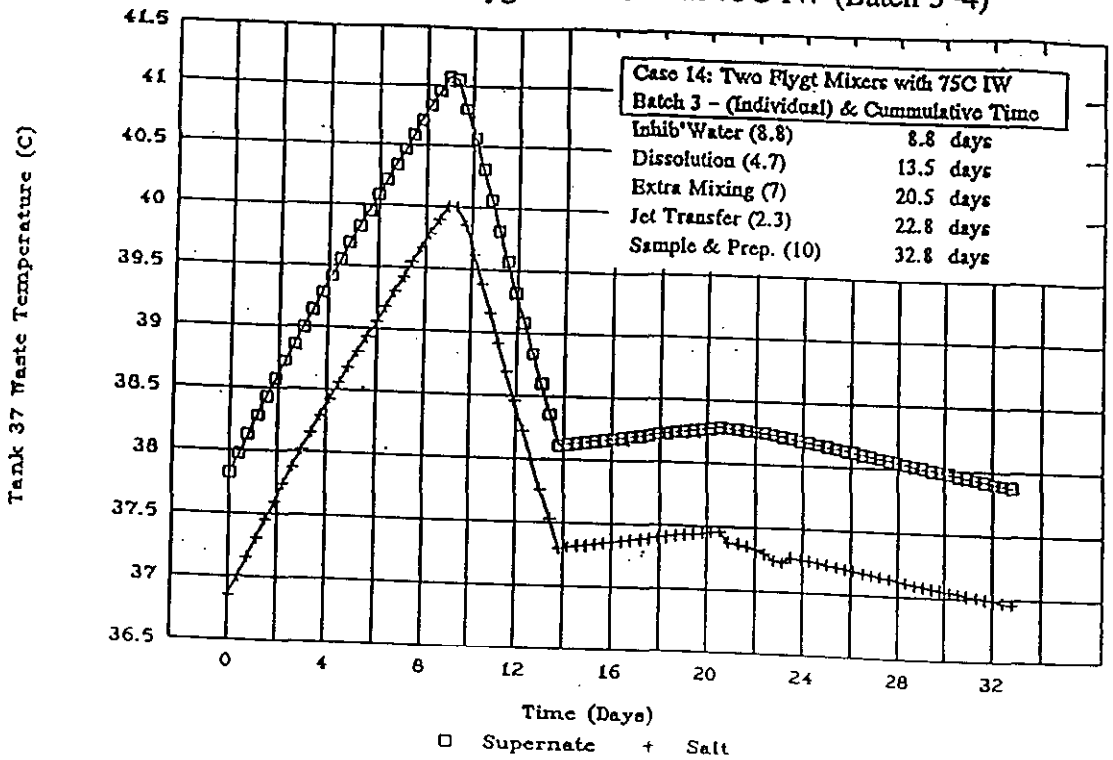


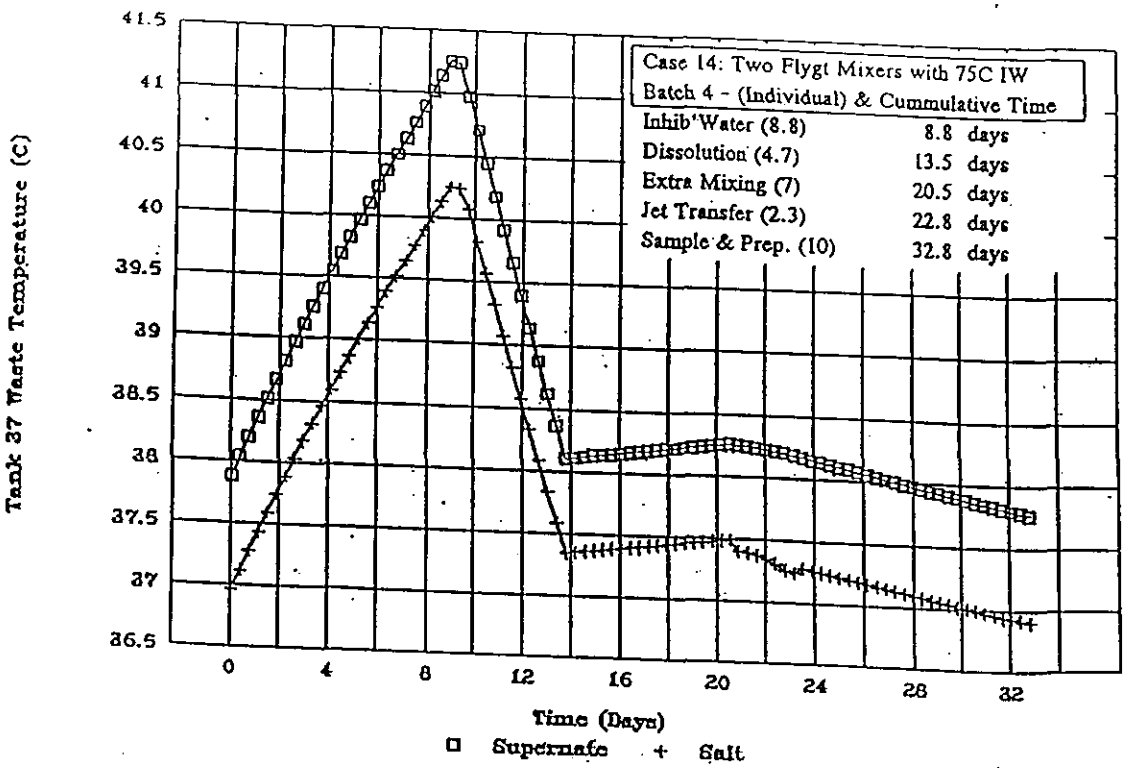
Case 14: Two