TENTATIVE PROCESS

FOR

PYDRAUL 280

246

3/26/64

DSW 176435

STLCOPCB4050322

...CHEMICAL COMPANY
St. Louis - General Offices

March 26, 1964

cc: EP Cunningham
~~HE Day~~
DB Hosmer
M McEwen
DF Smith
LR Stark
CM Williams
RS Wobus

Copy { Heisler Buckley Martin

FROM THE FILES OF THE WGK LABORATORY PLEASE RETURN

TO : QUEENY
W. R. RICHARD

The German Coal Mining Industry has called for a blend of 55% volume PYDRAUL A-200 and 45% volume PYDRAUL 625. They have been working with both of these products for over two years, and this blend apparently gives them the viscosity which they desire.

This blend will be called PYDRAUL 280 since this approximates the 100°F. (as measured) SSU viscosity. Prices have been established and we are anxious to be ready to accept the first order.

The International Division tells us that Monsanto Europe is ready to place an order for 40 drums to get things started, and that ultimate potentials can run as high as several hundred thousand pounds per month. Obviously, we don't want to miss any opportunities in this area.

Before we can do anything, we will need the following action from Research:

1. Prepare a blend of 55% volume A-200 and 45% volume PYDRAUL 625 to determine typical physical properties and establish specifications.

2. Prepare a process for the blend and forward to Manufacturing so that they can begin production as soon as orders are received. Since the blend will contain approximately 75% Aroclor, I would expect that it would be produced at WGK.

Process information should probably go to Paul Heisler, Des Hosmer and Herb Day.

I talked to Lew Stark and he agrees that we need not be concerned about the performance of the blend, so I hope that we can move forward without delay.

If you have any questions, please contact Dale Smith or me.

Thanks very much for your help.

G. R. BUCHANAN

DSW 176436

Dan, we plan to make this at W. GK. The ingredients are:

1. Aroclor 1248
2. Aroclor 1242
3. Aroclor 1260
4. Santolube 70
5. TCP
6. Santolube 393
7. D.C.F. 200
8. Dye Blue A

STLCOPCB4050323

MONSANTO CHEMICAL COMPANY
ORGANIC CHEMICALS DIVISION
J. F. QUEENY PLANT
FINISHED PRODUCT SPECIFICATION

PRODUCT CODE: 80071 or 80180
DEPT. OR JOB:
USE: H. S. Bergen/ Sales & Internal - C. R. Groninger, Mgrs.
SALES CODE: 8530-100-04/12-01

ISSUED DEC. 4, 1963
SUPERSEDES NEW ISSUE!
John F. Queeny Plant
By Paul N. Bivens

PRODUCT (Trade Name): TRICRESYL PHOSPHATE
TYPE: A GRADE
PRODUCT (Chemical Name):
TYPE

Must be made from cresylic acid meeting attached spec

CHEMICAL FORMULA: $(CH_3C_6H_4)_3PO_4$

MOL WT. 368.18

SUPERSEDES SPECS OF: May 20, 1963
SAMPLE FOR ANALYSIS: 1 x16-ounce NN Bottle

TEST	UNRESTRICTED SALES LIMITS	INTERNAL CONTROL LIMITS	PROCEDURES
On each lot			
Acidity	0.20 meq/100 grams max. (=0.01% as H_3PO_4)	0.08 to 0.17 meq/100 grams	4-A
Appearance	Clear, pratically colorless to lt. yellow liquid	Clear, practically colorless to lt. yellow liquid	16-B
Color	APHA 75 maximum	APHA 30 to 70	38-D
Moisture (By KF in methanol)	0.15% maximum	0.04 to 0.10%	78-B
Odor	No foreign odor	No foreign odor	84-A
Specific gravity @ 25/25°C	1.157 to 1.173	1.163 to 1.169	116-B
Stability to $KMnO_4$	65% transmission min.	70 to 80% ~~transmission~~	118-D
Upon request			
Viscosity @ 100°F	----	(For Pydrauls AC & 625)* ✓ 32 to 36 cs.	Pydraul 280 126-A

*NOTE: Typical sales material has lower viscosity. A special grade of Cresylic (high in xylenols) must be used for the high viscosity grade.

Sampling procedure

1. Circulate storage tank 16 hours before filling shipping containers.
2. While filling drums, tank trucks or tank cars, take one 16-ounce bottle from the filling line and submit to the laboratory for analysis.

General Product Information

The assay of Monsanto Tricresyl Phosphate is essentially 100%, as evidenced by the low acidity and by stability to permanganate solution. Free phenols rapidly destroy the color of permanganate solution. No specification for assay is given because none of the known methods of analysis give an accurate answer. This is true of the Monsanto method, the ASTM method and the methods given in the specifications of various government agencies.

Congealing point	Below minus 25°C
o-Cresol ester	3% or less
Flammability	non-flammable
Refractive index @ 20°C	1.556, approximate
Solution in benzene (1:1)	Clear
Specific gravity @ 20/20°C	1.160 to 1.176

DSW 176437

INTRODUCTION

Pydraul 280 was developed as a fire resistant hydraulic fluid, having a viscosity intermediate to Pydraul A-200 and Pydraul 625, to meet the requirement of a mining application for British Petroleum in Germany. This formulation is actually a mixture of Pydraul A-200 (56.2% by weight) and Pydraul 625 (43.8% by weight) and after the initial sales requirements have been produced, the blending process will be amended by eliminating Aroclor 1242 from the Pydraul 280 formulation. A minimum of six (6) months will be required to schedule this additional laboratory work into the Functional Fluids program.

SYNOPSIS OF PROCESS

Pydraul 280 is prepared by thoroughly mixing small amounts of Santolube 70 and Santolube 393 into a specified mixture of Aroclors, containing tricresyl phosphate. A dye, duPont Oil Blue A, is added to give the characteristic Pydraul color and Dow Corning 200 fluid is added to defoam the formulation. The resulting fluid is filtered into containers.

BILL OF MATERIALS

The process weights for 100 pounds of Pydraul 280 are as follows:

Aroclor 1260	- 21.9 pounds
Aroclor 1248	- 37.1 pounds
Aroclor 1242	- 18.5 pounds
Tricresyl Phosphate	- 21.85 pounds
Santolube 70	- 0.40 pounds
Santolube 393	- 0.25 pounds
duPont Oil Blue A	- 0.0007 pounds
Dow Corning 200 Fluid	- 0.002 pounds

PROCESS IN DETAIL

To a clean, dry vessel, equipped with an agitator, charge 21.9 lbs. of Aroclor 1260, 37.1 lbs. of Aroclor 1248, 18.5 lbs. of Aroclor 1242 and 21.85 lbs. of tricresyl phosphate. Stir and add 0.40 lbs. of Santolube 70 and 0.25 lbs. of Santolube 393. Santolube 70 is a viscous liquid and may be warmed to facilitate handling but in no instance should the temperature of this additive exceed 100°C. Add 0.0007 lbs. of duPont Oil Blue A and 0.002 lbs. of Dow Corning 200 Fluid (350 cs at 25°C) and stir the blend for 30 minutes to insure complete mixing. The final fluid is filtered through a sock or a string wound filter into drums. Filter equipment utilizing Dicalite or other filter aids cannot be used in this operation because these media remove the silicone defoamer and certain earths will also adsorb the blue dye. A one pound sample of the finished fluid should be submitted for analysis.

STLCOPCB4050325

MATERIAL SPECIFICATIONS

Raw materials used in this formulation are commercially available products and all of the components are produced by Monsanto, except the duPont dye and the Dow Corning fluid. The tricresyl phosphate must meet the specifications for A-grade material. The Aroclors, Santolube 70 and Santolube 393 must pass Monsanto's finished goods specifications. The duPont Oil Blue A should meet normal purchasing requirements and the Dow Corning 200 silicone, 350 cs at 25°C grade, is accepted on manufacturer's analysis.

No formal specifications have been established for Pydraul 280. Typical properties are as follows:

Acidity	- 0.65
Moisture	- 0.02
Pour Point	- 15°F
Flash Point	- 405°F
Viscosity	
at 100°F	- 59.80 cs
at 210°F	- 4.02 cs
Specific Gravity at 25/25°C	- 1.3949

TOXICITY AND HAZARDS

The raw materials and finished formulation should be handled with normal care. Repeated or continuous skin contact should be avoided and inhalation of vapors at elevated temperatures should be prevented. The formulation is only mildly irritating to the eyes (but can cause pain) and like any synthetic fluid, it exerts a solvent action on the skin. Eye irritation studies showed it to be a mild irritant with no permanent damage to the tissue.

STREAM POLLUTION

No waste streams are discharged from this process.

J. D. Sullivan

jd

3/30/64

File Copy Approved By
Manager of Research
W. R. Richard

Date of Final Approval _____

DSW 176439

IN 619

PHYSICAL CONSTANTS DATA

SUBSTANCE	STRUCTURAL FORMULA
Pydraul 280	A Formulation
COMPILED BY: J. D. Sullivan	DATE: 3/27/64

NAME		SOURCE & DATE
Formula	A formulation	
Molecular Weight		
Appearance		
Boiling Point at 760 mm		
Boiling Point at mm		
Boiling Point at mm		
Boiling Point at mm		
Crystallizing Point		
Melting Point		
Solution Point		
Specific Gravity @ 25°/25°C	1.3949	F2561
Specific Gravity @		
Pounds per Gal. @ °C		
Coefficient of Expansion		
Refractive Index @ n_D^{β}		
Infra Red Spectrum *(Reference)*		
Ultra Violet Spectrum *(Reference)*		
Viscosity @ 100°F	59.80 cs	F2561
Viscosity @ 210°F	4.02 cs	
Surface Tension		
Solubility in Water		
Solubility in		
Solubility in		
Flash Point °F *(Method)*	405°F	F2561
Fire Point °C		
Heat of Combustion		
Heat of Formation		
Thermal Stability (cal./kg/min.)		
Latent Heat of Fusion		
Latent Heat of Vap.		
Specific Heat		
Critical Temperature		
Critical Pressure		
Dissociation Constant		
Other Constants		
Toxicity *(Give Reference)*		DSW 176440

NOTE: *These data should not be released outside of Monsanto Chemical Company. Use additional sheets if necessary.*

STLCOPCB4050327

64

50 1250
50 TCP
Pyrolube

1407
REPORT P-1310

Thermal Prod
780 S.O Sullivan

Paraccon	1240	18.5
	1248	37.1
	1260	21.9
SANT 70		0.40
TCP Pyrolube (252)		21.85
SANTOLUBE 393		0.25
DCF 200		0.002
~~SANT 393~~		
DYE		0.0007

MUST MEET A GMDR MATERIAL SPECS

SPECS		A200	Pyrolube 250	Pyrolube 625
Acidity (Acid Number)	0.65	0.8 → 1.1	0.50 → 0.80	0.30 MAX
H2O	0.04	0.05	0.15 MAX	0.15 MAX
Compt	15°F	—	+20°F MAX	+20°F MAX
FLASH	405°F	350°F MIN	350°F MIN	—
VN @100°F	59.80	30-33	58 - 62 CS	132 - 138 CS
@210°F	4.02	3.80 - 3.0 1.395 1.415	3.9 - 4.1 CS	5.90 - 6.10
SP GR @25	1.3945 / 1.380	1.410 1.415 - 1.430	1.385 - 1.405	1.340 - 1.370

DSW 176441

STLCOPCB4050328

FSIVKN JFQ

PETTY

TCP - A GRADE

ACIDITY	0.20	MAX
ASH	15	MAX
H2O	0.15	MAX
ODOR	NONE	
SPGR 25/25	1.157 – 1.173	
BROMINE TEST	65%	TRANSMISSION
VISC @100°F	32 – 36	CS

DEICING JFQ

0 CREDIT / 0 PENALTY → COMBINED ≤ 1.0% MAX

DSW 176442

MONSANTO CHEMICAL COMPANY

ORGANIC CHEMICALS DIVISION

JOHN F. QUEENY PLANT

STANDARD PROCEDURE

Number 118-D

Department LABORATORY 2 Sheets: Page 1

Title PERMANGANATE STABILITY TEST

THIS FORM ~~SUPERSEDES~~ INSTRUCTION ISSUED ON 9-4-58 EPM/FNS Revised: RJB

SCOPE

This method is intended for the detection of oxidizable substances present in products such as triaryl phosphates. It involves mechanical agitation of the sample with 0.01N $KMnO_4$ for a specified period of time and photometric measurement of the change in color of the permanganate layer.

EQUIPMENT

(a) Model 401 Lumetron, Modified to accomodate tall glass stoppered stability tubes. - JFQ Standard Apparatus Drawing 12.

(b) Agitator, Stability Tube. - Standard Apparatus Drawing 18. This device is capable of rotating 2 stability tubes through 2 revolutions every 5 minutes for 30 minutes. Periodically check timers of agitator for proper functioning.

NOTE: This agitation of the stability tubes can be performed manually, also.

(c) Stability Tube fabricated from 22 mm OD Pyrex tubing cut so that 1 inch of head space is present when filled with 50 ml. of liquid (about 8-1/2 inches), sealed at one end and with a ground-glass stopper joint sealed on the other.

(d) N/100 Potassium Permanganate. - Accurately weigh 0.316 gram of AR potassium permanganate into a 1000 ml. volumetric flask. Dissolve in water and dilute to volume at room temperature. This solution should be prepared FRESH daily.

(e) Usual laboratory apparatus and reagents.

DETERMINATION

1. Introduce 10.0 grams of flakes or powder, or 10.0 grams of liquid sample, into a clean, dry stability tube.

   NOTE: The stability tubes should be thoroughly cleaned by washing in turn with methanol, conc. HCl, and distilled water.

2. Add 40 ml. of freshly prepared 0.01N potassium permanganate to the sample and to a second clean stability tube which will be the blank, and stopper both tubes.

3. Clamp the stability tubes into place in the agitator, push the re-set button and throw the toggle switch to the "on" position.

DSW 176443

Q 235

STLCOPCB4050330

4. Allow the agitator to run until the indicator light indicates that 30 minutes have elapsed; then throw the toggle switch to the "off" position.

5. Remove the stability tubes, then clean and dry the outside of each thoroughly.

6. Set each stability tube in its respective position in the tube carrier of the modified model 401 Lumetron colorimeter equipped with 420 filter.

7. Move the blank tube into the light path, hold the switch in the "on" position and adjust the galvanometer to 100% transmittance, allow the light switch to remain "on" while moving the sample tube into the light path, and record the percent transmittance of the sample.

NOTE: If the galvanometer cannot be adjusted to 100% transmittance with the blank in the light path because of a weakened light source or other difficulty, the following calculation should be used.

$$\frac{\text{percent transmittance of sample} \times 100}{\text{percent transmittance of blank}} = \text{corrected \% transmittance}$$

If the reading obtained for the blank is less than 80% the source of error should be corrected.

DISCUSSION

Duplicate determinations on 10 gram portions of the same sample should agree within 3 percent transmittance.

The color change of concern is one from the purple $KMnO_4$ color to a reddish purple color. It is probable that this change is due to the formation of finely divided MnO_2 from the oxidation of trace impurities.

The methanol used in cleaning the stability tubes is susceptible to oxidation by $KMnO_4$, therefore removal of all methanol used in washing is mandatory.

SAFETY

Care should be observed in handling potassium permanganate, since fire or explosion may result if it is brought into contact with readily oxidizable substances, either in solution or in the dry condition.

REFERENCE

1. Caldwell, J. E. and Fowler, L., ASTM Bulletin No. 194, 67-69, December, 1953.

ISSUED MAY 23, 1963
STANDARDS DEPARTMENT
John F. Queeny Plant
By Paul N. Bruen

MONSANTO CHEMICAL COMPANY

ORGANIC CHEMICALS DIVISION

JOHN F. QUEENY PLANT

STANDARD PROCEDURE

Method Number 4-A

Department 508 - LABORATORY 2 Sheets: Page 1

Title ACIDITY DETERMINATION IN PRODUCTS SOLUBLE IN ALCOHOL

THIS FORM SUPERSEDES ~~XXXXXXXXXX~~ INSTRUCTION ISSUED ON 10-18-50 (PNB/FNS) Revised HOS/FNS

SCOPE

This method is intended for the determination of free acid constituents in concentrations generally below one milliequivalent per 100 grams, in materials soluble in alcohol without imparting sufficient color to obscure an indicator end-point. It has the same general scope as the USAF MIL-T-9188a specification, method number 4.3.1.6.

EQUIPMENT

Usual laboratory apparatus and reagents.

DETERMINATION

1. Neutralize 25 ml. of formula 2-B alcohol to a thymol blue (or specified) end-point with N/50 KOH (or specified titrant).

2. Add 25.0 grams sample, dissolve, and titrate quickly to the same end-point.

   NOTE: 1. At no time should the alcohol solution be warmed above room temperature and the titration should be made as quickly as possible to minimize carbon dioxide absorption from the air.

   2. If the sample is a liquid and the specific gravity is known, use 25.0 ml. portion and multiply the volume by the gravity to determine the weight of sample.

3. Calculation:

$$\text{MEQ/100 grams} = \frac{\text{ml. N/50 KOH} \times 2}{\text{weight of sample}}$$

DISCUSSION

Trace amounts of free acid in a product may be expressed either as a function of the proton activity or pH (J.F.Q. method 90), as percent of a specific acid, or as the milliequivalents of base required to react with the free acid. By using the system of 'meq/100 grams', the acidity of various products may be compared directly without consideration of the character of the free acid.

The thymol blue end-point essentially coincides with that of phenolphthalein but is less susceptible to the "alcohol error" occasionally observed with phenolphthalein. Free acidity in weakly acidic or hydrolysis-liable materials such as sulfonamide-formaldehyde resins or chloro-alkyl esters is best determined by titration in the presence of indicators showing color

DSW 176445

change at lower pH levels such as brom thymol blue or brom cresyl purple, and occasionally by titration with a weaker base such as ammonium hydroxide.

To convert meq/100 grams to a specific acid, multiply the meq/100 grams by the milliequivalent weight of the acid.

SAFETY

Take cognizance of any potential hazards in the material being tested.

ISSUED NOV 15 1954
STANDARDS DEPARTMENT
John F. Queeny Plant
By Paul N. Bruer

STLCOPCB4050333

MONSANTO CHEMICAL COMPANY

ORGANIC CHEMICALS DIVISION

JOHN F. QUEENY PLANT

STANDARD PROCEDURE

Method Number 16-B

Department 508 - LABORATORY 1 Sheets: Page 1

Title APPEARANCE OF LIQUORS

THIS FORM SUPERSEDES ~~XXXXXXXXXX~~ INSTRUCTION ISSUED ON 10-25-53, Methods 16-B, 16-C and 16-D

SCOPE

This method is intended to provide general physical description of liquid materials when viewed under a constant set of conditions, and to define any visibly apparent contamination.

EQUIPMENT

Source of strong oblique illumination shaded from the observer's eyes, such as Turbidimeter, Clark, Catalog No. T11315, The Chemical Rubber Co., Cleveland, Ohio.

DETERMINATION

1. Rinse the outside of the sample container, a clear glass bottle, with methanol and water, wipe it with a towel and place it on a white card or opal glass background.

2. Describe the color of the sample.

3. Describe the clarity with respect to haze, sediment, globules or layers of immiscible liquids or other insolubles.

4. Swirl the sample, avoiding the introduction of air bubbles, and observe under the Clark Turbidimeter, describing any turbidity, opalescence, or sediment.

5. Describe the fluidity with respect to the specification requirement.

ISSUED MAY 24 1954
STANDARDS DEPARTMENT
John F. Queeny Plant
By Paul N. Bunce

DSW 176447

Q 235

STLCOPCB4050334

STANDARD PROCEDURE

Number 38-D

Department LABORATORY 3 Sheets: Page 1

Title COLOR OF LIQUIDS, MELTS, AND SOLUTIONS (APHA)

THIS FORM SUPERSEDES ~~XXXXXXXXX~~ INSTRUCTION ISSUED ON 4-16-60 EPM/FNS Revised: RJB

SCOPE

This method is intended for the estimation of the color of liquids in terms of platinum-cobalt (Hazen) standards established by the American Public Health Association (ref. 1). It involves visual comparisons of the sample with prepared standards in matched Nessler tubes.

EQUIPMENT

(a) Matched short form Nessler tubes of 50 ml. capacity and tall form Nessler tubes of 100 ml. capacity.

(b) 0.05 M. Periodic Acid. - Dissolve 11.4 g. of $HIO_4 \cdot 2H_2O$ in water and dilute to 1000 ml.

(c) Color Standards. - Prepare APHA 500 standard by dissolving 1.0 g. of cobaltus chloride ($CoCl_2 \cdot 6H_2O$) and 1.246 g. of potassium chloroplatinate (K_2PtCl_6) in water, adding 100 ml. of conc. HCl, and diluting to 1000 ml. with water.

From a buret add the amount of APHA 500 standard indicated in the following table to the respective tube, add 0.5 ml. of 0.05 M periodic acid and dilute to the mark with double distilled water. If the marks on a series of tubes vary in depth, a final adjustment of all standards to the depth of the shortest should be made. All tubes should be kept covered when not in use and wrapped in black paper so that no light enters from the side.

APHA No.	Short (50 ml.) Tubes	Tall (100 ml.) Tubes
5	--	1.0 ml. APHA 500
6	--	1.2 ml. APHA 500
7	--	1.4 ml. APHA 500
8	--	1.6 ml. APHA 500
9	--	1.8 ml. APHA 500
10	1.0 ml. APHA 500	2.0 ml. APHA 500
11	--	2.2 ml. APHA 500
12	--	2.4 ml. APHA 500
13	--	2.6 ml. APHA 500
14	--	2.8 ml. APHA 500
15	1.5 ml. APHA 500	3.0 ml. APHA 500
16	--	3.2 ml. APHA 500
18	--	3.6 ml. APHA 500
20	2.0 ml. APHA 500	4.0 ml. APHA 500
25	2.5 ml. APHA 500	5.0 ml. APHA 500
30	3.0 ml. APHA 500	6.0 ml. APHA 500
35	3.5 ml. APHA 500	7.0 ml. APHA 500
40	4.0 ml. APHA 500	8.0 ml. APHA 500
45	4.5 ml. APHA 500	9.0 ml. APHA 500

STLCOPCB4050335

COLOR OF LIQUIDS, MELTS, AND SOLUTIONS (APHA)

APHA No.	Short (50 ml.) Tubes	Tall (100 ml.) Tubes
50	5.0 ml. APHA 500	10.0 ml. APHA 500
60	6.0 ml. APHA 500	12.0 ml. APHA 500
70	7.0 ml. APHA 500	14.0 ml. APHA 500
80	8.0 ml. APHA 500	16.0 ml. APHA 500
90	9.0 ml. APHA 500	18.0 ml. APHA 500
100	10.0 ml. APHA 500	20.0 ml. APHA 500
125	12.5 ml. APHA 500	
150	15.0 ml. APHA 500	
175	17.5 ml. APHA 500	
200	20.0 ml. APHA 500	
250	25.0 ml. APHA 500	
300	30.0 ml. APHA 500	
350	35.0 ml. APHA 500	
400	40.0 ml. APHA 500	
450	45.0 ml. APHA 500	

DETERMINATION

1. Fill a (black paper-wrapped) Nessler tube, using a 50 ml. low form tube for off-white fluids or a 100 ml. tall form tube for water white fluids, to the depth of the standards with a portion of the sample, melt, or specified solution.

   NOTE: If the sample has any visible turbidity, filter it.

2. Compare with the APHA standards viewing vertically against a white glass plate.
3. Record the number of the APHA standard which most nearly matches the sample, making a note of any abnormality in tint or clarity of the sample. In the event the color lies midway between two standards, report the darker of the two.

SAFETY

Take cognizance of any potential hazards in the material being tested, such as the temperature of melts, corrosiveness, lachrymatory or dermatological properties, and exercise appropriate precautions.

DISCUSSION

The reproducibility of comparisons with clear materials of approximately the same color hue as the standards is within 10% of the numerical value of the standard matched. Under similar conditions, reproducibility with the short standards is within 15 or 20%.

The function of the periodic acid is to stabilize the colors of the standards. It will not, however, protect against contamination. Hence, care must be exercised against splashing samples into the standards. In any event, the standards below No. 20 should be renewed bi-monthly and those above No. 20 should be renewed monthly, unless obvious discrepancies dictate more frequent renewal.

The chart on next page shows some comparisons of color intensities as designated in various different systems. In the comparison of color intensities of the ASTM D-1500 and the NPA systems, the asterisk (*) indicates the colors are not matched by they are close approximations. See also references 2, 3.

REFERENCES

1. "Standards Methods for the Examination of Water, Sewage, and Industrial Wastes", American Public Health Association, Inc., New York, 1955.

2. "Color Conversion Chart" Technical Publication, Armour Chemical Division, Chicago.

3. Federal Standard Stock Catalog, Section IV, Part 5, TT-P-141b, Method 458.1.

4. Unpublished work, R. M. Hitchens, R. W. Towne, E. L. Will, H. O. Schott, P. N. Biven, J. F. Queeny Plant; L. Goldman: W. G. Krummrich Plant.

ISSUED MAR 25 1963
STANDARDS DEPARTMENT
John F. Queeny Plant
By Paul N. Biven

DSW 176449

STLCOPCB4050336

Color Intensity Comparisons

APHA	A-11	Barr-ett	ASTM D-1500	NPA	Say-bolt	Gard-ner 1933	Gar. Holt 1921	Hel-lige S-F	Pratt	Du-Pont	Fac	Par-lin	$K_2Cr_2O_7$ H_2SO_4
3	-	-	-	-	+29								
5	-	-	-	-	+27								
8	-	-	-	-	+26								
10	-	-	-	-	+24								
15	-	-	-	-	+23								
20	-	-	-	-	+22								
23	1	-	-	-	-								
25	-	-	-	-	+21								
30	-	-	-	-	+19								
35	2	-	-	-	+17								
40	3	-	-	-	+16								
45	4	-	-	-	+15								
50	5	-	-	-	+14								
60	-	-	-	-	+12								
65	6	-	-		-								
70	-	-	-	-	+11								
80	-	-	-	-	+10								
90	7	-	-	-	+ 9								
100	8	-	-	-	+ 6								
125	-	-	-	-	0								
130	9	-	-	-	-								
150	-	-	-	-	- 9								
170	10	-	-	-	-								
200	-	-	-	0.5	-13								
250	11	-	-	0.75	-	1	1	-	-	-	-	4	0.0039
300	-	1	0.5	1.0	-	-	-	1	-	-	-	-	-
400	-	-	-	1.25	-	2	-	-	-	-	-	5	0.0048
500	-	2	-	1.25	-	-	-	2	-	-	-	-	0.0071
-	-	-	-	-	-	3	-	-	-	-	1	8	-
		3	-	1.25+		-	-	-	-	-	-	-	-
		4	1.0*	1.5		4	2	3	-	-	-	10	0.0112
		5	1.5*	1.75		5	-	4	1	-	3	20	-
		-	-	2-		6	-	5	2	0.05	-	30	0.0205
		6		2.0		-	-	6	-	-	-	35	0.0322
		-	2.0*	2+		7	3	-	3	0.10	5	-	0.0384
		7	-	2.25		8	-	7	4	0.15	-	45	0.0515
		8	2.5*	2.5		9	4	10	5	0.22	7	60	0.078
		-	-	2.75		10	-	20	-	-	-	80	0.164
		9	3.0*	3.0		-	-	-	6	0.30	9	-	-
		10	-	3.25		11	-	30	7	0.43	-	100	0.250
		11	3.5	3.5		-	5	-	-	-	11-A	-	-
		12	4.0*	3.75		12	-	40	8	0.60	-	125	0.380
		13	-	3.75		-	6	-	-	-	-	-	-
		14		4.0		13	-	-	9	0.90	-	-	0.572
		-	4.5*	4.25		14	7	70	-	-	-	-	0.763
			5.0*	4.5		-	-	-	12	1.30	19	175	-
			5.5*	4.75		-	-	100	-	-	-	200	-
			6.0*	5.0		15	-	150	14	1.55	31	250	1.041
			-	5.75		-	-	-	-	-	33	-	-
			6.5	6.0		16	8	230	16	2.15	-	300	1.28
			7.0*	7.0		-	-	-	17	2.80	35	-	-
			7.5*	7.5		17	-	-	-	-	-	350	2.22
			-	8-		-	-	310	-	-	-	-	-
				8.0		-	-	-	-	-	37	-	-
			8*	8+		18	9	730	18	3.90	39	500	3.00

DSW 176450

STLCOPCB4050337

X

MONSANTO CHEMICAL COMPANY

ORGANIC CHEMICALS DIVISION

JOHN F. QUEENY PLANT

STANDARD PROCEDURE

Method Number 78-A,B

Department 508 - LABORATORY 4 Sheets: Page 1

Title WATER BY KARL FISCHER REAGENT

THIS FORM SUPERSEDES ~~XXXXXXXXX~~ INSTRUCTION ISSUED ON 11-2-51, 6-3-54 (FNS/PNB) Revised JEC/FNS

SCOPE

This method is intended as a general directive for the determination of water, titratable with Karl Fischer reagent, in various organic and inorganic substances. It involves the solubilization or dispersion of a sample of the material to be analyzed in a suitable solvent and the titrimetric determination of the moisture present with Karl Fischer reagent. The end point may be detected colorimetrically in colorless or nearly colorless solutions, or electrometrically in colored solutions.

EQUIPMENT

(a) N/100 methanolic iodine. - Dilute 10 ml. of N/10 iodine to 100 ml. with methanol.

(b) Standardized regular and low alcohol Karl Fischer reagents in automatic burettes protected with anhydrous silica gel traps. For details of preparation see Method 1 - Section VII.

(c) Standardized Water-in-Methanol Solution in an automatic burett protected with anhydrous silica gel traps. For details of preparation see Method 1 - Section VII.

(d) Dead-Stop Electrometric Titration apparatus. - A dual platinum electrode system in series with a galvanometer of about 0.1 a./mm. sensitivity with provision for impressing about 5 mv. across the electrodes by means of a 1.5 V dry cell shunted with a 100,000 ohm control resistor (see Standard Apparatus - Drawing 7); or a Leeds & Northrup pH indicator equipped with dual platinum electrodes and dead-stop adaptor leads.

(e) Closed system titration vessel constructed by sealing the dual platinum electrodes and burette tips through a 40/50 male STGG joint, and the female joint to a 125 ml. cylindrical bottle; with provision for magnetic stirring.

(f) Common laboratory apparatus and reagents.

APPLICATION

Solids are measured by weight. Liquids of known gravity may be measured from an appropriate volumetric pipette, multiplying volume by specific gravity to obtain weight.

Expected Moisture	Sample Size
0 - 0.5%	10 ± 0.1 g.
0.5 - 1.0%	5 ± 0.1 g.
1.0 - 5.0%	2 ± 0.01 g.
5.0 - 12.0%	1 ± 0.01 g.

DSW 176451

DETERMINATION

A - ELECTROMETRIC

1. Measure about 25 ml. of the solvent designated in the specification for the product (or see Discussion) into the titration vessel.

2. Add an excess of Karl Fischer reagent, as indicated by an iodine color in the solution, and sweep moisture out of the flask by swirling the solution up the walls of the flask.

3. Set the flask under the electrodes and turn on the magnetic stirrer. (If the galvanometer is not permanently off the scale, add additional reagent until a definite excess is present.)

4. Back titrate with water-in-methanol solution until the galvanometer needle begins to move toward the zero mark. Then titrate drop-wise, giving the electrode time to react after each addition, until the needle just reaches the zero mark.

5. Add the prescribed weight of sample to the blanked solvent, set the flask under the electrodes, turn on the magnetic stirrer, and stir until dissolved.

   NOTE: If the material to be analyzed is an insoluble porous solid, disperse the finely divided sample in the solvent and allow to stir in a closed system for periods up to 1 hour before titrating with Karl Fischer reagent.

6. Zero the Karl Fischer and water-in-methanol burettes.

7. Titrate with Karl Fischer reagent until a 2-4 ml. excess has been added.

8. Back titrate as before with water-in-methanol solution until the galvanometer needle just reaches the zero mark.

9. Calculate:

$$\% \text{ Moisture} = \frac{(\text{KF titre} \times F_{kf} - \text{H}_2\text{O-methanol titre} \times F_{\text{H}_2\text{O-methanol}})\ 100}{\text{Sample weight}}$$

   NOTE: In cases where pre-treatment of the sample is necessary to eliminate interaction between the material to be analyzed and Karl Fischer reagent, a separate solvent or reagent blank may be necessary. The calculation then becomes:

$$\% \text{ Moisture} = F_{kf}(\text{Sample KF titre} - \text{Blank KF titre}) - F_{\text{H}_2\text{O-methanol}}(\text{Sample H}_2\text{O-methanol titre} - \text{Blank H}_2\text{O-methanol titre})\ \ 100\ /\ \text{Sample weight}$$

B - VISUAL

1. Measure about 25 ml. of the solvent designated in the specification for the product (or see Discussion) into a dry 125 ml. Erlenmeyer flask.

2. Titrate with Karl Fischer reagent to an end point that matches the color of the N/100 methanolic iodine solution, sweeping moisture out of the flask by swirling the solution up the walls of the flask.

3. Zero the Karl Fischer burette.

DSW 176452

4. Add the prescribed weight of sample to the blanked solvent, swirl to dissolve, and immediately titrate to the same end point.

NOTE: If the material to be analyzed is an insoluble porous solid, disperse the finely divided sample in the solvent and allow to stand in a stoppered flask with occasional shaking for periods up to 1 hour at room temperature before titrating with Karl Fischer reagent.

5. Calculate:

$$\% \text{ Moisture} = \frac{\text{ml. titre} \times \text{factor} \times 100}{\text{sample weight}}$$

NOTE: In cases where pre-treatment of the sample is necessary to eliminate interaction of the material to be analyzed and Karl Fischer reagent, a separate solvent or reagent blank may be necessary. The calculation then becomes:

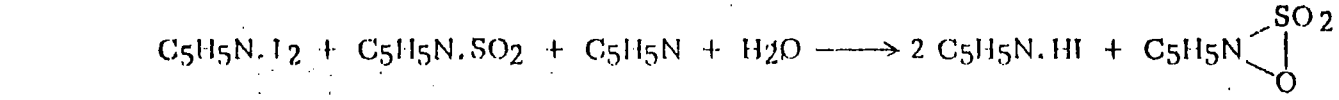
$$\% \text{ Moisture} = \frac{(\text{Sample ml.} - \text{Blank ml.}) \times \text{factor} \times 100}{\text{sample weight}}$$

PRECISION AND ACCURACY

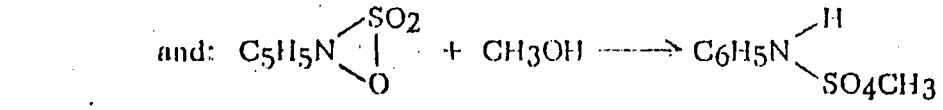
In the absence of interfering substances and provided that the usual precautions of good analytical technique are observed, routine visual determinations are reproducible with a maximum variation of 0.2 ml. of reagent. Electrometric titrations are reproducible to from 0.03 to 0.10 ml. depending upon the rate of delivery of the reagent. The accuracy will depend upon the absolute amount of water present in the sample and the accuracy of reagent standardizations and sample weight. With samples chosen to contain 125-200 milligrams of water, a precision and accuracy of 0.1 to 0.2% is obtainable for samples run in duplicate.

DISCUSSION

The stoichiometry of the reaction between water and Karl Fischer reagent is as follows:



and:



Pyridine is used to combine with acidic products, which will cause a reversal in the following reaction:

$$I_2 + SO_2 + 2\,H_2O \longrightarrow HI + H_2SO_4$$

It has the added advantage of combining with the sulfur dioxide, thereby reducing the vapor pressure of the latter.

Most substances are inert to Karl Fischer reagent and may be analyzed without special treatment. However, a number of compounds and classes of compounds react stoichiometrically with one or more of the components of Fischer reagent. Included among these are: ℓ-Ascorbic Acid, Hydrazine Salts, Substituted Hydrazine Salts, Mercaptans, Alkali Bicarbonates, Alkali Carbonates, Alkali Sulfites, Alkali Pyrosulfites, Boric Acid and Oxides, Carbonyl Compounds, Cupric Salts, Ferric Salts, Metal Hydroxides, Metal Oxides, Sodium Arsenate, Sodium Arsenite, Sodium Tetraborate, Sodium Thiosulfate, and Stannous Chloride.

In general these reactive compounds either may be rendered inert (the use of glacial acetic acid as a solvent eliminates amine and hydrazine interference) or may be estimated by an independent method and a stoichiometric correction applied to the water determination.

DSW 176453

STLCOPCB4050340

Although the cyanohydrin technique is the only general method for the determination of water in the presence of carbonyl compounds, low alcohol Karl Fischer reagent and/or special solvents may be used to inhibit interfering side reactions of many ketones and some aldehydes. By greatly reducing the methanol and increasing the pyridine in the regular Fischer solution, the tendency of carbonyls to form acetals and ketals by reacting with the methanol of the standard reagent is reduced. Appreciable quantities of lower alcohols in the sample will permit the interfering acetal or ketal reaction even with the use of modified reagent.

Details of other method variations are beyond the scope of this method and will be given in the methods of analysis for the specific compounds.

In general, methanol may be used as solvent for the determination of water in inert materials. Amines stronger than benzyl amine ($K_\beta = 2.4 \times 10^{-5}$) and other basic compounds are preferably treated with or dissolved in an excess of glacial acetic acid or spent Fischer reagent, which in both cases combines with the amines. Some organic acids, formic, acetic, adipic, etc., tend to give slightly high results when methanol is used as a diluent, because of the ease with which they esterify. When equal parts of dry methanol and pyridine are used as diluent, the inhibiting influence of the amine is sufficient to discourage any esterification of the acid at room temperature.

SAFETY

No unusual hazards are involved in this operation when cognizance of the inflammability and toxicity of the reagents and solvents is taken.

REFERENCE

1. "Aquametry", Mitchell and Smith, Interscience Publishers, Inc., N.Y., 1948.

ISSUED OCT 23 1956
STANDARDS DEPARTMENT
John F. Queeny Plant
By Paul H. Bowers

STLCOPCB4050341

MONSANTO CHEMICAL COMPANY

ORGANIC CHEMICALS DIVISION

JOHN F. QUEENY PLANT

STANDARD PROCEDURE

Number 84-A

Department LABORATORY 1 Sheets: Page 1

Title ODOR INSPECTION

THIS FORM ~~SUPERSEDES~~ INSTRUCTION ISSUED ON 2-28-61 EPM Revised: OJC

SCOPE

This method is intended for the characterization of the odors of materials by olfactory perception.

DETERMINATION

1. Remove sufficient material to allow about two inches of head room in the sample bottle above the contents to permit adequate trapping of the odor evolved.
2. If the nature of the sample permits, agitate the contents of the bottle.
3. Let the bottle stand closed at least 30 minutes before performing the odor evaluation.
4. If unfamiliar with the odor of the product being tested, carefully open a previously approved sample and cautiously smell the air in the neck of the bottle.
5. Describe the sample odor with respect to the specification requirement.

ISSUED JULY 25, 1963
STANDARDS DEPARTMENT
John F. Queeny Plant
By Paul N. Bruen

DSW 176455

Q 235

STLCOPCB4050342

MONSANTO CHEMICAL COMPANY

ORGANIC CHEMICALS DIVISION

JOHN F. QUEENY PLANT

X Use hydrometer

STANDARD PROCEDURE

Method Number 116-B

Department 508 - LABORATORY 2 Sheets: Page 1

Title SPECIFIC GRAVITY OF LIQUIDS BY BABCOCK GRAVITY BOTTLE

THIS FORM SUPERSEDES ~~SUPERSEDES~~ INSTRUCTION ISSUED ON June 17, 1957 Revised: OJC

SCOPE

This method is intended for the determination of the specific gravity of liquids with Babcock gravity bottles. It involves weighing equal volumes of liquids at a standard temperature.

EQUIPMENT

(a) Babcock gravity bottle, such as catalog number 12-700, Fisher Scientific Company, St. Louis 18, Missouri.

(b) Constant temperature bath, such as catalog number S-84805, E. H. Sargent and Company, Chicago 30, Illinois.

(c) Usual laboratory apparatus and reagents.

STANDARDIZATION

1. Weigh accurately a clean empty Babcock gravity bottle.

2. Fill with cool, recently boiled distilled water and adjust the volume so that the meniscus is within the graduated scale of the neck of the bottle.

3. Place in a 25.0°C constant temperature bath and allow to remain there until several readings show the volume to be constant.

4. Remove the bottle from the bath, read the level of the liquid and record; rinse the outside with methanol, dry, and weigh accurately.

5. Determine the weight of water in the bottle below the zero mark on the neck:

$$\text{Weight of water} = \left[\text{Gross weight} - (\text{neck reading} \times 0.2)\right] - \text{Tare weight}$$

6. Refill the bottle with water and replace it in the bath.

7. As temperature equilibrium is again approached, adjust the liquid level to zero reading by means of a small piece of cotton on the end of a wood applicator.

8. Remove the bottle, rinse, dry and reweigh.

9. Determine weight of water:

$$\text{Weight of water} = \text{Gross weight} - \text{Tare weight}$$

NOTE: The values for weight of water obtained in steps 5 and 9 should agree within 0.01 grams.

10. Empty the Babcock bottle and rinse thoroughly with methanol and with acetone. Then dry by aspiration, wipe dry, and reweigh.

11. Repeat steps 1 through 10 two or more times until individual values agree with average val ues within $\pm$ 0.01 grams.

DETERMINATION

1. Fill a clean and dry standardized Babcock gravity bottle with sample until the liquid level is within the graduated scale of the neck of the bottle. (If necessary, warm the sample until it is free flowing before filling Babcock bottle.)

2. Place the filled bottle in a 25°C constant temperature bath and allow to remain until several readings on the graduated neck show the volume to be constant.

3. Remove the Babcock bottle from bath, read the level of liquid and record; rinse with methanol, dry the outside of the bottle and weigh accurately.

4. Calculate:

$$\text{Specific Gravity @ 25°C/25°C} = \frac{\text{gross weight - tare weight}}{\text{water weight + (neck reading x 0.2)}}$$

Report answer to the nearest 0.0001

PRECISION AND ACCURACY

Based on the reproducibility of weighing this method has a repeatability of 0.0005 and a reproducibility of 0.001.

DISCUSSION

Although this method is written for specific gravity determinations at 25°/25°C, it can be used for determinations at other temperatures and/or with different standardization temperatures by employing constant temperature baths of the desired temperature.

In order to convert the specific gravity obtained at 25°C/25°C to other desired values the following formulae may be used:

1. Density at 25°C = Specific Gravity 25/25°C x 0.99707

2. Specific Gravity at 60/60°F = Specific Gravity 25/25°C x Factor

$$\text{Factor} = \frac{\text{specific gravity @ 15.6/15.6°C}}{\text{specific gravity @ 25/25°C}}$$

as determined on representative samples when the material is sufficiently uniform so that the factor shows a standard deviation of no more than 0.0001 in ten batches.

SAFETY

Taking appropriate precautions regarding possible toxic, corrosive, dermatological, flammable, or other hazardous properties of the material being tested, no unusual hazards are involved in this operation.

ISSUED AUGUST 23, 1963
STANDARDS DEPARTMENT
John F. Queeny Plant
By [illegible]

STLCOPCB4050344

MONSANTO CHEMICAL COMPANY

ORGANIC CHEMICALS DIVISION

JOHN F. QUEENY PLANT

STANDARD PROCEDURE

Number 126-A

Department 508 - LABORATORY 3 Sheets: Page 1

Title VISCOSITY BY OSTWALD (MODIFIED) VISCOMETER

THIS FORM SUPERSEDES ~~XXXXXXXXXX~~ INSTRUCTION ISSUED ON 4-28-60 Revised RJB

SCOPE

This method is intended for the measurement of the kinematic viscosities of simple liquids. It involves timing the efflux of a measured amount of sample through a Cannon-Fenske modified Ostwald pipet at a constant temperature.

EQUIPMENT

(a) Ostwald (Cannon-Fenske) Viscometers, series 50 through 600, Fisher Scientific Co., catalog No. 13-616.

(b) Thermometers, ASTM, Fisher Scientific Co., catalog No. 13-618. Check for accuracy against a standard thermometer.

(c) Constant temperature baths adjusted to 100°F and 210°F (+ 0.05°F), E. H. Sargent and Co., catalog No. 5-67428.

(d) Timer or stop-watch graduated in 0.1 seconds.

(e) ASTM Viscosity Oil Standards, S-3 through S-2000, Cannon Instrument Co., Box 812, State College, Pa.

CALIBRATION

1. Using the appropriate ASTM Viscosity Standard or Standards and the 100°F bath, follow steps 1 through 7 and step 9 of the Determination section of this method with each new viscometer and/or within 2 months of use.

2. Calculate:

$$\text{Calibration factor at } 100°F = \frac{\text{nominal KV of standard}}{\text{Average efflux time in seconds}}$$

$$\text{Calibration factor at } 180°F = \text{factor at } 100°F \times 0.999$$

$$\text{Calibration factor at } 210°F = \text{factor at } 100°F \times 0.996$$

DETERMINATION

1. From the table below select a clean, dry viscometer covering the expected range of the material to be tested:

DSW 176458

Q 205

STLCOPCB4050345

Expected Viscosity in Centistokes	Viscometer Series
0.4 to 1.6	25
0.8 to 3.2	50
3 to 12	100
7 to 28	150
20 to 80	200
50 to 200	300
100 to 400	350
240 to 960	400
500 to 2000	450
1600 to 6400	500
4000 to 16000	600

2. Immerse the working capillary of the viscometer in a clear portion of the sample and fill just to the second etched mark by suction.

   NOTE: If any doubt exists regarding the clarity of the sample, filter a 10-15 ml. portion through a dry filtering crucible into a dry receiver by suction.

3. Suspend the viscometer vertically in the appropriate bath and allow to remain for 5 minutes if in the 100°F bath, or for 10 minutes if in the 210°F bath.

4. By suction draw the head of the sample to about 5 mm. above the first etched mark on the viscometer capillary.

5. Release the suction, and when the liquid meniscus just reaches the first etched mark start the timer.

6. Stop the timer just as the meniscus reaches the second etched mark and record the efflux time to the nearest 0.1 second.

7. In like manner raise the liquid head and make 5 successive measurements of the efflux time.

8. From the average of the 5 measurements, calculate:

   KV (centistokes) = Efflux seconds x calibration factor.

   The corresponding viscosity in Saybolt Universal Seconds (SUS) may be obtained by reference to the attached table.

9. Thoroughly clean the viscometer with solvents for the sample measured, using filtered benzene for hydrocarbon oils or distilled water and acetone for water soluble materials. Use hot cleaning solution with appropriate caution followed by distilled water and acetone if necessary. Then dry by aspiration.

PRECISION

ASTM Method D 445-53T, from which this method was adapted, specifies a repeatability of 0.1% and a reproducibility of 0.2% of the mean viscosity found.

SAFETY

Exercise appropriate precautions against burns when working with the high temperature baths.

REFERENCE - ASTM Method D 445-53T

ISSUED MAR 9 S, 1962
STANDARDS DEPARTMENT
John F. Queeny Plant
By Paul M. Bowles

DSW 176459

VISCOSITY CONVERSION TABLE - CENTISTOKES TO SUS

Centistokes (Cs)	Saybolt Universal Seconds (SUS) At 100°F and 130°F	Saybolt Universal Seconds (SUS) At 210°F
2.0	32.6	32.9
2.5	34.4	34.7
3.0	36.0	36.3
3.5	37.6	37.9
4.0	39.1	39.4
4.5	40.8	41.0
5.0	42.4	42.7
6.0	45.6	45.9
7.0	48.8	49.1
8.0	52.1	52.5
9.0	55.5	55.9
10.0	58.9	59.3
11.0	62.4	62.9
12.0	66.0	66.5
13.0	69.8	70.3
14.0	73.6	74.1
15.0	77.4	77.9
16.0	81.3	81.9
17.0	85.3	85.9
18.0	89.4	90.1
19.0	93.6	94.2
20.0	97.8	98.5
21.0	102.0	102.8
22.0	106.4	107.1
23.0	110.7	111.4
24.0	115.0	115.8
25.0	119.3	120.1
26.0	123.7	124.5
27.0	128.1	129.0
28.0	132.5	133.4
29.0	136.9	137.9
30.0	141.3	142.3
31.0	145.7	146.8
32.0	150.2	151.2
33.0	154.7	155.8
34.0	159.2	160.3
35.0	163.7	164.9
36.0	168.2	169.4
37.0	172.7	173.9
38.0	177.3	178.5
39.0	181.8	183.0
40.0	186.3	187.6
41.0	190.8	192.1
42.0	195.3	196.7
43.0	199.8	201.2
44.0	204.4	205.9
45.0	209.1	210.5
46.0	213.7	215.2
47.0	218.3	219.8
48.0	222.9	224.5
49.0	227.5	229.1
50.0	232.1	233.8
51.0	236.7	238.4
52.0	241.3	243.1
53.0	245.6	247.7
54.0	250.6	252.4
55.0	255.2	257.0
56.0	259.8	261.6
57.0	264.4	266.3
58.0	269.1	270.9
59.0	273.7	275.6
60.0	278.3	280.2
61.0	282.9	284.9
62.0	287.5	289.5
63.0	292.2	294.2
64.0	296.8	298.8
65.0	301.4	303.5
66.0	306.0	308.1
67.0	310.6	312.8
68.0	315.3	317.4
69.0	319.9	322.1
70.0	324.4	326.7
Over 70.0	SUS = Cs x 4.635	SUS = Cs x 4.667

Viscosities not listed, but which are within the range given in this table, are obtained by linear extrapolation.

DSW 176460

STLCOPCB4050347

J. F. QUEENY PLANT
MONSANTO CHEMICAL COMPANY
ORGANIC CHEMICALS DIVISION

RAW MATERIAL SPECIFICATION

MATERIAL CODE
28000

USING DEPTS.
80071, 80077, 80151, 80180

SUPPLIERS: Allied Chem., Koppers & U.S. Steel

ISSUED JAN 30 1962
STANDARDS DEPARTMENT
John F. Queeny Plant
By Paul N. Bauer

MATERIAL
CRESYLIC ACID IMPROVED

CHEMICAL FORMULA

A mixture of chiefly meta and para cresols, together with some xylenols and small amounts of xylenol homologues.

MOL WT. ---

SUPERSEDES SPECS OF
1-4-61 tentative

SAMPLE FOR ANALYSIS
2 x 16-ounce NN bottles

TEST	UNRESTRICTED PURCHASE LIMITS	PROCEDURES
On each shipment		
Appearance	Describe color and state	16-B
o-Cresol	1.0% max	41.5-28000
Moisture (By KF in methanol)	0.2% max	78-B
Odor	Characteristic	84-A
Specific gravity at 25/25°C	1.0285 to 1.0335	116-A
Upon request		
Composition:		22-28000
Meta-para cresols	78.0% min	
Xylenols, total	20% max	
Phenol	0.5% max	
Neutral oils	0.1% max	84.7-28000b
Specific gravity at 20/20°C	1.0325 to 1.0375	116-A
Sulfur	0.05%	124-A & 120-B

Releasing Information

1. All shipments must comply with these specifications. Monsanto, at its option, may elect to accept material not meeting specifications provided notification is given by the vendor before shipment is made.

2. Shipper's analysis, covering the above requirements and any other properties routinely determined, will be mailed to the "J. F. Queeny Plant Laboratory - Raw Material Section Leader" the same day that shipment is made.

DSW 176461

IN 55 (REV. 12/58)

STLCOPCB4050348

MONSANTO CHEMICAL COMPANY

From : St. Louis Research Dept.

DATE : April 1, 1964

SUBJECT : Pydraul 280
Tentative Specification Limits

REFERENCE :

TO : P. E. Heisler
WGK Plant

cc: D.F. Smith
P.N. Biven
W.G.K. Standards Dept.
W.R. Richard
J.D. Sullivan
R.L.Miller/R.E.Bilger/
D.B. Hosmer

This will confirm our phone conversation of 4/1/64 concerning specification limits of Pydraul 280. These should be used as a guide until limits have been set. These limits based on limits for Pydraul A-200, Pydraul 625, and the typical analysis of Pydraul 280 follow:

X	Acidity (neut. no.)	0.5 to 0.8
X	Moisture	0.15 max.
	Pour Point	+20°F max.
	Flash Point	350°F min.
X	Viscosity, cs.	
	100°F	56 to 62
	210°F	3.90 to 4.10
X	Sp. Gr. 25/25°C	1.385 to 1.405

How big can we go?

L. R. Stark

jd

Dealy to write Specs

How much do we make?

How much is order for?

Reqd — 36000 #/mo.

Dallas

DSW 176462

STLCOPCB4050349

MONSANTO CHEMICAL COMPANY
Monsanto, Illinois

Messrs. T. W. Dalton - Off.
J. R. Kellogg - 246
H. S. Scott - NA
W. J. Gresham - Lab.
R. F. Schubert - Lab.
C. M. Edelblut - Anniston
J. Clegorn - Anniston
W. W. Klemme - Anniston
T. M. Patrick - Org. Res.
P. G. Benignus - B-2-S
S. E. Sankey - B-2-S

Mr. A. M. Ellenburg

Org. Res.

12/9/58

Your memo to Klemme/Gresham, 12/2/58

AROCLOR 1254 --
SPECIFICATIONS

As you requested we have made a statistical evaluation of the distillation range of Aroclor 1254. The survey covers the last two years production, with 51 lots of electrical grade finished goods produced. With the exception of two lots out on the 90% Distilled, all of the rest fall within the specification issued 12/3/58.

The suggested GE specification on 10% distilled is the same as we are showing. The 50% and 90% distilled are somewhat lower than our specification. If their suggested specifications are based on material actually received then it would seem that they are not getting shipments that represent our total production. Another possibility could be that our methods do not give comparable results. Based on our total production and assuming no method difficulties, it is proposed that we retain our present specification.

	SUGGESTED GE SPECIFICATION	MONSANTO SPECIFICATION
10% Distilled	366-378°C	366-378°C
50% Distilled	371-379°C	372-383°C
90% Distilled	379-394°C	383-396°C

A theoretical statistical evaluation of the data available is tabulated below for your evaluation:

	SUGGESTED GE SPECIFICATION		MONSANTO SPECIFICATION	
	% BELOW	% ABOVE	% BELOW	% ABOVE
10% Distilled	ca. 0.4%	ca. 1.0%	ca. 0.4%	ca. 1.0%
50% Distilled	<0.01%	ca. 27.1%	ca. 0.05%	ca. 0.2%
90% Distilled	<0.01%	ca. 7.0%	ca. 1.0%	ca. 1.5%

From a theoretical point of view it would also be advantageous to retain our present specification.

DSW 176463

STLCOPCB4050350

We have attached frequency distribution analysis sheets for the distillation range.

E. O. Martin

R. F. Schubert

LHP

STLCOPCB4050351

MONSANTO CHEMICAL COMPANY
QUALITY CONTROL

DSW 176465

FREQUENCY DISTRIBUTION ANALYSIS SHEET

IN 123

DEPT.	CODE	PRODUCT	TEST OF	DATE
246		AROCLOR 1254	10% DISTILLED BY WT	12/5/58

PLANT	UPPER SPECIFICATION LIMIT	LOWER SPECIFICATION LIMIT	PERIOD COVERED	DATA ANALYZED BY
W. G. K.	378°C	366°C	1/3/57 to 11/19/58	Eon

% UNDER SPEC	% OVER SPEC	DISTRIBUTION TYPE	n (FOR CC)
—	—	NORMAL	

1	TALLY	2	5	6
X		f	Acc. 2	5 ÷ 4 IN % OVER
378	I	1	1	1.0
377	I	1	3	2.9
376	II	3	6	5.9
375	II	2	10	9.8
374	𝍸 𝍸 I	11	23	22.5
373	𝍸 III	8	42	41.2
372	𝍸 𝍸 II	13	62	60.7
371	𝍸	5	79	77.4
370	II	2	86	84.3
369	IIII	4	92	90.2
368	II	2	98	96.1
367	I	1	101	99.0
366			102	100.0

UCL_X	$UCL_{\bar{X}}$	3 TOTAL	UCL_R
379.8		51	
LCL_X	$LCL_{\bar{X}}$	4 DOUBLE TOTAL	LCL_R
365.0		102	
PROC CAPABILITY	σ	$\bar{X}$	$\bar{R}$
14.8	2.5	372.4	

CONTROL LIMIT SCALES (3σ)

PERCENTAGE OVER

PERCENTAGE UNDER

CONTROL LIMIT SCALES (3σ)

COPYRIGHT 1958 | NORTH AMERICAN AVIATION, INC. MODIFIED AND REPRODUCED BY PERMISSION

STLCOPCB4050352

MONSANTO CHEMICAL COMPANY
QUALITY CONTROL

DSW 176466

FREQUENCY DISTRIBUTION ANALYSIS SHEET

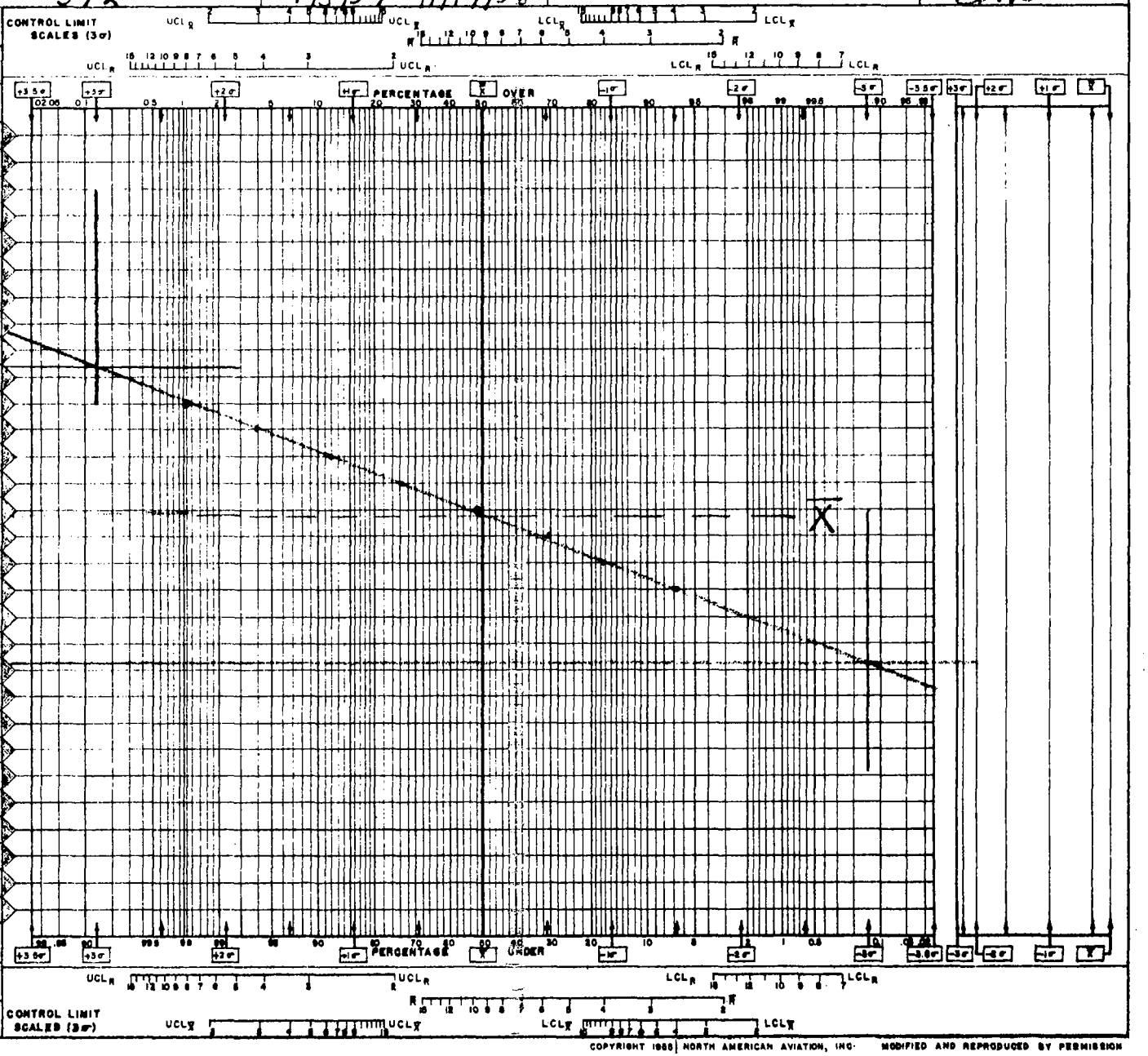
DEPT	CODE	PRODUCT	TEST OF	DATE
246		AROCLOR 1254	60% DISTILLED BY WT	12/5/58

PLANT	UPPER SPECIFICATION LIMIT	LOWER SPECIFICATION LIMIT	PERIOD COVERED	DATA ANALYZED BY
W.G.K.	383	372	1/3/57 - 11/19/58	Evans

% UNDER SPEC	% OVER SPEC	DISTRIBUTION TYPE	A (FOR CC)
—	—	NORMAL	

1 / X	TALLY	2 / f	5 / Acc. 2	6 / 5 ÷ 4 IN % OVER
383				
382	I	1	1	1.0
381	II	2	4	3.9
380	IIII	4	12	11.8
379	IIII IIII	9	27	26.5
378	IIII IIII III	13	49	48.0
377	IIII IIII	9	71	69.6
376	IIII	4	84	82.3
375	IIII II	7	95	93.1
374			102	100.0
373				
372				

$UCL_{\bar{X}}$ 383.4	$UCL_{\bar{X}}$	3 TOTAL 51		UCL_R
$LCL_{\bar{X}}$ 371.7	$LCL_{\bar{X}}$	4 DOUBLE TOTAL 102		LCL_R
PROC. CAPABILITY 10.7	σ 1.8	$\bar{X}$ 377.9		$\bar{R}$



COPYRIGHT 1958 NORTH AMERICAN AVIATION, INC. MODIFIED AND REPRODUCED BY PERMISSION

STLCOPCB4050353

410;2 NOT INCLUDED IN EVALUATION

MONSANTO CHEMICAL COMPANY
QUALITY CONTROL

DSW 176467

FREQUENCY DISTRIBUTION ANALYSIS SHEET

IN 123

DEPT	CODE	PRODUCT	TEST OF	DATE
246		AROCLOR 1254	90% DISTILLED BY WT.	12/5/58

PLANT	UPPER SPECIFICATION LIMIT	LOWER SPECIFICATION LIMIT	PERIOD COVERED	DATA ANALYZED BY
W.G.K.	396	383	1/3/57 - 11/19/58	Con

% UNDER SPEC	% OVER SPEC	DISTRIBUTION TYPE	* (FOR CC)
—	4.0%	NORMAL	

1	TALLY	2	5	6
X		f	Acc. 2	5 ÷ 4 IN % OVER
396	I	1	1	1.0
395	IIII	4	6	6.1
394	II	2	12	12.2
393	III	3	17	17.3
392	II	2	22	22.4
391	~~HH~~	5	29	29.6
390	~~HH HH~~ IIII	14	48	49.0
389	III	3	65	66.3
388	IIII	4	72	73.5
387	~~HH~~	5	81	82.7
386	III	3	89	90.8
385	II	2	94	95.9
384	I	1	97	99.0
383			98	100.0

UCL_X 398.1	$UCL_{\bar{X}}$	3 TOTAL	49	UCL_R
LCL_X 380.5	$LCL_{\bar{X}}$	4 DOUBLE TOTAL	98	LCL_R
PROD. CAPABILITY 17.6	σ 2.9	$\bar{X}$ 389.7	$\bar{X}$	

CONTROL LIMIT SCALES (3σ)

PERCENTAGE OVER

PERCENTAGE UNDER

CONTROL LIMIT SCALES (3σ)

COPYRIGHT 1955 | NORTH AMERICAN AVIATION, INC. MODIFIED AND REPRODUCED BY PERMISSION

STLCOPCB4050354

St Louis 4, Mo.

July 8, 1954

D. B. Hosmer - WGK
E. W. Liesen - WGK
G. N. Schwartz - WGK
H. L. Hubbard - Res. 2
R. M Munch - Res. 2
J. E. Crouch - Anniston
Jack Clegorn - Anniston

Mr. W. J. Gresham-WGK
Mr. J W. Carlson - Anniston

Gresham/Ellenburg 4/19/54

AROCLOR 12 - VISCOSITY

The work of Dr Munch and Dr Koerner in standardizing a lot of Aroclor 1254 for checking your Saybolt viscosimeters has shown that the differences between the two instruments at Anniston and Krummrich has been a matter of technique

After discussing the problem with the Research group in charge of physical measurements under Dr Munch, it is proposed that the Ostwald method be used wherever possible for Aroclor viscosity measurements It is well known that all oil standards are calibrated by the Ostwald method and then converted to Saybolt seconds.

So it is apparent that the Ostwald method would be the referee method in case of a difference of results on other type viscosimeters.

There are advantages in the Ostwald method over the Saybolt method which are of interest to all of us:

1. Better reproducibility - with different operators.
2. Greater accuracy.
3. Simpler operation - easier to control temperature.

All of these advantages result from the fact that no special analytical techniques are involved in maintaining a constant temperature during the effluent time of the liquid. Other factors such as less frequent standardization and less working time for a measurement may be advantageous.

Our opinion on the future Aroclor analyses as discussed with Dr. Munch and Mr. Hubbard is that W. G. Krummrich laboratory can use the Ostwald method for Aroclor viscosities. Since a number of individuals may be making the viscosity measurements, it is believed that more accurate Aroclor viscosities can be made by using the Ostwald viscosimeter.

Anniston has indicated a preference to continue using the Saybolt viscosimeter. They have been very successful in checking with the Saybolt viscosimeter and have been able to keep one analyst mainly on Aroclor analyses Anniston should continue to use the Saybolt method if they so desire. It is recommended that for any future purchase of viscosimeters, the Ostwald equipment be given earnest consideration.

If Anniston should encounter difficulty with viscosity measurements, the Ostwald method may be the best approach to resolving any differences.

DSW 176468

STLCOPCB4050355

Both laboratories should keep a supply of Aroclor 1260 Standard Lot M-220 on hand for calibrating their instruments.

I see no reason for consulting G. E. on this matter. We are only interested in obtaining the true viscosity of our Aroclor. Both methods have been shown to give the correct answers. However the Ostwald method is the referee method chosen to calibrate the Saybolt viscosimeter.

I trust this course of action is satisfactory to all concerned.

A. M. Kilenburg

wp

STLCOPCB4050356

SPECIFIC GRAVITIES AND COEFFICIENTS OF EXPANSION OF AROCLORS 1819, 1232, 1242, 1248, 1254 and 1262.

By

Morton Harris
C. B. Durgin

November 19, 1930

OBJECT:

To determine the specific gravities and coefficients of expansion of Aroclors 1819, 1232, 1242, 1248, 1254 and 1262.

SUMMARY:

The specific gravities or Aroclors 1819, 1232, 1242, 1248, 1254, and 1262 were determined at various temperatures between 25° and 100°C by means of a Westphal balance. The results are shown in Figure 1.

The following table gives the average coefficient of expansion, over the indicated temperature range, for these Aroclors. These values were calculated from the above specific gravity measurements.

Aroclor	Temperature Range °C	Coefficient of expansion c.c./c.c./°C
1819	25 - 100	.000792
1232	25 - 100	.000725
1242	25 - 100	.000733
1248	25 - 100	.000688
1254	25 - 100	.00067
1262*	60 - 100	.000635

* Too viscous below 60°C for Westphal balance determination.

CONCLUSIONS:

The coefficients of expansion as shown are average values over the indicated temperature range. Calculations were made to determine these coefficients over smaller temperature ranges. Unavoidable errors in the specific gravity measurements, however,

DSW 176470

STLCOPCB4050357

D A T A

I

AROCLOR	SPECIFIC GRAVITY					
	25/25°C	40/25°C	60/25°C	80/25°C	90/25°C	100/25°C
1819	1.160	1.146	1.129	1.1[illegible]2	--	1.095
1232	1.281	1.268	1.250	1.232	--	1.215
1242	1.381	1.366	1.347	1.328	--	1.309
1248	1.456	1.451	1.432	1.413	--	1.394
1254	1.547	1.532	1.512	1.492	--	1.473
1262*	--	--	1.612	1.592	1.582	1.572

I

* Too viscous below 60°C to be determined.

II

AROCLOR	COEFFICIENT OF EXPANSION					
	25-40°C	40-60°C	60-80°C	80-90°C	80-100°C	90-100°C
1819	.000815	.000753	.000763	---	.000774	---
1232	.000685	.000720	.00073	---	.00070	---
1242	.000732	.000706	.000715	---	.000726	---
1248	.000689	.000663	.000672	---	.000682	---
1254	.000652	.000662	.000670	---	.000645	---
1262	---	---	.000627	.000631	---	.000636

DSW 176471

STLCOPCB4050358

make these values unreliable. They are given along with the other data for thesake of completeness. Their accuracy may be increased greatly by the use of more accurate specific gravity data, as obtained by a specific gravity bottle or pycknometer.

EXPERIMENTAL:

Materials:

Samples of Aroclor produced in plant. (Note book No.91)

Apparatus:

Westphal balance

0 - 150°C thermometer.

800 cc. beaker

Hot plate.

Procedure:

The Westphal balance was adjusted to read unity for water at 25°C. With this setting the specific gravities of the different Aroclors at 25, 40, 60, 80, and 100°C were determined. The specific gravity of Aroclor 1262 could not be determined below 60°C by this method because of its high viscosity below 60°C.

The following calculation of the coefficient of expansion for Aroclor 1219 is typical of the method used.

Sp. Gr. at 25/25°C = 1.160

Sp. Gr. at 100/25°C = 1.095

Basis:

1000 cc. at 25°C.

Wt. per litter at 25°C = 1160 gms.

" " " " 100° = 1095 Gms.

65 gms.

Ft. of volume in excess of one liter after heating one liter at 25°C to 100°C = 65 gms.

cc. excess of one liter = $\frac{65}{1.095}$ = 59.3 cc.

Coefficient of expansion from 25 - 100°C = $\frac{59.3}{100-25)X\ 1000}$ = .000792cc/gc/°C

DSW 176472

STLCOPCB4050359

MANUFACTURE OF AROCLORS

Aroclor is a name used to designate the chlorinated products of diphenyl. The physical properties vary from a light mobile oil to crystalline and non-crystalline solids depending upon the degree of chlorination and the composition of the raw material. Straight diphenyl chlorinated yields a liquid product of increasing viscosity up to and including 63% chlorine. Above this the yield is a crystalline solid. Straight high boiler and mixtures of diphenyl and high boiler chlorinated yield products of increasing viscosity up to non-crystalline resins.

A numerical system of nomenclature consisting of four digits has been developed for identifying the various Aroclors.

The first digit denotes the raw material used for the chlorination. The figure "one" indicates 100% technical diphenyl. The second digit denotes whether or not the product is distilled. The figure "one" indicating undistilled, the figure "two" indicating distilled. The last two digits denote the approximate percentage of chlorine contained in the finished product. There are several arbitraty deviations from the above nomenclature as follows:

1. Aroclor 4065 and 4465. The former is the crude from which the latter is obtained by distillation. The starting raw material contains 40% distilled high boiler and 60% technical diphenyl. This is chlorinated to 65% chlorine.

2. Aroclors 5060 and 5460. The former is the crude from which the latter is distilled. The starting raw material is 100% distilled high boiler. This is chlorinated to 60%.

3. Aroclor 2565. This is an undistilled product. The starting raw material consists of 25% crude high boiler and 75% technical diphenyl. This is chlorinated to 65% chlorine.

The Aroclors are not pure compounds but are mixtures of two or more compounds. However, from their chlorine content they may be assumed to have the following compositions:

Aroclors	1142 and	1242	- $C_{12}H_7Cl_3$		
	1148	1248	- $C_{12}H_6Cl_4$		
	1154	1254	- $C_{12}H_5Cl_5$		
	1160	1260	- $C_{12}H_4Cl_6$	+	$C_{12}H_3Cl_7$
	1162	1262	- $C_{12}H_3Cl_7$		
	1168	1268	- $C_{12}H_2Cl_8$	+	$C_{12}HCl_9$
	1169	1269	- $C_{12}HCl_9$		
	4065	4465	- $C_{12}H_2Cl_8$	+	$C_{18}H_4Cl_{11}$
	5060	5460	- $C_{18}H_5Cl_{10}$		

DSW 176473

STLCOPCB4050360

AROCLOR 1248	AROCLOR 1254	AROCLOR 1260	AROCLOR 1262
Yellow tinted oily liquid	Yellow tinted viscous oil	Light yellow soft sticky resin	Light yellow sticky clear resin
0.5 Max.	1.0 Max.	1.0 Max.	1.2 Max.
0.01	0.01	0.015	0.02
0.000702 (25'--65'C) 0.000389 (77'--149'F)	0.000661 (25'--65'C) 0.000367 (77'--149'F)	-- --	0.000640 (25'--90'C) 0.000355 (77'--194'F)
1.447 to 1.457	1.538 to 1.548	1.618 to 1.629	1.646 to 1.629
12.08	12.83	13.50	13.72
330'--370'C Uncorr. 626'--698'F Uncorr.	365'--390'C 689'--734'F	385'--420'C 725'--788'F	373'--404'C Uncorr. 703'--759'F Uncorr.
3.0 to 4.0 --	1.06 to 1.28 0.4	-- 0.0 to 0.2	0.48 to 0.56 --
193'--196'C 379'--384'F	None	None	None
None	None	None	None
--7'C 19.4'F	8' to 12'C 46' to 54'F	26' to 36'C 79' to 97'F	34.9' to 38.0'C 95' to 100.4'F
--	--	--	--
--	--	--	--
1.630--1.631	1.637--1.639 at 25'C	--	1.6501--1.6517
36.0--37.0 69--78 185-240	43.5--48.5 260--400 1800--3800	70--82 2600--4500 --	90--103 600--850 at 160'F --

DSW 176474

STLCOPCB4050361

Form			AROCLOR 1242 Practically Colorless mobile oil
Color--NPA			0.5 Max.
Acidity--Maximum (Mgm. KOH per Gm.)			0.01
Coefficient of Expansion		cc/cc/'C	0.000678 (25'-65'C)
		cc/cc/'F	0.000377 (77'-149'F)
Density--Specific Gravity 25'/25'C(77'/77'F)			1.378 to 1.388
Pounds per Gallon--25'C(77'F)			11.50
Distillation Range--ASTM D-20 Mod.		'C	322'-365'C Uncorr.
		'F	612'-689'F Uncorr.
Evaporation Loss--%--ASTM D-6 Mod.			
163'C	5 hrs.		3.04 to 3.64
100'C	6 hrs.		--
Flash Point--Cleveland Open Cup		'C	176'-180'C
		'F	348'-356'F
Fire Point--Cleveland Open Cup		'C	334'C
		'F	633'F
Pour Point--ASTM		'C	--17.7' to--20.7'C
		'F	--0.2' to--5.2'F
Softening Point--ASTM		'C	--
		'F	--
Refractive Index--D-line--20'C			1.627--1.629
Viscosity--Saybolt Universal Sec. (ASTM--D-88)	210'F (98.9'C)		34.0--34.6
	130'F (54.4'C)		49-56
	100'F (37.8'C)		80-93

DSW 176475

Aroclor No.	Charging Temperature °C	Charged per Batch (lbs.)	Operating Pressure (mm)	Distillation Range at Operating Pres. °C	Distillation Range at Atmospheric Pres. °C.	Sp.Gr. H.P. S.P.	% Recovery	Capacity Per Day
1242	100 - 125	1,000	1 - 3	180 - 210	311 - 358	1.358 @ 65/65	96 - 97	3,000#
1248	100 - 125	1,000	1 - 3	200 - 230	331 - 358	1.439 @ 65/65	96 - 97	3,000
1254	100 - 150	1,000	1 - 3	210 - 245	353 - 373	1.538 @ 65/65	96 - 97	3,000
1260	125 - 150	1,000	1 - 3	220 - 255	372 - 397	1.610 @ 90/90	96 - 97	3,000
1262	125 - 150	1,000	1 - 3	220 - 260	373 - 404	1.635 @ 90/90	96 - 97	3,000
1268	200	1,000	1 - 3	240 - 270	Not Determined	150°C.H.P.	95 - 96	3,000
4465	150	1,000	1 - 3	235 - 350	Decomposes	71 - 76°C S.P.	88 - 90	2,000
5460	175	1,000	1 - 3	250 - 350	Decomposes	112°C S.P.	80 - 85	1,800

Note:

Sp.Gr. - Specific Gravity

H.P. - Hold Point

S.P. - Softening Point.

STLCOPCB4050363

ROCLOR

OPERATING SPECIFICATIONS

		Minimum Limit	Maximum Limit	Operate at
1154	Sp.Gr.	1.500	1.505	1.503
1160	"	1.555	1.562	1.560
2565	Soft Pt	66	72	69
4065	"	66	69	68
(Reg.)				
4065	"	69	73	71
(H.W.)				
5060	"	109	~~112~~ 116	~~110~~ 114
1254	Sp.Gr.	1.495	1.505	1.500
1260	"	1.550	1.560	1.557
4465	Soft Pt.	60	66	64
(Reg.)				
4465	"	67	70	68
(H.W.)				
5460	"	100	105.5	103

Viscosity Limits: 160-210 secs.

SAMPLE CAN SIZES

Pint can	Quart can	Half-Gal.
1154	1248	1254
1160		1260
2565		
4065		
5060		
4465 (Reg)	4465 (HW)	
Diphenyl		
D.H.B.		

12/4/41

DSW 176477

STLCOPCB4050364

1221

160°	-	8.763 #/gal.
150°	-	8.846 #/gal.
140°	-	8.930 #/gal.
130°	-	9.013 #/gal.
120°	-	9.096 #/gal.
110°	-	9.180 #/gal.
100°	-	9.263 #/gal.
90°	-	9.345 #/gal.
80°	-	9.430 #/gal.
70°	-	9.513 #/gal.
60°	-	9.596 #/gal.

1232

160°	-	9.496 #/gal.
150°	-	9.580 #/gal.
140°	-	9.663 #/gal.
130°	-	9.746 #/gal.
120°	-	9.829 #/gal.
110°	-	9.913 #/gal.
100°	-	9.996 #/gal.
90°	-	10.079 #/gal.
80°	-	10.163 #/gal.
70°	-	10.246 #/gal.
60°	-	10.329 #/gal.

1242

160°	-	10.429 #/gal.
150°	-	10.513 #/gal.
140°	-	10.596 #/gal.
130°	-	10.679 #/gal.
120°	-	10.762 #/gal.
110°	-	10.846 #/gal.
100°	-	10.929 #/gal.
90°	-	11.012 #/gal.
80°	-	11.096 #/gal.
70°	-	11.179 #/gal.
60°	-	11.262 #/gal.

1248

160°	-	10.954 #/gal.
150°	-	11.037 #/gal.
140°	-	11.121 #/gal.
130°	-	11.204 #/gal.
120°	-	11.287 #/gal.
110°	-	11.370 #/gal.
100°	-	11.454 #/gal.
90°	-	11.537 #/gal.
80°	-	11.620 #/gal.
70°	-	11.704 #/gal.
60°	-	11.787 #/gal.

1254

160°	-	11.704 #/gal.
150°	-	11.787 #/gal.
140°	-	11.870 #/gal.
130°	-	11.954 #/gal.
120°	-	12.037 #/gal.
110°	-	12.120 #/gal.
100°	-	12.203 #/gal.
90°	-	12.287 #/gal.
80°	-	12.370 #/gal.
70°	-	12.453 #/gal.
60°	-	12.537 #/gal.

1260

160°	-	12.412 #/gal.
150°	-	12.495 #/gal.
140°	-	12.578 #/gal.
130°	-	12.662 #/gal.
120°	-	12.745 #/gal.
110°	-	12.828 #/gal.
100°	-	12.912 #/gal.
90°	-	12.995 #/gal.
80°	-	13.078 #/gal.
70°	-	13.161 #/gal.
60°	-	13.245 #/gal.

