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COPY NO. 32

DATE: March 31, 1958

SUBJECT: Hydroclone Performance in the Solvent Recovery System of the Thorex Pilot Plant

TO: R. B. Lindauer

FROM: J. Cerny III

ABSTRACT

Tests on 1-gpm and 0.5-gpm hydroclones showed them to be unnecessary: solvent-aqueous phase separation, although effective when optimized, was infrequently required; the 1-gpm hydroclone produced better water separation than the 0.5-gpm hydroclone for similar control parameters. Decontamination factors for widely varying flow conditions ranged from 1-3. Introduction of water into the hydroclone feed stream had no effect on decontamination or particle removal.

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D. R. Hamrin
7/31/2007

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[redacted]

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1.0 INTRODUCTION

Studies were conducted on a 1-gpm and a 0.5-gpm hydroclone, which are liquid-liquid separation components of the solvent recovery system in the Thorex Pilot Plant. The hydroclone unit replaced a high-speed centrifuge because of the high maintenance requirements of the latter. Little quantitative data on operating conditions have been available since the hydroclone installation one year and a half ago.

The major purposes of these tests were to optimize the hydroclone operating procedure and to determine the relative performance of the two hydroclones.

Experiments were conducted on this system to determine water separation, decontamination, and crud removal for the solvent under process conditions with and without water purging.

The Thorex process utilized a mixture of 42.5% TBP in Amsco diluent as the solvent extraction medium. In the Thorex Pilot Plant spent solvent from the process was contacted with 0.1 M Na_2CO_3 in a standard vertical pulse column to remove fission and degradation products. From the column, the treated solvent was pumped through one of two hydroclones to separate entrained solids and water, collected in head tanks and pumped back to the process columns.

2.0 SUMMARY AND CONCLUSIONS

Testing, both of short and extended duration, was performed on the 1-gpm and 0.5-gpm hydroclones using the 42.5% TBP flowsheet and on the 1-gpm hydroclone using the 6% TBP flowsheet to determine the water separation, decontamination and "quality" improvement possible in this system with and without water purging. The following characteristics were found:

1. Owing to the nature of the solvent and the Thorex solvent recovery system, the hydroclone functioned primarily as a safety device for infrequent phase separation and some particle removal.

2. Studies on the 1-gpm and the 0.5-gpm hydroclones through widely varying operating conditions, with and without water purging, compared as follows:

Hydroclone	P	SF_w	D. F.	Operation
1-gpm	16-17 psi	1.5-6[a]	1-3	Steady
0.5-gpm	17 psi	1.0	1-2	Erratic

a. Relative performance based on the 0.5-gpm clone for identical values of the control function and essentially equal pressure drop.

3. No justification is seen for water purging in this system, since it had no effect on decontamination or particle removal and it increased the amount of water dissolved in the solvent.

4. The Thorex hydroclone unit was not a decontamination device as evidenced above; during these tests the feed contained 0.1-9x10^3 γ cts/min/ml.

5. Limited operation with 6% TBP showed increased liquid-liquid separation but no noticeable effect on the other system quantities.

Specifically, the Thorex hydroclones should be operated with no water purge at low values of the control function for 42.5% or 6% TBP. This can be accomplished as follows for the observed feed rates:

Hydroclone	% TBP	Feed, liters/hr	Underflow, liters/hr	C_F	SF_w possible	$\frac{FC_F}{UF}$
1 gpm	42.5	180	60	0-0.05	> 50	0-0.15
1 gpm	6	180	60	0-0.083	> 50	0-0.25
1/2 gpm	42.5	120	30[a]	0-0.037	> 20	0-0.15
1/2 gpm	6	120	30[a]	0-0.037	> 20	0-0.15

[a]Maximum allowable due to process requirement of 90 liters/hr of solvent.

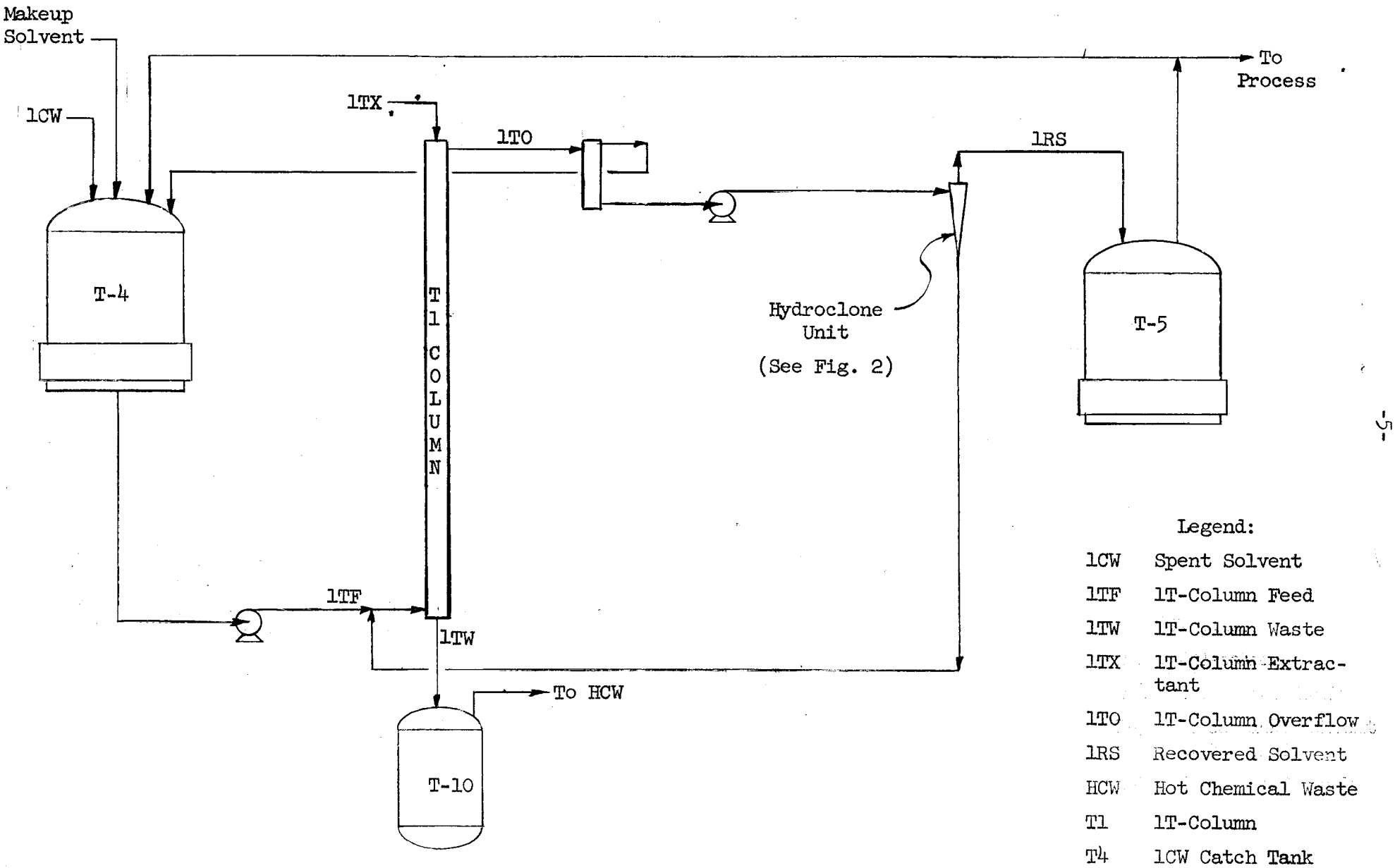
For other feed rates the UF should approach F/3 within process limitations, and for higher values of C_F the underflow should increase proportionately.

