WSRC-RP-93-767

ITP Filtrate Benzene Removal Alternatives

by

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MASTER

DOE Contract No. **DE-AC09-89SR18035**

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WSRC-RP-93-767

Keywords: Benzene stripping,
Gas Sparging,
In-Tank Process,
GOOD OLE HANK (Henry's Constant),
Supernate

Retention Period: Permanent

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May 21, 1993

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ITP Filtrate Benzene Removal Alternatives (U)

SUMMARY

Existing ITP filtrate hold tanks may provide sufficient capacity and residence time to strip dissolved benzene from the incoming filtrate using nitrogen sparging in the bottom of the hold tanks. This is based on equilibrium supported by Late Wash test data using aged washed slurry. Theoretical considerations indicate that benzene stripping will be more difficult from the ITP unwashed high salt filtrates due to reduced mass transfer. Therefore experimental sparging data is needed to quantify the theoretical effects. Foaming limits which dictate allowable sparging rate will also have to be established. Sparging in the

hold tanks will require installation of sintered metal spargers, and possibly stirrers and foam monitoring/disengagement equipment.

The most critical sparging needs are at the start of the precipitation/concentration cycle, when the filtrate flux rate is the highest, and at the end of the wash cycle where Henry's equilibrium constant falls off, requiring more gas to sparge the dissolved benzene.

With adequate recycle (for proper ~~packaging~~ distribution) or sparging in the hold tanks, the 30 inch column could be used for the complete ITP process. A coarser packing would reduce back pressure while enabling benzene stripping. The Late Wash tests indicate adequate benzene stripping even at reduced gas flow. This will require experimental verification under ITP conditions. Using the 30 in. column vs 18 in. during the wash cycle will enhance stripping without need for additional sparging provided the minimum flow requirements are met.

RECOMMENDATIONS

- Provide experimental data to validate sparging in hold tanks under ITP conditions.
- Use only the larger 30 in. stripper column for the whole ITP cycle.
- Evaluate other (coarser) packings in the 30 inch column.

BACKGROUND

Unexpectedly high pressure drops were observed in an ITP benzene stripping column during cold chemicals testing of cross-flow filters. The 30 in. column pressure drop reached the 40 in. water operating limit at half the design liquid flow and one quarter design nitrogen stripping gas flow. Subsequent vendor tests using simulated filtrates showed that the pressure drop is due to foaming and can be significantly reduced with tributyl phosphate. The dissolved benzene also had a small anti-foaming effect. Also different batches of simulant showed different levels of foaming and resulted in differing pressure drops.

The pressure drop was not predicted during the initial stripper column design and real tank waste may behave differently, even in the presence of tributyl phosphate. Benzene removal from ITP filtrate is essential to meet Class A saltstone quality. Existing ITP equipment has been examined to provide back-up benzene removal alternatives.

DISCUSSION

~~Mark Baiche~~ Late Wash sparging tests (Ref 1) show that benzene is removed to near equilibrium as determined by Henry's Law Constant. The stripping kinetics remain very fast down to about 2 ppm ~~goal~~ benzene concentration (Fig 2). The tests were conducted on washed aged (irratiated) slurry in a well stirred 30 gal. tank

(1/200 th scale STRAT) using sparge rates of 0.3 to 0.6 SCFM/ft^2. The sparge rate determines the benzene stripping rate and is ultimately limited by foaming. The vendor recommends 0.62 SCFM/ft^2 of sparge surface at 0.5 micron porosity. The Baich data provides only a product of Henry's Constant and sparging efficiency since the actual Henry's Constant for Late Wash irradiated solution is not known. For ITP stripping we assumed a 50% sparging efficiency. This may improve inside taller tanks as the contact time increases, or decrease as mixing becomes less effective in larger tanks. Based on Gus Georgeton's calculations (Ref 5), the mass transfer coefficient will decrease with increasing salt concentration and the assumed 50% efficiency may decrease during the concentration cycle. This will require experimental determination under selected ITP conditions.