1262

Sp. Gr. @ 90° C 1.572 - 1.583

DSW 176479

STLCOPCB4050366

TEMPERATURE CORRECTION FOR SPECIFIC GRAVITIES OF NAPHTHAS

Temp. °C	1142-1242	1154-	1160-1260	Temp. °C	1160-1260	5060	2665 4065 4465	Temp. °C	5060	2665 4065 4465
	1148-1248	1254	1168-1268		1168-1268	5460			5460	
	*65/15.5°	65/15.5	90/15.5		*90/15.5	90/15.5	90/15.5		*90/15.5	90/15.5
	** .0009	.00085	.0010		**.0010	.00095	.00105		**.00095	.00105
60	-.005	-.005		121	+ .031	+ .029	.030	121	+.027	+.075
1	-.004	-.004		2	.032	.030	.034	2	.028	.076
2	-.003	-.003		3	.033	.031	.035	3	.029	.077
3	-.002	-.002		4	.034	.032	.036	4	.070	.078
4	-.001	-.001		5	.035	.033	.037	5	.071	.079
65	*.000	*.000		6	.036	.034	.038	6	.072	.080
6	+.001	+.001		7	.037	.035	.039	7	.073	.081
7	+.002	+.002		8	.038	.036	.040	8	.074	.082
8	+.003	+.003		9	.039	.037	.041	9	.075	.083
9	+.004	+.004		130	+ .040	+.038	+.042	170	+.075	+.084
70	+.005	+.005		1	.041	.039	.043	1	.077	.085
1	.005	.006		2	.042	.039	.044	2	.078	.086
2	.006	.007		3	.043	.041	.045	3	.079	.087
3	.007	.008		4	.044	.042	.046	4	.080	.088
4	.008	.009		5	.045	.043	.047	5	.081	.089
5	.009	.010	-.015	6	.046	.044	.048	6	.082	.090
6	.010	.010	-.014	7	.047	.045	.049	7	.083	.091
7	.011	.011	-.013	8	.048	.046	.050	8	.084	.092
8	.012	.012	-.012	9	.049	.047	.051	9	.085	.093
9	.013	.013	-.011	140	+ .050	+.048	.052	180	+.085	+.094
80	+.014	+.014	-.010	1	.051	.048	.054	1	.086	.095
1	.014	.015	-.009	2	.052	.049	.055	2	.087	.097
2	.015	.016	-.008	3	.053	.050	.056	3	.088	.098
3	.016	.017	-.007	4	.054	.051	.057	4	.089	.099
4	.017	.018	-.006	5	.055	.052	.058	5	.090	.100
5	.018	.019	-.005	6	.056	.053	.059	6	.091	.101
6	.019	.020	-.004	7	.057	.054	.060	7	.092	.102
7	.020	.021	-.002	8	.058	.055	.061	8	.093	.103
8	.021	.022	-.002	9	.059	.056	.062	9	.094	.104
9	.022	.023	-.001	150	+ .060	+.057	+.065	190	+.095	+.105
90	+.023	+.024	*.000	1	.061	.058	.064	1	.096	.106
1	.023	.025	+.001	2	.062	.059	.065	2	.097	.107
2	.024	.026	+.002	3	.063	.060	.066	3	.098	.108
3	.025	.027	+.003	4	.064	.061	.067	4	.099	.109
4	.026	.028	+.004	5	.065	.062	.068	5	.100	.110
5	.027	.029	+.005	6	.066	.063	.069	6	.101	.111
6	.028	.029	.006	7	.067	.064	.070	7	.102	.112
7	.029	.030	.007	8	.068	.065	.071	8	.103	.113
8	.030	.031	.008	9	.069	.066	.072	9	.104	.114
9	.031	.032	.009	160	+ .070	+.067	+.073	200	+.105	+.115
100	+.032	+.033	+.010							
1	.032	.034	.011							
2	.033	.035	.012							
3	.034	.036	.013							
4	.035	.037	.014							
5	.036	.038	.015							
6	.037	.039	.016							
7	.038	.040	.017							
8	.039	.041	.018							
9	.040	.042	.019							
110	+.041	+.043	+.020							
1	.041	.044	.021							
2	.042	.045	.022							
3	.043	.046	.023							
4	.044	.047	.024							
5	.045	.048	.025							
6	+.046	.048	.026							
7	.047	.049	.027							
8	.048	.050	.028							
9	.049	.051	.029							
120	+.050	+.052	+.030							

NOTES:

* The mass temperature at which the specific gravity is determined or referred to (65°/ 15.5 and 90°/15.5)

** Specific Gravity corrections per °C from Plant "J" specifications with the exceptions of 5460, 4465 and 2665 which were calculated from the specific gravities of one sample of each at two or three different temperatures.

= The double line across a column indicates the maximum or minimum temperature for which the Specific Gravity correction was experimentally determined. For accurate work the specific gravity should be taken at a temperature below or between these double lines.

Example:

Sp.Gr. of sample at 1154

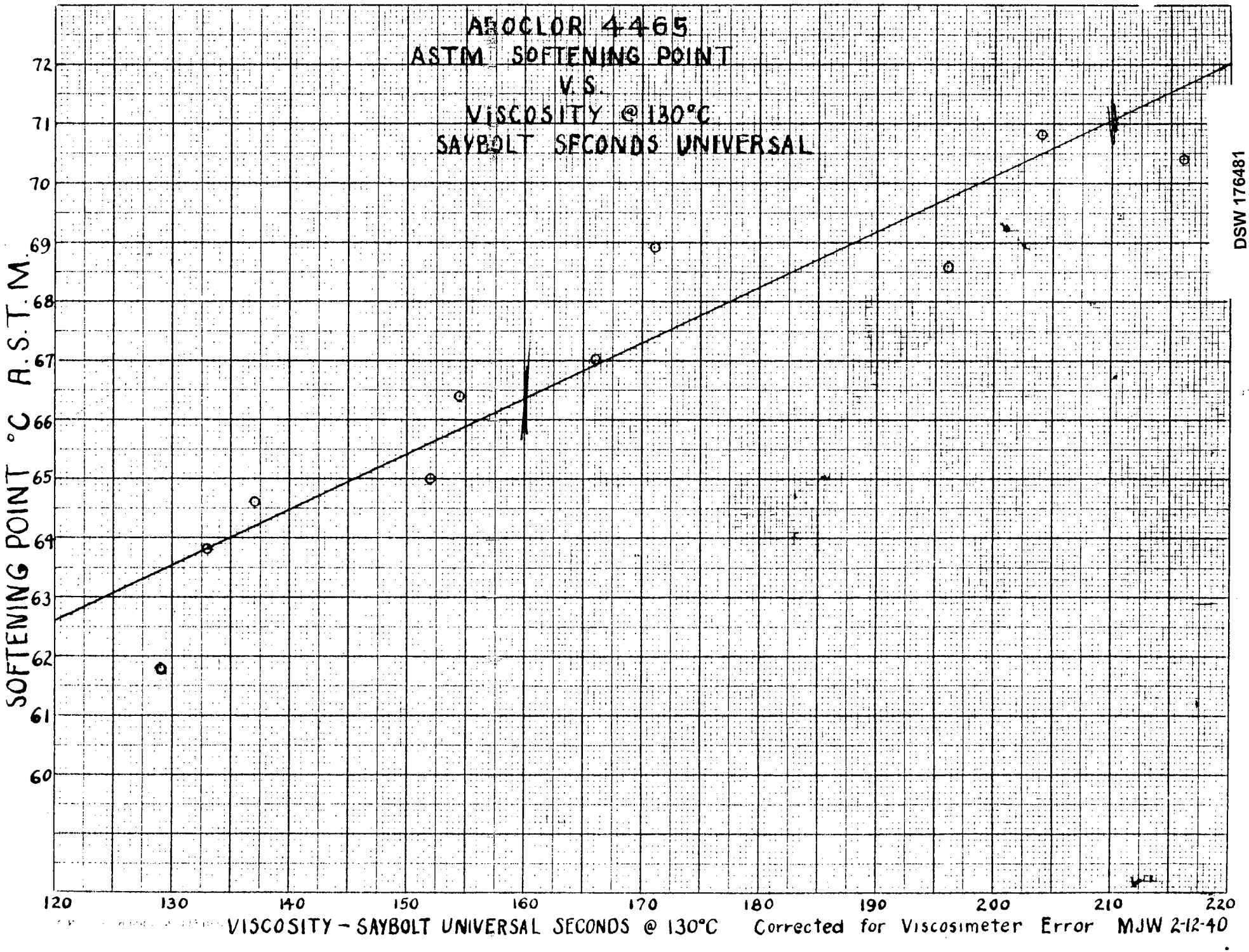
Sp.Gr. of sample of 1154 at 110°C	=	1.468
Sp.Gr. correction	=	-.043
Sp.Gr. at 65°C.	=	1.505

12-3-41
D. A. Roper

Copied 10-3-47 mgm

DSW 176480

STLCOPCB4050367



DSW 176481
STLCOPCB4050368

A. S. T. M.

MODIFIED METHOD OF TEST

FOR

SOFTENING POINT OF AROCLORS 2565, 4065 and 5060

Preparation of Sample

The sample shall be melted and stirred thoroughly, avoiding incorporating air bubbles in the mass, and then poured into the ring so as to leave an excess on cooling. The ring, while being filled, should rest on a metal plate. After cooling, the excess material shall be cut off cleanly with a slightly heated knife.

Fill the 600 cc. beaker to a depth of 3-1/4" with city water at room temperature. Suspend the ring containing the sample and ball in the water so that the lower surface of the ring is exactly 1 inch above the bottom of the beaker and its upper surface 2 inches below the surface of the water. Suspend thermometer so that bottom of bulb is level with the bottom of the ring and within 1/4", but not touching the ring.

Apply the heat in such a manner that the temperature of water is raised 5°C each minute.

The temperature recorded by the thermometer at the instant the material touches the bottom of the beaker will be the softening point.

Run a standard along with the sample for comparison and make corrections in same way as by old method.

Suppose S. Pt. of Std. is 78.0°C. and drops at 77.0°C. which indicates too rapid heating, then add 1° to S. Pt. of sample.

This is the same method used by laboratory and should give better comparable results. It is important to follow setting of ring and thermometer as well as rate of heating.

Place piece of tin on bottom of beaker for easier cleaning.

Copied/p
1/25/40
from Becker's
memo 1/22/40

DSW 176482

STLCOPCB4050369

THEORETICAL FIGURES FOR VARIOUS AROCLORS

1154

Charge - 3600# Diphenyl
Formula- $C_{12}H_5Cl_5$

Products - 7580# 1154
4200# HCl

Cl_2 Used - 8190#

Theoretical Chlorine Practice * 1.0805
Diph .47493

2565

Charge - 2250# Diphenyl
750# Crude H.B.
Formulas- $C_{12}H_2Cl_8$ & $C_{18}H_3Cl_{11}$

Products - 8130# 2565
5430# HCl

Cl_2 Used - 10,570#

Theoretical Chlorine Practice - 1.30
Diph .24775
@ HB .09225

4065

Charge - 1950# Diphenyl
1300# Dist.H.B.
Formulas- $C_{12}H_2Cl_8$ & $C_{18}H_3Cl_{11}$

Products - 8820# 4065
5890# HCl

Cl_2 Used - 11,465#

Theoretical Chlorine Practice - 1.30
Diph .22109
DHB .14739

5060

Charge - 3000# Dist.H.B.
Formula - $C_{18}H_5Cl_{10}$

Products - 7200# 5060
4440# HCl

Cl_2 Used - 8640#

Theoretical Chlorine Practice - 1.20
DHB .41667

1160

Charge - 3600# Diphenyl
Formulas- 75% $C_{12}H_4Cl_6$
25% $C_{12}H_3Cl_7$

Products - 8625# 1160
5325# HCl

Cl_2 Used - 10,350# 5/18/42
SPT

Theoretical Cl_2 Practice = 1.2000
Diph .41739

DSW 176483

STLCOPCB4050370

Typical Properties

Item	1254 Aroclor liq	1248 yellow liq	1254 yellow semi-solid	1260 soft sticky resin	1262 viscous liquid	1268 brittle resin	1270 white crystal powder	4465 Brittle resin
Color, Pt-Co	0.5 max	0.5	1.0	1.0	1.2 max	—	—	1.5 max
Acidity, mg KOH/gm	0.01	.01	.01	.015	.02	—	.175	.05
Sp. Exp. cc/gm/°C	.000678 (25-65°C)	.000702 (25-65)	.000661 (25-65)	—	.000640 (25-90)	—	—	.000611 (25-65)
cc/gm/°F	.000377 (77-149)	.000389 (77-149)	.000367 (77-149)	—	.000355 (77-194)	—	—	.000339 (77-149)
Density gm/cc 25°/25	1.378-1.388	1.447	1.538	1.618	1.646	1.801	1.960	1.712
#/gal 25°C	11.5	12.08	12.83	13.50	13.72	15.13	16.24	14.28
Boil Pt ASTM D-20 °C	322-365	330-370	365-390	385-420	373-404	—	450-460	
°F	612-689	626-698	689-734	725-788	703-759	—	842-860	
Evap. loss ASTM D-6								
163°C 5 hrs %	3.14-3.64	3.0-4.0	1.06-1.28	—	0.48-0.56	0.15-0.24	0.0-0.1	0.22-0.29
100°C 6 " %			0.0	0.0-0.2	—	—	—	—
Flash Pt - Cleveland °C	176-180	193-196	None	None	None	None	None	None
Open Cup °F	348-356	379-384						
Fire Pt - Cleveland °C	354	None	"	"	"	"	"	"
Open Cup °F	633							
Pour Pt ASTM °C	-17.7 to -20.7	-7	8-12	26-36	34.9-38	—	—	—
°F	-1.2 to -5.2	19.4	46-54	79-97	95-100.4	—	—	—
Softening Pt ASTM °C	—	—	—	—	—	135-160 Ring & Ball	294-300 Ring & Ball	
°F	—	—				275-320	561-572	
Refractive Index 20°C	1.627-1.629	1.630-1.631	1.637-1.639 @ 25°C	—	1.6501 1.6517	—	—	1.664 1.667
Visc ASTM D-88 Saybolt Universal 210°F (98.9°C)	34-34.6	36-37	43.5-48.5	70-82	90-103	—	—	92-156
150°F (54.4°C)	44-56	69-78	260-400	2600-4550	@ 160°F 600-850	—	—	@ 266°F or 130°C
100°F (37.8°C)	80-13	185-240	1800-3800	—		—	—	

DSW 176484

V

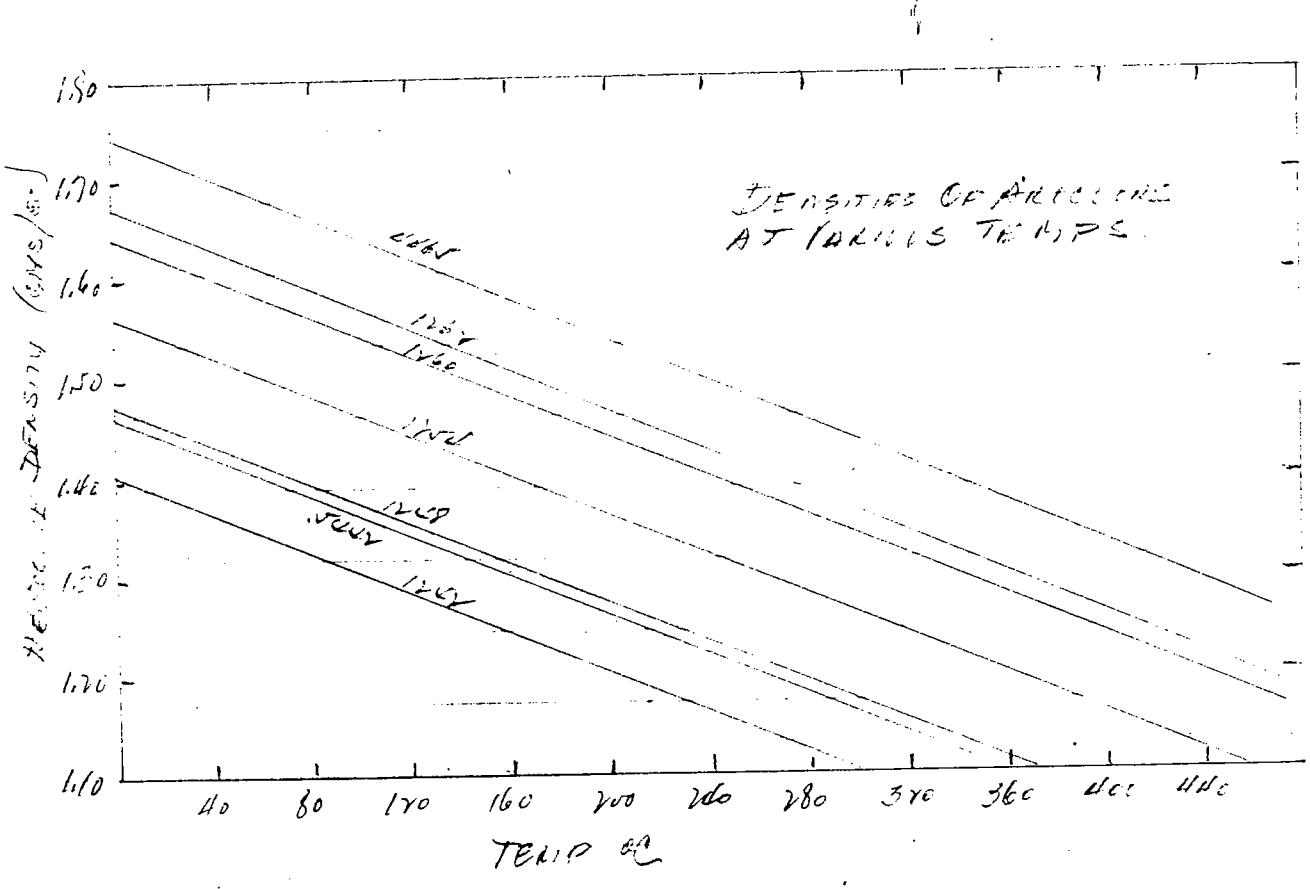
Form		yellow brown clear	yellow green clear	brown black magnetic solid
Color APHA		—	2.0 max	—
Viscosity		.128	.07	1.26
Exp. coef.	°C	.00123	.00179	.000656
	°F	.000683	.000994	.000364
Sp. Gr. 25/25°C		1.432-1.447	1.720 1.705	1.721 1.746
Wt/gal 25°C		11.96	14.50	14.41
Melt R			270-326 @ 4 mm.	
Evaporation 165°	5 hrs	2.0	.025	.021 - .026
175	6 "	.012	1.51 - 1.71 260° 5 hrs	—
Flash PT	C	247	Nonc	None
	F	477		
Fire PT	C	>350	4	4
	F	>662		
Pour PT	C	46		
	F	115		
Softening pt	C	48.5 - 53	100 - 105.5	70-77
	F	119 - 127	212 - 222	158 - 171
Refr. Index		—	1.660 - 1.665	—
Viscosity 210°F		313.5	—	—

DSW 176485

For converting from

~~x~~ A at ~~%~~ to ~~%~~ ~~to~~ ~~%~~ ~~to~~ ~~%~~

$$\text{x} = \frac{A \times \text{wt. H}_2\text{O at x}}{\left[1 + (\text{C.Exp.} \times \{D - C\})\right] \times \text{wt. H}_2\text{O at y}}$$



DSW 176486

Calculation -

Boiling Point at Atmospheric Pressure

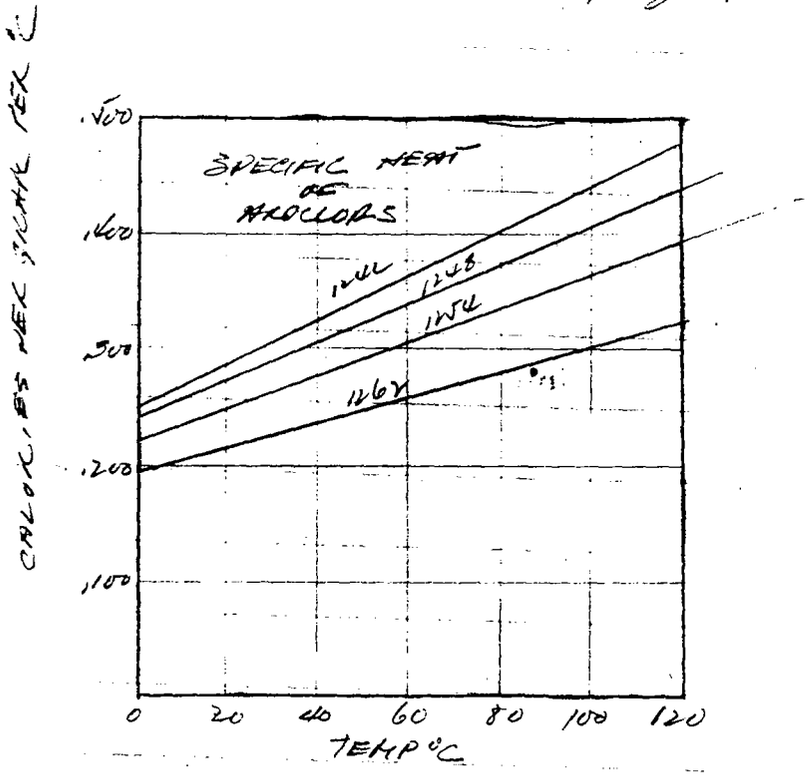
Vaporization - in/gram

at 325° C

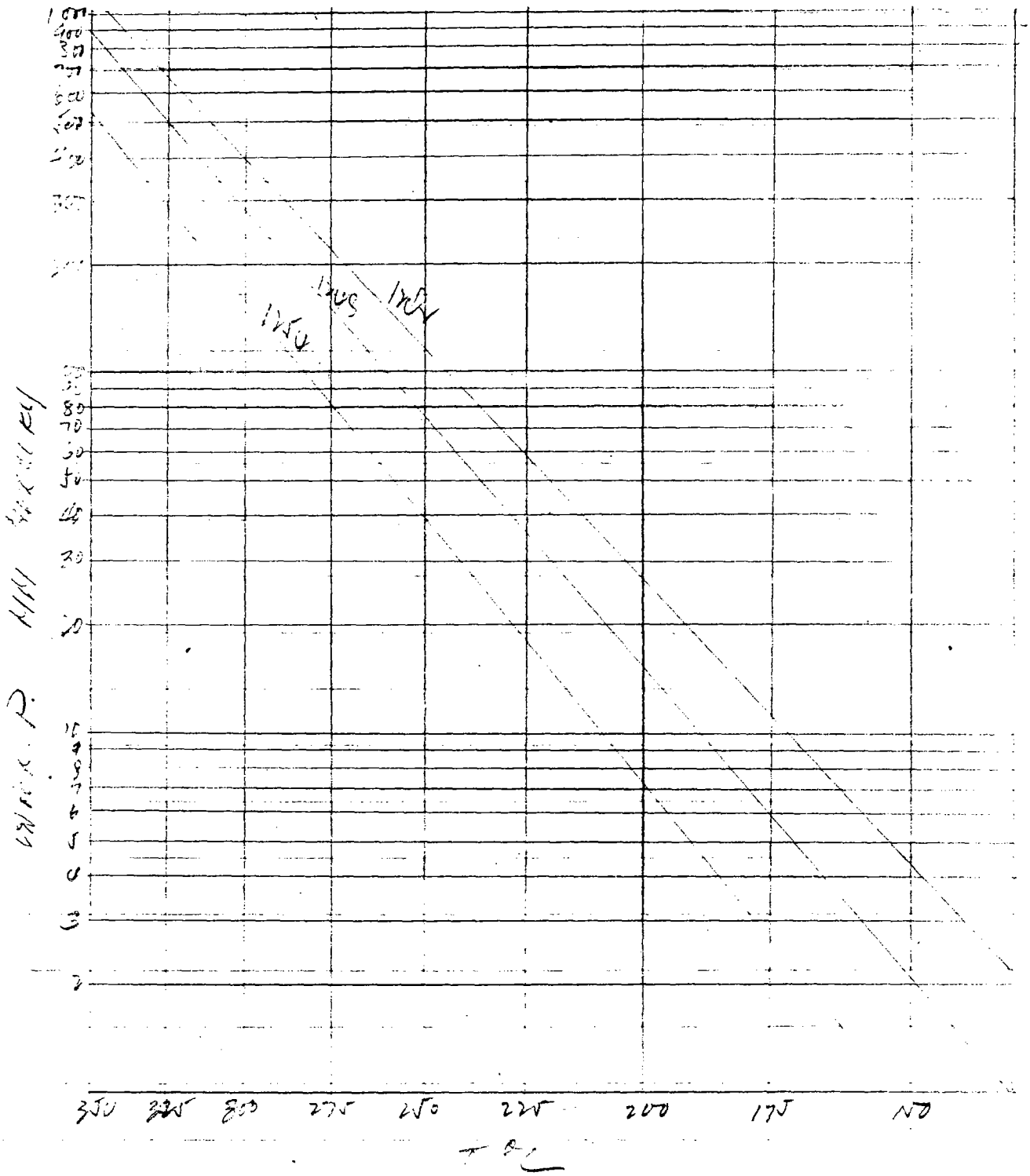
	Aroclor 1248	1254
Mixed ortho	0.1028	0.0045
Yellow Liquid	0.0647	0.0030
Vapor	0.0145	0.0650

Vapor Pressure

	1248	1254
Vp mm Hg		



DSW 176487



DSW 176488

$\frac{11\frac{7}{8} - 12\frac{1}{16}}{5/6}$

@ 5°C	1.9604 cc	=	1.500 grams
@ 65°C	1.0000 "	=	1.5[illegible] "
@ 66°C	1.0066 "	=	1.5[illegible] "
@ 125°C	1.0396 "	=	1.5[illegible] "

cc. × .0025[illegible] = gal.

gal. × .0032[illegible] = cu.

	12 5/16	1248
TEMP	Lbs./gal.	
20	12.90	
30	12.81	
40	12.73	
50	12.64	
60	12.56	
65	12.52	
70		
75	13.03	
95		11.45
125	12.04	
110.	12.16	

for 1/4 #/gal @ T = $\frac{.035069}{[1.0 + .0066(T-65)] \times .0032642}$

" 48 #/gal @ T = $\frac{.031173}{[1.0 + .0066(T-65)] \times .0032642}$

DSW 176489

STLCOPCB4050376

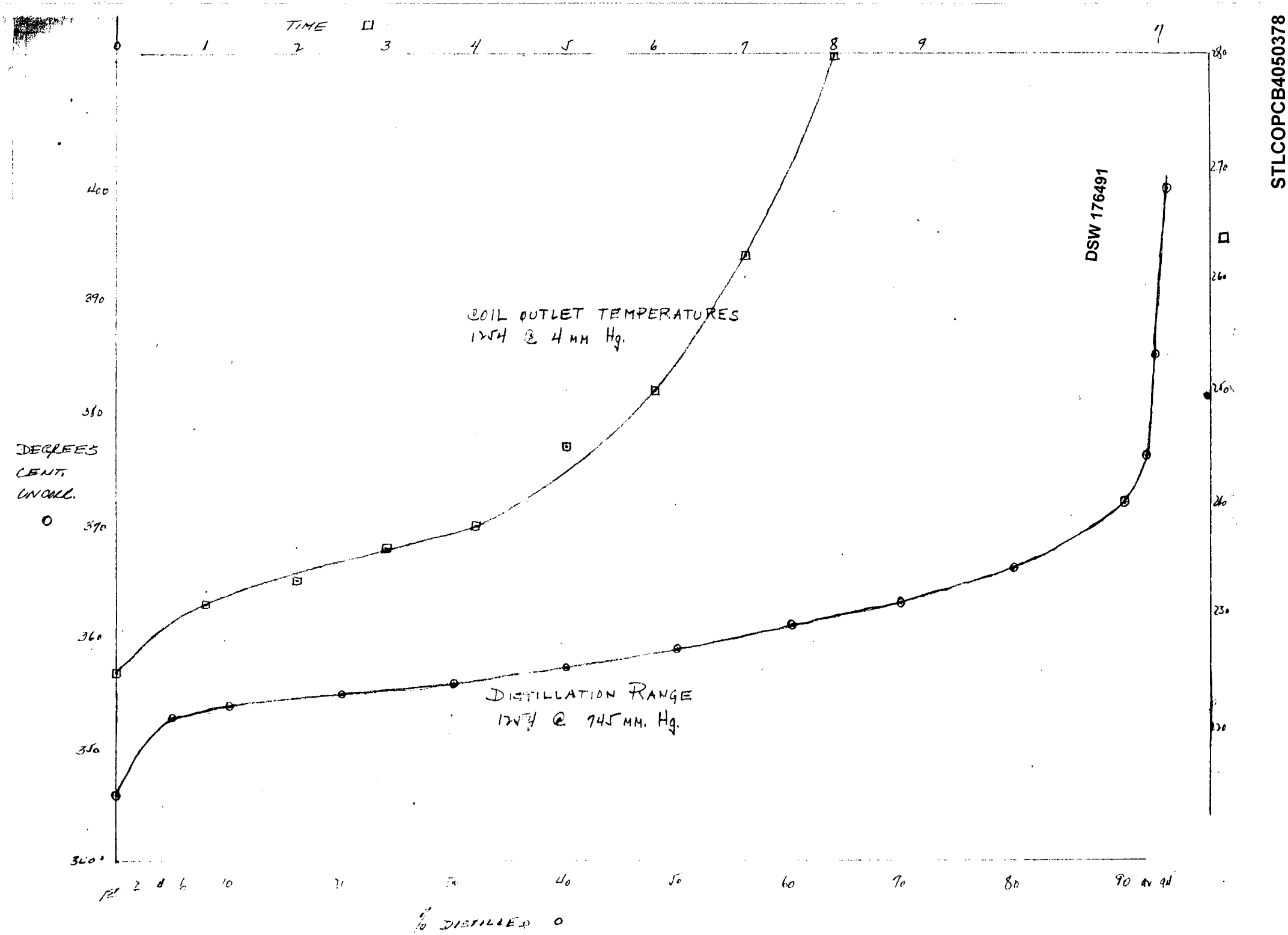
All quantities calculated as mol% except glycerol, water and 40% formaldehyde.

	10%	50%	90%	Average
1954 Kirk Range				
10% - 20°C	354	354	356	354
50 - 80°C	359	359	364	359
90 - 369	370	368	370	369

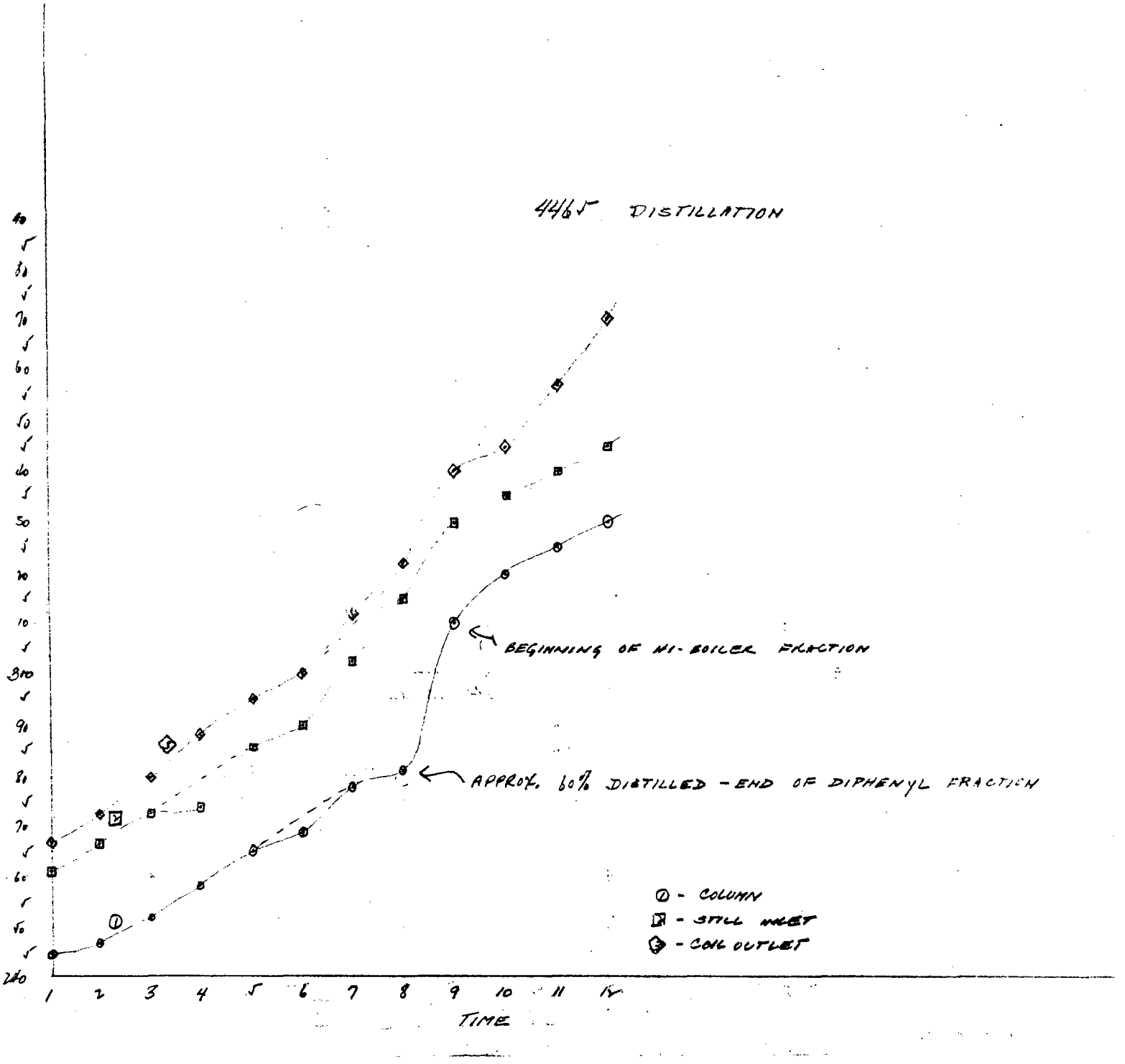
Average for 1941 373 - 379 - 390 Celsius °C
354 - 360 - 370 Thicorr °C

1960
Average for 1941 377 384 397 Thicorr °C

DSW 176490

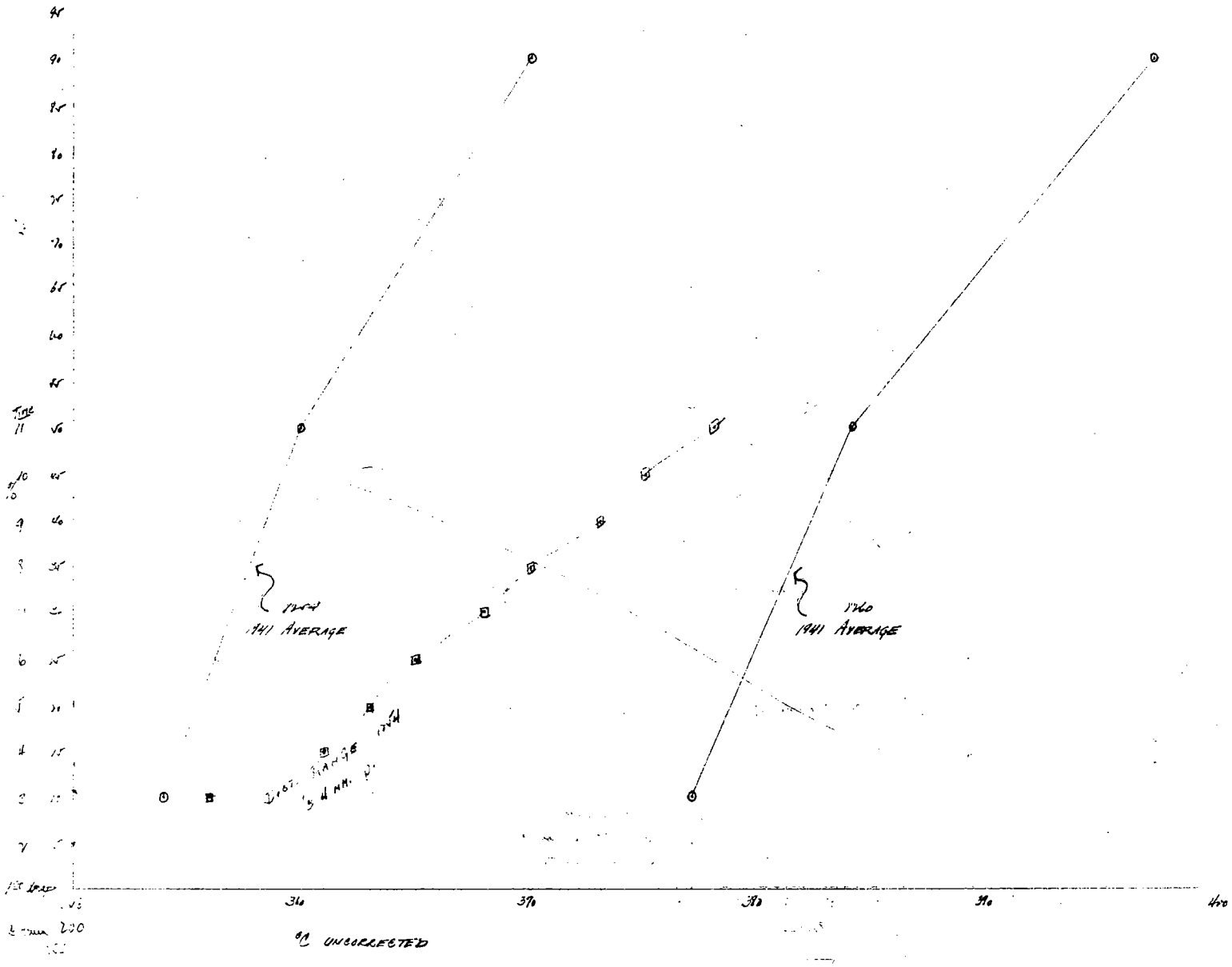


STLCOPCB4050378



DSW 176492

STLCOPCB4050379



DSW 176493

1 # 114/V Receptacle — # Ground

1 # 1148 " — # ck
12/10

12/20/61

Mr. Mercer:

Following is a list of Minimum and Maximum Specifications and Safety Points that are used in order numbers 1600 plus which are actually set up:

1167	1.353 – 1.373	1.358 – 1.368
1168	1.369 – 1.389	1.374 – 1.384
1169	1.380 – 1.410	1.397 – 1.403
1160	1.355 – 1.365	1.356 – 1.365
1167	1.377 – 1.387	1.380 – 1.386
2765	66°c – 72°c	69°c – 70°c
3065	66°c – 72°c	69°c – 70°c
1060	110°c – 116°c	110°c – 117°c

DSW 176495

STLCOPCB4050382

Table of C.

I General Properties

General physical properties
Adhesiveness
Corrosion
Density
Electrical Prop.
Sp. Heat & Thermal Conductivity
Thermo-dynamic properties
Non-inflammability
Stability
" Alkalis
" Acids
" Heat
" Oxidation
Solubility
Thermoplasticity
Vapor pressure
Viscosity
Volatility
Organization Laws
Other graphs

II Handling

III Production
A - Determination of Impurity Material
B - " " " "
C Crude specifications
D Det. "
E - Crude Summary
F - Dist. "
G - Chlorination sheets
H - Distillation "
- Production Summary
I - Equipment diagrams
A - Chlorinators
B - Stills
- Vacuum "
C - Receivers
D - Blending Tank
E - Filter press
F - Filtrate Tank
G - Storage Tank
H - Tank cars
J - Code Nos.

Graphs

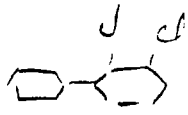
~~H Heat change with temp~~
~~Solubility in Acetic with temp~~

IV - Diagram of chlorination with properties of isomers
V Analytical Methods

DSW 176496

STLCOPCB4050383

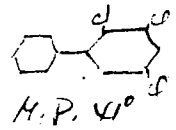
Gas per Gallon
Temp °C
DSW 176497

2-3 dichlorodiphenyl 
B.P. 170°/30 mm

2-5 - dichlorodiphenyl
Pale yellow oil BP 182/30 mm. 171°/5 mm
CrO_3 in AcOH → 2,5-dichlorobenzoic acid.
Scarborough, Waters, J. Chem. Soc. 1927, 94

3,4 - dichlorodiphenyl
Pale yellow crystals m.p. 46° BP 195-200/5 mm
CrO_3 in AcOH → 3,4-dichlorobenzoic acid
Scarborough, Waters: J. Chem. Soc 1926, 560

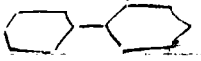
3,5 - dichlorodiphenyl
Pale yellow oil M.P. 18°/5 mm CrO_3 in
AcOH → 3,5-dichlorobenzoic acid
Scarborough, Waters: J. Chem. Soc 1927, 93

2,3,5 - trichlorodiphenyl 
Needles from EtOH. Aq. M.P. 41°
Winkel, Hey, J. Chem. Soc 1928, 2790

2,5,4' - trichlorodiphenyl M.P. 67°
3,4,2' - " M.P. 65-6 (55°)
3,5,2' - "
Pale yellow needles from EtOH M.P. 58°
Winkel, Hey: J. Chem. Soc. 1928, 2791 ←
3,5,4' - trichlorodiphenyl
Needles from EtOH M.P. 88°

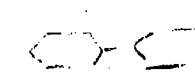
DSW 176498

STLCOPCB4050385

2 - chlorodiphenyl 

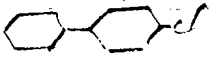
m.p. 32° B.P. 273-4° Sol. ligroin, EtOH, CCl_4

Jenkins, McCullough, Booth: Ind. Eng. Chem. 22, 31 (1930)

3 - chlorodiphenyl 

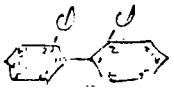
B.P. 284-5°

Ludwig, Bachmann. JACS 46, 2343 (1924)

4 - chlorodiphenyl 

Leaflets, m.p. 77° B.P. 291° Sol. from ligroin or EtOH

Jenkins, McCullough, Booth: Ind Eng Chem 22, 31 (1930)

2,2' - dichlorodiphenyl 

Prisms from pet. ether, m.p. 59° Sol. most org. solvents.

Dobbie, Fox, Gauge, J. Chem Soc. 99, 1619 (1911)

2-4' - dichlorodiphenyl

B.P. 191°/30 mm.

Cramm. Rec. trav. chim. 50, 776 (1931)

3-3' - dichlorodiphenyl

Needles from EtOH. M.P. 29°(23°)

B.P. 322-4°(298°) Sol. EtOH, Et_2O, C_6H_6

Ullman, Ann 332, 54 (1904)

Cain, J. Chem. Soc. 85, 7 (1904)

4-4' dichlorodiphenyl

Prisms or needles from toluene - pet. ether

m.p. 148-9 B.P. 315-19° CrO_3 in AcOH

→ p-chlorobenzoic acid

Shaw, Turner: J. Chem Soc 1932, 294

DSW 176499

STLCOPCB4050386

Physical Data of Aroclors

	Sp Gr	B.P. at 1 atm	Flash Pt	Flame Pt
Aroclor	1.107	255.6°C	118-119°C	139-143°C
1219		278-295°C	127	176
1242		320-360	174-178	224
1254		360-400	210°C	none below boiling
1260		374-410	221	"
1268		395-415	241	none up to 405°C
2565		250-360 (10 mm)	230	"
4465		240-290 (9 mm)	257	192°C

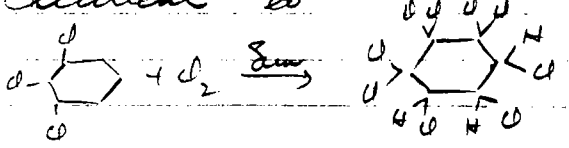
DSW 176500

Properties of Chlorinated Diphenyl

% Cl	Prop. @ room temp
18.30	Very light, mobile liquid
27.19	Light oil, less mobile than 1
42.11	" " (den = 1.375 @ 29° C)
42.86	Oil slightly heavier than 3
52.15	Viscous oil
57.19	Semi-solid, consistency of pitch
59.72	" S.P. 49½° C
60.26	Non crystl. solid, conchoidal fracture S.P. 61.5° C
60.40	Semi-conchoidal fracture partly crystalline S @ 63½° C
66.21	Crystalline fracture

Chlorine addition products made by Cl_2 on Diphenyl in direct sunlight - no HCl is formed - white crystl. solid m.p. 185-186° C.

On heating in test tube, HCl given off. Similar to



1,1',2,2',3,3',4,5,6 - nonachloro-cyclohexane m. 80° C

Sp Gr's @ 60°/15.5° C of Chlorinated Diphenyl

Sp Gr	% Cl
1.13	21.0
1.191	27.6
1.27	35.5
1.37	45.0

DSW 176501

2,2',4,4'- tetrachlorodiphenyl

Cryst. from C_6H_6 - ligroin - m.p. 83° very. sol.
from EtOH C_6H_6. Spar. sol. Lysaght
Literature: Chem. 332, 55 (1960)

2,2',5,5'- Tetrachlorodiphenyl

Cryst. from EtOH m.p. 74-5°
Mayer, Sappmann: Naturwiss. 38, 155 (1951)

2,6,2',6'- Tetrachlorodiphenyl

Plates m.p. 144°

3,4,3',4'- tetrachlorodiphenyl

Colourless needles from EtOH. m.p. 77°
B.P 230/50 mm. v. sol. EtOH, etc.
Lit: J. Chem. Soc. 57, 7 (1940)

3,5,3',5'- tetrachlorodiphenyl m.p. 161°

DSW 176502

STLCOPCB4050389

MONSANTO CHEMICAL COMPANY

ANNISTON ALABAMA PLANT

LABORATORY TEST REPORT

Report to Mr. Hoff. Date 1-22 194 2

Material Aroclor 2565 (Special)

From Caught at Various Stages of Chlorination.

Lot No.	Car No.	Sample No.

	% Cl-	soft pt-	Sp. gr-
(1)	29.3%	—	1.244 @ 89°C.
(2)	38.85%	—	1.301 @ 89.5°C.
(3)	48.7%	—	1.416 @ 90°C.
(4)	55.4%		1.510 @ 90°C. 1.482 @ 120°C.
(5)	60.3%	52.6°	1.559 @ 125°C.
(6)	62.8%	61.7 ou.	1.588 @ 135°C.

	Distribution	Samples	Units	To Date
	6-1400	6	117	

No. 60544 Tested by Dunlap & Hiefner

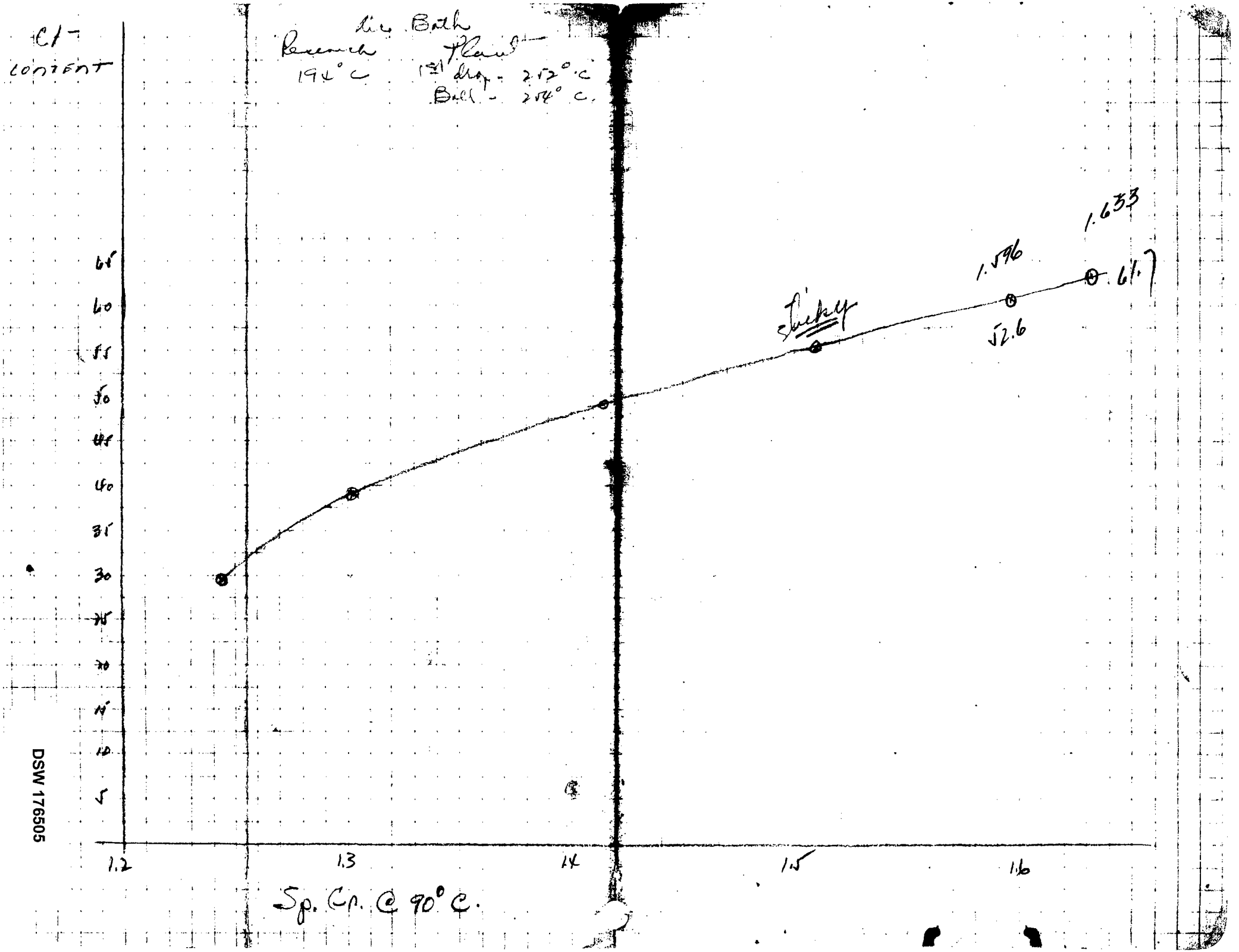
C78243 BUSINESS MARCO SYSTEMS, CHICAGO PAT'D NO. 1,534,478

DSW 176503

STLCOPCB4050390

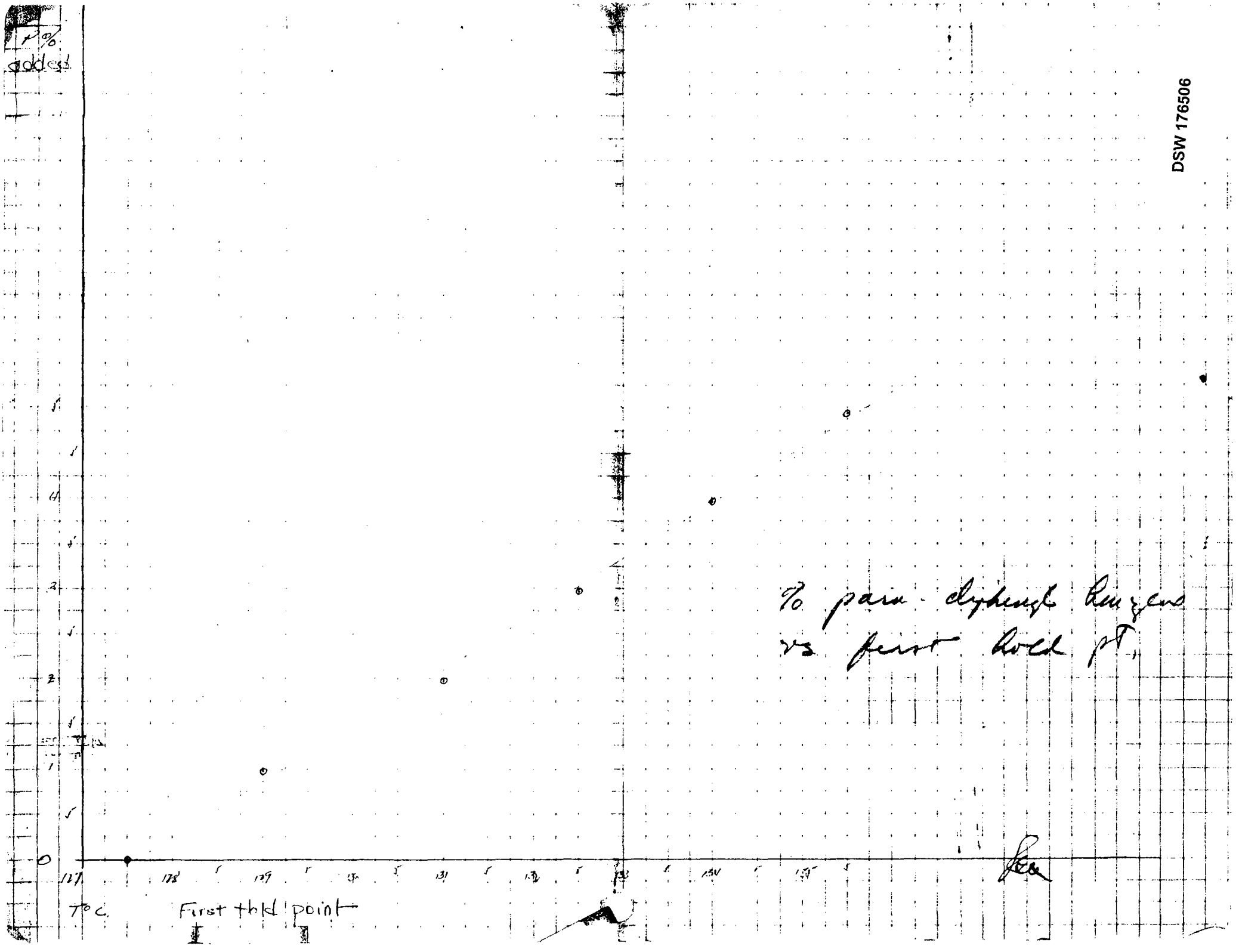
Cl⁻	SP.	SpGR
29.3		1.244 @ 89
38.85		1.501 @ 89½
48.7		1.416 @ 90
55.4		1.510 @ 91½
60.3	52.6	1.559 @ 125
62.8	61.7	1.598 @ 133

DSW 176504



DSW 176505

STLCOPCB4050392



DSW 176506
STLCOPCB4050393

Chlorinator No. 4 Aroclor 4065 Batch No. 235 Page No.

Raw Material Pounds	Diphenyl	Dist. Hi-Boiler	Crude Hi-Boiler	Trappings 1½
Crude Aroclor	Blowing Tank No #2	Outage Before Inches empty	Outage After Inches 76½	Inches Lbs.

	Cl. off Last Batch No.	Cl. On	Cl. Off	Chlorinating Time
Time	11:10 AM	12:15 AM	4:40 P.M.	Total Delays
Date	12/1/41	12/1/41	12-1-41	Time Between Batches

Chief Oper. L. Haynes
Shift 1 Oper. Cobb
Points per Shift not cir.

Time	Temp.	B P	Gr.-SP
100	150	10	
200	170	10	
300	150	10	

Chief Oper. Whelless
Shift 2 Oper. Cook
Points per Shift 275

Time	Temp.	B P	Gr.-SP
300	140	10	
400	150	12	
500	150	12	Cir
600	160	12	2:30 PM
700	150	12	
800	160	14	1375 6:45 PM
900	150	14	
1000	150	14	
1100			

Chief Oper. Adcock
Shift 3 Oper. DUNSTON
Points per Shift Very sticky

Time	Temp.	B P	Gr-SP
1100	145	14	1350 at 11:55
1200	145	16	
100	145	16	1400 at 1:15
200	145	16	
300	145	16	1455 at 4:15
400	160	18	
500	145	K	
600	150	K	Very sticky. 6:10
700	150	K	

Chief Oper. L. Haynes
Shift 1 Oper. Cobb
Points per Shift

Time	Temp.	B P	GR-SP
800	150	18	
900	160	18	Letting dumping 2:30
1000	160	18	cleaning dinner
1100	160	18	dumping 10:30
1200	170	18	12:00
100	160	18	
200	160	18	S.P. 64½ 1:30
300	160	18	

Chief Oper. Whelless
Shift #2 Oper Bell
Points per Shift

Time	Temp	B P	Gr-SP
300	170	18	SP 64 2:30 PM
400	175	18	SP 66 4:00 PM
500	Shut off 4:40 PM		
600			
700	S.P. 69		
800			
900			
1000			
1100			

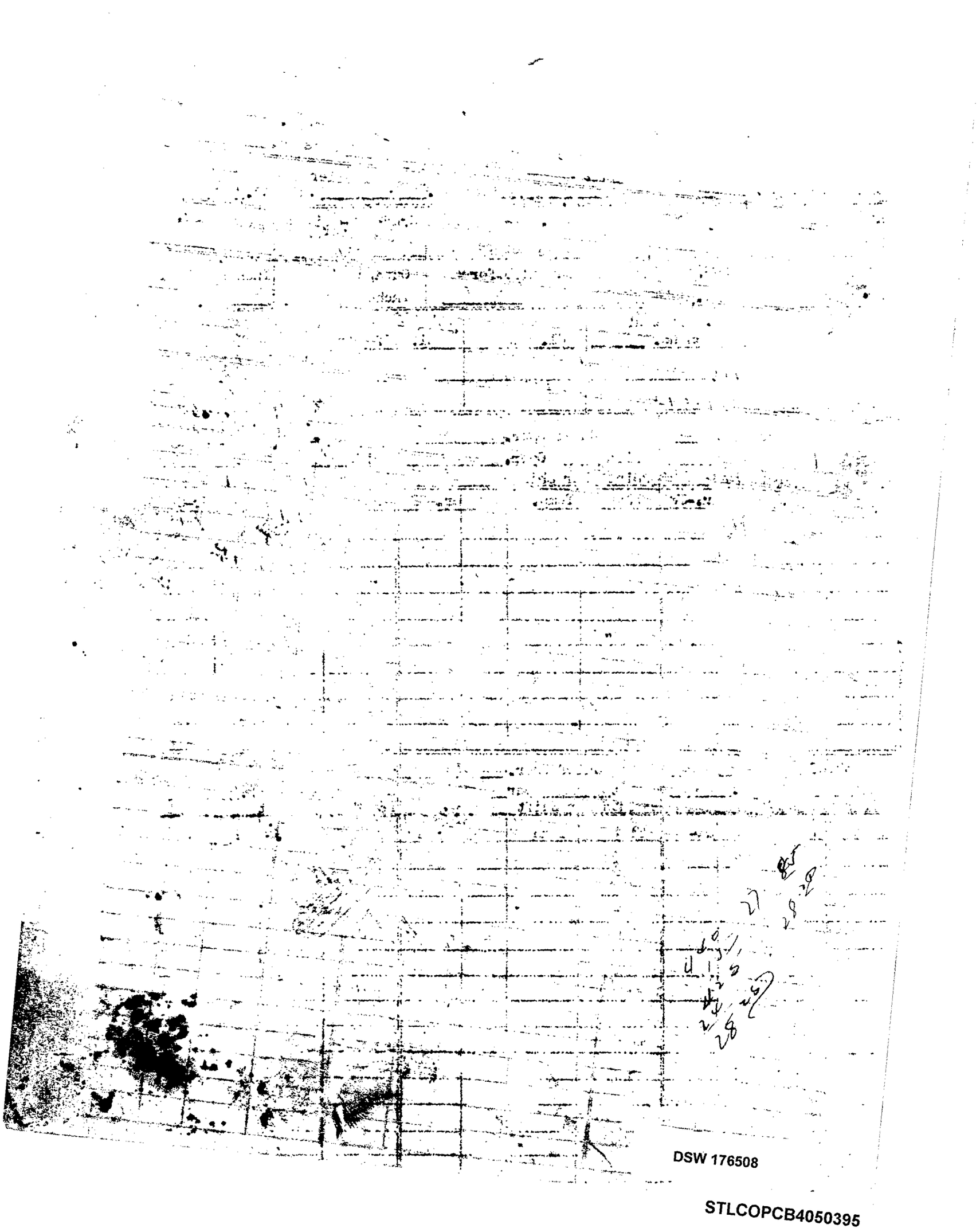
Chief Oper.
Shift Oper.
Points per Shift

Time	Temp.	B P	Gr-SP

NOTE: Explain delays on back of this sheet.

DSW 176507

STLCOPCB4050394



DSW 176508

STLCOPCB4050395

Chlorinator No. 4 Aroclor 4065 Batch No. 235 Page No.

Raw Material Pounds	Diphenyl 1950	Dist. Hi-Boiler 1300	Crude Hi-Boiler	Trappings 1½
Crude Aroclor	Blowing Tank No. 2	Outage Before Inches empty	Outage After Inches 76½	Inches Lbs.

	Cl. off Last Batch No.	Cl. On	Cl. Off	Chlorinating Time 28 25
Time	11:10 AM	12:15 PM	4:40 PM	Total Delays —
Date	12-1-41	12-1-41	12-2-41	Time Between Batches 1 05

Chief Oper. L. Haynes Shift 1 Oper. Cobb Points per Shift not circ

Time	Temp.	B P	Gr.-SP
1:00	150	10	
2:00	170	10	
3:00	150	10	

Chief Oper. Wheless Shift 2 Oper. Cook Points per Shift 275

Time	Temp.	B P	Gr.-SP
3:00	140	10	
4:00	150	12	
5:00	150	12	Circ
6:00	160	12	
7:00	150	12	
8:00	150	14	1,275 @ 8 45
9:00	150	14	
10:00	150	14	
11:00			

Chief Oper. Adcock Shift 3 Oper. Winston Points per Shift Very sticky

Time	Temp.	B P	Gr.-SP
11:00	145	14	1.350 @ 11 55
12:00	145	16	
1:00	145	16	
2:00	145	16	1.400 @ 2 15
3:00	145	16	
4:00	160	18	1.450 @ 4 25
5:00	165	18	
6:00	150	18	very sticky
7:00	150	18	

Chief Oper. L. Haynes Shift 1 Oper. Cobb Points per Shift

Time	Temp.	B P	Gr.-SP
7:00	150	18	Getting cloudy
8:00	160	18	8 30
9:00	160	18	Changed drain
10:00	160	18	Cloudy 10 50
11:00	160	18	
12:00	170	18	Hard
1:00	160	18	76½ SP @ 1 25
2:00	160	18	
3:00	160	18	

Chief Oper. Wheless Shift 2 Oper. Bell Points Per Shift

Time	Temp.	B P	Gr.-SP
3:00	170	18	64 S.P. @ 3 25
4:00	175	18	66 S.P. @ 4 45
5:00	Chlorine off 4 40 pm		
	S.P.	69	

Chief Oper. _____ Shift _____ Oper. _____ Points per Shift _____

Time	Temp.	B P	Gr.-SP

DSW 176509

STLCOPCB4050396

Chlorinator No._____ Aroclor_____ Batch No._____ Page No._____

Raw Material Pounds	Diphenyl	Dist. Hi-Boiler	Crude Hi-Boiler	Trappings
Crude Aroclor	Blowing Tank No._____	Outage Before Inches_____	Outage After Inches_____	Inches Lbs.

	Cl. off Last Batch No._____	Cl. On	Cl. Off	Chlorinating Time_____
Time				Total Delays_____
Date				Time Between Batches

Chief Oper._____
Shift_____ Oper._____
Points per Shift_____

Time	Temp.	B P	Gr.-SP

Chief Oper._____
Shift_____ Oper._____
Points per Shift_____

Time	Temp.	B P	Gr.-SP

Chief Oper._____
Shift_____ Oper._____
Points per Shift_____

Time	Temp.	B P	Gr.-SP

Chief Oper._____
Shift_____ Oper._____
Points per Shift_____

Time	Temp.	B P	Gr.-SP

Chief Oper._____
Shift_____ Oper._____
Points per Shift_____

Time	Temp.	B P	Gr.-SP

DSW 176510

Chlorinator No._____ Aroclor_____ Batch No._____ Page No._____

Raw Material Pounds	Diphenyl	Dist. Hi-Boiler	Crude Hi-Boiler	Trappings
Crude Aroclor	Blowing Tank No._____	Outage Before Inches_____	Outage After Inches_____	Inches Lbs.
Time	Cl. off Last Batch No._____	Cl. On	Cl. Off	Chlorinating Time_____
Date				Total Delays_____
				Time Between Batches

Chief Oper._____ Shift_____ Oper._____ Points per Shift_____

Time	Temp.	B P	Gr.-SP

Chief Oper._____ Shift_____ Oper._____ Points per Shift_____

Time	Temp.	B P	Gr.-SP

Chief Oper._____ Shift_____ Oper._____ Points per Shift_____

Time	Temp.	B P	Gr.-SP

Chief Oper._____ Shift_____ Oper._____ Points Per Shift_____

Time	Temp.	B P	Gr.-SP

Chief Oper._____ Shift_____ Oper._____ Points per Shift_____

Time	Temp.	B P	Gr.-SP

DSW 176511

STLCOPCB4050398

Chlorinator No. 4 Aroclor 1254 Batch No. 629 Page No.

Raw Material Pounds	Diphenyl 3600 #	Dist. Hi-Boiler	Crude Hi-Boiler	Trappings
Crude Aroclor	Blowing Tank No. 1	Outage Before Inches 77	Outage After Inches 54	Inches 28 Lbs.

	Cl. off Last Batch No.	Cl. On	Cl. Off	
Time	1:05 PM	2:20 PM	1:00 PM	Chlorinating Time 24:05 / Total Delays 1:15
Date	12-5-41	12-5-41	12-6-41	Time Between Batches 22:50

Chief Oper. [illegible] Shift 1 Oper. [illegible] Points per Shift not Cir

Time	Temp.	B P	Gr.-SP
300			

Chief Oper. J. Hayes Shift #2 Oper. Lipham Points per Shift

Time	Temp.	B P	Gr.-SP
3:00	125	10	
4:00	140	10	
5:00	150	10	change SIS PA switches
6:00	[illegible]	10	
7:00	160	12	
8:00	150	12	8:45 PM
[illegible]	140	12	
	135	12	
[illegible]			

Chief Oper. Whalen Shift #3 Oper. Bell Points per Shift 165

Time	Temp.	B P	Gr-SP
1100	140	14	12:40 - 1:45 AM
1200	140	14	
100	140	14	1:45 AM
200	140	14	
300	140	16	3:00 4:45 AM
400	140	16	
500	140	16	4:45 AM
600	140	16	5:30 6:25 AM
700			

Chief Oper. Adcock Shift 1 Oper. Dunstan Points per Shift 96

Time	Temp.	B P	GR-SP
700	135	16	140 50 225 PM
800	135	16	174 00 9:25 AM
900	135	16	174 00 10:30 AM
1000	135	16	
1100	145	16	
1200	155	16	
100			
200		150	
300			

Chief Oper. _____ Shift _____ Oper _____ Points per Shift _____

Time	Temp	B P	Gr-SP

Chief Oper. _____ Shift _____ Oper. _____ Points per Shift _____

Time	Temp.	B P	Gr-SP

NOTE: explain delays on back of this sheet.

DSW 176512

STLCOPCB4050399

Chlorinator No. 3 Aroclor 2565 Batch No. 93 Page No.

Raw Material Pounds	Diphenyl 2250 lbs	Dist. Hi-Boiler	Crude Hi-Boiler 750	Trappings
Crude Aroclor	Blowing Tank No. 1	Outage Before Inches empty	Outage After Inches 79½	Inches Lbs.
	Cl. off Last Batch No.	Cl. On	Cl. Off	Chlorinating Time 36 hrs. 5 MIN
Time	11:55 a.m.	1:00 p.m.	1:05 A.M.	Total Delays 0
Date	12-3-41	12-3-41	12-4-41	Time Between Batches 1 hr. 5 MIN.

Chief Oper. L. Hayn
Shift ____ Oper. Taft
Points per Shift not cir.

Time	Temp.	B P	Gr.-SP
1:00	160	8	
2:00	180	8	
3:00	180	8	

Chief Oper. Wheeler
Shift #2 Oper. Bell
Points per Shift 190

Time	Temp.	B P	Gr.-SP
5:00	150	10	
6:00	150	10	
7:00	160	10	
8:00	170	12	Circ. 6:00 PM
9:00	170	12	11:40 7:10 PM
10:00	160	12	
11:00	150	12	12:30 1:00 Shut
12:00	150	14	

Chief Oper. J. Haynes
Shift #3 Oper. Lipham
Points per Shift

Time	Temp.	B P	Gr-SP
11:00	146	14	Sp. 12 8:00 11:50 P.M.
12:00	145	14	
1:00	145	16	Sp. 1330 1:30 A.M.
2:00	145	16	
3:00	140	16	
4:00	145	16	Sp. 1400 bilum
5:00	140	16	Sp. 1420
6:00	145	16	5:40 A.M.
7:00			

Chief Oper. L. Hayn
Shift 1 Oper. Taft
Points per Shift

Time	Temp.	B P	Gr-SP
700	125	16	
800	125	16	
900	125	16	1445 9:30
1000	130	16	
1100	130	16	1460 11:30
1200	140	16	
100	150	16	Shut 1:00
200	150	16	1:30
340	160	16	

Chief Oper. J. Haynes
Shift #2 Oper. Lipham
Points per Shift

Time	Temp	B P	Gr-SP
3:00	175	16	
4:00	175	16	Start Pmp 4:20 PM
5:00	180	16	
6:00	155	16	Running 6:40 PM
7:00	155	16	Running 7:50 PM
8:00	165	16	
9:00	175	16	Road 9:20 PM
10:00	160	16	S.P. 61 10:45 PM
11:00			

Chief Oper. Wheeler Bell
Shift #3 Oper. Bell
Points per Shift

Time	Temp.	B P	Gr-SP
1100	160	16	S.P. 64 11:45 P.M.
1200	165	16	
100	180	16	
Cl. off 1:05 P.M.			
S.P. 68½			

NOTE: Explain all delays on back of this sheet.

DSW 176513

STLCOPCB4050400

Product	Charge			Technical recovery	Reactive Rm. per batch	Chlorine practice	Chlorination temps °C		Chlorinating time	Assumed chemical formula	Crude finished To. Sp. Gr. B.P.
	Dpd	DNB	CNB				St.	End			
1146	4,000						170	180	20	$C_{12}H_7Cl_3$	1.503 - 1.553 @ [illegible]
1148	4,000						170	180	22	$C_{12}H_6Cl_4$	1.419 - 1.419 @ [illegible]
1154	3600				7,600		170	170	26	$C_{12}H_5Cl_5$	1.570 - 1.570 @ [illegible]
1160	3600						170	170	30	$C_{12}H_4Cl_6 + C_{12}H_3Cl_7$	1.555 - 1.565 @ [illegible]
1162	3600						170	170	31	$C_{12}H_3Cl_7$	1.577 - 1.578 @ [illegible]
1168	3000						170	180	[illegible]	$C_{12}H_2Cl_8 + C_{12}HCl_9$	
1169	2,800						170	180	[illegible]	$C_{12}HCl_9$	
1170	2,800						170	190	26	$C_{12}HCl_9 + C_{12}Cl_{10}$	
2565	2250		750		[illegible]		[illegible]	[illegible]	36	$C_{12}H_2Cl_8 + C_{18}H_3Cl_{11}$	66 - 72° @
4065	1950	1300			[illegible]		[illegible]	[illegible]	33	$C_{12}H_2Cl_8 + C_{18}H_3Cl_{11}$	66 - 72° @
5044		4,100					150	225		$C_{18}H_{10}Cl_4 + C_{18}H_9Cl_5$	
5060		3600			[illegible]		[illegible]	[illegible]	30	$C_{18}H_8Cl_{10}$	110 - 115° @

DSW 176514

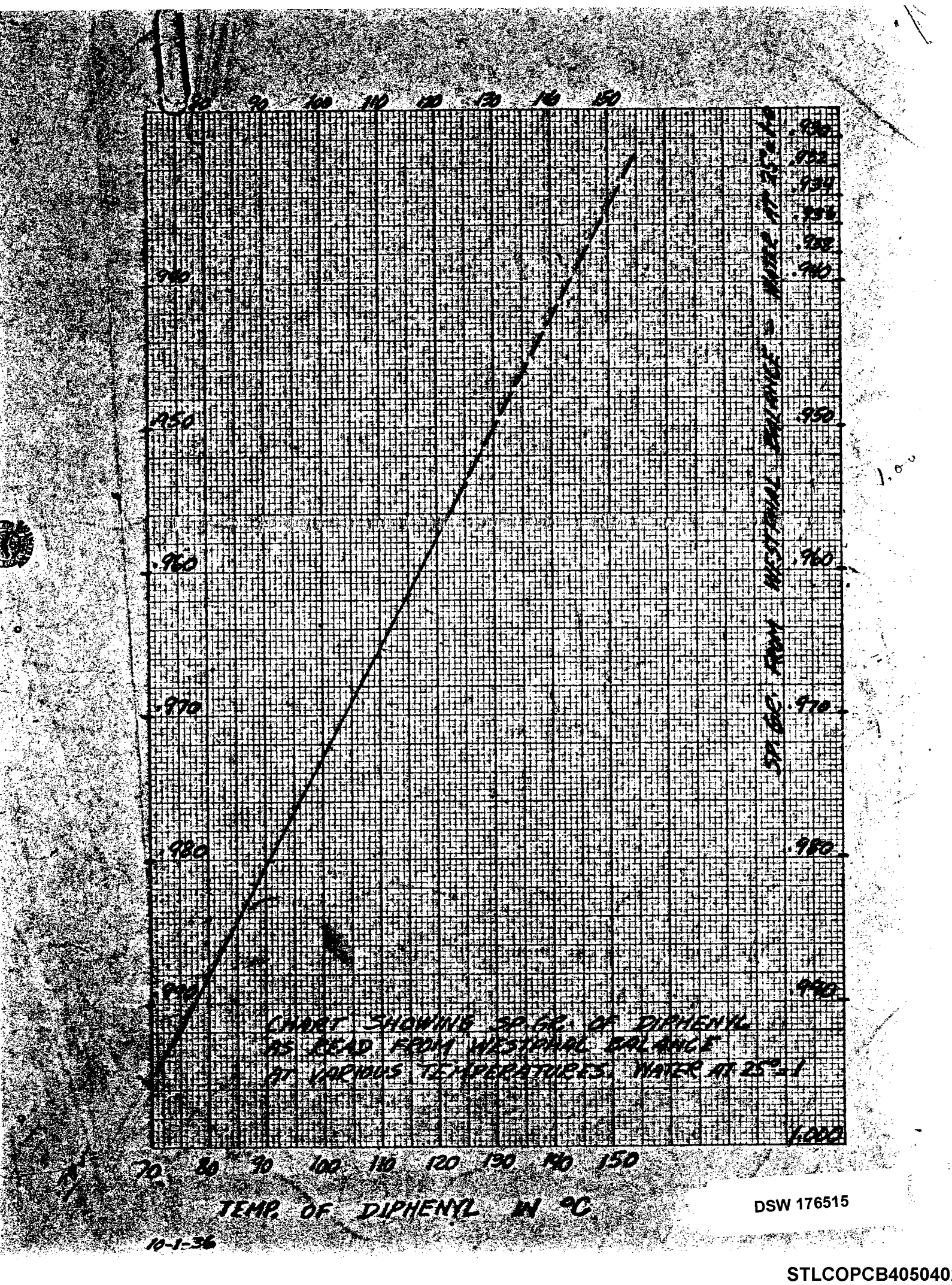


CHART SHOWING SP GR. OF DIPHENYL AS READ FROM WESTPHAL BALANCE AT VARIOUS TEMPERATURES. WATER AT 25° = 1

10-1-36

DSW 176515

STLCOPCB4050402

CHEMICALS - QUALITY
Monsanto
ST. LOUIS, U.S.A.

DON'T SAY IT — WRITE IT

MEMORANDUM

ANNISTON, ALA. **DATE** 10-5-36

TO Mr Williams **SUBJECT** Diphenyl

The 75 to 125° s.g. line is straight so this has been projected to 150°C. These are taken with a glass plummet which may or may not stand a temperature of 150°C. Would like to get this unit Aroclor testing before making the plummet at 150° as we have only the one.

Gerber

DSW 176516

STILL NO. 1 AROCLOR 5460 LOT NO. 25 PAGE NO. 1

CHARGE	LIME ADDED POUNDS 30 lbs	OUTAGE BEFORE INCHES 73"	OUTAGE AFTER INCHES 35"	INCHES 38 POUNDS
PRODUCT	BLENDING or FILTRATE TANK OUTAGE BEFORE Inches ° C AFTER Inches ° C		INCHES POUNDS	STILL BOTTOMS Overall fatline ~~2303~~ POUNDS

	VAC. OFF LAST LOT NO.	VAC. ON	VAC. OFF	TOTAL BATCH TIME 24 hr. 50 min.
TIME	12 30 AM	3.50 a.m.	1:20 a.m.	TOTAL DELAYS 9 hr. 35 min.
DATE	11-12-41	11-12-41	11-13-41	NET BATCH TIME 15 hr. 15 min.

SHIFT 3 CH. OP. L. Haynes OPER. L. Haynes

Time TEMP.	VAC.	BURNERS	COLUMN	STILL INLET	COIL OUTLET
	Charging Still.			Drawing out	
	Bringing up temp.			Hunting Leaks	
	Fixing Leaks				
12:30 - 3:50	- Charging.				
3:50 - 5:00	- Hunting Leaks				
5:00	4	22	285	310	320
6:00	7	22	295	315	325
7:00	6	22	300	316	325

SHIFT 2 CH. OP. ADCOCK OPER. HOKARI

TIME TEMP.	VAC.	BURNERS	COLUMN	STILL INLET	COIL OUTLET
4:00	4	22	300	321	332
5:00	4	22	303	324	332
6:00	4	22	305	326	334
7:00	4	22	307	330	337
8:00	4	22	310	335	
9:00	4	22	312	340	347
10:00	4	22	314	345	346
11:00	4	22	314	350	344

SHIFT CH. OP. OPER.

TEMP.	VAC.	BURNERS	COLUMN	STILL INLET	COIL OUTLET
Vac. off at 7:15 a.m.					
To lift jet and					
Power off					
Out-leak vent - 1:40 P.M.					
200	4	22	195	206	214

SHIFT 3 CH. OP. L. Haynes OPER. L. Haynes

TEMP.	VAC.	BURNERS	COLUMN	STILL INLET	COIL OUTLET
12:00	4	22	320	365	375
1:00	4	22	325	370	400
3:00					
4:00					
5:00					
6:00					

DSW 176517

STLCOPCB4050404

AROCLOR STILL

Page No. _____

Aroclor 1460
Lot No. ZZ
Still Outage Before Empty
Still Outage After 30"
Lime Added 30#

Started 11-5-41 by CS
Finished 11-5-41 by [illegible]
Vacuum on at 9:30 AM
Dist. over at 12:10 PM

#1

Time	Vac.	Burners	Rec.	Col.	Inl et	Outlet	Still	Stream
1 00	"	22	40	250	284	290	285	Small
2	"	42	50	275	300	306	300	Good
3	"	72	55	290	305	311	305	"
4	"	72	155	295	308	312	308	"
5	"	72	155	300	310	315	310	"
6	"	72	130	305	315	320	315	"
7	"	72	135	310	320	325	320	"
8	"	[illegible]	138	310	325	330	325	"
9	"	72	140	312	335	340	335	"
10	"	72	145	315	335	345	335	"
11	"	72	145	318	340	348	340	"
12	"	72	150	315	338	345	338	"
1	"	70	155	317	340	347	340	"
2	"	22	155	318	342	355	342	"
3	"	72	155	320	345	360	345	"
4	"	72	155	322	350	365	350	"
5	"	72	155	326	353	373	353	"
			S.P.	103½° C.	finished			

REMARKS: Vac. off at 6:00 AM to run S.P.

DSW 176518

STLCOPCB4050405

STILL NO. 2 AROCLOR 4465 LOT NO. 169 PAGE NO. 3

CHARGE	LIME ADDED POUNDS 30	OUTAGE BEFORE INCHES 29½	OUTAGE AFTER INCHES 25	INCHES / POUNDS
PRODUCT	BLENDING or FILTRATE TANK OUTAGE BEFORE Inches °C AFTER Inches °C		INCHES POUNDS	STILL BOTTOMS POUNDS 3 mo Run

	VAC. OFF LAST LOT NO.	VAC. ON	VAC. OFF	
TIME	8:30 Pm	11:10 P.m.	12:00 N.	TOTAL BATCH TIME 15 h. 30 m
DATE	12-1-41	12-1-41	12-2-41	TOTAL DELAYS 2 h. 40 m
				NET BATCH TIME 12 h. 50 m

SHIFT 3 CH. OP. Adcock OPER. Howard

TIME	VAC.	BURNERS	COLUMN	STILL INLET	COIL OUTLET
12:00	Out for Repairs				12:00
1:00	4	16	244	261	267
2:00	4	16	247	267	273
3:00	4	16	252	263	280
4:00	4	16	258	274	288
5:00	4	16	265	284	295
6:00	4	16	268	290	300
7:00	4	16	278	303	312

SHIFT 1 CH. OP. J Hayes OPER. Cook

TEMP.	VAC.	BURNERS	COLUMN	STILL INLET	COIL OUTLET
700	4	16	280	305	315
800	4	16	282	315	322
900	4	16	310	330	340
1000	4	16	320	335	345
1100	4	16	325	340	357
1200	4	16	330	345	370
100	Vac off 1:00				
200					
300					

SHIFT CH. OP. OPER.

TEMP.	VAC.	BURNERS	COLUMN	STILL INLET	COIL OUTLET

SHIFT CH. OP. OPER.

TEMP.	VAC.	BURNERS	COLUMN	STILL INLET	COIL OUTLET

DSW 176519

STLCOPCB4050406

DSW 176520

STLCOPCB4050407

STILL NO. 2 AROCLOR 1254 LOT NO. Indust 235 PAGE NO. ____

CHARGE	LINE ADDED POUNDS 30#	OUTAGE BEFORE INCHES 80"	OUTAGE AFTER INCHES 25"	INCHES ____ POUNDS ____
PRODUCT	BLENDING or FILTRATE TANK OUTAGE BEFORE Inches empty °C	AFTER Inches 61½ °C	INCHES ____ POUNDS ____	STILL BOTTOMS POUNDS ____

	VAC. OFF LAST LOT NO.	VAC. ON	VAC. OFF	
TIME	11:55 a.m.	12:15 p.m.	11.00 PM	TOTAL BATCH TIME 11.05 hr min
DATE	12-8-41	12-8-41	12-8-41	TOTAL DELAYS 20 min
				NET BATCH TIME 10.45

SHIFT 1 CH. OP. Adcock OPER. Howard

TIME TEMP.	VAC.	BURNERS	COLUMN	STILL INLET	COIL OUTLET
Roof Star Fl Open at 2:00 p.m.					
3:00	5	15	204	214	225

SHIFT 2 CH. OP. Stamps OPER. White

TIME TEMP.	VAC.	BURNERS	COLUMN	STILL INLET	COIL OUTLET
400	4	15	211	223	231
500	4	15	213	228	238
600	4	15	215	230	236
700	4	15	218	230	238
800	4	15	220	236	245
900	4	15	223	240	250
1040	4	15	225	243	262
1100	4	15	228	240	280

SHIFT ____ CH. OP. ____ OPER. ____

TEMP.	VAC.	BURNERS	COLUMN	STILL INLET	COIL OUTLET

SHIFT ____ CH. OP. ____ OPER. ____

TEMP.	VAC.	BURNERS	COLUMN	STILL INLET	COIL OUTLET

NOTE: Explain items of abnormal operation on back of this sheet.