3.0 EQUIPMENT AND OPERATION

3.1 Location and Description

The solvent recovery system (Fig. 3.1) removed process degradation products from used solvent prior to recycle to the solvent extraction system. Most objectionable impurities were removed from the organic solvent prior to the hydroclones by contacting the spent solvent with a one-fifth volume of 0.1 molar sodium carbonate. The solvent recovery column was a pulse column 25 ft long and 6 in. ID, operated with the organic phase continuous.

The Thorex solvent was a mixture of 42.5% tributyl phosphate in Amsco 125-82, a hydrocarbon diluent. The solvent used for recovery of U-233 from decayed Pa-233 was 6% TBP in Amsco.



Legend:

1CW	Spent Solvent
1TF	1T-Column Feed
1TW	1T-Column Waste
1TX	1T-Column Extractant
1TO	1T-Column Overflow
1RS	Recovered Solvent
HCW	Hot Chemical Waste
T1	1T-Column
T4	1CW Catch Tank
T5	1RS Catch Tank
T10	1TWC Catch Tank

Fig. 3.1. Solvent Recovery System in the Thorex Pilot Plant

The solvent stream was continuously passed to the hydroclone in the system by a 1-gpm canned-rotor centrifugal pump, which supplied the pressure for operation (Fig. 3.2). Process water addition for solvent contacting was on the pump discharge, since aqueous addition on pump suction produced an emulsion which the hydroclones could not "break." The solvent could be directed to either the 1-gpm or the 0.5-gpm hydroclone by operation of valves 1, 2, 3 and 4; rotameters permitted determination of the feed, water addition, and underflow rates and allowed visual solvent inspection. Samples could be taken of the feed (before the water purge), overflow, and underflow streams; pressure gauges indicated the feed to overflow pressure drop.

The hydroclone description and dimensions are found in Sect. 5.1.

3.2 Operating Procedure

Owing to the lack of quantitative data, the hydroclone unit had been operated with no water purge at an underflow ratio of 0.12. The hydroclones were used alternately at full feed conditions, giving a pressure drop of about 17 psi.

3.3 Testing Procedures

Testing with the 42.5% TBP flowsheet was done during Thorex run HD-26. The tests were conducted by permitting the maximum flow to the clones and adjusting the underflow rate (valve 1 or 2 open and valve 3 or 4 controlling, Fig. 3.2). Under these feed conditions essentially the same pressure drop occurred in each hydroclone, thus equalizing operation for comparative studies.

The first series of runs using the 42.5% TBP solvent were designed to determine operational characteristics for water separation, decontamination, crud removal, and "quality" improvement over extended periods of time. Each hydroclone was tested under variable conditions, with and without water purging, in a series of 12-hr runs. During each 12-hr period, 4 sets of samples were taken in 3-hr intervals, under as nearly controlled process conditions as possible. Samples of the feed, overflow, and underflow streams were taken.

The second series of runs using the 42.5% TBP solvent, each of 15 minutes duration, was performed on the 1-gpm hydroclone for the same purpose with rigidly controlled flow conditions. Similar sampling was done.

A scouting series of tests was performed during Thorex run AWD-1 on the 1-gpm hydroclone to determine the change in performance with 6% TBP. The same sampling and operational pattern as above was followed.

3.4 Analyses Used

The samples taken were analyzed for water content, radioactivity, and visible crud content.

