Notebook of

Captain John A. Anthes, Ph.D.

U.S. Army Corps of Engineers
Manhattan Engineering District
Madison Square Area
Special Materials

(page numbers not original)

A- Problems

New shipment order for helium
22414 for 2000 cyls.

616

616 Requirements for Kellex Test Floor

Requirement 4220#
Delivered 417#
Due 3803#

100#/week 3/4 to 5/6 inc
200#/week 5/13 to 6/10 inc.
100#/week June 17 to Oct 14 inc

1000 + 1000 + 1800 = 3800

Vapor Pressure of C-616

t °C	p mm Hg	p Atm	p #/in² abs
-183 b.p.	10^{-19}		
-103.8	1.3×10^{-5}		
-78.5 sub	1.7×10^{-3}		
0	17.5		
5	26.0		
10	38.0		
20	79		
30	156		
40	285	0.38	5.5
50	510	0.67	9.9
60	900	1.18	17.4
70	1385	1.82	26.8
80	1870	2.46	36.2
90	2455	3.24	47.6
100	3300	4.35	64.0

Melting Pt. Approx 65°C

C-616 Requirements for Large Plant

2000#	Aug 1, 1944
28,000	Sept 1
2000	Oct 11
3000	Nov 15
20000	Dec 15
15,000	Jan 15, 1945
15,000	Feb 15

Plus 150,000# in storage by Nov. 1
Plus 2150#/day beginning Jan 1, 1945

N.Y.A. 12 May 1944

HF < 0.03% by wt.
MoF_6 < 0.01% "
Fluorcarbons < 0.1% "

Letter 15 May 1944
Rosen to Bichowich

Off Gas

(a) 65# / day from test floor
starting 15 Aug 1944

(b)

Properties of F_2

Color Greenish yellow gas, yellow liquid, light yellow or white solid.

MW 38

Density Gas 1.31 (air) 15°C
Liquid 1.11 @ -187°C
Solid 1.3 @ -223°C

MP -223°C (50°K)

BP -187°C (86°K)

Volume Spec. Vol. of liq. 0.9025 cc/gm.
Mol. vol. " " 34.30 cc/mol.
Coeff. of expans. " 0.000304

Critical constants
Temp. 144°K (Cady)
Press. (calc) 55 atm. (Cady)
Vol. " 44.14 cc/mol. (RCD.)

Properties of F_2 (cont.)

Parachor 25.7

Decomp. Voltage 1.75 v.

Latent heat of vap. 1540 cal/mol.

" " " fusion 191 cal/mol.

Spec. Heat (C_p) $6.5 + 0.0011T$

Surface Tension Liquid

T° abs.	dynes/cm
61.41	13.85
65.20	13.17
71.00	12.20
81.50	10.41

Entropy

S° at 298°K + 1 atm = 48.6 cal/deg.

S at 82.19°K = 37.29 cal/deg.

Properties of F_2 (cont)

Vapor pressure

$\log P_{cm} = 7.3317 - \frac{406.8}{T} - 0.0077857T$

based on measurements from 72.53°K to 85.99°K

T°K	V.P. cm
72.53	14.54
76.70	27.10
80.09	43.00
84.13	68.64
85.99	85.50

R. P. Downing
Jackson Lab.
12/21/43

Large packaging equipment can load four cylinders per day (216#)

C-216 at site

Mar 1944	50#/day
Apr	100#/day
May	"
June	150#/day
July	150#/day
Aug. + thereafter	200#/day

Specs

HF	≯ 0.03% by wt.
MoF_6	≯ 0.01% by wt.
Total CF	≯ 0.1% by wt.

probably should be

N_2	< 1%
O_2	< 1%
HF	< 1%

C-216 for Test Flow

Date	Increment	Total
2/1/44	10#	10#
3/1/44	10#	20#
4/1/44	10#	30#

816 Costs

On 90% attainment basis

Plant exclusive of fee (816 only)
6,400,000
Opr. 11,700,000 (incl. P-45 @ 1.44/#)
18,100,000 → 5.05/# (90%)
4.55 est
816 less P-45 $77.75/gal

plant 6,400,000
Opr 9,200,000
15,600,000 → 4.15 (90%)
3.75 est.