DSW 176521

STLCOPCB4050408

1262		96-97		-3				1.338 - 1.348	6V/NV
1263		"		"				1.404 - 1.414	"
1264		"		"	200-230		10-12	1.495 - 1.505	"
1260		"		"			10-12	1.550 - 1.560	9c/NV
1267		"		"				1.572 - 1.583	"
1264		"		"					
1268		95-96		"					
1269		"		"					
1270		"							
4616		88-90		"	240 - 330		12-16	50 40 - 66 °C	
4464				"					
4460		80-85		"	250-326		15-18	100 - 105 1/2	

DSW 176522

STLCOPCB4050409

Cu Ho/Batch

	INV	2565	4065	5060
	27.8	37.1	41.0	37.3
	27.6	36.2	41.7	—
	27.8	46.7	—	42.3
	26.8	43.K.	43.7	40.5
	27.9	33.6	43.1	34.6
	26.2	33.3	—	30.0

Cu #/Batch

	INV	2565	4065	5060
Cu	7578	8366	8186	—
	7861	8449	—	7691
	7706	8481	8791	7076
	7795	7956	8531	7246
	7727	7773	—	6945
	7756	8199	8502	7691
Cu Eq.	8525	8580	9275	7500
%	95.8	95.7	91.8	94.5

DSW 176523

STLCOPCB4050410

#1 still

Bottoms drawn after 6 runs from 83½" entage

Run	Inches	Lbs. @ 11#/gal.
1st # 371	6-7	12,924
2nd # 372	6-8	12,636
2nd # 373	60½-18	12,240
1st # 375	60-19½	11,664
2nd # 376	61-21	11,520
2nd # 377	59-17½	11,952
		72,936
Bottoms sales @ 11½#		1,332½
		74,268½

Weight

Recd = 98.2%

#2 still

Bottoms drawn after 6 runs from 81½" entage

Run	Inches	Lbs @ 11#/gal.
1st # 374	6-60½	11,916
2nd # 375	68½-29	11,376
2nd # 375	6-60	12,060
1st # 376	6-61	11,772
1st # 377	6-62	11,484
1st # 378	6-59	12,348
		70,956
Bottoms sales		1,760
		72,716

= 97.6%

$C_8H_{18} + 10Cl_2 \rightarrow C_8H_8Cl_{10} + 10HCl$

DSW 176524

STLCOPCB4050411

Produced	Mfg. Code	Date Code
1145	6-1403	1040-130-75-09
1148	1405	1040-140-75-09
1150	1407	1040-160-75-09
1160	1408	1040-170-75-09
1165	1409	1040-180-75-09
1166		1040-190-75-09
1165		1040-200-75-09
1168		1040-211-75-09
1169		1040-220-75-09
1170		
1265	1411	1140-390-75-09
1266	1420	1040-410-75-09
1260		
1260	1423	1040-420-75-09
1268	1433	1040-240-75-09
1268	1435	1040-260-75-09
1270		1040-270-75-09
1266	1437	1040-280-75-09
1260	1438	1040-290-75-09
1269	1439	1040-310-75-09
1266	1440	1040-320-75-09
1265		1040-330-75-09
1268	1442	1040-340-75-09
1269		1040-350-75-09
1270		1040-355-75-09
1271		1040-356-75-09
1266	1450	1040-430-75-09
1266	1452	1040-470-75-09
1260	1453	1040-480-75-09

DSW 176525

Pressure readings on tops of chlorinators

Chlorinator	Outage on Chl.	Nipple	Blowing Tank Outage	Aroclor
6	59"	14½"	33" - 10"	1154
6	60"	"	E - 80"	"
5	58"	"	80" - 56"	"
4	34"	7¼"	76½" - 51"	"
3	63"	6¼"	51" - 31"	"
2	47½"		39" - 9"	5060

Chlorinator #6		Chlorinator #4		Chlorinator #3		Chlorinator #2			
Feed Gauge	Chl. Gauge	Feed Gauge	Chl. Gauge	Feed Gauge	Chl. Gauge	Feed Gauge	Chl. Gauge		
10	1	10	0	10	1	10	0		
10	1	10	0	-	-	10	0	40	0
10	1	-	-	10	1	10	0	40	0
10	½	10	0	10	1	10	0	40	0
10	½	10	0	10	1	12	0		
10	½	10	0	10	1	12	0		
10	½	10	¼	10	1½	12	0		
10	1	10	½	10	1¼	14	0		
10	1	10	1	12	2	14	0		
30	1¾	12	1½	12	2	16	0		
30	2	12	1½	12	2	16	0		
30	2	12	1½	12	2	16	0		
30	1½	12	1½	12	2	18	0		
30	1½	12	1½	12	1½	18	0		
30	1½	12	1	12	1½	20	0		
34	1¼	12	1	14	1½	20	0		
34	1¼	14	1¼	14	1½	20	5		
34	1¼	14	1¼	14	1¾	20	1		
34	1¼	14	1¼	14	1¾	20	1		
34	1½	14	1¼	14	1¾	20	1		
34	1½	16	1¼	16	1½	20	1		
34	1½	16	1	16	1¼	20	1		
34	1½	16	1	16	1¼	20	1		
34	1½	16	¾	16	1¼	20	1		
34	1½	32	¾	22	1	20	1		
		32	¾	22	1	20	1		
		32	1	22	1	22	1		
		32	1	22	1	22	1		
		32	1	22	1	22	1		
		30	0	22	1	22	1		
		30	0	22	1	22	1		
		-	-	-	-	22	1		
		-	-	-	-	(no check for			
		32	0	18	1	5½ hours)			
		32	0	17	1	24	0		
		32	0	16	1	24	0		
						24	0		
						24	0		
						24	0		
						24	0		
						28	0		
						40	0		
						40	0		

DSW 176526

STLCOPCB4050413

Fluid ounces

Changing still

Adjusting still

finishing

Siphoning, filling, pumping

steam pressure - see ch. 7

Cleaning up & upstairs still room and small [illegible]

Wash tubs

Aging & putting away finished ch.

Acid stones

Loading acid cars

Obtaining acid

Clean-up & platforms

Drawing & shipping in all cars 2-tower

S M T W T F S

20 21

13 14 15 16 17 18 19

IV

DSW 176527

STLCOPCB4050414

5

Highwarp Operations

A. Raw material
1. Source, grade, how furnished, average properties, specifications (see letter for methods & analyses)
Health dangers, chem + physical props
B. Unloading + storage facilities - where bought
C. Feeding facilities - where bought
D. Reactors
1. Types + structures (diagrams)
a. Materials used here - where bought - Remarks
E. Pump tanks → A - water in
F. Highwarp stills
G. Benzol still
H. Hi-Boiler stills
I. Disposal of By-products difficulties with above from A-H
J. Instruments Control, gas, water
K. ~~Shipment~~ Products
Highwarp Grade, average properties (give av. analysis sheet for 1939) specifications + chem and phys. props
2 (~~Benz~~) —
3 (Naphth) —
4 (Hydrogen) — cf. Research on This.

DSW 176528

STLCOPCB4050415

For methods of analysis of benzol see pages ____.

Benzol and benzol vapor are known to be dangerous as a fire, explosion and a health hazard.

See booklet of Slides.

Following are some of the physical and chem properties of benzol

B- The benzol tank cars are spotted at the unloading station grounded with a metal clip and unloaded from the bottom outlet with a ~~positive displacement~~ gear pump powered by a 2 H Howell motor thru a ~~rigid~~ flexible coupling. The pump is grounded. The unloading line is a jacketed steam "trace" line leading directly to the storage tanks where it can lead the benzol into any one of 5 storage tanks. ~~Here it may be placed~~ After the car is unloaded compressed air is put into the unloading line thru a check valve to blow out the benzol remaining in the line into the storage tank. The car is then disconnected sealed and the package forwarded. It is ready to be pulled.

The storage tanks

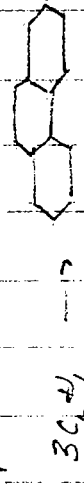
DSW 176529

STLCOPCB4050416

A. Introduction

Diphenyl is produced in benzol by the thermal dehydrogenation of benzene, the resulting phenyl groups uniting to form primarily diphenyl in the following manner.

$$2\,C_6H_6 \xrightarrow{\Delta} C_6H_5-C_6H_5 + H_2$$



The thermal dehydrogenation however may go further as shown by the following equations.

$$3C_6H_6 \longrightarrow C_6H_5-C_6H_4-C_6H_5 + 2H_2$$

o, m or p-diphenyl benzene

B Raw Materials

The benzene used as raw material is furnished by the Fairfield Steel Works-By-Product Coke Dept of T.C.I. in Fairfield, Ala. and is shipped by them in 10,000 gallon welded or riveted tank cars, having a steam jacket or steam coil, as the case may be. Manufacturer has set the following Specifications as the grade of benzol purchased:

(SPECIFICATIONS)

DSW 176530

An average analysis of the benzol is given on the following sheet supplied by the T.C.I. Laboratory.

Procedures: Introduction

1. How light is obt. lines, pumps, purity, fire hazards
2. How CTC is cut. etc
3. How DDB is obt. etc
4. Chlorine + properties where bought
5. Prod. of Crude Acetone

Nomenclature

Tabel

	Crudes	charge			Chro sec.	Acet. Rec.	Phac.
1.	1107 US 10 etc	Hyd.	CTC	DTC			

melting pot

2. Description of eliminators, piping system, fire hazards, valves, etc. packing
3. chlorine line from tank cars, loading hooks, scale trays, valves, vaporizers, feed lines, cone traps, lines to Towers
4. Operating technique for Hydrog absorbers, + TB towers How charged, drawn, circ., raising + pumping over.
5. drawing-trapping, vacuum pumps in #6
6. Prod. of dist towers
1. TBC Crude - dist - Rec, etc
2. description of lines, stills, pumps, towers, pots, boilers, heat Rec
3. " of blending, filtrate + storage tanks, lines, pumps, barrears, etc
4. Operating techniques - cleaning stills - charging, towers, drawing bottoms - finishing, pumping over, ~~vac towers~~

Drawing towers calibrations

D. Laboratory Testing + charges
E. Specifications
7. Calibrations of tanks

Sales Prod. Code Nos 2 years Prot. Relays in Lab. operators names

(cleaning acetone from floor)

DSW 176531

STLCOPCB4050418

1,350,000 =

2006 – 115,000

2005 – 107,000

2004 – 850,000

1,072,000

Auditors –

Mr. Clegorn

TEST REPORT

MONSANTO CHEMICAL COMPANY
ANNISTON, ALABAMA

TESTS ON PYRANOL #1482

Customer's Order No. Ps-3-164480

Lot No. 1965

Car No. M.O.N.X. 838 Date Shipped 6/20/48

		Specifications
Color, APHA Scale	40	100 Max.
Condition	Clear	Clear
Specific Gravity at 90/15.5°C	1.560	1.550-1.560
Acidity, Mgm. NaOH/gm.	.0008	.01—
Inorganic Chlorides, ppm.	.05	0.10 Max.
Saybolt Viscosity at 98.9°C, sec.	76.2	75-80
Dielectric Constant at 100°C	3.69	3.6-3.8
Resistivity at 100°C, ohm-cm. at 500 volts	11000	Above 500 x 10^9
Refractive Index at 25°C	1.6465	1.6455-1.6465
Distilling Range, Observed, 10%	372	370-377°C
" 50%	378	377-385°C
" 90%	391	385-400°C
Pour Point	30	26 - 34
Water, ppm.	35	35 Max.
Evaporation, 6 Hrs. at 100°C	.018	0.2—%
Corrosion Test-Change in weight	None	0.0%
Acidity_____ after test	.0016	0.01—
Inorganic Chlorides_____after test	.05	0.10 Max.
Condition_____after test	Clear	Clear
Color_____after test	40	150 Max.

Tested By Denman & Meltzer

Date 7/13/48

F.A.Barker
Chief Chemist

DSW 176533

STLCOPCB4050420

60-W-62116

1565

M.O.W.X. 821

	8/20/48
	30
65	1.502
	.0008
	.05
	45.9
	[illegible]
	820
	1.6382
	370
	376
	368
	8
	35
	.048
	None
	.0008
	.05
	Clear
	40

Denman

8/13/48

F.A. Berber
Chief Chemist

DSW 176534

STLCOPCB4050421

HALOWAX PRODUCTS DIVISION
UNION CARBIDE AND CARBON CORPORATION
UCC
30 EAST 42nd STREET, NEW YORK 17, N. Y.



TRADE-MARKS

HALOWAX
PRODUCTS

DSW 176535

MARCH 1947

MATERIALS FOR LUBRICATION • ELECTRICAL INSULATION
SEALING COMPOUNDS • INSECTICIDES • COATINGS • PLASTICIZERS •

STLCOPCB4050422

HALOWAX is a registered trade-mark which identifies products manufactured by the Halowax Products Division of Union Carbide and Carbon Corporation. These materials include chlorinated hydrocarbons of varying chlorine content. Chlorinated naphthalenes, identified by the trade-mark HALOWAX, range from a low viscosity oil to a hard microcrystalline wax having a softening point of approximately 280 deg. F. The waxes have sharp melting points. The basic HALOWAX products listed below are refined from crude materials having essentially the same properties. Crude materials are available. Both the refined products and crude materials may be compounded with various other ingredients for formulations to meet specific requirements and colors.

PROPERTIES OF BASIC "HALOWAX" PRODUCTS

MATERIAL NUMBER	No. 1000	No. 1001	No. 1013	No. 1014
Colors	White to Pale Straw	White to Pale Yellow	Pale Yellow	Pale Yellow
Flow Point (Mod. ASTM Softening Point) deg. F.	Liquid	194-201	247-252	277-283
Specific Gravity at 77 deg. F.	1.19-1.25	1.53-1.59	1.65-1.71	1.75-1.81
Penetration (Mod. ASTM) 200-g. load at 77 deg. F.	—	10-15	5-8	5-8
Viscosity (Saybolt Universal Seconds)	33-37 @ 77 deg. F.	33-37 @ 266 deg. F.	31-35 @ 266 deg. F.	33-37 @ 302 deg. F.
Distillation Range (ASTM) deg. F.	480-590	600-650	615-655	680-730
Flash Point (ASTM Cleveland Open Cup) deg. F.	203	284	356	392
Fire Point (ASTM Cleveland Open Cup) deg. F.	338	None to boiling	None to boiling	None to boiling
Power Factor at 1,000 cycles	—	Less than 0.2%	Less than 0.2%	Less than 0.2%
at 10^6 cycles	—	0.43%	0.70%	0.70%
Dielectric Constant at 1,000 cycles	—	5-6	4-5	4-5
at 10^6 cycles	—	5-6	4-5	4-5
D.C. Resistivity (meg. cm.) at 30 deg. C.	—	Over 10^7—10^8	Over 10^7—10^8	Over 10^7—10^8

Some suggested applications for HALOWAX products are as follows:

Lubrication

HALOWAX oil is recommended both as a crankcase oil additive and as an upper cylinder lubricant. Its high boiling point, low viscosity, and active cleaning action on various types of gums make it of exceptional value for these uses as well as for use in motor tune-up compounds. Because of its excellent wetting properties, HALOWAX oil is also used as an ingredient in penetrating oils. Other HALOWAX products have been especially developed to be used in EP lubricants. High load carrying properties of lubricants can be improved by the use of these products, which will prove valuable also in preparing general and special-purpose cutting oils of unusually excellent properties.

Coatings

HALOWAX compounds can be successfully employed as coatings to provide mechanical protection and resistance to most alkalies and acids, excepting certain strong oxidizing agents. The versatility of these waxes makes it possible to use them for the coating or treatment of paper, fabric, wood, metal and plastics. They may be applied either alone, or as ingredients in varnishes or other standard treating materials.

Pest Control

As a contact insecticide, HALOWAX oil in liquid sprays is particularly effective in the control of red spiders, mites and thrips. In the case of red spiders, HALOWAX oil kills not only the insects but prevents the eggs from hatching. When used in soilicides, this oil is a very good soil poisoner. Wood treated with HALOWAX oil and waxes exhibit effective action against attack by termites.

Sealing Compounds

Because of high flow-point characteristics, and ease of application, HALOWAX products are adaptable to a variety of uses in this field. In this application, these materials may be used alone or in combination with various other waxes, resins, and plasticizers to give the required electrical properties as well as flame and moisture resistance.

Dielectrics

In the dielectric field, HALOWAX products are used because of their good dielectric properties and good heat stability. The high dielectric constant and low-loss characteristics make them especially suitable as a capacitor impregnant, yielding higher capacitance per unit volume as compared with many other impregnants.

HALOWAX products can also be used for plasticizers, refractive index oil, photo-elastic immersion fluid, and flow meter oil. The services of HALOWAX Products' engineers can be readily obtained for assistance in choosing and applying the most suitable HALOWAX products for particular problems.

STLCOPCB4050423

PYBRAULS

1971

DSW 176537

STLCOPCB4050424

Monsanto

file Pydraul

FROM (NAME & LOCATION) J. L. Solari, JFQ

DATE December 29, 1971

SUBJECT Polymer-Alkalate Blend for Selector II Pydrauls

REFERENCE

TO S. Abbot
R. A. Dykstra
L. R. Stark

cc D. H. Bolliger - G.O.
P. D. Fowlkes - G.O.
J. S. Gillies - JFQ
H. C. Granneman - JFQ
J. F. Herber - G.O.
E. D. Malone - JFQ
J. R. Savage - G.O.
M. J. Smid - JFQ
R. L. Wagner - JFQ

One part of the Pydraul Reformulation Program, calls for the make-up of a "concentrate" to add to Selector II Pydrauls. This "concentrate" is a 10% polymer (rubber) solution in a heavy alkalate oil (H-230H). It has been proposed that we make-up this "concentrate" in the BB Building.

I have talked with Harry Grannemann about the possibility of doing this in the BB Building. Harry felt that adequate time would be available in the South Pfaudler (1000 gallon) reactor. This reactor is currently used for Coolanols. The volume required in 1972 would be a maximum of 40,000 gallons of "concentrate" (36 days per year).

In terms of the total operation, the preparation of the "concentrate" is visuallized as follows:

1. Receipt of the heavy alkalate (H-230H)

   A storage tank in Central Drumming will have to be made available for receipt of H-230H from Chocolate Bayou.

   H-230H can be transferred from Centeal Drumming to the BB Building (South Pfaudler) in one of two ways:

   a. Direct transfer thru either the Acryloid or S-394C line. Piping changes would be involved and product contamination must be considered.

   b. Trucking from Central Drumming to the BB Building. Truck unloading facilities are presently available at BB.

   Lou, we will need physical constant data on H-230H (viscosity, x-pt, flash pt, sp.gr. etc.). Will you please supply us with this information?

2. Receipt of Polymer (Rubber)

   Polymer (rubber) addition can be done via addition thru the manway on the South Pfaudler. Manufacturing will require receipt of shredded rubber in 50 pound bags, to do this job.

   Lou, when polymer specifications and/or supplier have been finalized, please send us this information.

DSW 176538

STLCOPCB4050425

3. Batch Cycle

The batch cycle requirements for this operation are estimated as follows:

a. Charge 700 gallons of H-230H to the South Pfaudler Reactor ---------- $\frac{1}{4}$-$\frac{1}{2}$ hr.
b. Heat H-230H to 150°C ---------- 4 - 6 hr.
c. Add 14 - 50 pound bags of shredded polymer to the batch ---------- 1 - 2 hrs.
d. Hold batch at 150°C---------- 3 - 4 hrs.
e. Transfer batch or drum off---------- $\frac{1}{2}$ - 2 hrs.

Total time ---------- 8 3/4 - 14$\frac{1}{2}$ hrs.

Assuming a total batch cycle of 15 hours, the maximum time required in the South Pfaudler would be 36 days per year. Bob, from a production planning viewpoint will this operation fit for 1972?

4. Product (Concentrate) Handling (H-230 HP)

The finished "concentrate" batches produced in the South Pfaudler, can be transferred back to Central Drumming in one of three ways.

a. Batches can be pumped directly from the South Pfaudler thru either the Acryloid or S-394C line to Central Drumming. Again product contamination must be considered. Additional piping costs would be required and some provision for receipt of the "concentrate" at C.D. would also have to be worked out.

b. Batches can be drummed at the BB Building. Re-usable drums can be used to reduce costs if we go this route.

c. Batches can be trucked from BB to C.D.

Lou, we will also need physical constant data on the "concentrate". Will you please supply us with this information?

5. General

The South Pfaudler reactor in the BB Building has a rather large patch in it. Lou, I have assumed that we will not have a corrosion problem with this product. Is this a fair assumption?

Sam, do you see any problems with this operation from the manufacturing viewpoint?

If there are any questions, problems or comments, please let me know. If not, we will plan to use the facilities in the BB Building for the preparation of the H-230H "concentrate".

J. L. Solari

DSW 176539

:kk

STLCOPCB4050426

J. R. Savage - General Office

December 22, 1971

W. R. Richard T3A
E.M. Potter B2NK

H230H FOR PYDRAULS

W. C. Brandenburg
General Offices A2NH

Howard Bergen has written to Bart Macdonald asking for allocation of H230H to our Pydraul program. To give you more insight into the volume requirements, the following may be helpful.

Some question remains as to the concentration of H230H. There is a good possibility that a "Bright Stock" hydrocarbon could substitute for part of the alkylate. There is also some uncertainty in the level of market acceptance of the new formulations. This leads to the following ranges of possible annual H230H requirements:

	High Conc.	Low Conc.
Good market acceptance	3,100M	1,819M
Poor market acceptance	1,618M	943M

We will reach our full annual rate midway in the second quarter. My estimate of quarterly take is:

1st quarter	'72	100M
2nd quarter	'72	350M
3rd quarter	'72	500M
4th quarter	'72	450M

As you are aware, we are attempting to make use of your "stripped oil" stream, which could reduce the need for H230H.

J. R. Savage

DSW 176540

STLCOPCB4050427

Monsanto INDUSTRIAL CHEMICALS CO.

FROM (NAME & LOCATION) D. R. Cova, So. 2nd St., St. Louis, Mo.

DATE : December 22, 1971

SUBJECT : Topping of Alkylate H-230L

REFERENCE :

TO : L. R. Stark
LSTAR

cc: O. DeGarmo - Res 1
P. D. Fowlkes - PFOWL
J. F. Herber - JHERB
W. G. Knapp - WW Bldg
J. F. Quinn - Res 1
W. R. Richard - WRICH
J. R. Savage - JSAVA

A sample of Alkylate H-230L was topped in the laboratory in a 10-tray 2 in. diameter Oldershaw column at a reflux ratio of 3/1. Head pressure was 15 mm. Hg. and stillpot pressure was 25 mm. Hg. These pressures were chosen in order to approximate stillpot pressures in pilot plant equipment.

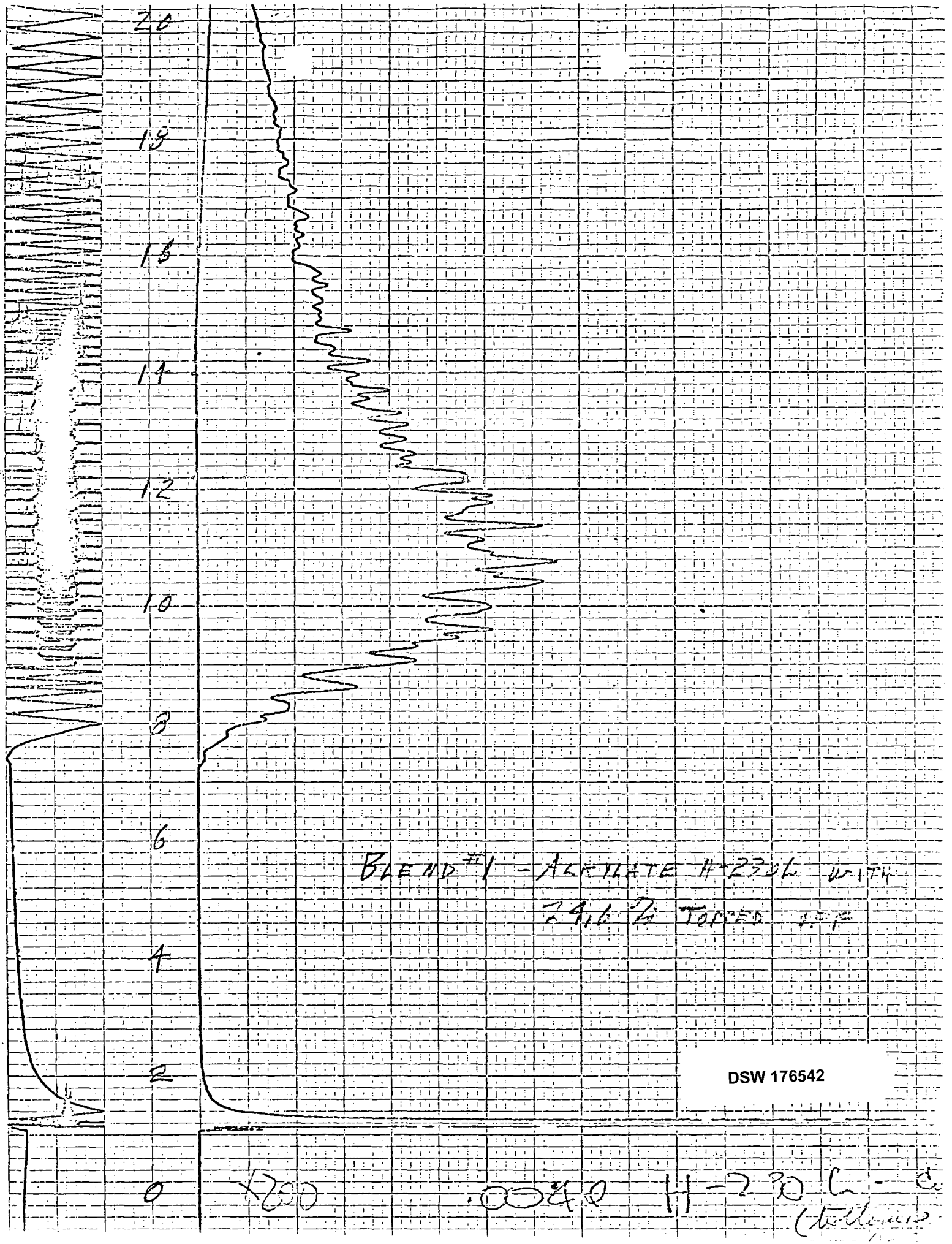
A total of 27.4% of the charge was taken off as distillate in 10 approximately equal sized cuts. Aliquots of the appropriate cuts were then blended back into samples of the residue to give 3 blends corresponding to 24.6% of the charge topped off (blend #1), 19.2% topped off (blend #2), and 14.0% topped off (blend #3). Open cup flash points and refraction indices of the blends were determined. These were as follows:

Blend #	% Topped	Flash point (°F)	Refractive Index at 25°C.
1	24.6	370	1.5050
2	19.2	375	1.5048
3	14.0	375	1.5037

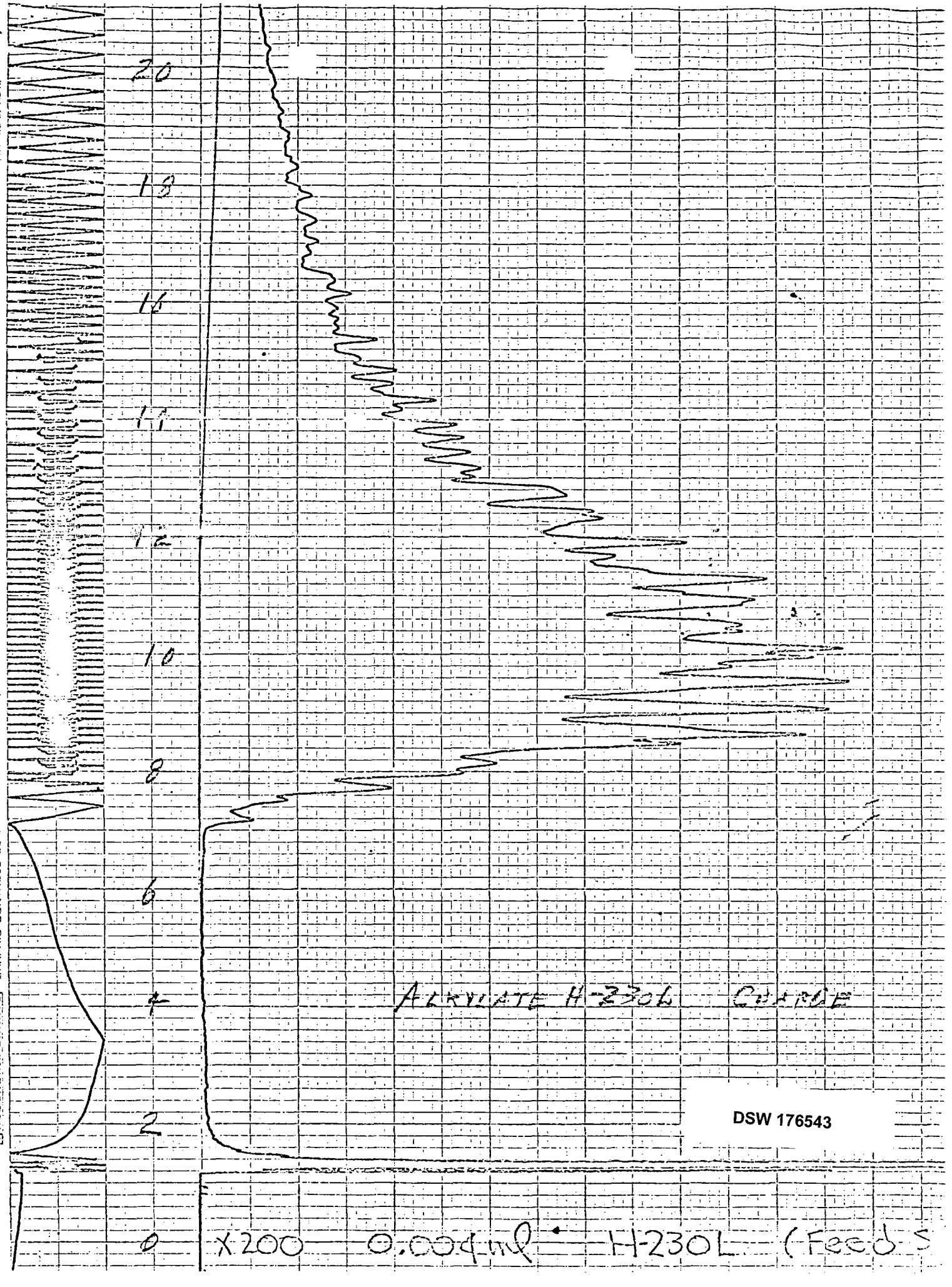
Copies of chromatograms of blend #3, of the Alkylate H-230L charge, and of a sample of Alkylate H-230H are attached to this memo. It can be seen from these that to achieve a molecular weight similar to that for Alkylate H-230H would require topping off 70 to 80% of the Alkylate H-230L charge.

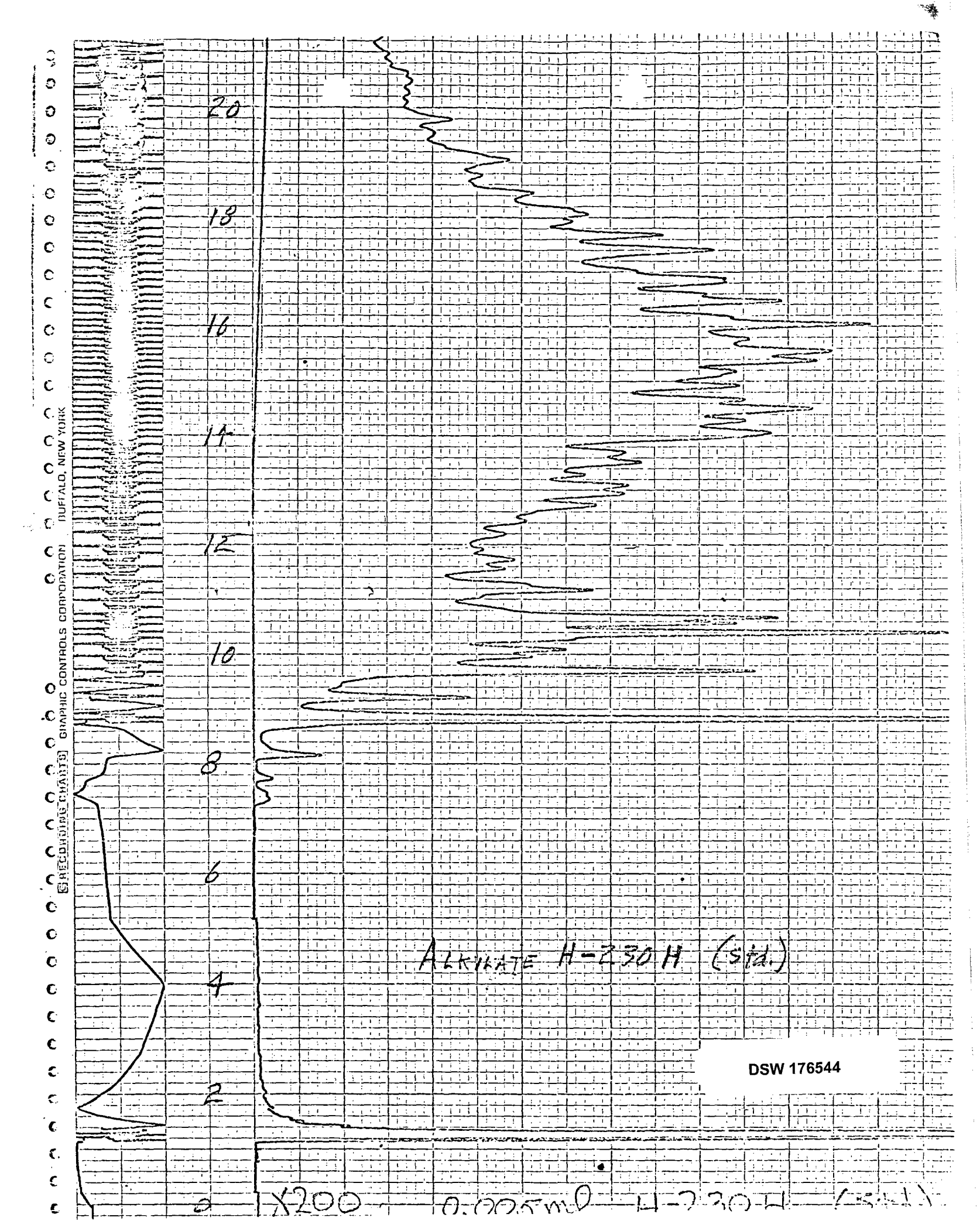
D. R. Cova

attach
ds



STLCOPCB4050429


20
18
16
14
12
10
8
6
4
2
0
ACRYLATE H-230L CURVE
DSW 176543
X200 0.004 inl H-230L (Feed S
PRINTED IN U.S.A.
GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK



DSW 176544

STLCOPCB4050431

file Pydraul

Monsanto

FROM (NAME & LOCATION) H. S. BERGEN - B2SA

note & return

J.R.Savage - B2SL

DATE December 20, 1971

SUBJECT HEAVY ALKYLATE HIGH BOILER
H230-H

REFERENCE

TO : Bart MacDonald - A2NB

Our Research Department has determined that H230-H is an essential ingredient in our Pydraul reformulations which, as you know, we are doing because of the PCB problem. It is necessary that we have all of our Pydraul fluids completely reformulated by June 30, 1972, and accepted by the customers by that date.

Our Research Department has now developed the technique for utilizing H230-H only to find that this product is no longer available to us, at least for this year.

We have also looked at H230-L but this product does not work because it is too flammable.

We need 1-1/2 to 2M pounds in 1972 and an estimated 3 to 4M pounds in 1973.

I realize you have made some short-term commitments for this product but, in light of the seriousness of the PCB problem and its effect on our total Pydraul line, I would like you to review your commitment to supply in 1972, as well as the ability to supply us our anticipated needs in 1973.

We would appreciate an early review of this because of the critical nature of our reformulations and customer conversions.

Thanks.

H. S. BERGEN

/jf

DSW 176545

Monsanto

DATE 12/20/71 | TIME 9:05 am | SENDER'S ACCOUNT NO. 2-OC-721.44

INDICATE DESIRED SERVICE → ☐ FULL RATE ☐ DAY LETTER ☐ NIGHT LETTER

Names of addressee and sender must include initials. Show complete address for telegrams and cables.

J. N. Haggart - Brussels

file

Re Pydraul 312A separation problem, Jim Savage under impression your manufacturing people have the info they need to solve the problem. Apparently you do not have any of the lots we made that we recognize could have a permanent separation problem. The lots you do have you should be able to warm and mix and have no further separation problem if the fluid is kept above 45-50° Fahrenheit. If you do mix and still have a problem above 50°F. we would suspect contamination of some sort and would want a sample. Re another order of Pydraul 312A, we would not expect you to have a separation problem unless the fluid temperature goes below 50°F.

C. L. Bradford - St. Louis

cc: L. R. Stark/P. D. Fowlkes
J. H. Davidson
J. R. Savage

DSW 176546

IN-IR REV. 7-64 | *for* BETTER *service* – Forward to transmitting operator IMMEDIATELY after preparation.

STLCOPCB4050433

Monsanto

OUTGOING MESSAGE BLANK
Tele--Communications System

DATE	TIME	SENDER'S ACCOUNT NO.
11/30/71		2-00-613.00

INDICATE DESIRED SERVICE → ☐ FULL RATE ☐ DAY LETTER ☐ NIGHT LETTER

Names of addressee and sender must include initials. Show complete address for telegrams and cables.

CABLE

cc: L. Stark

E. V. Weekes
Brussels, Belgium
Telex: 22110
Cable: Monsanturop Belgium

Send sample of 312A to L.R. Stark, Research Center, W Building here.

J.R. Savage
St. Louis

DSW 176547

IN–IR
REV. 7-64

for **BETTER** *service* – Forward to transmitting operator IMMEDIATELY after preparation.

A/BL851/N030/1020/1022 ''/CH609/QZQ

J R SAVAGE ST LOUIS NOV 30/71 EN

THANKS FOR INFORMATION ON PYDRAUL 312A.
THE LOTS WE HAVE RANGE FROM QA 250 - QA 390 - QA 550 AND SHOULD THEREFORE BE OK. A SAMPLE OF QA 280 ON MY DESK LOOKS AS IF IT MAY HAVE SMALL AMOUNTS OF WATER IN IT.

AM PROPOSING TO AIRMAIL A FRESH SAMPLE FROM ANTWERP TOMORROW. TO WHOM SHOULD WE SEND IT/Q/.

MY QUESTION ON D.B.T. WERE INSPIRED BY DICK BAXTER WHO SAID THAT WIGGINS TEAPE HAD ASKED IF WE WERE PREPARED TO MAKE THIS PRODUCT FOR THEM.

E V WEEKES BRUSSELS

1971 NOV 30 AM 10 24

DSW 176548

8550-4 PT. 27 MOORE BUSINESS FORMS INC. CONTINUOUS INTERLEAVED® PAPER PAT'D BY N.C.R. CO

Monsanto

OUTGOING MESSAGE BLANK
Tele--Communications System

DATE 11/29/71 | TIME | SENDER'S ACCOUNT NO. 2-00-613.00

INDICATE DESIRED SERVICE → ☐ FULL RATE ☐ DAY LETTER ☐ NIGHT LETTER

Names of addressee and sender must include initials. Show complete address for telegrams and cables.

CABLE

E.V. Weekes
Brussels, Belgium
Telex: 22110
Cable: Monsantusop Brussels

RE: PYDRAUL 312A PROBLEM -----

Have had liquid/liquid phase separation problem on lots QA 130, QA 160, QA 175 QA 190 and QA 210 STOP Other lots produced near the same time may separate on long standing below 60 Deg F but can be restored to single phase by heating above 25 Deg C and agitating, and will probably remain okay. STOP Problem is esthetic rather than functional but still real at some accounts. If you have any of the specific lots mentioned above, they cannot be held in a single phas and will have to be blended off with current production if no customer will accept. STOP Have seen no problem here since QA 220.

Also a few lots in the QA 600-800 period may show fine white solids due to QC problem in Aroclor 5432. Filtration can correct.

DIBENZYL TOLUENE SITUATION -----
Essential that we not communicate U.S. program to NCR-UK or Wiggins-Teape. However, if you want to pursue question of European manufacture, basic process will be benzylation in a glass lined reactor followed by filtration

DSW 176549

IN–IR REV. 7-64

for **BETTER** *service* – Forward to transmitting operator IMMEDIATELY after preparation.

Monsanto

OUTGOING MESSAGE BLANK
Tele--Communications System

DATE	TIME	SENDER'S ACCOUNT NO.
11/29/71		2-0-613.00

INDICATE DESIRED SERVICE → ☐ FULL RATE ☐ DAY LETTER ☐ NIGHT LETTER

Names of addressee and sender must include initials. Show complete address for telegrams and cables.

E. V. Weekes
Brussels Belgium

AND standard distillation in a steel still. Repeat even though Wiggins-Teape has seen Mariotherm we must not reveal nature of U.S. candidate products.

J. R. Savage
St. Louis

DSW 176550

IN–IR
REV. 7-64

for **BETTER** *service* – Forward to transmitting operator IMMEDIATELY after preparation.

4/ BL589/NO29/0920/094 1/AH715/GZ9

ATTN J R SAVAGE ST. LOUIS NOV. 2?/71/AP.

CC J N HAGGART BRUSSELS.

PYDRAUL 312 A

WE HAVE HAD TWO COMPLAINTS FROM THE SAME CUSTOMER /S C. FRANCAISE DES PETROLES BP/ ABOUT SEPARATION OF PYDRAUL 312A. EXAMINATION OF SINGLE DRUM FROM EACH LOT CONTAINED IN RECENT DELIVERIES SHOWS OK RESULTS. CAN Y U PLEASE SUPPLY INFORMATION ON HOW WE CAN CORRECT THE DEFECTIVE MATERIAL.

EW WEEKES BRUSSELS

NOV 29 AM 9 47

DSW 176551

PAPER PAT'D BY N.C.R. CO. CONTINUOUS INTERLEAVED® MOORE BUSINESS FORMS, INC. 27
8550-4 PT.

Ted Weekes from Belgium called 10:50 our time
5:50 their time

Need to get this information from you right away. Urgent.

1) We are having problems with Pydraul 312. We find we don't seem to have any good material at all. Urgent we do something. Want to know if there is any means at all for bringing this material back to salable condition.

?

2) Wonder whether there has been any developments with NCR about di benzyl toluene. Any processinformation available. This is for NCR Wiggins/Teape -- replacement for HB-40.

Urgent that I ~~XXXX~~ get this information right away.

Jim, I told him that we would teletype him the information.

Mary D

QM-210 phone

QM-1050 xtn

DSW 176552

STLCOPCB4050439

Message from Lou Stark:

There were several lots which potentially could show two liquid layers and these were QA 130, 160, 175, 190 and 210. There may be a few lots between these which may have a tendency for 2 liquid phases to form at lower temperatures. Loss QA 600 through 800 were made during a period when Aroclor 5432 had high solids.
A few of these lots may show some fine white crystalline material at the bottom.

md

Monsanto

OUTGOING MESSAGE BLANK
Tele--Communications System

DATE	TIME	SENDER'S ACCOUNT NO.
11/23/71	1:30	2-00-721. M

INDICATE DESIRED SERVICE → ☐ FULL RATE ☐ DAY LETTER ☐ NIGHT LETTER

Names of addressee and sender must include initials. Show complete address for telegrams and cables.

P. L. SLAYTON NEW YORK
L. T. JOHNSON NEW YORK

T/T OF A-200-B FOR INCINERATION FROM CHEVY MASSENA WAS RECEIVED AT KRUMMRICH PLANT ON SAT EVE. THIS MEANT WE HAD TO CALL IN MEN TO UNLOAD AND CLEAN THIS TRUCK. WE SHOULD ASK MASSENA TO SHIP ANY MORE MATERIAL EARLY IN WEEK (TO BE RECEIVED LATE IN THE WEEK) SO WE DO NOT HAVE OVERTIME CHARGES WHEN MATERIAL IS RECEIVED. WE SHOULD AVOID HAVING TO RECEIVE TRUCKS OF RETURNED MATERIAL ON WEEKENDS IF AT ALL POSSIBLE. THANKS FOR YOUR HELP.

J. H. DAVIDSON

lb

cc: C. L. Bradford
N. T. Johnson
J. F. Savage B2 A/B

DSW 176554

IN-IR REV. 7-64

for **BETTER** *service* – Forward to transmitting operator IMMEDIATELY after preparation.

file Antwerp Pydraul

Monsanto

JN HAGGART - Brussels

November 17, 1971

PHOSPHATE ESTERS FOR PYDRAUL BLENDING.-

JNH/cdl

J GYSEMANS - Brussels

EV WEEKES - Brussels
JR SAVAGE ✓ - St. Louis
JH DAVIDSON - St. Louis
EK MOLLER - Brussels
CL BRADFORD - St. Louis
EJ VAN GILS - Antwerp Pl
CR PERRY - Brussels

Jeff,

As discussed with you today we'd appreciate a fresh look at the availability of coal tar based phosphate esters in Europe.

Although we laid in enough phosphate ester ex USA to cover our forecasted needs over the dock strike period it may well turn out that we run into a raw material shortage.

Bob Stephenson was having Geigy's phosphate esters TCP and CDP evaluated in St. Louis. Has any progress been made ?

I also suggest that you contact Coalite and Chemical UK who are known to manufacture tricresyl phosphate and may be able to manufacture cresyl diphenyl phosphate as well.

Our preference for supplies at equal price is St. Louis, Geigy and any others in that order but total dependence on St. Louis is bad from a supply position and sometimes it is cheaper to buy in Europe eg. Trecresyl phosphate.

I'd appreciate a review of the phosphate ester supply position as soon as you can manage it.

JN HAGGART

P.S.
In a previous conversation I suggested that Coalite might even be able to issue feeding trial certificates with their tricresyl phosphates since they are reported to offer a quality called NTP the initials of which stand for non-toxic phosphate.-JNH

Walker's may be tied up

DSW 176555

Monsanto

OUTGOING MESSAGE BLANK
Tele--Communications System

DATE 10/12/71 | TIME | SENDER'S ACCOUNT NO. 2-0-613.00

INDICATE DESIRED SERVICE → ☐ FULL RATE ☐ DAY LETTER ☐ NIGHT LETTER

Names of addressee and sender must include initials. Show complete address for telegrams and cables.

CABLE

R. J. Stephenson
Brussels, Belgium
Cable: Monsanturop Brussels
Telex: 22110

cc; Dwayne Fowlkes-St. Louis

Gulf 200 Bright stock not compatible with new Pydraul formulations due to solubility problem -- not aromatic enough.

One alternate to Mobil 750 would be Humble Corsy 70. If it is not available look for an oil of aniline point 190 to 200 and viscosity of 700 to 950 SUS at 100 degrees F.

Another subject -- Medical Department has given clearance to Geigy phos esters TCP and CDP.

J. R. Savage
St. Louis

DSW 176556

IN-IR REV. 7-64

for **BETTER** *service* – Forward to transmitting operator IMMEDIATELY after preparation.

STLCOPCB4050443

A/BL407/OC11/1413/1411/AH753/QZQ

File Pydraul Antiwear
072

J SAVAGE MONSANTO STLOUIS OCT.11/71 CDB

CC J HAGGART MONSANTO BRUSSELS
V WEEKES MONSANTO BRUSSELS
L BUDD MONSANTO BRUSSELS

INVESTIGATING EUROPEAN AVAILABILITY OF MOBIL 750 OIL FOR PYDRAULS BUT SITUATION DOES NOT APPEAR ENCOURAGING. IN 1970 MEMO R.HALL TO J.HAGGART FEB.13TH CONFIRMED ACCEPTABILITY OF GULF 200 BRIGHT STOCK WHICH IS MARKETED OVER HERE. IS THERE TECHNICAL REASON WHY THIS COULD NOT BE USED -QUERY-

RJ STEPHENSON BRUSSELS

Humble
Conoco 70
Cumbria Pt 198 190-200 Gulf
194 4915
Visc 700-950 SUS
100 °F

DSW 176557

PAPER PAT'D BY N.C.R. CO. CONTINUOUS INTERLEAVED® MOORE BUSINESS FORMS INC 27
8550-4 PT.

Monsanto

Ltd Antwerp Pydraul

FROM (NAME & LOCATION) E.V. WEEKES Brussels

DATE 30th September 1971

SUBJECT P.C.B. CONTROL ANTWERP

REFERENCE EVW/mtc

TO R.A. BAXTER Ruabon

P.J.A. MARSH	Bru DB 52
J.J. JANSEN	Antwerp
E.J. VAN GILS	Antwerp
J.E. BISHOP	Antwerp
J.R. SAVAGE	St. Louis

We are about to start up the Pydraul blending plant at Antwerp using Aroclors shipped over from Newport and other materials either purchased locally or shipped from MC.

The plant has been designed to prevent spillages and leaks escaping to drains or penetrating into the soil. Operating instructions are being prepared to cover the handling of spillages and for dealing with containers which have held P.C.B. products.

Another problem pertinent to the plant is that we wish to use it for products which are free from P.C.B.'s and will go into non-controlled uses.

These include :

(a) Santomelt
(b) A plasticiser containing HB 40 and Aroclor 5460.

We shall need to establish procedures to ensure that these products do not become contaminated with P.C.B.'s either through inefficient cleaning when changing over from Pydrauls to other products or by accident.

It would be useful to have a control test which we could apply to ensure that contamination has not occured.

Is a reasonably simple test available or must we rely on manufacturing procedures to reduce the risk to negligible proportions ?

What would you regard as the maximum level of P.C.B.'s which could be tolerated in the products I have mentioned.

E.V. WEEKES

DSW 176558

From the desk of
J. R. SAVAGE

DSW 176559

Tom Stanke - Rosemont

Apparently Gelago doesn't have Cresylic lower in o-cresol than 1 Dr.

Am including copy to Medical (w. Hunt) with analytical results.

LRS 8/26/71

STLCOPCB4050446

File Phosphate

August 17, 1971.

CIBA - GEIGY (U.K.) Limited
Manchester
MANCHESTER M 22 5 LB.
U.K.

Attention : Mr. Hamilton.

Dear Sirs,

Thank you for the toxicity data relating to Tri-Sodyl Photes and for the information on the three dead fish for any use for natural acrylic acid based T.C.P.

I will let you know our position by that time.

Yours faithfully,

A.J. STEPHENSON
Manager Purchasing Research - Europe.

cc : E.V. Meekes. Brussels.
J. Cyselaans Antwerp Plant
J. Savage Ste Louis
M.L. Budd Brussels

P.S.

Toxicity data supplied is designated to support case for Geigy's synthetic phosphates.

DSW 176560

STLCOPCB4050447

Industrial Chemicals Division
CIBA-GEIGY (UK) Limited
Simonsway
Manchester M22 5LB

A member of the U.K. Plastics and Additives Group

Telephone: 061-437 5252
Telex: 667336
Telegrams: Geigy Manchester

CIBA-GEIGY

Our ref KK/mmb
Your ref

Monsanto Europe S.A.,
Place Madou 1,
B - 1030 Brussels,
BELGIUM

11th August, 1971

Attention Dr. R. Stephenson

Dear Sirs,

Following the writer's recent visit to your offices, we have pleasure in enclosing as requested some data on the toxicity of Tri-aryl Phosphates. We have included a statement from the Technical Press on the nature of the toxicity occuring with normal Tri-cresyl Phosphate together with a statement on the relative toxicity of our Reofos Tri-aryl Phosphates. You will notice that Tri-cresyl Phosphate with as little as 0.7% of ortho cresol isomer gives rise to clinical damage at low treatment levels. Our Tri-cresyl Phosphate made from commercial meta cresol would contain a maximum of 3% ortho cresol. Tri-cresyl Phosphate made from a mixed tar acid feedstock would contain a mximum of 1% ortho cresol. Therefore, we regard any phosphate based on the natural tar acids commercially available today as being relatively toxic when compared to the Reofos esters.

Should you require any further information, please let us know. The work was carried out in our own Biological Testing Laboratory approved by the Ministry of Technology as a test house.

RECEIVED 13 AUG 1971

Yours faithfully,
CIBA-GEIGY (UK) Limited

K. Knowlton
Export Marketing Manager

DSW 176561

STLCOPCB4050448

Industrial Chemicals Division
CIBA-GEIGY (UK) Limited
Simonsway
Manchester M22 5LB

A member of the U.K. Plastics and Additives Group

Telephone: 061-437 5252
Telex: 667336
Telegrams: Geigy Manchester

CIBA—GEIGY

Our ref KK/mmb
Your ref

Monsanto Europe S.A.,
Place Madou 1,
B - 1030 Brussels,
BELGIUM

11th August, 1971

Attention Dr. R. Stephenson

Dear Sirs,

Following the writer's recent visit to your offices, we have pleasure in enclosing as requested some data on the toxicity of Tri-aryl Phosphates. We have included a statement from the Technical Press on the nature of the toxicity occuring with normal Tri-cresyl Phosphate together with a statement on the relative toxicity of our Reofos Tri-aryl Phosphates. You will notice that Tri-cresyl Phosphate with as little as 0.7% of ortho cresol isomer gives rise to clinical damage at low treatment levels. Our Tri-cresyl Phosphate made from commercial meta cresol would contain a maximum of 3% ortho cresol. Tri-cresyl Phosphate made from a mixed tar acid feedstock would contain a mximum of 1% ortho cresol. Therefore, we regard any phosphate based on the natural tar acids commercially available today as being relatively toxic when compared to the Reofos esters.

Should you require any further information, please let us know. The work was carried out in our own Biological Testing Laboratory approved by the Ministry of Technology as a test house.

Yours faithfully,
CIBA-GEIGY (UK) Limited

K. Knowlton
Export Marketing Manager

DSW 176562

STLCOPCB4050449

815 BESSERO, C. Circa il nesso causale diretto tra polineuriti tossiche e ortotricresilfosfato (T.O.C.P.). [Direct causal connexion between toxic polyneuritis and triorthocresylphosphate (TOCP)] *Securitas*, 1967, v. 52, No. 4, 55–72. English summary (6 lines).

An article from the medical inspectorate of labour covers problems associated with episodes of polyneuritis occurring among workers in manufacturing industries in north Italy, and certain conclusions are offered. Preventive measures are surveyed in detail.

Severely affected workers had been investigated in university clinics in 1956; the illness is described. From 1962 to 1966 there were 72 notifications of similar illness in groups of workers, mostly young women. After prodromal gastrointestinal symptoms the lower limbs were weakened or paralysed, and occasionally arm and trunk muscles also. Recovery was complete but slow. There were no blood dyscrasias or epidemic features.

Most of the 72 patients worked in the shoe industry. Others made dolls, treated textiles for waterproofing, covered cases with vinyl products or prepared car-upholstery. The common factor was the use of varnishes, adhesives, natural hides, synthetic skins or cloth treated with gum.

In all probability the cause was work with materials which contained an organic phosphorus compound, more specifically triorthocresylphosphate (TOCP) in the commercial mixture, tricresylphosphate (TCP).

The description of TCP and its many uses, *e.g.* for plasticizing purposes, includes an account of conditions under which constituents may be freed from materials containing them. Properties and toxicity data of TOCP are fully dealt with, absorption taking place mainly by the digestive tract and skin and only doubtfully by the respiratory tract. Materials used at work by the patients were tested by chemical and chromatography methods which are described.

The clinical picture was similar to that reported from ingestion of food or substances containing TOCP. The sudden episodes at long intervals suggested that the cause—the nature of the materials used being considered—could be related to constituents presenting only accidentally in those materials. Only minimal amounts of the phosphorus compound were found, hardly enough to induce the illness. Although many convincing factors testified to poisoning of occupational origin it was not absolutely possible to exclude the remote possibility of food contamination—*e.g.* from contact with plastic containers or wrappings.

The toxic action may have been increased by solvents used at work. No specific toxic effects attributable to them were found, but by de-fatting the skin, solvents could facilitate penetration of the poison, or possibly they could extract it from certain materials handled. *M. Patricia Fitzsimons*

DSW 176563

STLCOPCB4050450

We would like to set out the position with regard to the toxicity of our new Reofos range of Tri-aryl phosphate plasticisers.

We have developed a testing scheme and have concentrated on feeding trials with hens since we have been concerned primarily with producing low neural toxicity (the most recognised hazard with conventional phosphate esters) in the new Reofos products. After dosing and observation for clinical effects, the hens are sacrificed at varying intervals, and examined histologically in our Pharmaceutical Testing Laboratories. This histological examination has predominantly been concerned with the detection of damage in the spinal cord typical bilaterally symmetrical lesions (axon damage and demyelination).

The test procedure we have used is described in the report - "Working Document No. 2 - Tests for neurotoxicity of organo phosphorus compounds." It was developed in this country by the Medical Research Council and is published in a booklet entitled "Pesticides Safety Departments Scheme agreed between Government Departments and Industry" by the Pesticides Branch of the Ministry of Agriculture, Fisheries, and Food, Great Westminster House, Horseferry Road, London S.W.1. The tests we ourselves have carried out conform to an, as yet unpublished, slightly revised procedure for compounds where difficulty is experienced in obtaining a true LD50 dose level, i.e. compounds with low acute toxicity - in such cases the hens are required to be fed 2 g. per kilogram bodyweight on day 1 and day 21. This procedure has been followed in our own work.

When applied to tri tolyl (cresyl) phosphate containing 0.7% by wt. o-cresol, both clinical effects and neurohistopathological damage were detected after one single dose of 2 g/kilogram. With tri xylyl phosphate containing 0.5% by wt. of o-cresol (plus small amounts of other recognisable toxic isomers), histology revealed damage at 3 x 2 g/kilogram bodyweight. You will realise that both these products have very low toxic isomer contents and are not representative of general commercial production.

The new phosphate esters all satisfy the requirement of "Working Document No. 2" in that no detectable clinical or histological effects are demonstratable at the 2 x 2 g/kilogram level and indeed the dosage has been continued to the 3 x 2 g/kilogram level with no neurological damage. The latest results we have obtained appear to indicate that the threshold level at which histological damage occurs is around the 5 x 2 g/kilogram bodyweight although at this level no clinical effects can be detected. These, as you will realise, are extremely high dosage rates when compared, say, with general LD50 testing.

We, therefore, believe that the new phosphates constitute less of an industrial hazard than conventional phosphates and since they satisfy the requirement of "Working Document No. 2", this is good evidence that the compounds will not produce a delayed neurotoxic effect in man.

Dermatological testing has also been carried out at a Manchester Skin Hospital and the results indicate that the new phosphates are neither primary irritants nor sensitisers.

STLCOPCB4050451

FROM: M. P. Lux (4-8101) - General Offices (F4WA)

DATE: August 3, 1971

SUBJECT: Estimated Costs for Pydraul Recovery

REFERENCE: Memo, Overall to Savage, 6-29-71

cc: N. T. Johnson
R. M. Kountz
W. R. Richard
J. R. Savage
Cost File

TO : Wilson W. Overall

As you requested, cost estimates for rework of Pydraul have been prepared. These estimates exclude cost for containers and freight.

The rework scheme visualized consists of:

1. Settling to remove solids and water.
2. Heat and air blow for further water removal.
3. Filtration using Dicalite filter aid.
4. Treatment with activated earth (e.g., Super Filtrol).
5. Addition of additive package to meet Pydraul specifications (10% dosage of FRA 1129).

Costs estimated are:

	Volume, M Lbs/Yr		
	600	3,000 ①	6,000
Manufacturing Cost, ¢/Lb			
Raw Materials	1.3	1.3	1.3
Direct Conversion	8.9	2.8	1.4
Indirect Conversion	2.1	0.9	0.4
Total Manufacturing Cost	12.3	5.0	3.1
Round Off To	12	5	3
Capital, M$	100	200	200

① For a 6,000M lbs/yr plant operating at 3,000M lbs/yr.

The above costs have a probable accuracy of ±30%, which should suffice for your present feasibility study. Attached are a graph of rework cost versus volume and the production cost estimate sheet.

M. P. Lux

js

Enclosures

DSW 176565

STLCOPCB4050452

CENTRAL ENGINEERING DEPARTMENT

Pydraul Rework

PROJ/DEPT

PLANT DIVISION

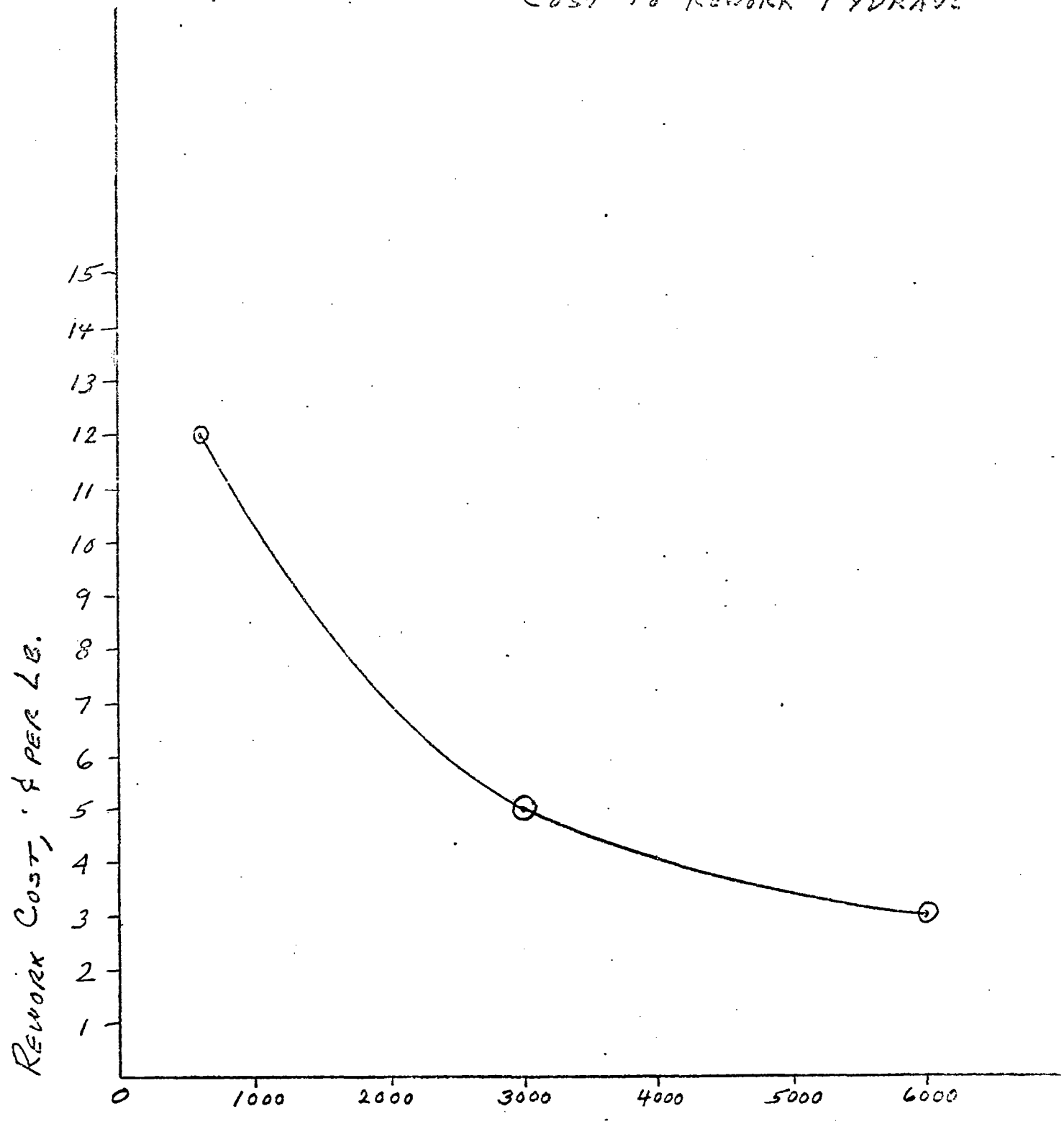
EQUIP. IDENT. NO

CEA NO. AREA NO.

BY J.P. Lux

DATE 5-2-91 SHEET 1 OF 1

Cost To Rework Pydraul



DSW 176566

PREPARED BY	M P Lust	APPROVED BY	APPROVED BY
DATE	8-2-71	DATE	DATE
REVISED			

PREMISES

1. Operation set up for minimum capital & operating costs, not at an optimum location.
2. Capital Estimate:

Volume M lbs/yr	M $
600	100
3000	200
6000	200

CREDITS BASED ON:

RAW MATERIALS

MATERIAL	UNIT	PRICE	FREIGHT	WHSE & HAND.	DEL COST	ANNUAL USE LBS. CAPACITY

SERVICES – ANNUAL QUANTITY USED

PRODUCTION BRACKET	UNIT COST				
STEAM MMBTU					
ELECTRICITY CKWH					
COMP. AIR MCF					
WATER PURCH. M GAL.					
WATER PLANT M GAL.					
FUEL					
LABOR HRS.					
LABORATORY HRS.					

PACKING COST

KIND OF CONTAINER			
PKG. NET WT.			
COST OF CONTAINER			
COST OF LINER			
OTHER COSTS			
COST PER CONTAINER			
ANNUAL NO. CONTAINERS			
ANNUAL CONTAINER COST			
ANNUAL PACKING LABOR			
TOTAL			

DEPRECIATION

CAPITAL $	%/YR.	$/YR.
M & E	10	
BLDG.		

REPAIRS

CAPITAL $	%/YR.	$/YR.
M & E	4	
BLDG.		

AREA REQ'D. SQ. FT.

INVENTORY VALUES

RAW MATERIALS $ IN PROCESS $ FINISHED GOODS $

REMARKS

DSW 176567

Monsanto

CEA NO. 7817

PRODUCTION COST ESTIMATE

ORGANIC CHEMICALS DIVISION
PRODUCT Paraquat A-312 Rework
YIELD ON % THEO.
YIELD ON % THEO.
PLANT LOCATION
PRODUCT CODE
UNIT 100 lbs.

MATERIALS

	QUANTITY PER UNIT	UNIT PRICE	COST PER
Used Paraquat	100	—	—
Diquat	1.0	$0.06	.06
Super Filtrol	1.0	0.06	.06
FRA 1129	10.0	0.12	1.20
GROSS TOTAL MATERIALS			
CREDITS			
TOTAL CREDITS			
NET TOTAL MATERIALS			1.32

ANNUAL PRODUCTION BRACKETS

	6 MM lbs.		600 M lbs.		3 MM lbs.			
	UNIT COST	AMOUNT	UNIT COST	AMOUNT	UNIT COST	AMOUNT	UNIT COST	AMOUNT
MATERIALS	1.32		1.32		1.32			
DIRECT CONVERSION COST: STEAM	.10	6000	.50	3000	.20			
ELECTRICITY	.05	3000	.25	1500	.10			
COMPRESSED AIR	—	—	—	—	—			
WATER PURCHASED	.01	600	.05	300	.02			
WATER PLANT	—	—	—	—	—			
FUEL	.01	600	.05	300	.02			
				—				
LABOR	.40	24000	2.00	12000	.80			
SUPERVISION	.40	24000	4.00	24000	.80			
S.S. TAX, COMP. INSPENS	.17	10000	1.00	6000	.35			
REPAIRS EQUIPMENT	.13	8000	.67	4000	.25			
REPAIRS BUILDING		—		—				
SUPPLIES	.02	1000	.10	600	.04			
LABORATORY	.07	4000	.17	1000	.14			
CLOTHING & LAUNDRY	.02	1000	.10	600	.04			
TECH. SERVICES		—		—				
PLT. PROCESS RES.		—		—				
PACKING LABOR		—		—				
PACKING OVERHEAD		—		—				
TOTAL DIRECT CONV.	1.38		8.99		2.76			
INDIRECT: DEPRECIATION M & E	.33	20000	1.67	10000	.66			
DEPRECIATION BLDG.		—						
FACTORY INDIRECT EXP.	.10	6000	.50	3000	.20			
TOTAL INDIRECT CONV.	.43	26000	2.17		.86			
TOTAL PROD. COST	3.13		12.38		4.94			

G-2055

STLCOPCB4050454

J. R. Savage - B2NA

August 2, 1971

J. K. Sears - Queeny
L. R. Stark - W4A

SAMPLES

Mr. J. L. Corder
Anniston

We need "Researeh" amounts of two lower hydrogenated product candidates:

1) HQ-30

As I mentioned on the phone, we still haven't enough of this to permit full-scale fire testing [illegible] Pydraul component. Please pull a drum of this (55 gal.) from this month's WCM run and send prepaid Attn: L. R. Stark, Researeh T Bldg., General Offices. We recognise that you may not be able to hit 30% very accurately.

2) HB-20

This is a candidate as a blend component in carbonless copy paper applications. It is recognized that another solvent/extender may be needed to avoid crystallization. What is desired is something in the 20-25% range. Pull a 5 gal. sample from an HB-40 (or 30) batch and send prepaid Attn: J. K. Sears, Research, So. 2nd Street.

J. R. Savage

/bt

DSW 176568

STLCOPCB4050455

MONSANTO TC
8550-4 PT.
PAPER PAT D BY N C R CO CONTINUOUS INTERLEAVED® MOORE BUSINESS FORMS INC 27

A/BL611/JL30/0812/0816/1/CH431/QZQ

J R SAVAGE ST LOUIS JULY 30/71 BG

PYDRAUL BLENDING. TRICRESYL PHOSPHATE.
THERE ARE MORE CARDS TO PUT ON THE TABLE THAN I HAD APPRECIATED.
THESE ARE

1. GEIGY ARE PROPOSING TO RAISE THE PRICE OF THE T.C.P. OF QUALITY OF SAMPLE SENT /AIRWAY BILL NO . 026-8217182 T.W. 711 LONDON-ST LOUIS ETA 21.28 2.7.71/
2. THEY ARE OFFERING ANOTHER CHEAPER GRADE T.C.P. /M/ USING A WIDE CUT CRESYLIC ACID INSTEAD OF PURE META CRESOL. SAMPLE OF THIS HAS ALSO BEEN SENT TO L. STARK /NO DETAILS OF DESPATCH/.
3. U.C. B. ARE ALSO OFFERING A CONTINENTAL SUPPLY /HENCE DUTY FREE/ WHICH IS ATTRACTIVE. SAMPLE IS GOING TO ANTWERP FOR CLEARANCE AGAINSTCHEMICAL SPECIFICATION. I ASSUME THIS SHOULD BE CLEARED FOR TOXICITY IN ST.LOUIS BEFORE USE IN PYDRAULS.

WE SHALL NEED SUPPLIES IN NOVEMBER AND ASSUME ORDERS MUST BE PLACED IN OCTOBER . IF TESTING OF SAMPLES IS EXPENSIVE OR TROUBLESOME I SUGGEST WE CONCENTRATE ON U.C.B.

E V WEEKES BRUSSELS

DSW 176569

MONSANTO TC
MONSANTO TC
MONSANTO TC

V. R. Gaertner - T3F

July 27, 1971

MONOEPOXIDE PROCESS

VRG/RMK 6/16/71

D. S. Gilmore - F4WC

J. F. Herber - T3G
R. M. Kountz - F4WA
W. R. Richard - T3A
R. Savage - B2NB

We have continued to investigate this process in the light of your preliminary engineering findings on our procedures of June 16. The accompanying procedures are submitted for your further consideration.

Our recent objectives were determined from the sources of large costs, and these were dictated by the equipment available for the conversion.

1. Reduce the reaction time (31-48 hrs.) in Step 2 (epoxidation).

2. Reduce the amount of unconverted adduct present in the crude epoxide, in order to eliminate the necessity for fractionation and recycle.

3. Reduce the excess of peracetic acid.

Briefly, the first two objectives were accomplished, but at a sacrifice in conversion. Yield is also reduced because increased by-product formation occurs at the elevated temperature necessary to both objectives 1 and 2. Objective 3 was not achieved, although it was possible to hold the excess at 20% at further loss in conversion.

In summary, the three procedures described have the following effects:

Method	Peracid Excess	Buffer-Ratio	Time/Temp.°C.	Conv.	Adduct
C	20	$NaHCO_3$-0.8	7.5/45°	73.2%	4.9%
D	30	$NaHCO_3$-0.8	7.5/45°	78.2	2.9
E	40	$Na_2CO_3 \cdot H_2O$-0.4	21/20-23°	89.1	0.8

In all of these cases, we believe the flash-distilled product would be satisfactory for the stabilizer use. We suggest that the best combination be determined from a cost point of view.

Please call on me if there are questions.

V. R. Gaertner

/is
Attach

DSW 176570

STLCOPCB4050457

PROCEDURES

(Notes on Methods A and B are referred to as 1A, for example)

Method C (20% excess oxidant, 181654A)

Crude adduct, containing 135.1 lbs. of n-butyl 3-cyclohexene-carboxylate, and 60 lbs. of sodium bicarbonate are charged to a stirred, cooled, vented reactor (Note 1A).

"40% Peracetic Acid" (Note 2A, assay 46.5%), 145.6 lbs., is added as rapidly as the initial exotherm can be removed, while allowing the temperature to rise to 30-35°. Carbon dioxide is evolved rapidly, without serious foaming. The early stage of the reaction (up to 2 hrs.) is decreasingly exothermic (Note C1). This temperature is maintained by cooling for one hr., then slow heating is begun to bring the temperature to 45° in another hour. The total reaction time is 7.5 hrs.

The stirred slurry is then diluted rapidly with 150 lbs. of 20-25° tap water, stirred to dissolve salts, layered (15 min.), and separated. The aqueous lower layer is discarded (Note 6A).

The oil layer is washed with sulfite solution, bicarbonate twice, and sulfate twice, then dried, as described in Method A. The crude product weighs 151 lbs. and contains 100 lbs. (73.2% conversion) of the epoxide, 6.1 lbs. of unchanged adduct, 24.0 lbs. of hydroxy acetate, the difference being nonvolatiles. The epoxide and adduct are separated by flash distillation as previously described.

Notes: C1. Laboratory runs required only water bath cooling for good control at 30-35°C., and showed no evidence of a dangerous exotherm. However, this procedure is potentially hazardous and should be closely controlled for the first 2 hrs.

Method D (30% excess, 181654B)

The method is similar but the charge is 124.3 lbs. of adduct, 59.6 lbs. of sodium bicarbonate and 145.2 lbs. of 46.5% peracetic acid. The reaction is conducted similarly, at 30-35° with cooling for 1 hr., 1 hr. to 45°, and total time 7.5 hrs.

The work-up is the same. The crude oil, 140.3 lbs., contains 100 lbs. of epoxide (78.2% conv.), 3.49 lbs. of unchanged adduct, and 22.7 lbs. of hydroxy acetate.

Method E (40% excess, 181657A)

The charge is 103.8 lbs. of adduct, 39.5 lbs. of sodium carbonate monohydrate, and 131.6 lbs. of 46.2% peracid. The reaction is conducted as in Method A, addition being completed below 20° and the mixture being stirred at 20-23° for a total of 21 hrs., then worked up as described. The crude product, 111.4 lbs., contains 100 lbs. (88.2% conversion) of epoxide, 1.61 lbs. of adduct, and 2.82 lbs. of hydroxy acetate.

V. R. Gaertner
7/27/71

DSW 176572

STLCOPCB4050459

L. R. Stark - W4A

June 16, 1971

PYDRAUL AC-A QUALITY

J. H. Davidson - B2SG

C. L. Bradford - B2SG
W. L. Higgins - 1760
N. T. Johnson - B2SG
W. R. Richard - T3A
A. F. Uelner - 1760
R. L. Wagner - 1760
PDF/PFH

Listed below are Pydraul AC-A lots which are potential crystal problems in air compressor lubricators:

Lot	Initial Analysis Date
QM-1	6/11/70
QM-2	7/14/70
QM-3	8/4/70
QM-4	9/29/70
QM-5	10/20/70
QM-6	12/15/70
QM-7, 71	12/17/70
QA-80, 85, 801	1/8/71

I have a high degree of confidence that the following lots will not be a problem:

QA-10, 101	3/31/71
QA-20, 21, 201	4/13/71
QA-335, 340, 341, 350	5/19/71

Aroclor 5442 received in July, 1970, and mid-November, 1970, has a relatively high crystallizing tendency. That received 3/21/71 and 4/7/71 is low. These latter shipments probably represent the remainder in CLHS storage which also checks out as low crystal forming material. This material probably can be made into AC-A with no crystal problem.

A process amendment to use Aroclor 5432 has been written and should issue soon. Although we are still checking this point, all reserve lots of Aroclor 5432 received to date look like they will be low crystal formers. We are checking the worst in finished formulations to confirm this. Raw material specifications will be set up to check this quality.

Relative to actions with customers on problem lots, I don't think we need to be too alarmed about these crystals.

DSW 176573

STLCOPCB4050460

All information to date indicates the deposits were found incidental to some other situation (overhaul, chance observation, etc.) and no lubrication failure has been directly attributed to these deposits. The deposits seem to be agglomerates of extremely fine needle-like crystals. If left undisturbed, these gradually settle to form a soft paste. The main cause for alarm will be customer reaction on finding these deposits, especially in the light of knowing we have recently made a product change.

L. R. Stark

/is

STLCOPCB4050461

Monsanto

FROM (NAME & LOCATION) W. R. Richard - Research Center

DATE June 3, 1971

cc J. F. Herber - JHERB
L. R. Stark - LSTAR

SUBJECT SANTICIZER 140
CDP CHANGES AT KRUMMRICH

REFERENCE

TO : J. R. Savage - JSAVA

J. Quinn called to report Plasticizers has decided to change the charge ratios from 2.0 phenol/cresol to 1.5/1.0 phenol/cresol to decrease the freezing point of the Santicizer 140. This will cost 3/4¢/lb. on raw materials cost. I don't know how much more will be required in manufacturing costs.

I said we probably had no objection to the quality improvement, but we were not happy about the prospects of higher manufacturing costs.

I don't know what it will cost to have two products. The change will cost Plasticizers a reported $30,000/year but they had to make the change or lose customers.

WR

W. R. Richard

/is

DSW 176575

STLCOPCB4050462

Monsanto

OUTGOING MESSAGE BLANK
Tele--Communications System

DATE | TIME | SENDER'S ACCOUNT NO.

INDICATE DESIRED SERVICE CABLE → ☐ FULL RATE ☐ DAY LETTER ☐ NIGHT LETTER

Names of addressee and sender must include initials. Show complete address for telegrams and cables.

E. V. Weekes
Brussels, Belgium
Cable: Monsanturop Brussels
Telex: 22110

Pydraul formulations for AC-A and 625-A using Aroclor 5442 are giving trouble with crystallization in the drums. You should not order any 5442 or plan to make the 5442 versions of these products.

In a few weeks, we will have documentation available on the 5432 versions and will forward

J. R. Savage
St. Louis

DSW 176576

IN-IR REV. 7-64

for **BETTER** *service* – Forward to transmitting operator IMMEDIATELY after preparation.

Xerox for J. Savage ✓ C.L. Bradford & fr lists for your info.

MINUTES OF MEETING HELD ON PYDRAUL BLENDING PROJECT

AT ANTWERP ON JUNE 8, 1971

file

BOTM.

Present :		cc :	
M. Brughmans	Ant.	A.C. Hiron/ C.J. Smith	New.
H. Cools	Ant.	F. Macdonald/A.C. Nethercott	New.
G. Gysemans	Ant.	E.J. Van Gils	Ant.
H. Laes	Ant.	R.E. Dubois	DB 99
L. Plasmans	Ant.	J.N. Haggart	DB 52
C.R. Perry	Bru.	P.J.A. Marsh	DB 52
R.J. Stephenson	Bru.	A.D. Meadowcroft	DB 60
		R.H. Simpson/F.S. Poulos	DB 63
		E.V. Weekes	DB 59

The purpose of the meeting was to review and agree action on the following subjects related to the Pydraul blending project at Antwerp.

1. Project Timing

Startup of the project was scheduled for mid August 1971. Organisation of all matters affecting production must be completed prior to this time.

2. Raw Material Requirements

The completed list of raw material requirements based on the latest sales forecasts was examined and commented upon.

Copies of the revised monthly requirements are detailed on the attached table for end 1971 to early 1972. The source of all materials was agreed as indicated in the table with the exception of Tricresyl Phosphate. Status of Tricresyl Phosphate material was that Geigy or Bayer or MC were potential suppliers. Geigy material had been submitted to MC for approval. Purchasing were requested to clear status of the sample and confirm source of raw material by the 14th June.