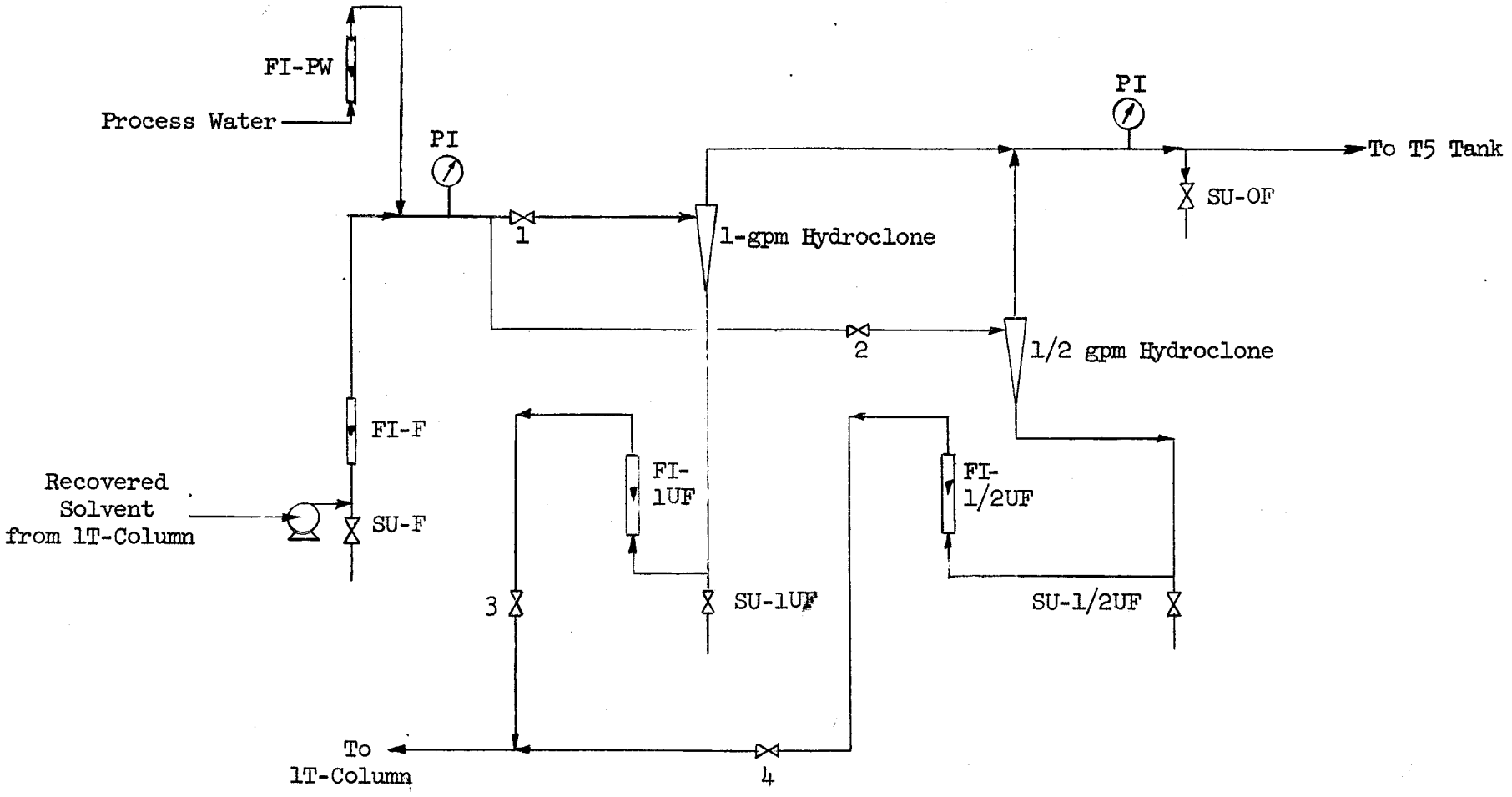


Fig. 3.2. Hydroclone Unit in the Solvent Recovery System

Legend:

F - Clone Feed

OF - Clone Overflow

UF - Clone Underflow

The water was found to exist as soluble water in the organic phase and as a separate phase. Karl Fischer[a] water analyses were performed to determine the aqueous concentration in the organic phase. The water content as a separate phase was measured by micropipetting when very small and by relative volumes when appreciable.

The activity of the samples was determined on the basis of scintillation gross gamma counts in one of two control laboratories. In both laboratories samples which were entirely an organic phase were untreated before counting.[b] Two-phase samples were centrifuged and the organic phase counted in one laboratory, while in the other laboratory similar samples were made miscible with absolute alcohol and then counted. Analytical work showed the aqueous phase, when present, had activity of the same magnitude as that of the organic phase.

Although crud had been seen in previous Thorex runs, the quantity present during runs HD-26 and AWD-1 was not large enough to be analyzed by gravimetric methods. The presence of crud, therefore, is included in the term "quality."

4.0 RESULTS AND DISCUSSION

4.1 Data

All pertinent experimental data may be found in Sect. 5.2.

4.2 Solvent Properties

The percentage of water entering the solvent was a direct function of the per cent TBP; the values plotted in Fig. 4.1 were obtained with solvent contacted with an equal volume of water, and for low percentages of TBP, they approximately represent saturation solubility values. The hydroclone feed solvent contained 0.9 to 1.4 volume per cent water (Table 4.1) with the approximate saturation value indicated by Fig. 4.1 being 1.4 volume per cent.

---

[a] Analytical method purportedly accurate to 3%. Standard deviation was found to be 2.3%. Analyses influenced by 0.1 M Na_2CO_3 from the solvent recovery column, but to only 0.3%.

[b] Centrifuged organic samples exhibited activity gradients sporadically, indicating the random appearance of particulate matter.