Benzene stripping for batch operation can be represented by (Ref 1):

$$C(t) = C_0 \exp(-SHEt/V)$$

where
- $C(t)$ is benzene concentration at time t (min)
- C_0 is benzene concentration at the start
- S is sparge gas flow (SCFM)
- H is Henry's Constant
- E is the stripping efficiency
- V is the tank liquid working volume (ft^3)

Henry's Constants for "average" salt solution have been provided by Walker (Ref 2) as a function of temperature and [Na^+] concentration. The values for "average" salt can be adjusted for high and low OH^- as shown in Table 1 to better represent the ITP precipitation/ concentration/ washing cycle (Ref 3).

The calculated time for sparging 10,000 gal of high OH filtrate during the concentration cycle is shown in Figure 3. The sparging time to reduce benzene concentration from 120 ppm to 2.5 ppm falls off rapidly as the salt concentration increases, assuming the efficiency remains at 50%. However, we would expect the efficiency to decrease with increased salt concentration and experimental data must be provided to validate the assumptions.

During the wash cycle benzene concentration will be higher, and the stripping time will increase as the salt is washed out from 5M to say 1M sodium, Figure 4. At 500 ppm starting concentration it may take 10 hrs. to strip the benzene to 2.5 ppm.

The estimated time to fill the hold tanks and to strip the benzene over the whole ITP cycle is shown in Figure 1, based on ITP cold chemicals filtrate flux rate Figure 5 (Ref 4). During the concentration cycle benzene stripping will be relatively constant and quick since the highly concentrated salt solution holds little benzene. As the solids are concentrated the filter flux rate will fall off allowing more time for stripping.

During the wash cycle the filter flux will remain relatively constant and low, however, the stripping time will increase as the salt is washed out and Henry's constant decreases by a factor of 10. The flowrates, benzene concentration, and Henry's constant used are highlighted in Table 1.

REFERENCES

(1) M.A. Baich, "Qualification of Data 1/200 th Scale STRAT Late Wash Permeate Sparging", WSRC-RP-93-229, 1/20/93.

(2) D.D. Walker to G.T. Wright, "Vapor Pressure of Benzene, Methanol and Isoprapanol over Salt Solutions", DPST-88-661, 3/28/89.

(3) D.D. Walker, "Material Balance for the ITP Process with Late Washing", SRT-LWP-92-074, 7/14/92.

(4) L.O. Dworjanyn to W.L. Tamosaitis, "ITP Filter Particulate Decontamination", WSRC-RP-93-768, 5/21/93.

(5) G.K. Georgeton, "Development and Application of a Mathematical Model for the Benzene Stripping Columns in the ITP Process", WSRC-RP-89-1442, 12/28/89.