2144
FL incl F&S rec. for starting from eng 47
plant 1,100,000
Opr 2,100,000
3,200,000
FL excl F&S from eng 47
plant 1,100,000
opr 1,800,000 excl. after treating
2,900,000

816 (7000#/day) .63# OG/# 816

716 (200#/day) 3.0# OG/# 716

FL (25-75#/day) 3.0# OG/# 2144

4400
600
75
5075 # OG/day

5000 × 4 = 20,000
× 1 = 5,000
15,000 saving

Properties

	716	816
M.W	388	400
B.P °C	82.43	101.9-102.1
d 20°	1.733	1.854
SIC	1.765	1.85-1.88
F.P. °C	-53.85	ca -55°C

	P-45
MW	214
BP °C	115.7
d 20°	1.395
SIC	3.6
FP °C	-47.12

C-716 Requirement

	Gal	Cum	Lbs	Cum. Lbs.	Ship. Date
May 1	65	65	936	936	4/15
June 1	65	130	936	1872	5/15
July 1	130	260	1872	3744	6/15
Aug 1	130	390	1872	5616	7/15
Sept 1	130	520	1872	7488	8/15
Oct 1	260	780	3744	11,232	9/15
Nov 1	520	1300	7488	18,720	10/15
Dec 1	900	2200	12,960	31,680	11/15
Jan 1	900	3100	12,960	44,640	12/15

Plus 100#/day beginning Nov. 1, 1944

N.Y.A. 12 May 1944

Factor 14.4

SWMcC 1/10/44

Test Floor

C-716 Sealant

Req. 200 gal.
Del. 1 gal
Due 199 gal

100 gal by 2/1	1440#
99 gal by 2/15	1426#
	2866#

C-716 Coolant

Req. 1200	2/1	250 gal	3600#
Del. 78	2/15	737 gal	10613#
Due 1122	2/15 *	135 gal	1944#
		1122 gal	16,157#

987
130
1117

16157
2866
19023
1123
20146

Cumulative #

2/1	3600#	Kellex
2/15	14213#	Kellex
2/15	16157#	K+Chrysler

* Date for Chrysler shipment is not definite

C-716 Specs

	Coolant	Sealant	2nd Order
Acidity	Nil	Nil	Nil
Residue	< 1%	< 0.1%	< 0.15%
ASTM Dist.			
IBP	≮ 86°F	≮ 172°F	— — —
5%	—	≮ 174°F	≮ 174°F
95%	—	≯ 183°F	≯ 185°F
Dry Pt.	≯ 266°F	—	≯ 182°F ± 6°
Cloud Pt.	< 68°F	—	< 68°F
Z. 714	—	—	≯ 2% above Std.

C-816 Specs

Mol % 7/4 as ϕmethyl Cyclohexane + Methyl Cyclopentane	[redacted] above Std. < 0.5% Std. No. GD-1208C
Acidity	Nil
Inertness Residue 3 hrs @ 212°F	< .15 %
Cloud Point	< 68°F
ASTM Dit.	
IBP	≯ 172°F
Dry Point	≯ 266°F

Requirement

Date	Gals.	Cum Gals	Cum. Lbs.
Apr 1, 44	10,000	10,000	154,300
June 1	20,000	30,000	
Sept 1	30,000	60,000	
Oct 1	30,000	90,000	
Nov 1	25,000	115,000	
Dec 1	25,000	140,000	
Jan 1	10,000	150,000	
Daily from Jan 1.	100	1540±	

Shipments of C-716 toor for Kellex

Week Ending	Lbs.	Total #	Shipped to:
6/10/43	50	50	The Elliott Co.
7/15/43	71	121	Columbia U.
8/12/43	1½	122½	Kellex (Sealant)
8/19/43	8	130½	Col. U. (Sealant)
8/26/43	15	145½	Westinghouse
"	73 75	220½	Ingersoll-Rand
"	125	345½	Kellex
9/16/43	82½	428	Westinghouse
9/23/43	50	478	Allis-Chalmers
10/7/43	120	598	Bryant Chucking Grinder
11/11/43	15	613	Linde Air Products
11/18/43	73½	686½	Kellex
11/25/43	394	1080½	Kellex
2/ /44	3525	4605½	Kellex

C-816 Requirement

Date	Gal.	Cum. Gal.	Lbs.	Cum. Lbs.	Tons
4/17	300	300	4620	4620	2.3
5/15	3200	3500	49,280	53,900	26.95
6/1	1500	5000	23,100	77,000	38.5
7/15	12,000	17,000	184,800	261,800	130.9
8/15	11,000	28,000	169,400	431,200	215.6
9/15	16,000	44,000	246,400	677,600	338.8
10/15	30,000	74,000	462,000	1,139,600	569.8
11/15	13,000	87,000	200,200	1,339,800	669.9
12/15	25,000	112,000	385,000	1,724,800	862.4
1/15	19,000	131,000	292,600	2,017,400	1006.7
2/8	19,000	150,000	292,600	2,310,000	1155