Flygt Mixers with 75C IW (Batch 1-2)



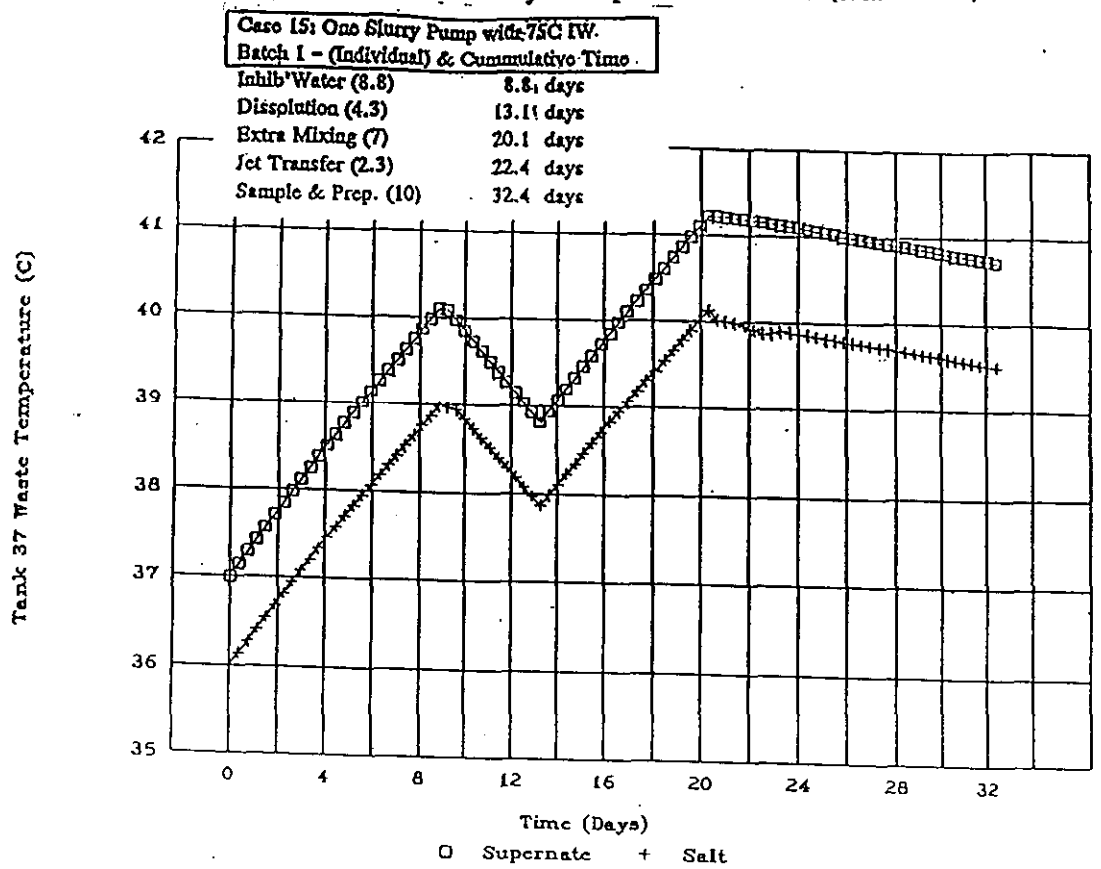