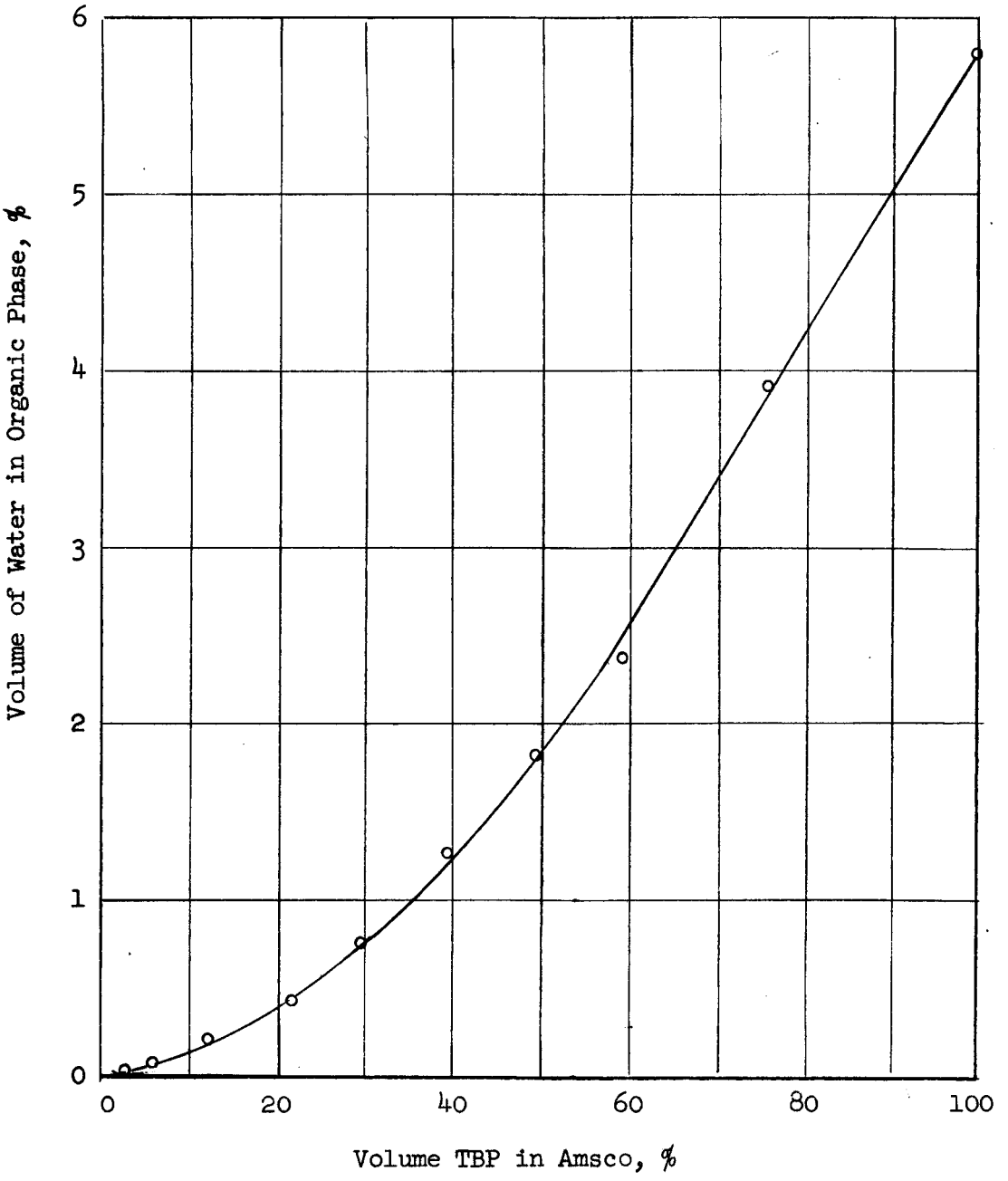


Fig. 4.1 Per Cent Water Dissolved in the Thorex Solvent as a Function of the Per Cent TBP in Amsco

The data represent water readily dissolved in the TBP and, in general, do not represent maximum solubility.

4.3 Effect of Hydroclone Operation on the Solvent

Since the feed to the hydroclones was from an organic continuous column, the presence of a separate water phase was infrequent (occurring during these tests 8 of 112 times and ranging in volumetric water per cent from 0.04 to 1.23, with an average value of 0.4 per cent). The effect of water purging was therefore determined.

Without water purging, a random distribution of aqueous in the solvent was noticed along with an overflow having the same clarity as the preceding feed (Table 4.1). With minute amounts of crud present the same relation was seen, i. e., the hydroclone without water purging had no pronounced effect on the solvent.

With water purging, the dissolved water concentration in the overflow organic was appreciably higher than it was in the feed before water contacting (Table 4.1). This water purge before the hydroclones increased the aqueous in the organic phase seemingly in direct proportion to the variation of the water concentration in the feed from saturation. Water purging, in addition, had no marked effect on solvent clarity or crud distribution[a].

4.4 Water Separation Factors Attained

The presence of the water in the organic and the effect of the hydroclone upon it (Sects. 4.2 and 4.3) complicated evaluation of system performance.

The water present in samples was considered as the per cent water as a separate phase alone (denoted the "phase" water basis). This basis evaluated the liquid-liquid separation effect, considering the system to be two immiscible phases (the way it was seen by the hydroclones).

Water separation factors on the basis of phase water are found in Fig. 4.2 for the 1-gpm hydroclone and Fig. 4.3 for the 0.5-gpm hydroclone; these data represent the possible liquid-liquid separations in the system. Operation of the larger clone was better, giving more consistent results, and the SF_w results of this clone were a factor of 1.5-6 higher than for the smaller clone under the same pressure drop. Whether this was an effect of an increased throughput due to the larger diameter (0.500 in. to 0.400 in.) or an effect of decreased shear through a lower than scale-up entrance velocity (entrance dimensions: 1 gpm - 0.100 in. x 0.125 in.; 0.5 gpm - 0.080 in. x 0.080 in.) is not known.

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[a]Although insufficient crud to analyze appeared during these runs, no directed trend of the observable crud to the underflow was seen. In run CF-17, during which testing procedures were developed, a random distribution of crud, then appreciable and unaffected by water addition, to both the overflow and underflow was seen.

Table 4.1. Effect of Water Purging on Dissolved Water in the Organic Phase

Clone, gpm	Purge	Water Dissolved in Organic Phase, %[a]		
		Feed	Overflow	Underflow
1	No	1.08	1.05	1.19
1	No	1.09	1.16	1.17
1	No	1.20	1.21	1.16
1	No	1.26	1.25	1.27
1	No	1.33	1.38	1.38
1	No	1.37	1.40	1.48
0.5	No	0.89	1.06	0.94
0.5	No	0.97	1.15	1.11
0.5	No	1.04	1.01	1.04
0.5	No	1.06	0.97	0.94
0.5	No	1.21	1.25	1.28
0.5	No	1.30	1.23	1.23
1	Yes	0.90	1.05	0.97
1	Yes	0.91	1.07	1.03
1	Yes	1.02	1.19	1.09
1	Yes	1.04	1.21	1.16
1	Yes	1.20	1.28	1.31
1	Yes	1.26	1.36	1.34
1	Yes	1.31	1.42	1.38
1	Yes	1.34	1.43	1.40
0.5	Yes	1.10	1.26	1.30
0.5	Yes	1.19	1.33	1.31
0.5	Yes	1.21	1.31	1.34
0.5	Yes	1.24	1.33	1.32
0.5	Yes	1.35	1.39	1.39
0.5	Yes	1.38	1.41	1.41

[a]Coulometric water determinations using the Karl Fischer reagent.