Plus 100 Gal/day beginning 1 April 1945

N.Y.A. 12 May 1944

Eng 6 C-816 schedule

	#
by 4/1	4620
5/1	53,900
6/1	77,000
7/1	261,800
8/1	431,000
9/1	627,600
10/1	1,114,000
11/1	1,340,000
12/1	1,725,000
1/1	2,017,000
2/1	2,314,500

duPont Data	BP
$C_5F_8(CF_3)_2$	71.47-71.54
$C_5F_9C_2F_5$	75.064
$C_6F_{11}CF_3$	76.316
C_7F_{16}	82.434
$C_7F_{15}H$	87.5-91.9
$C_7F_{14}H_2$	95.3

"Material boiling 71.68 to 73.73 is quite pure 714 (SIC ca 1.85) Fract. 73.72 to 74.84 prob. stable hydro 714 (residue 0.038, SIC 2.20).

P-45 Schedule

Memo 11 April '45 WMH

	P-45	P-45CL
May	40,000	
June	110,000	4000
July	165,000	11,000
Aug	185,000	~~20,000~~ 16,500
Sept	185,000	~~20,000~~ 19,500
Oct	185,000	~~20,000~~ 19,500
Nov		~~5,000~~ 11,500
	870,000	80,000

C-816 Requirement

Aug/May	K-25	K-27	Total
1 June	115,500		115,500
1 July	231,000		231,000
1 Aug	346,500		346,500
1 Sept	462,000		462,000
1 Oct	693,000	154,000	847,000
1 Nov	808,500	462,000	1,270,500
1 Dec	924,000	693,000	1,617,000
1 Jan	1,039,500	788,500	1,828,000
1 Feb	1,155,000	825,500	1,980,500

P-45CL Specs

1. Water white
2. No sediment, no moisture visible
3. Cl not over 14.5% by Parr Bomb.
4. Distillation by Barrett method
   5% ✗ 140°C
   95% ✗ 157.5°C

C-2144 Specs.

Vis. @ 210°F	✱25±0.04 cp.
Inertness Residue	<0.3% by wt.
Acidity	Nil
Vapor Pressure 140°F	$< 8 \times 10^{-3}$ mm.
Water Content	<0.005% by wt.

Shipments of C-2144

Wk. Ending	#	Total #	Shipped to:
8/26	17.7	17.7	R. Rosen, Kellex
9/9	18.0	35.7	John Avery, A-C
10/28	29.4	65.1	John Avery, A-C
12/9	17.7	82.8	R.B. Jacobs, Kellex
12/9	8.8	91.6	S.C. Schumen, Kellex
12/23	85.8	177.4	J.R. McCordic, Chrysler
1/27	172.0	349.4	R. Rosen, Kellex
2/16	138.8	488.2	L. Van Orden, Kelley

C-2144 Requirement
N.Y.A. 20 July 1944

June 45 gal 45
July 135 " 135
Aug. 100 " 100
Sept. 110 " 100
Oct. 90 " 80
Nov. 85 " 135
Dec. 90 " 210
~~805~~
655

30 Dec 1944

		2144	MFL
Jan	45 206	129.5	166
Feb	217	76	162
Mar	200	65	152
April	224	69	146
May	289	54	126
June	142	77	48-60
	1168		

MRL for Site
3/15/45

March 1	120 gal
April 1	78.5 gal
May 1	165 gal
June 1	205 gal

Prices of D-29

Shredded Padding #20/lb
40% filled Sheets #14/lb.
Quote dated May 10

Tape 25/#
Preforms 22/# 16/#, filled
Sheets 20/#
Granular Polymer 15/#
Quote dated April 25
F.O.B. Arlington, N.J.

Sheets .050" thick or less
25/#
Quote dated 24 May

filled means 40% CaF_2

Prod 891A

37

$BF_3 \cdot (CH_3)_2O$ 890

B_{10} ---------- 891A

BF_3 - - - - Tribrid, Synthane

BCl_3 - - - - Chlorthane

$(CH_3)_2O$ — — { Monomer Product 88

Cost of 890A Est #830/gal.