In view of the anticipated U.S. Longshoreman's Strike predicted for end September 1971 it was agreed that orders would be placed for six months raw materials supply.

.../...

STLCOPCB4050464

3. Raw Materials Ordering

Initiation of raw materials orders will be from Distribution Department Antwerp. (All orders to be initiated by 19th June).

Action : M. Brughmans.

Orders for all products imported ex MC will be placed via Production Planning Brussels. Orders for MCL material will be placed on Newport via London.

In order to place orders, transfer prices need to be established for all raw materials (manufacturing cost + 10 % has been suggested).

Transfer prices will be established for all Monsanto transferred raw materials by J.N. Haggart.

Deadline for completion of action : June 14.

Details of package, weight and physical form for all MC origin raw materials is needed to assist in final design of plant handling equipment plus specifying quantities which should be ordered.

Action : C.R. Perry complete by June 14.

4. Description of Raw Materials for Duty Purposes

The raw materials in the attached list include 5 Aroclors and 2 Santicizers which are normally handled as finished products for sale or resale in Europe. In the Pydraul blending project these finished products will be used as raw materials. It is essential that their chemical names only should be used so that duty will be based on the C.I.F. prices which are to be established for the raw materials rather than the finished products values.

Chemical names and finished products numbers only have been specified in the attached raw material list. Special instructions should be incorporated in the orders so that there is no reference, on the packages or containers supplied, to the Monsanto trade names.

Action : M. Brughmans/G. Gysemans/R.C. Windey.

5. Finished product cover for Longshoreman's Strike

Up until the time of this meeting all European requirements for the reference Pydrauls have been covered by import ex MC. To cover the possibility of the U.S. Longshoreman's Strike occuring from 30th

DSW 176578

September 1971. Orders have been placed for 5 months supply of all products. This situation is altered from the date of this meeting and orders will be cancelled so that 2 to 3 months cover only is provided.

Action : C.R. Perry/R.C. Windey.

6. Finished Product Containers

The Business Group proposed that reconditioned drums should be used for finished product packaging.

Action on this was delegated to M. Brughmans/E.J. Van Gils who could consult with A.E. Meadowcroft on U.K. experience in this field.

7. Label Requirements

Label requirements for Pydrauls would be specified by A.E. Meadowcroft and ordered by M. Brughmans by end June.

C.R. Perry

C.R. Perry

PYDRAUL BLENDING, ANTWERP

RAW MATERIAL REQUIREMENTS PER MONTH, 71/72

PRODUCT		F-9A	A 200	280	281	TOTAL REQUIREMENTS PER MONTH, KGS	ORIGIN
Sales per Month, Metric Tons		25	70	53	8.5		
RAW MATERIALS							
Trichloro Biphenyl	%		33.3		54.6		MCL
FP 2071333 (liquid)	Kg		23,300		4,650	27,950	
Tetrachloro Biphenyl	%		66.6	61.9			MCL
FP 2071343 (liquid)	Kg		46,600	32,800		79,400	
Hexachloro Biphenyl	%			15.9			MCL
FP 2071363 (liquid)	Kg			8,420		8,420	
Trichloro Terphenyl	%	42.5					MC
FP 1040-460-17-02 (viscous liquid)	Kg	10,600				10,600	
Tetrachloro Terphenyl	%				19.3		MC
FP 1040-470-17-02 (solid)	Kg				1,640	1,640	
Cresyl Diphenyl Phosphate	%	45.5					MC
FP 7680-940-04-02 (liquid)	Kg	11,400				11,400	
Tricresyl Phosphate	%			21.8			Europe
(liquid)	Kg			11,540		11,540	
Triphenyl Phosphate	%				22.8		MC
(solid)	Kg				1,940	1,940	
Mixed Alcohol Phthalate	%	11.3					MC
FP 3960-300-04-02 (liquid)	Kg	2,820				2,820	
Paraplex G 62	%	0.4					MC
(liquid)	Kg	100				100	
Na-Sul BSB	%	0.2					MC
solid)	Kg	50				50	

DSW 176580

STLCOPCB4050467

Tolyltriazole	%	0.1					MC
(solid)	Kg	25				25	
DC-200, 350 CS	%	0.002	0.006	0.002	0.002		M C
(liquid)	Kg	0.5	4.2	1.06	0.17	6.93	
Dupont Oil Blue A	%	0.0015	0.0007	0.0007	0.0007		MC
(solid)	Kg	0.39	0.49	0.37	0.06	1.31	
Lubrizol 1360	%		0.5				MC
(liquid)	Kg		350			350	
Santolube 70A	%		0.5	0.4	0.3		MC
(liquid)	Kg		350	212	25.5	587.5	
Acryloid 732	%				3.0		MC
(viscous liquid)	Kg				255	255	

NOTE : Monsanto Finished Product Trade Names are not to be used to describe Raw Materials. This is in order to benefit from tax concessions on Raw materials which will be forfeit if FP's are described by trade names.

Monsanto

FROM (NAME & LOCATION) L. R. Stark - W4A

DATE June 8, 1971

SUBJECT PYDRAUL AC-A QUALITY PROBLEM

REFERENCE

cc: J. T. Bell - 1060
C. L. Bradford - B2SG
P. F. Heimsch - W4A
W. L. Higgins - 1760
W. R. Richard - T3A
R. Savage - B2NB

TO :

G. L. Arnett - 1060
J. H. Davidson - B2SG
P. D. Fowlkes - W4A
A. F. Uelner - 1760
R. L. Wagner - 1760

This will present the status of a potentially serious product quality situation with Pydraul AC-A and possibly with 625A and AC-A, Winter Grade 28. Over an extended period of time white crystalline material has formed in some air compressor lubricators which are using Pydraul AC-A. Although this has been associated with only a few lots, this same thing might occur with all lots of fluid given the proper conditions.

We do not have all the answers at this time. However, I am recommending several actions to minimize further problems. The addressees will have some part of these actions or in decisions to help resolve this situation. Please involve others as you see fit.

Background

AC-A, 625A, and AC-A Winter Grade 28 were formulated in 1969 using various ratios of Aroclor 5442 and Santicizer 140 (CDP) to get the desired viscosity grades. A 300 SUS variant was tested successfully from October 1969 to March 1970 in a JFQ air compressor. In March 1970 Pydraul AC-A was started in this unit and was continued until May 1971 when a change was made to test the all-phosphate ester lube. No crystalline deposits were observed in the lubricator or lines. Fluid used in this test was from technical lab or pilot plant blends.

In January 1971 Air Products observed white deposits in a compressor lubricator. This was traced to Lot QM-3 which had a control analysis indicating white particles present (spec calls for clear blue liquid). Analysis indicated deposit was a chlorinated terphenyl isomer.

In mid-April 1971 a similar white deposit was found in a lubricator at Electric Energy, Inc. Although drum labels were not clear, this material was associated with Lot QM-1.

Now a third deposit situation has been reported by U. S. Steel, Homestead Works, and this is reported to be Lot QM-2.

STLCOPCB4050469

Probable Cause

Aroclor 5442 is probably in a super-cooled state at room temperature. Blending with CDP lowers viscosity so crystallization can proceed at a greater rate. Presence of many chloroterphenyl isomers as well as CDP slows crystal growth. Lubricators provide gentle agitation, a moderate and cycling temperature gradient, mechanical action and vibration to encourage crystallization. Initial indications are that some lots of 5442 are more prone to crystal formation than others. This combination of circumstances has delayed recognition of this problem. These same things also delay getting a good definitive answer on extent of the problem and assuring a complete solution.

Suggested Actions

Who	What
Res., A Lab	Check reserve samples of AC-A for crystal tendency. Status: See next item; work continuing.
Research	Advise Marketing on Pydraul AC-A lot acceptability. Status: Visual observation using a flashlight indicate the following lots to be potential crystal problems:

Lot	Analysis Date
QM-1	6/11/70
QM-3	8/4/70
QM-4	9/29/70
QM-6	12/15/70
QA-80	1/8/71
QA-85 (95?)	2/3/71
QA-801	3/15/71
QA-20	4/13/71
QA-340	5/20/71

Recomend possible recall of the above lots. Marketing may consider it more expedient in some cases to find if a problem exists and how much material remains before making recall.

Although seeded crystallization studies are still underway, the following lots appear to be free of crystals and there is a chance these will not have to be recalled.

Who	What	
	Lot	Analysis Date
	QM-2	7/14/70
	QM-5	10/20/70
	QM-7	12/17/70
	QA-71	3/30/71
	QA-10	3/31/71
	QA-101	4/15/71
	QA-201*	4/15/71
	QA-21	5/3/71
		5/12/71
	QA-335	5/19/71
	QA-350	5/21/71

*This appeared to be a resample of QA-20 which had indications of crystals; whereas this did not yet.

Mkt., Mfg. — Decide on procedure and extent of fluid recall.

Research — Suggest procedure for compressor lubricator clean-up.

Status: Deposit appears to be agglomerates of very fine needle-like crystals. Trichloroethylene and dichloromethane (methylene chloride) are best solvents to remove these crystals from equipment. Acetone, alcohol, and common petroleum solvents are not suitable.

Res.,Mfg.A-Lab — Check reserve lots of Aroclor 5442 for crystal tendency and attempt correlation with AC-A problem lots.

Status: 5442 lots AM-5, 6 and 7 were shipped to JFQ in tank car GATX 34798. This is believed to be JFQ incoming control analysis lot QM-11639 and is probably the material used to produce AC-A lot QM-3. This 5442 and the lot received 11/19/70 (AM-12847) have a greater tendency to crystallize than lots received 3/21/71 and 4/7/71 (QA-10445 and QA-10533). Analysis of deposits from 5442 by the acetone crystallization procedure are being made to see if these are the same as material separated from AC-A. Similarly, deposits from 5432 are being checked. (See items below on reformulation and 5432 quality control.)

STLCOPCB4050471

Who	What
Res., Mfg.	Suggest procedure for recovery of returned or withheld AC-A. Status: No action. Crystallization studies may suggest way.
Research	Issue process amendment to incorporate Aroclor 5432 in AC-A, 625A and Winter Grade 28 blends. Status: Preliminary blends and fire tests complete. Pump tests and property tests to complete. Will probably initiate amendment before above complete. Note: This change will require some specification property changes and may require some future changes in Air Compressor Selector bulletin. Preliminary crystallization studies on 5432 indicate much less tendency for crystal formation; however, there is a lot-to-lot variation and we don't know what level is acceptable.
Res., Mfg.	Check reserve lots of 5432 for crystallization tendency and recommend specification limits and procedure to check. Status: Acetone solubility test appears to allow differentiation between 5432 (and 5442) lots. Test as normally conducted is run at room temperature. Suggest change to include seeding and cooling to -10 to +10°F. (refrigerator ice compartment or food freezer temperatures). When crystals are at maximum (usually 24 hours) return to room temperature for 8 to 24 hours to observe extent. This procedure needs to be speeded and made more quantitative.
Research	Devise method for assuring that no crystals will form in finished blend. Status: Not much progress. In January, 1971, when problem first came up, lab blends of AC-A were formulated using 5442 QM-5, 6 and 7. These were seeded with crystals from the Air Products complaint. Crystal growth was not observed for 3 months with these samples held at room temperature. We need to find a way to accelerate this growth if it is going to occur.

Who	What
Res., Mkt.	Make similar study of 625A and Winter Grade 28. Process amendment to use 5432 and possible product recall are to be done. Status: Specification analysis of Pydraul 625, QM-2 and QA-40 indicate white particles and white sediment. These should be considered for recall if in air compressor applications. If in hydraulic applications, problems will probably not occur.

L. R. Stark

/is

D. Danna - General Offices

May 17, 1971

W. R. Richard
J. R. Savage
N. T. Johnson

E. V. Weekes
Brussels

Your telex of May 7 to Jim Savage was passed on to me for processing and attached are the Pydraul Blends you asked for. I have been asked to pass on to you that we no longer prepare blend sheets as such, that the attached type format will be used.

Incidentally, it is planned to revise Pydraul 625A to use Aroclor 5432 instead of 5442 and that a rust inhibitor now used may be changed. When the revised blend is issued we will forward it to you.

Please acknowledge receipt.

Regards,

Dominic Danna

sa

Attachments

Pydraul	Tentative Process Report No.	Date
135A	P-1603	2/17/71
150A	P-1609	2/27/71
230A	P-1604	2/17/71
312A	P-1596	12/31/70
540B	P-1605	2/17/71
625A	P-1549	12/80/69
	Amendment A	4/29/70
A-200B	P-1588	11/11/70
F-9A	P-1563	4/27/70
	Amendment A	8/10/70
	Amendment B	3/31/71
281	P-1506	4/15/70

DSW 176587

STLCOPCB4050474

Monsanto

FROM (NAME & LOCATION) D. Danna - General Offices

DATE : April 27, 1971

SUBJECT : PYDRAUL

REFERENCE :

TO : J. J. Jansen
Antwerp

CC: H. S. Bergen
D. B. Hosmer
J. R. Savage
L. Plasmans - Antwerp

On April 8, 1971 Jim Savage, Manufacturing Manager for Specialty Products, received a telex from L. Plasmans - TSD Antwerp, requesting blending instructions and specifications from Pydraul F9 and F9-A, as well as specifications for Triphenyl Phosphate. Since Jim realized that all formal technology must flow from my office, he turned it over to me for processing. Once again, will you please advise those who have a need for confidential technology or know-how documents to direct such requests to me. I prefer to see your name as receiving a copy of the request which would assure me that you approved or concur that the request initiator has a "need to know". As you well know, I always seek approval for release from the Business Group Director before processing these requests and I can assure you of prompt action if this channel of communication is adhered to.

Best regards.

Dominic Danna

sa

Attachments:
1. Tentative Amendment B to the Tentative Process for Pydraul F-9A, dated April 27, 1970.
2. Tentative Amendment A to the Tentative Process for MCS1007 (Pydraul F-9A, dated April 27, 1970.
3. Blend sheet Pydraul F-9, issued Oct. 25, 1968.
4. Blend sheet Triphenyl Phosphate, issued 6/13/68.

file Pydraul

Monsanto

FROM (NAME & LOCATION) P. D. Fowlkes - Research Center

DATE March 23, 1971

SUBJECT DISPOSAL OF SANTICIZER 144 IN PYDRAUL BLENDS

REFERENCE

TO : J. R. Savage - JSAVA

cc: C. L. Bradford - CBRAD
J. H. Davidson - JDAVI
E. M. Potter - EPOTT
W. R. Richard - WRICH
L. R. Stark - LSTAR
R. L. Wagner - JFQ Plt.

It has been suggested to substitute Santicizer 144 for Santicizer 141 in Pydraul 60 and 150 to liquidate our inventory of S-144 which is no longer used in Pydraul 312.

As far as industrial fluids research is concerned, this change is perfectly acceptable. The physical and chemical properties of the two materials are so similar that a 100% substitution may be made. The slightly higher viscosity (1 cs. at 100°F.) of S-144 should cause no problems in Pydraul 150. The extremely narrow viscosity specifications of Pydraul 60 (9.85-10.05 cs.) could be raised 1 cs. if S-144 is used.

P. D. Fowlkes

P. D. Fowlkes

/is

DSW 176589

STLCOPCB4050476

Monsanto

FROM (NAME & LOCATION) L. R. Stark - Research Center

DATE : March 23, 1971

SUBJECT : PHOSPHATE ESTER-OIL BLEND

REFERENCE :

TO : J. F. Herber - JHERB

cc: C. L. Bradford - CBRAD
P. D. Fowlkes - PFOWL
R. E. Hatton - RHATT
P. F. Heimsch - PHEIM
E. D. Malone - JFQ Plt
D. B. Redington - JFQ Plt
W. R. Richard - WRICH
J. R. Savage - JSAVA
J. D. Sullivan - JSULL

John, this will confirm several items we have discussed verbally relative to need for high alkyl NC ester (N_2C phosphate) for an oil-phosphate ester blend. In addition, several situations exist which you should be aware.

First, one of our 1971 objectives was the formulation of an oil-phosphate ester, very low cost FR hydraulic fluid. Competitive pressures from D. A. Stuart and E. F. Houghton have enhanced the need for such a fluid.

Next, Marketing has asked when is the soonest we can have a finished formulation ready. Dwaine Fowlkes' estimate was by September 1, provided we can get raw material ester suitable for this application. On the basis of preliminary lab blends, NC phosphate, per se, was not oil soluble enough to do the job.

As you know, Jim Sullivan has supplied several potential ester candidates in small amounts to be used in such blends. In addition, a larger amount of N_2C ester was prepared for further lab blending (see JDS November monthly summary). Due to priority of getting PCB containing Pydrauls complete by the edicted deadline, no work other than simple oil solubility has been completed on this fluid. This work indicates 40 to 60% of N_2C ester would probably be used in such a blend.

At Jim Savage's last meeting with Manufacturing and by Bill Richard's questions on a memo of 3/10/71 CLBradford to TLGossage, which you have seen, the subjects of process, quantity, and scheduling have been raised. Will you and Jim Sullivan please confirm or answer the following:

a) A tentative process for high alkyl NC phosphate (N_2C phosphate) has not been issued. Jim indicates that sufficient lab work has been done to show that such a process will be identical to the NC process with the exception of varying the ratio of nonyl and cumyl phenols. Can this be done and can we proceed to issue a process?

DSW 176590

IN 10 REV 11 65

b) Indirectly I have heard that a pilot plant run has been scheduled in the near future for NC phosphate. Is it practical to have an additional batch of N_2C phosphate prepared to check the tentative process and supply additional fluid for full scale pump tests?

c) This leads to the May-June plant run on NC phosphate. It may be desirable to schedule enough batches for full scale pump tests and possible field trial. Does the tentative process need to be pilot planted before such a run?

Relative to quantities of N_2C phosphate needed, Larry Bradford was at Jim Savage's meeting and is to answer the question on short and long term quantity needs. This information coupled with our estimate of percentage will be supplied to Jim Savage so that additional quantities of cumyl phenol from Dixie Chem can be obtained.

Other thoughts and items of which you should be aware:

a) General quality of N_2C phosphate for a low cost oil-phosphate blend does not have to be nearly as good as for NC phosphate. Applications for which this fluid is intended are not too demanding on thermal, oxidative, or hydrolytic stability. We need to discuss minimum quality needed. Incidentally, this might be an outlet for off-spec NC phosphate if higher than normal alkyl ester could be produced (N_3 phosphate) for blending as needed to get proper oil solubility.

b) We plan some me-too formulations using FMC ester to confirm FR and physical properties of the competitive oil-phosphate fluids and to learn if there is some unknown which provides better than expected FM spray performance. Their base stocks appear to be an isopropyl phenol phosphate or xylenyl phosphate. We will try to carry such a fluid along as an alternate and should stay in touch with your process studies on these base stocks.

c) Tentative timing from now for our oil-phosphate ester fluid may be as follows:

Preliminary candidate through initial fire tests - 2 weeks to 1 month

Confirming fire tests, formulation alterations and pump screening - 1 month to 2-1/2 months

Full scale pump, FM approval, major property determinations - 2-1/2 to 5 months, which gets us to mid-August

STLCOPCB4050478

We are aware that full scale continuing production of NC or N_2C phosphate will not be possible in EE-Bldg. with Oct.-Nov. due to construction schedule. However, it may be expedient to have our oil-phosphate fluid field tested as soon as possible to meet competition and beat possible EPA regulations on new fluids.

L. R. Stark

/is

General Offices

→ D. B. Hosmer - DHOSM
E. M. Potter - EPOTT

March 11, 1971

Reclamation Program - Pydraul 312

H. N. Howe - HHOWE
W. T. Bryant

We were trying to design a system and make cost analysis for the reclaiming program for Pydraul 312 using Chicago as a collection area.

In a recent meeting with Des, he indicated that this program was not to be continued as a new method of manufacture would be employed.

I now understand that we should reactivate our program. By copy of this memo to Des and Earl, I ask that they confirm that we should again continue the study. We sure don't want to spend time making economic analyses for something we don't need. If either of you will let me know what the status is, we will take it from there.

G. W. Kasten

jb

DSW 176593

STLCOPCB4050480

Monsanto

FROM (NAME & LOCATION) L. F. Smith - Research Center

DATE February 23, 1971

SUBJECT RECOMMENDED REPLACEMENT FOR SANTOLUBE 70A

REFERENCE

TO : J. R. Savage - JSAVA

cc: CLBradford/REH/JHD - CBRAD
P. D. Fowlkes - PFOWL
P. F. Heimsch - PHEIM
N. T. Johnson - NJOHN
R. A. Miller - JFQ Plt.
W. R. Richard - WRICH
L. R. Stark - LSTAR

As you know, it was decided to replace Santolube 70A with a lower cost rust inhibitor. My memo dated 1021/70 advised that several competitive products had been screened by means of the ASTM D-665 Test Method and these preliminary results had produced four potential candidates which were then eligible for further bench and full scale testing to further evaluate their merits before the final selection could be determined.

These results are now complete and the attached table summarizes them. It is recommended that Na-Sul BSB, a product of the R. T. Vanderbilt Co., Inc., should be considered as the replacement for Santolube 70A. In addition to the dollar savings that will be realized (0.30¢/lb. vs. $1.30/lb.), this product also offers improved rust protection at lower concentrations, lower acidity with improved pH values and less tendency to foam.

Leonard F. Smith

/is
Attach.

DSW 176594

STLCOPCB4050481

Product % Concentration	Fluid	D-665		O&C	Foaming Tendency	V-105E Pump Test	Neut. Number (Mg KOH/gm)		Cost per lb.
		.10%	.20%	.20%	.20%	.20%	pH	TAN	
Na-Sul BSB (Ba.Sulf. Basic Salt)	Pyd.312A	Pass	Pass	Pass	360 ml W/O DCF	Pass	7.8	.02	$0.30
	Pyd.F-9A	Pass	Pass	Pass	300 ml W/O DCF	Pass	7.7	.04	
	Pyd.AC-A	Fail	Pass	Pass	---	--	-	-	
Santolube 70A	Pyd.312A	Fail	Fail	Pass	750 ml W/O DCF	--	6.7	.30	$1.30
	Pyd.F-9A	Fail	Fail	Pass	770 ml W/O DCF	--	6.7	.28	
	Pyd.AC-A	Fail	Fail	Pass	---	--	-	-	
Na-Sul BSN	Pyd.312A	--	Pass	Pass	500 ml W/O DCF	--	4.0	.05	$0.30
	Pyd.F-9A	--	Pass	Pass	500 ml W/O DCF	--	4.2	.07	
	Pyd.AC-A	--	--	--	---	--	-	-	
Na-Sul LP	Pyd.312A	--	Pass	Pass	400 ml W/O DCF	--	5.5	.10	$0.25
	Pyd.F-9A	--	Pass	Pass	450 ml W/O DCF	--	5.6	.13	
	Pyd.AC-A	--	--	--	---	--	-	-	
Tolad MFA-2	Pyd.312A	--	Pass	Pass	500 ml W/O DCF	--	7.0	.04	$0.40
	Pyd.F-9A	--	Pass	Pass	550 ml W/O DCF	--	7.1	.05	
	Pyd.AC-A	--	--	--	---	--	-	-	

DSW 176595

STLCOPCB4050482

CONFIDENTIAL

P. D. Fowlkes - Research Center

February 4, 1971

LOW-COST PYDRAUL
REFORMULATIONS

R. A. Dykstra - JFQ Plt
N. T. Johnson - NJOHN
W. R. Richard - WRICH
J. R. Savage - JSAVA
L. R. Stark - LSTAR

E. M. Potter - EPOTT

Enclosed are the recipes for Pydraul 135A, 230A, 312A, 540B, and 150A. The tentative process for 312A has been issued and the others will be issued later this month.

Pydraul 135A

45051	Mobil 750 Stock	17.5%
86840	Santicizer 711	7.0
80151	Santicizer 140	28.5
82621	Aroclor 5432	27.6
60200	Trichlorobenzene	16.0
48073	Jeffox OL-2700	2.5
46310	Paraplex G-62 or	0.5
10575	Admex 710	
51351	Santolube 70A	0.3
60015	Tolyltriazole	0.1
20640	DuPont Oil Blue A	0.003
31100	DC 200 Fluid 350 cs.	0.003

Pydraul 230A

45051	Mobil 750 Stock	13.5%
86840	Santicizer 711	18.0
80151	Santicizer 140	37.0
82621	Aroclor 5432	29.1
48073	Jeffox OL-2700	1.5
46310	Paraplex G-62 or	0.5
10575	Admex 710	
51351	Santolube 70A	0.3
60015	Tolyltriazole	0.1
20640	DuPont Oil Blue A	0.003
31100	DC 200 Fluid 350 cs.	0.003

DSW 176596

STLCOPCB4050483

Pydraul 312A

45051	Mobil 750 Stock	20.5%
86840	Santicizer 711	16.0
80151	Santicizer 140	28.5
82621	Aroclor 5432	31.1
48073	Jeffox OL-2700	3.0
46310	Paraplex G-62 or	0.5
10575	Admex 710	
51351	Santolube 70A	0.3
60015	Tolyltriazole	0.1
20640	DuPont Oil Blue A	0.003
31100	DC 200 Fluid 350 cs.	0.003

Pydraul 540B

45051	Mobil 750 Stock	27.0%
86840	Santicizer 711	7.0
80151	Santicizer 140	19.0
82621	Aroclor 5432	41.5
80781	Tributyl Phosphate	1.6
48073	Jeffox OL-2700	3.0
46310	Paraplex G-62 or	0.5
10575	Admex 710	
51351	Santolube 70A	0.3
60015	Tolyltriazole	0.1
20640	DuPont Oil Blue A	0.003
31100	DC 200 Fluid 350 cs.	0.003

Pydraul 150A

80150	Santicizer 141	68.7%
50031	Acryloid 732	8.0
60200	Trichlorobenzene	8.2
82621	Aroclor 5432	14.8
51351	Santolube 70A	0.3
20640	DuPont Oil Blue A	0.0007
31100	DC 200 Fluid 350 cs.	0.005

P. D. Fowlkes

/ls

STLCOPCB4050484

Date: January 6, 1971

cc: J.R. Savage
E.D. Malone
J. Herber
C. Bradford
J. Davidson
D. Sutter / J. Gillies
D. Bolliger
L. Stark
R. Wagner.

Subject: Raw Material Requirements - Pydraul Reformulation Program.

To: R.A. Dykstra - JFQ
W.C. Brandenburg - G.O.
D. Dealy - Wok.

Based on the January 4, 1972 meeting of the Pydraul Reformulation Teams, I have upgraded the month-by-month estimates for material requirements. (See attachment)

Significant changes include:

1) An additional 670,000 pounds of para cumyl phenol from Dixie.
2) Increased nonyl phenol requirements in June 1972.

If there are any questions or comments, please call

Jim Solari
J.F.Q - 3520

Nonyl Phenol Req. attached.

DSW 176598

STLCOPCB4050485

	C.B	FF BLDG		DIXEY	KEARNY	EE BLDG			PYDRAUL. RAW MAT'L.					SELECTOR I							SELECTOR II			
	d-NS	Phenol	PCP	PCP	NP	DBPP	N-CP	NCP	TPP WGK	H 230 CH	POLY.	EP. Conc.		10E	29ELT	30E	50E	65E	90E	115E	135C	230C	312C	540C
Inv. 1-1-72					100	400	200	70																
Jan (Prod)						710			Prod Run								50	50						
(Req)						-	30		10								20	20						
Inv 2-1-72					100	1110	170	70	200								30	30						
Feb (Prod)				200	110		275		-	247														
(Req)				55	110		405		108	147	1.3	13.6					243	145					272	
Inv 3-1-72				145	100		40	70	92	100														
Mar (Prod)				-	220		550		-	116														
(Req)				110	220		197	18	57	116	.5	5.0		1	15	10	95	45	14	5	26	7	167	3
Inv 4-1-72				35	100		393	52	35	100														
Apr (Prod)	248	200	0	220	180		400	124	259	198														
(Req)				130	180		288	35	94	198	1.7	17.0		2	40	16	141	40	26	12	60	11	262	5
Inv 5-1-72				125	100		505	141	200	100														
May (Prod)				-	220		550	-	-	221														
(Req)				110	220		360	45	123	221	1.9	19.0		2	52	20	180	76	32	16	77	14	274	6
Inv 6-1-72				0	100		695	96	77	100														
June (Prod)	531	427	0	450	670	June/July	0	-	249	224														
(Req)							366	46	126	224	1.9	19.0		2	54	20	180	78	34	16	78	14	279	7
Inv. 7-1-72				450	770		339	50	200	100														
July (Prod)					100		1850	150	219	332														
(Req)				450	770		366 / 190	50	126 / 93	224 / 108	1.9 / 1.0	1.9 / 1.0		2	54	20	180	78	34	16	78	14	279	7
Inv 8-1-72				0	100	200	1304	150	200	100				-	30	10	90	40	20	10	40	10	140	-
Aug (Prod)					100	710		-	-	224														
(Req)							366	50	126	224	1.9	19.0		2	54	20	180	78	34	16	78	14	279	7
Inv 9-1-72					200	910	938	100	74	100					30	10	90	40	20	10	40	10	140	
Sept (Prod)	432					Open	Open	Open	252	224														
(Req)							366	50	126	224	1.9	19.0		2	54	20	180	78	34	16	78	14	279	7
Inv 10-1-72	432				200		572	50	200	100					30	10	90	40	20	10	40	10	140	-
Oct (Prod)	100		400		200		200	200	-	224														
(Req)	432	380	240	xxx	400		366	50	126	224	1.9	19.0		2	54	20	180	78	34	16	78	14	279	7
Inv 11-1-72	100		160		100		1006	250	74	100					30	10	90	40	20	10	40	10	140	

BF_3 (also)

(Pyridine) also

① All numbers are in 1000 pounds.
② Inventory build up of Pydraul's in July.
③ Inventory on TPP is WGK Methanol Sig.
④ Circled Numbers represent monthly production requirements from various locations.

DSW 176599

STLCOPCB4050486

J. R. Savage - General Office

December 16, 1970

Messrs.
R. O. Taylor JFQ
M. J. Smid JFQ
R. L. Rettke JFQ

PYDRAULS - CONSOLIDATED COST REPORT

Mr. R. L. Wagner
J. F. Queeny Plant

It may indeed be too late to modify methods of allocating CD costs in 1971 because of the numerous variances that would result (granted, they would cancel each other out). Personal experience says that if you want to change the '72 practice, you'll have to begin to seek agreement in April or May of '71. The number of us bureaucrats who will be involved is truly astounding.

However, my interest in a consolidated cost report for Pydrauls is not related to the way costs flow, or to what paperwork the accountants need for financial reporting. I simply feel that you and I need a consolidated report of actual Pydraul costs vs a consolidated scheduled cost for all the blend components. As things now stand, we could spill $10,000 worth of say, Santolube 70-A, and never notice it, because the loss could be spread among 14 products. This report can be put on the standard Cost Report form with very little programming. It could be done by hand in less than a man-hour/month.

J. R. Savage

md

DSW 176600

STLCOPCB4050487

Monsanto

FROM (NAME & LOCATION) W. R. Richard - T3A

DATE September 20, 1971

SUBJECT PYDRAUL REFORMULATIONS

REFERENCE

TO : C. W. Roos - 1760

cc
H. S. Bergen - B2SA
O. DeGarmo - 1760
T. L. Gossage - B2SL
F. J. Holzapfel - B2NB
R. M. Kountz - F4WA
J. Mason - B2SA
J. R. Savage - B2NB

To keep the record straight on chlorinated products in Pydraul products, Specialty Products first removed Aroclor 1248, 1254 and 1260 as agreed with management in 1970. We believed these were the non-degrading products being found in the environment. Research next developed formulations to remove all chlorinated biphenyls from Pydrauls, feeling this would be a desirable step. (Exceptions were Turbinol 153 and Pydraul being sold in Germany where we could not pass the fire tests.)

Management agreed to remove chlorinated biphenyls from Pydraul in 1971. The list of present Pydraul products is given on page 2 and 3 of the attached. The "book" assembled by O. DeGarmo omitted several reformulations, Pydraul A-200B, Pydraul 540B, which eliminated the use of Aroclor 1242.

Research and Marketing are now trying to prepare for the replacement of PCT, should this become desirable. Key products are NCP and N_2CP plus certain VI improvers which are required. We need project approvals for changes in EE-Bldg. plus successful trial production this month on NCP.

I hope you approve of the efforts we have made and are making to control chlorinated components, phosphate ester toxicity, fire resistance and to maintain continued customer service for Pydraul fluids.

WR.

W. R. Richard

/is
Attach.

DSW 176601

STLCOPCB4050488

Monsanto

FROM (NAME & LOCATION) J. H. Davidson - St. Louis B2S J

DATE: September 10, 1971

SUBJECT: RESEARCH/MARKETING MEETING
INDUSTRIAL FLUIDS

REFERENCE:

CC: T. L. Gossage - B2S L
R. E. Hatton - B2S G
N. T. Johnson - B2S J
W. R. Richard - T3A



TO :

C. L. BRADFORD - B2S G
P. D. FOWLKES - W4A
L. R. STARK - W4A

The following will summarize the meeting held on 9/7/71 to determine:

I. The strategy and timing on a low cost N_2C ester-oil fluid to be sold at Vital 29 prices.

II. The formulation plans and timing for development of chlorine free Pydrauls as back-up for the existing products.

P. D. Fowlkes reported formulations for three different candidate fluids to compete with Vital 29 had been developed as follows:

I. N_2C ester-oil fluid
II. PCT-oil fluid (lowest cost)
III. MCS 1167 (lower cost version of Pydraul 312-A)

I. It was agreed that we would concentrate research and marketing effort on only one of these fluids due to the time necessary for acceptance of a fluid by customers and to minimize confusion and pricing problems in the marketplace. Due to the threat to PCT's (regardless of whether it is a short or long term threat), the N_2C ester-oil fluid was chosen. This fluid will be offered only where a customer is using a competitive low cost fluid (Vital 29, Dasco 300, Citgo FR 300) or as a last resort to save a Pydraul 312-A customer about to convert to a competitive low cost fluid. The phosphate ester-oil fluid will not be considered as part of the regular Pydraul line and will require product group approval before presentation to a customer. Timing on further work before marketing of the phosphate ester-oil fluid will be as follows:

DSW 176602

Gain FM approval for PE-oil fluid	11/1/71
Prepare (low profile)literature for PE-oil fluid	11/1/71
Present PE-oil fluid to appropriate customers (Florida Steel, Pollack Steel, Ford, etc.)	2/1/72

II. If chlorinated terphenyls are banned, we must be ready with back up fluids. The following shows the existing Pydraul lines (Selector 1 and Selector 2) and the proposed replacement products:

Selector 1

Existing Product	Replacement Product
Pydraul 60 (no PCT's)	Pydraul 60
Pydraul 150-A	Pydraul 150-B (N_2C + S 141)
Pydraul A-200-B	Pydraul 50 E (NC ester)
Pydraul F-9-A	Pydraul 50 E (NC ester)
Pydraul 625-A	Pydraul 115 E (NC ester)
Pydraul AC-A	Pydraul 65 E (NC ester)
Pydraul AC A Winter Grade	Pydraul 30 E (NC ester)

Formulation work is essentially complete on these products but considerable physical and functional property data must be completed. We have a high degree of confidence in these products and our ability to change our customers to the replacement products with no major loss of business. The only major question mark is on Pydraul 115 E where we need to run pressure AIT to insure satisfactory performance for air compressors. L.R. Stark is negotiating with ME to obtain BAM apparatus from Germany.

Selector 2

Existing Product	Replacement Product
Pydraul 135-A	Pydraul 135-B (N_2C, S-141, light oil)
Pydraul 230-A	Pydraul 230-B (N_2C, S-140, oil)
Pydraul 312-A	Pydraul 312-B (N_2C, oil)
(Low cost N_2C-oil blend - 300 SSU)	Low cost N_2C oil blend
Pydraul 540-B	Pydraul 540-C (N_2C, heavy oil)

Formulation work is essentially complete on the low cost N_2C - oil product. However, formulation work on replacement products for the existing (higher quality) Selector 2 products is just beginning. Our goal will be to make the Selector 2 replacement products higher in FR and stability than the low cost oil-PE fluid so that these products can command a premium price compared to our low cost oil-PE and competitive oil-PE fluids. This will be a difficult job since small increases in PE content (to increase FR) dramatically affect costs and gross profit. It may be necessary to raise the price of the replacement products for the Selector 2 fluids above present levels in order to achieve adequate gross profit. This price increase assumes a demonstrable FR and stability advantage over oil-PE fluids.

Our goal is to gain FM approval for all candidate replacement products for the existing Pydraul line by 4/1/72.

Research priorities on formulation and testing of PCT-free fluids will be as follows:

1. Low cost N_2C - oil fluid (testing, FM approval)
2. Pydraul 312-B (final formulation work, testing)
3. Pydraul 150-B (final formulation work, testing)
4. Pydraul 135-B, 230-B, 540-C (formulation work, testing)

Formulation and testing work on the NC ester products (to replace Selector 1 fluids) is essentially complete compared to above fluids.

If any priorities should be changed, suggestions and discussion are welcome.

J. H. Davidson

1b

STLCOPCB4050491

Monsanto

FROM (NAME & LOCATION) M. J. Smid - J. F. Queeny Plant

Xerox CC: H S Bergen, CL Bradford, TL Gaetano, WR Richard
9/16/71 mrb

DATE September 14, 1971

cc P. F. Gatens
D. E. Munie

SUBJECT Eastern Airlines
Pydraul 312-A Incident

REFERENCE C. L. Bradford's Memo 9/9/71

TO : J. R. Savage - JSAVA
GENERAL OFFICE

As mentioned in Larry Bradford's memo, we are taking several steps to make certain this incident does not happen again.

1. We are now marking the top head of each drum with the product name and lot number.

2. We have changed drum painting and markings so that the Skydrol drum can easily be distinguished from a distance. The Skydrol 500-B, C and LD will be purple and white. Skydrol 7000 will be green and white.

3. All labels will be marked with the lot number, packer's initials and sequential drum number. Any break in the drumming run will require a new lot number and a new set of labels. Therefore, when the sample is taken from the 1st drum, as our procedure prescribes, we can identify a problem before it develops.

4. The operator will be allowed to label only two drums ahead of the loading lance.

All of these changes are designed to draw more attention to routine type work. We feel the man will check himself if he is required to think and we will have the tools to identify a problem more specifically if the need arises.

M. J. Smid

/jw

Enclosure

DSW 176605

STLCOPCB4050492

Monsanto

FROM (NAME & LOCATION) C. L. Bradford - G. O.

DATE : September 9, 1971

SUBJECT : EASTERN AIRLINES/
PYDRAUL 312A INCIDENT

REFERENCE :

TO : FILE

cc: F. H. Langenfeld
J. F. Herber
M. Smid/D. Wagner
H. R. Ford
A. B. Capps, III
T. L. Gossage
N. T. Johnson

On Friday, August 27, Eastern Airlines notified us that they had at their Boston station a drum of fluid that was labeled Skydrol LD but which was "green". Our first suspicion was that the fluid was Skydrol 7000, but the maintenance man in Boston knew that fluid and assured us it was not. We asked for a sample which was put on the next flight to St. Louis and picked up at the airport. Analysis that night proved it to be Pydraul 312A.

Though it appeared that anywhere from 10-20 gallons of Pydraul 312A had been put into various Eastern aircraft, they were certain of only one aircraft that they knew had the fluid in it - aircraft 125. That aircraft was scheduled through St. Louis Friday night and a sample was taken. We picked that sample up Saturday morning and analyzed it with particular concern for low temperature viscosity since, except for that property, Pydraul 312A was compatible in their systems. Analysis proved that the low temperature viscosity was slightly higher than new Skydrol LD but nothing to be concerned about. At operating temperatures the viscosity of the sample was lower than new Skydrol LD. We estimated that they had perhaps 5% Pydraul 312A in their system.

Numerous telephone calls and a telegram to Eastern Airlines pointed out to them that we did not feel there should be any great concern over the airworthiness of their aircraft. They agreed with that position and, after replacing the drum of 312A with a drum of Skydrol LD, the incident appears to be closed.

Another concern was that two drums of 312A got out, but we have not been able to verify that. Most of the lot in question, QA-40, was repacked in 5 gallons and quarts and therefore reanalyzed. Of the remaining drums all except one went to Eastern Airlines, and Eastern Airlines

DSW 176606

STLCOPCB4050493

personally inspected every drum of fluid they had, including lots other than QA-40. A single drum went to Wright-Patterson Air Force Base, but we telephoned them and ascertained that they did not have Pydraul 312A.

We are taking several steps to make certain this type incident does not happen again.

C. L. Bradford

C. L. Bradford

/pep

file Pydraul Blending - Antwerp

Monsanto

FROM (NAME & LOCATION) L. R. Stark

cc: J. Savage B2NB
W. R. Richard
J. F. Herber T3G
C. L. Bradford B2SG
JHD/REH
PFHeimsch/PDFowlkes

DATE August 26, 1971

SUBJECT Phosphate Esters
Europe Blending

REFERENCE

TO :

W. H. Hunt

A2SA

You recently reported results of Acute Toxicity Screen on a Ciba-Geigy cresyl diphenyl phosphate which is being considered for European blending of Pydraul fluids. Two lots of tricresyl phosphate have been submitted and are now being evaluated.

In addition to the toxicity screen it was desired to know o-cresyl and o-ethyl phenyl contents of these esters before complete approval was given for their use. Please refer to the attached Table which lists the composition of these esters as determined by JFQ A-Lab. Also attached are copies of correspondence from Ciba-Geigy relative to ortho contents of their esters.

The cresyl diphenyl phosphate and TCP designated Ciba-Geigy Batch M (our OR-147468-B) are the prime candidates for purchase. Please let us know if further information is needed to pass judgment on these materials.

L. R. Stark

cp
att.

DSW 176608

STLCOPCB4050495

Org. N. B. No.	OR-177067	OR-147468-B	OR-147468-A
Geigy Ident.	CDP Ba. 17-18	TCP Ba M	TCP Ba 11
Low Boilers	0.1%	0.2%	none reported
Phenol	62.5	32.0	5.7%
o-Cresol	none reported	0.6	1.6
m and p-Cresol	"	3.8	48.8
2,6 Xylanol	"	none reported	0.4
o-Ethyl phenol	"	0.2	2.1
2,4 and 2,5 Xylanol	7.3	15.1	13.8
m and p Ethyl phenol	16.2	28.4	13.2
2,3 Xylanol	2.4	4.2	7.3
3,4 Xylanol	4.2	5.9	1.8
High Boiler	2.9	4.1	4.3
High Boiler	4.4	5.6	1.1

DSW 176609

STLCOPCB4050496

Industrial Chem ls Division
CIBA-GEIGY (UK) Limited
Simonsway
Manchester M22 5LB

A member of the U.K. Plastics and Additives Group

Telephone: 061-437 5252
Telex: 667336
Telegrams: Geigy Manchester

CIBA-GEIGY

Our ref KK/mmb
Your ref

Monsanto Europe S.A.,
Place Madou 1,
B - 1030 Brussels,
BELGIUM

11th August, 1971

Attention Dr. R. Stephenson

Dear Sirs,

Following the writer's recent visit to your offices, we have pleasure in enclosing as requested some data on the toxicity of Tri-aryl Phosphates. We have included a statement from the Technica Press on the nature of the toxicity occuning with normal Tri-cresyl Phosphate together with a statement on the relative toxicity of our Reofos Tri-aryl Phosphates. You will notice that Tri-cresyl Phosphate with as little as 0.7% of ortho cresol isomer gives rise to clinical damage at low treatment levels. Our Tri-cresyl Phosphate made from commercial meta cresol would contain a maximum of 3% ortho cresol. Tri-cresyl Phosphate made from a mixed tar acid feedstock would contain a mximum of 1% ortho cresol. Therefore, we regard any phosphate based on the natural tar acids commercially available today as being relatively toxic when compared to the Reofos esters.

Should you require any further information, please let us know. The work was carried out in our own Biological Testing Laboratory approved by the Ministry of Technology as a test house.

Yours faithfully,
CIBA-GEIGY (UK) Limited

K. Knowlton
Export Marketing Manager

DSW 176610

STLCOPCB4050497

815 ( ) SURO, C. Circa il nesso causale diretto tra polineuriti tossiche e ortotricresilfosfato (T.O.C.P.). [Direct causal connexion between toxic polyneuritis and triorthocresylphosphate (TOCP)] *Securitas*, 1967, v. 52, No. 4, 55–72. English summary (6 lines).

An article from the medical inspectorate of labour covers problems associated with episodes of polyneuritis occurring among workers in manufacturing industries in north Italy, and certain conclusions are offered. Preventive measures are surveyed in detail.

Severely affected workers had been investigated in university clinics in 1956; the illness is described. From 1962 to 1966 there were 72 notifications of similar illness in groups of workers, mostly young women. After prodromal gastrointestinal symptoms the lower limbs were weakened or paralysed, and occasionally arm and trunk muscles also. Recovery was complete but slow. There were no blood dyscrasias or epidemic features.

Most of the 72 patients worked in the shoe industry. Others made dolls, treated textiles for waterproofing, covered cases with vinyl products or prepared car-upholstery. The common factor was the use of varnishes, adhesives, natural hides, synthetic skins or cloth treated with gum.

In all probability the cause was work with materials which contained an organic phosphorus compound, more specifically triorthocresylphosphate (TOCP) in the commercial mixture, tricresylphosphate (TCP).

The description of TCP and its many uses, *e.g.* for plasticizing purposes, includes an account of conditions under which constituents may be freed from materials containing them. Properties and toxicity data of TOCP are fully dealt with, absorption taking place mainly by the digestive tract and skin and only doubtfully by the respiratory tract. Materials used at work by the patients were tested by chemical and chromatography methods which are described.

The clinical picture was similar to that reported from ingestion of food or substances containing TOCP. The sudden episodes at long intervals suggested that the cause—the nature of the materials used being considered—could be related to constituents presenting only accidentally in those materials. Only minimal amounts of the phosphorus compound were found, hardly enough to induce the illness. Although many convincing factors testified to poisoning of occupational origin it was not absolutely possible to exclude the remote possibility of food contamination—*e.g.* from contact with plastic containers or wrappings.

The toxic action may have been increased by solvents used at work. No specific toxic effects attributable to them were found, but by de-fatting the skin, solvents could facilitate penetration of the poison, or possibly they could extract it from certain materials handled. *M. Patricia Fitzsimons*

DSW 176611

STLCOPCB4050498

We would like to set out the position with regard to the toxicity of our new Reofos range of Tri-aryl phosphate plasticisers.

We have developed a testing scheme and have concentrated on feeding trials with hens since we have been concerned primarily with producing low neural toxicity (the most recognised hazard with conventional phosphate esters) in the new Reofos products. After dosing and observation for clinical effects, the hens are sacrificed at varying intervals, and examined histologically in our Pharmaceutical Testing Laboratories. This histological examination has predominantly been concerned with the detection of damage in the spinal cord typical bilaterally symmetrical lesions (axon damage and demyelination).

The test procedure we have used is described in the report - "Working Document No. 2 - Tests for neurotoxicity of organo phosphorus compounds." It was developed in this country by the Medical Research Council and is published in a booklet entitled "Pesticides Safety Departments Scheme agreed between Government Departments and Industry" by the Pesticides Branch of the Ministry of Agriculture, Fisheries, and Food, Great Westminster House, Horseferry Road, London S.W.1. The tests we ourselves have carried out conform to an, as yet unpublished, slightly revised procedure for compounds where difficulty is experienced in obtaining a true LD50 dose level, i.e. compounds with low acute toxicity - in such cases the hens are required to be fed 2 g. per kilogram bodyweight on day 1 and day 21. This procedure has been followed in our own work.

When applied to tri tolyl (cresyl) phosphate containing 0.7% by wt. o-cresol, both clinical effects and neurohistopathological damage were detected after one single dose of 2 g/kilogram. With tri xylyl phosphate containing 0.5% by wt. of o-cresol (plus small amounts of other recognisable toxic isomers), histology revealed damage at 3 x 2 g/kilogram bodyweight. You will realise that both these products have very low toxic isomer contents and are not representative of general commercial production.

The new phosphate esters all satisfy the requirement of "Working Document No. 2" in that no detectable clinical or histological effects are demonstratable at the 2 x 2 g/kilogram level and indeed the dosage has been continued to the 3 x 2 g/kilogram level with no neurological damage. The latest results we have obtained appear to indicate that the threshold level at which histological damage occurs is around the 5 x 2 g/kilogram bodyweight although at this level no clinical effects can be detected. These, as you will realise, are extremely high dosage rates when compared, say, with general LD50 testing.

We, therefore, believe that the new phosphates constitute less of an industrial hazard than conventional phosphates and since they satisfy the requirement of "Working Document No. 2", this is good evidence that the compounds will not produce a delayed neurotoxic effect in man.

Dermatological testing has also been carried out at a Manchester Skin Hospital and the results indicate that the new phosphates are neither primary irritants nor sensitisers.

DSW 176612

STLCOPCB4050499

CENTRAL RESEARCH DEPARTMENT

APPLICATION OF MONSANTO POLYMERS IN WATER AND WASTEWATER TREATMENT

CRD-71 Final Report No. 1971 June 1971

Authors: Bruce W. Eley and
Richard A. Kimerle

Job No. 3405

DISTRIBUTION:

	Copy No.
Technical Reports Library (permanent copy)	1
Technical Reports Library (loan copies)	2-8
B. L. Williams/R. Buchdahl/H. W. Mohrman	9
B. W. Eley/R. A. Kimerle	10
J. D. Upham, Patent Department	11
E. P. Benzing	12
J. T. Garrett	13
R. T. Haynes	14
A. J. Lauck	15
J. W. Lyons	16
R. D. McDaniel	17
~~J. A. Mullendore~~	18
J. P. Petrovich	19
W. R. Richard	20
D. H. Swan	21
D. L. Taylor	22
G. V. O'Connor, Biodize, Great Neck, N.Y.	23
P. Hayden, Enviro-Chem, Dayton, Ohio	24
H. Azad/W. H. Hedley, Enviro-Chem, Dayton, Ohio	25

This report and the information contained therein is the property of Monsanto Company. It should not be sent outside the company without proper approval and should be returned to the Central Reports Library, St. Louis, for proper disposal.

DSW 176613

STLCOPCB4050500

APPLICATION OF MONSANTO POLYMERS IN WATER AND WASTEWATER TREATMENT

Bruce W. Eley
Richard A. Kimerle

ABSTRACT

Various cationic and anionic polymers manufactured by Monsanto Company were evaluated under laboratory conditions for applications in wastewater sludge conditioning prior to dewatering and raw water flocculation of suspended solids and color colloidal material. After the dewatering capabilities proved competitive with that of several commercially available materials, the cationic polymer, Monsanto RPC-926, underwent further laboratory study and was eventually used as a chemical sludge conditioner at four wastewater treatment facilities practicing vacuum filtration in their final dewatering stage. A survey of some 44 domestic waste treatment plants was conducted to provide insight into the general polymer market, present and future, and to determine the characteristics of sludge being treated and the methods used. Following this general appraisal, plant visits were scheduled at nine of the larger municipal facilities for purposes of laboratory testing and personal contacts. Recommendations concerning the possible entrance of Monsanto polymers into the waste treatment field are given.

DSW 176614

STLCOPCB4050501

TABLE OF CONTENTS

	Page
INTRODUCTION	1
SUMMARY	5
CONCLUSIONS & RECOMMENDATIONS	8
LABORATORY POLYMER EVALUATIONS	11
Sludge Dewatering	11
Raw Water Clarification	15
INITIAL TREATMENT PLANT TESTING	18
Kansas City, Mo.	18
St. Louis, Mo.	19
DOMESTIC POLYMER USAGE SURVEY	22
FIELD TRIP SURVEY	30
FINAL TREATMENT PLANT TESTING	40
Cincinnati, Ohio	40
Detroit, Michigan	41
ESTIMATED POLYMER MARKET	43
PATENT STATUS	45
REFERENCES	48
ACKNOWLEDGMENTS	49
APPENDIX	50
FIGURES	83

DSW 176615

STLCOPCB4050502

LIST OF TABLES

No.		Page
1	Common Sludge Treatment Processes and Methods of Final Disposal	2
2	List of Polymers Used in Laboratory Evaluations	13
3	Water Clarification Using Polymer Treatment	17
4	Kansas City Polymer Trial Summary	20
5	St. Louis Polymer Testing: Treatment Cost Summary	21
6	Summary of Polymer Usage Survey	23-26
7	Sludge Handling Practices of Treatment Plants Surveyed	27
8	Estimated Trends in Sludge Handling Practices - 1980	27
9	Present and Future Sludge Dewatering Polymer Market in Cities of Greater Than 200,000 Population	29
10	Summary of Field Survey	32-33
11	Commercial Polymers Used at Field Locations	37
12	Summary Sheet: Polymer Trial at Cincinnati, Ohio	42
13	Distribution of Primary and Secondary Treatment in United States	44
14	Polymer Applications in Water and Wastewater Treatment	46
15	Estimated Polymer Market: 1970 vs. 1976	47

DSW 176616

STLCOPCB4050503

LIST OF FIGURES

No.		Page
I	Belt-type Continuous Drum Vacuum Filter	84
II	Typical Dual-Polymer Feeding System	84
III	Laboratory Phipps & Bird Flocculation Unit	85
IV	Buchner Funnel Apparatus	86
V	Filter Leaf Apparatus	86
VI	Cationic Polymer Evaluations	87
VII	Anionic Polymer Evaluations	90
VIII	Filtration Performance of Commercial Dual Polymer Systems	91
IX	Cationic Cost-Performance Data	92
X	Typical Installation for Preparing Powered Polymer Solutions	93
XI	Zimpro® Wet Air Oxidation Process	94
XII	Columbus, Ohio Dewatering Test	95
XIII	Indianapolis, Ind. Dewatering Test	96
XIV	Louisville, Kentucky Dewatering Test	97
XV	Cincinnati, Ohio Dewatering Test	98
XVI	Baltimore, Md. Dewatering Test	99

STLCOPCB4050504

APPLICATION OF MONSANTO POLYMERS IN WATER AND WASTEWATER TREATMENT

Bruce W. Eley and Richard A. Kimerle

INTRODUCTION

The primary objective of all separation processes employed in modern waste treatment facilities is the removal of dissolved or suspended impurities which represent approximately 0.04 percent of the total sewage composition. This complex mixture of waste solids termed sewage sludge consists of proteins, fats, carbohydrates, polysaccharides, microorganisms and anything else that should get into the sewerage system. Primary treatment of domestic wastewater results in the removal of settleable suspended material with approximately 65 percent organic content. Secondary sludge is principally biological resulting from microbial synthesis during the metabolism of dissolved organic impurities.

Numerous individual processes exist for the treatment of sludge. Listed in Table 1 are some of these processes and methods of final disposal. These methods comprise the end stage of sewage treatment and account for 30 to 50 percent of the total cost of treatment. The method which is of particular significance in this report is that of sludge dewatering, or more specifically, vacuum filtration. Described as the separating of solids from a liquid by passing the liquid through a porous medium on which the solids portion remain to form a cake, the process results in a high quality filtrate water and a dewatered cake with 65-75 percent moisture content. In continuous drum vacuum filtration (Figure I) the pressure differential is maintained by a continuous vacuum on each section of the filter. The drum is rotated in the slurry vat by a mechanical drive removing the filter medium from the drum in each cycle and carrying the formed cake to the discharge point, usually some form of conveyor system. (2, 3)

STLCOPCB4050505

Table 1. Common Sludge Treatment Processes and Methods of Final Disposal (1)

A. Concentration
   1. Clarifier Thickening
   2. Separate Concentration
      a. Gravity Thickening
      b. Flotation

B. Digestion
   1. Aerobic
   2. Anaerobic

C. Dewatering
   1. Drying Beds
   2. Lagoons
   3. Vacuum Filtration
   4. Centrifugation

D. Heat Drying and Combustion
   1. Heat Drying
   2. Incineration
      a. Multiple Hearth
      b. Fluid Solids
   3. Wet Oxidation

E. Final Sludge Disposal
   1. Land Fill
   2. Soil Conditioning
   3. Discharge to Sea

DSW 176619

STLCOPCB4050506

In order to develop optimum conditions for sludge dewatering, the filter cake structure must provide sufficient rigidity and porosity which under vacuum will allow a multitude of avenues to exist within the filter cake for the effective withdrawal of water. Such a structural matrix is formed by the flocculation of sludge particles using chemical conditions. Simply described, flocculation is the agglomeration of particles into large colonies. Domestic wastewater sludges can be represented by hydrophilic colloids which possess a negative charge caused by either preferential adsorption of hydroxide ions or ionization of component functional groups (in this case, carboxyl groups). These particles remain stable due to their electrostatic and hydrophilic nature until these conditions can be adjusted so as to effect a charge reduction with attendant release of water and aggregation of particles in close proximity.

Until recently, the chemical conditioners most often used were iron salts and lime. However, these chemicals while being acidic and caustic, also had to be applied in very large dosage levels (FeCl, 2-5% by sludge solids weight; CaO, 8-10%) which consequently necessitated large storage facilities. Another disadvantage of inorganic flocculants is the decreased heat value of resulting cake because of the calcining effect of ferric chloride and lime associated with sludge combustion processes.(2)

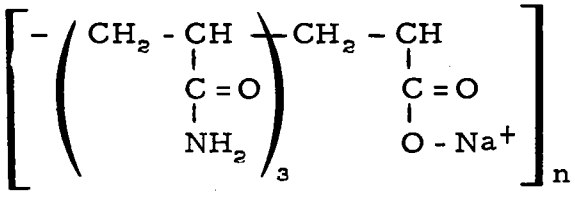
During the last five years the use of synthetic, organic, high molecular weight polymers has been a major advancement in the sludge handling field. All but a few major treatment facilities now use these organic polymers and are dewatering sludges for $2.00-$6.00/dry ton of cake, the higher costs being associated with the treatment of sludge combinations. The polymers perform the mechanism of flocculation by three basic phenomena: adsorption, charge neutralization and interparticle bridging.(4, 5, 6) Polymers which abound with active functional groups along the molecule's stem and branches, are classified as to their charge in the ionized form. Anionic polymers possess a negative charge after ionization of functional groups whereas those exhibiting a positive charge after ionization are cationic. The nonionic forms do not ionize in solution but do contain active surface sites that assist in the binding of particles into aggregates. Illustrated below are some structural forms of these various types.(6) The anionic molecule shown is believed to represent Dow's Purifloc A-23.

Cationic Polyamine:

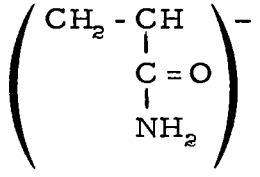
$$H_2N - (C_nH_nR_n - NR)_x$$

where R = H, CH_3, C_2H_5, OH, OR, etc.

Anionic (Molecular Weight ~ 2-3 $\bar{M}$)



Nonionic (Molecular Weight ~ 1-2 $\bar{M}$)



Polymers can be used as primary flocculants, flocculant aids, filter aids or sludge conditioners. Their effectiveness will vary with concentration, molecular weight, degree of agitation, and the solids content and surface area of the flocculated material. There are many suppliers of polymers for usage in wastewater treatment. Included are Dow Chemical Company, Calgon, Hercules, Nalco, American Cyanamid, Dearborn Division of W. R. Grace, Drew Chemical Company, National Starch and Chemical Company, Betz Laboratories and W. E. Zimmie Company. Dow Chemical Company, which has been marketing polymers since 1954 when it introduced Separan® NP10, is best established in all areas of application.

Monsanto's renewed interest in wastewater treatment occurred approximately one and a half years ago when the cationic polymer coded PE-65 was tested by Monsanto Biodize as a sludge flocculant. Previous to this time, PE-64, the insoluble analog of PE-65, had been used in virus removal studies conducted by NED of Monsanto.

Approximately six months later CRD became aware of other cationic polymers used as wet strength resins in the paper industry by the Organic Division. Therefore several of these materials along with PE-65 underwent further testing by CRD in flocculation, wastewater COD removal, bacterial removal, algae growth inhibition, fish toxicity and sludge settling. Results of testing indicated that the cationic polymer RPC-926 might have potential value in the sludge dewatering field. RPC-926, which is manufactured by the polymerization of the still bottoms from the hexamethylenediamine process for nylon with ethylene dichloride, represented a low cost product of abundant supply. This report, therefore, summarizes subsequent evaluations conducted using both cationic and anionic polymers presently manufactured by Monsanto Company in the hope that Monsanto could possibly position itself in this new environmental polymer market.

SUMMARY

The performance of RPC-926 was compared to other commercially available cationic polymers in the areas of sludge dewatering and water flocculation. These studies using the Buchner funnel technique indicated that performancewise RPC-926 was equal to or better than other cationic polymers, including Dow C-31, Calgon 565, Hercofloc 828.1 and Calgon 260. Numberous anionic polymers were tested with RPC-926 under conditions of dual polymer treatment; Dow's A-23 and Calgon's 269 were more effective. Based on prices quoted on cationic polymers, it was felt that a price range of $0.12 - $0.15/lb. 25% material would establish RPC-926 as a competitive product.

Approximately 20 Monsanto anionic polymers (EMA and SMA types) were tested in conjunction with the cationic material in order that Monsanto could potentially offer a dual system of polymers or possibly supply a competitive anionic material. However, because of low molecular weight limitations, most were found to be unsuitable with the exception of two compounds, ammonium salt of EMA 31 and an SMA with a specific viscosity of 13. If further research is instituted, these polymers should dictate initial study.

Laboratory flocculation and sludge dewatering testing with a homologous series of HMD/DCE cationic polymers (manufactured by polymerization of HMD with ethylene dichloride) of varying molecular weights indicated the value of having a "polymer family" specific for different situations. Certain polymers in the series plus RPC-926 were compared with Nalco's Nalcolyte 607 in the clarification of natural water systems and found to be as effective as was 607. However, large scale testing of Monsanto's polymer in such potable water systems would require approval by the FDA.

After in-house testing was completed, initial field trials using RPC-926 were scheduled at the Blue River Treatment Plant in Kansas City, Missouri and the LeMay Treatment Plant in St. Louis, Missouri. Both facilities treat primary sludge with two polymer systems. The first trial, a four-day comparative run between Monsanto RPC-926 and Hercules Hercofloc 828.1, showed that our polymer could successfully compete both in cost and performance with an established product. Usage of RPC-926 resulted in good sludge cake production with 25-30% solids content and a chemical cost of $2.77/ton dry cake. Costs using the Hercules material approached $4.00/ton dry cake. The same anionic material was fed to the sludge conditioners prior to each cationic polymer.

The St. Louis trial gave Monsanto the opportunity to use RPC-926 in a facility which was using Dow's highly respectful dual system, the cationic C-31 and anionic A-23. The one-day test was fairly successful considering the similar performance noted for each cationic polymer used in conjunction with the A-23. However, in order for the Monsanto product to be cost competitive with C-31, the price would have had to be decreased from the original estimate of $0.60/lb. to approximately $0.35/lb. (dry). At this lower price, the cost of cationic treatment would have been in the range of $2.50/dry ton of cake as compared with the plant's present cost using C-31 of $2.57/dry ton of cake.

Before the polymer could ever be made commercially available, the current status of the polymer market has to be ascertained in order that decisions concerning potential market, marketing procedures, price structure, and chance of success can be made intelligently. Therefore, a telephone survey of 44 of the larger domestic waste treatment facilities throughout the nation was conducted. Information requested at each plant included such items as present and estimated future polymer usage, amount of sludge production, treatment cost, type of treatment, method of sludge disposal, procedure for bidding, and type of polymer contract, if any. The survey, representing cities

STLCOPCB4050510

greater than 200,000 population, covered 62% of the total population in cities of that size. Sludge-handling practices in the cities contacted revealed that most sludges consisted of combinations of primary, digested and waste activated sludge and more importantly, were being conditioned with single cationic polymer systems and not the dual systems with which we had experienced. Also, it was noted that Dow Chemical Company, which we originally thought commanded a major portion of the market with C-31, was being strongly challenged by Calgon and Hercules. The annual total market was estimated at $6.5 M for cities over 200,000 population with this figure increasing to $10.6 M by 1980.

From the list of surveyed cities, the following nine treatment facilities were selected for personal visits: Akron, Ohio; Baltimore, Md.; Chicago, Ill.; Cincinnati, Ohio; Cleveland, Ohio; Columbus, Ohio; Detroit, Mich.; Indianapolis, Ind.; and Louisville, Kentucky. Purpose of the trips was to obtain more detailed information on treatment operations and determine the effectiveness of RPC-926 in conditioning mixed sludges. The most significant attribute of sludge-handling at these facilities was the trend in polymer usage toward single application of higher molecular weight cationic polymers. In almost every case, the RPC-926 polymer at a large enough dosage level could dewater mixed sludge in the laboratory; however, the conditioning efficiency was not high enough to make it cost competitive with those polymers presently being used. Also of interest at several facilities was the expected increase in anionic polymer usage in primary treatment for purposes of increased BOD and solids removal and phosphate removal. Such applications would greatly increase (perhaps tenfold) the value of the polymer contract at those facilities.

The final stage of polymer testing included additional field trials of the Mill Creek Plant in Cincinnati, Ohio and the Metropolitan Sewer District Facility in Detroit, Michigan. Results at these plants could verify any conclusions arrived at through laboratory study. In this respect, the Cincinnati trial was of special significance since the comparative performance of RPC-926 and Calgon's WT-2650 (high molecular weight powered cationic polymer) all but duplicated on the filters the results obtained during previous laboratory work. Equal or better performance was observed using the Monsanto polymer, but again, due to lower treatment efficiency, its related cost ($2.96/dry ton) could not match that of the Calgon product ($1.65/dry ton).

The Detroit trial, originally scheduled for a week's operation, was cut short when results indicated that RPC-926 could not economically condition the type sludge produced at that facility. The sludge consisting of high concentration of waste pickle liquor was being conditioned with Dow's anionic A-23 because of the sludge's cationic nature. The RPC-926 was able to form a cake, but poor cake yield and extravagant treatment cost ($6.50/dry ton compared to Dow's $2.00/dry ton) resulted in test termination.

CONCLUSIONS AND RECOMMENDATIONS

1. Monsanto's RPC-926 cationic polymer will experience limited applications in sludge dewatering.

2. A competitive price per dry pound of RPC-926 material should be established in the approximate range of $0.35.

3. The area best suited for RPC-926 usage is the conditioning of wastewater sludge with dual polymer addition. Under such conditions, it will prove competitive in performance with any of the commercially available cationic materials of similar molecular weight and, when compared with the more HMW polymers, it should be cost competitive.

4. The practice of conditioning only primary sludge is not as extensive as once thought. Of the treatment facilities either contacted or visited, only two municipalities, St. Louis, Mo. and Kansas City, Mo. treat such sludge.

5. Most sludges being dewatered by vacuum filtration consist of various combinations of primary, waste activated and/or digested sludge. Moreover, of these facilities chemical conditioning is being performed by application of single cationic polymers of higher molecular weight than that characteristic of RPC-926.

6. These higher molecular weight cationic materials not only exhibit the charged sites as does RPC-926 but also an augmented bridging mechanism characteristic of HMW anionic polymeric compounds.

7. At locations defined in item 5, neither RPC-926 nor the HMD/DCE series of cationic polymers evaluated could effectively flocculate sludge as efficiently as those compounds being used.

8. There exist exceptions in single polymer usage where given a flexible price structure, RPC-926 might prove competitive in cost/performance with HMW polymers. On the other hand, it might be more economically feasible to substitute the HMW single system with a dual polymer system such as RPC-926 plus an anionic material. However, in such instances, the resulting cost reduction would probably have to average at least 15% to warrant such a change because of added capital costs (mixing tanks and pumps) and operating costs (storing and handling of polymer) associated with two polymer usage.

9. The most difficult sludges to dewater are sludges of biological origin or industrialized sludges consisting of high organic content in which excess polymer is regulated to satisfy the organic demand.

10. Some treatment facilities require or expect some degree of technical service from supplies of polymeric conditioners whether that service be in the form of product service or general consulting. On the other hand, personnel at several of the larger municipalities relate that little contact is made between customer and supplier except during contract renewal. Generally, expertise in polymer technique is such that plant personnel can adequately handle any difficult situations that arise.

11. Ease of handling is one polymer characteristic highly considered by the customer. Most powered materials are difficult to solubilize but require less storage space. The liquid polymer is easiest handled at facilities containing large tanks for storage of polymer after transfer from tank cars. A polymer with the highest solids content and yet retains its liquid properties is most economical both for the customer and supplier.

12. The present market for organic flocculants in municipal sludge dewatering is estimated to be approximately $8-9 $\bar{M}$/yr. The projected figure for the year 1976 is $15 $\bar{M}$/yr. representing an annual growth rate of 10-12%. Based on information supplied by surveyed facilities, the largest growth area in the polymer market may be the increased usage of anionic materials in primary waste flocculation and chemical coagulation prior to advanced treatment methods.

13. Monsanto is presently in a position to evaluate the two possible avenues of entrance into the polymer wastewater field: (a) establishment of a water management group within the company whose responsibilities would include development research and the sale and service of polymeric compounds to industrial and municipal treatment facilities, or (b) selling polymeric chemicals through existing company channels to a specialty chemical company already established in the market.

14. Item (a) would require the development of an anionic polymer similar in cost and performance with those commercially available. Buying such chemicals would price Monsanto out of the anionic market. Reasons for anionic development include the following:

    (1) Dual polymer systems imply the application of both a cationic and anionic material.

    (2) The customer (treatment plant) prefers or insists in buying all polymers used in sludge handling from the same supplier. This handling includes not only the actual filtration step but also any sludge concentration that may be required prior to conditioning.

    (3) A big potential market exists in the area of anionic flocculation of wastewaters.

15. General product service is expected in sludge dewatering. However, a more extensive service function would be required in the areas of water and sewage clarification because of the tremendous cost to the customer in sewage clarification and the criticality involved with the performance of coagulants in treating potable waters.

16. Also to fulfill item (a) Monsanto must develop new cationic polymers with which a greater segment of the total market may be served. The polymer foundation has been laid. What lies ahead would represent the addition of various building blocks until the final structure could be utilized in a profitable manner. Furthermore, through product development, newer blocks could be substituted for those old and tarnished.

LABORATORY POLYMER EVALUATIONS

Sludge Dewatering. Filtration test using the Buchner funnel technique was performed in the laboratory for the purpose of relating the dewatering capabilities of various synthetic organic polymers now on the market to those observed using Monsanto's experimental polymers. The test itself falls short of a complete vacuum drum simulation but is of great value as a parameter in comparing the flocculating and filtering performance of sludge dewatering aids.

Equipment used during the evaluations include the following: 11 cm. Buchner funnel, Whatman No. 4 filtering paper, 250 ml. filtering funnel complete with vacuum connections, and a Phipps and Bird stirrer (Figs. III - IV). A constant filtration vacuum of 15 in. Hg was applied to the filtering media. Primary sludge samples obtained from the LeMay Treatment Plant in St. Louis, Mo. consisted of 5-8% solids. Included below is a brief outline of the test procedure.

1. To a 500 ml. sample of sludge add the desired concentration of anionic material while stirring at 100 rpm. Continue mixing for 45 seconds.

2. Add a desired concentration of cationic material. Mix at 100 rpm for approximately 5 seconds and then decrease speed to 40 rpm and mix until optimum coagulation is observed. This generally occurs within another 5 seconds.

3. Obtain 150 ml. of the treated sludge and pour into the Buchner funnel of zero vacuum. Let the sample set for a few seconds and then apply 15 in. Hg vacuum.

4. Monitor the quantity of filtrate collected at any desired increment of time. The filtration data sheet in the appendix of this report (Appendix A) was used to record performance. Generally, the number of mL. collected during the first minute of operation will indicate the quality of the treatment.

Another method useful in the study and control of vacuum filtration, but which was not extensively used during these evaluations, is the filter leaf test. The test procedure can be conducted as follows:

a) Condition a two liter sample of sludge with polymer treatment.

b) Apply the desired vacuum to the leaf assembly (Figure V) and immerse it in the sludge for the desired time. During this time mix the filter leaf back and forth.

c) Remove the leaf and bring it to a vertical position for the duration of the desired drying time.

d) Shut off the vacuum and remove the cake from the leaf. Measure the amount of filtrate volume collected.

e) Dry and weigh the cake and if desired, calculate the filter yield using the equation:

$$\text{Yield (lb./hr./sq. ft.)} = \frac{\text{wt. of dry cake (g) x cycles/hr.}}{454 \text{ x leaf area (sq. ft.)}}$$

Polymers were evaluated as to performance using three classifications: cationic evaluation, anionic evaluation, and commercial dual-system evaluation. The first type compares the capabilities of several cationic polymers in dewatering sludge when applied in conjunction with a mutual anionic material. Listed in Table 2 are the various cationic and anionic polymers used during the study. Figure VI (a, b and c) illustrate the relative performance of each of the cationic products at dosage levels of 100 mg/L and 200 mg/L. Each polymer was used along with the anionic polymer, Purifloc A-23.

STLCOPCB4050516

Table 2. List of Polymers Used in Laboratory Evaluations

Cationic Polymers:

Product	Supplier	% Solids	Price ($/lb.)
RPC-926	Monsanto	25	0.15*
HMD/DCE (0.90 - 0.99)	Monsanto	20	0.15*
Purifloc C-31	Dow	48	0.22-0.26
Hercofloc 828.1	Hercules	15	0.28
WCL-565	Calgon	100	≈ 2.00
ST-266	Calgon	46	0.40
ST-260	Calgon	100	≈ 2.00

Anionic Polymers:

Product	Supplier	Price ($/lb.)
EMA's and SMA's	Monsanto	—
Purifloc A-23	Dow	1.20
Magnifloc 835-A	Amer. Cyanamid	1.36
Hercofloc 846.2	Hercules	1.25
ST-269	Calgon	1.25-1.50
ST-270	Calgon	1.25-1.50

* Estimated competitive pricing.

STLCOPCB4050517

Shown in Figure VII are the filtering performances of seven different anionic materials used with RPC-926 in concentrations of 100 mg/L. Other anionic polymers tested consisted of those in Monsanto's EMA series (11, 21, 31, 34, 61, 63, 71, 74, 81, 84, 91, 93) and Monsanto S-500. However, these performed about as poorly as EMA-54 and 94 (shown on Figure VII) and, consequently, were not included in the results.

Results of the test depicting the relative performances of several dual-polymer systems presently used in commercial applications are displayed in Figure VIII. Systems studied were Calgon ST-266/ST-269, Hercules 848.1/846.2, Dow C-31/A-23, and Hercules 828.1/Amer. Cy. 835-A.

Cost-performance data was difficult to obtain due to the problem of test duplication. Several parameters influence the experimental results, the most crucial being sample volume, polymer addition, degree of mixing, sludge sample consistency, and sludge moisture and volatile content. However, as shown in Figure IX an attempt was made (accuracy is questionable) to economically compare observed performance of several cationic materials. The curves relate the conditioning quality as measured by sludge filterability to polymer dosage levels (mg/L). Then the polymer costs ($/MG sludge) at equal performance levels (80 mL. in 30 seconds time) are compared. Of particular interest is the relatively low cost of the more expensive Calgon 565. This cost is reflected by the greater efficiency with which the higher molecular weight 565 performs.

Based on the sludge dewatering tests the following results are of interest:

1. Monsanto's RPC-926 in conjunction with an anionic polymer was quite effective in conditioning primary sludge for dewatering.

2. Performance of RPC-926 was equal to the performance noted for Dow C-31, Calgon 266, and Calgon 565 in dual polymer treatment of primary sludge.

3. Use of RPC-926 resulted in superior performance than did Hercofloc 828.1 and Calgon 260.

4. Dow A-23 and Calgon 269 were found to give better performance than the other anionics when applied with RPC-926.

5. Due to lower molecular weight and perhaps less charge functionality, Monsanto's EMA and SMA based polymers could not effectively compete with commercial anionic materials used in wastewater treatment.

STLCOPCB4050518

6. A competitive price of the RPC-926 would be in the range of $0.12 - 0.15 per lb. of 25% material.

Raw Water Clarification. The classical approach to coagulation of raw water in water treatment plants involves the presence of positive aluminum or ferric ion originating from addition of alum ($Al_2(SO_4)_3 \cdot 14H_2O$) or ferric salts to form the insoluble aluminum of ferric hydroxide floc. These aluminum or ferric hydroxo complexes formed, aid in the removal of color, turbidity or calcium carbonate and magnesium hydroxide crystals resulting from lime-soda softening of water.

Anionic polymers such as Dow Purifloc A-21 have during the last few years been demonstrated for use as secondary coagulants or filter aids. Recently Nalco Co. introduced a cationic polymer, Nalcolyte 607, for use in potable water systems.(7) The product as advertised is recommended as being a substitute for the inorganic salts and is probably the only polyamine approved for such usage because of the time and money required in obtaining FDA clearance.

Since Monsanto's RPC-926 and the HMD/DCE series of cationic polymers possessed similar characteristics as Nalcolyte 607, these polymers were evaluated in raw water flocculation using the influent water collected at the Chain of Rocks Treatment Plant in St. Louis, Mo. and the Central County Treatment Plant in St. Louis County. These plants receive water from the Mississippi and Missouri Rivers. The Chain of Rocks facility is using lime (89 mg/L CoO), ferric sulfate (2.6 mg/L Fe^{+++}) and alum (4.3 mg/L AL^{+++}) as flocculating agents. The chemical cost of treatment is approximately $6.50/MG with 85% of the total being attributed by lime addition. The Central County Plant was at that time using Nalcolyte as a filter aid. The chemical was being shipped in liquid form as a 54% solution costing $0.40/lb.

The clarification test was performed as follows:

1. Desired chemicals are added to 1000 mL. river water samples at a flocculating speed of 100 rpm (see Figure III).

2. Rapid mix the solutions at 100 rpm for one minute.

3. Decrease mixing to 35 rpm for two minutes.

4. Slow mix the solutions at 10 rpm for 3 minutes and then allow solids to settle for 45 seconds before sampling.

5. Measure the initial and residual turbidities of the raw and treated waters using a spectrophotometer which has been calibrated using the Jackson Candle technique of turbidity measurement. (9)

Results of the flocculation tests are given in Table 3. Performance (turbidity removal) of RPC-926 and the HMD/DCE series is compared with that noted for Nalco 607. This study indicated the following:

1. Certain polymers such as RPC-926 and HMD/DCE 0.90 and 0.95 were as effective as Nalcolyte 607 in removing turbidity and colloidal color.

2. Optimum dosage levels were approximately 3 ppm and resulted in 90-97% turbidity removals.

3. Use of a cationic polymer of 1 ppm in conjunction with 2-3 ppm Al^{+++} resulted in better turbidity removal than use of polymer alone.

4. Cost associated with obtaining approval of cationic polymer usage in potable waters is expensive ($200,000) and would require up to two years for complete toxicological studies.

5. Because of greater purity, the HMD compounds would have a far better chance of successful approval than RPC-926.

6. The marketing success of Nalcolyte 607 is not known. However, it may be that the chemical at present is finding only limited application as a filtering aid. Considering the large detention times inherent in many sedimentation tank designs, polymer usage may not be competitive with inorganic salts on a cost-performance basis.

7. The polymers used as inorganic salt replacements would be of greatest value in water treatment facilities exhibiting overloaded conditions depicted by inadequate detention times not suitable for conventional flocculation and settling.

Table 3. Water Clarification
Using Polymer Treatment

Test Water Missouri River
Initial Turbidity: 410 Jackson Turbidity Units (J.T.U.)

Residual Turbidity (J.T.U.)

Chemical	Concentration (mg/L) 1	2	3	4	5	6	8
Nalco 607	67	44	38	--	32	33	34
Monsanto RPC-926	64	42	36	--	32	34	38
Monsanto HMD 0.90	70	47	42	--	36	38	38
Monsanto HMD 0.98	88	49	42	--	34	36	38
Aluminum (AL^{+++}) + 2 mg/L HMD 0.90	--	18	--	12	--	12	--
Aluminum (AL^{+++}) + 1 mg/L HMD 0.90	26	19	14	--	--	--	--

Test Water: Mississippi River
Initial Turbidity: 680 J.T.U.

Residual Turbidity (J.T.U.)

Chemical	Concentration (mg/L) 1	2	3	4	5	6	8
Nalco 607	78	46	--	32	30	32	30
Monsanto HMD 0.90	80	--	38	--	34	--	--
Monsanto HMD 0.50	>150	--	>150	--	119	--	--
Monsanto HMD 0.95	88	--	38	--	32	--	--
Monsanto HMD 0.99	109	--	53	--	40	--	--

INITIAL TREATMENT PLANT TESTING

Kansas City Polymer Trial. The performance of the experimental cationic polymer RPC-926 in field testing was first evaluated at the Blue River Waste Treatment Plant in Kansas City, Missouri during the week of December 7. This facility which serves a majority of the people and industry in the Kansas City area, consists of primary sedimentation, sludge vacuum filtration and sludge incineration. Type filters used are Eimco continuous vacuum drum filters with nylon mesh filter media.

Their present polymer contract with Hercules Company includes a dual system using the cationic polymer Hercofloc 828.1 and an anionic polymer, Hercofloc 846.2. However, due to late shipment of the Hercules product, American Cyanamid's Magnifloc 835-A served as the anionic polymer during the first few days of testing. The use of two filters receiving the same anionic treatment but competitive cationics, Hercofloc 828.1 on one and RPC-926 on the other, enabled us to obtain comparative cost-performance data.