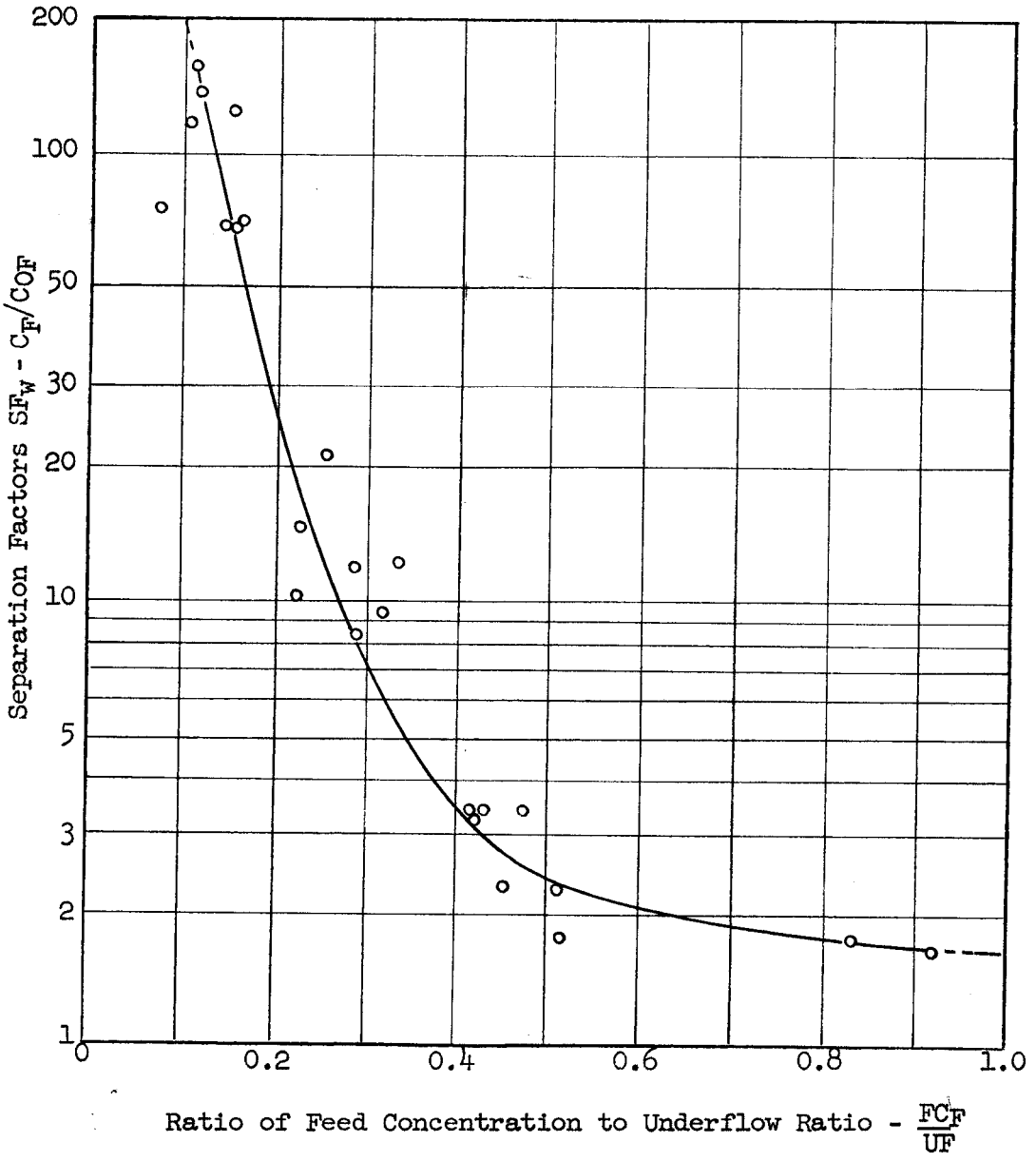


Fig. 4.2. Separation Factors Attained with a 1-gpm Hydroclone

System: 42.5% TBP in Amsco-Water

Conditions:

ΔP 16-17 psi

C_F 1.3-10.7% water

C_F, C_{OF} Based on water present as a separate phase

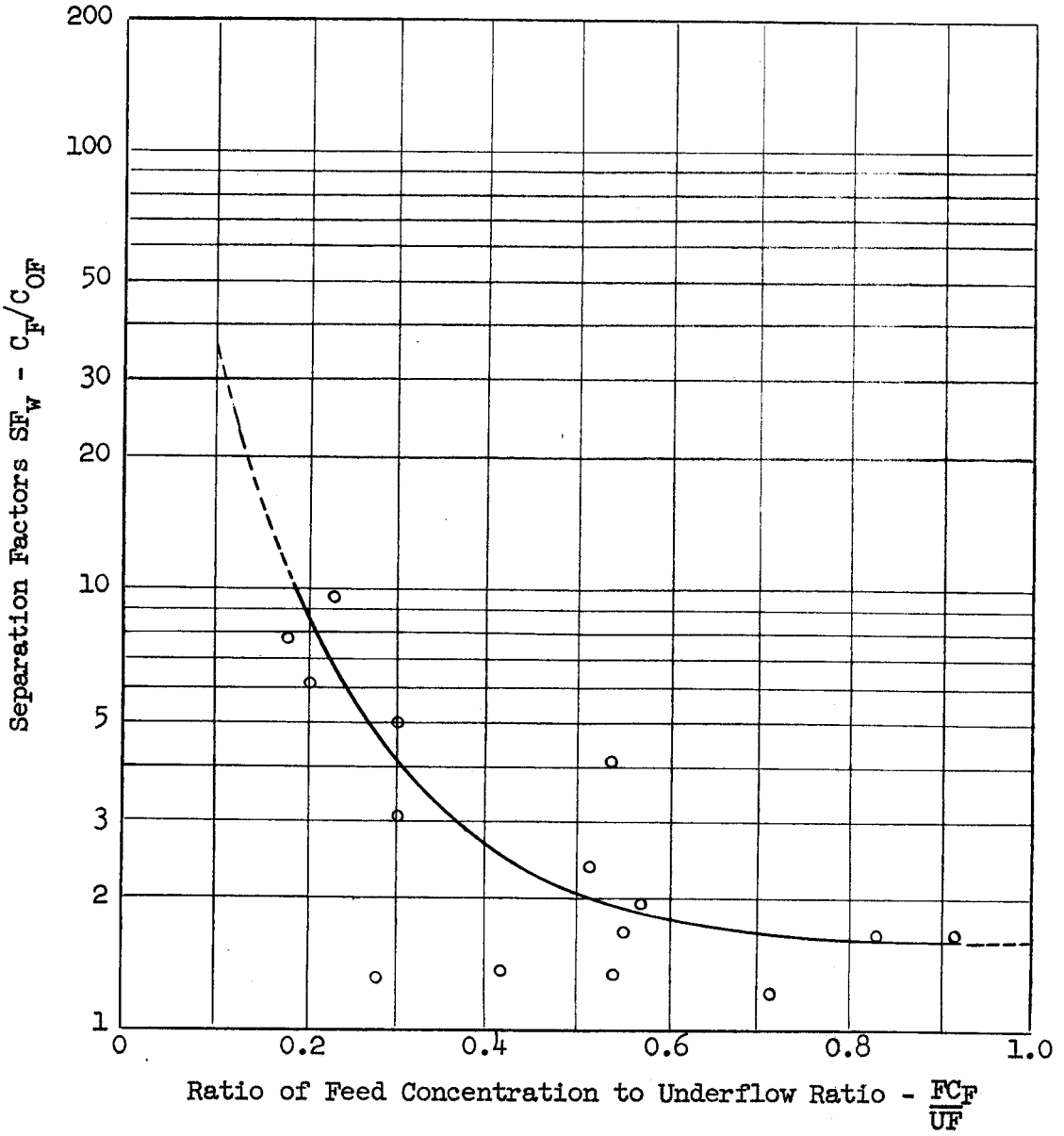


Fig. 4.3. Separation Factors Attained with a 1/2-gpm Hydroclone

System: 42.5% TBP in Amsco-Water

Conditions:

ΔP	17 psi
C_F	4.0-13.0% water
C_F, C_{OF}	Based on water present as a separate phase

Separation factors obtained with 6% TBP are seen in Table 4.2.