38

Product 891A

Requirement Schedule

T T Fr. Stewart 30 June 1944 # 1185

1 Kg	As soon as possible
5 "	15 Sept 1944
10 "	15 Oct
15 "	15 Nov
20 "	15 Dec
25 "	15 Jan 1945
30 "	15 Feb
35 "	15 Mar
40 "	15 Apr
45 "	15 May
50 "	15 June

39

Receipts of 890A

Date	Quantity	Approx. Conc. A
Dec 8	5 gal	53
Jan 10	1 gal	80 ✓82
Jan 16	1 gal	82 - 84
Jan 23	10 gal	83 ✓85
Jan 30	10 gal	82 ✓83.5
Feb 6	10 gal	83 ✓85.5
Feb 13	10 gal	82 ✓84
Feb 20	10 gal	84.5 ✓85
Feb 27	10 gal	82.5

Shipments of 891A

	Date	Quantity	Approx. Conc. A
1	Dec 13	480g +22.625 lbs of CaF_2 complex	53
2	Dec 16	358g	53
3	Jan 17	1010g	~~81~~ 82
4	Jan 24	1202g	~~81~~ 83.5
5	Jan 31	2871g +333 lbs CaF_2 complex	~~82~~ 85
6	Feb. 7	2231g	~~82~~ 83.5
7	Feb 15	3382	~~83~~ 85
8	Feb 21	3285	84
9	Feb 28	3390	84.8
	Mar 7	1500	~~82.0~~
	Mar 14	2734	82

du Pont Densities

SW McC. 1/10/44 letter

C-716	
Coolant	14.4±.3 #/gal
Sealant	14.4#/gal.
2nd order	14.4#/gal
C-816	15.4#/gal
C-2144	16.7#/gal.
C-2144 crude	16.7#/gal.

C_8F_{16}

$C_8H_{10} \xrightarrow[-60°C\ 7\text{hrs}]{Cl_2\ light} C_8H_{10}Cl_6$

$C_8H_{10} \xrightarrow[100°C\ 24\text{hrs.}]{Cl_2\ light} C_8H_4Cl_6$

$\xrightarrow[Fe\ 16\text{h.}]{Cl_2} C_8HCl_9$

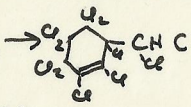
$C_8HCl_9 \xrightarrow[-60°\ 36\text{hrs.}]{Cl_2\ light\ 200W}$ O

200W
Cl_2 light
$+F_2$
$-60°$, 40hrs → O

Cl_2 light
60°C 36h → O

Cl_2 liq 100°C
8×500W
36h. → C_6HCl_9 + hexachlorobenzene + hexachloroethane

Might try Prins reaction with $CH{=}Cl_2$ on C_6Cl_{10} or

$C_6Cl_{12} \rightarrow$  C_8HCl_{13}

$C_8H_{10} \xrightarrow[light]{Cl_2} C_8H_4Cl_6$

$\xrightarrow[SbCl_5\ 140°C\ \text{at. pr.}\ 16\text{hr.}]{HF}$ $C_8H_4Cl_5F$, $C_8H_4Cl_4F_2$, $C_8H_4Cl_3F_3$

$C_8H_4Cl_3F_3$

$\xrightarrow[135°C\ 20\text{hrs}]{Cl_2\ F_2}$ $C_8H_2Cl_5F_3$, $C_8H_3Cl_4F_3$

62.8% Cl, 12.7% F ← liq Cl_2, 60°C, 8×500W

	Cl/6	F/15
$C_8H_3Cl_6F_3$	56	
$C_8H_2Cl_7F_3$	61	14
$C_8H_3Cl_8F_3$	65	13
$C_8H_2Cl_9F_3$	67	12.6

$C_8HCl_9 + HF \xrightarrow{SbCl_5}$ (good yield) $C_8HCl_5F_4$

Now trying to add Cl_2 60° light

Want $C_8HCl_{11}F_4$

then use SbF_5

Use of F_2 to induce chlorination

35g org. → 42g org.
80g Cl_2
6g F_2 −50°C.