Figure II illustrates a typical dual polymer feeding system like that used in Kansas City. Here the anionic fed solution is prepared and then added to the sludge before entrance into the conditioning tank. Afterwards, the sludge is mixed with cationic solution just as it spills into the filter vat where it is dewatered. Sludge pumped to both filters was identical and had a solids content of 5-6%. The average cake production conveyed to the incineration units is approximately 2200 dry tons/month or 26,400 tons/year. At a chemical cost of $2.50/dry ton, the total polymer contract would be $66,000/year.

During the trial, RPC-926 in liquid form (25% solids) was mixed in 600 gallon tanks. Generally, one-half drum (238 lb.) of cationic polymer was diluted to 600 gallons resulting in each inch of tankage height representing 5.94 lbs. of original polymer added. Measurement of "inches used" could then be equated to pounds of material used and cost incurred during the time interval (usually one hour) between readings. The diluted solution strength of RPC-926 was 1.18%. The powered anionic polymer used with both cationics was prepared by dispersing 10 lbs. of material in a 600 tank (0.2% fed solution). Figure X shows such an installation.

Complete results of the four-day run are included in the Appendix section (Appendix B). RPC-926 achieved comparable or superior performance in sludge dewatering than did the Hercules polymer while reducing the chemical cost per ton of dry cake as much as 30%. The sludge cakes processed by each filter were of good quality with the higher molecular weight Hercofloc producing a cake of poorer consistency. Cake moisture content being very acceptable using belt-type filters varied from 70 to 74%.

STLCOPCB4050522

Table 4 reviews the average cost data obtained on each of the four days of testing. The quantities of polymer (lb./dry ton) were derived from measurements of chemical pounds used and cake tons produced. The quoted prices per lb. for the commercial polymers were $0.27 (Hercules Hercofloc 828.1), $1.25 (Hercofloc 846.2), and $1.36 (Magnifloc 835-A). Price per lb. of RPC-926 was assumed to be $0.15 for the 25% liquid. These cost/ton figures indicate an overall savings of $1.30/dry ton with the use of RPC-926.

St. Louis Polymer Trial. The second full scale polymer trial was conducted in cooperation with the St. Louis Metropolitan Sewer District of the LeMay Treatment Plant on January 12, 1971. This primary treatment facility dewaters primary sludge using Kromline-Sanderson coil filters and disposes of cake by incineration. The annual sludge production is approximately 24,000 dry ton. With the chemical cost averaging $2.25/dry ton, the total polymer contract is valued at $54,000/year. Their present polymer usage consists of a dual system using the cationic polymer Dow Purifloc C-31 and the anionic polymer Dow Purifloc A-23.

The test was scheduled as a two-batch trial which would run about ten hours. It was not possible to directly compare performances of both cationic materials since facilities were not adequate for operation of two different polymer systems. However, data recorded during a ten-hour period after termination of the Monsanto trial was obtained in order that some comparisons could be made. RPC-926 was mixed in 300 gallon tanks with 25 gallons of 25% polymer and 20 gallons being added for each respective run. The anionic material (supplied by the city) was diluted to a solution strength of 0.05% by solubilizing 2.5 lbs. of the powder in 600 gallon mix tanks.

Details of the performance and cost for both RPC-926 and C-31 are included in Appendix C. Table 5 summarizes this data. The performance of RPC-926 on the filters was equal to that of C-31. However, the original price figure of $0.60/dry lb. used in the Kansas City trial was lowered to $0.35/lb. in order to maintain a competitive position in the range of $2.50/dry ton cake. Consequently, the cost/performance data suggested that since Dow's C-31 and A-23 were considered to be the best polymer system in usage, Monsanto's RPC-926 at $0.35/dry lb. could compete with any other cationic polymer provided a suitable anionic polymer could be supplied also.

STLCOPCB4050523

Table 4. Kansas City Polymer
Trial Summary

Plant: Blue River Treatment Plant
Sludge Type: Primary sludge treated with dual polymer system

Present Treatment: Cationic: Hercofloc 828.1 @ $0.28/lb.
Anionic: Magnifloc 835-A @ $1.36/lb.
Hercofloc 846.2 @ $1.25/lb.

Day	*Polymer Usage Cationic (lbs/dry ton)	Anionic (lbs/dry ton)	Polymer Cost Cationic ($/dry ton)	Anionic ($/dry ton)	Treatment Cost ($/dry ton)
12/8	12.44	0.36	$3.47	$0.49	$3.96
12/9	13.37	0.58	3.73	0.79	4.52
12/10	11.00	0.61	3.07	0.74	3.81
12/11	11.91	0.48	3.32	0.60	3.92
Average	12.18	0.51	$3.40	$0.65	$4.05

Monsanto Treatment: Cationic: **RPC-926 @ $0.15/wet lb.
Anionic: Same

Day	Polymer Usage Cationic (lbs/dry ton)	Anionic (lbs/dry ton)	Polymer Cost Cationic ($/dry ton)	Anionic ($/dry ton)	Treatment Cost ($/dry ton)
12/8	13.50	0.52	$2.02	$0.71	$2.73
12/9	13.94	0.59	2.09	0.82	2.91
12/10	15.74	0.51	2.36	0.64	3.00
12/11	12.06	0.52	1.81	0.65	2.46
Average	13.81	0.53	$2.07	$0.70	$2.77

* Dosage level in wet lbs. polymer/dry ton sludge.
** Based on competitive price of $0.60/dry lb. polymer.
Given a price structure of $0.35/dry lb., above cationic polymer cost would be $1.21/dry ton with a total treatment cost of $1.91/dry ton.

STLCOPCB4050524

Table 5. St. Louis Polymer Testing
Treatment Cost Summary

Date: January 12, 1971
Plant: LeMay Treatment Plant
Sludge Type: Primary sludge using dual polymer system
Filter Type: Coil

Present Treatment: Cationic Polymer: Dow Purifloc C-31
Anionic Polymer: " " A-23

Treatment Period	Cationic Usage (total wet lbs)	Cake Tonnage (dry tons)	Cationic Dosage Level (wet lb/dry ton)	*Polymer Treatment Cost ($/dry ton sludge
1/12/71 (9:00 pm - 7:00 am on 1/13/71)	152	13	11.69	$2.57

Monsanto Treatment: Cationic: RPC-926 (25% material)
Anionic: Same

Treatment Period	Cationic Usage (total wet lbs)	Cake Tonnage (dry tons)	Cationic Dosage Level (wet lb/dry ton)	*Polymer Treatment Cost ($/dry ton sludge
1/12/71 (11:00 am - 9:00 pm)	346	12.2	28.4	$2.49

* Cationic polymer cost based on following price structure:
Dow C-31: $0.22/wet lb (48% solids)
RPC-926: $0.0875/wet lb (25% solids), or $0.35/dry lb.

DSW 176638

STLCOPCB4050525

DOMESTIC POLYMER USAGE SURVEY

A telephone survey of 44 sewage treatment plants in 23 states was conducted as a means of obtaining a large volume of information on polymer usage in a cross section of the total polymer market (see Appendix D for questionnaire). The survey was directed at metropolitan areas with populations of greater than 200,000. There are approximately 58 such cities in the U.S. We have defined this portion of the total market as the most desirable, thus avoiding low-volume sales and high-service time associated with smaller municipal contracts. The survey covered 44 cities using vacuum filtration units, or about 70% of our defined market (Appendix E). Also included in the survey were numerous large cities that were not using polymers for vacuum filtration.

Purposes of Survey.

1. Determine current sludge disposal practices across the U.S.

2. Determine present volume of sludge being dewatered with polymers or ferric salts.

3. Estimate present and future polymer market in areas of sludge dewatering and wastewater treatment.

4. Determine which polymers are established in the market and estimate dollar sales.

5. Determine procedures of bidding and conditions of contracts.

6. To select treatment plants for future trial runs.

Survey Data. Date obtained in the survey are tabulated in Table 6. Size classes of > 200, 100-199, 40-99 and <40 mgd were arbitrarily chosen and designated as types I, II, III and IV, respectively.

Table 7 summarizes the methods used by the surveyed sewage treatment plants to handle their sludge. The data in Table 8 were generated for the purpose of presenting our opinion of the future trends in polymer usage.

STLCOPCB4050526

Table 6 Summary of Polymer Usage Survey

LOCATION	TREATMENT	FLOW	SLUDGE TYPE	FILTERS NUMBER	FILTERS TYPE	DISPOSAL	TONS/MONTH	INORGANIC CHEMICALS	POLYMERS CAT.	POLYMERS AN.	EXPERIENCE	CONTRACT	REMARKS
TYPE I Chicago, Illinois	Pri., I.T. Clar. Sec., A.S.	900MGD	Raw	98	Belt	Landfill, Incin. Digested		$FeCl_3$ (Vac.Filt)	Herc. I.T.	---		Year supply	Sludge: Lagoons & Zimpro
Boston, Massachusettes	Pri., Dig.	340MGD	Digested			Pipe to ocean							
Detroit, Michigan	Pri.	720MGD	Raw	12	Belt	Incin.			Dow		Dow, 5 years	$1.35 as needed	Secondary treatment in near future
Minneapolis-St. Paul, Minnesota	Highrate A.S.	215MGD	Thickened A.S.	20	Belt	Incin.	66,000	$FeCl_3$ $FeSO_4$ Lime			Experimenting A-21, C-31	$3.09	Must reduce cost by 30%
Milwaukee, Wisconsin	A.S.	200MGD	Thickened W.A.	24	Belt	Fertil-izer	6,000	$FeCl_3$			Tried all; none work w/o $FeCl_3$	$2.58	
New Orleans, Louisiana	Pri.	140MGD	Raw	Centrifuge					Am.Cy. 560			$1.25	Experimenting w/Union Carbide Zimpro
TYPE II Indianapolis, Indiana	Pri., Sec., A.S.	135MGD	Mixed Pri-W.A. Air floted w/polymer	12	Belt	Incin.	5,000		Calg.		2 years	$8-$17 yearly contract	Formerly raw sludge w/Calgon $2.50/Ton
Baltimore, Maryland	Pri., Sec., T.F. A.S.	170MGD	Mixed W.A. & digested	4	Belt	Piling Up	900		Dow		2 years	$5.25 yearly contract	Used to barge sludge to ocean; hope to go to Zimpro
Cincinnati, Ohio	Pri., w/dig.	100MGD	Mixed raw & digested	8	Belt	Incin.	15,000		Calg.		3-4 years	$2.00 yearly contract	Going to Zimpro
Cleveland, Ohio	Pri., Sec., W.A.	100MGD	Mixed W.A. & digested					$FeCl_3$ Lime					Interested in phys/chem tertiary treatment
Columbus, Ohio	Pri., Sec., W.A.	160MGD	Mixed W.A. & digested; Thickened with R&H C-7	12	Belt & Coil	Incin.	2,000		Dow 1569		4 years	$11.50 needs contract	
Portland, Oregon	Pri.	100MGD											Wants to use Zimpro with Centrifuge

DSW 176640

STLCOPCB4050527

Table 6 (con't)

LOCATION	TREATMENT	FLOW	SLUDGE TYPE	FILTERS NUMBER	FILTERS TYPE	DISPOSAL	TONS/MONTH	INORGANIC CHEMICALS	POLYMERS CAT.	POLYMERS AN.	EXPERIENCE	COST/TON CONTRACT	REMARKS
TYPE III													
Denver, Colorado	Pri., Sec.	50MGD	Mixed Pri. & Sec.			Piped to desert							
Hartford, Connecticut	Pri.	40MGD	Digested, thickened	2	Belt	Landfill	290,000	$FeCl_3$			Experimented only	$6.00	
Miami, Florida	No Pri. Aerated Sec.	50MGD	W.A. Sec.	(Not Used)	Coil	Landfill			Dow, Herc.				Filters not used.
Louisville, Kentucky	Pri., dig.	75-80MGD	Digested, thickened w/An. pol.	3	Coil	Landfill	180		All		Nalco, Herc., Calgon	$2.00 no contract	"Open Door Policy"
Kansas City, Missouri	Pri.	70MGD	Raw	6	Belt	Incin.	2,200		Hercules 828	846	5 years	$2-$3 yearly contract	
St. Louis, Missouri	Pri.	50MGD	Raw	6	Coil	Incin.	1,500		Dow C-31	A-23	2 years	$2-$2.50 year's supply	
Omaha, Nebraska	Pri.	40MGD	Digested	3	Coil	Landfill, w/ability to incin.			Herc. 828		Very little	$6.00	
Akron, Ohio	Pri., Sec., W.A.	80MGD	Mixed W.A. & dig. Imhoff Tanks	4	Belt & Coil	Incin.	1,000		Dow Nalco		4 years	$4.40 needs contract	Expanding plant; Dual system = No work.
Dayton, Ohio	Pri., Sec.	55MGD	Dig. Pri./Sec.	2 (Not Used)	Coil	Landfill					$20.00/Ton when polymers used		
Toledo, Ohio	Pri., Sec., W.A.	82MGD	Pri. digested, Sec. W.A.	2	Coil	Landfill	2,000 to 3,000	$FeCl_3$ Lime			Nalco, Dow no luck	$5.00	
Seattle, Washington	Pri., dig.	?	Digested Pri.										
TYPE IV													
Boulder, Colorado	Pri., Sec., T.F.	7MGD	Mixed raw Pri. & Sec.	2	Coil	Landfill	220	$FeCl_3$ Lime			Tried Dow, Herc. & Nalco	$6.80	
New Haven, Connecticut	Pri.	14MGD	Raw thickened	2	Coil	Incin.	200,000 (dry)				None	None	Fibrous indus. waste = easy filtering
Pensicola, Florida	Pri., Sec., W.A.	9MGD	Mixed dig. & W.A.	2	Belt	Landfill					6 companies		

DSW 176641

STLCOPCB4050528

Table 6 (con't)

LOCATION	TREATMENT	FLOW	SLUDGE TYPE	FILTERS NUMBER	FILTERS TYPE	DISPOSAL	TONS/MONTH	INORGANIC CHEMICALS	POLYMERS CAT.	POLYMERS AN.	EXPERIENCE	COST / TON CONTRACT	REMARKS
St. Petersburg, Florida	Pri., Sec., A.S. T.F.	10MGD	Mixed	1	Coil	Landfill & Plant. Soil		$FeCl_3$ Lime			None		
Atlanta, Georgia	Pri., Sec., A.S. T.F.	13.5MGD	Mixed Pri. & Sec. Thickened	2	?	Landfill	1,020		Dow 1188		9 years	$6.50 (guaranteed)	Testing raw water treatment (Calgon)
Augusta, Georgia	Pri.	12MGD		2	Belt			$FeCl_3$ Lime					Will go to polymers by March
Council Bluffs, Iowa	Pri.	8MGD	Digested	1	Coil	Landfill			Cal.		5 years	buy as needed	
Des Moines, Iowa	Pri., Sec., T.F.	35-40 MGD	Digested	1	Coil	Landfill	1,500		Cal. 2160		?	yearly contract	
Dubuque, Iowa	Pri.	10MGD	Raw	4	Coil & Belt	Landfill & Incin.			Dow C-31		Numerous years	$1.00/T. no contract	
Kansas City, Kansas	Pri., Sec., T.F.	12MGD	Mixed Pri. dig & Sec.	2	Coil			$FeCl_3$ Lime					
Flint, Michigan	Pri., Sec., A.S. T.F.	32MGD	Raw Pri., Sec. air floted	3	Coil	Incin.	3,500	$FeCl_3$ Lime			None	$6.00	Polymers + $FeCl_3$ Furnace problems. Wants Zimpro.
Grand Rapids, Michigan	Pri., Sec.	8MGD	Mixed Dig. & Sec.	2	Belt	Landfill & Incin.	7,380	$FeCl_3$ Lime			Experimenting w/ Dow	$7.00	Going to Zimpro PO_4 removal w/ Dow
Duluth, Minnesota	Pri.	17MGD	Digested	2	Belt	Incin.	900	$FeCl_3$ Lime			Experimented with Dow, Herc.	$0.05 per T.	
Lincoln, Nebraska	Pri., Sec.	19MGD	Mixed Pri. & Sec.	1		Landfill	450		Herc.		1-2 years	$5.00 no contract	Tried Dow C-31 & 1488.
Burlington, North Carolina	Pri., Sec.	6MGD	Mixed dig. Pri.&Sec.						Calgon ST260	Calgon 266			
Greensborough, North Carolina	Pri., Sec., T.F.	26MGD	Mixed Pri. & Sec.	3	Belt & Coil	Landfill & Incin.			Dow C-31		8 years	$8.26 calendar year	

DSW 176642

STLCOPCB4050529

Table 6 (con't)

LOCATION	TREATMENT	FLOW	SLUDGE TYPE	FILTERS NUMBER	FILTERS TYPE	DISPOSAL	TONS/MONTH	INORGANIC CHEMICALS	POLYMERS CAT.	POLYMERS AN.	EXPERIENCE	COST/TON CONTRACT	REMARKS
Knoxville, Tennessee	Pri., Sec.	30MGD	Mixed Pri. dig & Sec.	5	Belt	Landfill	75	$FeCl_3$			Experimenting with Nalco & Am.Cy.	$9.00	
Dallas, Texas	Pri., Sec., A.S.	30MGD	Mixed Pri. dig & A.S.										
Huntington, West Virginia	Pri.	12MGD	Thickened Pri.	2	Belt	Incin.	540	$FeCl_3$ Lime (Industrial)	Nalco 610	(lime)	4 years	$11.00 no contract	

DSW 176643

STLCOPCB4050530

Table 7. Sludge Handling Practices of Treatment Plants Surveyed

Size Class		Mgd	% Total	Mgd of each size class using $FeCl_3$/Lime	Polymers	Lagoons/Dumping
I	> 200	2375	56	1116	926	332
II	100-199	1005	24	100	703	201
III	40-99	547	13	120	323	104
IV	< 40	296	7	139	118	38
TOTAL		4223		1475	2070	675
Percent				35	49	16

Table 8. Estimated Trends in Sludge Handling Practices - 1980

Size Class	Mgd	% Total	Mgd of each size class using $FeCl_3$	Polymer	Dumping	Wet Air Oxidation
I	4125	55	1031	2475	206	412
II	1950	26	136	1462	98	254
III	1125	15	112	844	56	124
IV	300	4	45	225	15	15
TOTAL	7500		1324	5006	375	805
Percent			12	70	8	10

DSW 176644

STLCOPCB4050531

Conclusions.

1. The survey revealed that sludge-handling practices across the U.S. are considerably different than our initial opinion derived from the limited experience at the Kansas City and St. Louis sewage-treatment plants. Few plants handle raw sludge only as is done in Kansas City and St. Louis. Most plants dewater combinations of primary, digested, and waste-activated sludges.

2. We originally thought that Dow commanded most of the cationic polymer market with C-31. Although C-31 is still strongly positioned in the market, Dow is being challenged by Calgon, Hercules, Nalco and American Cyanamid. Dow has demonstrated the ability to survive in the sludge polymer market with a single good product (C-31); however, with keener competition this is not as likely to happen in the future.

3. Approximately one-half (49%) of the sludge produced in the surveyed treatment plants is conditioned with polymers. The order of importance in polymer usage was Dow, Calgon, Hercules and American Cyanamid. The remaining sludge is mostly conditioned with $FeCl_3$ (35%) or dumped into landfills, lagoons or the ocean.

4. Calgon and Dow were involved with studies in some cities on application of polymers, mostly anionic, in raw wastewater to improve BOD removal and/or reduce phosphate level in effluents.

5. The total polymer market in all cities over 200,000 is presently estimated to be approximately \$6.5 $\bar{M}$ and should increase to \$10.6 $\bar{M}$ by 1980. (See Table 9.) The only foreseeable threat in the near future to polymers used as conditioning aids could be the wet-air oxidation processes which convert settled organics in the solid phase to soluble forms in the liquid phase. The resulting mixture is a high organic supernatant requiring secondary treatment and a relatively inert solid phase which, after being dewatered (without chemical addition), is suitable for landfill but not for incineration processes.

STLCOPCB4050532

Table 9. Present and Future Sludge-Dewatering Polymer Market in Cities of Greater Than 200,000 Population

	1971	1980
Mgd	6,500	7,500
Lb. sludge/mg[1]	x 1,850	x 1,850
$\bar{M}$ lb. sludge/day	12.025	13.875
Lb./ton	÷ 2,000	÷ 2,000
Tons/day	6,012	6,937
Days/yr.	x 365	x 365
$\bar{M}$ tons/yr.	2.194	2.532
Polymer cost/ton[2]	x 6	x 6
Potential market if all sludge dewatered with polymers, $\bar{M}$	13.164	15.192
Percent polymer usage	x .50[3]	x .70[4]
$\bar{M}$ $/yr.	6.582	10.634

1. Water and Wastewater Engineering, Vol. 2.

2. Estimated mean cost for all sludges in survey.

3. Estimated from survey.

4. Estimate based on opinion.

DSW 176646

STLCOPCB4050533

6. Most treatment plants operate on yearly contracts, a few on calendar year. Types of arrangements for supplying polymers include:

a) Don't buy. Let all companies use treatment plant as research facility, < 2%.

b) Buy as needed from anyone that can do the job, 50-70% of Class IV plants.

c) Contract for estimated one-year need, Class I, II, III.

d) Guaranteed $/ton, 10-15% Class II, III.

FIELD TRIP SURVEY

Perhaps the most interesting and informative segment of the polymer project was the field visits which followed the nationwide usage survey. The purposes of these trips were: (a) to obtain more detailed information on present and future waste treatment operations; (b) to determine the effectiveness of RPC-926 in conditioning sludges other than primary; (c) to estimate trends in polymer usage; and (d) to establish a working relationship between Monsanto and some of the major treatment facilities in the United States.

Municipalities included in the survey were Akron, Ohio; Baltimore, Md.; Chicago, Ill.; Cincinnati, Ohio; Cleveland, Ohio; Columbus, Ohio; Detroit, Mich.; Indianapolis, Ind.; and Louisville, Kentucky. All of the facilities practiced dewatering with vacuum filtration and used organic polymers in one or more treatment applications.

The agenda of each meeting consisted of first interviewing the plant superintendent or operations chief and discussing with him topics outlined on the survey sheet (Appendix D). Contiguous to this discussion would be a mutual exchange of ideas concerning new treatment methods and successful polymer applications in other plants. Afterwards, a trip through the sludge processing building was made and the following

STLCOPCB4050534

items observed: type and number of filters, polymer dilution tanks, polymer storage facilities, method of handling, geometry of sludge conditioning tank, degree of sludge flocculation, quality of cake resulting from present polymer usage, method of sludge concentrating before dewatering, if any, and method of final cake disposal.

Finally, laboratory dewatering tests were performed using the particular sludge type encountered at each plant. Polymers taken included RPC-926, HMD/DCE 0.98 and 0.99, and the anionic polymer A-23. Similar procedures were used during the plant tests as during previous studies. Generally, a potential customer requires that either Buchner funnel or leaf filter tests on plant sludges be conducted in order that the feasibility of proceeding with a preliminary plant trial can be determined. A typical procedure used by many municipalities in accepting a polymer supplier as a qualified bidder is included in the appendix (Appendix F). As stated, any preliminary trial, if successful, will usually be succeeded by extensive testing in which the customer purchases a specified supply of polymer.

Table 10 summarizes the field survey information. Each topic is discussed separately below.

Flow Rate. The total flow rate equaled 2398 MGD and represented 48% of the total sewage flow reported for all surveyed cities. The flow rates varied from 350 MGD (Chicago) to 80 MGD (Akron and Louisville) with 260 MGD being average.

Treatment Type. Six of the nine facilities had secondary treatment, activated sludge aeration or trickling filters, while only primary sedimentation and sludge disposal were used at the other three. All plants having primary treatment were planning on the installation of secondary units by 1974. The city of Chicago has the most diversified group of treatment processes including the anaerobic digestion of waste activated sludge, vacuum filtration followed by sludge heat drying, Imhoff settling followed by drying beds, and the wet air oxidation of primary sludge using the Zimpro® method.

The Zimpro® process of sludge oxidation is being used not only at Chicago but also at Akron, Ohio and is in the design stage or being considered for installation at Columbus, Ohio and Cincinnati, Ohio. Basically, the process chemically oxidizes waste sludge organic solids

STLCOPCB4050535

Table 10 Summary of Field Survey

LOCATION	FLOW RATE	TYPE OF TREATMENT	SLUDGE TYPE	MONTHLY TONNAGE	POLYMER APPLICATION	TYPE OF CONTRACT	PRESENT POLYMER	CHEMICAL COST	TOTAL ANNUAL CONTRACT	FUTURE POLYMER APPLICATION	ESTIMATED FUTURE* CONTRACT
Akron, Ohio	80 MGD	Secondary w/digesters and incineration. Future: Zimpro process w/dewatering of primary and oxidized sludge.	40% Raw 60% Digested & Act. Sludge	1,000	Dewatering w/single cationic	Performance (needs) --July 1--	Hercules 810 (powdered) $0.90/lb. cationic material	$4.40 /dry ton	$37,000	Primary flocculation using Nalco anionic at 0.5ppm.	(C)$40000 (A)126000 $166000
Baltimore, Maryland	170 MGD	Secondary w/A.S. & T.F. & sludge heat drying. Future expansion to 310MGD w/complete Act. sludge.	Digestion of primary, A.S., & T.F. humus	1,900	Dewatering w/single cationic	Cost --Feb. 3--	Hercules "Hercofloc" 828.1 cationic $1.21/dry ton (liquid)	$3.75 /dry ton	$71,617	Perhaps air flotation of A.S. (requires anionic).	(C)$70000 (A) 15000 $85000
Chicago, Illinois	850 MGD (2 small plants have 400 MGD)	(Secondary) A.S. w/digesters, Imhoff tanks air drying, vac. filtration heat drying, primary sludge Zimpro process (in future, 90% sludge will be used for land reclamation).	Sludge from Imhoff tanks (75-80% sludge from A.S.)	24,000 w/3,900 from Imhoff tanks	Treatment of Imhoff sludge before air drying (use $FeCl_3$ for sludge filtration	Cost (present enough polymer for 2 years	Hercules "Hercofloc" 210 cationic 0.5 lbs/ton & $1.75/lb.	$0.88 /dry ton	$41,518	1) Imhoff sludge 2) II clarification 3) PO_4 removal w/Alum & Dow A-23(?)	Greater than $50,000
Cincinnati, Ohio	100 MGD	Primary clarification w/ digesters. (Secondary treatment by 1974) Sludge incineration after filtration.	Digested & raw sludge	1,500	Dewatering w/single cationic polymer	Cost/Performance --Nov 1--	Calgon 2650 (powdered) cationic 1.6 lbs/ton & $1.25/lb.	$2.00 /dry ton	$36,500	Will use heat treatment of sludge w/hope of no polymer usage	$30,000
Cleveland, Ohio	160 MGD (in future 320 MGD)	Secondary activated sludge w/digesters & Imhoff tanks. Future: Tertiary treatment using phys-chem treatment. 320 MGD to primary clarification 160 aerated secondary clarifiers 160 ammonia rem. carbon columes Bed filtration disinfection.	Dewatering of waste activated & digested sludge w/$FeCl_3$ & lime $2/dry ton	4,050 to filters	Treatment of Imhoff tank supernatant before pri. clarification 1ppm 2MGD	Cost-- buy when needed	Calgon 2630 (powdered) cationic	$6.00 /MG	$5,000	Primary flocculation w/anionic polymer Possible change to polymer dewatering	$400000 (0.5ppm to 250MGD $120000 $520000
Columbus, Ohio Jackson Pike & Southerly Plants	120 MGD	Secondary treatment w/A.S. & digesters, sludge incineration. Future: design for low pressure oxidation of 32 ton/day sludge w/elimination of digesters.	Mixed (1:1) primary & waste activated --digested.	1,830	Dewatering of sludge w/single cationic polymer	Performance --Feb 18--	Dow SA-1938 Liquid C-41	Jackson- $8.25 /dry ton Southerly $13.40 /dry ton	$93,348 146,730 $240,000	1) Possible dewatering of primary + Zimpro treated sludge. 2) Use of anionic for air floting of A.S.	C)$120000 A) 10000 $130000

*Year Estimated: 1976

DSW 176649

STLCOPCB4050536

Table 10 (con't)

LOCATION	RATE	TYPE OF TREATMENT	SLUDGE TYPE	MONTHLY TONNAGE	POLYMER APPLICATION	TYPE OF CONTRACT	PRESENT POLYMER	CHEMICAL COST	TOTAL ANNUAL CONTRACT	FUTURE POLYMER APPLICATION	ESTIMATED FUTURE* CONTRACT
Detroit, Michigan	700 MGD	Primary w/Secondary planned for 1974, sludge incineration. Also planned PO_4 removal using "pickle liquor" ($FeCl_3$) and anionic polymer.	Primary sludge	5400 MGD	Sludge dewatering w/anionic polymer	Performance --July 1-	Dow "Purifloc" A-23 anionic (powdered) $1.25/lb.	$1.35 /dry ton	$91,323	1) Treatment of primary sludge. 2) Perhaps air flotation of A.S. 3) PO_4 removal w/anionic in primary clarification	C)$134000 A) 10000 A) 800000 $944,000
Indianipolis, Indiana	135 MGD	Secondary treatment w/A.S. & dissolved air flotation, sludge incineration.	Mixed primary and A.S. after air flotation (25% A.S. & 75% primary)	5100 MGD	Anionic polymer used at 1 lb/dry ton in air flotation unit & cationic polymer at 12 lb/dry ton used in sludge filtration	Cost	Anionic: Calgon WT3000 Cationic: Calgon WT2870	$10.50	Anionic: $70,000 Cationic: 500,000 $570,000	Same as present	$600000 to $700000
Louisville, Kentucky	80 MGD	Primary w/digesters. Future A.S. w/dissolved air flotation. Considering Unox oxygenation system.	Digested after thickening	600 (5-day filtering	Anionic polymer used in thickening and cationic material used in dewatering	None, order as needed	Anionic: Nalco 2339 Cationic: Calgon WT2630 (both powder)	$2.75	Anionic: $5400 Cationic: $14400 $20,000	1) Sludge dewatering of mixed primary & A.S. 2) Anionic polymer in air floting	$120,000 10,000 $130,000
TOTALS	2398 MGD			25280 MGD					$1,112,958		$2,705000

*Estimated Year: 1976

Table 10a Company Distribution of Polymer Contracts

COMPANY	Number of Contracts	Percent of Total Number	Percent of Total Value
Hercules	3	33	13.5
Dow	2	22	29.8
Calgon	3.5	39	56.2
Nalco	0.5	6	0.5
		100%	100%

DSW 176650

STLCOPCB4050537

in an aqueous phase by dissolved oxygen in a specially designed reactor at elevated temperatures and pressures (see Figure XI). It is reported that the resulting solids exhibit such qualities as sterility, biological stability, settleability and drainability which make the end products suitable for ultimate disposal, including dewatering, without requiring chemical conditioners.

Two cities, Louisville and Detroit, are now undergoing extensive pilot plant studies of secondary units. Louisville is considering either extended activated aeration or Union Carbide's Unox process of waste oxygenation for biological treatment and the dissolved air flotation method of concentrating wasted activated sludge. Detroit, on the other hand, has installed a complete pilot secondary unit centered around activated sludge aeration. The unit has capabilities for primary and/or final effluent flocculation with phosphate removal using waste pickle liquor in conjunction with an anionic polymer.

Cleveland, Ohio which at present is under attack by the Environment Protection Agency expects to go to tertiary treatment using both biological and chemical-physical methods. Half the sewage flow will undergo conventional secondary treatment while the other half will be treated by ammonia stripping, carbon columns, and bed filtration.

Sludge Type. Types of sludge encountered include:

1. Primary
2. Mixed w/primary sludge and digested activated sludge
3. Mixed w/primary, digested primary, and waste activated sludge
4. Concentrated sludge from dissolved air flotation unit
5. Digested primary sludge
6. Mixed w/primary plus air floated waste activated sludge
7. Imhoff sludge.

Optimum chemical conditioning will vary with the type of sludge and degree of industrial waste content in the influent sewage. Generally, the most difficult sludges to dewater are those of a more biological nature (i.e., waste activated) or those originating from a highly industrialized waste (soluble organics tend to exert a high polymer demand).

STLCOPCB4050538

Cake Tonnage. The total amount of cake produced by the filters was 25,280 tons/month, or 303,360/year. The greatest production conditioned with polymer was in Detroit and Indianapolis, 5400 and 5100 tons/month, respectively.

Polymer Applications. Generally, polymers, both cationic and anionic, were being used in two areas, sewage concentration and sludge dewatering. The following table lists the various applications.

Area	Application	Polymer Type
sewage concentration	sludge thickening	anionic
	clarification of Imhoff supernatant	cationic
	dissolved air flotation	anionic
	primary flocculation	anionic
sludge dewatering	vacuum filtration	cationic
	vacuum filtration	cationic/anionic
	vacuum filtration	anionic

Considering future applications, there was not expected to be any significant changes except for the increased usage of anionic materials in dissolved air flotation and primary flocculation to aid BOD, suspended solids, and phosphate removal. With the addition of biological oxidation to treatment facilities resulting in an increased production of biological sludge which is characteristically lower in solids content (0.5-2.0%) and more difficult to gravity settle, more emphasis will be placed on the use of dissolved air flotation units complete with polymer addition as the method best suited for concentrating such sludges. The trend in primary flocculation aided by polymer addition is quite apparent since Akron, Cleveland and Detroit have all experimentally tested the effect of anionic polymers in sewage flocculation or phosphate removal and have stated that such operations will be included in future treatment.

What effect the Zimpro® process will have on the future polymer market in conditioning sludge is difficult to assess at this time. However, some plant personnel have said that its use will be mainly restricted to the oxidation of secondary sludges which possess a higher organic content. In such cases, the primary sludge produced will still require chemical conditioning even if the oxidized sludge is mixed with it before filtration. Positive effects on the general wastewater polymer market could conceivably stem from: (a) increased usage of sludge concentrating to

DSW 176652

STLCOPCB4050539

decrease the reactor loading and therefore, operating cost, and from (b) greater stress placed on BOD removal in primary sedimentation unit due to the main waste stream.

A Calgon representative in Indianapolis indicated that if the Zimpro® process became extensively used, Calgon could rely on its Polysorb® process being used to decrease excess organic loading caused by effect (b). Also, Zimpro, Inc. has recently introduced its own wastewater reclamation system in which the sewage is first sent through a chemical coagulation step and then to a carbon adsorption system. The activated carbon when spent is, of course, regenerated by wet air oxidation.

Type of Contract. There were found to be three types of polymer contracts with the first two listed below being more prevalent than the last.

a) Cost contract: States that the customer will buy a year's supply of polymer at an established price per pound of material. This type of contract was used to a greater extent since it can allow lower chemical costs as operating efficiency increases. Included in Appendix G is a set of polymer specifications that was supplied by the LeMay Treatment Plant in St. Louis. Their contract is of a cost type.

b) Performance (commonly called "needs") contract: The supplier guarantees to treat the customer's sludge for an established cost/dry ton solids. If the actual cost of treatment exceeds the predetermined cost, the customer has the advantage since he still pays a firm cost for every ton produced.

c) Cost/Performance contract: Supplier establishes a guaranteed cost/dry ton cake and also a firm price per pound of polymer. If actual cost is greater than established cost, the situation is the same as with the "needs" contract. However, if the customer can produce sludge at a lower cost than that established, he only pays the lower or actual cost of treatment based on the price per pound of polymer used.

Commercial Polymers. Table 11 lists the polymers, both cationic and anionic, used in the various facilities visited. All of these cationic materials are very high molecular weight in relation to such polymers as RPC-926, Dow C-31 or Calgon 266 and were being used either in single systems or in the cationic conditioning of sludge which had been previously concentrated with an anionic polymer (indirect dual-polymer system). Also a majority of the materials were shipped in powdered form. One of the products which we received in the CRD laboratory, C-41 (formerly SA-1938), seemed to possess extremely high molecular weight when considering its high viscosity characteristic at 4.7% solids content.

DSW 176653

STLCOPCB4050540

Table 11. Commercial Polymers Used in Field Locations

Polymer Type	Supplier	Name	Form	Price ($/lb. dry)
Cationic	Hercules	Reten 810	pow.	0.90
	Hercules	Hercofloc 828	15% liq.	1.21
	Hercules	Reten 210	pow.	1.75
	Calgon	WT-2650	pow.	1.25
	Calgon	WT-2630	pow.	≈ 1.00
	Calgon	WT-2870	liquid	?
	Dow	C-41 (SA-1938)	liquid	?
Anionic	Dow	Purifloc A-23	pow.	1.25
	Calgon	WT-3000	pow.	?
	Nalco	2339	pow.	?

DSW 176654

STLCOPCB4050541

Chemical Costs. Chemical costs associated with sludge conditioning plus any prior concentration (air flotation or gravity thickening) ranged from $13.40/dry ton to $1.39/dry ton cake. Columbus, Ohio and Indianapolis, Indiana reported the highest costs, $13.40 and $8.25 for the Jackson Pike and Southerly plants in Columbus and $10.50 for Indianapolis. As would be expected, the most difficult sludge types were also attributed by the areas. The Indianapolis sludge was a mixture of primary and waste activated which had undergone air flotation and consisted of a high organic content. On the other hand, sludge from Columbus consisted of a combination of primary sludge and mixed digested and waste-activated sludge. Generally, the average costs incurred were $3.00-$5.00/dry ton.

Annual Contract Value. The contract value is a function of the average treatment costs and cake tonnage produced during the year. The highest contracts were awarded by Indianapolis ($570,000) and Columbus ($240,000). The total value of all contracts was e timated to be $1,113,000 with approximately 85% represen ing cationic polymer costs. The future market for these locations was crudely estimated to be $2,705,000 by 1976. This figure is dependent upon the facilities completing their expanding schedules by 1974, the year designated by the EPA for completion of secondary treatment. These projections show an increase of 145% in future polymer usage with a substantial portion of the increase due to increased usage of flocculants in primary flocculation. For example, of the total 1976 market, Table 10 shows approxima tely 50% usage being attributed by anionic polymers; at present, they represent 15%.

The distribution of contracts to specific suppliers is illustrated in Table 10(a). Calgon is first with 39% of the number which depicts 56% of the total contract value (equal to combined value f Dow's and Hercules' contracts).

STLCOPCB4050542

Figures XII through XVI are filtration performance graphs of various treatment combinations applied during laboratory tests at five of the treatment plants. Shown is the performance, as measured by quantity of filtrate collected in two minutes' time, corresponding to polymer dosage levels. The cost figures above some bar graphs can be compared with the present chemical cost shown below each figure title. These costs were estimated by first determining the proper treatment level and then using the following equations for calculations.

A. $\frac{\text{Dosage level (mg/L)(2000 lb/ton)}}{\text{(mg of sludge in 1 liter sample)}}$ = lb. polymer/dry ton of solids

B. (lb. polymer/dry ton solids) polymer price ($/lb.) = Estimated Cost/dry ton ($/dry ton)

Figures XII and XIII indicate two significant items of interest:

(a) Sludges varying in composition and origin exhibit different demands for different polymers. The Columbus, Ohio sludge could be better conditioned with RPC-926 than with either HMD 98 or 99, whereas the opposite was true when dewatering the Indianapolis sludge; the HMD's were superior to RPC-926.

(b) Even though RPC-926 and the HMD series could not alone compete against the higher molecular weight treatments in cost, the use of an anionic material in conjunction with the cationic could possibly lower present treatment costs (e. g., treatment Nos. 3 and 2 on Figures XII and XIII, respectively).

The sludge dewatered at Louisville (Figure XIV) was highly dependent on the anionic dosage level as indicated by treatments 1, 3, 4, 5, and 7. The sludge handling method used consists of dosing the sludge with one half lb. per dry ton (25 mg/L) of anionic polymer in order to thicken it before being sent to the fitters where cationic polymer is added. Based on laboratory results, the sludge seemed to have an anionic demand in excess of this 25 mg/L, and therefore, could possibly be treated at less cost using a dual system at the conditioning box.

Before the last two visits to Cincinnati and Baltimore, we received another polymer similar to RPC-926 except that the origin of the still bottoms was Pensacola, Florida and the solids content was 15%. The new RPC compound was designated Baxley No. 1 RPC-926 while the old compound was changed to RPC-926A (Baxley No. 2). Figures XV and XVI illustrate the better performance (approximately 10%) achieved by RPC-926 compared with RPC-926A. The new polymer also outperformed the HMD compounds (98 and 99). The higher efficiency associated with the higher molecular weight compounds is indicated by comparing treatment No. 2 (500 mg/L RPC-926) with treatment No. 8 (150 mg/L Calgon 565) in Figure XV.

As discussed, polymers function on most part by charge neutralization and polymer bridging. This bridging mechanism, upon which most of the presently used cationic materials seem to rely, interferes with the free movement of the sludge particles by particle adsorption and mutual bridging and is thus critically dependent upon polymeric molecular weight (Ref. 10). In short, the HMH cationics possess the charge characteristic of RPC-926 and the extended bridging mechanism associated with anionic materials.

FINAL TREATMENT PLANT TESTING

Cincinnati Polymer Test. During March 23-26, 1971 filtration tests were conducted at the Mill Creek Treatment Works in Cincinnati, Ohio. The facility treats an average of 100 MDG with primary sedimentation and anaerobic digestion. The resulting sludge, a mixture of primary and digested, is dewatered on Eimco belt and Kromline-Sanderson string filters. Their present polymer contract with Calgon is valued at $36,500/year.

The trial consisted of comparative parallel operation between Monsanto RPC-926 (15% solids) and Calgon's HMW WT-2650 in the cationic conditioning of sludge. Calgon's WT-2650 was mixed by adding a 50-lb. sack of material to a 3000 gallon tank (0.2% solution or 0.0167 lb./gallon). Monsanto's RPC-926, on the other hand, was diluted in 900-gallon tanks installed especially for such purposes. Three drums

STLCOPCB4050544

of 15% polymer were added per batch resulting in a 2.84% solution, each inch of tank height representing 4.27 lbs. of dry polymer. Incremental readings of inches of polymer used, polymer flow rate, and cake tonnage were used in calculating the detailed data shown in Appendix H. Also in that appendix are listed figures relating influent sludge solids, filtrate solids, and filter yield.

A summary of filter operation is shown in Table 12. The cost of chemical treatment using RPC-926 was approximately 44% higher ($.96/dry ton) than that reported using WT-2650 ($1.65). However, the cake resulting from RPC-926 usage was of better quality (dryness and consistency). For example, as the polymer dosage level was decreased, the yield decreased not because of a wetter cake but because of the formation of a thinner cake of similar dryness. Using the Calgon product, a similar decrease resulted in a wetter cake of identical thickness. During the latter portion of the trial, the filter yield was increased by manipulating the drum speed and vat sludge level. These parameters are mentioned since familiarity with RPC-926 and the optimum operating conditions using the product all promote greater efficiency in polymer conditioning.

In this facility the use of two polymers probably would have been able to reduce costs to between $2.75 and $1.75/dry ton. However, if a supplier cannot achieve at least 10-15% lower costs at a similar performance level using a dual system, the customer would probably not, and rightly so, alter his present system. Of course, the situation could occur where a change might be economically feasible, but the current supplier does not recommend it because of decreased polymer sales (especially under cost contract conditions).

Detroit Polymer Test. During the week of March 29, 1971, the full scale testing of Monsanto's RPC-926 cationic polymer was scheduled at the municipal waste treatment facility in Detroit, Michigan. However, after filter operation on Monday, March 29, the trial was terminated by Monsanto when results indicated that sludge dewatering using RPC-926 at that facility could not be performed in an economical manner.

The Detroit plant, treating a combination of industrial and municipal waste averaging 700 MGD, includes primary treatment with twelve (12) vacuum filtration units and sludge incineration. Their

DSW 176658

STLCOPCB4050545

Table 12. Summary Sheet
Polymer Trial at Cincinnati, Ohio
March 23-26, 1971

	3/23	3/24	3/25	3/26*	Total/ Avg.
Monsanto RPC-926 @ $0.35/lb					
Dry cake production (tons)	14.0	38.4	43.4	7.5	103.3
Polymer usage (dry lbs.)	123.8	291.0	337.3	72.6	824.7
Polymer usage (lbs/dry ton cake)	8.80	7.58	7.77	9.68	8.46
Chemical cost ($/dry ton cake)	$3.08	$2.65	$2.72	$3.39	$2.96
**Calgon Cationic 2650 @ $1.25/lb					
Dry cake production (tons)	--	83.6	34.0	--	117.6
***Polymer usage (dry lbs.)	--	111.1	44.8	--	155.9
Polymer usage (lbs/dry ton cake)	--	1.32	1.31	--	1.32
***Chemical cost ($/dry ton cake)	--	$1.65	$1.65	--	$1.65

* Cost based on $/dry ton of influent sludge for 3/26.
** Dual filter operation
*** Estimated

DSW 176659

STLCOPCB4050546

present polymer contract with Dow Chemical Company includes the use of Purifloc A-23 anionic polymer at a guaranteed cost of $1.39/dry ton sludge produced.

The unsatisfactory performance of Monsanto's polymer at Detroit can be attributed, we believe, to the two following characteristics of the sludge and filter geometry:

1. The plant's influent wasteflow contains a high concentration of waste pickle liquor (10 ppm Fe) from the surrounding steel industry with the resultant sewage sludge being slightly cationic. This characteristic accounts for Dow's usage of the anionic A-23 which will, under such conditions, coagulate the sludge particles more effectively than the cationic RPC-926.

2. The pump transporting sludge to the conditioning unit at a minimum flow rate of 75-80 gpm delivered an amount of material in excess of that which could be filtered using RPC-926 under the condition previously discussed. As a result, excess treated sludge had to be wasted in order that the proper vat sludge level could be maintained.

Treatment costs incurred by Monsanto during the limited filter operation approached $6.50/dry ton of sludge solids. Comparing this cost with Detroit's present chemical cost of $2.00-$2.25/dry ton solids and the contract cost of $1.39/dry ton, we felt the polymer's performance could not economically justify continuance of the trial.

ESTIMATED POLYMER MARKET

Of the total present population of 210 $\overline{M}$ people in the United States, approximately 62% live in areas which are sewered and are treating their waste water in some manner. The other segment either do not have sewered outlets or are discharging raw sewage into natural water systems. Of the population connected to sewer lines, 93.2% are discharging treated sewage, 65.8% having secondary treatment, and 34.2% being represented by primary or less waste treatment.(11) A further breakdown into types of primary and secondary treatment and percent of treated population attributed to each is given in Table 13.

STLCOPCB4050547

Table 13. Distribution of Primary and Secondary Treatment in United States*

	Percent of Estimated Population Served
A. Primary Treatment	
Septic tanks	1.5
Imhoff tanks	6.2
Mechanically clean tanks	85.0
Others and unknown	7.3
B. Secondary Treatment	
Activated	45
Extended aeration	3.2
Trickling filters:	
standard rate	14.0
high rate	19.2
Intermittent sand	0.4
Application to land	0.5
Stabilization ponds	7.1
Others and unknown	10.6

* 1968 Inventory of Municipal Waste Facilities (11)

DSW 176661

STLCOPCB4050548

McCarty(1) has estimated that in 1971, 101 MGD and 10 MGD of sludge will be produced in secondary and primary facilities, respectively. He also illustrated that by 1980 these figures will have increased to 139 MGD of secondary sludge and 12 MGD of primary sludge. The potential market for chemicals used in concentrating this tremendous sludge volume is apparent.

Future applications of synthetic polymers will encompass almost every area of water and wastewater treatment. Table 14 lists a number of areas in which polymer usage should make a significant impact in future years. Many of the applications listed have been practiced for several years whereas others will not flourish until governmental action requires the absolute adequate treatment of all wastewaters flowing into this nation's rivers and lakes. Mr. F. H. Siegely of American Cyanamid Company, in a meeting of the Chemical Marketing Research Association, estimated the present polymer market in the water and wastewater field to be $20 $\bar{M}$ - $25 $\bar{M}$/yr. and the annual growth rate of organic coagulates to average 10-12% through 1976. (12) Table 15 shows the estimates stated by him and the projected market in 1976. Mr. Siegely in his discussion considers that segment of the market attributed by usage of polymeric chemicals in wastewater flocculation as representing $12.5 $\bar{M}$/yr. ($11 $\bar{M}$ industrial and $1.5 $\bar{M}$ municipal). The reason for this lag in municipal usage has been stated in one article as being the unavailability of federal funds for operating expenses which include chemical usage. (13) It estimates the biggest potential market to be in the clarification of primary waste streams. The authors are in complete agreement.

PATENT STATUS

It is believed that there is no patentable subject matter discussed in the area nor are we aware of any patent problems connected with the practice of this subject matter.

DSW 176662

STLCOPCB4050549

Table 14. Polymer Applications in Water and Wastewater Treatment

Cationic Polymers

A. Sludge dewatering
   1. Vacuum filtration
   2. Centrifugation
   3. Pressure filtration

B. Water clarification
   1. Filter aid
   2. Primary coagulant
   3. Secondary coagulant

C. Industrial wastewater clarification

D. Sludge thickening

E. Turbidity removal in natural water system

Anionic Polymers

A. Sludge dewatering

B. Water clarification as secondary coagulants

C. Sludge thickening

D. Dissolved air flotation

E. Primary flocculation for enhancement of BOD, suspended solids and phosphate removal

Table 15. *Estimated Polymer Market: 1970 vs. 1976

	Polymer Market (Million $)	
	1970	1976
Inorganic Coagulants in Water Treatment	35	45.5
Organic Coagulants in Water Treatment	23	43
A. Water Clarification		
1. Industrial	11	20
2. Municipal	1.5	4
B. Dewatering		
1. Industrial	1.5	4
2. Municipal	9	15

* F. H. Siegely, presented at the meeting of the Chemical Marketing Research Association in Chicago, Illinois (12)

DSW 176664

STLCOPCB4050551

REFERENCES

1. Perry C. McCarty, "Sludge Concentration - Needs, Accomplishments and Future Goals," Journal WPCF, Vol. 38, No. 4 (April 1966).

2. R. S. Burd, A Study of Sludge Handling and Disposal, Publication No. WP-20-4, FWPCA, U.S. Department of the Interior (May 1968).

3. WPCF Manual of Practice No. 20, Sludge Dewatering, Water Pollution Control Federation, Washington, D.C. (1969).

4. Victor K. La Mer and Thomas W. Healy, "Adsorption-Flocculation Reactions of Macromolecules of the Solid-Liquid Interface," Rev. of Pure and Applied Chemistry, Vol. 13, No. 3 (September 1963).

5. Mark W. Tenney, et al., "Chemical Conditioning of Biological Sludges for Vacuum Filtration," Journal WPCF, Vol. 42, No. 2 (February 1970).

6. Stanley J. Mogelnicki, "Experiences in Polymer Applications to Several Solids-Liquids Separation Processes," Proc. 10th San. Engr. Conf., Univ. of Illinois Bulletin, Vol. 65, No. 115 (1968).

7. Anon., "Synthetic Water Clarifier Clears Major Hurdle," Chemical & Engineering News, August 31, 1970.

8. "Sludge Conditioning Without Chemicals," Bulletin, Catalog No. 2130, Zimpro Inc., Rothschild, Wis. (1971).

9. Standard Methods for the Examination of Water and Wastewater, 12th Ed., APHA, AWWA, WPCF, American Public Health Assoc., Inc. (1965).

10. Wilhelm E. Walles, "Role of Molecular Weight in the Coagulation of Suspensions," Journal of Col. and Interface Science, Vol. 27, No. 4, (August 1968).

11. Kenneth H. Jenkins, Municipal Waste Facilities in the United States, Statistical Summary, 1968 Inventory, FWQA, U.S. Dept. of the Interior, Publication No. CWT-6 (1970).

12. F. H. Siegely, American Cyanamid Co., Chemical Marketing Research Assoc. Conference, Chicago, Ill. (1970).

13. Anon., "U.S. Cleanup Funds: Boost for Polyelectrolytes?"; Chemical Week, March 3, 1971.

DSW 176665

STLCOPCB4050552

ACKNOWLEDGMENTS

The authors wish to acknowledge Mr. J. P. (John) Petrovich, Dr. D. C. (Dave) Taylor and Miss Rita M. Schroeder for the work they performed in bringing this report to its final form.

Dave Taylor and John Petrovich from the Organic Chemicals Division were responsible for the manufacture of the Monsanto polymers that were evaluated and for comments concerning the marketing of those products.

Miss Rita Schroeder spent much time and energy in performing the necessary filtration tests and in preparing a majority of the figures and graphs produced in this report for publication.

DSW 176666

STLCOPCB4050553

APPENDIX

The notebook pages in which the laboratory work for this project are recorded are:

CR 709501 - 709551

A. Filtration Data Sheet

B. Kansas City Polymer Sheets

C. St. Louis Test Data

D. Polymer Treatment Survey Sheets

E. List of Surveyed Municipal Waste Treatment Facilities Using Vacuum Filtration

F. Procedure for Bidder Acceptance

G. Polymer Contract Specifications

H. Cincinnati Polymer Test Data

STLCOPCB4050554

SAMPLE IDENTIFICATION NO. : _____

APPENDIX A.

FILTRATION DATA SHEET

MONSANTO CO.
CRP
DATE : _____

POLYMER APPLICATION : CAT- _____ AN- _____
SLUDGE TYPE : _____
SAMPLE VOLUME : _____
APPLIED VACCUM : _____
FILTER APPARATUS : _____

INITIAL SLUDGE SOLIDS : _____
% FILTER MAT SOLIDS : _____

LBS. CATIONIC POLYMER / TON OF DRY SOLIDS : _____
LBS. ANIONIC POLYMER / TON OF DRY SOLIDS : _____

FILTRATION TIME (MIN)	VOLUME FILTRATE (ML)
1/2	
1	
1 1/2	
2	
2 1/2	
3	
3 1/2	
4	
5	
7	
10	

REMARKS : _____

DSW 176668

STLCOPCB4050555

COST DATA

APPENDIX B.
POLYMER & TONNAGE RECORD

Date: 12/8/70
Shift: 1st

Polymer: CATIONIC: Hercofloc 828.1 #0.279/lb
ANIONIC: Magnifloc 835-A #1.36/lb

TIME	DRY TONS	CATIONIC IN./HR	CATIONIC LBS./TON	ANIONIC IN/HR	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
7 AM	1.8	4	8.9	1½	0.21	#2.48	#0.29	#2.77
6 "	2.12	5½	10.4	2	0.24	2.90	#0.33	3.23
5 "	1.0	5½	22.0	2	0.50	6.14	0.68	6.82
4 "	1.95	6	12.31	2	0.26	3.43	0.35	3.78
3 "	1.6	4½	11.25	2	0.31	3.14	0.42	3.56
2 "	1.6	5½	13.75	1¾	0.27	3.84	0.37	4.21
1 AM	1.10	3½	8.29	2	0.29	2.30	0.39	2.69
12 AM	1.10	XXXXX	XXXXX	3	0.44	XXXX	0.60	XXXXX
AVG.			12.41		0.32	#3.46	#0.44	#3.90

Remarks: _____

Polymer: CATIONIC: Monsanto 926
ANIONIC: Magnifloc 835-A #1.36/lb

TIME	DRY TONS	CATIONIC in/hr.	CATIONIC lbs/TON	ANIONIC in/hr.	ANIONIC lbs/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
7 AM	1.82	4¼	13.7	2¾	0.38	#2.08	#0.52	#2.60
6 "	2.03	7	2.5	3¾	0.46	3.07	0.62	3.69
5 "	1.90	7	21.7	4¼	0.56	3.28	0.76	4.04
4 "	1.80	5	16.5	4¼	0.59	2.48	0.82	3.29
3 "	1.69	5	17.6	4	0.59	2.64	0.82	3.46
2 AM	1.69	7	24.6	4	0.59	3.69	0.82	4.51
1 AM	1.82	6½	21.2	1	0.14	3.18	0.19	3.37
12 AM	1.82	6½	21.2	4¼	0.58	3.18	0.79	3.97
AVG.			19.67		0.47		#0.67	

Remarks: _____

Plant Site: _____

DSW 176669

STLCOPCB4050556

Appendix B (Cont)

POLYMER & TONNAGE RECORD

Date: 12/8/70

Shift: 2nd

Polymer: CATIONIC: Hercofloc 828

ANIONIC: Magnifloc 835A

TIME	DRY TONS	CATIONIC IN./HR	CATIONIC LBS./TON	ANIONIC IN/HR	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
3 pm	1.90	5	10.53	2½	0.33	#2.94	#0.45	3.39
2	1.90	—	—	3	0.39	—	0.53	—
1	1.60	6¼	15.60	3	0.47	4.35	0.64	4.99
12N	1.56	5¾	14.74	—	—	4.11	—	—
11	1.70	6¼	14.70	2	0.29	4.10	0.39	4.49
10	2.12	7½	14.15	2¼	0.27	3.95	0.37	4.32
9	1.6	4¼	10.62	4¼	0.66	2.96	0.89	3.85
8 AM	1.17	5¼	17.95	1¾	0.37	5.01	0.50	5.51
Avg			14.04		0.40	#3.92	#0.54	#4.46

Remarks: _____

Polymer: CATIONIC: Monsanto 926

ANIONIC: Magnifloc 835A

TIME	DRY TONS	CATIONIC in/hr.	CATIONIC LBS/TON	ANIONIC in/hr.	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
3 pm	2 0.68	3¾	—	3¼	—	—	—	—
2	0.95	2	12.50	2	0.52	1.87	0.71	2.58
1	1.49	3¼	12.95	4¾	0.80	1.94	1.09	3.13
12N	1.62	2¼	8.24	2½	0.38	1.24	0.52	1.76
11	1.76	3¾	12.65	2	0.28	1.90	0.38	2.28
10	2.02	3¼	9.55	3½	0.40	1.43	0.54	1.97
9	1.76	—	—	4	0.57	—	0.78	—
8 AM	1.4	3	12.72	4¼	0.76	1.91	1.03	2.94
Avg.			11.43		0.53		0.72	

Remarks: _____

Plant Site: _____

DSW 176670

STLCOPCB4050557

Appendix B (Cont)

POLYMER & TONNAGE RECORD

Date: 12/8/70

Shift: 3rd

Polymer: CATIONIC: Hercofloc 828

ANIONIC: Magnifloc 835A

TIME	DRY TONS	CATIONIC IN./HR	CATIONIC LBS./TON	ANIONIC IN/HR	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
11 pm	1.8	5 3/4	12.77	2 1/2	0.35	#3.56	#0.48	4.04
10	1.8	2	4.44	2 1/4	0.31	1.24	0.42	1.66
9	2.1	3 1/4	6.19	3	0.36	1.73	0.49	2.22
8	2.12	4 1/4	8.02	2 1/4	0.26	2.24	0.35	2.59
7	1.80	6	13.33	3	0.42	3.72	0.57	4.29
6	1.92	4 1/4	8.85	2 1/4	0.29	2.47	0.39	2.86
5	1.40	6 1/2	18.57	3	0.53	5.18	0.72	5.90
4 pm	1.56	5 3/4	14.74	2 1/4	0.36	4.11	0.49	4.60
AVG.			1086		0.36	# 3.03	#0.49	#3.52

Remarks: _____

Polymer: CATIONIC: Monsanto 926

ANIONIC: Magnifloc 835-A

TIME	DRY TONS	CATIONIC in/hr.	CATIONIC lbs/TON	ANIONIC in/hr.	ANIONIC lbs/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
11 pm	1.59	2	7.47	3 1/4	0.51	#1.12	#0.69	#1.81
10	1.74	2 1/2	8.53	2 3/4	0.39	1.28	0.53	1.81
9	1.77	3	10.06	2	0.28	1.51	0.38	1.89
8	1.90	3 1/2	7.81	3 3/4	0.49	1.17	0.67	1.84
7	1.54	3	11.56	5	0.81	1.73	1.10	2.83
6	1.80	2 1/2	8.24	4 1/4	0.59	1.24	0.82	206
5	0.68	3 1/2	—?—	4 1/4	—?—	——	——	——
4 pm	1.1	2 1/4	12.14	3 1/4	0.74	1.82	1.00	282
AVG.			9.40		0.54		#0.73	

Remarks: _____

_____

Plant Site: _____

_____

DSW 176671

STLCOPCB4050558

Appendix B (Cont)

POLYMER & TONNAGE RECORD

Date: 12/9/70

Shift: 1st

Polymer: CATIONIC: Hercofloc 828

ANIONIC: 835-A

TIME	DRY TONS	CATIONIC IN./HR	CATIONIC LBS./TON	ANIONIC IN/HR	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
7 AM	1.50	5	13.33	4	0.67	#3.72	#0.91	#4.63
6	1.53	—	—	5	0.82	—	1.11	—
5	1.43	5½	14.54	3	0.52	4.05	0.71	4.76
4	1.98	5	10.10	3¼	0.41	2.82	0.56	3.38
3	1.76	5	11.36	2¾	0.39	3.17	0.53	3.70
2	1.43	5	13.98	2½	044	3.90	0.60	4.50
1 AM	1.9	5¾	12.78	2	0.28	3.56	0.38	3.94
12 M	1.62	6	14.81	2½	0.38	4.13	0.51	4.64
			12.98		0.49	#3.62	#0.67	#4.29

Remarks: _____

Polymer: CATIONIC: Monsanto 926

ANIONIC: 835-A

TIME	DRY TONS	CATIONIC in/hr.	CATIONIC LBS/TON	ANIONIC in/hr.	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
7 AM	1.45	2½	10.23	5¼	0.90	#1.53	1.22	#2.75
6	1.74	2	6.82	4	0.57	1.02	0.77	1.79
5	1.74	2½	8.53	4	0.57	1.28	0.77	2.05
4	2.18	2	5.45	5¼	0.60	0.81	0.82	1.63
3	1.89	2½	7.85	5	0.66	1.18	0.90	2.08
2	1.45	3	12.28	4	0.69	1.84	0.94	2.78
1 AM	1.74	2	6.82	4	0.57	1.02	0.77	1.79
12 M	1.74	2½	8.53	3½	0.50	1.28	0.68	1.96
			8.31		0.56		#0.76	

Remarks: _____

_____

Plant Site: _____

_____

DSW 176672

STLCOPCB4050559

Appendix B (Cont)

POLYMER & TONNAGE RECORD

Date: 12/9/70

Shift: 2nd

Polymer: CATIONIC: Hercoflox 828

ANIONIC: 835 A

TIME	DRY TONS	CATIONIC IN./HR	CATIONIC LBS/TON	ANIONIC IN/HR	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
3 pm	1.80	6 1/2	13.89	4 1/2	0.62	#3.87	#0.84	#4.71
2	1.44	5 1/4	14.58	3 1/2	0.61	4.08	0.83	4.91
1 PM	1.62	—	—	4 1/2	0.69	—	0.94	—
12 N	1.66	—	—	—	—	—	—	—
11	1.50	6	16.00	3 3/4	0.62	4.46	0.84	5.30
10	1.53	5 1/4	13.72	3 1/4	0.53	3.83	0.72	4.55
9	1.60	6 1/4	15.62	4 1/2	0.70	4.36	0.95	5.31
8 AM	1.25	5 1/2	17.6	3 1/2	0.70	4.91	0.95	5.86
AVG			15.23		0.64	#4.25	#0.87	#5.12

Remarks: _____

Polymer: CATIONIC: Monsanto 926

ANIONIC: 835-A

TIME	DRY TONS	CATIONIC in/hr.	CATIONIC lbs/TON	ANIONIC in/hr.	ANIONIC lbs/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
3 pm	—	—	—	—	—	—	—	—
2	1.21	2	969	1 1/4	0.26	#1.45	#0.35	#1.80
1	1.76	4 3/4	15.82	4 1/4	0.60	2.37	0.82	3.19
12 N	1.90	* 3 1/4	10.03	2	0.26	1.50	0.35	1.85
11	1.38	3 5/8	15.40	4 1/2	0.81	2.31	1.10	3.41
10	1.3	3	13.50	3 1/4	0.62	2.02	0.84	2.86
9	1.82	3 1/2	11.28	3 3/4	0.51	1.69	0.69	2.38
8 AM	1.5	1 3/4	6.84	4 3/4	0.79	1.03	1.07	2.10
AVG.			11.79		0.55		#0.75	

Remarks: * 1" = 5.865 lb cationic after 11:00 AM

Plant Site: _____

DSW 176673

STLCOPCB4050560

Appendix B (Cont)
POLYMER & TONNAGE RECORD

Date: 12/9/70
Shift: 3RD

Polymer: CATIONIC: Hercofloc 828
ANIONIC: 835A

TIME	DRY TONS	CATIONIC IN./HR	CATIONIC LBS./TON	ANIONIC IN/HR	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
11pm	1.10	4	14.54	4½	1.02			
10	1.30	3½	10.77	5½	1.06			
9	1.3	4	12.31	3	0.58			
8	1.56	4	10.26	4	0.64			
7	1.40	3½	10.00	4¼	0.76			
6	1.64	4	9.75	3¾	0.57			
5	1.50	7	14.73	6	0.79			
4pm	1.75	5½	12.57	4	0.64			
AVG.			11.89		0.63	#3.31	#0.86	#4.17

Remarks: _____

Polymer: CATIONIC: Monsanto 926
ANIONIC: 835A

TIME	DRY TONS	CATIONIC in/hr.	CATIONIC LBS/TON	ANIONIC in/hr.	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
11pm	1.54	5½	21.20	4	0.65			
10	1.6	6	22.26	4½	0.70			
9	1.69	8¼	24.98	4½	0.66			
8	1.8	6¾	22.26	4½	0.62			
7	1.63	4	14.57	4½	0.69			
6	1.34	4	17.72	4	0.75			
5	1.40	7	29.68	3½	0.62			
4pm	1.2	3½	17.31	2¾	0.57			
AVG.			21.72		0.66	#3.16	#0.90	#4.16

Remarks: _____

Plant Site: _____

DSW 176674

STLCOPCB4050561

Appendix B (Cont)

POLYMER & TONNAGE RECORD

Date: 12/10/70

Shift: 1st

Polymer: CATIONIC: Hercofloc 828

ANIONIC: 835A

TIME	DRY TONS	CATIONIC IN./HR	CATIONIC LBS./TON	ANIONIC IN/HR	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
7 AM	1.76	4 3/4	10.80	4 3/4	0.67			
6	2.1	4 1/4	8.10	5 3/4	0.68			
5	1.62	3 1/2	8.64	4 1/4	0.65			
4	2.0	—	—	4 3/4	0.59			
3	1.62	3 1/2	8.64	4 1/2	0.69			
2	1.70	4 1/2	10.58	5	0.74			
1 AM	1.99	4 3/4	9.56	5 1/2	0.69			
12 M	0.78	3 3/4	(2)	4 1/2	(2)			
			9.39		0.67	#2.62	#0.91	#3.53

Remarks: _____

Polymer: CATIONIC: Monsant 926

ANIONIC: 835-A

TIME	DRY TONS	CATIONIC in/hr.	CATIONIC LBS/TON	ANIONIC in/hr.	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
7 AM	1.88	3 1/4	10.20	4 1/2	0.60			
6	2.10	4	11.24	4 3/4	0.56			
5	1.49	4	15.83	3 3/4	0.63			
4	2.16	4 1/2	12.24	4	0.46			
3	1.89	6 1/2	20.24	4 1/4	0.59			
2	2.10	4	11.24	4	0.48			
1 AM	2.5	—	—	—	—			
12M	0.9	4	(?)26.22	4	(?)1.00			
AVG.			13.51		0.55	#2.03	#0.75	#2.78

Remarks: _____

_____

Plant Site: _____

_____

DSW 176675

STLCOPCB4050562

Appendix B (Cont)

POLYMER & TONNAGE RECORD

Date: 12/10/70

Shift: 2nd

Polymer: CATIONIC: Hercofloc 828

ANIONIC: 835A + @11:00 Hercofloc 846

TIME	DRY TONS	CATIONIC IN./HR	CATIONIC LBS./TON	ANIONIC IN/HR	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
3pm	1.85	5 1/2	11.89	5	0.47			
2	1.66	4 1/2	11.25	5 3/4	0.63			
1	1.93	—	—	4 1/4	0.52			
12N	1.6	3 3/4	9.38	5 1/2	0.60			
11	1.66	3 3/4	7.98	* —	—			
10	1.99	4 1/2	12.50	5 1/4	0.91			
9	1.69	4 1/2	10.65	4 3/4	0.70			
8 AM	1.40	3 1/2	10.00	4 1/2	0.80			
AVG:			10.52			#2.93	#0.66	#3.59

Remarks: * Mixed Hercofloc 846 @ 71b/550 gallons

Polymer: CATIONIC: Monsanto 926

ANIONIC: 835A & Hercofloc 846 @9:00

TIME	DRY TONS	CATIONIC in/hr.	CATIONIC lbs/TON	ANIONIC in/hr.	ANIONIC lbs/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
3pm	2.0	3 1/4	19.09	5 3/4	0.50			
2	2.12	3 3/4	20.78	3 1/2	0.29			
1 pm	1.35	2 1/2	21.75	5	0.65			
12N	1.79	3 1/2	22.00	5	0.99			
11	1.68	* 2 3/4	19.23	3 1/2	0.36			
10	1.98	—	—	* —	—			
9	1.86	3	9.57	4	0.54			
8 AM	1.68	2 1/2	8.83	4	0.59			
AVG:			17.32			#2.60	#0.63	#3.23

Remarks: * Start of 846 application 71b/550 gallons

** Mixed 1 drum of 926 per batch

Plant Site: _____

_____

DSW 176676

STLCOPCB4050563

Appendix B (Cont)

POLYMER & TONNAGE RECORD

- 60 -

Date: 12/10/70

Shift: 3rd

Polymer: CATIONIC: Hercofloc 828

ANIONIC: 846

TIME	DRY TONS	CATIONIC IN./HR	CATIONIC LBS./TON	ANIONIC IN/HR	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
11pm	1.43	5	13.99	2	0.29			
10	1.50	5½	14.10	5¼	0.59			
9	1.4	~~5¼~~	—	4¼	0.53			
8	1.40	5¼	14.38	5½	0.66			
7	1.60	5	12.50	5½	0.60			
6	1.38	4¼	12.32	—	—			
5	1.6	5	12.50	5	0.55			
4pm	1.68	5	11.91	4½	0.47			
			$\bar{x}$ = 13.1		$\bar{x}$ = 0.52	#3.66	#0.65	#4.31

Remarks: _____

Polymer: CATIONIC: Monsanto 926

ANIONIC: Hercofloc 846

TIME	DRY TONS	CATIONIC in/hr.	CATIONIC LBS/TON	ANIONIC in/hr.	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
11pm	1.54	2	7.71	4½	0.51			
10	1.90	—	* —	5	0.46			
9	2.06	2¼	12.96	3¾	0.32			
8	1.89	3½	22.00	4¾	0.44			
7	2.02	3	17.64	5½	0.48			
6	2.02	2¾	16.16	—	—			
5	2.16	3	16.5	4¾	0.38			
4pm	1.80	3½	22.00	4¼	0.41			
			$\bar{x}$ = 16.42		$\bar{x}$ = 0.43	#2.46	#0.54	#3.00

Remarks: * Mixed ½ drum/batch

Plant Site: _____

DSW 176677

STLCOPCB4050564

Appendix B (cont)

POLYMER & TONNAGE RECORD

Date: 12/11/70

Shift: 1st

Polymer: CATIONIC: Hercofloc 828
ANIONIC: Hercofloc 846

TIME	DRY TONS	CATIONIC IN./HR	CATIONIC LBS./TON	ANIONIC IN/HR	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
7 AM	1.80	4 1/4	9.44	4	0.39			
6	1.17	5 1/2	18.80	4 1/2	0.67			
5	1.8	—	—	4 1/2	0.44			
4	1.56	4 1/2	11.54	4 3/4	0.53			
3	1.6	5	12.50	5 1/2	0.60			
2	1.15	3 1/2	12.17	2 1/4	0.34			
1 AM	821	6	11.42	—	—			
12M	1.35	4	11.85	6 3/4	0.88			
			12.53		0.55	#3.50	#0.69	#4.19

Remarks: _____

Polymer: CATIONIC: Monsanto 926
ANIONIC: Hercofloc 846

TIME	DRY TONS	CATIONIC in/hr.	CATIONIC LBS/TON	ANIONIC in/hr.	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
7 AM	1.68	2 1/2	8.83	4 1/4	0.47			
6	1.40	2 3/4	9.92	4 1/2	0.56			
5	1.06	3	16.80	4 1/4	0.74			
4	1.75	3 1/4	11.02	5 1/2	0.55			
3	1.75	3	10.18	4 1/2	0.45			
2	1.43	2 1/2	10.38	—	—			
1 AM	1.89	4	12.56	6	0.55			
12N	1.26	4 1/2	21.20	3 1/2	0.49			
			$\bar{X}$ = 12.61		0.54	#1.89	#0.68	#2.57

Remarks: _____

Plant Site: _____

DSW 176678

Appendix B (Cont)

POLYMER & TONNAGE RECORD

Date: 12/11/70

Shift: 2nd

Polymer: CATIONIC: Hercofloc 828

ANIONIC: " 846

TIME	DRY TONS	CATIONIC IN./HR	CATIONIC LBS./TON	ANIONIC IN/HR	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
9 AM	1.175	4¼	9.71	3¾	0.38 ~~0.45~~			
8 PM	2.002	6½	12.87	5¼	~~0.45~~			
			$\bar{x}$ = 11.29		0.41	#3.15	#0.51	#3.66

Remarks: _____

Polymer: CATIONIC: Monsanto 926

ANIONIC: Hercofloc 846

TIME	DRY TONS	CATIONIC in/hr	CATIONIC LBS/TON	ANIONIC in/hr	ANIONIC LBS/TON	CATIONIC #/TON	ANIONIC #/TON	TOTAL COST #/TON
*								
9 AM	1.40	2¾	11.66	4½	0.56			
8 AM	1.96	3¾	11.36	5	0.45			
			$\bar{x}$ = 11.51		0.50	#1.73	#0.63	#2.36

Remarks: * End of Monsanto 926 Run @ K.C. Plant

Plant Site: _____

DSW 176679

STLCOPCB4050566

Sheet No: 1

POLYMER DOSAGE RECORD

Monsanto Co.
CRD

Date: 1/12/71
Plant: LeMay Treatment Plant - St. Louis, Mo
Polymer Application: RPC-926 vs. Dow C-31 (Anionic A-23)

TIME	POLYMER READING (GPM)	POLYMER READING (INS.)	POLYMER USAGE (gal.)	POLYMER USAGE (lbs.)	SLUDGE (GPM)	POLYMER CONC. (mg/L)	CAKE READING	CAKE PRODUCTION (TONS)	% SOLIDS CAKE	DRY CAKE PRODUCTION (TONS)
RPC-926										
11 AM		65.5	—	—			1050000	—		—
12 N		52.5	60	42.8			068000	9.0		1.71
1 pm		—	—	—			088000	—		—
2		28.7	109.7	78.2			097600	14.8	19.1	2.83
3		17.0	54	38.5			113500	8.0		1.53
3:30pm		11.0	27.7	19.7			120400	3.45		0.66
4:15pm		76	—	—			131200	—		—
5		67	41.5	23.6			141700	5.25	18.4	0.965
7		43	110.8	69.2			169500	13.9		2.56
9 pm		13	138.4	78.9			191000	10.75		1.98
TOT./AVG.				346.0				65.15		12.2
C-31										
9 pm		53	—	—			191000	—		—
11 pm		26/76	124.3	35.6			219500	14.25	18.0	2.56
1 AM		58	83	23.8			249500	15.0		2.70
3 AM		31	124.4	35.6			280500	15.5		2.79
5 AM		72/10	96.8	27.7			306500	13.0	19.0	2.34
7 AM		50	101.3	29.0			335500	14.5		2.61
TOT./AVG.				152.0				72.25		13.0

DSW 176680

STLCOPCB4050567

APPENDIX C.

Sheet No: 2 — POLYMER TREATMENT COSTS — Monsanto Co. CRD

Date: 1/12/71

Location: LeMay Treatment Plant - St Louis, Mo

Polymer: RPC-926 vs. Dow C-31

TIME	POLYMER USAGE (wet lb/dry ton)	(dry lb/dry ton)	TREATMENT COST ¢/dry ton	REMARKS
RPC-926				
11 AM	—	—	—	Start 1st Batch: 25 gal RPC-926 / Batch
12N	25.1	6.27	2.19	
1 pm	27.6	6.90	2.42	
2	—	—	—	
3	25.2	6.30	2.21	
3:30 pm	29.9	7.47	2.61	
4:15 pm	—	—	—	Start 2nd Batch: 20 gal. RPC-926 / Batch
5	24.5	6.12	2.14	
7	25.1	6.27	2.20	
9 pm	39.6	9.90	3.46	
TOT/AVG	28.4	7.12	¢2.49	Cost based on ¢0.35/dry lb polymer
C-31				
9 pm	—	—	—	
11 pm	13.93	6.67	3.06	
1 AM	8.90	4.27	1.95	
3	12.8	6.15	2.81	
5	11.8	5.66	2.59	
7 AM	11.1	5.33	2.44	
TOT/AVG	11.69	5.61	¢2.57	Cost based on ¢0.458/dry lb of C-31

DSW 176681

STLCOPCB4050568

Monsanto Co.
CRD

APPENDIX D

POLYMER TREATMENT SURVEY

DATE: _____

GENERAL:

TREATMENT PLANT: _____
LOCATION: _____
ADDRESS: _____
SUPERINTENDENT: _____

OPERATION:

TYPE of TREATMENT: _____
_____
TYPE of WASTE INFLUENT: _____
RAW SEWAGE FLOW: _____
NUMBER of VACUUM FILTERS: _____
SOURCE of FILTERED SLUDGE: _____
TYPE FILTERS & MEDIA: _____
% SOLIDS of CAKE: _____
" " RAW SLUDGE: _____
DISPOSAL of SLUDGE CAKE: _____
AVG. DRY TONS / MONTH: _____

POLYMER USAGE:

POLYMERS PRESENTLY USED: Cationic _____
Anionic _____

QUANTITY POLYMER USED (lbs/dry ton): Cationic: _____
Anionic: _____

POLYMER TREATMENT COST (¢/dry ton): _____

EXPERIENCE W/ POLYMERS: _____
_____

DESCRIPTION of MIXING SYSTEM: _____
_____
_____
_____

DSW 176682

STLCOPCB4050569

APPENDIX D

POLYMER SURVEY

POLYMER CONTRACT:

TERMS OF POLYMER CONTRACT: _____

_____

_____

_____

DATE OF CONTRACT RENEWEL: _____

PROCEDURE FOR ACCEPTING BIDS: _____

_____

_____

_____

TYPICAL No. OF BIDS RECEIVED: _____

_____

_____

_____

CABORATORY TESTS:

EQUIPMENT AVAICABLE: _____

_____

TECHNIQUE USED: _____

_____

_____

_____

_____

DSW 176683

REMARKS: _____

_____

_____

_____

APPENDIX E

List of Surveyed Municipal Waste Treatment Facilities Using Vacuum Filtration

State	City	Sewage Flow, mgd.	Class
Colorado	Boulder	7	IV
	Denver	50	III
Connecticut	Bridgeport	20	IV
	Hartford	40	III
	New Britain	14	IV
	New Haven	14	IV
	Stamford	20	IV
Florida	Miami	50	III
	Pensacola	9	IV
	St. Petersburg	10	IV
Georgia	Atlanta	14	IV
	Augusta	12	IV
Illinois	Chicago	1350	I
Indiana	Indianapolis	135	II
Iowa	Council Bluffs	8	IV
	Des Moines	40	III
	Dubuque	10	IV
Kansas	Kansas City	12	IV
Kentucky	Louisville	80	III
Louisiana	New Orleans	180	II
Maryland	Baltimore	170	II
Massachusetts	Boston	343	I
Michigan	Detroit	720	I
	Flint	32	IV
	Grand Rapids	55	III

DSW 176684

STLCOPCB4050571

APPENDIX E (Cont.)

State	City	Sewage Flow, mgd.	Class
Minnesota	Minneapolis	215	I
	Duluth	17	IV
Missouri	Kansas City	70	III
	St. Louis	110	II
Nebraska	Lincoln	20	IV
	Omaha	40	III
No. Carolina	Greensboro	18	IV
Ohio	Akron	80	III
	Columbus	160	II
	Cincinnati	100	II
	Dayton	55	III
	Toledo	82	III
	Cleveland	100	III
Oregon	Portland	100	II
Tennessee	Knoxville	30	IV
Texas	Dallas	120	II
Washington	Seattle	100	II
West Virginia	Huntington	12	IV
Wisconsin	Milwaukee	200	I
		5024	

DSW 176685

STLCOPCB4050572

Columbus, Ohio

PROCEDURE FOR ACCEPTANCE AS A QUALIFIED BIDDER FOR CHEMICALS USED IN CONDITIONING SLUDGE PRIOR TO DEWATERING BY VACUUM FILTERS.

1. LABORATORY BENCH TESTS

Space will be furnished in the laboratories for making Buchner Funnel, leaf filter, or other tests, on plant sludges to determine the flocculating characteristics of chemicals. These tests are for the evaluation by the supplier to determine if it is feasible to make a preliminary plant trial. Appointment for this time should be made in advance.

2. PRELIMINARY PLANT TRIALS

Jackson Pike: Operation of two filters, simultaneously in either, or both, North and South Filter Rooms for a total of not less than ninety six filter hours.