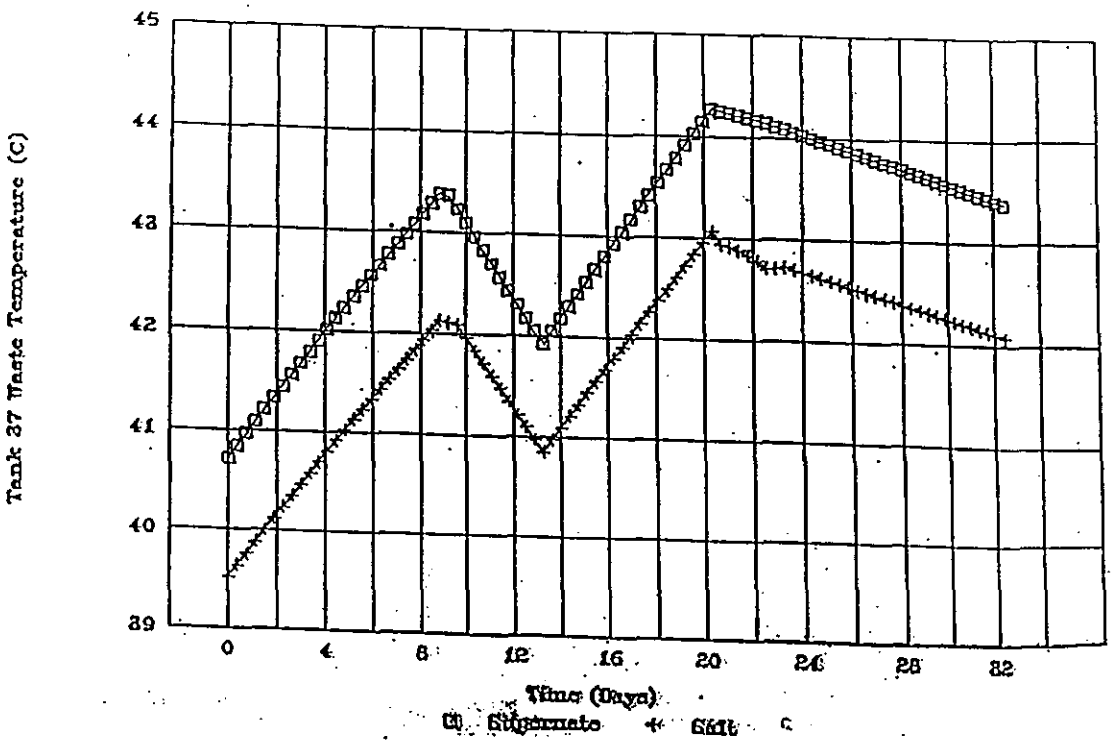
Case 14 Two Flygt Mixers with 75C IW (Batch 3-4)



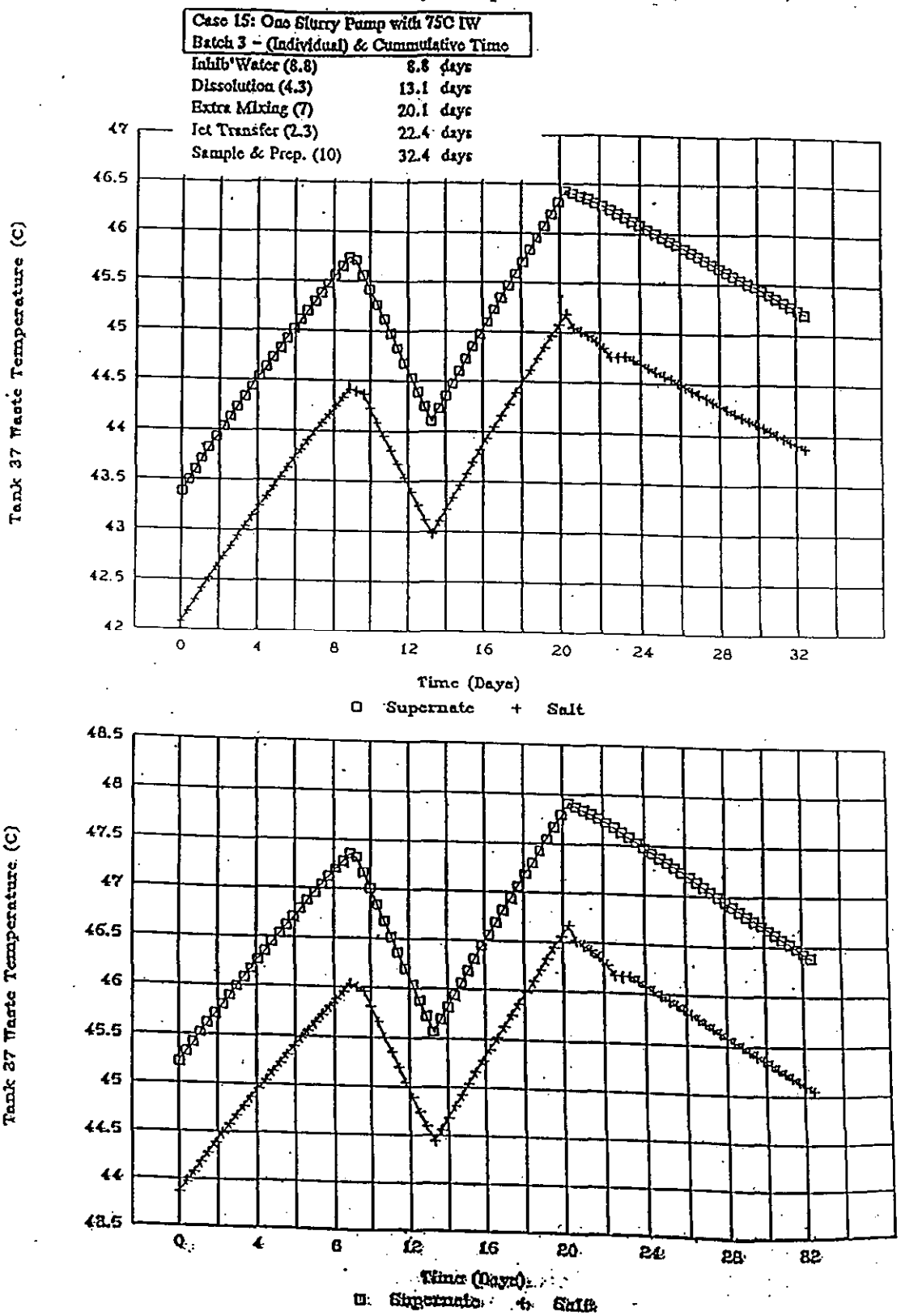