TABLE 1

21-May-93 Hold Tank Stripping 10,000 gal Tank

C:\APP\ITP\STRIP.WQ1

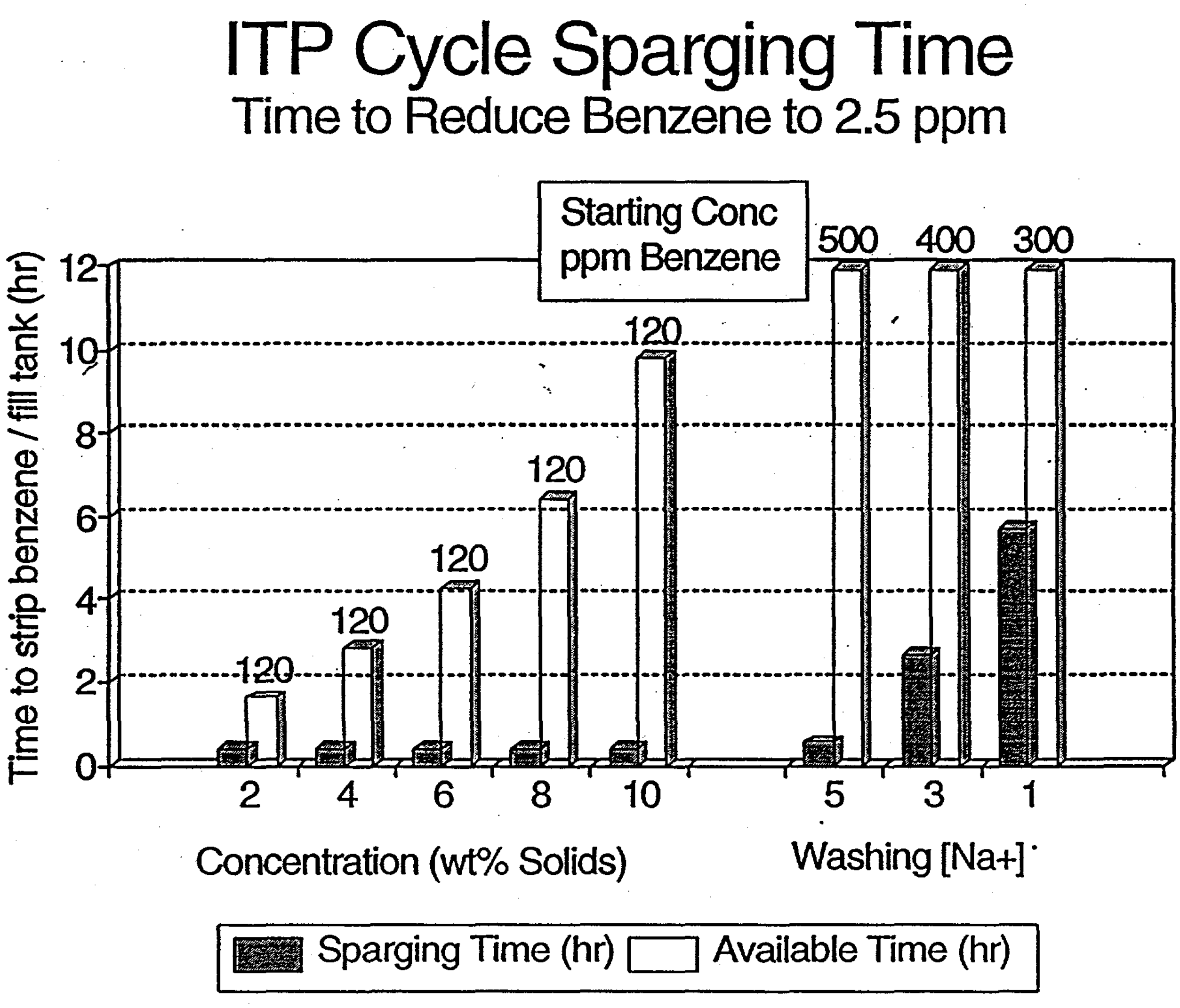
Precipitation/Concentration, High OH — 120 ppm Benzene

	25 deg		Strip	35 deg C			Fill 115	45 deg C		
Na+	Avg	Hi OH	hr	Avh	Hi OH	hr	hr	Avh	Hi OH	hr
0	0.23	0.23	10.7	0.33	0.33	7.5	1.4	0.44	0.44	5.6
1	0.35	0.37	6.6	0.5	0.53	4.6	1.4	0.67	0.71	3.4
2	0.56	0.63	3.9	0.78	0.88	2.8	1.4	1.03	1.17	2.1
3	0.87	1.04	2.4	1.22	1.46	1.7	1.4	1.58	1.90	1.3
4	1.35	1.71	1.4	1.91	2.42	1.0	1.4	2.43	3.08	0.8
5	2.13	2.84	0.9	2.98	3.97	0.6	1.4	3.73	4.97	0.5
6	3.33	4.66	0.5	4.65	6.51	0.4	1.4	5.72	8.01	0.3