Southerly: Operation of available filters for a total of not less than seventy two filter hours

Data from these tests will be evaluated on the bases of the following parameters:

(a) Filter production in terms of pounds of dry solids per square foot-hour.
(b) Percent moisture in cake.
(c) Estimate of costs per ton of dry solids produced.
(d) Ease of handling, to include solubility, dispensing equipment, accessory polymers or chemicals, etc.

The chemicals used for these preliminary plant trials are to be furnished to the city without costs.

The city will make available the physical equipment and manpower used in the normal current operation of the filter rooms. Any additional equipment, supplies or manpower required for the test will be furnished by the supplier.

It is to the advantage of the supplier to furnish supervision to ensure their product is used properly and best results are obtained.

The decision to proceed with further testing will be determined solely by the city.

A Preliminary Plant trial may be waived under certain circumstances. If in previous plant trials, a chemical has been used and demonstrated to be effective, and the supplier has submitted a competitive bid for the current annual contract no preliminary plant trial may be required.

3. PLANT TRIALS

Chemicals will be purchased from selected suppliers for a trial period in both the Jackson Pike and the Southerly Plants. The amount of chemicals required should be estimated as follows:

DSW 176686

STLCOPCB4050573

Jackson Pike Plant: Using Komline Sanderson coil type and/or Eimco belt type filters, for a total of six hundred and seventy two filter hours, or seven calendar days (four filters).

Southerly Plant: Using Eimco belt type filters for a total of five hundred and four filter hours, or seven calendar days (three filters).

Data pertaining to average volume and dry solids content of sludge pumped to filter rooms will be furnished. Continous operation over twenty four hour day is desirable.

It is necessary to submit a proposal for a plant trial showing the amount and cost of the chemicals to be used. The total costs must include shipping charges, i.e. F.O.B., Columbus. No charges for the trial not shown in the proposal will be paid.

A proposal must be submitted at least eight weeks in advance of trial date to allow sufficient time for approval and processing by the city administration and the council.

Plant trials will be scheduled in three week intervals. The week before the trial should be used in making preparations, such as installing additional equipment, for the run. The third week will be used to exhaust chemical supply, if any, and to dismantle any accessories installed for the period.

Preference for allotting time periods for plant trials will be given to the companies in the order of the lowest bids submitted for the annual contract of the current fiscal year.

In evaluating the lowest and best bid for the annual contract, the parameters listed previously will be used. Data originating from the plant trials period will be used for computations.

Contract for chemicals will cover the period March 1, 1970 to February 29, 1972.
Bid date - January 14, 1971
Last Plant Trial Week - January 3, 1971

METROPOLITAN ST. LOUIS SEWER DISTRICT

SPECIFICATIONS FOR ORGANIC POLYMERS

1. Scope and Purpose - It is the intent of these specifications to request Suppliers of organic polymers to submit proposals for supplying these chemicals and related services as herein described.

2. Eligible Bidder - Before any bid can be accepted, the Supplier selling organic polymers must satisfy the following conditions:

   Item a - The Supplier must conduct a full plant study, providing technical assistance, chemicals and equipment at their expense for a minimum 30-hour period, unless chemical has previously been tested or used at the Lemay or Bissell Point Treatment Plant.

   Item b - The organic polymers must be available in commercial quanitites.

   Item c - The Supplier must satisfactorily complete a 30-day trial period at the Lemay or Bissell Point Treatment Plant, unless chemicals have previously been used at either of the plants. During this trial period, the performance of the organic polymers will be judged by filter yield, cake moisture, ease of operation and filter control, and effects on overall plant operations.

   The Metropolitan St. Louis Sewer District reserves the right to reject any or all bids.

3. Use of Polymers - The organic polymers are to be used for the flocculation or conditioning of primary sewage sludge for vacuum filtration at the Lemay or Bissell Point Treatment Plant and must be suitable for the purpose. Bids will be received for either a single or dual system.

4. Ordering - The organic polymers are to be shipped as ordered by the Metropolitan St. Louis Sewer District.

5. Shipment - The organic polymers are to be shipped by means and at such times as the Executive Director, or his designated representative, may direct. Liquid polymers may be shipped only by tank trucks. Powdered material will be received only in water-proof bags not exceeding 60 pounds each. Orders will be placed for a minimum of 5,000 pounds of powdered material.

DSW 176688

STLCOPCB4050575

6. F.O.B. Lemay or Bissell Point Treatment Plant - The Supplier must prepay freight on tank trucks or trucks at shipping point, as well as all freight on returned empty tank trucks or trucks, thus relieving the Metropolitan St. Louis Sewer District of the payment of any or all freight charges. Any demurrage or special handling charges will be the responsibility of the Supplier.

7. Place of Delivery- The place of delivery shall be the Lemay Treatment Plant, 9200 South Broadway, or Bissell Point Treatment Plant, 10 E. Grand Avenue. Truck deliveries will be accepted only between 8:00 A.M. and 2:00 P.M., Monday through Friday.

8. Defective Delivery Equipment - Defective tank trucks or valves which permit the polymers to escape, or which prevent the polymer from being discharged, shall be rejected. Tank trucks from which polymer cannot be withdrawn, because of defective valves, viscosity, or other reasons shall be returned.

   Damaged bags of dry polymer will be rejected at the time of delivery and the Supplier will be responsible for their return.

9. Service - As an integral part of furnishing the Metropolitan St. Louis Sewer District with polymers, the Supplier will be expected to provide technical assistance to maintain maximum filter yield with a minimum polymer dosage. Technical assistance will also be expected during unusual sludge conditions or other emergency situations directly associated with the polymers. These services are to be provided at no additional cost to the District.

   Metropolitan St. Louis Sewer District reserves the right to terminate the contract upon evidence of failure to provide this service to the satisfaction of the District.

10. Certified Weight - Each load delivered shall have a certified weight statement included with shipment.

11. Samples - The Metropolitan St. Louis Sewer District reserves the right to take such samples and make such tests as it so deems, in order to determine the quality of the polymers delivered.

12. Contract Terms - Bids will be taken for a one-year supply of organic polymers for the purpose of conditioning wastewater sludge.

DSW 176689

STLCOPCB4050576

13. Contract Annulment - The Metropolitan St. Louis Sewer District reserves the right to cancel or annul this contract, upon giving ten (10) days written notice thereof, if the Metropolitan St. Louis Sewer District should be of any of the following opinions:

    a - The polymer being furnished by the Supplier is not proving satisfactory.

    b - The chemical use in pounds per ton of filtered solids has exceeded a reasonable limit above past experience.

    c - The Supplier does not meet the requirements specified as regards the condition of the tank truck or suitable containers.

    d - Objectionable delays in obtaining deliveries are noted, or

    e - The Supplier has failed to provide satisfactory technical assistance.

    The said Supplier shall not be entitled to any claim for damages on account of such annulment, nor shall such annulment affect the right of the Metropolitan St. Louis Sewer District to recover damages which may arise from such failure on the part of the Supplier to fulfill the terms of the contract.

14. Estimated Quantities - Approximately Twenty-Four Thousand (24,000) tons dry solids will be processed during the one year period. The District will not be responsible for claims due to any deductions or additions to this estimated quantity.

15. Use of Existing Plant Equipment - Existing bulk storage tanks, PVC storage lines, and chemical transfer pumps will be used to handle any liquid cationic material. It will be the responsibility of the Supplier to furnish and install at no cost to the District, equipment necessary to transfer cationic material if the existing plant equipment will not handle this material.

16. Continued Testing - During the time this contract is in force, the District plans to continue plant trials of polymers from various Suppliers.

DSW 176690

STLCOPCB4050577

17. Basis of Bids - The Supplier may use his own information to determine the approximate yearly chemical demand for 24,000 dry tons of sludge. The bidder is to note on his proposal sheet the cost per pound of the polymers being offered. This cost is to include prepaid freight, F.O.B. Lemay or Bissell Point Treatment Plant.

18. Bid Evaluation - The bids will be evaluated on a total polymer cost per dry ton of solids along with other important considerations. A dosage rate in pounds of polymer per dry ton of solids filtered will be established by the Executive Director for the evaluation of these bids.

    Other items which will be considered critical in the evaluation include but are not limited to the performance of the organic polymers as judged by filter yield, cake moisture, ease of operation, and controlability of filters and effects on overall plant operations.

19. Prebid Conference - Prior to submitting a bid, the Supplier will be required to meet with representatives of the District for the purpose of review and clarification of the various terms and conditions of the contract. Dates and times for this conference will be arranged by the Supplier with the Executive Director.

20. Completion of Proposal Information - All bidders will provide on their proposal the following information:

    a - Acceptance of all terms of these specifications.

    b - Polymers offered along with complete specifications concerning the polymers.

    c - Cost per pound for polymers offered according to terms of specifications.

    d - List three major waste-water treatment plants which have used your polymer material for at least 90 days.

    e - Delivery time after order placement.

DSW 176691

STLCOPCB4050578

APPENDIX H. Cincinnati Polymer Test Data

The following is a table of test conditions and results:

Type of Filter: Cloth Roto-Belt #6
Type of Cloth: Nylon 50 x 50
Type of Polymer: Monsanto RPC - 926 (Liquid).

	Mar. 23	Mar. 24	Mar. 25	Mar. 26	Tot./Av
Total Solids (Sludge to Filters) %	16.8	16.2	16.3	14.6	16.2
Total Solids (Filter Cake) %	45.6	41.9	43.0	42.5	42.7
Volatile Solids (Filter Cake) %	43.5	46.3	45.0	45.5	
Filtrate Solids (pick-up) ppm	-	-	-	-	-
Filtrate Solids (drying) ppm	-	-	-	-	-
Total dry solids (Sludge to Filters) lbs	18,000	61,000	79,000	15,000	173,000
Polymer Used (lbs.)	132.4	313.9	337.0	72.6	864.0*
Filter Operation (hrs.)	8.0	24.0	24.0	5.0	61.0
Polymer Dosage (%)	0.74	0.51	0.43	0.48	0.50
Yield - lbs/ft^2/hr.	4.5	5.1	6.6	6.0	5.7
Duration of Test					61.0 hours

* Pounds Polymer used was based on 12 drums liquid polymer; 480 lbs./drum and 15% concentration for a total of 72 lbs./drum of dry polymer equivalent.

Grand Total: 864 lbs.

128,000 gallons sludge was filtered during above test.

(1) Summary data supplied by the Operations Division of the Metropolitan Sewer District of Cincinnati.

DSW 176692

STLCOPCB4050579

Sheet No: 1

POLYMER DOSAGE RECORD: APPENDIX H

Monsanto Co.
CRD

Date: 3/23/71

Plant: Cincinnati Ohio Mill Co. Plant — Furnace #3 —

Polymer Application: RPC-926 (15%) [Filter #6] Nylon Cloth Filter Media

TIME	POLYMER READING ~~(GPM)~~ (SETTING)	(INS.)	WET POLYMER USAGE ~~(gal.)~~ (in./hr)	(lbs.) (DRY)	x100 GAL. SLUDGE ~~(GPM)~~	POLYMER CONC. (mg/L)	CAKE READING x 0.01 TONS	CAKE PRODUCTION (TONS)	% SOLIDS CAKE	DRY CAKE PRODUCTION (TONS)
4:00 pm	85%	2"	—	—	675167	—	9380550	—		—
5:00 pm	80%	6½"	4½	128 (19.2)	675187	1150 mg/L	9381043	4.93		2.25
6:00 pm	78%	10½"	4	114 (17.1)	675206	1080	9381506	4.63		2.11
7:00 pm	75%	14"	3½	100 (14.9)	675222	1110	9381844	3.38		1.54
8:00 pm	73%	18"	4	114 (17.1)	675238	1270	9382295	4.51	45.6	2.06
10:00 pm	73%	25	7"	199 (29.9)	675269		———	13.35		6.10
12 M	73%	31"	6"	171 (25.6)	675299		9383630			
TOTALS	—	—	29"	826 (123.8)	—	1135 mg/L	—	30.8	45.6	14.04
(3/24/71)										
2:00 AM	73%	36"	5"	143 (21.3)	675330	880	9384350	7.2		3.02
4:00 AM	76%	40"	4"	114 (17.1)	675359	710	9385010	6.6		2.76
6:00 AM	83%	45"	5"	143 (21.3)	675391	800	9385690	6.8		2.85
7:25 AM	85%	50/-5	5"	143 (21.3)	—		—	—		
8 AM	75%	-3½	1½"	39 (5.8)	675429	855	9386460	7.5		3.14
10 AM	75%	5	8½"	220 (33)	675463	1160	9387280	8.2		3.44
12 N	75%	12	7"	181 (27.2)	675492	1120	9388151	8.71		3.65
1 pm	75%	15¾	3¾"	97 (14.6)	675510	980	9388546	3.95		1.65
2 pm	72%	19"	3¼"	84 (12.6)	675528	840	9388929	3.83	41.9	1.61
3 pm	70%	22¼"	3¼"	84 (12.6)	675546	840	9389298	3.69		1.55
4 pm	70%	25	2¾"	71.5 (10.7)	675564	714	9389641	3.43		1.44
5 pm	66%	27½	2½"	64.7 (9.71)	675581	685	9389966	3.25		1.36
6 pm	60%	29½	2"	51.8 (7.78)	675598	554	9390246	2.80		1.17
7 pm*	85%	31	1½"	38.8 (5.84)	675613	453	9390500	2.54		1.06
8 pm	92%	34⅔	3⅔"	95 (14.2)	675634	815	9390838	3.38		1.42
9 pm	90%	40	5⅓"	137 (20.6)	675661	915	9391273	4.35		1.82

DSW 176693

STLCOPCB4050580

Sheet No: 1

Date: 3/23/71

Location: Cincinnati Ohio Mill Cr. Plant

Polymer: RPC-926 (15%)

POLYMER TREATMENT COSTS: Appendix H

Monsanto Co. CRD

TIME	POLYMER USAGE (wet lb/dry ton)	(dry lb/dry ton)	@ $.35/dry lb TREATMENT COST $/dry ton	REMARKS	SLUDGE SOLIDS (%)	INFLUENT SLUDGE (Gal. per hr.) (GPM)
4:00 pm	—	—	—	Feed No. 1 Batch		—
5:00 pm	56.8	8.53	2.98	Cake to dry	11%	2000 (33 gpm)
6:00 pm	54.0	8.10	2.84	1.75 hr./batch Rate		1900 (31.6)
7:00 pm	65.0	9.67	3.38	Polymer flow Rate = 1.05 gpm		1600 (26.7)
8:00 pm	56.3	8.30	2.91	12.5 hr./batch Rate		1600 (11)
10:00 pm						1600 (26.7)
12 M						1500 (25)
TOTAL (AVG)	58.8	8.80	$3.08/TON	—	16.8%	13,200 GAL
(3/24/71)						
2 AM	47.3	7.05	2.46	Polymer flow rate = 0.75 gpm	10%	1550 (26)
4 AM	41.3	6.20	2.17	" " " = 0.60 gpm	10%	1450 (24)
6 AM	50.2	7.48	2.61	Polymer flow rate = 0.75 gpm	10%	1600 (26.7)
7:25 AM	—	—	—	Change to #2 Batch	10%	
8 AM	58.0	8.62	3.02	Initial Reading (-5)	10%	1900 (31.6)
10 AM	64.0	9.60	3.36	(1" = 3.89 lb of polymer	10%	~~1950~~ 1700 (28.5)
12 N	49.6	7.45	2.61	Good quality cake (dryer)	11%	1450 (24)
1 pm	58.8	8.85	3.10	Polymer flow rate = 1.12 gpm	—	1800 (30)
2 pm	52.2	7.83	2.74	" " " = 0.98 gpm	11%	1800 (30)
3 pm	54.2	8.13	2.84	Polymer Rate = 0.98 gpm		1800 (30)
4 pm	49.7	7.43	2.60	" " = 0.825 gpm	10%	1800 (30)
5 pm	47.6	7.13	2.49	" " = ~~0.60~~ gpm (0.75)		1700 (28.5)
6 pm	44.2	6.65	2.33	" " = 0.60 gpm	10%	1700 (28.5)
7 pm	36.6	5.52	1.93	0.45 gpm polymer rt.		1500 (25)
8 pm	66.9	10.0	3.50	Flow Rate = 1.1 gpm	10%	2100 (35)
9 pm	75.3	11.3	3.90	" " = 1.6 gpm		2700 (45)

DSW 176694

STLCOPCB4050581

Sheet No: 2

POLYMER DOSAGE RECORD

Appendix H

Monsanto Co. CRD

Date: 3/24/71

Plant: Cincinnati, Ohio

Polymer Application: RPC-926 (15% Solids)

TIME	POLYMER READING (~~GPH~~)	POLYMER READING (INS.)	WET POLYMER USAGE (gal.)	WET POLYMER USAGE (lbs.)	x100 GAL. SLUDGE (~~GPH~~)	POLYMER CONC. (mg/L)	CAKE READING x0.01 TONS	CAKE PRODUCTION (TONS)	% SOLIDS CAKE	DRY CAKE PRODUCTION (TONS)
	SETTING		(in/hr.)	(DRY)						
	95	9½								
10 pm	~~9½~~	~~9½~~	9½	116 (17.5)	675687	806 mg/L	9391754	4.81	~~40%~~	2.02
11 pm*	75	50/0	5½	142 (21.3)	675716	880 mg/L	9392264	5.10		2.14
12 M	73	4"	4"	115 (17.1)	675744	731 mg/L	9392794	5.30	~~40%~~	2.22
			73"	1922 (291)				91.64	41.9	38.4 TONS
(3/25/71)										
2 AM	73	12	8"	228 (34.1)	675796	785	9393710	9.16	~~40%~~	3.94
4 AM	74	18	6"	171 (25.6)	675845	628	9394660	9.50	43.0%	4.08
6 AM	76	25	7"	199 (29.8)	675894	610	9395580	9.20	~~40%~~	3.96
8 AM	78	31	6"	171 (25.6)	675940	561	9396440	8.60		3.70
10 AM	80	37	6"	171 (25.6)	675985	682	9397370	9.30	43.0%	4.00
12N	83	43	6"	171 (25.6)	676031	668	9398300	9.30		4.00
2 pm	83	49	6"	171 (25.6)	676077	667				
4	83/73	50/6.5	1/6.5	214 (32)	676130	725	Cake production			
6	73	13.5	7.0	199 (29.9)	676179	732	based on			19.71 tons
8	73	20	6.5	185 (27.7)	676226	708	influent sludge			
10	80	26.5	6.5	185 (27.7)	676273	707	solids			
12 M	82/84	33	6.5	185 (27.7)	676321	694				
			79	2251 (337.3)					43%	43.39 tons
(3/26/71)										
2 a.m	84	40	7	199 (29.9)	676368	762	See above		42.5%	7.5
4 a.m	90	98	8	228 (34.1)	676417	835				
6 AM	90	50	2	57 (8.53)	676440	440				
			17	484 (72.59)					42.5%	7.5 tons

DSW 176695

STLCOPCB4050582

Sheet No: 2
Date: 3/24/71
Location: Cincinnati Mill Cr. Plant, Ohio
Polymer: RPC-926 (15% solids) (Filter #6)

POLYMER TREATMENT COSTS

Appendix H

Monsanto Co. CRD

TIME	POLYMER USAGE (wet lb/dry ton)	(dry lb/dry ton)	TREATMENT COST #/dry ton	REMARKS	SLUDGE SOLIDS (%)	Influent SLUDGE (gph)	(gpm)
10 pm	58.4	8.65	3.02	Flow Rate = 1.35 gpm	10%	2600	43.5
11 pm *	66.4	9.95	3.48	Start Batch #3, 3 dr./900 gal		2900	48.5
12 M	51.8	7.70	2.69	Flow Rate = 1.2 gpm	10%	2800	46.7
	50.1	7.58	#2.65/TON		16.2%		
(3/25/71)							
2 AM	57.9	8.65	3.03	Flow Rate = 1.20 gpm	"	2600	43.5
4 AM	41.9	6.27	2.19			2450	40.8
6 AM	50.3	7.47	2.61	Flow Rate = 1.05 gpm	"	2450	40.8
8 AM	46.2	6.92	2.32			2300	38.4
10 AM	42.7	6.40	2.24	Flow Rate = 0.9 gpm	"	2250	37.6
12 N	42.7	6.40	2.24			2300	38.4
2 pm					"	2300	38.4
4						2650	44.2
6					"	2450	40.8
8	57.83	8.66	#3.03			2350	39.2
10					"	2350	39.2
12 M						2400	40.0
	51.87	7.77	#2.72/TON		16.3%		
(3/26/71)					"		
2 AM	64.5	9.68	#3.39		14.6	2350	39.2
4					"	2450	40.8
6 AM					"	1150	—
	64.5	9.68	#3.39/TON		14.6%		

DSW 176696

STLCOPCB4050583

Sheet No: 1-A

POLYMER DOSAGE RECORD: Appendix H

Monsanto Co. CRD

Date: 3/23/71

Plant: Mill Cr. Plant, Cincinnati, Ohio

Polymer Application: Calgon 2650 Cationic [Filters #3 & 4]

TIME	POLYMER READING (GPM)	POLYMER READING (INS.)	TOTAL POLYMER USAGE (gal.)	TOTAL POLYMER USAGE (lbs.)	TOTAL SLUDGE (GPM) (GALLONS)	POLYMER CONC. (mg/L) lbs/GAL x 10^{-3} x 1.2×10^{2}	CAKE READING	CAKE PRODUCTION (TONS) (TOTAL)	% SOLIDS CAKE	DRY CAKE PRODUCTION (TONS)
4 pm										
6 pm										
8 pm										
10 pm										
12 M							9744630		39.3	
(3/24/71)										
2 AM			543	9.06	7600	143	9746390	17.6		6.75
4 AM			554	9.25	7700	144	9748160	17.7		6.80
6 AM			563	9.40	9000	125	9749900	17.4		6.68
8 AM			560	9.35	7600	148	9751580	16.8		6.45
10 AM			561	9.37	7400	152	9753290	17.1		6.56
12 N			555	9.27	7100	156	9754990	17.0	38.4	6.53
2 pm			556	9.28	7700	145	9756610	16.2		6.22
4 pm			563	9.41	9000	126	9758640	20.3		7.80
6 pm			555	9.45	9100	125	9760623	19.8		7.60
8 pm			557	9.33	9400	119	9762550	19.27		7.40
~~4 pm~~							~~9763400~~	~~19.5~~	—	—
10 pm			550	9.18	9000	122	9764439	18.9		7.26
12 M			537	9.00	9200	117	9766420	20.0		7.68
(3/25/71)			6654	111.12			—	217.9	38.4	83.6
2 AM			559	9.32	9100	123	9768280	18.6		7.16
4 AM			555	9.27	8400	132	9770090	18.1		6.97
6 AM			560	9.35	8500	132	9771960	18.7		7.20
8 AM			431	7.20	6400	135	9773500	15.4		5.93

DSW 176697

STLCOPCB4050584

Sheet No: 2A

POLYMER DOSAGE RECORD: Appendix H

Monsanto Co.
CRD

Date: 3/25/71

Plant: Mill Cr. Plant

Polymer Application: Calgon 2650 Cationic Filters #3 & 4

TIME	POLYMER READING (GPH)	POLYMER READING (INS.)	TOTAL POLYMER USAGE (gal.)	TOTAL POLYMER USAGE (lbs.)	TOTAL SLUDGE (GPM) GALLONS	POLYMER CONC. (mg/L) lbs/GAL x10⁻³ x1.2x10²	CAKE READING	CAKE PRODUCTION (TONS) TOTAL	% SOLIDS CAKE	DRY CAKE PRODUCTION (TONS)
10AM			288	4.81	4300	134	9774400	9.0		3.47
12AM			288	4.81	4300	134	9775260	8.6		3.31
			268	44.8				88.4	36.5%	34

DSW 176698

STLCOPCB4050585

Sheet No: 1-B

Date: 3/23/71

Location: Cincinnati, Ohio

Polymer: Calgon 2650 Cationic Filters #3#4

POLYMER TREATMENT COSTS Appendix H

Monsanto Co. CRD

@ #1.25/lb.

TIME	POLYMER USAGE (wet lb./dry ton)	(dry lb./dry ton)	TREATMENT COST #/dry ton	REMARKS
3/24/71				
12 M		—	—	
2 AM		1.34	1.67	
4		1.36	1.70	
6		1.41	1.76	
8		1.45	1.81	
10		1.43	1.79	
12 N		1.42	1.77	
2 pm		1.49	1.86	
4		1.21	1.51	
6		1.24	1.55	
8		1.26	1.58	
10 pm		1.26	1.58	
12 M		1.17	1.46	
	—	1.32	#1.65/TON	
3/25/71				
2 AM		1.30	1.62	
4		1.33	1.66	
6		1.30	1.62	
8		1.21	1.51	
10 AM		1.38	1.72	
12 N		1.45	1.81	
		1.315	#1.65/TON	

DSW 176699

STLCOPCB4050586

FIGURES

Figures I - XVI follow.

STLCOPCB4050587

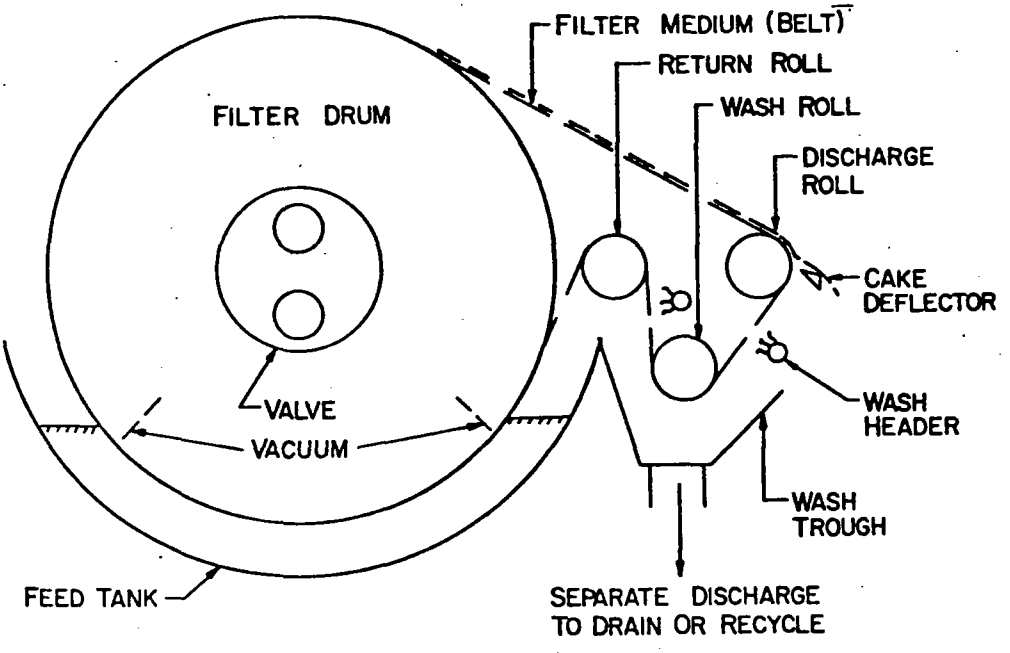


FIGURE I. Belt-type Continuous Drum Vacuum Filter

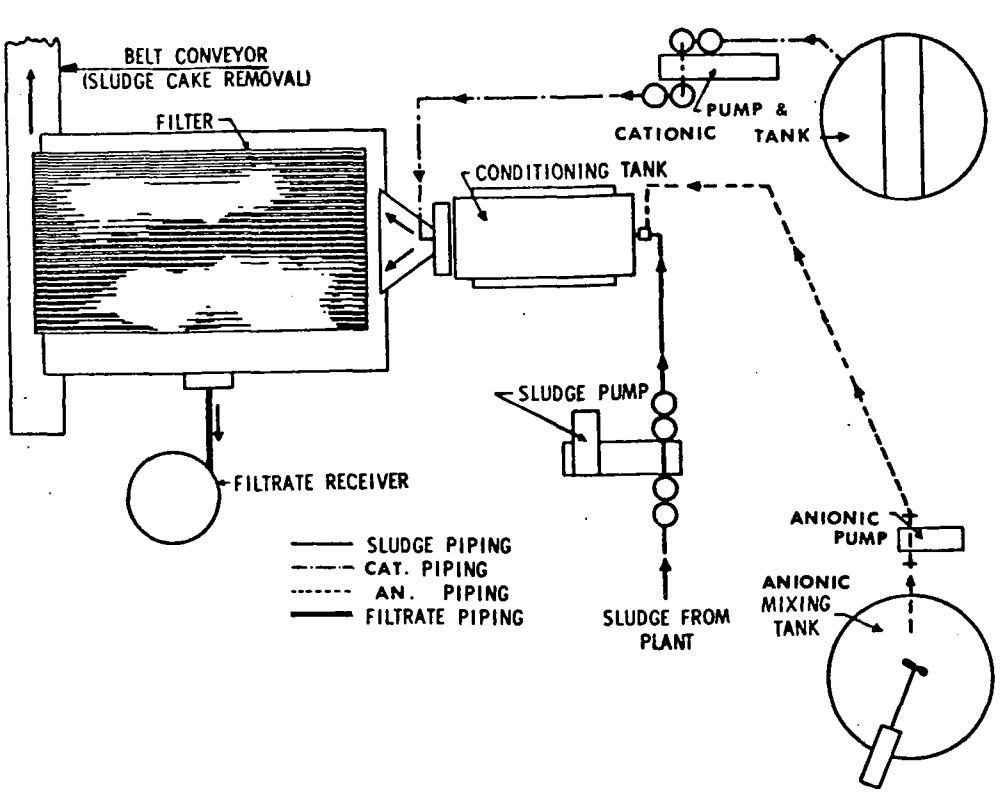


FIGURE II. Typical Dual-Polymer Feeding System

DSW 176701

STLCOPCB4050588

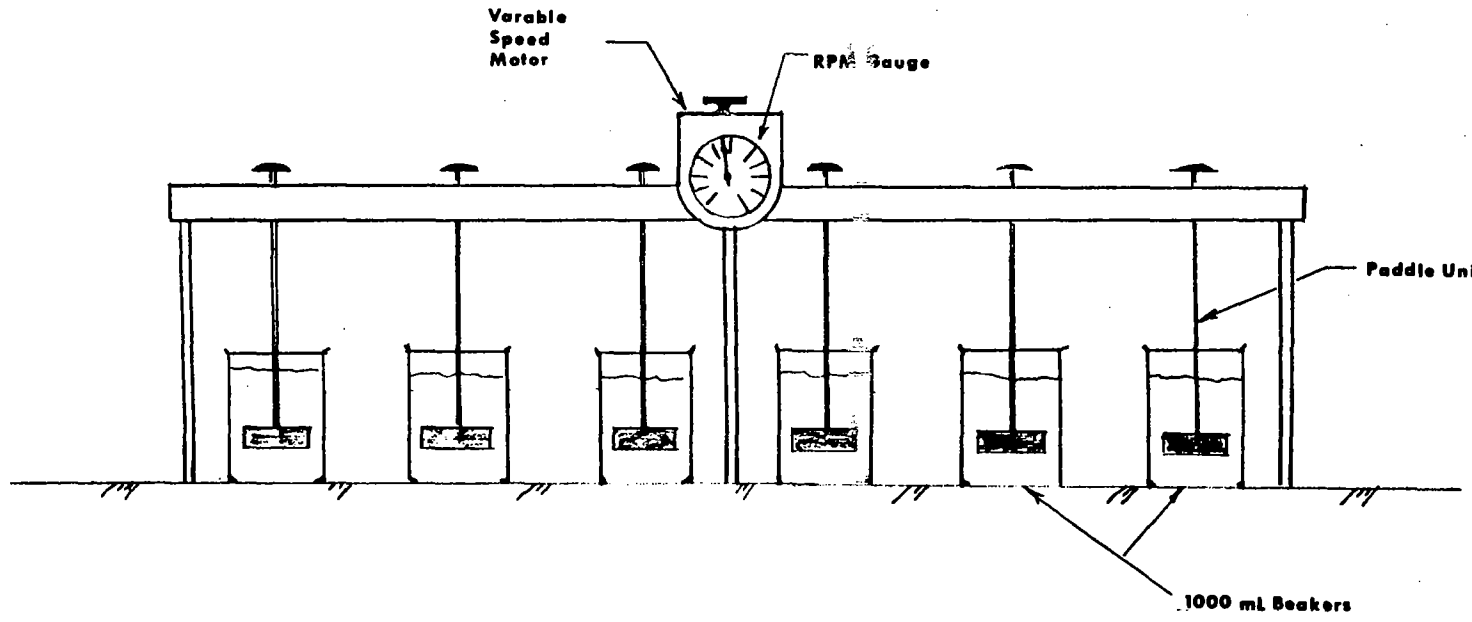


FIGURE III. Laboratory Phipps & Bird Flocculation Unit

DSW 176702

STLCOPCB4050589

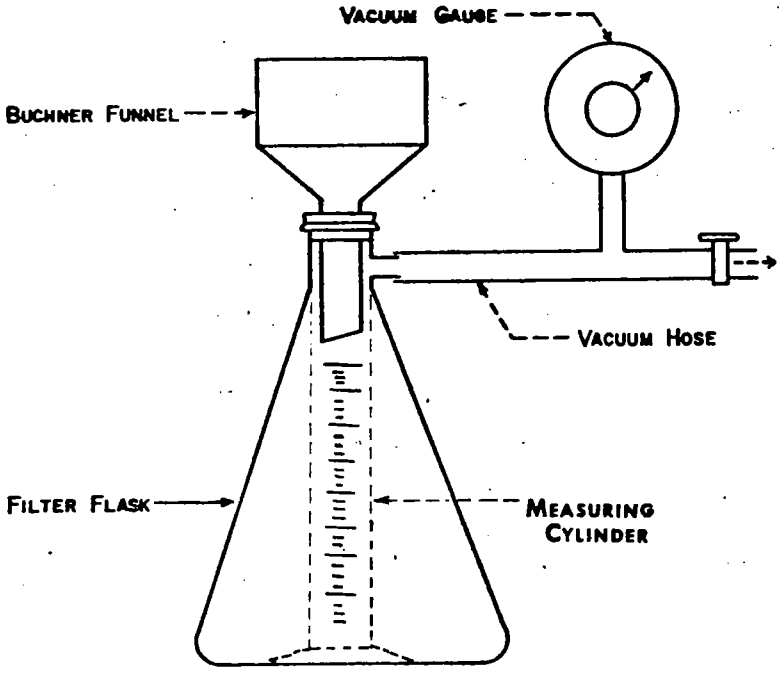


FIGURE IV. Buchner Funnel Apparatus

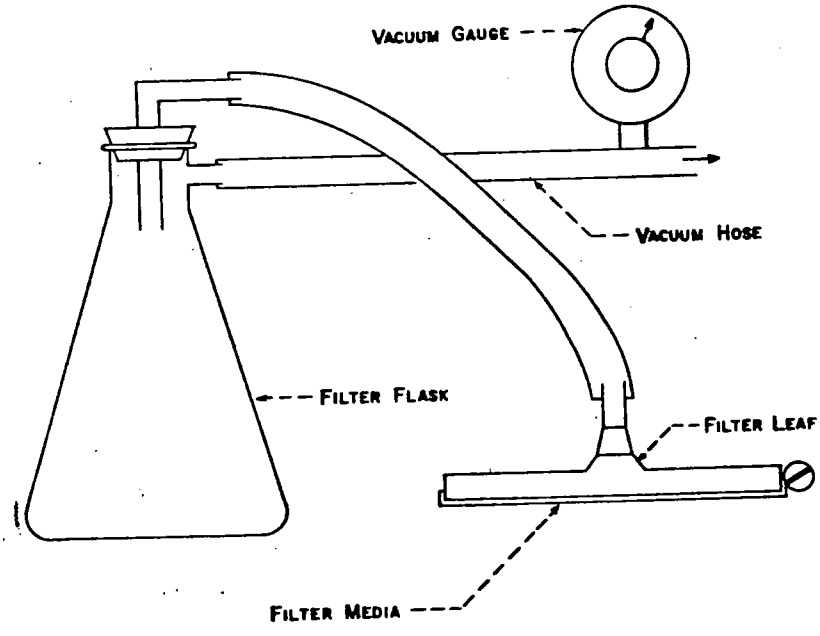
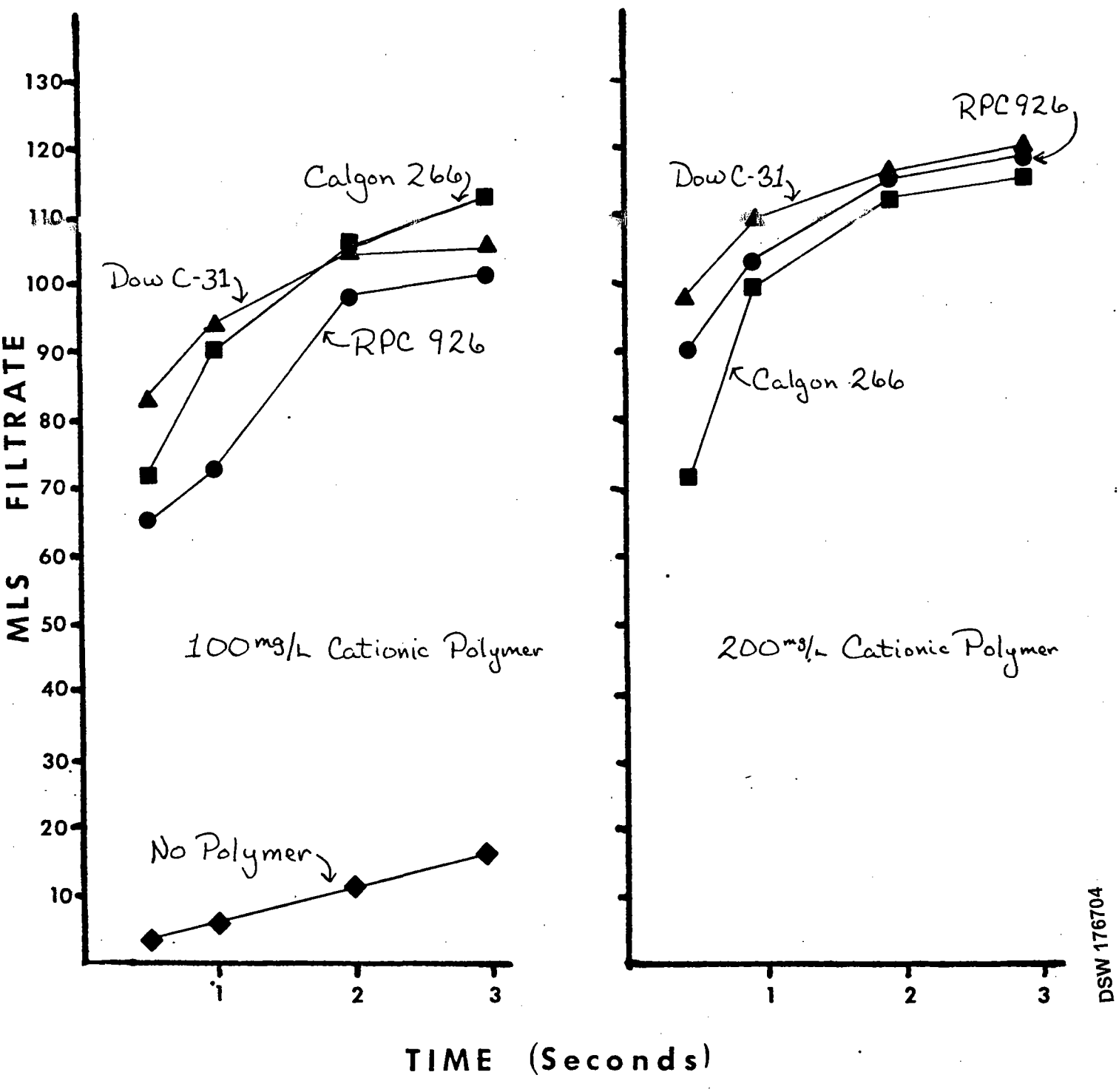


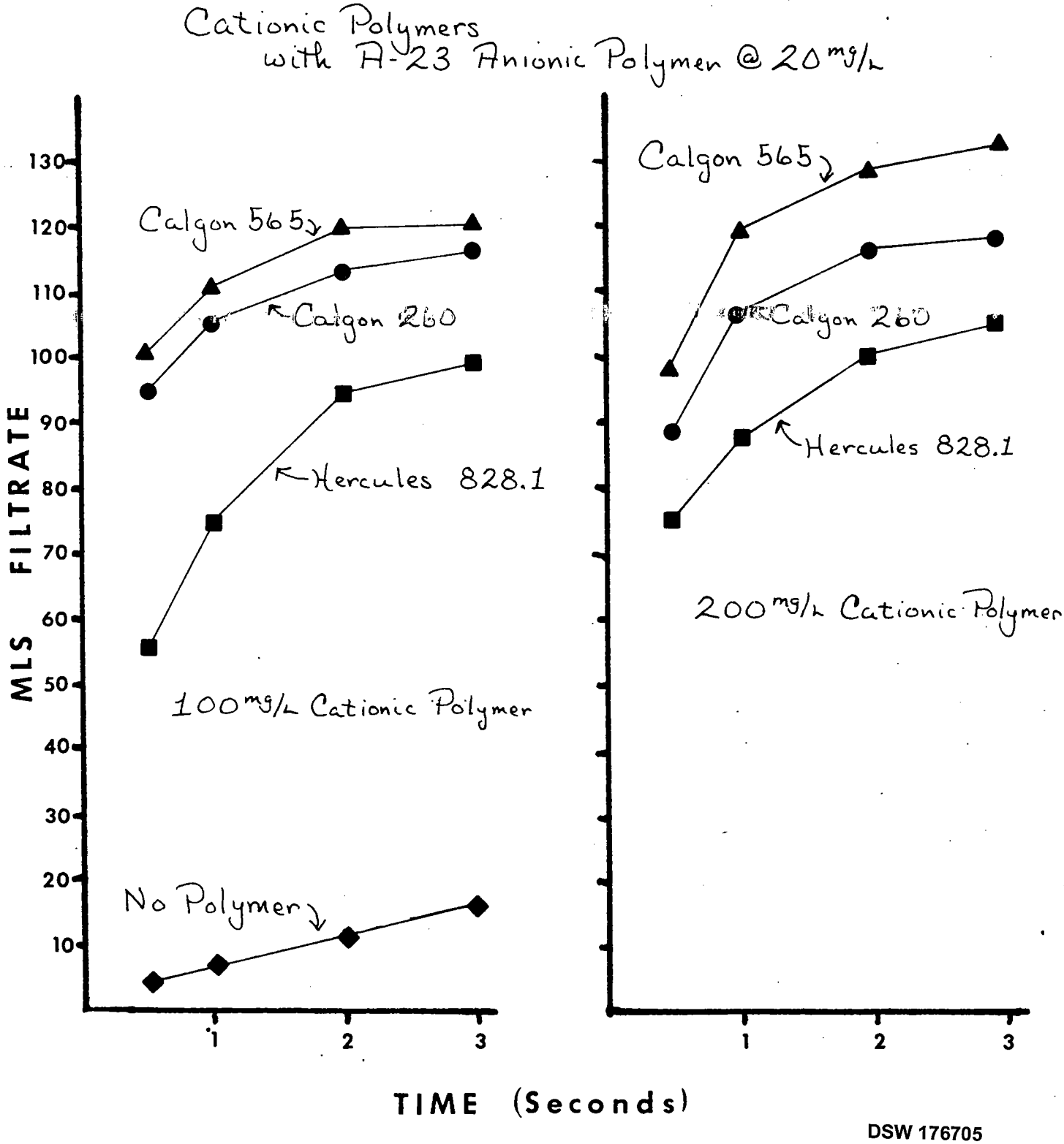
FIGURE V. Filter Leaf Apparatus

FIGURE VI(a). Cationic Polymer Evaluation



STLCOPCB4050591

FIGURE VI(b) Cationic Polymer Evaluation



DSW 176705

FIGURE VI(c) Cationic Polymer Evaluation

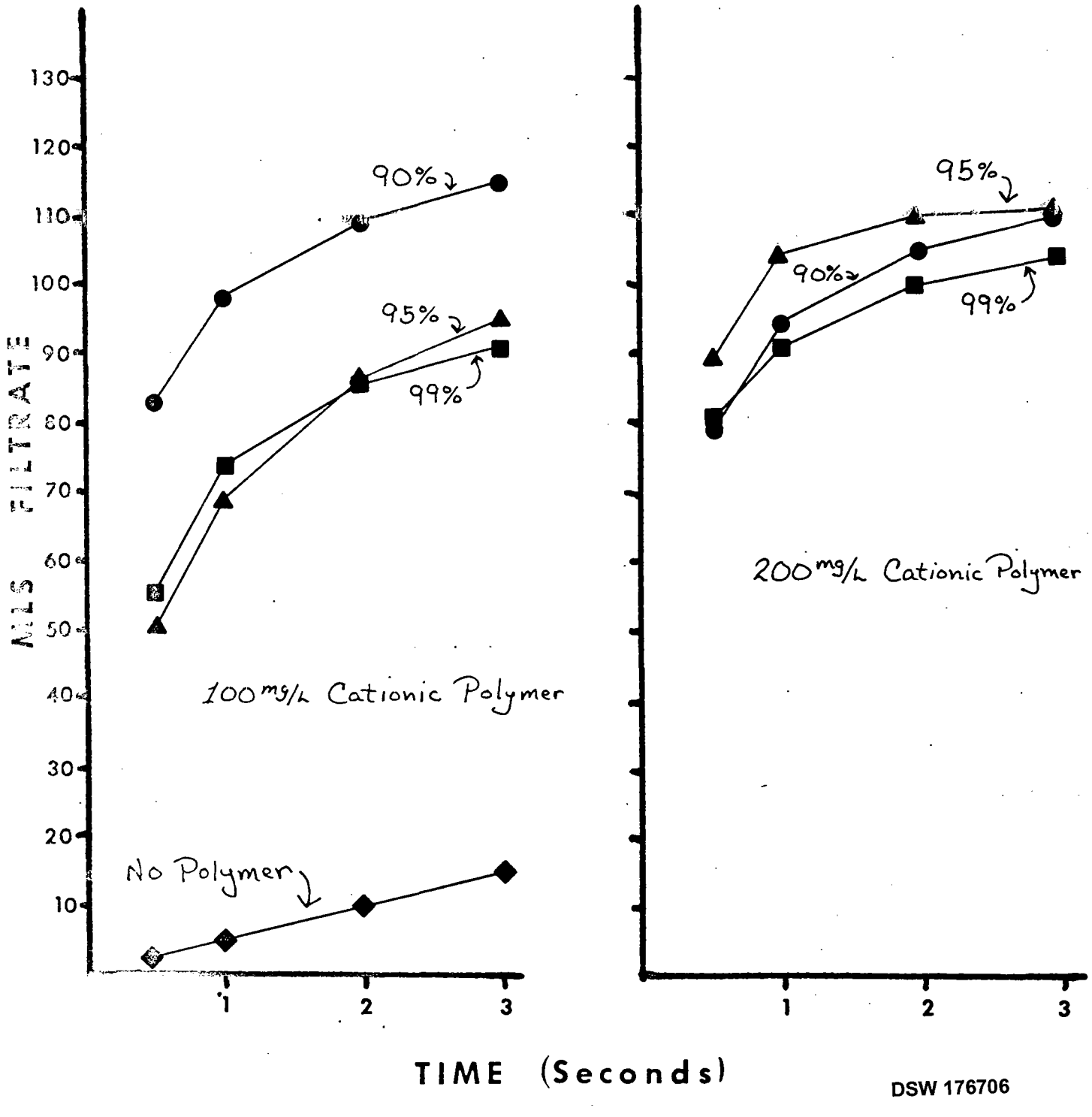
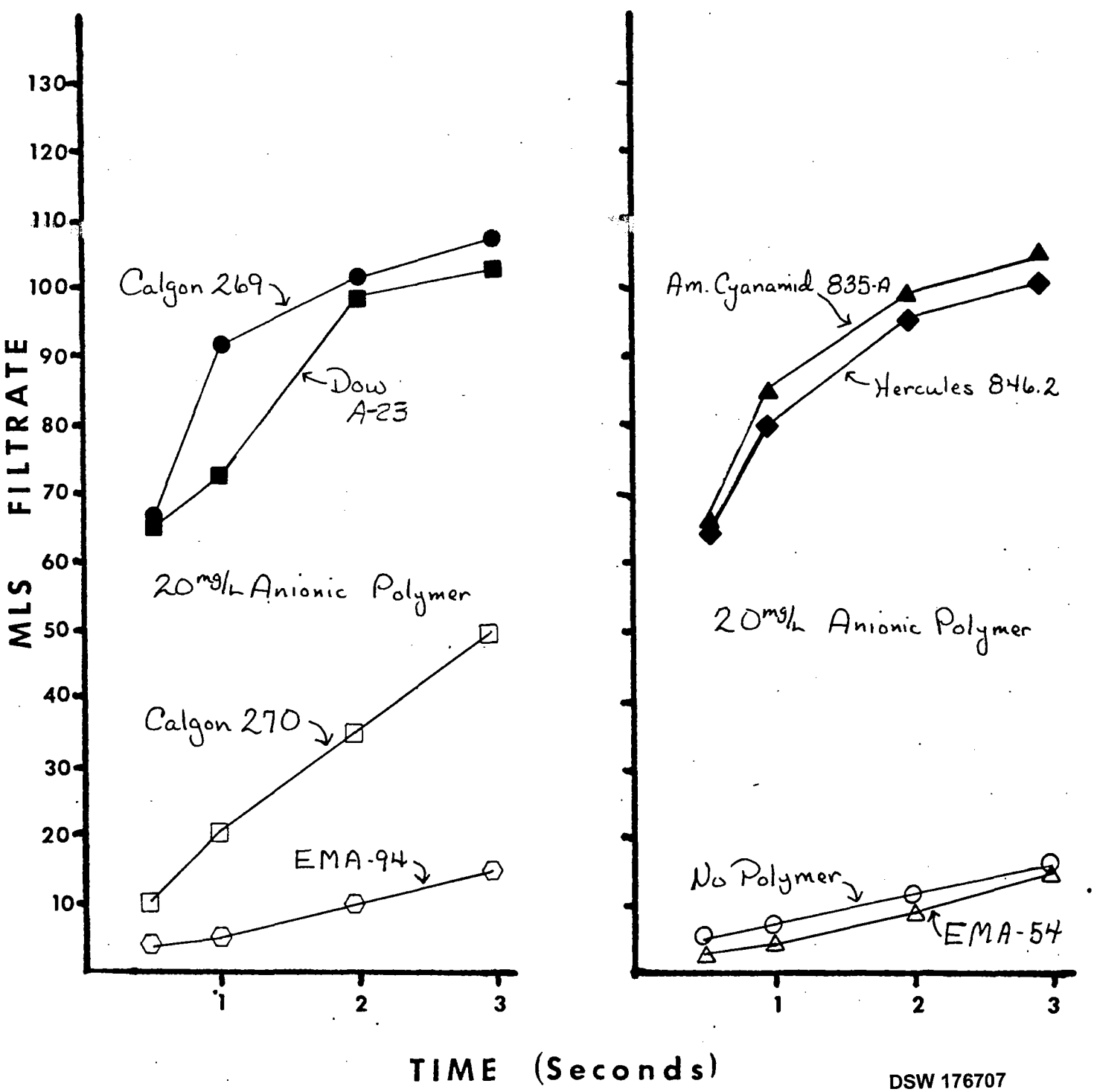
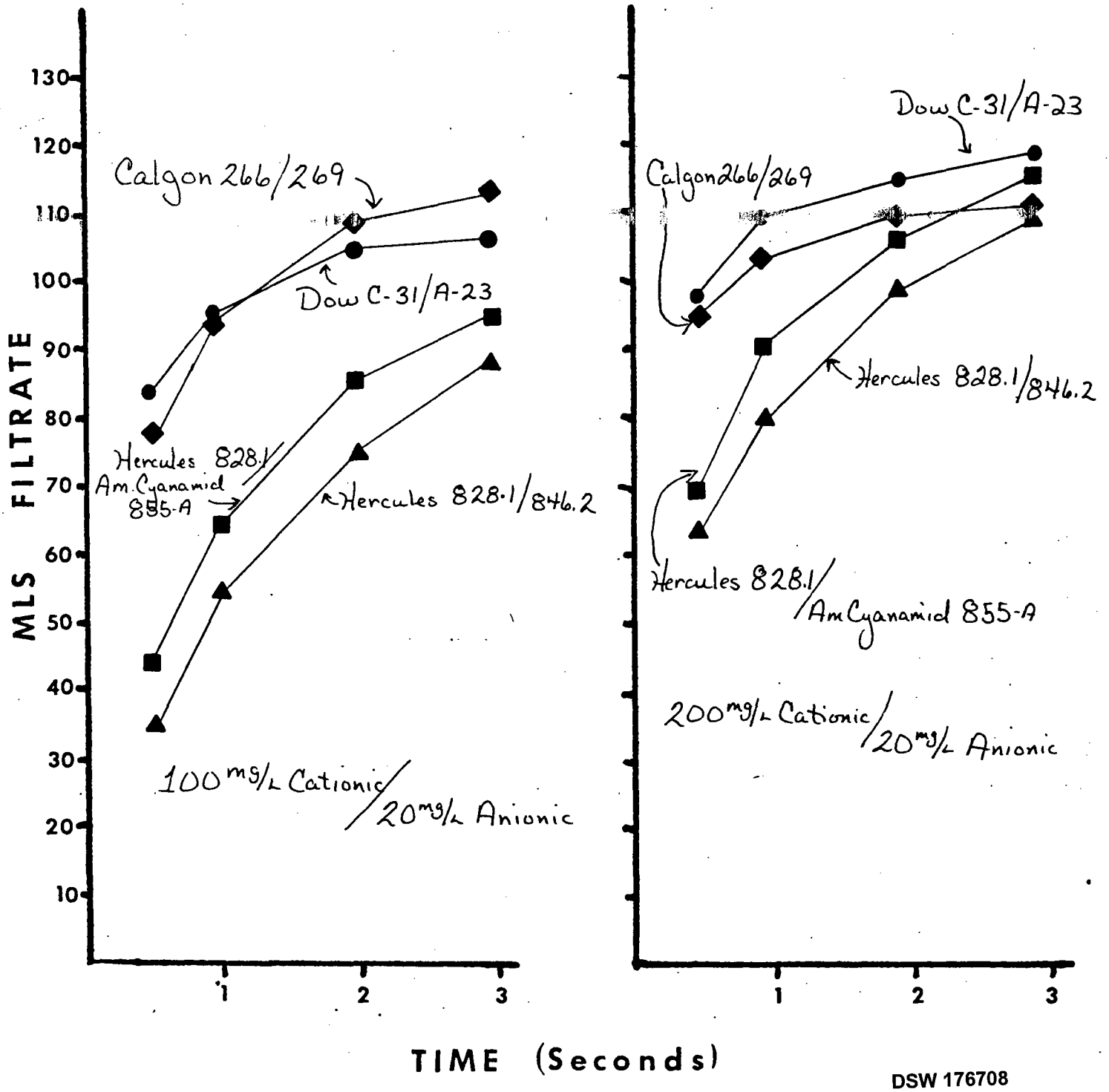


FIGURE VII. Anionic Polymer Evaluation



STLCOPCB4050594

FIGURE VIII. Filtration Performance of Commercial Dual Polymer Systems

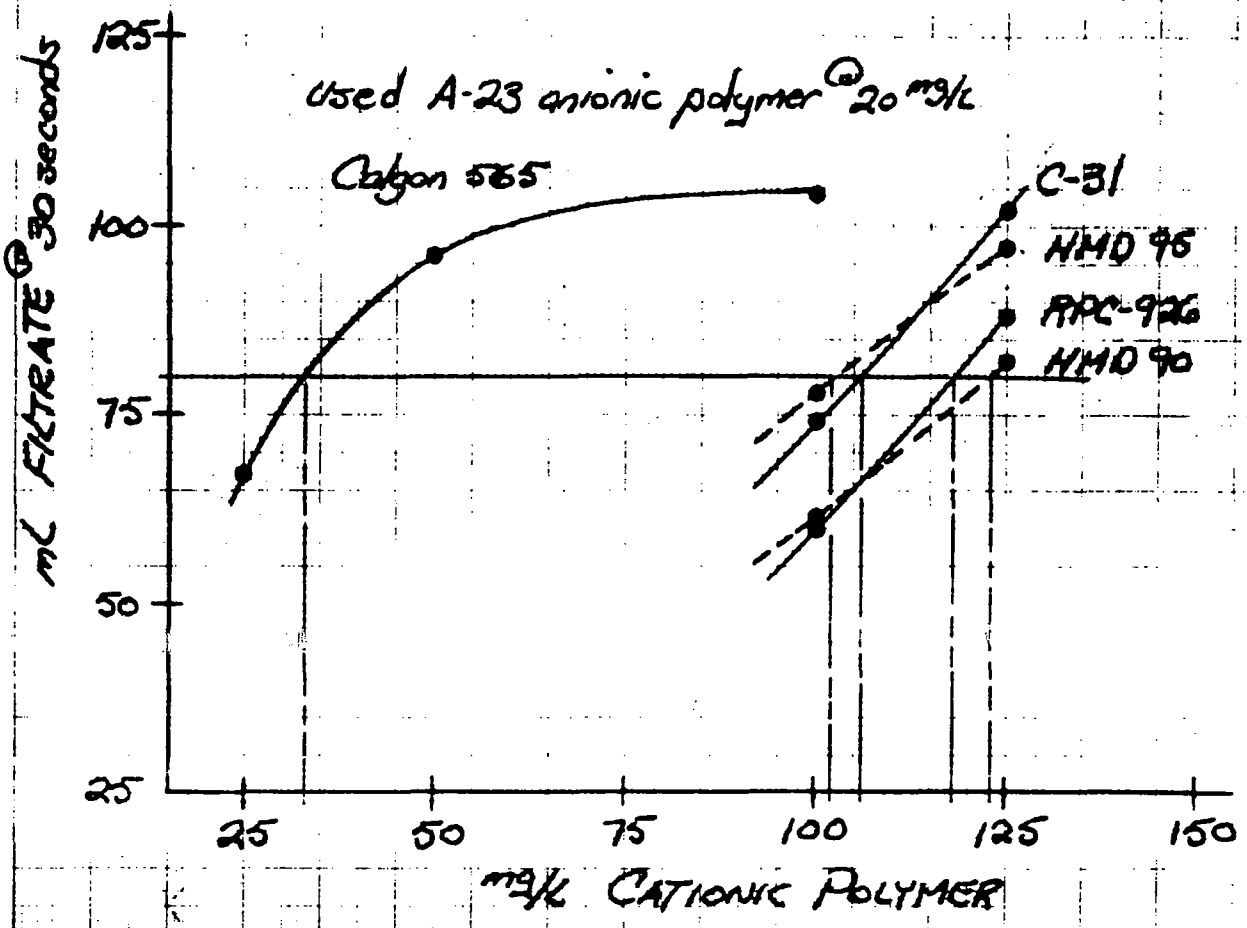


DSW 176708

STLCOPCB4050595

FIGURE IX. CATIONIC COST-PERFORMANCE DATA

B. Eddy & R. Kinnear



COSTS @ EQUIVALENT PERFORMANCE

Cationic Polymer	Concentration (mg/L)	Cost #/MG sludge
Calgon 565	33	$ 550.
Dow C-31	106	530.
PPC-926	118	590.
NMD-95	102	637.
NMD-90	123	768.

DSW 176709

STLCOPCB4050596

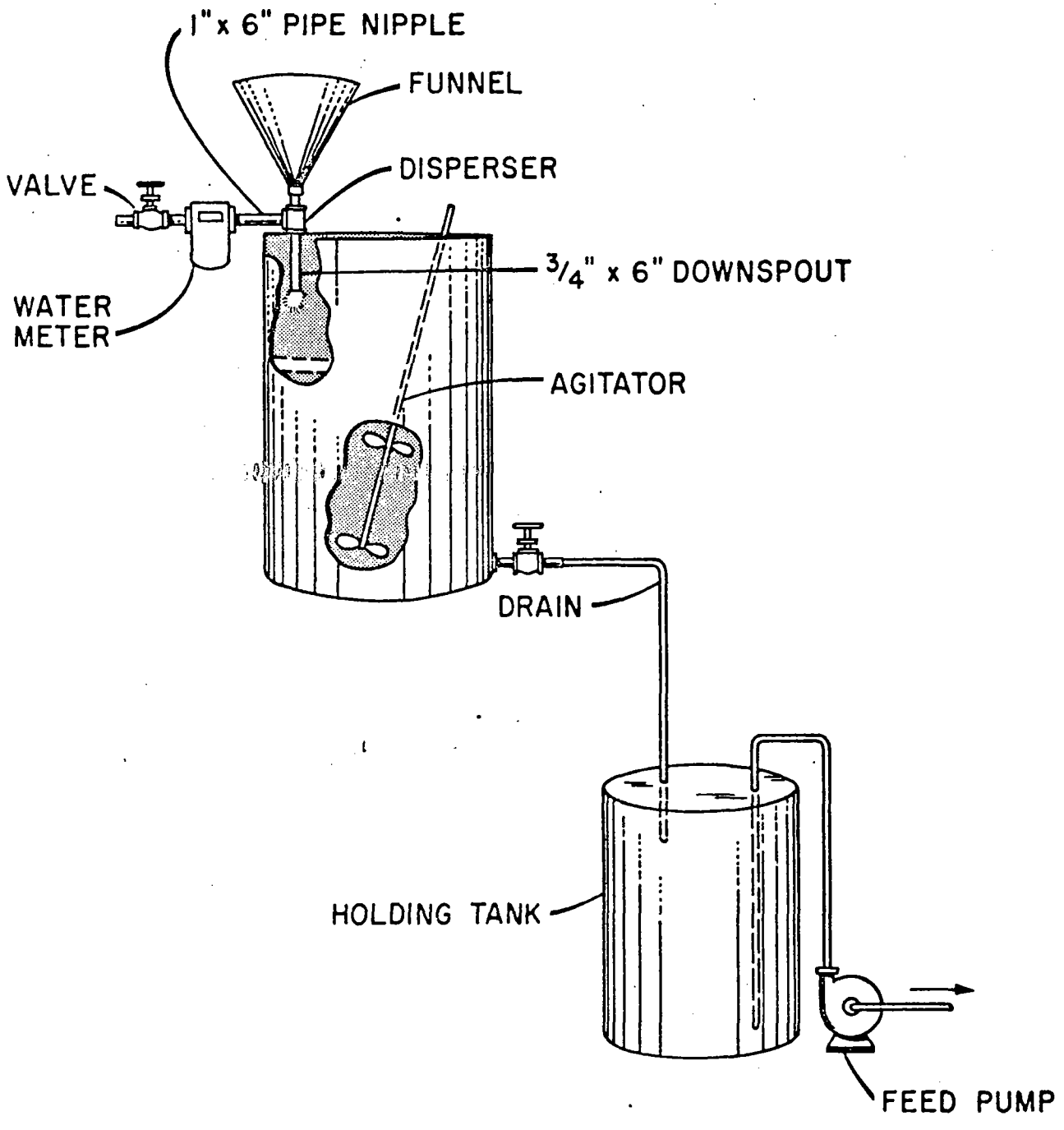


FIGURE X. Typical Installation For Preparing Powered Polymer Solutions

DSW 176710

FLOW DIAGRAM

OPERATION

1 Sludge is ground and pumped to about 300 psig reactor pressure.

2 Compressed air is introduced into the sludge and the mixture is brought to an operating temperature above 350° F by heat exchange and direct steam injection.

3 The heated conditioned sludge is cooled by heat exchange with the incoming sludge.

4 Gases are separated and released through a catalytic afterburner or equivalent odor control device.

5 Conditioned sludge is concentrated by settling and dewatered by filter, centrifuge or on drying beds.

6 Liquor, readily biodegradeable, flows to secondary plant or to separate treatment unit. Short reaction time assures minimum color and BOD.

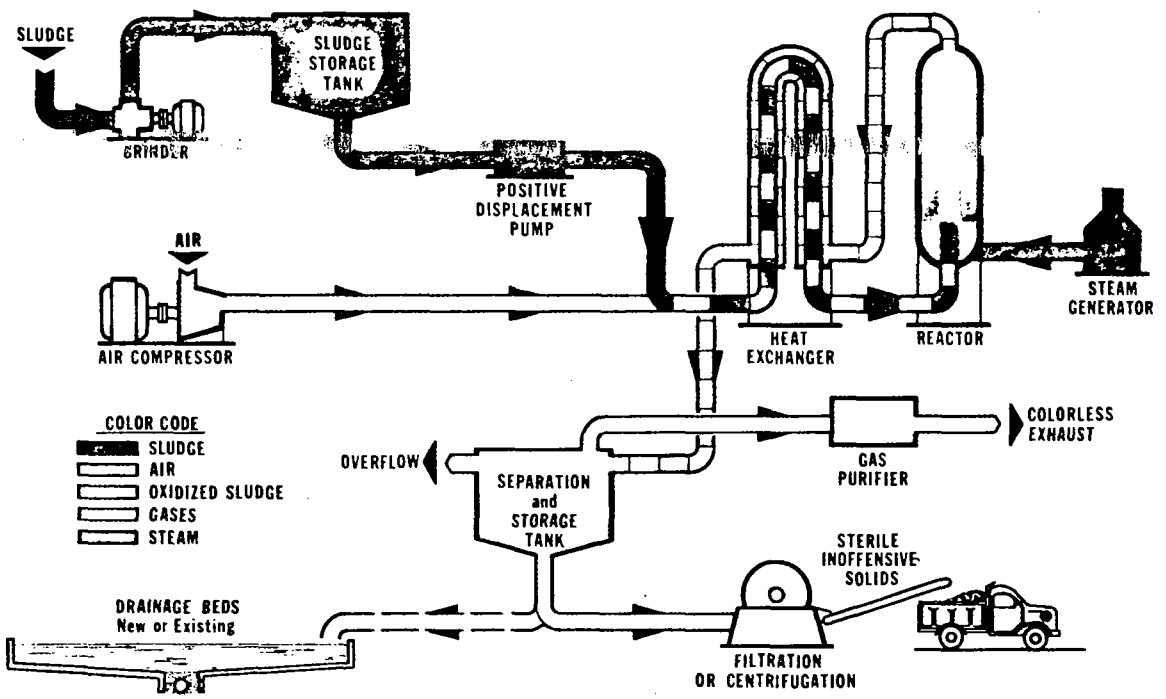


FIGURE XI. ZIMPRO® WET AIR OXIDATION PROCESS (8)

Cat. No. 2130, Zimpro® Inc.

DSW 176711

STLCOPCB4050598

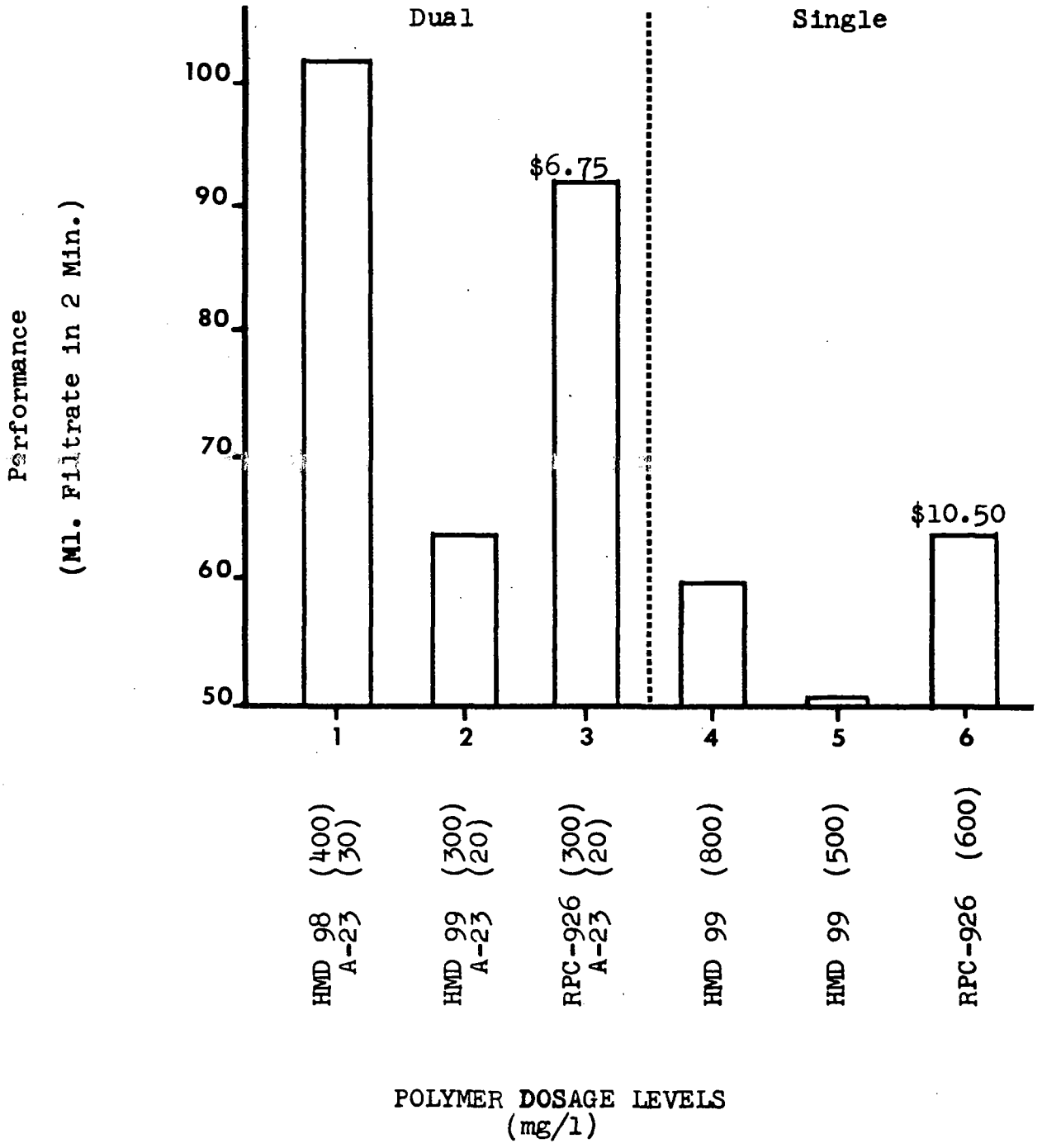


Figure XII. Columbus, Ohio. Dewatering Test
Present Cost: $8.25/dry ton

DSW 176712

STLCOPCB4050599

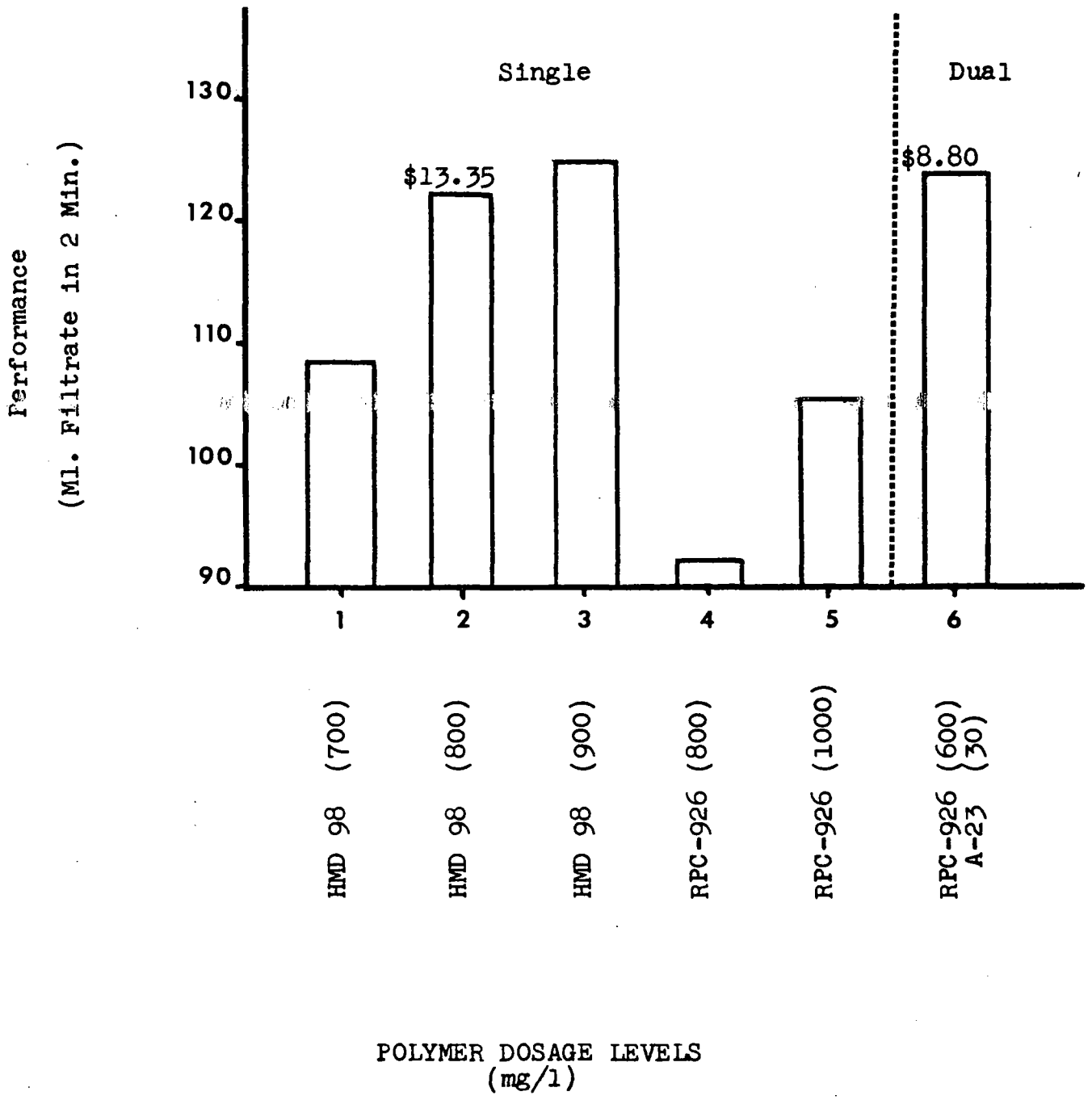


Figure XIII. Indianapolis, Ind. Dewatering Test

Present Cost: $10.00/dry ton

DSW 176713

STLCOPCB4050600

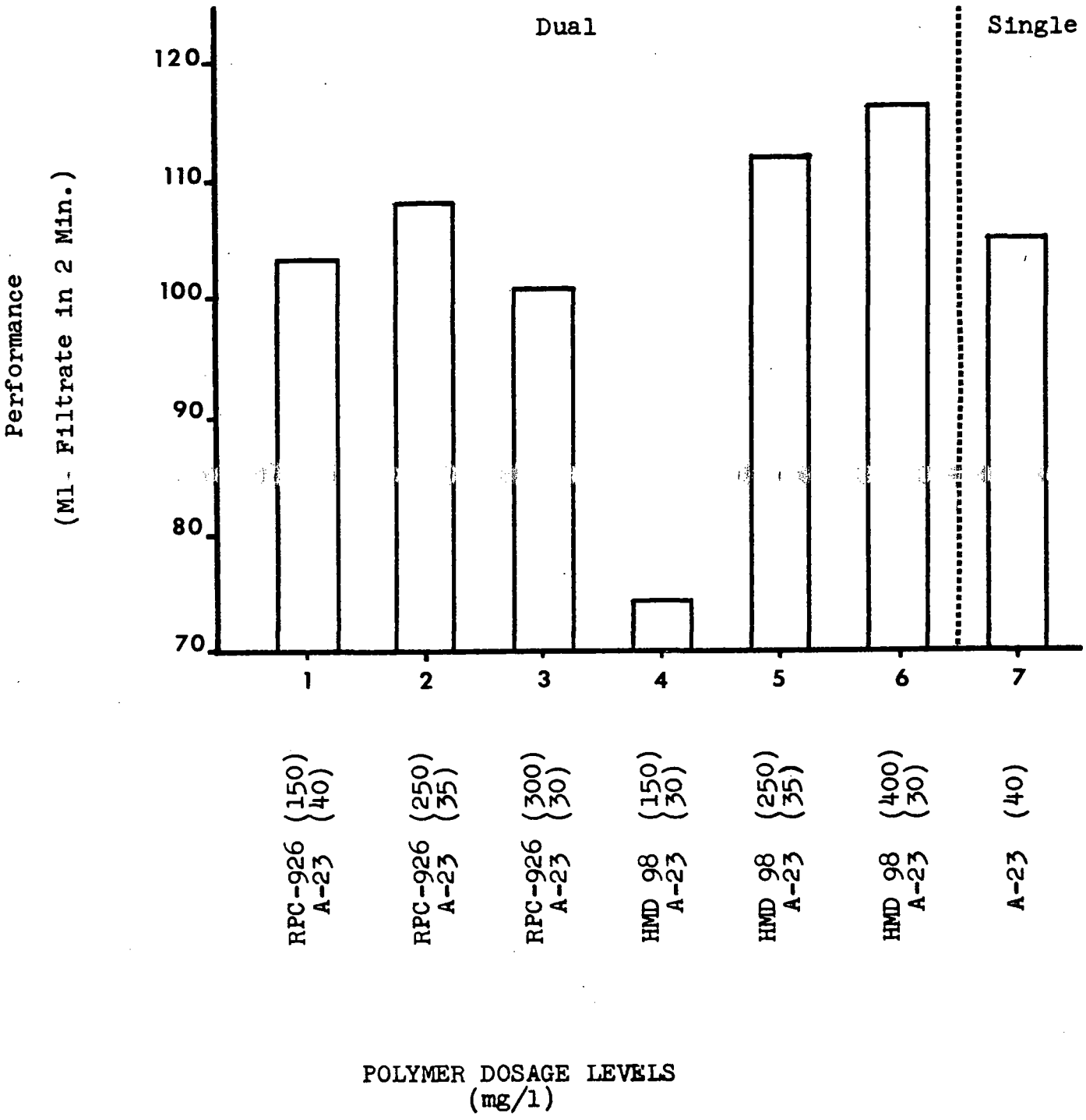


Figure XIV. Louisville, Ken. Dewatering Test
Present Cost: $2.75/dry ton

DSW 176714

STLCOPCB4050601

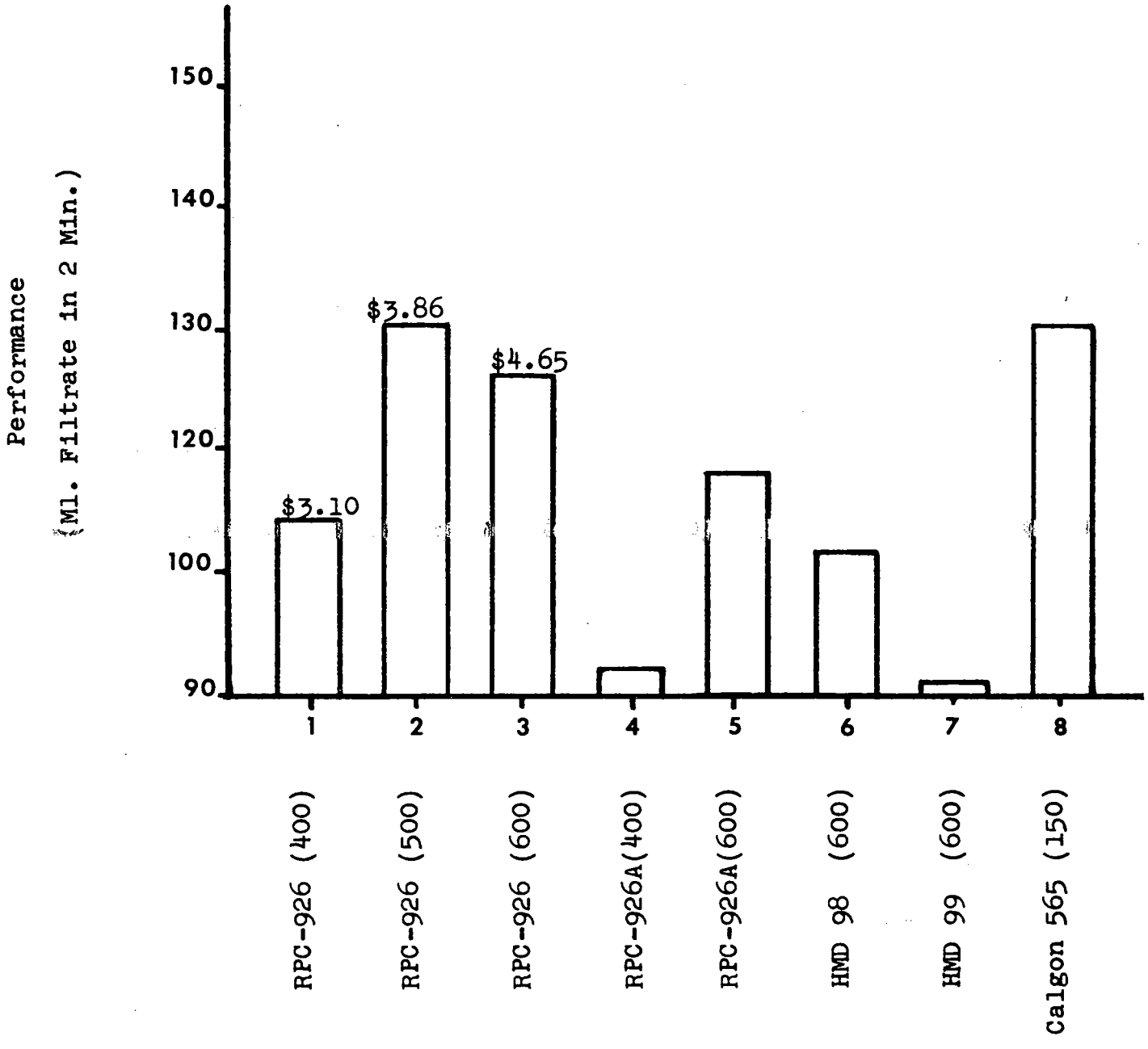


Figure XV. Cincinnati, Ohio. Dewatering Test

Present Cost: $2.00/dry ton

DSW 176715

STLCOPCB4050602

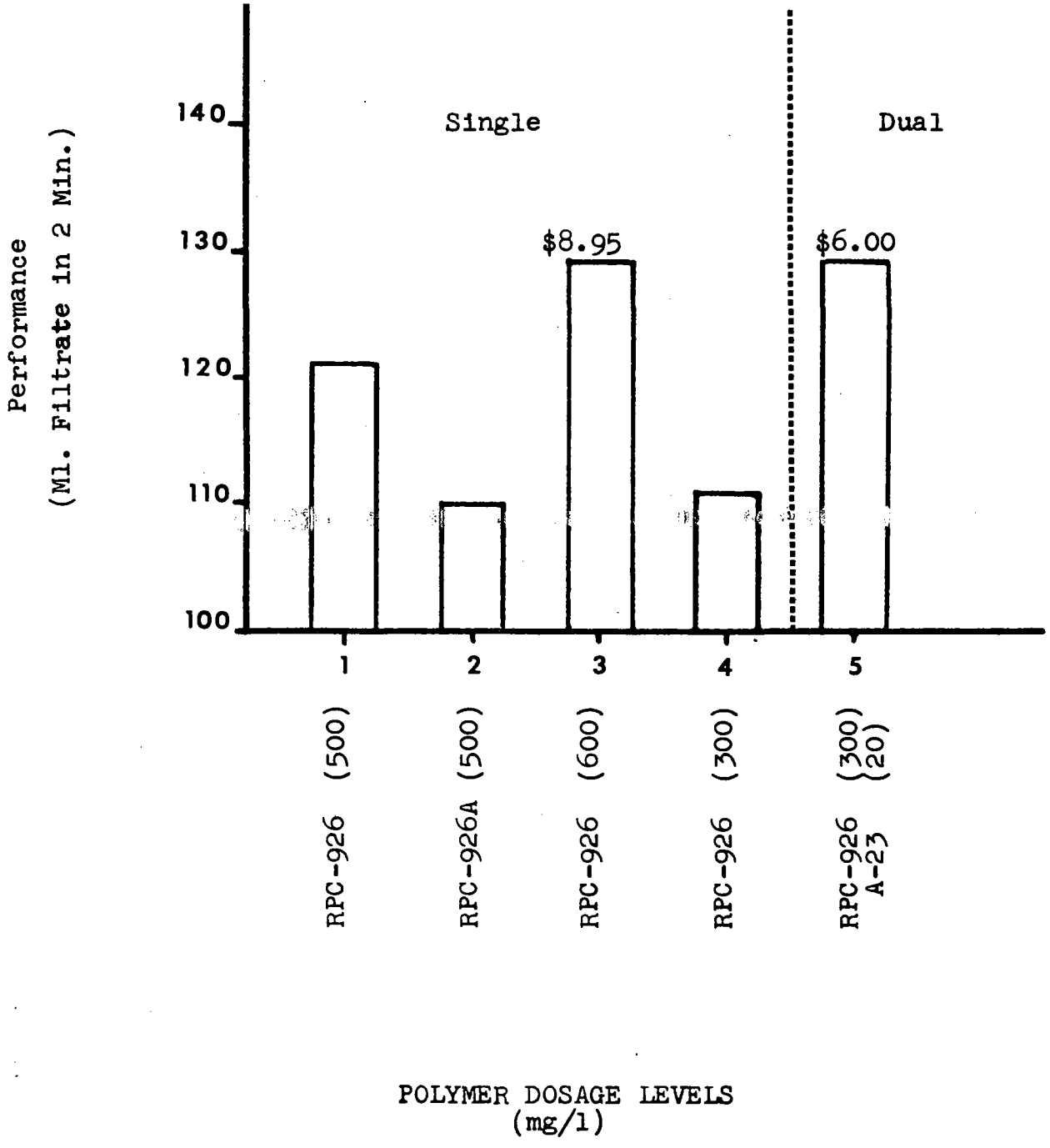


Figure XVI. Baltimore, Md. Dewatering Test

Present Cost: $3.27/dry ton

DSW 176716

STLCOPCB4050603

FLUIDS RECLAMATION PLAN

DRAFT

D. R. Pogue
November 20, 1970

DSW 176717

STLCOPCB4050604

TABLE OF CONTENTS

1. Objective 1

2. Recommendations and Conclusions 3

3. Reclamation Market - Industrial Fluids 6

   Diecasting 8
   Steel Industry 13
   Aluminum Industry 16
   Foundry and Others 17

4. Impact on Competitive Business and New Markets 18

5. Industrial and Dielectric Fluids Reclamation Potential 19

6. Recovery Methods and Economics 22

   Bulk 22
   Absorbent 23
   Proprietary Absorbent 24

7. Recovery Alternates 26

   Inhouse vs. External Reprocessing via Fluids Supplier 26

8. Economics of Recovery 28

   Distribution 29
   Water Glycol/Pydraul Blending 31
   Contribution to Profits - Income 32
   Plant Locations 32
   Plant Investment Alternates 34

9. Program Actions Required. 36

   Possible Obstacles and Alternates 38

OBJECTIVE

The objective of this study was to explore the reclamation and reuse of synthetic fire resistant fluids in the metalworking industry and to submit a business plan to:

1) Provide a "systems" capability to economically recover waste fluids from these plants.
2) Provide capability at selected sites to reclaim synthetic fluids of all types from the wastes of these plants.