Case 15 One Slurry Pump with 75C IW (Batch 1-2)

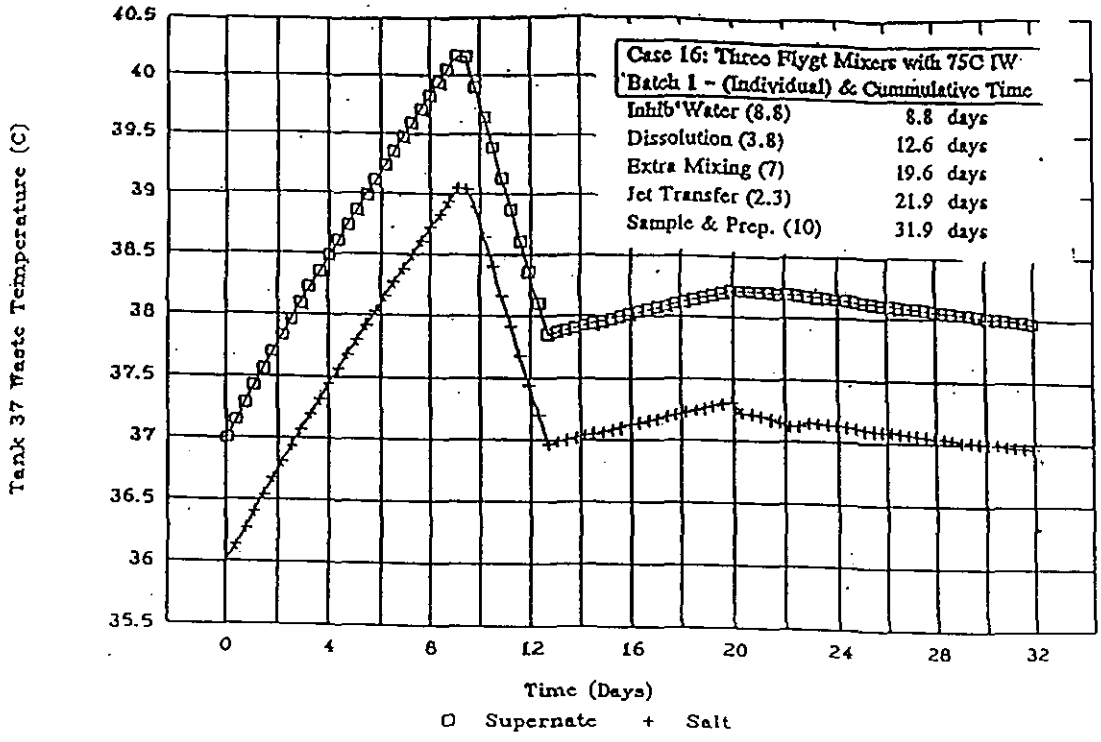