Table 4.2. Water Separation Factors Attained With the 1-gpm Hydroclone and 6% TBP-Amsco

Run	C_F Phase	C_{OF} Phase	SF_W on C_F, C_{OF} Phase	$\frac{FC_F}{UF}$
5	4.66	0	∞	0.093
2	4.81	0	∞	0.128
6	9.33	0	∞	0.185
3	9.58	0	∞	0.243

Complete phase separation is seen with values of FC_F/UF of 0.09 to 0.24, with the total range of control function values giving this effect unknown.

Table 4.3 below shows the phase density and interfacial tension of the two solvents:

Table 4.3. Phase Density and Interfacial Tension of 6% and 42.5% TBP-Amsco Mixtures

Solvent	Specific Gravity			Interfacial Tension, dynes/cm^2
	Aqueous Phase	Organic Phase	Difference	
42.5%	1.0	0.84	0.16	10.7 (pure H_2O-42.5% TBP 12.5 (process H_2O-42.5% TBP)
6%	1.0	0.76	0.24	16.6 (pure H_2O-6% TBP)

Contrasting these variables with operational performance, it is seen that the SF_W is better with 6% TBP---the solvent having the higher interfacial tension and greater specific gravity difference. (These results are in accord with theoretical predictions.)

4.5 Solvent Decontamination

The hydroclones as installed in the Thorex solvent recovery system were not decontamination devices. Through all operating conditions (UF/F ratios of 9 to 50% and no water purge to 12.5% water--giving control function values of 0.02 to 1.2) with hydroclone feed activity varying from 100-9000 γ cts/min/ml the hydroclones produced primarily a decontamination factor of 1 to 3

(see experimental data, Sect. 5.2). No significant variation of decontamination factor with any process operation was noticed, even to the extent of maintaining a consistent decontamination factor of 3; the system did not repeat.

No effect was seen with this factor of 90 variation in solvent activity, and with increased activity (2×10^6 γ cts/min/ml or a factor of 2×10^4) found in short-decay runs (SD-1), the obtainable decontamination factor with the system operated with no water purge was still 1 to 3 (Table 5.5).

Table 5.4 gives the hydroclone decontamination factor with 6% TBP. The decontamination was of the same magnitude as with 42.5% TBP, with a trend toward higher values with no water purge.

4.6 Miscellaneous Observations

Process liquid-liquid separation with hydroclones should have automatic-controlling instrumentation. Plants such as Thorex in which the hydroclone unit functioned primarily as a safety device can operate without this instrumentation since varying performance has little effect; in this case an empirical relation for flow conditions can be established, such as designing the underflow as feed flow/3, permitting a high underflow which will aid particulate removal and give low values of the control function for separation of the infrequently appearing water phase. The hydroclone unit as shown in Fig. 3.2 has the minimum instrumentation necessary for accurate manual process control; a system having two identical hydroclones would be preferable.

In general, liquid separation in a TBP-Amsco system will increase as the per cent TBP decreases, due to an increasing specific gravity difference and an increasing interfacial tension.

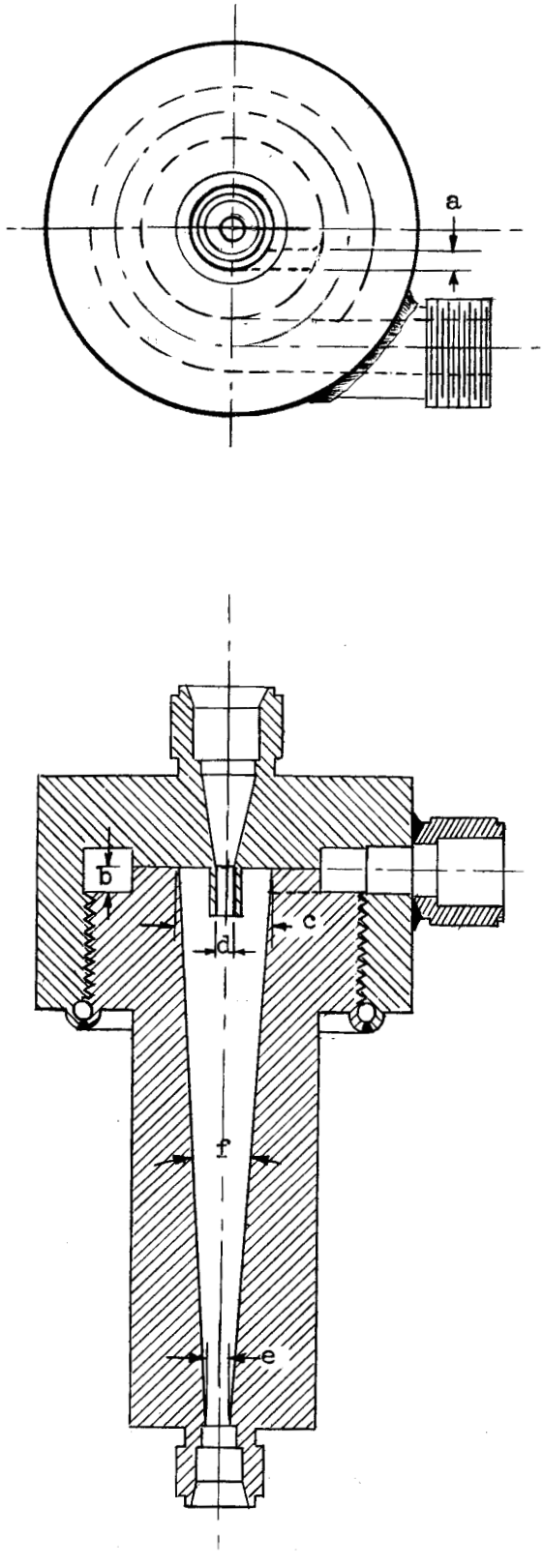
5.0 APPENDIX

5.1 Hydroclone Description

The significant dimensions of the Thorex hydroclones are shown below (Fig. 5.1).