Precipitate Washing, High OH — 500 ppm Benzene

	25 deg		Strip	35 deg C			14	45 deg C		
Na+	Avg	Hi OH	hr	Avh	Hi OH	hr	hr	Avh	Hi OH	hr
0	0.23	0.23	14.7	0.33	0.33	10.2	11.9	0.44	0.44	7.7
1	0.35	0.37	9.0	0.5	0.53	6.3	11.9	0.67	0.71	4.7
2	0.56	0.63	5.3	0.78	0.88	3.8	11.9	1.03	1.17	2.9
3	0.87	1.04	3.2	1.22	1.46	2.3	11.9	1.58	1.90	1.8
4	1.35	1.71	2.0	1.91	2.42	1.4	11.9	2.43	3.08	1.1
5	2.13	2.84	1.2	2.98	3.97	0.8	11.9	3.73	4.97	0.7
6	3.33	4.66	0.7	4.65	6.51	0.5	11.9	5.72	8.01	0.4

Operation:	Concentration						Washing			
X-Axis Plot	2	4	6	8	10		5	3	1	
Solids, wt%	2	4	6	8	10		10	10	10	
[Na+], gmol/l	5	5	5	5	5		5	3	1	
[OH] Level	Hi	Hi	Hi	Hi	Hi		Hi	Mid	Hi	
Henry's constant	6.51	6.51	6.51	6.51	6.51		6.51	1.22	0.53	
Walker Cycle, gpm	115	115	115	115	50		14	14	14	
ITP Test Flow, gpm	104	59	39	26	17		14	14	14	
Benzene Conc, ppm	120	120	120	120	120		500	400	300	
Strip Time, hr	0.4	0.4	0.4	0.4	0.4		0.5	2.6	5.7	
Fill Time, hr	1.6	2.8	4.3	6.4	9.8		11.9	11.9	11.9	
Air Flow, SCF/min	70	70	70	70	70		70	70	70	
Liquid, CF/min sparge	58.9	58.9	58.9	58.9	58.9		43.0	8.4	3.9	
Gas/Liquid	1.19	1.19	1.19	1.19	1.19	Total	1.63	8.32	17.95	Total
Gallons to filter	160000	160000	160000	160000	160000	800M	173000	173000	174000	520M
Hours Needed	25.6	45.2	68.4	102.6	156.9	373	206.0	206.0	207.1	619
Walker Hours	23.2	23.2	23.2	23.2	53.3	123	206.0	206.0	207.1	619
#3 ITP Filter Flux										
KTPB, wt%	1.5	4	8.38		9	+ST				
Flux, gpm/SF	0.265	0.128	0.043		0.029					
Flow/filter, gpm	61.0	29.4	9.9		6.7					
Two Filters, gpm	121.9	58.9	19.8		13.3					