The incentives for pursuing a Monsanto reclamation business include:

1) Profitable solution to water and disposal pollution problems.
2) Unique service to gain additional share of FR Fluids market.
3) Potential marriage with Enviro-Chem Biodize technology for industrial plant waste treatment.
4) Monsanto's image with 20 years industrial fluids experience.
5) A logical "systems approach" to expand our fluids base and protect our fluids franchise.

In analyzing this business joint personnel contacts with our field representatives were made on five (5) basic steel customers, five (5) medium and large diecasting customers, two (2) aluminum accounts and two (2) large automotive foundries.

Internally, Manufacturing (J. Savage) and the following groups

STLCOPCB4050606

were involved in evaluating phases of this business.

1) Fluids Research - Pydraul recovery and floor absorbent extraction studies.
2) Organic Development - Vapocoupling extraction techniques.
3) Applied Science - JFQ - Effluent analyses (PCB and Chemicals composition).
4) Central Engineering - Preliminary reclamation cost and investment estimates.
5) Distribution & Materials Handling - JFQ - Economical distribution methods of reclaimed fluid.

RECOMMENDATIONS & CONCLUSIONS

1. An important customer need exists for effective recovery of FR hydraulic fluids due to tightening pollution laws and the dollar value in fluids now being discarded.

2. FR Fluid recovery can be increased from about 5% industry wide to 10-75% per customer depending upon the operation, i.e. steel 10-20% and diecasting 75%).

3. Recovery should be controlled by the fluids supplier as recovery techniques are difficult and fluid performance must be insured by the supplier.

4. Recovery and resale of reconditioned FR fluids is profitable and economically feasible. Monsanto economics require a new fluids distribution program utilizing recycle bins and bulk truck shipments for new and salvaged fluid.

5. An effective program that offers the customer fluid cost savings and a total service approach will expand the Monsanto synthetic fluids market and penetrate competitive accounts.

6. A Monsanto FR hydraulic fluids recovery program with start-up in early 1972 will yield about $2.7 $\overline{M}$ in sales by 1976 @ 40% avg. gross profit annually. This includes $1.5 $\overline{M}$ (10 $\overline{M}$ lb. sales from an expanded market and competitive account penetration. Net Income (BT) is projected @ $0.2 $\overline{M}$ in 1972 and $1.0 $\overline{M}$ by 1976.

STLCOPCB4050608

7. Indirect income from distribution savings and blending water glycols at strategically located reclamation centers should yield $1.1 M by 1976, and increase total Net Income (BT) to $2.1 M (78% of sales).

8. Preliminary investment calculations indicate either new captive Monsanto sites or an addition onto existing metalworking fluid plants is a profitable venture. Payback is projected at 4 years and 2 years, on $2.4 M and $1.2 M cumulative investment by 1976 for captive vs. metalworking plant additions, respectively.

9. A total of 5 reclaiming-blending sites by 1975 (Great Lakes (2), midwest, east and west coast) is estimated to handle anticipated volume and our wide geographical markets.

10. Monsanto should enter this market as soon as possible. Our goal should be to construct sites at existing metalworking plant facilities. The arrangement should provide for eventual acquisition of the firm to gain their sales volume, established products and organization. This alternate will increase our capabilities to serve our growing markets.

11. Program actions outlined on page 36 and 37 of this report are required to commercialize this program and should be approved for 1971. Marketing, process, design and construction estimates indicate Jan. 1, 1972 as start-up date for this program.

STLCOPCB4050609

12. The recovery and resale volumes on Therminols and dielectric Aroclors have been estimated in this report but were not included in financial calculations. Therminol recovery techniques are similar to Pydraul and this business should be handled by the reclamation centers. The feasibility of reconditioning used dielectric fluids does not appear adequately defined. Fluid volume and process steps required should be determined by the Dielectric Fluids Group in early 1971 as part of this service-business expansion program.

13. The large volume potential for proprietary recycle absorbents has immediate application to our products and the reclamation concept. Further work in 1971 by research and development is warranted to determine:

    1) Feasibility of producing economical proprietary material.
    2) Total potential for recovering other fluids.
    3) Market acceptance.

STLCOPCB4050610

RECLAMATION MARKET-INDUSTRIAL FLUIDS

In the case of virtually all companies contacted, the need for an effective fluids waste control program was evident. This need affects two primary areas: improved recovery and reuse of fluids and prevention of environmental pollution.

The impact of pollution on our metalworking markets is by now evident to everyone. Although the focal point for pollution activity has centered recently on the steel industry, we can expect similar confrontations in our other major markets: foundries, diecasting and aluminum. Each market is quite similar in that processed metals require organic and inorganic chemical cleaning and conditioning and nearly all require large volumes of oil and oil/water based fluids for hydraulic and process cooling requirements. In accordance with the volume of pollutable chemicals consumed, the larger plants, particularly steel, have been required to take action first. It is inevitable that effective waste control measures now prevalent in the steel industry will extend rapidly to our other metalworking markets.

Capital requirements to control industrial pollution are staggering. In 1966 over 50% of all steel plants had waste treatment facilities of varying degrees of effectiveness. On the average, water pollution control capital versus total plant investment represented around 3% in 1966 and around 4-5% in 1967. These costs have risen substantially since then. For example, Armco Steel, Middletown, Ohio, has $39 million in water treatment facilities representing

STLCOPCB4050611

18% of their total plant investment. Inland Steel, East Chicago, Indiana, has invested $26 million, Youngstown Sheet and Tube, Indiana Harbor, $30 million, and Jones and Laughlin, Pittsburgh Works, $20 million. Industry Week (April, 1970) reports that the average foundry will have to spend in excess of $100,000 to install enough equipment to stay "legal" with no way in sight to recoup the expenditure. The Industry Week's reference to "pollution investment with no way in sight to recoup the expenditure" has been the situation in the past on practically all metalworking waste treatment facilities. However, industry is now looking at every conceivable means of obtaining value from their large pollution investments. The modern steel treatment facility recovers about 50% of all other organic wastes. Wheeling Pittsburgh Steel reports that in addition to themselves, Ford and Kaiser Aluminum are now purchasing lubricating oils on a specification basis built around recovered and re-refined product. With this approach petroleum oil waste can now be converted into a usable product at some savings.

Salvage of fire resistant fluids has not been of concern to many of our customers as the volume is low compared to the volume of other chemicals consumed in their plant. This is particularly true of steel, foundries and the aluminum industry. However, as indicated earlier future emphasis will be placed on fire resistant fluids as large volume chemicals are brought under effective control. It is doubtful if more than 5% of salvageable synthetic fluids is presently being recovered for reuse. Most of these reclamation operations today are found in selected diecasting accounts. There

is no question that recovery can be effectively increased in every major industry we now serve. If Monsanto does not assume or initiate this program for our own fluids it will be done by another company.

In the case of synthetic fluids, perhaps more so than other chemicals, the customer can, through improved or modified housekeeping procedures, recover synthetic fluids and most do not have to install a waste treatment facility. Each of our key industries is discussed separately with regard to feasibility of synthetic fluids recovery.

Diecasting

Waste treatment facilities are rare in this industry. The only area where treatment is found is for cutting oils and plating chemicals, where the plant machines and paints or plates the diecast part. This market represents about 30% of the 1000 diecasting accounts in the United States, according to Detrex Incorporated, the major supplier of degreasing chemicals and systems.

The major products consumed by the diecaster are dielubes (water or solvent base), lubricating oil and greases, cleaning solvent and hydraulic fluids. Hydraulic fluid (Pydraul) usage is substantial at 20-50% of total fluids consumed in the plant, with larger die-cast plants, i.e., Johnson Motors using the smaller ratio of FR fluid to total chemicals. Although the amount of other products consumed is substantial there appears to be limited intermixing with the waste Pydraul. Dielubes are vaporized when contacted with the hot diecast part and lubricating oils and greases are used in machining

STLCOPCB4050613

outside or adjacent to the immediate diecasting area.

Pydraul usage escapes into four separate sources in the diecast plant. These sources include bulk waste (major line breaks and spills) adhered to diecast parts, water effluent and through floor dry absorbent material. A diecaster's "water effluent" is an open trench network in the plant floor that carries cooling water to the diecast machine dies. This water is normally recirculated to a cooling tower with limited overflow to sewer.

Table I displays results found by personal contacts at 9 different diecasting accounts. In all cases either the floor absorbent or the water effluent represented 80-100% of the Pydraul consumed at the account. Those plants reporting no Pydraul escaping into the water effluent have closed cooling water circulating lines. The other accounts reporting escape to water have open accesses where liquids flow freely from the diecasting area directly into the water. In the case of Johnson Motors the machines are cleaned regularly with solvent and everything is flushed into the troughs. At Johnson Motors a total of 85-90% of their Pydraul consumption escapes directly into the water stream.

Based on the above results and our knowledge of the diecasting market, several points are important:

1) Of the estimated 400-500 diecasting shops using synthetic fire resistant fluids only a small percentage have open access trenches where Pydraul contacts water directly.

Although a small percentage, however, these accounts are the larger diecasters (Johnson Motors, Central Foundry, Lester Castings, etc.).

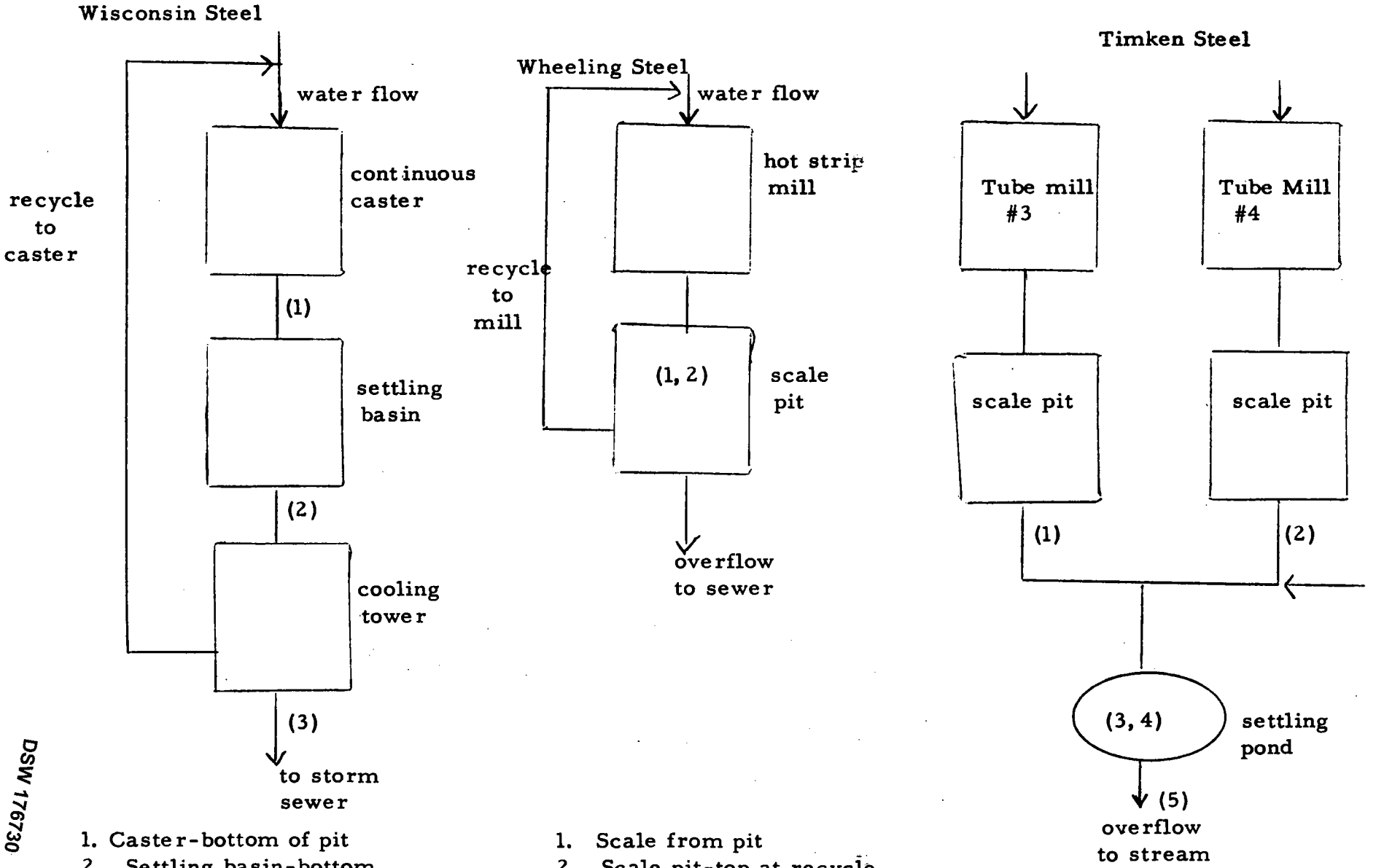
2) The diecaster is concerned about pollution and all are anxious to maximize cost savings. We must expect that the larger volume of fluid escaping into the stream will require the customer to provide adequate sumps/ponds or virtually close off access to his water stream. The logical choice for most is closing off access to insure complete safety from tighter pollution laws. Thus, the majority of the diecasting industry would revert to absorbent as the primary escape source for hydraulic fluids.

Separate fluid analyses from the interceptor pits of "sumps" of Johnson Motors, Lester Castings and Central Diecasting are reported in Table II. In all cases the Pydraul was found to be of high purity. In all cases the Pydraul isn't being reclaimed. The presence of large amounts of solids in the Johnson Motors and Lester Castings samples as well as the 30% non-Pydraul content in the sump of Johnson Motors is felt to be a direct result of housekeeping. Both the level of solids and the amount of contamination from oil, etc., can be controlled. Milt Tegethoff of Findett has indicated that of all the bulk waste and "sump" Pydraul forwarded to him by our customers over the past several years for reclamation all have been of reclaimable quality. In the few cases where analysis beforehand indicated unacceptable fluid quality discussions with plant personnel resulted in fluid of reclaimable quality. It is

important to note that in cases where the level of solids is high a solvent extraction technique is required for effective Pydraul recovery. Solvent extraction techniques were successfully evaluated by Research on Pydraul-absorbent mixtures. This subject is discussed separately.

FIGURE 1

SCHEMATIC OF WATER FLOW-STEEL ACCOUNTS
SAMPLE ANALYSIS



1. Caster-bottom of pit
2. Settling basin-bottom
3. Cooling tower-top at recycle and overflow point

1. Scale from pit
2. Scale pit-top at recycle and overflow point

1. & 2. Flow from scale pit to pond
2. Pond-top floating oil
4. Pond-bottom sludge
5. Pond-overflow to stream

DSW 176730

STLCOPCB4050617

Steel Industry

Figure I outlines the operations at Wisconsin Steel, Wheeling-Pittsburgh Steel and Timken Steel where Pydraul is currently being used and where samples were taken of the water and scale pit areas to analyze for Pydraul content and recoverability. The results of these analyses are valuable because each process is different yet typical of high volume Pydraul consumption that comes in direct contact with water. The processes analyzed were a continuous caster, hot strip mill and two tube mills.

In these hot steel operations hydraulic fluid leakages directly contact the cooling water. Oxidized steel solids (scale) settle from the cooling water in the scale or settling pits where residence times were as much as 1-8 hours. Cooling water flow rates through vary from 300-10000 gpm, depending upon operation and size of plant.

Results of the Pydraul analyses from Wisconsin, Wheeling and Timken Steel are reported on Table III. The high Pydraul content in the casting pit and scale pits equals almost the entire reported Pydraul usage at that plant even when using a conservative estimate for the amount of scale produced per day.

The overflow from the pits contains minute quantities of Pydraul. The small amount of fluid and the presence of other chemicals precludes economical recovery using conventional absorptive filtration techniques. Pydraul in the overflow from the settling areas of

STLCOPCB4050618

these steel companies ranged from less than one gallon per year to about 200 gallons per year at parts per million levels of 1 or less. Although Pydraul levels are too low for recovery, escape is directly to the sewer which opens questions to pollution control. In the case of every steel company contacted during this study (total 6) waste treatment plants were either in existance or planned for the immediate future. All plants follow essentially the same basic approach to treatment which involves:

1) Deemulsification and flotation of oils.
2) Skimming and concentration of oils both at the scale pit and clarifier areas. Oils are then pumped to storage and either disposed of or reclaimed.
3) Chemical flocculation and clarification of solids and precipitable salts and acids.
4) Filtration of precipitated sludges.
5) Disposal of filtered sludges either by incineration, lagooning or land fill.

The minute quantities of Pydraul overflowing from the scale pits can thus be expected to end up in the sludge. The growing trend for sludge disposal is incineration due to restrictions now being placed on land fills and private lagoons.

For those operations using FR fluids in direct contact with the cooling water, the descaling area has been identified as the prime escape source. Economic recovery of the FR fluids from scale would require solvent extraction. This process, although favorable for

STLCOPCB4050619

diecasting appears impractical for the steel industry as:

1) Outside contaminates are high and uncontrollable. In the case of Wheeling Steel the ratio of Pydraul to the other products consumed in their 80 inch hot strip mill is about 1:2 Pydraul:kerosene solvent and 1:500 Pydraul: soluble rolling oil.
2) The growing practice in the steel industry is to sinter dredged scale from the scale pits. The by-product is reused in the steel making process. Sintering temperatures are over 1000°F. indicating adhered Pydraul is vaporized at the sintering plant.

A substantial amount of synthetic fluids are consumed in the steel industry in equipment not in direct contact with water. For example, scrap chargers, increased use of hydraulically operated furnaces, GPE soaking pits fuel-air regulators, etc. Findett customers for reclaimed Pydraul have included Laclede Steel and Wisconsin Steel. It is reasonable and conservative to assume that at least 10-20% of the consumption from the primary steel producers is reclaimable. Fluid in these cases will come from leakage, spillage and mass line breaks.

STLCOPCB4050620

Aluminum Industry

This industry is characterized by fewer applications involving direct Pydraul-water contact. The only volume applications in the aluminum industry where direct Pydraul-water contact is found is in vertical pit casting units. Here fluid leaks directly into the pit in contact with cooling water that is either recycled by a cooling tower or pumped directly to waste treatment facilities.

The growing concerns of pollution are now affecting the aluminum industry to almost the same degree as felt in the steel industry. Major aluminum producers are planning waste treatment facilities to handle cooling and process water effluent. The need is due to the high volume of emulsified rolling oils, cleaning and conditioning agents and electrolytic solutions consumed in the plant.

Although unconfirmed by analysis, effective Pydraul recovery can be expected from many caster pits as:

1) Cooling water flow rates are typically 300 gallons per minute or as much as 1/10th the rate found in many large steel mills where Pydraul has been found to be effectively removed at the first stage scale pit.
2) Pydraul does not come in intimate contact with gross chemical contaminates as found in the steel industry where high volumes of rolling oils and solvents are consumed.

Major applications for synthetic FR hydraulic fluids in this industry are in the melting furnaces, billet saws and furnace chargers.

STLCOPCB4050621

These are applications where recoverability can be expected from line breaks, leakages and spillages. An estimated 20-40% of synthetic fluid usage can be recovered from the combined sources of the casting pit and other equipment sources.

Foundries and Others

Foundries, typical of the large automotive grey iron foundries, offer definite recovery potential for synthetic hydraulic fluids. At GMC, Pontiac, Michigan, fluid usage was reduced about 50% following the installation of their own reclamation unit. The system involved collecting Pydraul leakage from overhead hydraulic power pack units. Drummed fluid is then filtered through a bank of Purolator oil filters and reused. Ford, Dearborn, who does not have effective reclamation discussed with Monsanto their spotty efforts to recover bulk drainage which indicated a 25-30% level of recoverability.

Pydraul in the foundry escapes from three separate sources. These include the hydraulic power pack drainage and leakage losses in the mold sand and floor absorbent. Practically the foundry can be expected to yield about 25-30% recovered material in bulk and 20-25% saturated Pydraul-absorbent material. The remainder of the usage is volatilized during the mold curing process. During this process the mold sand reaches temperatures of 1800-2400°F. GMC, Pontiac has agreed to simulate actual vaporization rates of Pydraul in mold sand where a measured amount of Pydraul is introduced to new sand.

STLCOPCB4050622

Following the cure cycle the Pydraul content can be reanalyzed. This should be done.

Our other non-key markets where Pydraul fluids are used should yield at a minimum 30% of the original sale volume in recoverable fluid. These markets will include primarily forging, extrusion, welders and hot forming presses.

IMPACT ON COMPETITIVE BUSINESS AND NEW MARKETS

Overall fluid costs of an effective recovery program offer substantial savings to our customers and to industry. It is an invitation to expand the market for safe fluids and should promote better housekeeping programs to minimize the threat of pollution controls.

Using the prices of reclaimed Pydraul now offered by Findett Services, Inc., St. Charles, at about $1.50/gallon, the potential savings offered to our customers is substantial. At $2.35/gallon, the current average selling price of Pydraul 312, the diecaster is offered a 30% fluids savings for a 75% recovery operation. In our other industries where 20-40% recovery is projected the customer is offered 10% or better savings, depending upon selling price of new fluid.

Product	($/gallon) Avg. Selling Price	% Recovery	Total Fluid Savings (%)
Pydraul A-200	$2.60	75	32
		40	17
		20	8
Pydraul F-9	$3.32	40	22
		20	11
Pydraul 150	$4.00	40	25
		20	12

DSW 176736

STLCOPCB4050623

It is estimated that with fluid cost savings and a total service concept (sales and reclamation) substantial penetration into the competitive synthetic fluids market can be achieved. Particular impact should be felt in the diecasting industry, foundries and aluminum where recovery rates are highest. Similarly, turbines, both gas and steam, are new growth markets for FR fluids. These units operate in relatively clean environments that offer efficient fluid recovery. A prime market for these turbines is the utility industry where operating costs are critical. Savings through an effective reclamation program will:

1) Promote the Monsanto fluid program versus competition.
2) Aid acceptance of safety fluids versus petroleum oil within the utility industry and other industries.

Penetration of large volume markets, i.e., forging, extrusion, plastic injection molding, like turbines, lend themselves to efficient fluid recovery. Each has eluded the FR fluid market because of high fluid costs and compatible sealing materials. Seals are becoming less of a problem. A significant reduction in FR fluid operating costs should expand FR fluids to these growth market areas.

INDUSTRIAL & DIELECTRIC FLUIDS RECLAMATION POTENTIAL

The total synthetic fire resistant fluids market is currently estimated at 30-35 M lbs./year of which our current market share is 40%, or 12-14 M lbs./year. Table V estimates our industrial fluids market by major industry to aid pinpointing existing reclamation markets and total potential available. Diecasting is our largest

STLCOPCB4050624

market with approximately 100 accounts of 400-500 on synthetic fire resistant fluids. This represents over 50% of our total fluids volume at 5.7 M lbs. of Pydraul per year. Our second largest industry is basic steel where 32 plants of 80-90 estimated on Pydraul fluids. Similarly we have 23 of an estimated 38 primary aluminum accounts using Pydraul fluids. Like aluminum, foundries represent another 10% of our business. In total these four industries -- diecasting, steel, aluminum and foundries -- comprise our key industries with over 80% of our total market volume. An unsold synthetic fluids potential of 18-21 M lbs. is available in diecasting, basic steel, foundry and other non-key industries.

Using our market and total potential market as a basis to define the fluids recovery market we see a total recovery potential for Pydraul of 4-5 M lbs./year. Including competitive fluids potential of 5.5-7 M lbs./year, the total recovery market is about 10-12 M lbs. per year. This potential is broken down by industry categories in Table VI, which includes an allowance of 20% for fluid fill in new equipment.

Fluids reclamation extended to both dielectric askarel and our Therminol fluids should comprise an immediate additional fluids market of about 0.9-2.2 M lbs. annually. Major dielectric customers have been notified to return waste dielectric fluids to Monsanto for disposal. At present small quantities of dielectric fluids have been returned to Monsanto for incineration. In the case of used transformer fluids, where practical, the Aroclor 1242 is reconditioned

and blended into Pydraul. One capacitor manufacturer, Westinghouse-Bloomington, has indicated that based on material accummulated historically, about 35,000 lbs. is recoverable from leakage or bulk spillage. This approximates 1% of their 3 M lbs./year annual consumption requiring reclamation where practical. Dielectric marketing estimates that of our total annual sales of both transformer and capacitor fluids 1% of sales or 0.4-0.5 M lbs./year of transformer and capacitor fluids is realistic for reclaimable volume. In the case of capacitor fluids recovery would require stripping and filtering and for transformer fluids filtration and reblending. Capacitor fluids not meeting dielectric specifications can be used as blend for Therminol FR-1 products. Preliminary estimates indicate that recovery in this market is small but significant. Under the current program with volumes of both transformer and capacitor fluids being returned to St. Louis, an analysis program should be pursued here and with the customer to confirm the above potential. According to manufacturing thus far it may be impractical to attempt recovery of contaminated transformer fluids.

The Therminol heat transfer market is about 3.7 M lbs. annually. About 50% (2 M lbs.) is makeup requirements due to leakage and degraded fluid. On a virtually unsolicited basis, Findett services 0.1-0.3 M lbs. annually from 10-15 separate accounts. An effective recovery program in the heat transfer area should net 25-50% or 0.5-1 M lbs. of the make up losses. The nature of recovery techniques for Therminol is similar to Pydraul and would be a natural

part of any recovery system program. Presently Therminol recovery involves vacuum distillation, filtration and analysis.

RECOVERY METHODS AND ECONOMICS

As indicated earlier on Table I the primary source for synthetic fluids recovery is the floor absorbent for Pydraul and in bulk from sumps and from spillage, etc.; for Pydraul, dielectric fluids and Therminol. An effective program must recover in both bulk and from absorbent.

Bulk

Bulk Pydraul reclamation has been the standard source for reused material. Used Pydraul is recovered in bulk from spills, mass hydraulic breaks and occasional reservoir clean outs. The major source for reclaimed-bulk presently comes from the large diecaster via settling ponds. Typical accounts with settling basins are Chevy, Massena; Johnson Motors, Central Foundry, Bedford,Indiana; Central Diecasting, Chicago; Lester Industries, Bedford, Ohio, and Chrysler, Kokomo, Indiana.

Processing steps for bulk Pydrauls at Findett involve:

1) air stripping to remove moisture
2) activated clay treatment for moisture and acidity removal
3) two to three pass sub-micron paper filtration for final fluid quality
4) addition of inhibitors, dye and antifoam when required
5) final fire test and property checks before shipment to customer

STLCOPCB4050627

Analysis as reported in Table II indicates solvent extraction capacility will enhance bulk reclaiming program due to the presence of solids at many accounts. Findett processes bulk used Pydraul at costs estimated between 2-5¢/lb., and Therminol reclaiming costs for vacuum distillation and processing average 4-5¢/lb. excluding freight and containers. Thus average Monsanto bulk reclaiming costs of 4-5¢/lb. maximum excluding freight and containers appears quite reasonable, both for Pydraul and Therminol.

Absorbent

The industry now depends upon clay type floor sweeping compounds to absorb liquid wastes. Samples taken from the diecast machine area of customers of Pydraul soaked absorbent indicate that the absorbent-Pydraul ratio is typically 1:1 by weight. Contaminants normally found in this mixture include aluminum fines and small quantities of die and plunger lubricants. Research indicates that over 95% of absorbed Pydraul can be effectively recovered from the clay floor sweeping compounds using chlorinated solvent extraction techniques. Overall results indicate that a solvent recycle extraction technique for separating synthetic FR fluids from floor absorbent material should pose no process problems on a larger scale. The solvent used in these experiments was trichloroethylene, which is common to most industrial solvent cleaning operations.

At present saturated absorbent material is being discarded to dumpsters and delivered to land fills by private disposal firms. Most customers are not aware that this is the major outlet for the bulk of their

STLCOPCB4050628

fluid consumption. In light of existing pollution laws this method of disposal to toxic land fills will give way to costly incineration.

Costs to solvent extract are comparable with the 4-5¢/lb. average for bulk recovery of Therminol and Pydraul. Central Engineering preliminary estimates on recovery, based on solvent extraction techniques were 5-7¢/lb., including capital amortization for a 2.5-5.0 $\overline{M}$ lb. Monsanto reclamation facility.

Proprietary Absorbent

The use of a proprietary Monsanto material that would be easily relieved of absorbed fluid was assessed. Absorbent, if permanent in nature, could be recycled following solvent extraction and reused by the customer. Present absorbent costs are 2¢/lb. plus minor costs to dispose of the material. Proprietary recycled material costing 30¢/lb. maximum is equivalent on a cost per pound basis to present material as recycling means usage is cut by 60-80% and disposal costs are eliminated.

Disadvantages of present absorbent materials include:

1) no permanency -- problem in breaking apart and reuse
2) good but limited absorbency power
3) material becomes sticky, almost mud, when soaked.

Research evaluated a variety of absorbent materials offering abrasion resistance, improved absorbency power, ease of solvent extraction and ability to recycle. The range of products studied include

STLCOPCB4050629

clay types (for comparison), styrene acrylonitrile, nylon, polyester fibers, PVC and several materials from outside suppliers. Results were encouraging, particularly on PVC fiber, which is proprietary. It gave excellent abrasion resistance, an absorbency capacity of 6-10 times conventional absorbents, improved solvent extraction capacilities.

The present absorbent market in the metalworking industry is estimated at 500-1000 $\overline{M}$ lbs./year. The average diecast machine consumes from 1,350-2,500 lbs. per year per machine. This equates to approximately 30 $\overline{M}$ lbs./year in diecasting alone.

Other major FR fluids market areas for fluid type absorbent fall in other industries where machines operate on the plant floor, for example, forging, extrusion and foundries. On a recycled basis the total metalworking absorbent volume would be reduced by about 75%, to 100-250 $\overline{M}$ lbs./year and diecasting to 7 $\overline{M}$ lbs./year.

The high absorbency extraction ratio shown by products like PVC fiber offers Monsanto an opportunity to penetrate the metalworking industry for FR fluids recovery and can also extend itself to the effective recovery of other chemical products, i.e. petroleum oils (transformer oils, machining lubricants), fluorocarbon electronic coolants and cleaning agents. Here, as in FR fluid applications, losses are significant and spillage and leakage is lost in the disposed, saturated absorbent. In addition, contaminated absorbent presents customer problems to insure safe disposal or incineration.

STLCOPCB4050630

RECOVERY ALTERNATES

Inhouse vs. External Reprocessing

Approximately 30% of all diecasters and a smaller, undefined percentage of the metalworking industry using FR hydraulic fluids have parts cleaning systems called degreasers. These units are required to further process the diecast part. These systems average $5000 per unit with the smaller (5-10 machine) shops operating one and the larger, i.e., Johnson Motors (100 machines) operating up to 6 units. The degreaser operates on chlorinated solvents including trichloroethylene, which was used by Research as the solvent extraction vehicle.

The existing degreaser would require modifications in incorporate a separate distillation-extraction concept for the removal of synthetic fluid from solids. These modifications do not appear extensive as only a solvent-Pydraul contact chamber and a separate solvent distillation system for the Pydraul-solvent solids is required. This method appears unattractive, however, as

1) solvent cleaning methods do not apply to the majority of diecasters.
2) CED cost estimates on inhouse solvent-extraction reclamation indicate high operational costs (10-12¢/lb.).
3) reclamation by a competent supplier appears economically equivalent to an inhouse system.
4) fluid performance requires constant monitoring by the supplier for safe, quality product.
5) An inhouse, high maintenance system has questionable market

acceptance. Likely results are reversion from synthetics to water glycols or petroleum oil.

Several Pydraul customers have moderately effective, large scale bulk inhouse recovery systems. Accounts include Chevy, Massena, and GMC, Pontiac, among others. Others have evaluated the approach and prefer an outside agency to provide the service. Sample analyses confirm that simple, inhouse filtration techniques present an inadequate answer to trouble free FR fluids performance. The presence of solids, moisture, graphite and oils contamination require a competent source for processing, analysis and end disposal of unreclaimable fluid.

This service can be performed by the fluids supplier or an outside reclamation agency. Oil reclaimers like Jesse Eagan-Dearborn, Michigan, Wallover Oil-Pittsburgh, are presently doing this job. Other chemical reprocessing firms like Findett Services-St. Louis, Eppi Services-Chicago, Inland Chemical-Toledo and American Chemical Company-Los Angeles also have the capability. They must rely on the fluids supplier, however, to insure fire resistance and chemical property balance (i.e., inhibitors) is maintained.

Via Fluids Supplier

This program handled or sponsored by the fluids supplier has marketing strength:

STLCOPCB4050632

1) Offers a fluid contract approach with the customer for total fluid service, new and used material.
2) Minimizes customer risks and maximizes FR fluid acceptance by eliminating questionable outside reprocessors.
3) The fluid contract would offer incentive pricing on recovered material of good quality. Improved housekeeping and reduced costs are directly attributed to image of the fluids supplier.

ECONOMICS OF RECOVERY

Reclamation of our industrial fluids offers protection to our fluids franchise and expansion of our market position. Table VII outlines estimated revenue from an effective captive Monsanto reclamation program. Basis is realistic revenues obtainable for 1972 through 1976, with reclamation operations in operation for full 1972 year.

Our total virgin Pydraul sales will be reduced by about 20% (3 M lbs.) in 1972 and 30-40% by 1974-75. This will come primarily in diecasting and foundry accounts, as outlined earlier. Total reduction in new fluid sales dollars equates to $0.75-1 M (1972) and about $1.5-2 M by 1974-75. Several tangible factors act to offset the reduction in new fluid sales:

1) Reclaimed Pydraul replacing lost new Pydraul business.
2) New business-reclaiming competitive fluids, increased market penetration and new markets.

STLCOPCB4050633

3) Distribution cost savings through changes in present distribution methods.
4) Cost savings by blending water/glycol and selected Pydraul fluids at the reclamation site(s).

Reclaimed Pydraul will generate about the same volume (M lb.) as lost in virgin sales. At 15¢/lb. average resale price total revenue is $0.4 M (1972) rising to over $1 M by 1975.

Reclamation from new business will open an additional $0.2 M in 1972 and $1 M by 1975. Sources for new business will include new markets, and recovery of competitive synthetics at many accounts, particularly larger ones. Overall market penetration will come primarily at these large accounts in industries with high recovery to new fluid ratios. Once fluid cost savings and "closing the loop" aids acceptance of synthetic fluids over water/glycol fluids, decreased preference of water/glycol should enhance this forecast. New growth markets that should provide 3-5 M lbs. reclamation volume by 1975-76 include forging, steam-gas turbines, injection molding and extrusion.

Distribution

As noted earlier, average reclamation processing costs based on Findett operations are feasible at 4-5¢/lb. for both Pydraul and Therminol fluids. Central Engineering estimates on reclamation based on solvent extraction techniques including capital amortization were 5-7¢/lb. based on a 2.5-5 M lb./year reclaiming capability.

STLCOPCB4050634

The wide geographical distribution and small size of many of our customers require economics below our present LTL distribution costs which average 5¢/lb. (containers, packaging, warehousing and freight). The presence of solids in a ratio as high as 1:1 solids to Pydraul will increase these distribution costs to uneconomical levels of 7-9¢/lb. Thus, the key to profitable reclamation lies in low freight charges and reusable containers. In order to realize acceptable gross profits of 40% or better on an average selling price of 15¢/lb. for reclaimed fluid, distribution costs cannot exceed 3-4¢/lb. for a total COGS of 9-10¢/lb. on reconditioned fluid. Present distribution methods are prohibitive for this concept.

Solids handling-JFQ (B. Reager) indicate distribution costs of 2-3¢/lb. are realistic for reclamation involving both bulk and the solids-Pydraul complex. This concept recognizes that our present method of common carriers is not feasible and recommends purchasing or leasing bulk and cargo trucks to handle both new Pydraul and used fluid. The LTL and TL customer is provided with recycle 500 gallon bins and/or open end drums for both new and salvage material. The TL customer will get deliveries and salvage pick-up via captive bulk trucks. Of three alternate methods investigated using captive recycle bin and bulk truck combinations, total distribution costs ranged between 1.56-2.78¢/lb. The geographical area chosen for the study was our Great Lakes market, where sales are concentrated and total immediate reclamation potential approaches 4 M lbs./year.

A copy of JFQ's report on economical distribution is attached for

reference. Total investment for captive trucks and recycle containers is approximately $100 M for a 5 M lb./year plant. Further evaluations are now being made by Organic Distribution (Gil Kasten and Earl Potter). They indicate this concept and distribution cost parameter should be feasible by using common carriers, thus about 50% of the $100 M investment per plant for trucks may not be required.

Water Glycol/Pydraul Blending

Marketing forecasts our resale water glycol sales to reach about 3 M lbs. by 1975 from 0.3 M projected in 1970. Presently glycol is shipped from West Virginia to St. Louis, blended with thickener and 40% deionized water and shipped to the customer. An estimated 2¢/lb. on finished product savings can be realized by blending on the reclamation site, at the center of our markets. Glycol shipments would be directed to the reclamation center. Here blending, packaging, and shipment to the customer would be handled.

Phosphate ester and terphenyl material will be required to adjust chemical properties of reclaimed fluid. Additional savings not shown on Table VII can also be realized by blending selected new Pydrauls at the reclamation center. High volume products, i.e., Pydraul 312 A and Pydraul F-9-A are logical candidates. Savings result from reduced warehousing charges and reduced drum shipment costs out of St. Louis.

STLCOPCB4050636

Contribution to Profits-Income

A Monsanto captive fluids reclamation concept is profitable. Gross profits should average over 40% including 2¢/lb. charges for disposal of waste residues (solids and Pydraul residues). Table VIII reflects revenues for the period 1972-1976 based on projected sales volume. Total net income is reported for both direct revenues (reclamation) and for indirect revenues accrued through distribution savings on Pydraul and water/glycol blending at the site(s). Indirect revenues from Therminol-Dielectric recovery and the potential absorbent recycling program are excluded.

Investment-Plant Locations

In order to economically handle anticipated volume from our widespread sales geography, this program will require several reclamation sites. A geographical breakout of our existing reclamation market and potential is given on Figure II. The bulk of our sales is concentrated in the Great Lakes area followed by the East Coast. Based on these geographical sales concentrations, required plant sizes, their locations and approximate date of need are estimated as follows:

DATE	CAPACITY	LOCATION
1971	5M pounds/year	Chicago-Detroit area
	2.5 M lbs./year	Midwest (St. Louis)
1973	5 M lbs./year	Chicago-Detroit-Pittsburgh area (expansion or new facility)
1974	2.5 M lbs./year	East Coast (N.J. or N.Y.)
1975	2.5 M lbs./year	West Coast (Los Angeles)

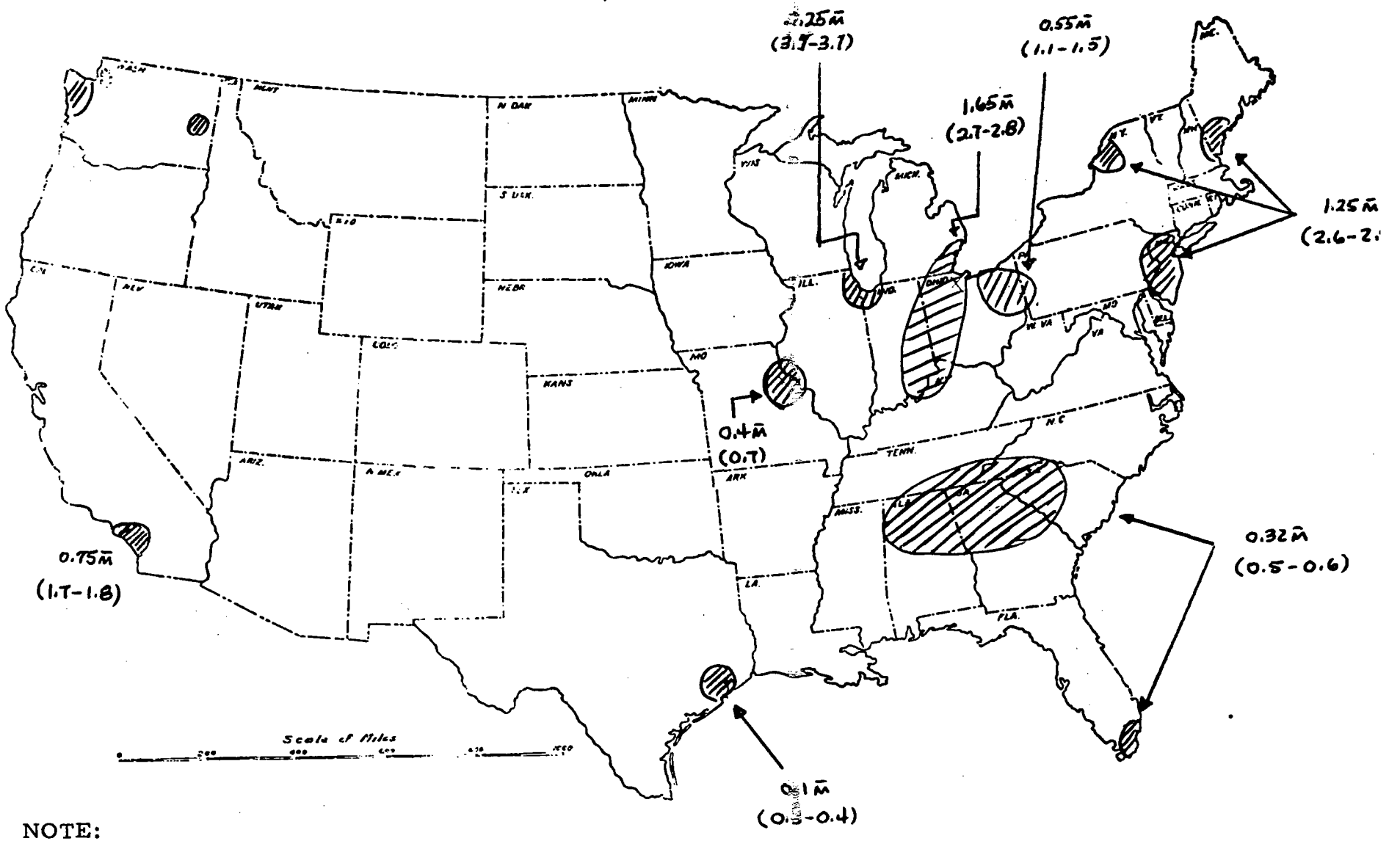
DSW 176750

STLCOPCB4050637

Figure II

Fluids Reclamation Potential

$\bar{M}$ lbs/Yr



NOTE:

1) Values represent immediate reclamation potential for Pydrauls, Therminols and Dielectrics. Numbers in parentheses include available competitive synthetic FR hydraulic fluids reclamation potential.
2) ▨ Denotes concentrated market areas.

DSW 176751
STLCOPCB4050638

The 5 M lbs./year site in the Chicago-Detroit area can handle short term requirements for the Great Lakes and East Coast. Similarly the midwest location satisfies longer range (1975) demands from the midwest, the west coast, Texas and southern states. Increased recovery volume (note Table VII) demands would justify an additional or expanded facility in the Great Lakes area by 1973 and smaller capabilities (2.5 M lbs./year) on East Coast and West Coast by 1974 and 1975 respectively. As the West Coast facility is longer range, distribution costs on recovered material and economics for blending water/glycol and hydraul should dictate interim facilities in the Los Angeles area on a smaller scale (0.5-2 M lbs./year) by 1972-73.

This capability can best be handled through a licensed combination reclaimer who can also serve as a West Coast distribution point.

Plant Investment Alternates

Two alternate approaches to required capital investment were considered. They were:

- Captive Monsanto facility (new or at existing Monsanto plant, i.e. Delaware River).
- Existing plant reclaiming or producing metalworking fluids.

Total plant investment for a captive 2.5 M lbs./year plant with solvent extraction and bulk fluids recovery is estimated at $350 M.

STLCOPCB4050639

Capabilities besides recovery include drumming, blending, quality control, trucks (3) and recycle container investment. Estimated investment is outlined on Table IX. Although, at best preliminary, these investment estimates should be liberal.

The investment for solvent extraction and bulk recovery are based on CED's preliminary cost estimates and the estimated investment of Findett for bulk Pydraul-Therminol reclamation @ 1.8 $\overline{M}$ lbs./year capacity. JFQ reports their Pydraul blend facilities are satisfactorily interchanged for water/glycol also. Analytical and quality control investment includes equipment for routine fluid analysis and fire resistance monitoring.

The total investment required to install reclamation and blending at an existing plant producing other metalworking fluids is projected at 50% or less of a captive plant. Additional investment would be required for additional storage, blending, filtration and solvent extraction equipment.

The investment required to incinerate fluids is substantial. Per J. Savage our investment (installed) for 10 $\overline{M}$ incineration capacity for waste Aroclor is $400 M. Pydraul wastes should be minimal as fluid coming in will be pre-analyzed to insure reclaimability. Solids, i.e. aluminum fines and absorbent are inert and will be disposed by land fill. A proprietary absorbent will offer recycling and further plant economics. Unreclaimable Pydraul will be forwarded by the customer to an outside firm (i.e. Rollins-Purle)

STLCOPCB4050640

or at 2-3¢/lb. plus freight to Krummrich for incineration.

Using the above premises regarding investment and plant timing, Table X shows payback on captive production is 4 years (1974) on $2.4 M invested during the sales period 1972-76 for 4 reclamation points. Return on investment for the operation including only revenues from reconditioned FR synthetic hydraulic fluids is 19% in 1972 and 42% by 1976. Including indirect revenues (blending and distribution savings) ROI exceeds 30% in 1972 and 80% by 1976.

Reclaiming through existing locations producing metalworking fluids and/or reclaiming chemicals offers payback within 3 years (1973) minimum, as indicated on Table XI. Either alternate appears attractive with acquiring the established fluids supplier/reclaimer most profitable for Monsanto. Acquisition of an established fluids supplier has an immediate added benefit of adding other metal-working fluid sales to our product line.

PROGRAM ACTIONS REQUIRED

Management approval of concept and of Monsanto entering reclamation systems business. Through research work and the experience of Findett, the recovery and reclamation of FR synthetic fluids is assured. Economics appear favorable. In order to complete this project for sales by 1972, the following areas should be detailed:

STLCOPCB4050641

ACTION	RESPONSIBILITY	COMPLETION DATE
Site location recommendations and management approval of new distribution method.	Organic Distribution Department (G. Kasten)	12/70
Pilot solvent extraction system start-up absorbed Pydraul recovery. (Material from selected accounts)	Research/CED/DRP	1/71
Market assessment--other chemicals recovery.	Marketing (DRP)	1/15/71
Modifications feasibility - WGK incineration for phosphate ester disposal.	Manufacturing (J. Savage)	2/1/71
Evaluate licensing vs. acquisition arrangements for reclamation sites. Analysis will include specific reclaimers vs. metalworking (blend) facilities.	Marketing (DRP)	2/1/71
*Final recommendations and committment on source for reclamation... captive; specific acquisition or external licensing arrangement. Note: A temporary joint product resale-reclamation license agreement may be required with an outside metalworking fluids producer if available capital will not allow acquisition in 1971.	Marketing (Fluids -HSB)	2/15/71
Process detailed for equipment selection (i.e., filtration rates, yields and other operation variables) for Pydraul and Therminol recovery.	Organic Research (L. R. Stark)	3/1/71

STLCOPCB4050642

ACTION	RESPONSIBILITY	COMPLETION DATE
Marketing strategy for new distribution system and total service approach.	Marketing/Distribution	4/1/71
Final process design, investment and costs.	CED(P. Lux/R. Kountz)	5/1/71
*Issue final reclamation business plan incorporating distribution and market strategy, process and design and updated economics.	Marketing (DRP)	5/20/71
Appropriation request and approval.	CED/Marketing/HSB	6/71
Plant construction or licensing arrangement completed.	--	12/31/71

R&D Expense: $10-20,000 (Equipment + 1-3 man months)

---

* Denotes meeting and decision points

STLCOPCB4050643

Possible Obstacles and Alternates

1) Distribution method disapproved by Organic Distribution.
   a) Revise distribution method to give 2-3¢/lb. costs.
   b) Investigate licensed Monsanto reclaimers.
   c) Drop project.

2) Final plant investment and costs unattractive (doubtful).
   a) Investigate licensed reclaimers.
   b) Drop project.

3) Scale-up requires pilot plant demonstration of solvent recovery process. Delay plant start-up 2-3 months.
   a) Arrange with J. F. Queeny for equipment additions and pilot plant runs. Cost $25-50,000.
   b) Locate outside reclaimer (i.e. Findett) with existing capabilities. Cost $10-20,000.

STLCOPCB4050644

TABLE I

PYDRAUL USAGE ESTIMATES-SELECTED DIECASTING PLANTS

	Gallons/Year		Source - % Total Usage				
	Pydraul Usage	Nr. Machines	Water Effluent	Floor Absorbent	Bulk	Diecast Flash	Other
Johnson Motors Waukegan	90,000	100	23-60%[1]	66-25%[2]	<5%	5-10%	--
Lester Castings Bedford, Ohio	12,000	20	25-50[1,3]	60-40%	<5	5	--
Central Diecasting Chicago	3,000	18	----->95[1]-------		<5	--	--
Milwaukee Diecasting Milwaukee	3,000	22	0	>90	<5	5	--
Carter Carburetor St. Louis, Missouri	18,000	48	0	70-80	25-20	5	--
Peat Mfg. Company[4] Norwalk, California	7,000	18	0	100	--	--	--
International Cast. Products, Gardena, Calif.[4]	3,000	9	20	80	--	--	--
ITT General Controls[4] Clendale, California	10,000	17	0	100	--	--	--
Withrow Diecasting[4] Hollywood, California	3,300	16	25	75	--	--	--

1. From actual water effluent sample analyses.
2. Absorbent solvent washed down water drains, thus effluent estimated @ 85-90% total usage.
3. Storm sewer sample. Total includes their estimate of 500-1000 gallons per year recovered from sump.
4. J. H. Davidson survey 5/70.

DSW 176758
STLCOPCB4050645

TABLE II

SALVAGE FLUID QUALITY-DIECASTING

Company	Johnson Motors		Lester Castings	Central Diecasting
Fluid Used	Pydraul A-200		Pydraul 312	Pydraul 312
Location-Sample	Sump	Stream Bed	Sump	Sump
Analysis-Sample				
% Solids	70	80	44	2
% Fluid	30	20	56	98
Specific Gravity Fluid	1.22	1.41	1.09	1.13
Specific Gravity New Pydraul	1.42	1.42	1.10-1.20	1.10-1.20
% Pydraul	70%	100%	95-100%	100%
Solids Present	Absorbent Aluminum Fines	Absorbent & Inorganic	Absorbent Aluminum Fines	Absorbent Aluminum Fines
Comments on Pydraul Recovery	Solvent extraction required	Solvent extraction required	Solvent extraction required	Filtration type only

STLCOPCB4050646

TABLE III

PYDRAUL EFFLUENT ANALYSES
STEEL INDUSTRY
(see Figure I.)

	Solid/Fluid[a] Ratio	ppm[b]	Pydraul gal/yr	%Total Usage	Recoverability
Wisconsin Steel					
(1) Caster Pit	--	3727	2400[c]	~100%	Difficult-solvent extract
(2) Settling Basin	--	1.53	0.2	nil	N/A
(3) Cooling Tower Overflow	--	0.63	0.1	nil	N/A
Wheeling Steel					
(1) Scale	--	155	2200[d]	≥ 90	Difficult-solvent extract
(2) Scale Pit overflow	--	0.1	200	10-12	N/A
Timken Steel					
(1) #3 Tube Mill	--	0.017	25	0.1	N/A
(2) #4 Tube Mill	--	0.125	200	1	N/A
(3) Pond-Top	1:50	--	--	nil	No evidence of Pydraul-all oil
(4) Pond-bottom	4:1	--	--	--	No evidence of Pydraul, all oil. Solvent extraction from solids required
(5) Pond-overflow	--	0.126	--	--	--

a)excluding water
b)expressed as PCB content
c)at 100 lbs per day scale (solids) throughput
c)at 1 ton per day scale (solids) throughput

STLCOPCB4050647

TABLE IV

PYDRAUL EFFLUENT ANALYSES-PROCESS MOLD SAND

FOUNDRY INDUSTRY

	Pydraul content ppm	Pydraul content %	Pydraul loss[1] gal/yr	% Total Usage
Ford Dearborn				
un-heated mold sand (recycled)	2820	1.10	7000[1]	5-8%
heated mold sand (recycled)	1980	0.77	5000[1]	
Pydraul burned off	840	--	>200,000	>100
GMC, Pontiac				
unheated mold sand (recycled)	192	0.08	500	5%

1 Basis - 2 - 2.5 tons/hour (1000 tons/year) mold sand losses @ Ford and GMC

2 Basis - 300 tons/hour mold sand recycled continuously

STLCOPCB4050648

TABLE V

ESTIMATED MARKET (SYNTHETIC FLUIDS)

	Total No. Plants	No. on Synthetics	--M lb-- Monsanto	Market	Potential[1]	Total
Industrial						
Diecasting	1000-1350	400-530	100	5.7	6-8[3]	12-14
Basic Steel	105	80-90	32	2.5	6-7	8.5-9.5
Primary Aluminum	38	38	23	1.3	0.7	2 M
Foundry	--	--	23	1.1	5[3]	8.5-10
Other[2]	--	--		1.5-3.5		
Total			700-800	12-14	18-21	31-25

1 Basis:
Diecasting - estimate DRP
Steel - 79 M lb/yr/plant. Average of 32 plants
Aluminum - 49 M lb/yr/plant. Average of 23 plants.

2. Includes immediate potential on synthetic fluids in forging, forming presses, turbines and other non-key industrie
3. Estimated DRP

DSW 176762
STLCOPCB4050649

TABLE VI

RECOVERY MARKET (SYNTHETIC FLUIDS)

	Recovery Available %	Available[1] Monsanto	Recovery[2] Monsanto	Available[1] Competition	Recovery[2] Competition	Total Recover
Industrial						
Diecasting	75%	4.5	3.4	6	4.5	7.9
Basic Steel	10-20	2	0.2 - 0.4	4.8-5.6	0.5 - 1.1	0.7-1.5
Primary Aluminum	20-40	1	0.2-0.4	0.6	0.1-0.2	0.3-0.6
Foundry	20	0.9	0.2	4	0.4-1.2	0.7-2.2
Other	10-30	1.2-2.8	0.1-0.8			
Total			4.1-5.2		5.5-7.0	9.6-12.2

1 Available = total market less 20% for new fluid fill

2 Recovery = percent of available

DSW 176763

STLCOPCB405065O

TABLE VII

DIRECT AND INDIRECT REVENUES-RECOVERY PROGRAM
(M Units)

	1972		1973		1974		1975		1976	
	lb	$	lb	$	lb	$	lb	$	lb	$
DIRECT Reclaimed Synthetic Fluids										
Pydraul @ current growth rate[1]	2.5	0.4	5	0.8	6	0.9	7	1.1	8	1.2
@ New Business[2]	1.5	0.2	3	0.4	5	0.7	7	1.1	10	1.5
TOTAL DIRECT	4.0	0.6	8	1.2	11	1.6	14	2.2	18	2.7
INDIRECT Distribution Savings										
New Pydraul[3]	5	0.06	10	0.1	15	0.2	20	0.3	25	0.3
New Water Glycol[4]	0.7	0.14	1.0	0.2	1.5	0.3	2.5	0.5	4.0	0.8
Reclaimed Therminol and Dielectrics[5]	0.5	0.07	1.0	0.1	1.5	0.2	2.0	0.3	2.5	0.4
TOTAL INDIRECT		0.3		0.4		0.7		1.1		1.5
TOTAL DIRECT & INDIRECT		0.9		1.7		2.3		3.3		4.2

1 50% market 1971; 100% thereafter at 15¢/pound average price recovered fluid.
2 Based on reclaiming competitive fluids and capturing 30-50% competitive business and 3-5M pounds new business by 1975.
3 @ 1.25¢/pound on new fluid shipments via reclamation center to customer. Container savings.
4 @ 2¢/pound savings for blending and shipment to customer from reclamation center versus St. Louis.
5 @ 50% available market in 1972.

DSW 176764
STLCOPCB4050651

TABLE VIII

ESTIMATED CONTRIBUTION TO PROFITS-RECLAMATION

$\bar{M}$ $

1971-1976

	1971	1972	1973	1974	1975	1976
$\bar{M}$ Pounds		4.0	8.0	11.0	14.0	18.0
Sales		600	1200	1600	2200	2700
COGS[1]		350	720	1000	1260	1620
Gross Profit		250	480	600	940	1280
Gross Profit %		42%	40%	37%	43%	47%
SARE (10% S)		60	120	160	220	270
NIBT[2]		190	360	440	720	1000
Other Income[3]		200	300	500	800	1100
NIBT (ADJ)		390	660	940	1520	2100
NIBT (ADJ) %		65%	55%	59%	69%	78%
NIAT (ADJ)		195	330	470	760	1050

1 - @ 8¢/pound including freight. Also includes disposal of solid wastes. @2¢/pound @ 50% total fluids reclaimed volume (lb).

2 - Net income before tax on direct revenues from FR synthetic hydraulic fluids recovery only.

3 - Including indirect revenues from blending and distribution savings. Excludes Therminol-Dielectric business and potential proprietary recycle absorbent program.

DSW 176765

STLCOPCB4050652

TABLE IX

RECLAMATION INVESTMENT-ESTIMATED

Capacity $\bar{M}$ lb Pydraul/Year	Operation	Captive Plant New	Existing Plant Producing metal-working fluids[4]
1.5 $\bar{M}$	Solvent extraction	$150 M[1]	$100 M
1.0 $\bar{M}$	Bulk Recovery (Filtration and flash still)	$50 M[2]	$25 M
	Drumming, instrumentation belnding-glycols and Pydraul	$40 M[4]	--
	Analytical, quality and control & other	$10 M[4]	--
(5 $\bar{M}$ pounds/year)	Trucks (3) and recycle containers	$100 M[5]	--
2.5 $\bar{M}$	Total	$350 M	$175 M
5 $\bar{M}$		$500[4]M	$300
10 $\bar{M}$		$750[4]M	$400
10 $\bar{M}$	Other-incineration, waste	$400[3]M	$400

1 - CED - P. Lux memo to DRP 7/10/70
2 - Estimated Findett investment-capacity 1.8 M pounds/year
3 - Krummrich cost $400M-10 $\bar{M}$ pound/year capacity
4 - Estimated DRP
5 - B. Reager (JFQ) memo to DRP 8/5/70

DSW 176766
STLCOPCB4050653

TABLE X

INVESTMENT AND PAYBACK-CAPTIVE RECLAMATION
M $
1971-1976

	1971	1972	1973	1974	1975	1976
Cum. Investment	900	1000	1550	1950	2350	2370
Invest./Year	900	100	550	400	400	20
WC Added/Year		100	50	50	50	20
Fixed Assets/Year	900	--	500	350	350	--
Cum. Fixed Assets	900	900	1400	1750	2100	2100
Dep'n (10%)	90	90	140	175	210	210
ROI (~~10%~~) (Pretax)						
@ NIBT*		19%	23%	23%	31%	42%
@ NIBT (ADJ)*		39%	42%	48%	65%	89%
Cash Flow						
NIAT (ADJ)	--	195	330	470	760	1050
Dep'n	90	90	140	175	210	210
Total Cash		270	470	645	970	1260
Total Invest./Year	900	100	550	400	400	20
Net Cash Flow	(810)	170	(80)	245	570	1240
Cum. Cash Flow	(810)	(640)	(720)	(475)	95	1335

* See Footnotes Table VIII

DSW 176767
STLCOPCB4050654

TABLE XI

INVESTMENT AND PAYBACK-RECLAMATION BY ACQUISITION
M $
1971-1976

	1971	1972	1973	1974	1975	1976
Cum. Investment	475	525	850	1050	1250	1260
Investment/Year	475	50	325	200	200	10
WC Added/Year*		50	25	25	25	10
Fixed Assets/Year	475		300	175	175	
Cum. Fixed Assets	475	475	775	950	1125	1125
Dep'n (10%)	48	48	78	95	113	113
ROI (%) Pretax		74%	78%	90%	135%	168%
Cash Flow						
NIAT (ADJ)	--	195	330	470	760	1050
Dep'n	48	48	78	95	113	113
Total Cash	48	233	408	565	873	1163
Total Invest./Year	475	50	325	200	200	10
Net Cash Flow	(427)	183	83	365	673	1153
Cum. Cash Flow	(427)	(244)	(161)	204	804	1925

* 50% of working capital required for captive plant

DSW 176768
STLCOPCB4050655

Monsanto

50

FROM (NAME & LOCATION) E. R. Reager - J. F. Queeny Plant

DATE August 5, 1970

cc D. C. Malm
M. P. Lux MLUX
J. R. Savage JSAVA

SUBJECT Pydraul Reclamation

REFERENCE

TO : Don Pogue DPOGU
B-2-E, O. O.

The material handling and distribution cost for pydraul reclamation has proved to be a freight cost problem. The logical way to distribute the reclaimed material seems to be through a small number of reclamation centers. Maybe only two or three will be required, if well located.

I used the Great Lakes area as a sample problem, using the figures you gave me on customers and volumes. I used a hypothetical reclamation center located at Gary, Indiana and analyzed the costs associated with various methods of material handling and distribution. My idea is that this Great Lakes area is the easiest one to work with and it has the highest market density. If reclamation can't be made to work there, it certainly won't work anywhere else.

My conclusion is that no method that uses common carriers for deliveries and pickups can be made economically sound. Freight charges will total at least 9¢/# vs. our target of 3-4¢ for freight plus packaging. Freight costs can only be brought within reason by operating a captive trucking system. The use of throw-away containers is also too expensive. We can get container costs in line by re-cycling them or by eliminating them from the system.

Two methods of operation appear attractive:

1. Captive tank truck delivery to all customers, or

2. Captive tank truck delivery to high-volume customers, with captive container truck and tote-bins or drums for small volume customers.

In my hypothetical example, the first method produced distribution costs of 1.6¢/# for bulk customers and 2.1¢ for LTL customers, with an investment of $116M. The second method produced distribution costs of 1.6¢ and 2.8¢, with a maximum investment of $230M, which would be reduced significantly by using drums instead of tote-bins for smaller customers.

The key to success is to use a captive distribution system and re-cycle the containers. A truck and driver will cost around $100 a day. If he can distribute an average of 10,000 lbs. per day you get the job done for 1¢/#.

DSW 176769

STLCOPCB4050656

Both of these proposals will achieve our objective of 3¢/# if we can get the material distributed in real life at the rate of 10M# per manday. This requires that the reclamation centers be well located with respect to customer volumes. A small volume reclamation business (less than 2.5M lb. per year) would not keep the truck driver fully occupied - but he could conceivably do other jobs or just be a part time employe.

The attached pages give a better description of the proposals and a tabulation of the data for the alternates I studied.

There would be some additional savings available by this route on the distribution of virgin pydraul. Probably most customers will expect to get virgin pydraul at the same time they get reclaimed material, and the use of the reclamation center for this purpose could save 1.25¢/# over our present distribution costs.

Bert Reager

/ksl

STLCOPCB4050657

PYDRAUL RECLAMATION

Descriptions of Material Handling Alternates

LTL

1. Common Carrier - Deliver recovered pydraul to customers in new steel drums (present practice). Return salvage material in 50 gal. PE-lined fiber drums.

2. Common Carrier - Use re-cycled steel drums to deliver pydraul to customer and to return salvage material to recl. center. Some of the drums will probably be open-top to accomodate solids. Re-condition drums that are to be used for delivering good pydraul.

3. Common Carrier - Use re-cycled steel drums for delivery of good pydraul and return of liquid salvage material. Re-condition drums for delivering good pydraul. Use tote-bins for return of all solids salvage material.

4. Common Carrier - Use re-cycled tote-bins for liquid deliveries and salvage as well as solids. Clean tote-bins that are used for deliveries.

   NOTE: Alternates 1 through 4 require heavy freight costs for return of salvage goods and for delivery of empty containers. Customer would do all of the handling and storing of containers.

5. Captive Tank Truck - Use our own 4-compartment tank truck to make deliveries - like fuel oil is delivered to homes. Measure deliveries with meter. Pick up liquid salvage material at the same time. Pump salvage material into separate compartment of the truck. Supply 500 gal. tanks to customer. Supply bins for solids salvage. Solids pick-up will be with a separate bulk truck.

   Customers will be given adequate number of standardized 500 gal. stg. tanks (fuel oil tanks with special paint and labels) for good pydraul and for liquid salvage pydraul, and perhaps bins for absorbent salvage materials.

   Equipment: 1 4500 gal. 4-comp. fuel oil truck with two pumps. 1 35-40 M lb. bulk truck for solids - may have boom to handle bins.

   People: 1 truck driver.

STLCOPCB4050658

Procedure: Driver delivers liquid pydraul to customers' tanks. He picks up liquid salvage at the same time, puts it in a separate compartment of the truck. He records the accumulation of solids salvage but does not pick up any. Between pydraul deliveries he picks up solids with the bulk truck, making the rounds as efficiently as possible based on his records. Pick-ups will require tests for pydraul identification, acidity, and assay so proper credit can be given. Pick-ups will be mixed into bulk so the condition of the salvage material must be determined before putting in into the truck. Customer does not have to handle any containers.

6. Captive Cargo Truck - Use our own special cargo truck to deliver containers to customers, either tote-bins or drums. Must deliver empties for solids salvage also. Truck will pick up liquid and solid salvage materials at the same time he delivers new pydraul. It will be a one-truck, one-stop operation. Truck can hold 12 tote-bins or 48 drums, and will have its own handling crane. Truck driver will do all of the handling as long as the container station is accessible.

   Deliveries will be made in either tote-bins or drums, which will be continuously re-cycled. Cargo truck will deliver containers of new pydraul and necessary number of empties for salvage material.

   Equipment: 1 50M-lb. 30' bed open-top cargo truck with 8M# hydraulic boom hoist. Containers are standard tote-bins or drums with special coating and identification, quantities to suit customers needs.

   Example: tote bins - min. of 5 for a customer, 3 at his plant - for good pydraul, liquid salvage, and solids salvage, and 2 in transit. Smaller volume customers can use drums or a combination of drums and tote-bins.

   People: 1 truck driver

   Procedure: Driver delivers liquid pydraul in containers plus any necessary empty containers. He unloads these and picks up all filled salvage containers on the same trip. Analysis for quality and assay can be made at the recl. center. - No - of time

TRUCKLOAD

7. Captive Tank Truck - Those customers that now get TL deliveries from St. Louis will get TL deliveries from the recl. center. Truck will pick up as much liquid salvage

STLCOPCB4050659

material as possible for his return trip. Solids salvage will be picked up by separate bulk truck, as in alternate 5. (stg. bins may be required, but for now I am assuming existing bins can be adapted)

Equipment: 1 4500 gal. 4-comp. fuel oil truck with 2 pumps. 1 35-40 M lb. bulk truck for solids - share with LTL business.

People: 1 truck driver

Procedure: Driver delivers TL of good pydraul and picks up liquid salvage. He picks up the solids on a separate trip, perhaps during a run for LTL solids pick-ups. Analysis on liquid salvage can be made at the recl. center or on the spot. Analysis of solids salvage must be made on the spot.

8. Common Carrier - Use normal routines for tank truck deliveries. Make a back-haul of liquid salvage material with the same truck - at 50% freight rate. Use common carrier bulk truck for returning solids salvage in TL quantities.

The logical final choice will probably be a marriage of two or more of these alternatives, such as:

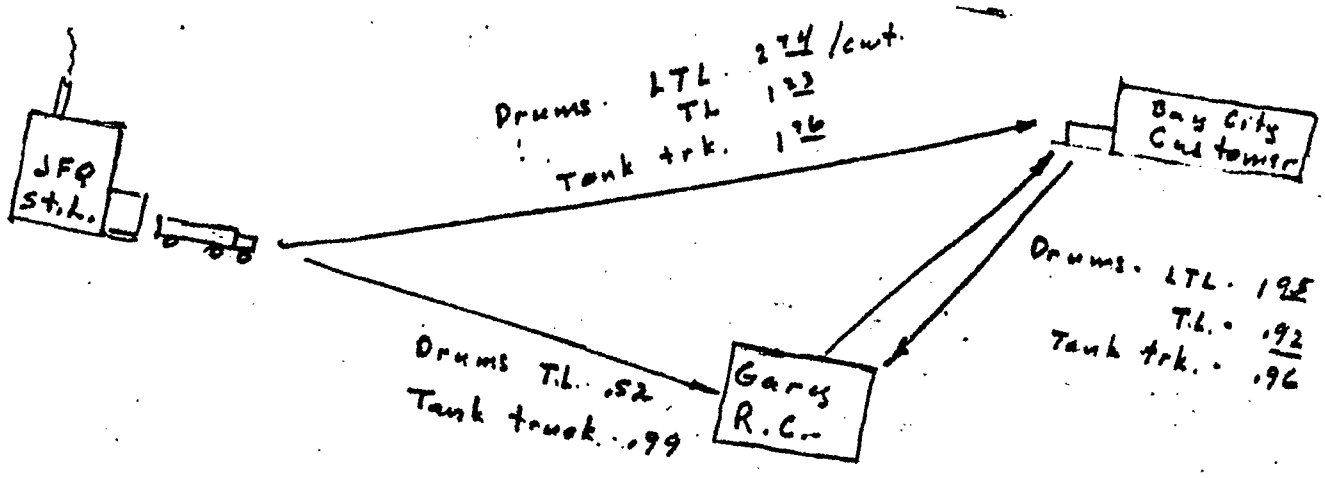
a. All customers keep tanks and bins on their premises, all distribution and pick-up in bulk trucks.

b. High-volume customers get deliveries and pick-ups via bulk trucks, but low volume customers use re-cycled containers.

In any event it looks to me like the Great Lakes area business would require 3 vehicles and two truck drivers and the average cost of distribution should be between 2¢ and 3¢ per lb.

STLCOPCB4050660

Hydraul Reclamation.



LTL customer. · 100M #/yr. T.L. 500M #/yr

		1.	2.	3.	4.	5	6	7.	8
Ship via.		6t. Drm. LTL	Re. St. Dm LTL	Re. St. Dm LTL	Tote Bin LTL	Tank Trk Captive	Tote Bins — Drums — Captive trk	Tank trk. captive	Tank trk T.L.
Salvage via		Fib Dm. LTL	Re. St. Dm LTL	Tote Bin LTL	Tote Bin LTL	same + Bulk trk.	same.	Same.	Bulk trk. TL.
Eds.	unit cost	9.00	8.00	8.00	50.00/yr.	25.00/yr	50.00/yr		
ntnrs.	Quan.	160	28/yr.	28	3	3	3	0	0
	Total	1134	224	224	150	75	150	0	0
alvage	Unit Cost	3.00	8.00	50.00	50.00	25.00	50.00		
ntnrs	Quan.	400	46	6	6	6	6	0	0
	Total	1200	384	300	300	150	300	0	0
reight	Rate	1.95	1.95	1.95	(?) 1.95	1.15	1.00	.78	.96
t. to	Vol., net	80 M	80 M	80 M	80 M	80 M	80 M	400 M	400 M
ust.	Total, Gross	1730	1730	1730	1730	920	800	3120	3840
reight	Rate	1.95	1.95	(?) 1.95	(?) 1.95	Dry .45 Liq. .21	? .50	Dry .45 Liq. .21	Dry 1.30 Liquid .48
alvage	Vol, net	160 M	160 M	160 M	160 M	120 40	160 M	600 200	600 200
ge.	Total, Gross	3460	3460	3460	3460	624	800	3120	8760
reight	Rate		? 12.00	? 12.00	? 12.00	—	0		
apty	Vol, net	0	.14 M	11 M	11 M	0	11 M	0	0
ntnrs	Total, Gross	0	1680	1320	1320	0	0	0	0
ntnr.	Unit		2.00	2.00	10.00	-	10.00		
leaning	Quan.	0.	160	160	18	0	18	0	0
	Total	0	320	320	180	0	180	0	0
sts	Freight	5190	7190	6830	6690	1544	1600	6240	12,600
er	Cntnrs.	2334	608	524	450	225	630	0	0
er	Total	7524	7798	7354	7140	1769	2230	6240	12,600
nit	Freight	6.46 ¢/#	8.96	8.51	8.34	1.93	2.00	1.56	2.52
sts	Cntnrs	2.92	.76	.65	.56	.28	.78	0	0
	Total	9.38 ¢/#	9.72	9.16	8.90	2.21	2.78	1.56	2.52
Investment		7-wlg solicit.	$ 10 M	$ 135 M	$ 170 M	$ 78 M	$ 192 M	$ 38 M	15
Break down:									
Tank trucks		0	0	0	0	18 M	0	18 M	0
Bulk truck		0	0	0	0	0	0	15	15
Room·cargo truck		0	0	0	0	0	22 M	0	0
Containers.		0	0	(300) 120 M	(400) 160 M	(220) 55 M	(400) 160 M	0	0
Cntnr. Cleaning.		0	10	10	5	0	5	0	0
Cntnr. Handling.		0	0	5	5	0	5	0	0
Truck Cleaning.		0	0	0	0	5	0	5	
		0	10 M	135 M	170 M	78 M	192 M	38 M	
ngs on 1M #/yr						1.24 ¢/#	.57 ¢/#		
in Hydraul.						$ 12 M/hr.	$ 6 M/hr.		

DSW 176775

BERT REAGER

AUG 5 - 1970

STLCOPCB4050662

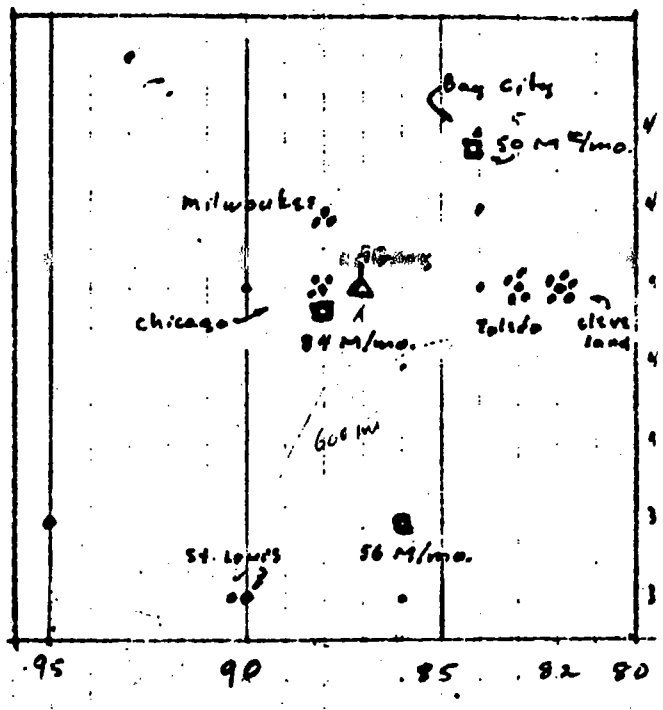
North Central Region.

■ = TL Market distribution
● = LTL " "

	Stops	LTL M #/mo.	Long.	Lat.	Cust. Tons
Ill.	Chicago. (3)	13	88	42	6
	Rockford.	1.2	90	42	2
	Waukegan.	1	88	42	2
Ind.	Logansport	.3	86	41	2
Ky.	Louisville.	9	86	38	5
Mich.	Bay City.	2	84	44	2
	Detroit	10	83	42	5
	Oak Park	1	84	43	2
	St. Joseph	2	84	42	2
Minn.	New Brighton	18	93	45	7
Mo.	K.C.	2	95	39	2
	St. L. (2)	24	90	38	4
Ohio.	Bedford } Same	11	82	42	6
	(5) Cleveland }	12	82	42	10
	Sandusky	8	83	42	4
	(3) Toledo	15	83	42	9
Wis.	(2) Milwaukee	14	88	43	4
	Racine.	1.2	88	43	2
					86
Base:	Gary	100.5	87	42	

27 stops for 100M #
or 4 M #/stop.