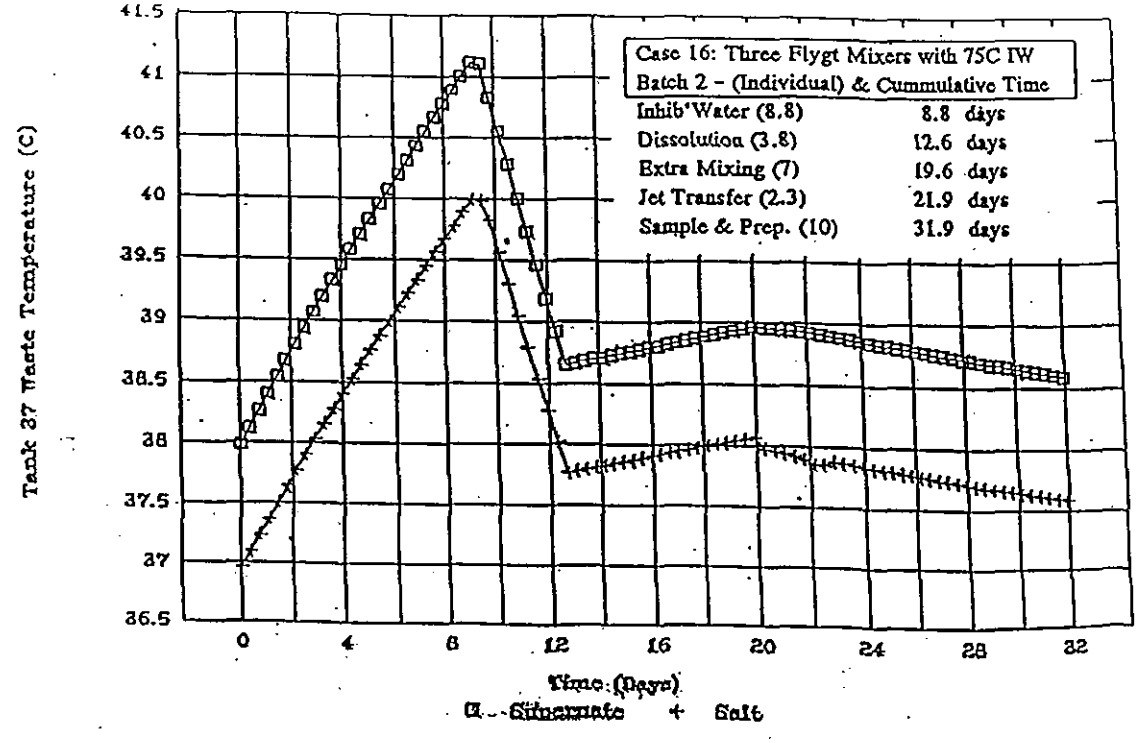
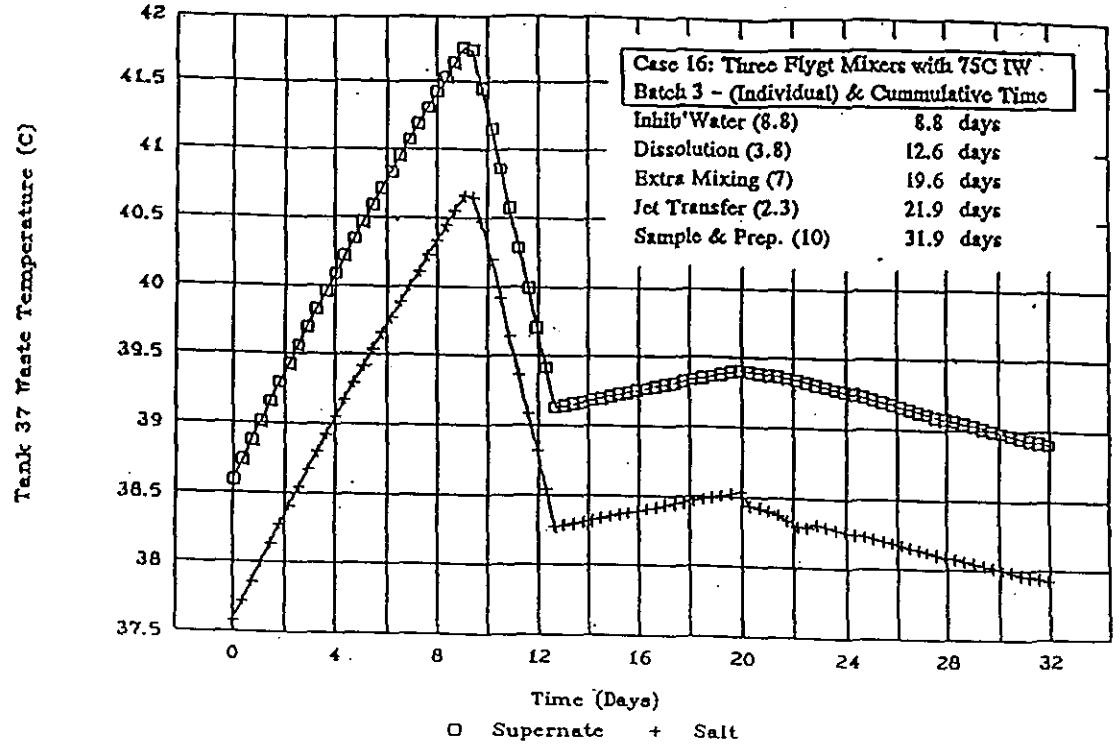