ORNL drawings D-H PP-43 (1-gpm) and D-H PP-44 (0.5-gpm), show construction details.

5.2 Tables of Data (continued page 17)



Hydroclones		
	gal/min	
Dimensions	1/2	1
a	0.080"	0.100"
b	0.080"	0.125"
c	0.400"	0.500"
d	0.075"	0.125"
e	0.100"	0.125"
f*	$5^{\circ}30'$	$7^{\circ}10'$

*Angle of taper.

Fig. 5.1 Hydroclones for Solvent Recovery

Table 5.1. Experimental and Computed Data on the 1-gpm Hydroclone - Extended Tests[a]

Thorex Run HD-26: Solvent 42.5% TBP in Amsco

Run	Feed		Overflow		Underflow	F[b]	UF	H_2O				
	C_F[c]	C_F[d]	C_{OF}[c]	C_{OF}[d]	C_{UF}[d]		liters/hr		SF_w[c]	FC_F/UF[c]	DF[e]	ΔP, psi
1	0	1.13	0	1.14	1.17	182	19	0	-	-	1.0	17
2	0	1.25	0	1.32	1.33	174	37	0	-	-	1.2	17
3	0	1.17	0	1.21	1.31	176	54	0	-	-	2.2	17
4	0	1.24	0	1.32	1.30	172	74	0	-	-	-	17
5	0	1.32	2.11	2.89	54.1	132	17	8.0	2.7	0.473	-	11
5G	0	1.31	2.08	3.50	57.9	130	13	7.3	2.6	0.563	-	10
6	0	1.18	0.28	1.59	22.5	166	35	8.2	16.8	0.235	1.50	15
6G	0	1.26	0.17	1.53	22.5	166	36	8.5	29	0.236	0.8	15
7	0	1.16	0.07	1.30	12.9	168	59	8.5	69	0.144	3.5	17
7G	0	1.18	0.08	1.36	13.0	162	58	9.1	67	0.157	1.2	16
8	0	1.12	0.04	1.23	13.3	170	78	8.2	115	0.105	1.6	17
8G	0	1.20	0.03	1.31	10.9	166	72	8.0	153	0.111	-	17
9	0	1.05	10.7	11.8	64.8	148	17	17.5	0.98	1.02	5.6	13
9G	0	1.13	10.9	12.2	68.5	150	17	17.5	0.95	1.03	2.3	13
10	0	1.03	2.77	3.98	44.5	164	36	17.0	3.4	0.471	1.9	16
10G	0	1.23	4.55	5.91	50.4	160	41	18.5	2.3	0.451	-	16
11	0	1.01	0.82	1.98	24.6	157	58	16.6	11.7	0.287	2.8	17
11G	0	1.08	1.18	3.34	32.3	146	55	17.5	9.0	0.318	1.2	16
12	0	0.96	0.69	4.79	22.4	162	77	17.5	14.1	0.227	2.7	17
12G	0	1.16	0.96	2.11	20.2	162	78	17.5	10.1	0.225	-	17

[a]Data recorded is the average for the 12-hr run. Runs labelled G show the data for the third sampling in the 12-hr runs with water addition and are also considered representative.

[b]Before water addition.

[c]Basis is phase water.

[d]Basis is total water (phase water + soluble water).

[e]Activity: $0.1\text{-}3\times10^3$ γ c/m/ml.

Table 5.2. Experimental and Computed Data on the 1-gpm Hydroclone - Short Tests[a]

Thorex Run HD-26: Solvent 42.5% TBP in Amsco

Run	Feed[b]		Overflow		Underflow		F^b	UF	H_2O	SF_w[c]	FC_F/UF[c]	DF[e]	Δ P
	C_F[c]	C_F[d]	C_{OF}[c]	C_{OF}[d]	C_{UF}[c]	C_{UF}[d]	liters/hr						
1	0	1.12	0	1.20	0.30	1.63	185	18	0	-	-	1.4	16
2	0	1.04	0	1.27	9.90	11.2	185	46	2.5	∞	0.054	1.4	16
3	0	1.09	0.05	1.37	7.35	8.66	180	93	7.0	75	0.075	1.4	16
4	0	1.05	0.01	1.28	-	-	180	22	2.5	137	0.114	1.8	16
5	0	0.96	0.03	1.30	15.8	17.0	180	46	7.0	125	0.151	2.2	16
6	0	1.14	0.02	1.25	8.00	9.22	180	16	2.5	70	0.163	1.6	16
7	0	0.99	0	1.21	18.0	19.3	177	30	7.0	∞	0.236	1.1	16
8	0	1.14	0.39	1.61	21.4	22.8	177	62	16.0	21	0.257	1.6	16
9	0	1.13	0.46	1.74	28.2	29.5	177	24	7.0	8.3	0.289	1.4	16
10	0	1.19	0.67	2.00	36.5	37.8	174	47	15.7	12	0.334	1.7	16
11	0	1.17	0.46	1.74	31.6	32.9	177	18	7.0	8.2	0.388	1.4	16
12	0	1.16	2.48	3.77	24.5	25.8	173	39	16.1	3.4	0.415	1.8	16
13	0	1.16	2.78	4.11	53.7	55.0	177	23	11.8	2.25	0.511	1.6	16
14	0	1.11	4.93	6.23	36.9	38.2	173	32	16.3	1.75	0.513	1.8	16
15	0	1.21	1.82	3.11	55.6	56.9	167	18	12.1	3.71	0.675	1.1	15
16	0.01	1.31	2.91	4.77	54.8	56.1	165	25	16.3	3.08	0.650	1.8	15
17	0.01	1.22	1.52	2.86	41.7	42.9	152	22	12.7	5.08	0.589	1.7	13
18	0	1.18	0	1.30	0.03	1.26	180	86	0	-	-	1.3	16
19	0	1.21	5.03	6.35	45.4	46.7	170	20	16.3	1.74	0.832	1.8	16
20	0	1.20	5.57	7.03	61.7	63.0	150	17	15.7	1.67	0.920	1.7	13

[a]Recorded data is for 15-min settings which were continuously maintained and undisturbed after sampling.

[b]Before water addition.

[c]Basis is phase water.

[d]Basis is water (phase water + soluble water).