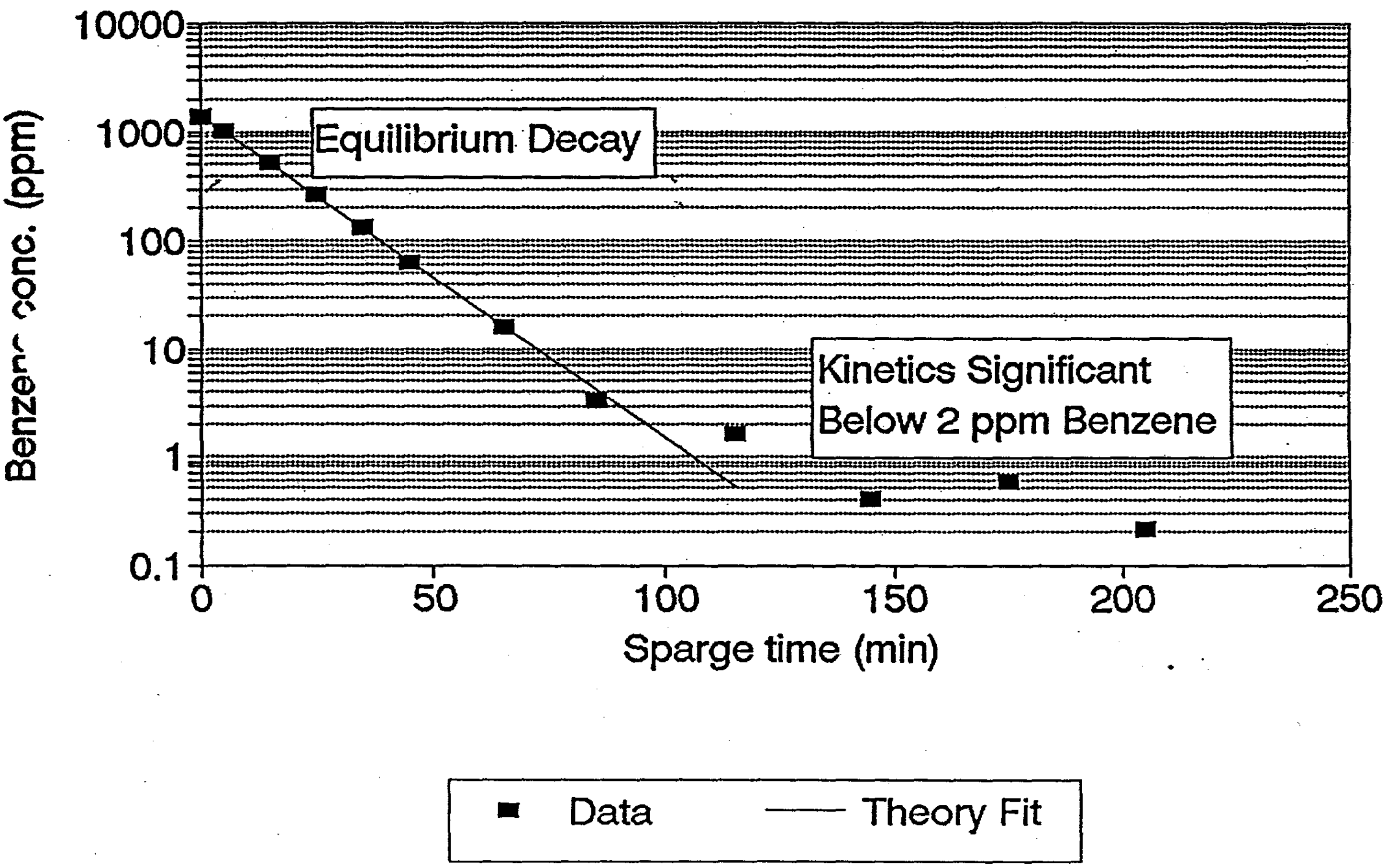


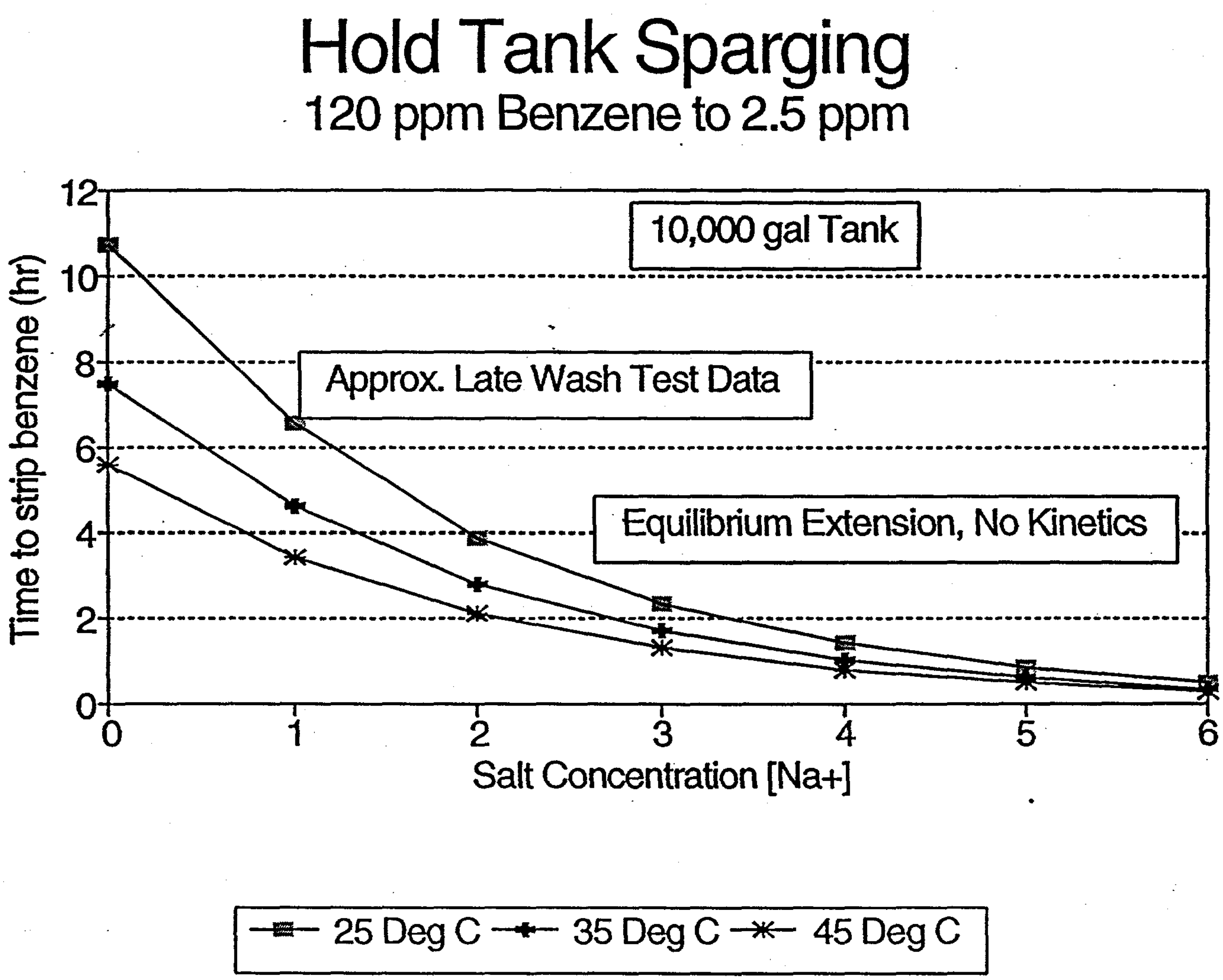
NOTE: During CONCENTRATION filtrate flux rate decreases, increasing the available time for sparging. Assumed temperature = 35°C