$C_6H_2Cl_2(CF_3)_2$ → 34.4% Cl_2, 37.9% F_2
25.8% Cl_2
43.7% F_2

No reaction if F_2 not used

$C_8H_3Cl_2F_5$ → M.W. 290
26.6% Cl → 29.9%
34.3% F → 33.9%

107g → 128g

9.6g Cl_2 added
4.5g F_2 added

Might try

$C_6Cl_5CF_3 \xrightarrow[F_2]{Cl_2} C_6Cl_8F_3CF_3$

$C_6Cl_8F_3CF_3 \xrightarrow{HF} C_6Cl_2F_9CF_3$ (SbCl$_5$)

Suggested at last meeting

$C_4H_{10} \rightarrow C_4Cl_8H_2 \xrightarrow{HF} C_4H_2Cl_4F_4 \xrightarrow{-2HCl} C_4Cl_2F_4$

Gave 3 fractions

BP -5°
83°
120°

C_4F_6 B.P 5-8°
C_4Cl_6 B.P. 215

Miller dimerizes C_4F_6 at 135°C for 36 hrs in Ni tube

$C_4Cl_2F_4 \rightarrow C_8Cl_4F_8$?

not tried yet

$CCl_2=CCl-CCl_3 + Cu_2Cl_2 \rightarrow$

$CCl_2=CCl-CCl_2-CCl_2-CCl=CCl_2$

C_6Cl_{10} Prins

Perkins has had no luck getting good yields of this

C_2HCl_3

$CCl_2=CCl-\underset{|}{C}Cl-CCl_2-CCl=CCl_2$

object $C_{HCl}-CCl_3$

Might try

$C_6Cl_6 \xrightarrow{2Cl_2}$ $\xrightarrow{C_2HCl_3}$ $C_8Cl_{13}H$

$C_6HCl_5 \xrightarrow{3Cl_2}$ $\xrightarrow{-HCl}$

$C_8Cl_{13}H \xrightarrow[SbF_5]{HF} C_8Cl_6HF_7$?

$C_8Cl_6HF_7 \xrightarrow{?} C_8HF_{15}$ or C_8HClF_{14}

$CCl_2=CCl-CCl_3 + Cu_2Cl_2$

$\downarrow$

$CCl_2=CCl-CCl=CCl-CCl=CCl_2$

would like to get

$C_6Cl_2F_{12}$

MW 371
BP 100°C est.

Work on n-octane

$C_8H_{18} \xrightarrow[light]{Cl_2} C_8H_5Cl_{13}$

treatment with acetone gave 8% of a white solid

195.5-196°C M.P. MW 555
84% Cl

$C_8H_5Cl_{13}$	82% Cl	M.W.	562
$C_8H_4Cl_{14}$	83.2		597
$C_8H_3Cl_{15}$	84.3		632

C_6Cl_{14}		~~C_4Cl_8~~ C_6Cl_{12}	
72	71	72	71
497	7	426	6
569	497	498	426

Wojcik

Step I. fairly well worked out.

Step II indications of better results when carried out under pressure.

Antimony recovery. Nickel equipment will be Al lined. May be more economical not to try to recovery antimony. Equipment could be cheaper & more rugged.

Since cost of process beyond step II is much higher than I+II, it is economical to separate most highly fluorinated material from step II & recycle remainder

Fractionation of Hooker step II product. CP-323 2200g. Nonpress.

% of sample	B range °C	% Cl	% F
9	<120°, 50mm	40	39
23	70-79, 8mm	45	35
31	97-117, "	50	32
13	117-150, "	35	28
11	65-100 ½"	58	24
4	100-111 ½"	64	19
9	residue	68	14
	$C_7Cl_4F_8$ =	37	40
	$C_7Cl_8F_4$	64	19

Press. rem 1500g. CP 322

% of sample	B range	% Cl	% F	* F
37	<100, 50	33	48	C_4F_9
4	100-131, "	35	45	C_4F_8
28	<97, 8mm	40	42	C_4F_8
14	97-117, "	47	35	C_5F_7
7	117-130, "	53	30	C_6F_6
10	residue	tar		

This sort of technique might eliminate step III & maybe step IV

Steam distillation of step II product quite good separation and apparently less decomposition than vac. dist. Hydrolysis is about ½ of 1%. Distillation carried until instantaneous organic/H_2O ratio was 1/35. This was 85% of total. Overall organic/H_2O ratio was 1/4.5.

Fractionation of step I product to remove low boilers removes low boilers from step II product. So they are formed in step I.

CP-323 fraction 1 was chlorinated

$C_7H_{3.5}Cl_5F_{7.5}$ apprx.

↓ Cl_2 light, 50 hrs.

$C_7H_{1.2}Cl_{7.3}F_{7.5}$ apprx.