[e]Runs 1-14: activity $1\text{-}3\times10^3$ γ c/m/ml; runs 15-20: activity $2\text{-}4\times10^2$ γ c/m/ml.

Table 5.3. Experimental and Computed Data on the 0.5-gpm Hydroclone - Extended Tests[a]

Thorex Run HD-26: Solvent 42.5% TBP in Amsco

Run	Feed[b]		Overflow		Underflow	F[b]	UF	H_2O	SF_w[c]	FC_F/UF[c]	DF[e]	ΔP, psi
	C_F[c]	C_F[d]	C_{OF}[c]	C_{OF}[d]	C_{UF}[d]	liters/hr						
1	0	0.99	0	1.05	1.01	101	19	0	-	-	1.1	17
2	0	1.06	0	1.05	1.02	101	29	0	-	-	1.3	17
3	0	1.23	0	1.21	1.23	148	40	0	-	-	1.6	17
4	0	1.19	3.33	4.65	41.4	132	21	6.0	1.31	0.286	1.2	17
5	0	1.19	1.25	2.60	25.3	111	11	6.0	4.1	0.545	1.2	7
6	1.18	2.64	0.63	1.98	23.3	116	31	6.0	9.6	0.238	1.1	15
7	0	1.22	0.69	2.00	17.1	136	30	6.0	6.1	0.201	1.2	17
8	0	1.19	0.53	1.86	18.8	136	32	6.0	7.8	0.183	1.0	17
9	0	1.27	5.08	6.36	53.2	109	21	12.0	1.95	0.570	1.7	17
10	0	1.22	5.26	6.60	27.9	136	19	10.3	1.34	0.540	1.7	17
11	0	1.12	5.88	7.18	38.3	110	22	12.1	1.69	0.551	1.5	17
12	0	1.09	5.63	6.84	33.8	146	29	12.1	1.36	0.416	1.9	17
13	0	1.36	7.81	9.17	65.4	116	17	12.1	1.21	0.712	1.6	17
14	0	1.25	1.82	3.15	35.7	121	40	12.1	5.0	0.302	1.7	17
15	0	1.25	4.29	5.59	41.7	121	27	13.9	2.40	0.515	0.8	17
16	0.04	1.36	2.99	4.36	32.5	121	40	12.1	3.05	0.302	1.2	17
17	0	1.14	7.86	9.03	48.5	117	19	17.5	1.65	0.918	2.0	17
18	0	0.97	8.00	9.03	45.7	118	21	17.5	1.62	0.831	2.4	17

[a]Data for runs of 3 to 12 hr duration with 1 sampling every 3 hr. The variation in run length is due to the erratic operation of this hydroclone.

[b]Before water addition.

[c]Basis is phase water.

[d]Basis is total water (phase water + soluble water).

[e]Activity: $0.1\text{-}9 \times 10^3$ γ c/m/ml.

Table 5.4. Experimental and Computed Data on the 1-gpm Hydroclone[a]

Thorex Run AWD-1: System 6% TBP in Amsco

Run	Feed[b]		Overflow		Underflow	F^b	UF	H_2O	FC_F/UF^c	$SF_w{}^c$	DF^e	ΔP, psi
	$C_F{}^c$	$C_F{}^d$	$C_{OF}{}^c$	$C_{OF}{}^d$	$C_{UF}{}^d$	liters/hr						
1	0	0.09	0	0.07	0.07	170	60	0	-	-	1.5	15
2	0	0.06	0	0.07	13.51	168	66	8.5	0.128	∞	1.0	15
3	0	0.06	0	0.07	25.7	165	72	17.5	0.243	∞	1.0	15
4	0	0.06	0	0.07	0.07	174	85	0	-	-	3.6	15
5	0	0.06	0	0.07	8.68	174	92	8.5	0.093	∞	1.2	15
6	0	0.07	0	0.07	19.5	170	95	17.5	0.185	∞	1.2	15

[a]Each run was of 2 hr duration, closely controlled.

[b]Before water addition.

[c]Basis is phase water.

[d]Basis is total water (phase water + soluble water).

[e]Activity: $0.1\text{-}4 \times 10^4$ γ c/m/ml.

Table 5.5. Decontamination Across Hydroclone Observed During Thorex Run SD-1

(1-gpm hydroclone operating with no water purge at an underflow ratio of 1/3)

Sample, 1-Day Intervals	Feed, Sc γ c/m/ml	Overflow, Sc γ c/m/ml	DF
1	1.1×10^6	9.3×10^5	1.2
2	2.0×10^6	1.8×10^6	1.1
3	3.1×10^6	1.2×10^6	2.6
4	4.0×10^6	4.0×10^6	1.0

5.3 Material Balances

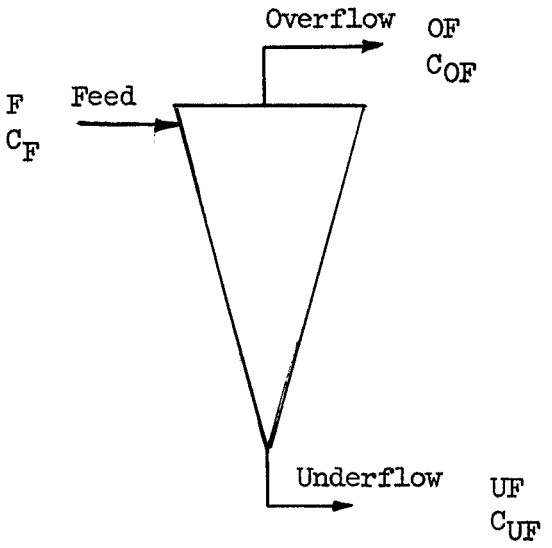
Water material balances were run throughout the tests. Errors were sometimes high--an expected result when balancing the minor stream constituent.

Water balances $\left[\frac{\text{output}}{\text{input}} \times 100\right]$ with no aqueous addition varied from 99 to 106 per cent. The majority of these balanced within analytical error; the ones not falling in this category could be attributed to poor sampling.

Water balances with aqueous addition varied between 77 and 157 per cent, with average values of 92 and 116 per cent.

6.0 GLOSSARY

F, OF, UF	Feed, overflow and underflow volumetric flowrates
UF/F	Underflow ratio
C_F, C_{OF}, C_{UF}	Volume fraction water as a separate phase in the feed, overflow and underflow streams
SF_w	Separation factor for water removal from the solvent in the overflow, C_F/C_{OF}
$\frac{FC_F}{UF}$	Control function, ratio of the feed concentration to underflow ratio



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