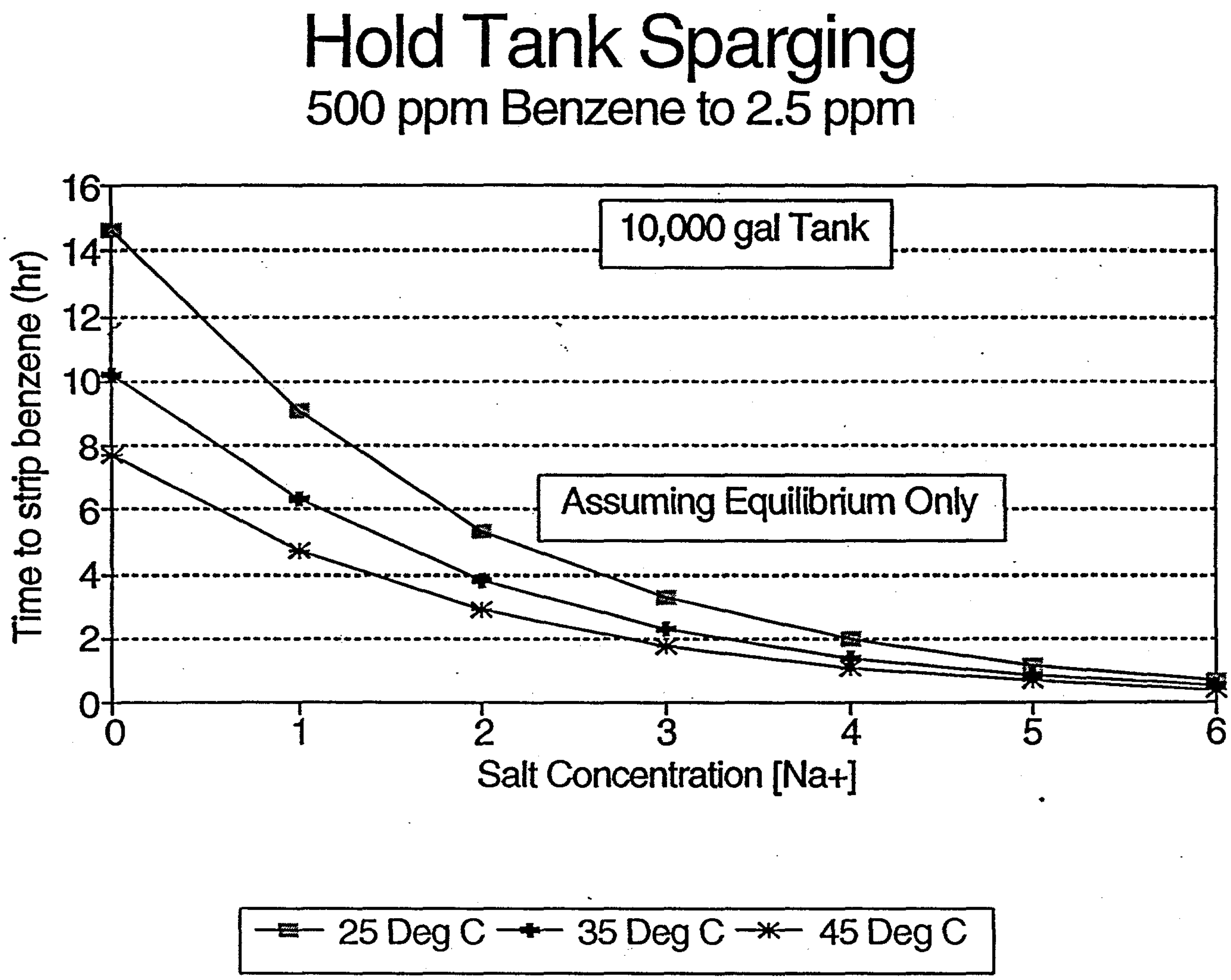
During PRECIPITATE WASHING salt concentration decreases, decreasing Henry's constant and increasing sparging time.