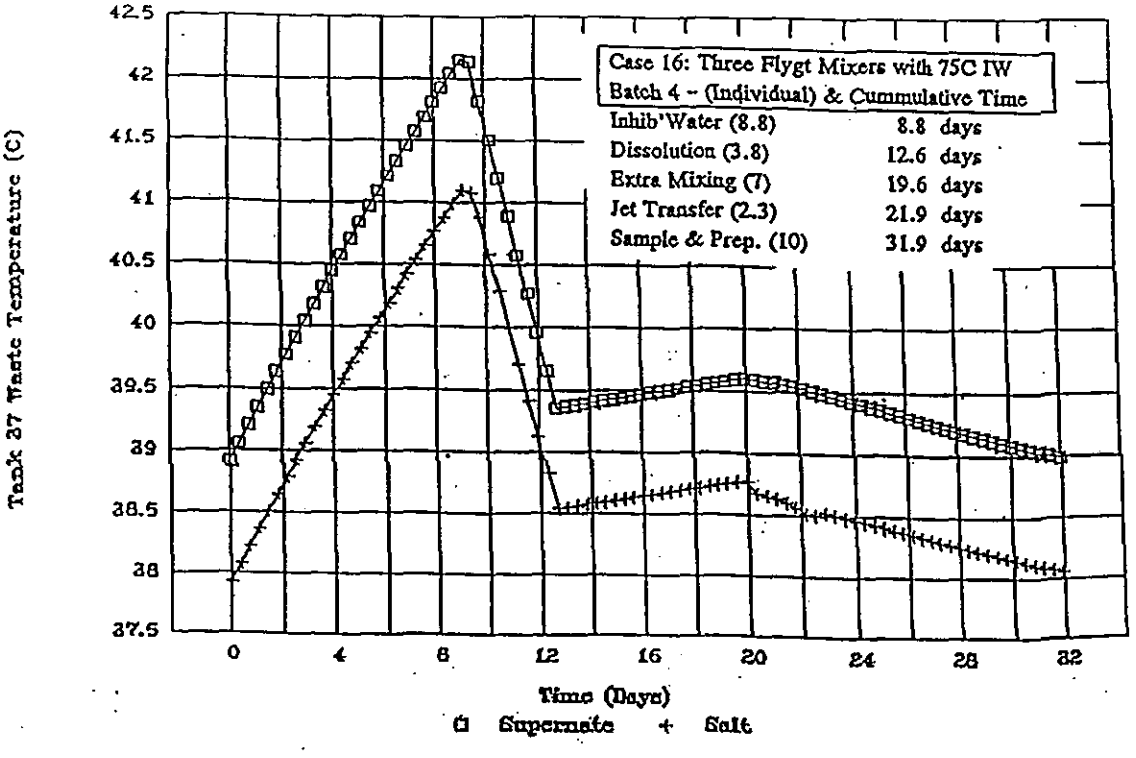


Case 15: One Slurry Pump with 75C IW (Batch 3–4)



Case 16: Three Flygt Mixers with 75C IW (Batch 1-2)





Case 16: Three Flygt Mixers with 75C IW (Batch 3-4)