This should be put thru step II again

Dehydrohalogenation

$C_7H_4Cl_5F_7 \xrightarrow[CH_3OH]{NaOH} C_7H_2Cl_7F_6$

↓ SbF_5

$C_7H_2Cl_2F_{10}$ 30%

Cl_2 → $C_7H_2Cl_6F_6$ → ↓ SbF_5 → $C_7H_2Cl_2F_{10}$ 80%

AgF_2 → C_7ClF_{15}, $C_7Cl_2F_{14}$, C_7F_{14} not cyclic

AgF_2 → $C_7Cl_2F_{12}$ cyclic

$C_7H_4Cl_{12} \xrightarrow[+Cl_2\ 100°]{1\%\ CaO} 0$

$\xrightarrow[Cl_2]{1\%\ FeCl_3} 0$

$\xrightarrow[120°\ lite\ 22\ hr.]{100\#/in^2\ Cl_2} C_7H_3Cl_{13}$

CP-323 fract. $C_7H_4Cl_{5.5}F_{6.5}$ treated

$\xrightarrow[CH_3OH]{25\%\ NaOH}{}^{65°} C_7H_2Cl_4F_6$

" $\xrightarrow{25°C} C_7H_2Cl_{3.5}F_{6.5}$

Step IV

Modification to give H removal without Cl removal

Hooker Step II

↓ Step III

$C_7H_2Cl_2F_{12}$ → AgF_2 →

- 10% < 80°
- 5% C_7F_{16}
- 50% $C_7F_{15}Cl$
- 30% $C_7F_{14}Cl_2$
- 5% > 160°

Hooker Step 2 $-2HX \rightarrow$ ( )

↓ SbF_5

$C_7H_2Cl_2F_{10}$ → AgF_2 →

- 10% 75-78° C_7F_{14}
- 25% 98-105° C_7ClF_{15} + C_7ClF_{13} cyclic
- 30% 120-127° $C_7Cl_2F_{14}$ + $C_7Cl_2F_{12}$ cyclic

Total abt. 40% cyclic

Step V

Vapor phase unsuccessful, Gave no reaction or degradation

End Purdue Meeting

Oct. 23

JB Roberts
MA Perkins
~~Mayers~~ WA Menges
BH Wojcik
W Blumbloom
Omar Adams
JA Anders

Based on
100 gal (1500#/day)
New facilities
365 days/year
Site development not included.
Includes process bldgs, equipment, operating costs.

Operating cost
Labor
% Investment (maintenance)
Power

Process to be considered should be 20% better
$400,000. Therefore differences of less than $25,000 between Hooker & duP are not very significant.
Agreed to assume 50% Sb recovery in $SbCl_5$-HF step

Standard Unit Operations

Chlorination
HF autoclave (no Sb)
HF " + $SbCl_5$
Drying + solvent recovery
wash
Caustic dehydrohalogenation
plus drying
SbF_5
CoF_3 including wash
Deionization - pyrolysis
Distillation
2 - ale. Dehydrohal

14 processes

OG cost

duPont use actual figures on nickel cells adjusted for expected higher eff. and longer life for carbon cells. Investment costs only used.

Hooker figures based on design of CEW plant + operation of 1 C cell.

duPont OG invest

A based on nickel cell know how about 10 months ago
B adjusted to 90% eff and 90% operating attainment

	A	B	C
100 #/day	$185,000	$105,000	95
500 #/day	225,000	130,000	213
1000 #/day	355,000	210,000	291
2000 #/day	600,000	350,000	522
3000 #/day	750,000	440,000	

~~Hooker~~

Hooker C

Bldg, cells, D.C. converter, control equipt, misc equipt, 20% contingency, Engring, drafting, overhead. no fee

Compromise OG Investment Costs

150 #/day	175,000	~~175,000~~
400	210,000	~~200,000~~
750	280,000	~~240,000~~
1000	330,000	~~270,000~~
1500	440,000	~~365,000~~
2000	550,000	~~475,000~~
3000	770,000	~~650,000~~
4000	970,000	~~735,000~~

Process #2 (McBee 4 step)

HF-SbCl5 step

$C_7H_{16} \rightarrow C_7F_5Cl + C_7F_{16}$

dupont	Hooker	
0.86 #/#	.87 #/#	HF
0.78 #/#	0.157 #/#	$2 1/2 SbCl5
assume all new.	assuming 20% discard	
$4000	$3888	wash metals
$200,800	$177,665	Total cost

Proc. # 3 $C_7F_{14}Cl_2$ from C_7H_{16} 3 step.

same step

	dP	H	
HF	$150,000	$78,000	
	1.71 #/#	.906 #/#	
$SbCl_5$	$177,000	$18,360	
Misc	5,600	4000	
Total	$340,000	$205,000	
Invest	323,000	180,000	