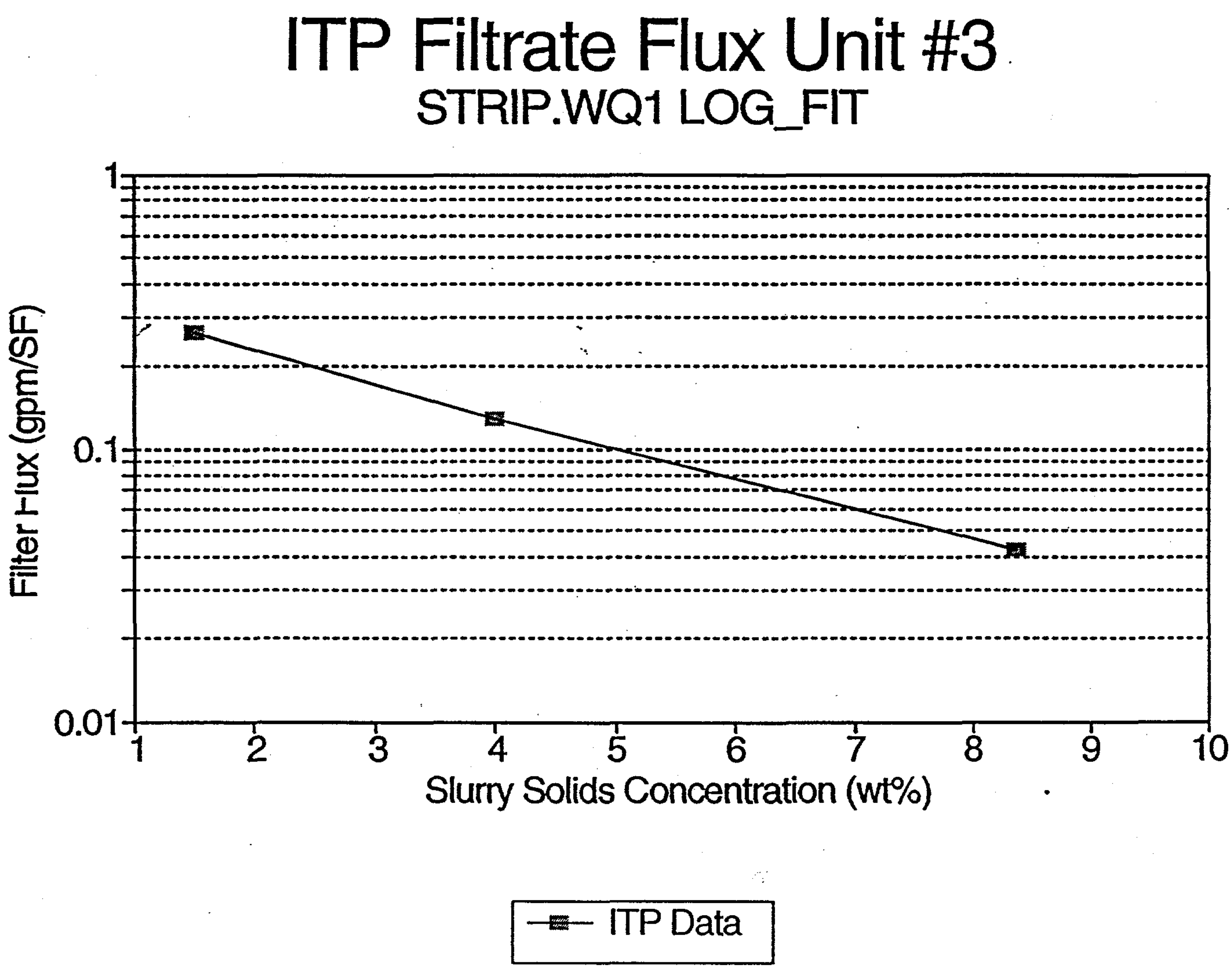
Late Wash Sparging

Mark Baich, Test Run #3




Hold Tank Sparging
120 ppm Benzene to 2.5 ppm
10,000 gal Tank
Approx. Late Wash Test Data
Equilibrium Extension, No Kinetics
Time to strip benzene (hr)
0
2
4
6
8
10
12
Salt Concentration [Na+]
0
1
2
3
4
5
6
25 Deg C
35 Deg C
45 Deg C


Hold Tank Sparging
500 ppm Benzene to 2.5 ppm
10,000 gal Tank
Assuming Equilibrium Only
Time to strip benzene (hr)
Salt Concentration [Na+]
0
2
4
6
8
10
12
14
16
0
1
2
3
4
5
6
25 Deg C
35 Deg C
45 Deg C


ITP Filtrate Flux Unit #3
STRIP.WQ1 LOG_FIT
1
0.1
0.01
Filter Flux (gpm/SF)
1
2
3
4
5
6
7
8
9
10
Slurry Solids Concentration (wt%)
ITP Data