Proc. 4B

	dP	H
HF	144,800	113,788
$SbCl_5$	192,000	30,182
Total	342,000	207,000

7D

HF	69,500	68,256
$SbCl_5$	127,000	25,600
Invest	201,000	148,000
	201,000	175,000

9D

	dP	H
HF	54,200	51,840
	101,000	26,000
Misc	5,000	2,100
Labor	2 men	2 1/2
Invest	252,000	157,500
Total	236,000	181,000

10 D

	dP	H
HF	37,7000	37,260
Sb	111,000	22,000
Misc	4400	1900
Labor	2 men	2⅓
Invest	323,000	159,000
Power	18,800	8,000
Total	280,000	182,000

11 B

	dP	H
HR	71,400	63200
	.182#/# (using MW used)	.73#/#
Sb	113,300	26,600
Misc	5000	
Invest	201,000	148,900
Power	13,000	7,765
Total	201,000	~~188,000~~ 175,900

Sb F5 steps including dist.

2C

	dP	H.
Sb+HF	291,000	106,000
dist	24" 20 plate column	12" 12 plate
labor	2¾	3
invest	218,000	133,000
Total	229,000	188,565

7 f

Sb+HF	205,000	113,000 prob. low.
Inv.	219,000	133,000
Labor	2¾	3
Power	10,600	7,200
Total	224,000	188,700

9 e

Sb+HF	140,400	107,000
Inv.	177,000	118,060
Lab.	2 men	3
Pow	8,400	7,700
Total	181,900	179,000

dP did not include dist.

10 e

	126,000	
Inv	177,000	117
Lab	2	3
Pow	8000	7700
	181900	179,500

11c

	dP	H
HF+Sb	218,000	104,000
Dur	177,000	133,000
Por		
Total	184,000	188,000

Proc. 1 C-716

		I	RM	X
564	A Du	1,889,000	1,433,000	478,800
920		53,900	—	44,500
1484		24,000 refrig		

A_1 1484,000

~~920,000 lbs~~

Process 2 McBee 4 step

Step.		Dur	RM	Cost x
A	H	94200	78900	91,300
B	H	151800	100200	177,700
	Du	201,000	187500	200,800
C	H	132900	108700	188500
C_1	Du	177000	298700	189200
C_2		241,700		40,400
D	Du	448,000	112700	186200
		48700	~~x~~	42,200
		37,000 Refrig		

163,000 05-116 190,000 85 3

B	175,000	Compromise 135,000	185,000
C	175,000	225,000	190,000
	305# OG/day		
D_1	353,300		

Proc 3 $C_2F_4Cl_2$ McBee 3 step #1 # OG

	Inv	RM	Cost X
A	H 94200	85900	91300
B	H 180000	100700	205400
	Du 323,000	332,300	339,100
C_1	Du 645,000	283100	275300
			42200
C_2	48700		
	30,000 refrig.		

Compromise 766 #/day OG

B	275,000	185,000	290,000
C_1	533,000		

Proc. 4 $C_2F_{12}Cl_2$ by Prim reaction

	Inv	RM	Cost X
A	Du 101000	176700	124000
B	H 183100	149800	207300
	Du 367000	342100	342200
C_1	596000	244500	260200
	45500		41200
	30,000 Refrig		

Comp. 662 #/day

B	290,000	220,000	300,000
C_1	492,000		

Proc 5 reg 816 from P-45

	I	RM	X
A	H 93900	60000	76400
B	H 220,400	90,800	221,000
C	Du 1,034,000	449400	342900
	43,000		40300
	22,000 refrig		

1217 # OG/day

New OG investment 310,000

Cost X not effected, Based only on Co treatment cost not OG cost

C_1	~~700,000~~ 760,000		

Total

I	RM	X
1,079,300	600,200	680,600
760,000		
1079300		
600200		
680600		
2,360,100		

assuming OG at $1/#

Proc. 6

	I	RM	X
A	H 93,900	43400	76800
B	H 220,400	64800	221,000
C	Du 1002000	419000	332900
	44700		40900
390	10,000		
	1134 #/day OG		
	350,000		
C1	740,000		

Proc. 7 $C_8F_{15}Cl_6$ by Prime

	I	RM	X
A	Du 98000	339400	105200
B	Du 48,000	25200	54200
C	Du 78000	39700	82200
D	Du 201,300	197600	201000
	H 148600	96400	175700
E	Du 34000	16400	44500
F	H 133300	115000	188700
	Du 177000	219800	184100
	42100		40200
G1	Du 443000	135600	172300
	45400		41100
	43,000 Refrig	969 #/day	
D	175,000	134,000	185,000
F	180,000	190,000	200,000
G1	368,000		

Proc 8 ΔEt direct

	I	RM	X
A	1,489,000	1,064,900	419900
	43,000		40300
	22,000 Refrig		
A1	1,209,000		

Proc 9 816 from ΔEt McBee

	I	RM	X
A1	H 80,900	87,100	70,800
B2	H 44,800	32,300	44,700
B	H 201,500	62,900	201,400
	H ~~157,000~~	~~80700~~	~~181,000~~
C	H 141600	13200	85300
D	H 152,500	80,700	181,000
	Du 252000	188300	286,000
E	H 117900	109100	179600
	~~Du~~ 177000	150600	181900
B2F	Du 394000	105700	152100
	45400		41100
	30 000 Refrig		

Proc 10

C-816 from octachlorotoluene

		I	RM	X
A	H	88900	81000	74300
B	H	200600	97300	200900
C	H	144600	15800	86600
D	H	159500	60,700	182,500
	Du	323000	153500	280000
E	H	117900	98900	179600
	Du	177000	130300	181900
F_1	Du	380000	57700	152100
		45400		41100
		32000 refrig		

D	200,000	105,000	205,000
E	150,000	125,000	180,000
F	307,000		

156# OG/day

Proc 11

		I	RM	X
A	H	94200	141600	91300
B	H	148900	92200	175900
	Du	201300	189700	201600
B'	Du	46000	17900	53100
C	H	132900	105900	188500
	Du	177000	216000	184100
		42100		40200
D		532000	195900	225900
	@ .53 Fv	45400		41100
		40000 refrig		

B	175,000	135,000	185,000
C	180,000	185,000	200,000
D_1	441,000		

Proc 12

A	H	94200	96700	91300

rest same as 11

Proc 13 A		94200	118700	91300

Proc 14

Miller Proc.

	I	RM	X
A	79000	1,562,600	86800
B	99000	—	110100
C	62000	51300	72100
D	90,000	—	109,500
E	435000	130100	169300
	41900	—	46100
	43000 refrig		

352#/day OG = 200,000

E_1	358,000

Proc	Direct Mfg	Refrig	1000's of BTU OG	Total Inv
1)	617,900	24000	920.	1561.9
2)	655.9	37	190	882.9
3)	670.9	30	280	980.9
4)	668.5	30	260	958.5
5)	747.3	22	370	1139.3
6)	749.0	10	350	1109.0
7)	821.4	43	205	1069.4
8)	517	22	735	1274.0
9)	~~796.2~~ ~~1211.2~~	30	185	1211.2
10)	961.4	32	175	1168.4
11)	746.6	40	235	1021.6
12)	"	"	"	"
13)	"	"	"	"
14)	~~772.9~~ 529.9	43	200	772.9

	Raw Materials OG $1/#	Cost X	Tot
1	1433.0	523.3	1956.3
2	571.6	694.7	1266.3
3	554.0	698.8	1252.8
4	641.2	725.4	1366.6
5	600.2	680.6	1280.8
6	527.2	671.2	1198.4
7	880.3	884.5	1764.8
8	~~1064.9~~ ~~625.~~	460.2	1525.1
9	572.2	980.5	1552.7
10	481.8	940.0	1421.8
11	675.4	796.4	1471,8
12	630.5	796.4	1426.9
13	652.5	796.4	1448.9
14	1,744.0	578.9	2322.9

Process	Total cost ~~#~~		
1	2831.7	3518.2	4891.2
2	2093.5	2149.2	2260.5
3	2093.8	2233.7	2513.4
4	2204.3	2325.1	2566.7
5	2198.1	2420.1	2864.1
6	2100.4	2307.4	2721.4
7	2767.2	2834.2	2968.2
8	2282.6	2799.1	3832.1
9	2711.7	2763.9	2868.3
10	2561.7	2590.2	2647.2
11	2396.6	2493.4	2686.9
12	2351.7	2448.5	2642.0
13	2373.7	2470.5	2664.0
14	3031.5	3095.8	3224.3
	50¢ OG	$1.00 OG	$2.00 OG

Based on 1 year investigation

9og816 cont

	50¢	1.00	2.00
1	129		171
2✓	95		79
3✓	95		88
4✓	100		89
5✓	—	—	—
6✓	96		95
7	126		103
8	104		134
9	124		100
10	117		92
11	109		94
12	107		92
13	108		90
14	138		112
5	95		95

with chlor P-45

82