SCATTER DIAGRAM.



major LTL market in this area is 100 M #/mo. of fin. gds.

Total LTL market is probably 2 or 3 times that say 300 M #/mo.

TL Market is now 190 M #/m

DSW 176776

STLCOPCB4050663

A MONSANTO BUSINESS

IN

FLUID HEAT TRANSFER SYSTEMS

Functional Fluids
Business Group
July 26, 1968

DSW 176777

STLCOPCB4050664

CONTENTS

		Page No.
1.	Our Business Group Today	1
2.	The Heat Transfer Fluids Market	2-4
3.	Our Performance to Date	5-10
4.	The Heat Transfer Systems Market	11-14
5.	A Business Opportunity for Us	15-16
6.	Our Recommendations	17-19
7.	Financial Aspects of our Recommendation	20-23
8.	Profile of our New Business	24-25
9.	Appendix	26-29
	Detailed Financial Aspects	

OUR FLUIDS BUSINESS

Products - Engineered, chemical based fluids

Charter - Satisfy performance needs of industry with fluids and fluid related materials, equipment systems and services

Financial Picture - 1968 Prospects

Sales	$23.1M
Income	$ 3.2M
ROI	14.2%
Growth Rate	12.0%

Business Objective - Materially increase rate of growth maintaining ROI of at least 9%

Business Summary -

Markets / Materials	Aviation	Electrical	Metalworking	Heating
Aroclor		$8M	$3M Opportunity	$1M Opportunity
Phosphate Ester	$7M Threat		$1M	
Others	$1M Opportunity			

DSW 176779

STLCOPCB4050666

HEATING MARKET

(Fluid Heat Transfer Systems)

Key Issue

Realize maximum sales and profits from our opportunity in the heating market where we have:

1. Strong raw material position - Aroclor
   - No. 1 profit maker - Organic Division
   - Half of fluids net income
   - Objective to increase sales while maintaining U.S. and U.K. sole supply position profitability
2. Certain technical and marketing skills
   - Heat transfer for chemical processing is basic to Monsanto operations
   - We have successful heat transfer fluids business

Long Range Plan

Expand participation in the heating market to achieve at least $3M sales of fluids by 1972

Develop business plan of forward integration and acquisitions which will be related to and an integral part of our business to expand 1972 sales by $5-10M and capitalize on our technical, marketing and financial strengths

DSW 176780

STLCOPCB4050667

FLUID HEAT TRANSFER SYSTEMS

Almost every chemical process involves some type heat transfer: Electrical, direct fired, steam Dowtherm or Therminol

There is a growing market for high temperature process heating and Therminol has a place in it because it permits a heating system to operate:

- at high temperatures-600-700°F
- with safety-fire resistant and non-pressurized
- simply and economically-liquid phase

DSW 176781

STLCOPCB4050668

HEAT TRANSFER FLUID MARKET 1968 (DOMESTIC)

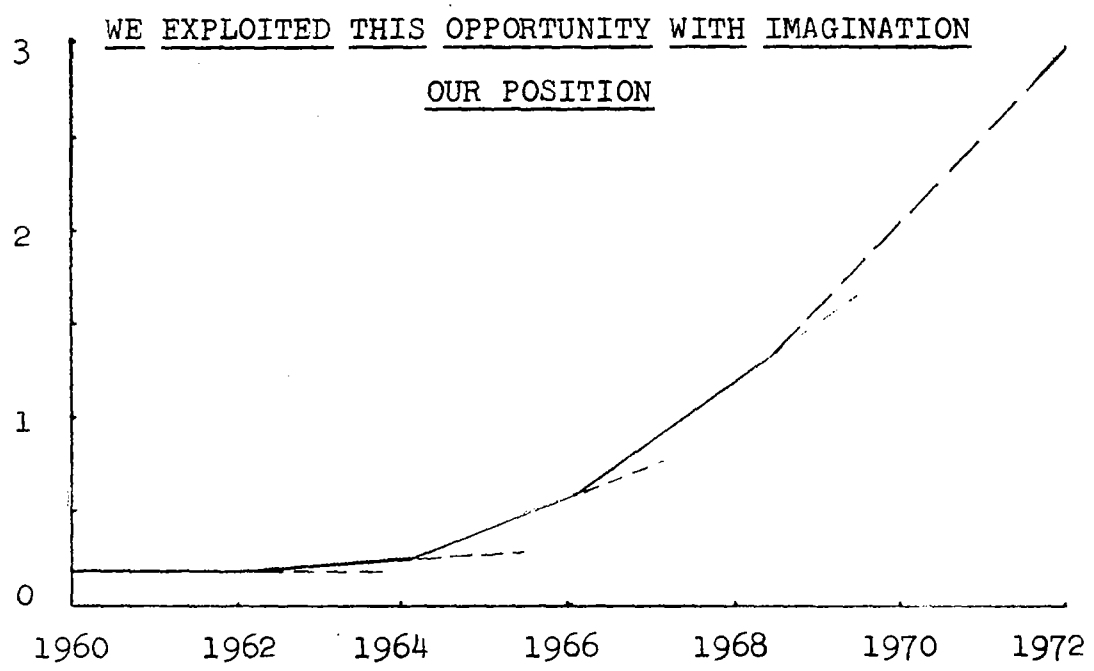
	M GALLONS			$M
	NEW SYSTEMS	TOP UP AND REPLACEMENT	TOTAL	TOTAL
Monsanto (Therminol)	0.2	0.1	0.3	1.0
Dow (Dowtherm)	0.6	1.0	1.6	4.8
Petroleum Oils	0.7	1.5	2.2	1.3
Other Fluids	0.2	0.3	0.5	1.0
TOTALS	1.7	2.9	4.6	8.1

OPPORTUNITY TO GROW

- Fluid market $8M, growing at 15% rate
- Therminol has 12% of market, growing at 30% rate
- Major supplier Dow has lead time, but narrow product line and small marketing effort

DSW 176782

STLCOPCB4050669



		Domestic	
Period	Concept	Sales	Net Income (AT)
1960-1962	Aroclor	$175,000	$ 18,000
1962-1964	Therminol: marketing, promotion, application information, increased price	$250,000	$ 50,000
1964-1966	System engineering service	$600,000	$120,000
1966-1968	Broaden product line	$900,000	$180,000
1968-	System salesmen in field		

World-wide Sales (1968 Prospects) are $1,200,000

DSW 176783

STLCOPCB4050670

We Are Growing at Twice the Rate of Competition Because:

- We have the products that best meet the needs of our customers
- We have strong marketing program with a lot of application assistance for our customers
- We are pioneering sales to fast growing markets

We Follow a Three-Prong Strategy:

- Compete with other fluids in present applications (General chemicals, resin cooking)
- Beat competition to emerging applications (rubber molding, food processing)
- Establish a new application - solely ours (space heating)

COMPARISON WITH COMPETITION

	MONSANTO IS		
In Terms of	Poorer	Equal	Better
Market Coverage			X
Market Reputation		X	
Quality		X	X
Innovation			X
Process Economics		X	
Customer Service			X

DSW 176784

STLCOPCB4050671

Examples of what we've done

(a) Hooker Chemical - General chemical processing

Application - Standard heat transfer system for varied unit operations

Past practice - Dowtherm, oils, Aroclor (plant autonomy)

Need - Design assistance

Strategy - Sell fluid benefits and design assistance to each plant

Results - Ten systems on Therminol

(b) Interchemical

Application - Resin cooking

Past practice - Dowtherm, vapor (central engineering)

Need - Fire safety, simplified operation

Strategy - Sell benefits of fire-resistant liquid system, design assistance, plants and central engineering

Results - Seven systems on Therminol to cook resins, heat storage tanks, space heating

Benefit to customer - remove a known fire-hazard, gave them heating systems more simple and economical to operate and maintain

DSW 176785

STLCOPCB4050672

(c) Firestone

Application - Rubber molding (tank treads)

Past practice - Steam

Need - Higher temperatures, control, production rate

Strategy - Sell liquid system concept, give design assistance

Result - Converted 20 presses

Benefit to customer - doubled his production rate and lowered his maintenance costs

(d) Joe Lowe Division Consolidated Foods

Application - Deep frying doughnuts

Past practice - Direct fire

Need - Better temperature control, beat competition (DCA)

Strategy - Sell indirect (fluid) heat transfer, give design assistance

Result - Installed 31 systems, lead to frying fish, shrimp, etc.

Benefit to customer - Better product and lower costs through increased production rate, 10 percent larger doughnuts, 6 percent less flour, longer life of cooking oil

DSW 176786

STLCOPCB4050673

(e) Riverhouse Apartments

Application - Space heating

Past practice - Steam and hot water

Need - Lower costs (co-operative) and more heat

Strategy - Establish concept of automated boiler room, give design assistance

Result - Installation successful here, expanded to Parkside Garden Apartments, Holy Cross Hospital, National Tea Company, and Monsanto's new office/laboratory in Akron

Benefit to customer - Automated, saved $36,000 per year ($75 per apartment), 3 year payback

(f) VNS Ship Lines

Application - on board heating: waste heat recovery; heating cargo and fuel; space heating

Past practice - High pressure steam

Need - Safe, low pressure system

Strategy - Sell Therminol system benefits strong engineering assist (new components involved)

Result - Two ships now serving Amsterdam/Sidney, three more under construction, other companies follow

DSW 176787

STLCOPCB4050674

In Summary We Have Been Successful in Selling Therminol Fluid Because:

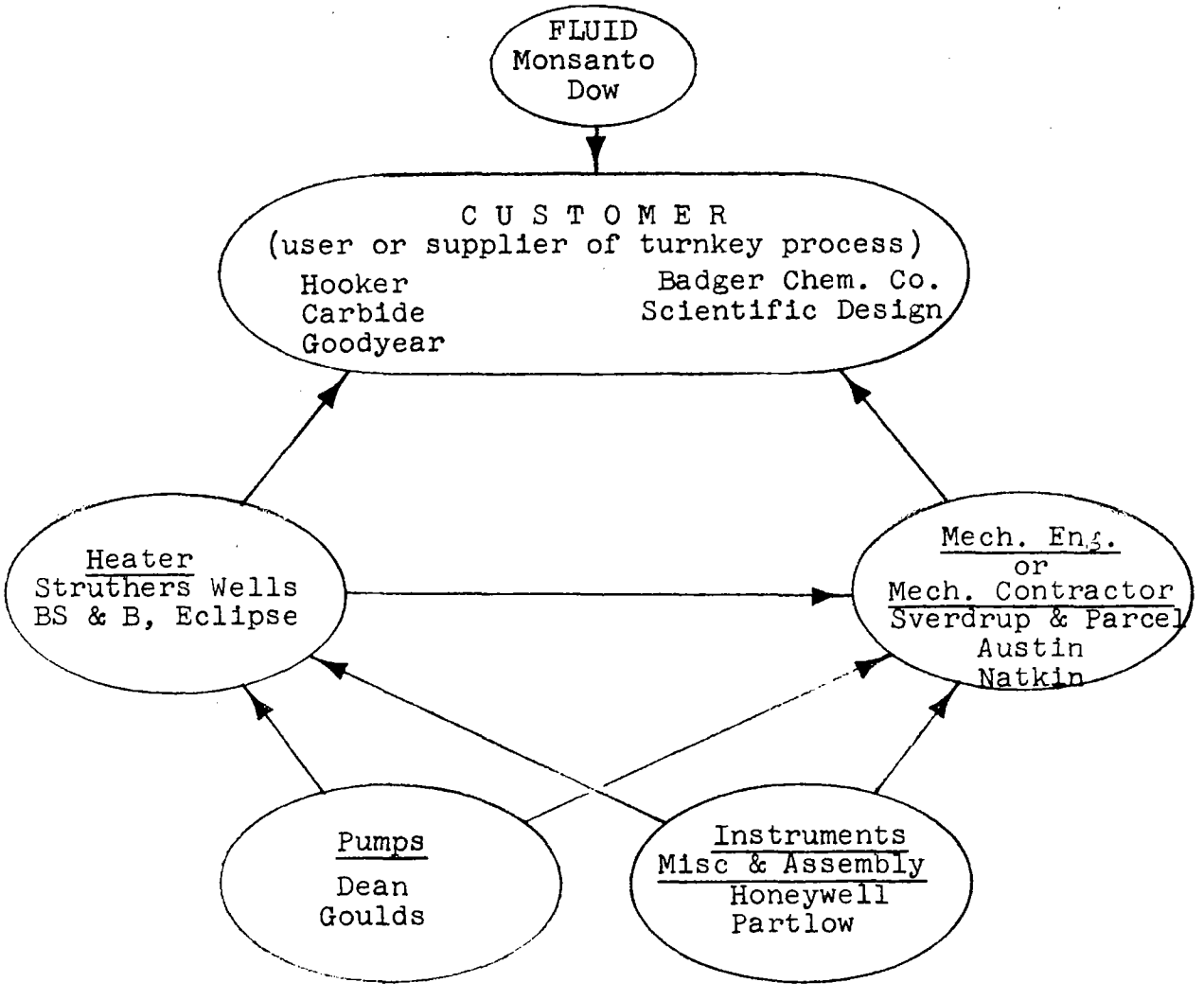
1. In selling the fluid we have also sold the concepts and benefits of the system and gave needed assistance in the design of the system and the selection of components.

2. We have brought to the customer a single working force, the fluid supplier, existing equipment suppliers and engineering staffs.

DSW 176788

STLCOPCB4050675

PRESENT MARKETING CHANNELS FOR FLUID HEAT TRANSFER SYSTEMS



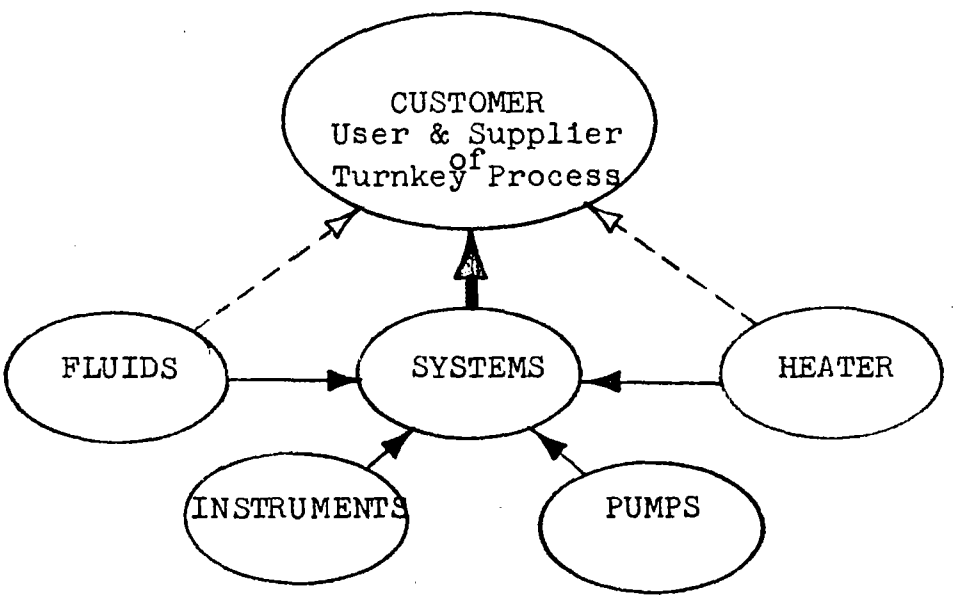
The customer must now come to at least two separate sources to get his complete heat transfer system.

DSW 176789

STLCOPCB4050676

WHAT THE CUSTOMER WANTS IS

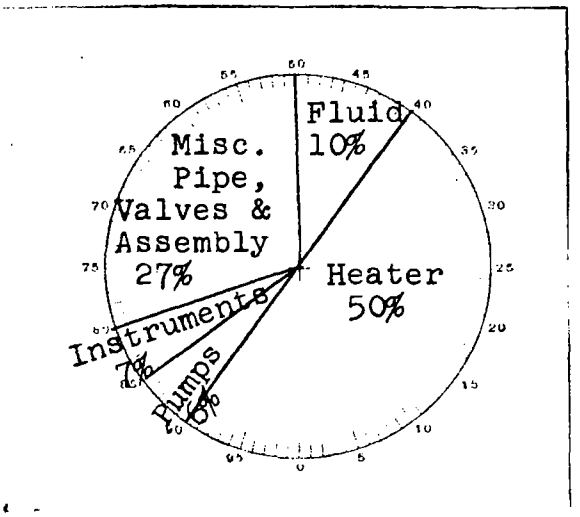
A reputable, single-source responsibility for fluid heat transfer systems with reasonable guarantee of performance. . . . .



DSW 176790

STLCOPCB4050677

SALES OF THE COMPONENT PARTS OF
A FLUID HEAT TRANSFER SYSTEM



Tenneco

Application - Drying natural gas on off-shore processing platforms

Need - Fire safety, fluid stability and non-corrosiveness, engineering assistance

Result - Converted to Therminol in three platforms
Other customers following and application expanding to space heating of gas drilling rigs

Benefits to Customer -
Achieved required performance plus saved $1M because fire-resistant fluid eliminated need for separate platform

Sales and Profits -

System Component	Supplier	Sales Volume
Fluid	Monsanto	$ 5,000
Heater	BS and B	20,000
Pumps	Dean	2,800
Instruments	(Various)	3,000
Misc and Assembly	---	11,500
TOTALS		$42,300

Market: 100 platforms per year

DSW 176791

STLCOPCB4050678

United Resins - Manufacturing hot melt adhesives

System Component	Supplier	Sales Volume
Fluid	Monsanto	$ 1,800
Heater	Hopkins	10,000
Pump	Dean	1,200
Instruments	(Various)	1,000
Misc and Assembly	———	5,800
TOTALS		$19,800

Market: 10 systems per year

Van Dyk - Manufacturing of chemicals and generating steam for process and space heating

System Component	Supplier	Sales Volume
Fluid	Monsanto	$ 3,000
Heater	Eclipse	15,000
Pump	Dean	1,800
Instruments	(Various)	2,000
Misc and Assembly	———	8,000
TOTALS		$29,800

Market: 20 systems per year

DSW 176792

STLCOPCB4050679

Hence, Our Opportunity:

To supply both the fluid and the heat transfer system equipment package, not just fluid alone. This would:

1. Increase our sales of fluid
2. Protect the sale of fluid when and where we have Aroclor (Therminol) competition
3. Increase our volume of sales and profits in the heating market

This is consistent with our Long Range Plan:

- To increase our participation in the heating market...
- To expand in fluid-related activities so as to achieve $5-10M of new business in 1972 while maintaining an ROI of at least 9%

There are Four Alternate Approaches We Can Take:

1. Continue as we are--selling only the fluid
2. Enter the systems business by internal growth alone
3. Enter the systems business by a single, key acquisition.
4. Enter and expand in the systems business by a series of related acquisitions.

DSW 176793

STLCOPCB4050680

ANTICIPATED FINANCIAL RESULTS OF ALTERNATE APPROACHES

	$M		Long Range Plan Target $5-10M By 1972
	1969	1972	
Alternate Approaches			
1. Sell only the fluid			
Sales	1.6	3.0	Does not meet
Net Income (AT)	0.32	0.60	plan
ROI	22%	22%	
2. Systems via Internal Growth			
Sales	1.6	4.0	Does not meet
Net Income (AT)	0.32	0.68	plan
ROI	22%	23%	
3. Systems via Single, Key Acquisition			
Sales	4.3	9.4	Meets plan
Net Income (AT)	0.46	1.12	
ROI	18%	20%	
4. Systems and Expansion via Several Realted Acquisitions			
Sales	4.3	18.7	Exceeds plan
Net Income (AT)	0.46	1.73	
ROI	18%	16%	

(See Appendix for more details)

DSW 176794

STLCOPCB4050681

WE RECOMMEND ALTERNATE APPROACH NO. 4

That we enter and expand in the systems business by a series of related acquisitions - specifically:

1. That to enter the systems business we begin immediately by the acquisition of a heater builder established in the sale of Therminol heat transfer systems and staffed for marketing, design engineering and field service.

   The heater builder is selected as the key because

   (a) Present route of systems to marketplace

   (b) The major component of system at 50% of sale and 35% of net income

   (c) It is technically critical to match fluid and heater and system to heater

   (d) Maximum result from innovation - the key to system capital cost and fuel economy

2. That we expand by a 1970 acquisition of a manufacturer of heat transfer pumps - the one remaining key engineered product in the system.

3. That we expand by a 1971 acquisition of a heater builder in the U.K. or Europe to enable us to enter the systems business there and to exploit further our sole supply position in Aroclor in the U.K.

DSW 176795

STLCOPCB4050682

PROFILE OF ECLIPSE

Eclipse Lookout Company, Inc. - Chattanooga, Tennessee

(Wholly owned subsidiary of Eclipse Fuel Eng. Company- Rockford, Illinois)

Formed in 1958 by Parent Company to purchase Lookout Boiler Company

All stock held by A. Camp. Perks (47) - Chairman of Eclipse Lookout and President of Parent Company

Managed by E. E. Magnuson (63) - President of Eclipse Lookout

Sales	$2,000,000
Worth (est.)	200,000
No. Accounts	2,000
Employees	125
Marketing	47 Mfg. Rep. Firms
Territory	United States and Foreign
Facilities	Plant in Chattanooga equipped for complete fabrication of heaters and boilers

FINANCIAL

All detailed financial information has been withheld from D and B

It is understood income has been low until recent design of competitively priced boiler.

Fluid heater sales have been profitable:

Sales	$1.00M
Gross Profits	$0.50M
S Expense	$0.23M
"GA" + ARE	$0.05M
Net Income (AT)	$0.11M
Return on Sales	11%
Investment (est.)	$0.5 M
ROI	22%

DSW 176796

STLCOPCB4050683

PROFILE OF HEATER BUILDERS

(Domestic Manufacturers of Applicable Equipment)

APPLICABLE COMPANY OR DIVISION	HEATER SALES $M	TOTAL SALES $M	
Struthers	3	30	Process equipment
BS & B	1	50	Process equipment
Eclipse	1	2	Boilers
Hopkins	1	1	---
IBW	1	3.5	Boilers
Petrochem	1	--	Process furnaces and equipment
Cleaver Brooks	0.5	5	Boilers
Vapor	0.5	3.5	Boilers, instruments and controls
Waste Heat Eng.	0.5	2	Waste heat equipment

COMPARISON OF ECLIPSE WITH COMPETITION

IN TERMS OF	ECLIPSE IS		
	Poorer	Equal	Better
Market coverage			X
Market reputation		X	
Quality			X
Innovation			X
Process economics		X*	
Customer service			X

*Manufacturing cost of boilers was poor--is now equal to competition. Cost of heaters is equal to competition.

DSW 176797

STLCOPCB4050684

ANTICIPATED FINANCIAL RESULTS

Alternate Approach No. 4

	$M			
	1969	1970	1971	1972
THERMINOL				
Sales	1.6	2.2	3.0	4.0
Investment	1.4	2.0	2.7	3.6
Net Income (AT)	0.32	0.44	0.60	0.80
HEATER (ECLIPSE)				
Sales	2.4	3.0	3.5	4.2
Investment	1.0	1.4	1.6	2.0
Net Income (AT)	0.12	0.18	0.21	0.26
PUMPS (DEAN)				
Sales	--	4.0	4.5	5.0
Investment	--	3.0	3.3	3.5
Net Income (AT)	--	0.20	0.25	0.30
U.K./EUROPE HEATER (BEVERLY, HYGROTHERM OR WANSON				
Sales	--	--	3.0	3.5
Investment	--	--	1.4	1.6
Net Income (AT)	--	--	0.18	0.21
AUXILIARY EQUIPMENT RESALE AND ASSEMBLY				
Sales	0.3	0.8	1.4	2.0
Investment	0.1	0.2	0.3	0.4
Net Income (AT)	0.02	0.06	0.11	0.16
TOTALS				
Sales	4.3	10.0	15.4	18.7
Investment	2.5	6.6	9.3	11.1
Net Income (AT)	0.46	0.88	1.35	1.73
RETURN ON SALES	11%	9%	9%	9%
ROI	18%	13%	14%	16%

DSW 176798

STLCOPCB4050685

HEAT TRANSFER FLUIDS

EFFECT OF HEAT TRANSFER SYSTEMS

	DOLLARS IN $\bar{M}$ - YEAR 1972		
	FLUIDS ONLY	H. T. SYSTEMS	SYSTEMS INCREMENT
Sales	3.000	18.700	15.700
Investment	2.700	11.100	8.400
NIAT	0.600	1.730	1.130
Margin	20%	9.3%	7.2%
Turnover	1.1	1.7	1.9
ROI	22%	15.6%	13.5%

DSW 176799

STLCOPCB4050686

HEAT TRANSFER SYSTEMS

SARE EXPENSES

YEAR 1972

DOLLARS IN M

	FLUIDS	HARDWARE	TOTAL
Sales	4.000	14.700	18.700
G.P.	2.600	5.800	8.400
Sales Expense	400	2.900	3.300
R & E	350	680	1.030
Adm.	50	200	250
Operations Income	1.800	2.020	3.820
NIAT	800	930	1.730

DSW 176800

STLCOPCB4050687

LONG RANGE PLANS

YEAR 1972

DOLLARS IN M

	WITHOUT H.T.S.	WITH H.T.S.	LRP TARGET
Net Sales	36.5	53.7	50.0
Gross Profit	15.0	20.3	19.5
SARE	6.0	9.2	8.0
Operation Income	9.0	11.1	11.5
Net Income (AT)	4.2	5.2	5.4
Gross Investment	38.0	50.0	50.0
Margin	11.0%	9.8%	11.0%
Turnover	.96	1.08	1.00
ROI	11.0%	10.4%	10.8%

DSW 176801

STLCOPCB4050688

PROFILE OF OUR NEW BUSINESS

From the customer/market viewpoint the new business would be viewed as:

- A responsible, single source for heat transfer systems. The best value for his money.
- Combining the Monsanto image of chemistry & technology with heretofore scattered, small independent businesses
- An image of quality and technology based on engineered fluids and systems - with total back-up
- A flexible organization selling either systems, individual fluids or heaters
- An adjunct to other Monsanto products from a process viewpoint. More Monsanto account participation.

From our competitors' viewpoint the anticipated reaction would be:

- Initially, a new competitive factor
- Ultimately, through our continued effort to broaden the market and sell fluid, they would gain in this growing market
- Therminol is unique and they will use regardless
- No Therminol sales will be lost even initially
- More profit is made on liquid phase heaters; therefore, they will support it after the initial reaction
- No Monsanto sales will be lost to heater builders-as they are not customers of Monsanto

From Monsanto viewpoint this new business would:

- Provide a new opportunity on a world-wide basis to diversify our business and increase profits and meet our Long Range objectives
- Provide a basis for further innovation of processing systems (food cooking, space heating, waste heat recovery)
- Offer the base for further "hardware"and "systems" diversification related to our other Fluids Businesses either by acquisition or internal growth. (Filters, control instruments, etc.)

DSW 176802

STLCOPCB4050689

- Organizationally, fit in well. Marketing-wise - we would at least for the present utilize Eclipse's sales agents and supplement with our own professional Therminol sales engineers. As time progressed, we would, where advantageous, replace agents with Monsanto personnel; thus reducing the high sales commission which the agents enjoy.

Eclipse would provide the field service engineers and the design engineers for heaters and boilers (Monsanto has none of these).

Eclipse would provide the manufacturing capability (Monsanto has none).

Monsanto would provide the Research & Development capability on fluids and process systems.

From a top management viewpoint - Mr. Perks would stay with his parent company and Monsanto Management would integrate into Eclipse Lookout Company.

DSW 176803

STLCOPCB4050690

APPENDIX

DSW 176804

STLCOPCB4050691

ANTICIPATED FINANCIAL RESULTS

Alternate Approach No. 1

	$M			
	1969	1970	1971	1972
THERMINOL				
Sales	1.6	2.1	2.5	3.0
Investment	1.4	1.9	2.3	2.7
Net Income (AT)	0.32	0.42	0.50	0.60
Return on Sales	20%	20%	20%	20%
ROI	22%	22%	22%	22%

DSW 176805

STLCOPCB4050692

ANTICIPATED FINANCIAL RESULTS

Alternate Appraoch No. 2

	$M			
	1969	1970	1971	1972
THERMINOL				
Sales	1.6	1.9	2.4	3.0
Investment	1.4	1.7	2.2	2.7
Net Income (AT)	0.32	0.38	0.48	0.60
SYSTEMS (EQUIPMENT RESALE AND ASSEMBLY)				
Sales	0	0.2	0.5	1.0
Investment	0	0	0.1	0.2
Net Income (AT)	0	0.01	0.04	0.08
TOTALS				
Sales	1.6	2.1	2.9	4.0
Investment	1.4	1.7	2.3	2.9
Net Income (AT)	0.32	0.39	0.52	0.68
Return on Sales	20%	19%	18%	17%
ROI	22%	23%	23%	23%

DSW 176806

STLCOPCB4050693

ANTICIPATED FINANCIAL RESULTS

Alternate Approach No. 3

	$M			
	1969	1970	1971	1972
THERMINOL				
Sales	1.6	2.1	2.8	3.7
Investment	1.4	1.9	2.5	3.3
Net Income (AT)	0.32	0.42	0.56	0.74
HEATER (ECLIPSE)				
Sales	2.4	3.0	3.5	4.2
Investment	1.0	1.4	1.6	2.0
Net Income (AT)	0.12	0.18	0.21	0.26
AUXILIARY EQUIPMENT RESALE AND ASSEMBLY				
Sales	0.3	0.8	1.1	1.5
Investment	0.1	0.2	0.2	0.3
Net Income (AT)	0.02	0.06	0.09	0.12
TOTALS				
Sales	4.3	5.9	7.4	9.4
Investment	2.5	3.5	4.3	5.6
Net Income (AT)	0.46	0.66	0.86	1.12
Return on Sales	11%	11%	12%	12%
ROI	18%	19%	20%	20%

DSW 176807

STLCOPCB4050694

Monsanto

Richard Davis - St. Louis

CONFIDENTIAL

SUMMARY

January 5, 1970

H. S. Bergen-HBERG
J. Mason-JMASO
H. L. Minckler-HMINC

HEAT TRANSFER BUSINESS

TO : T. K. Smith
TSMIT

E. J. Bock asked if a major business for Monsanto could be built from our present growth plans in heat transfer fluids and systems.

A study of the marketplace and Monsanto capabilities suggests that it can and that a business of $90 M to $100 M annual sales can be created in ten years or less by a combination of acquisition and related internal developments.

Summary:

An opportunity exists for Monsanto to exploit its heat transfer and engineering technology to build a business of $90 M to $100 M sales by 1979.

This business would evolve in four phases:

I. Heat Transfer Fluids

Continue growth of the product line and expand to world markets.
(Sales-1970: $1.6 M, 1979: $10 M)

II. Heater Systems and Equipment

Begin a program in Europe by acquisition of Wanson and expand it to the U.S.A. and other world areas. Add heat recovery equipment, incinerators and other equipment.
(Sales-1970: $9 M, 1979: $26 M)

III. Proprietary Process and Equipment

Develop, manufacture and sell proprietary processes and proprietary heat transfer equipment.
(Sales-1970: 0, 1979: $25 M)

DSW 176808

STLCOPCB4050695

IV. Heating and Air Conditioning

Sell the space heating equipment now made by Wanson and develop new products.

Sell and/or lease central heating and air conditioning systems for industrial plants, business and residential complexes, universities and hospitals.
(Sales-1970: $9 M, 1979: $31 M)

The plan is based on growth from the present Therminol fluids program; acquisition of one large, profitable international company already in this business (Establissements Wanson) and subsequent growth by internal developments. There is opportunity for additional acquisitions in latter phases of the program.

The plan defines sale of technical products primarily to large, industrial companies to whom Monsanto now sells a variety of products and has in-depth technical relations.

Acquisition of Wanson gives Monsanto:

- A large, profitable start.
- People and management experienced in the heat transfer equipment business.
- The ability to design, manufacture and sell heat transfer equipment including fluid heaters and space heating equipment.
- An international capability in heat transfer equipment.
- A European base for engineered equipment compatible with Monsanto Europe plans for growth.

There appear to be no other acquisition candidates in the heater field (world-wide) which give the size, scope and profitability of Wanson.

The following pages summarize the targeted sales and financial results of this plan.

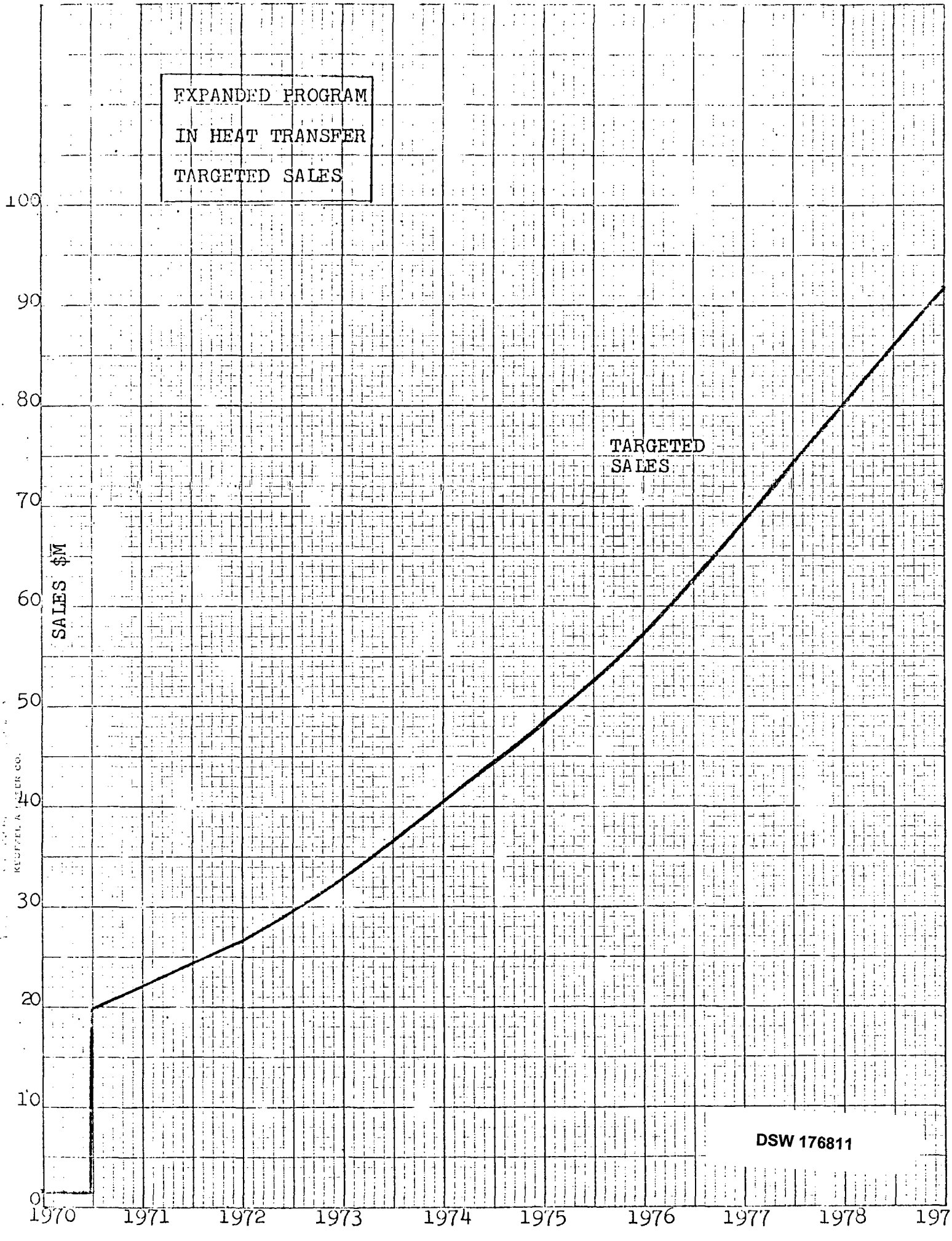
STLCOPCB4050696

TARGETED RESULTS

	Program Phase	Estimated Size of Present World Market $M		Estimated Monsanto Participation $M 1970	'71	'72	'75	'79
I.	Heat Transfer Fluids	40		1.6	2.5	3.6	7.3	10.0
I.	Heater Systems and Equipment	150	Wanson	9.0	10.5	12.2	17.1	26.0
I.	Proprietary Processes and Equipment	2,200	Wanson	-	-	0.5	8.2	25.0
V.	Heating & Air Conditioning	4,500	Wanson	9.0	9.8	10.4	20.6	31.0
	Totals			19.6	22.8	26.7	48.2	92.0
	Source of Sales							
	Fluids			1.6	2.5	3.6	7.3	10.0
	Wanson (present products) heaters, burners & boilers air heaters, etc.			18.0	20.3	22.4	28.7	37.0
	USA heater systems			-	-	0.2	0.8	4.0
	New Products Added							
	Process Equipment			-	-	0.5	8.2	25.0
	Heating & Air Conditioning			-	-	-	3.2	16.0
	Totals			19.6	22.8	26.7	48.2	92.0

DSW 176810

STLCOPCB4050697


EXPANDED PROGRAM
IN HEAT TRANSFER
TARGETED SALES
SALES $M
TARGETED
SALES
0
10
20
30
40
50
60
70
80
90
100
1970
1971
1972
1973
1974
1975
1976
1977
1978
197
DSW 176811

ESTIMATED FINANCIAL RESULTS

$M

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Avg. Growth 1970-79
Sales	19.6	22.8	26.7	31.9	39.5	48.2	57.6	67.9	79.1	92.0	16.7%
Total Expenses	16.4	19.0	21.9	26.1	32.1	39.0	46.6	55.1	64.3	75.0	16.4%
Net Income (A.T.)	1.6	1.9	2.4	2.9	3.7	4.6	5.5	6.4	7.4	8.5	18.2%
Gross Investment	20.0	22.0	23.2	31.4	37.5	40.6	53.9	60.8	68.4	74.8	14.1%
ROI On Gr. Invest. (A.T.)	8.0%	8.7%	10.3%	9.2%	9.9%	11.3%	10.3%	10.5%	10.8%	11.3%	3.5%
Net Income	1.6	1.9	2.4	2.9	3.7	4.6	5.5	6.4	7.4	8.5	18.1%
Depreciation	.5	.6	.6	1.6	2.1	2.1	3.7	4.1	4.5	4.6	24.0%
Total Generated	2.1	2.5	3.0	4.5	5.8	6.7	9.2	10.5	11.9	13.1	20.0
New Property	-	1.4	0.4	7.2	4.6	1.4	11.4	4.8	5.4	3.8	-
New Working Capital	-	0.6	0.8	1.0	1.5	1.7	1.9	2.1	2.2	2.6	-
Total Cash Investments	-	2.0	1.2	8.2	6.1	3.1	13.3	6.9	7.6	11.4	-
Net Operating Cash Flow	(17.9)	0.5	1.8	(3.7)	(0.3)	3.6	(4.1)	3.6	4.3	1.7	-
Cumulative Cash Flow	(17.9)	(17.4)	(15.6)	(19.3)	(19.6)	(16.0)	(20.1)	(16.5)	(12.2)	(10.5)	-
Acquisitions	20.0	-	-	-	-	-	-	-	-	-	-

DSW 176812

STLCOPCB4050699

Definitions of the Four Phases of This Business

Phase	Example of What We Sell
I. Heat Transfer Fluids	A fluid to operate at 600°F.
II. Heater Systems and Equipment	A system to deliver 5 $\overline{M}$ BTU/hr. at 600°F. - consisting of: fluid, heater, pump, instruments, plus systems design and responsibility. (See Figure A)
III. Proprietary Processes and Equipment	A process to deep fry 250,000 donuts per day - consisting of: heater system, processing equipment plus process design and responsibility. (See Figure B)
IV. Heating and Air Conditioning	A system to heat and cool an apartment building - consisting of: heater system, water chiller, air handling heat exchanger, control instruments, plus system design and responsibility. (See Figure C)

STLCOPCB4050700

FIGURE A

PHASE II - HEATER SYSTEMS & EQUIPMENT

The System:

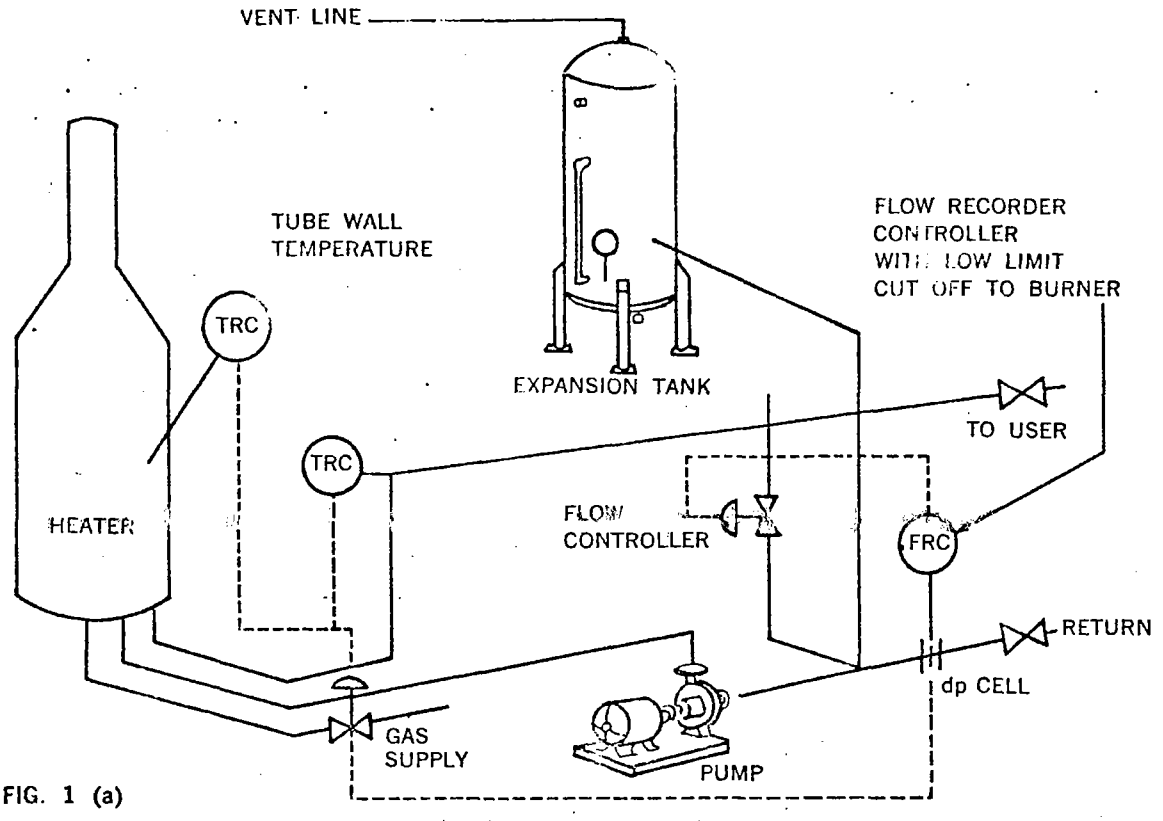


FIG. 1 (a)

...including the heater.

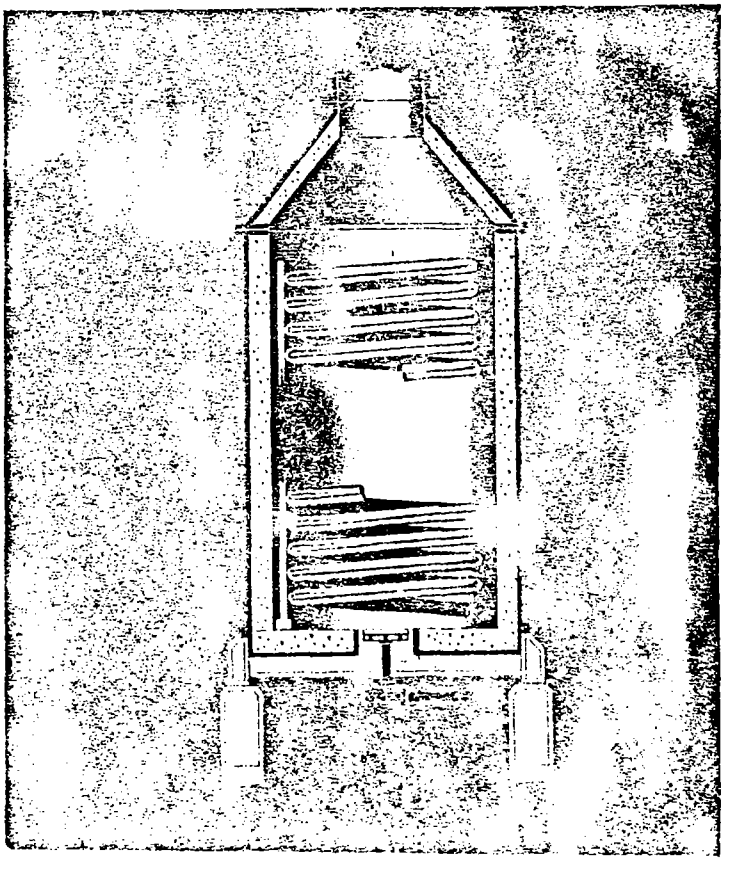


FIG 1 (b)

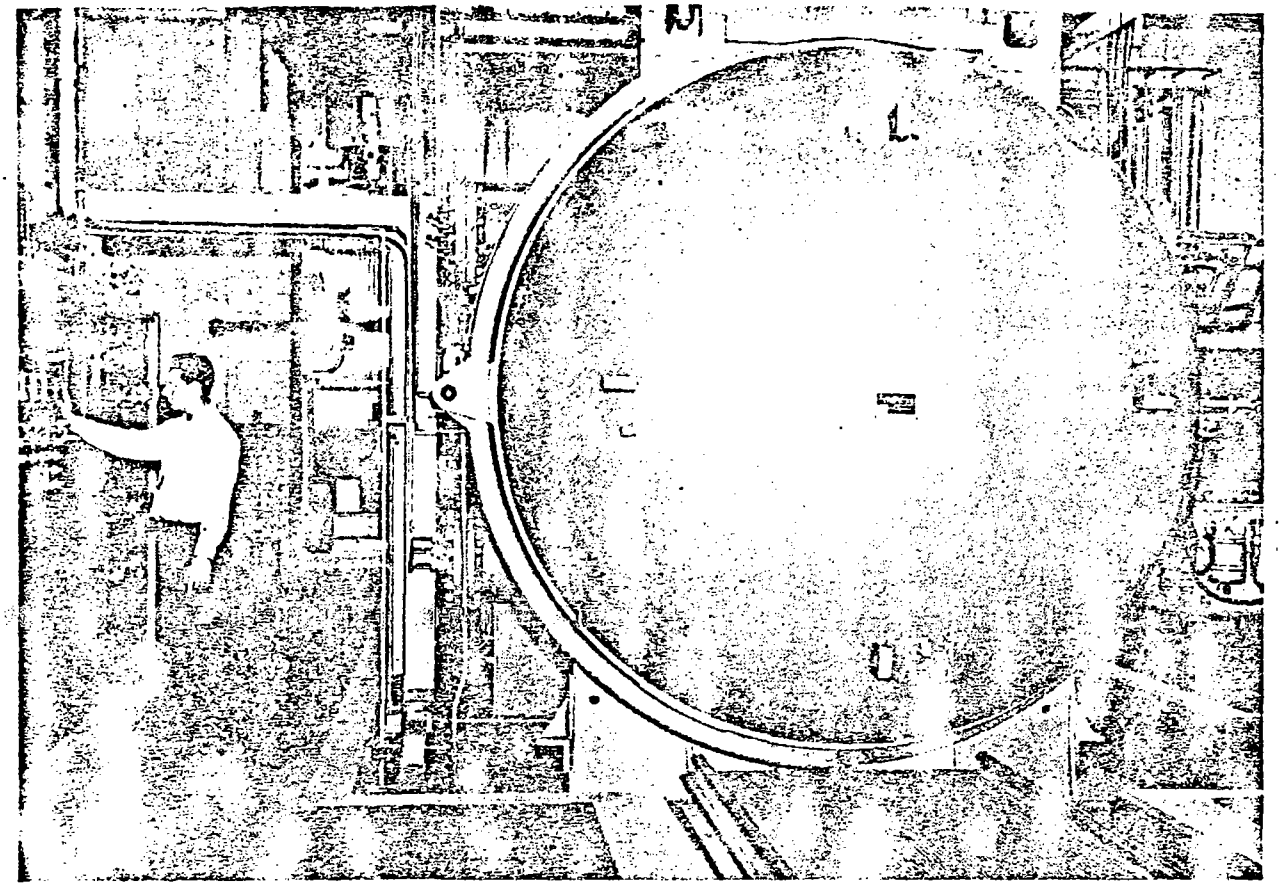
DSW 176814

STLCOPCB4050701

FIGURE B

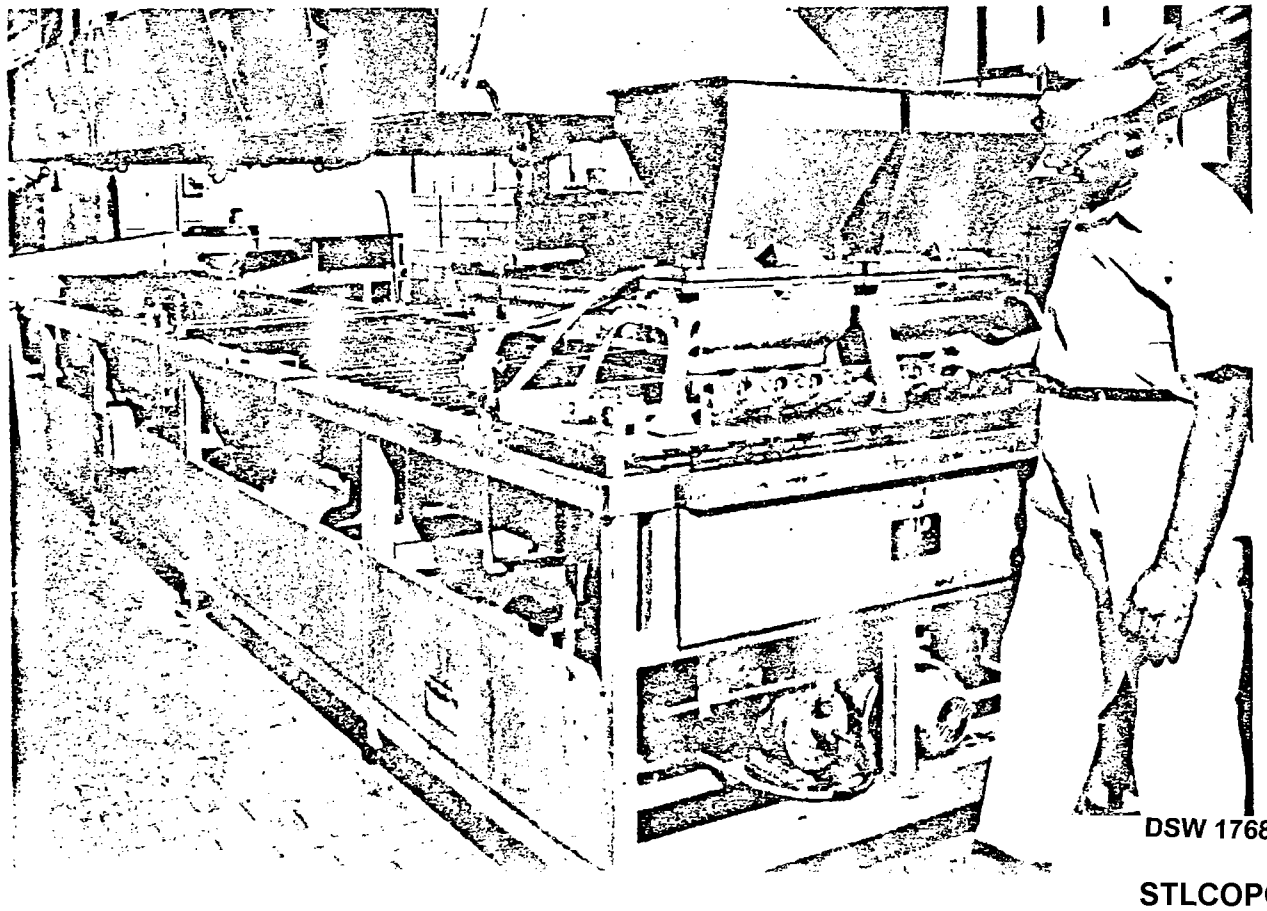
PHASE III - PROPRIETARY PROCESSES AND EQUIPMENT

Liquid heat transfer ... for Resin ... nding



"Solid heat" with Therminol liquid heat transfer means uniform heat without local "hot-spots." In the new Remo-Therm donut machine, made by the Joe Lowe Corporation, it means donuts with 10 percent greater expansion, 6 percent savings on flour, and 250,000 donuts for dog—the last as tasty as the first!

... heat transfer ... in Food Processing



Grumman Aircraft Engineering Corporation builds maximum strength with minimum weight into vital parts by bonding "skin" to the honeycomb structural network with an epoxy adhesive.

DSW 176815

FIGURE C

PHASE IV - HEATING AND AIR CONDITIONING

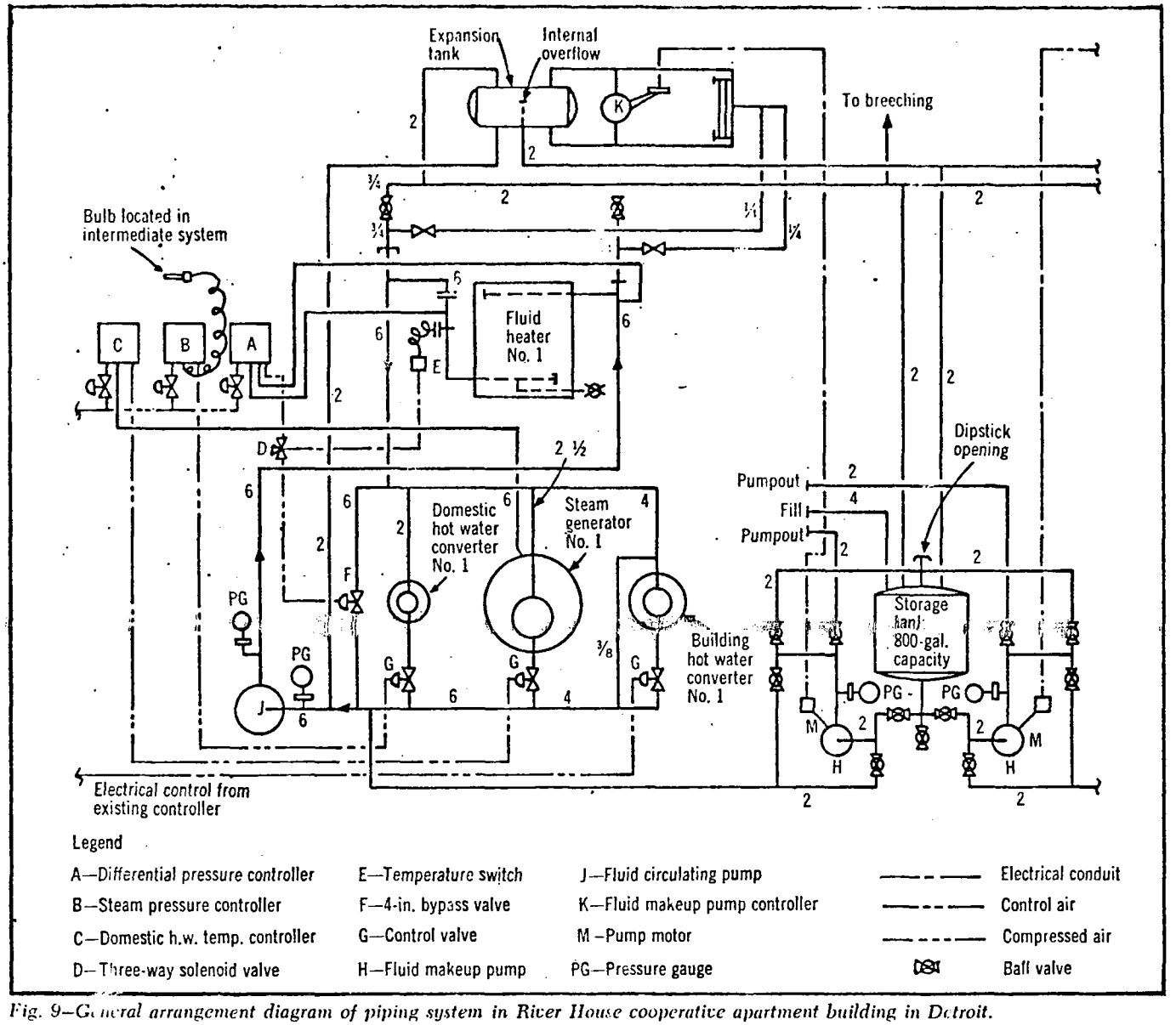
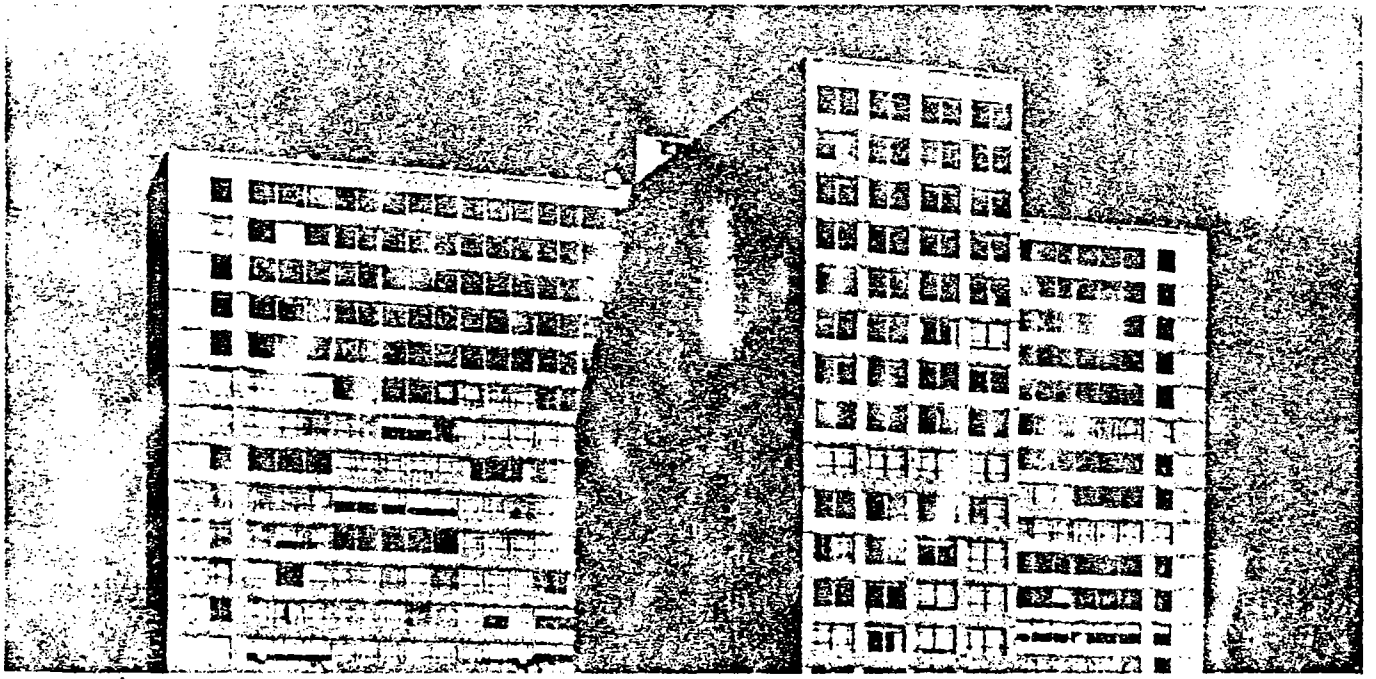


Fig. 9—General arrangement diagram of piping system in River House cooperative apartment building in Detroit.



River House cooperative apartment building in Detroit was the first actual application of a thermal liquid system. The high temperature non-pressurized organic fluid replaced steam as the heat transfer medium.

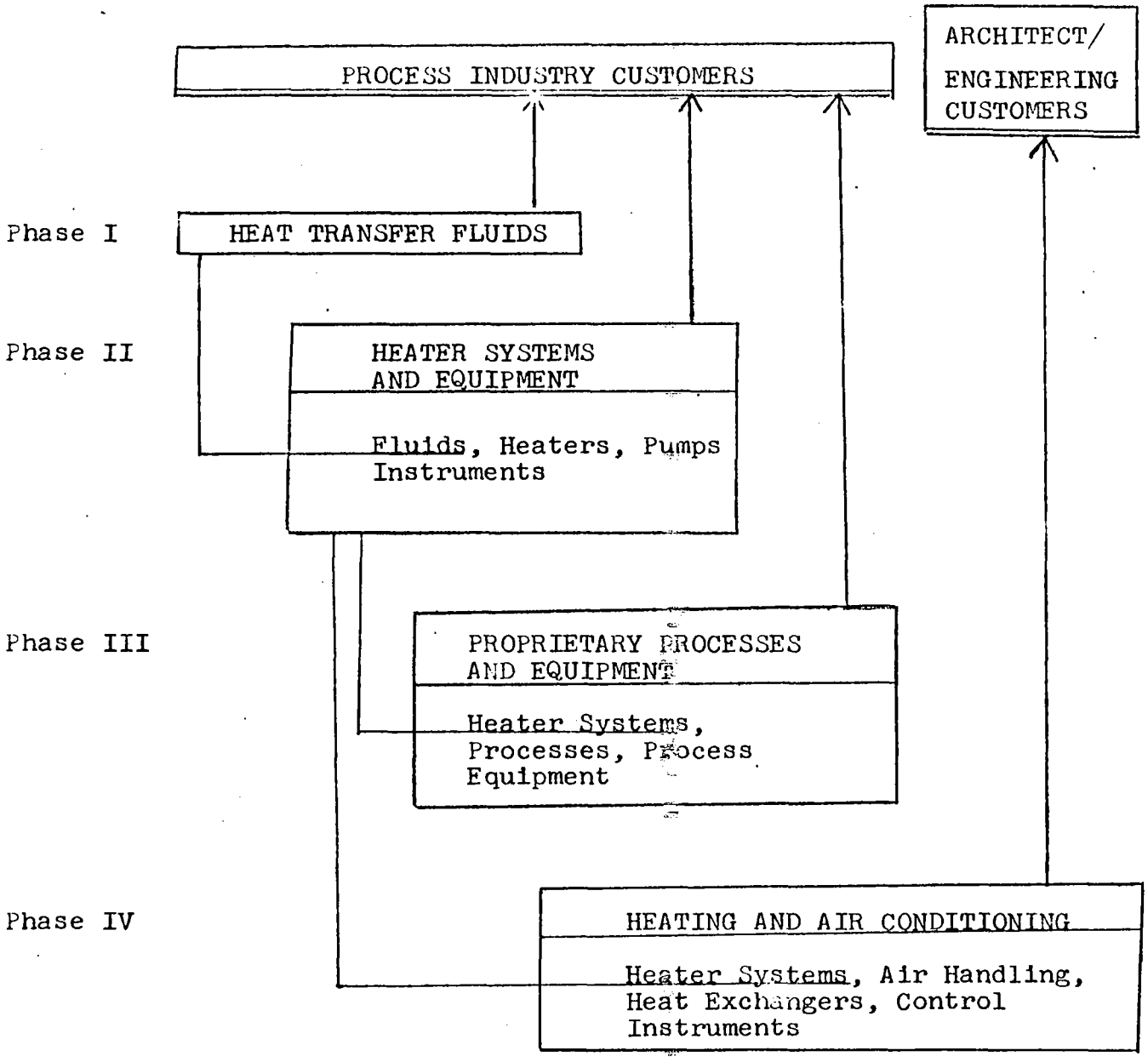
DSW 176816

STLCOPCB4050703

STLCOPCB4050704

DSW 176817

EXPANDED PROGRAM IN HEAT TRANSFER



ADDED CAPABILITIES and (source)

-

Systems Engineering
(Monsanto and Wanson)
Heaters
(Wanson)
Equipment Sales and Service
(Wanson, Monsanto and new)

Process Engineering
(Monsanto)
Process Equipment
(Wanson and new)

Heating and Air Conditioning Engineering
(Monsanto and new)
Heating and Air Conditioning Equipment
(Wanson and new)

FIGURE I

I. Heat Transfer Fluids

Summary and Conclusions:

By expanding our fluid marketing effort to Europe and other world areas and continuing to expand our product line to satisfy more application needs, we can increase fluid sales to $7 M in 1975, $10 M in 1979.

We already have a broad line of eleven heat transfer fluids of six different chemistries. All (except two specialties) are existing Monsanto products made in volume for other uses. Therefore, manufacturing costs are low and gross profits are high (65% G.P. on domestic sales).

The U.S. market for heat transfer fluids is $15 M per year, growing at 15% per year. Our U.S. sales are 1.2 M growing at 25% per year. We will continue to increase market share and can forecast $3 M sales by 1975 from continuation of the present level of sales effort and product developments.

A market study made in November confirmed that the fluid market and growth rate in Europe/U.K. is as large as in the U.S. Our effort and results have been modest to date but with effort similar to that in the U.S., we can forecast $2.5 M sales by 1975.

New, rapidly growing markets in Japan, Australia, Latin America and other world areas are estimated at $10 M and represent a potential for Monsanto fluid sales of $1.5 M by 1975.

In total the world market for heat transfer fluids is $40 M, growing at 15% per year. We can forecast sales of $7 M in 1975 and $10 M in 1979. Our sales growth will be accelerated and profitability upheld by selling systems as well as fluids.

DISCUSSION

STLCOPCB4050705

II. Heater Systems and Equipment

Summary and Conclusions:

A Monsanto business in heater systems and equipment can reach world-wide sales of $17 M in 197[illegible] and $26 M in 1979 through acquisition of Wanson plus internal development of a U.S. business.

Internal development in the U.S. would be fairly slow but faster growth could be achieved by applying Wanson know-how to an acquired, U.S. manufacturer and marketer of heaters or process equipment.

Wanson sales of air heaters, incinerators and other heat transfer equipment would add sales of $12 M in 1975, and $15 M in 1979.

An existing business plan already presented to the CDC explains that Monsanto is selling the concept and benefits of fluid heat transfer systems for new applications. In doing this, Monsanto is providing much of the engineering work of specifying components and outlining system design.

The growth rate of our fluid sales confirms the success of this approach. However, our reward in sale of fluids represents only 10% of the system's value (heaters represent 50%).

The market wants, but is not yet offered, a single source responsible for these systems providing fluid, equipment and engineering. We propose to become that supplier and to enter the market through acquisition of an established manufacturer of fluid heaters.

The market for fluid heater systems in the USA is in its infancy, but already exceeds annual sales of $35 M and is growing at 15% per year.

The market for fluid systems in Europe/U.K. is similar to that in the U.S. in size ($35 M), growth rate and applications. The market is a bit advanced of the U.S. in that there is already common use of the fluid systems in food, paper, rubber, wood and other industries besides basic chemicals and fibers. Large numbers of low cost heaters are produced specifically for these markets. Most heater builders provide only their component and give a minimum of systems engineering assistance, assuming the least amount of responsibility they can.

One exception is Establissements Wanson (headquartered in Brussels), a major, international manufacturer of heaters and other heat transfer equipment. They actively promote varied new applications for fluid systems, provide engineering assistance and take much of the responsibility for performance of the system.

Wanson is our first choice candidate for acquisition to gain a heater systems base in Europe. Their current international status would give us position in most other ex-U.S. world markets as well. Their current sales are about $18 M and ROI is reported to be 7-10% (after tax) including income from license arrangements around the world. Continued growth of the company at industry growth rate (10%) indicates sales of $29 M by 1975 and $37 M by 1979. Sales could be even larger if we were to acquire increased equity in Wanson's partly-owned subsidiaries in England, France and Germany. All Wanson products are heat transfer equipment, including fluid heaters, burners, incinerators, package boilers and air heaters. A profile of Wanson is attached.

Wanson expertise can be brought to the USA and a domestic heater systems business developed to $1 M in 1975, and $4 M in 1979. Wanson's product designs, manufacturing know-how and management make this internal development feasible. If Wanson expertise could be applied to an acquired U.S. manufacturer and marketer of heaters or process equipment growth of the U.S. program would be accelerated.

The second choice candidate in Europe is Konus Kessel of Hockenheim, Germany. This is a much smaller company (sales $2.5 M) manufacturing and selling only fluid heaters, and exporting throughout Europe and certain other world areas. A profile of Konus Kessel is attached.

III. Proprietary Processes and Equipment

Summary and Conclusions:

Food, rubber, metal and certain other materials processing industries require new, innovative means of heat transfer to meet their changing needs. DuPont, Dow and others have demonstrated the opportunity to use their engineering techniques to develop and sell proprietary processes and equipment to these industries.

A survey of the food and rubber processing industries identified opportunities for Monsanto to develop and sell special processes and equipment through expansion of a Monsanto/Wanson operation. The program could be accelerated further by acquisition of one or more modest size firms specializing in certain types of equipment or processes we are not familiar with.

The process equipment market for these industries exceeds 1 billion dollars annually (in the USA alone). The opportunity for Monsanto in proprietary products and processes is estimated at $5-10 M by 1975 and $20-30 M by 1979.

Introduction:

DuPont sells the Helicure process and its equipment for curing of rubber goods in a hot fluid bath and, of course, they sell the rubber chemicals as well. DuPont also sells a food freezing process and its equipment. The process utilizes their Freon 11 fluid.

Dow sells textile treating processes, equipment and processing fluids to prepare textiles for dying, sizing, etc.

When Monsanto sells the concept of using a fluid heating system for deep frying foods, comfort heating of hospitals, specialty processing of rubber goods, treating of sewage or other new applications, we are often asked if we can define and supply the entire process. This is particularly common in industries with little engineering provided by their own companies or by their equipment suppliers. Typically, these are industries which convert paper, rubber or other materials, rather than produce the basic materials themselves. Certainly, when we supply total heat delivering systems, these requests will multiply.

STLCOPCB4050708

Food Processing:

A survey made in October confirmed that the food processing industry needs, but is not yet receiving enough innovative, specially engineered processes and equipment and that Monsanto would be welcomed as a supplier.

Generally standard chemical processing equipment is offered to the food industry and processes must be modified to accommodate this. New types of heat transfer equipment are required to meet changing needs for aseptic canning, electronic cooking, microwave processing, etc. and for improvements in vacuum drying and spray drying.

Other companies are beginning to recognize the opportunities. In frozen convenience foods, for example: (1) DuPont is successful with their Freon freezing process and (2) Design & Process Engineering Company is equally successful with a fluid heated fish fryer. Design & Process Engineering, founded in August, 1965, to serve this market, has a sales record of $0.25 M in 1967, $0.50 M in 1968 and $1.0 M in 1969. They have neither saturated their market nor begun to diversify to other food processes.

A study was made this October of Monsanto opportunities for heat transfer systems, proprietary processes and equipment in the food industry.

Conclusions are:

1) There are opportunities for "standard" Therminol heat transfer systems in many, varied food processing applications (frying, baking, drying, materials handling, etc.).

2) There are opportunities for specific systems. For example, the indirect generation of steam that is injected directly into the food product. This eliminates the problem of FDA approval on boiler water treating chemicals because steam generated from a Therminol system requires little or no water treatment.

3) There are opportunities for special processes and equipment based primarily on heat transfer. These range from one of a kind for the basic food processor himself, to several hundreds of units such as the donut cooker for his commercial customers to many thousands of units for better conversion of convenience foods for his customers in institutional markets (hospitals, schools, etc.).

STLCOPCB4050709

Monsanto's image with the major food processors is excellent. Every company visited during the study looked to us as a reputable potential source of many types of new products. We have received inquiries since the survey for heat transfer fluids, processing equipment and new packaging materials.

General Mills, specifically, is seeking a major reputable firm to supply innovative cooking equipment for their institutional customers* to convert prepared foods; something proprietary and better suited to their customers' needs than the standard appliance and process equipment available today. They are very interested in the possibility of Monsanto developing and supplying such equipment.

Sales of food processing and packaging machinery in the U.S. is currently $600 M. Sales of institutional heating and cooking equipment is $140 M per year, estimated to reach $200 M by 1975 and $350 M by 1979. The General Mills request is only an example of Monsanto's opportunity. Development and production of other specialized, industrial type food processing equipment for the institutional food market alone offers an opportunity for Monsanto estimated at $3 M by 1975 and $10 M by 1979.

The high volume (heat transfer) equipment manufacturing capability at Wanson is applicable to making this type of equipment. Expansion of the U.S. facility would give us similar manufacturing capabilities domestically.

Rubber Industry:

Processing of rubber goods is another industry in which heat transfer is important and specialized equipment and processes are required to meet changing needs.

A preliminary survey of the rubber industry was made in October with the following conclusions:

---

*As incomes increase, more prepared, storable foods of more variety and better taste are being used in place of fresh, perishable foods. This trend exists in hospitals, universities, industry cafeterias and aboard planes as well as in restaurants and homes.

The plant processing and therefore cost and quality of these prepared foods is influenced directly by the equipment available to "convert" them before serving. What is needed is specialized equipment with faster cycles, more automatic operation at lower cost and with greater flexibility for types of foods handled.

A) There is potential for "standard" Therminol systems:

1) in molding of non-tire products...to increase production rates and to improve uniformity of product quality;

2) in curing of butyl rubber tire bags to achieve faster cure through higher mold temperatures (800 units exist that can be converted from steam);

3) in automating boiler rooms to provide processing steam requirements without the need for licensed operators;

4) in additional opportunities, not yet specified but involved with raw material manufacture, mixing, processing, fabricating and curing.

B) There is opportunity for specialized equipment. For example, calendar rolls heated with Therminol and designed to have an extremely even temperature across the face of the roll to control the viscosity of the rubber and therefore the gauge of the sheet.

C) There is potential for proprietary processes. B.F. Goodrich, for example, defined one specific need as safe, low-cost radiant heating systems for preheating tires to shorten their cure times. Goodrich is looking only at standard components made for general use. They are anxious to accept help in radiant heat technology, and to purchase a packaged process from Monsanto, if it becomes available.

The potentials cited are only examples of Monsanto's opportunities to supply heat transfer equipment and processes to the rubber industry.

Rubber industry capital equipment sales are $660 $\bar{M}$ per year. Almost all of the equipment used involves some form of heat transfer. More innovations and proprietary equipment and processes are coming from outside the rubber processing industry itself; for example, the AFM Autotread and the Orbitread process for tire building, and the DuPont Helicure process for liquid curing of extrusions, etc.

The opportunity for Monsanto sales of proprietary processes and equipment is estimated at $2 $\bar{M}$ in 1975 and $5 $\bar{M}$ in 1979. Again, the manufacturing capabilities of Wanson apply.

STLCOPCB4050711

IV. Heating and Air Conditioning

Summary and Conclusions:

The heating and air conditioning market is very large, growing rapidly and undergoing changes that represent opportunities for Monsanto.

Sale of existing Wanson products to this market should be $12 M in 1975 and $15 M in 1979. Sale of Therminol systems for heating and cooling and sale of certain new heating and air conditioning equipment should bring our total sales to this market to $20 M in 1975 and $31 M in 1979.

Introduction:

Monsanto pioneered the use in the USA of fluid systems for heating and air conditioning high-rise apartment buildings, garden apartments, hospitals, factories and offices. Now, these systems are in use or under study in England, Germany, Italy, Japan and other countries.

The advantage of these installations is the generation of steam in an "automated boiler room" that does not require the expense of licensed operators in attendance. In addition, maintenance costs proved to be lower than for conventional steam boiler operation.

More recently, larger systems have been studied for central heating plants to serve universities, hotels, airports, shopping centers and city districts.

The heating and air conditioning market is very large, growing rapidly and undergoing changes that offer opportunities for Monsanto to sell systems and certain types of equipment. Marketing and engineering directed to the "architectural-consuling-mechanical" trade will, of course, be required.

Size and Growth Rate:

The heating and air conditioning equipment market for commercial and institutional buildings (excludes single family dwellings) is 3.5 billion dollars per year in the USA and growing at 7% per year (air conditioning is growing at 15% per year).

STLCOPCB4050712

Total environmental comfort has become a way of life in America -- in homes, theaters, shops, offices and cars. Now, industrial plants are installing air conditioning. Over 35% of new industrial construction is now air conditioned. Heating and air conditioning is growing in the U.K., Europe, Japan and other world areas now, expanding the market further.

Changes:

a) People are demanding more sophistication in comfort in the form of closer control of temperature, control of humidity, absence of drafts, noise and odor. Further, they demand independent temperature control for each room or zone.

b) There is a trend to centralized heating and cooling systems in place of individual units because of lower capital cost, lower fuel cost (interruptable gas service), lower total maintenance costs and less pollution.*

> *The American Chemical Society stated that, "Space heating is a difficult abatement problem because of the large number of relatively small sources involved ...one long-range alternative might be to heat domestic and commercial operations from central production units that would be large enough to use advanced pollution abatement technology economically. Heating systems of this kind would not be new to this country, but have never been widely used." Their recommendation A-24 states that "the economics of centralized production of heat for space heating should be re-evaluated."
>
> Cleaning Our Environment
> A.C.S., 1969

There is a strong trend now towards systems to supply electric requirements of commercial and institutional sites and utilize the waste heat for heating and cooling. This stems from competition between the gas and electric utilities and utilizes modern engineering technology to develop systems that reduce the cost of energy requirements for medium and large installations.

c) New modular construction of buildings is going to mean that heating and air conditioning equipment is sold in the form of mass produced systems rather than individual components. Systems will be sold to large industrial manufacturers who produce the modules rather than to contractors and jobbers.

STLCOPCB4050713

Low rent housing needs, indeed the whole construction market, will be changing slowly to pre-fabricated or modular construction for lower construction costs. This program is led by the mobile home market which now represents 26% of the single family housing starts (and 80% of those under $15,000). Over 400,000 units were produced in 1969 and the industry is growing at 25-30% per year. All these units are heated (International Thermal Corporation of St. Louis claims to have 40% of the market), but only 10% are air conditioned. It is expected that most will be air conditioned soon.

Areas of Opportunity for Monsanto:

The trend to central systems of large equipment in place of small individual systems lends itself to the use of high temperature fluids and their systems. Steam is used, but is not practical for the long runs of piping required in large campus sites. The losses encountered in pressure become losses in heat energy. To get around this and to use smaller, lower cost piping, high temperature water (350°-400°F) has been used, primarily in Europe. This method is losing popularity, however, because of the capital expense and high maintenance costs from the corrosive and high pressure water. Synthetic fluid systems appear to be the best answer. Monsanto has the opportunity to design, manufacture and sell such central heating systems. The greatest needs are found now in the U.S., England, Germany and Japan.

The desire for independent zone control of temperature in addition to the use of central plants brings requirements for fluid control systems. Our Electronics and Control Division might make a contribution here. The survey revealed that Fisher Governor has an excellent reputation in the heating and air conditioning market.

Total energy sites offer similar opportunities for Monsanto, particularly for professional buildings and structures of similar size that use small gas turbines and may even use organic fluid thermodynamic cycles to generate electric power.

That there are opportunities that can be exploited is suggested by the following:

1) Dow Chemical formed a joint venture with Southern Gulf Utilities (called Environmental Systems, Inc.) "to serve as a contractor which designs, finances, supervises, services and operates total energy systems."

STLCOPCB4050714

2) Esso sells large central heating systems in Europe, primarily in Italy.

3) Northern Natural Gas, Oklahoma Natural Gas, Washington Gas and Light Company and other gas utilities own and operate central systems selling heat energy to city districts rather than fuel gas.

4) Small companies have been created to own and finance total energy sites for commercial and institutional facilities though clients prefer that larger companies fill this need.

5) As a result of calls on gas utilities during the survey, Monsanto has been asked to provide fluid heating systems to generate the steam requirements of garden apartments, high-rise apartments and industrial plants. These system installations are normally valued at $100,000 to $400,000 of equipment.

6) Kaiser Engineering has urged Monsanto to design and supply fluid heating systems for their series of Kaiser Foundation Hospitals.

7) The Sheraton Corporation is planning a $1.5 billion investment in 500 new hotels and has encouraged Monsanto to develop, franchise or lease central heating and air conditioning plants for these hotels.

Specific Opportunities for Monsanto:

	$\overline{\$M}$ 1975	$\overline{\$M}$ 1979
1) Wanson now manufactures and sells unit heater and radiant heat equipment for the space heating market.	12	15
2) Promote and sell complete unattended package systems for the generation of steam via a fluid system.	2	4
3) Expand Wanson and U.S. product lines to the manufacture of waste heat recovery equipment for central heating plants.	1	2

STLCOPCB4050715

	$\bar{M}$ 1975	$\bar{M}$ 1979
4) Design central plant heating and cooling systems for commercial and institutional facilities; (sell, franchise, lease or own and operate).	3	5
5) Same as above for total energy systems.	-	1
6) Manufacture and sell air conditioning equipment by either:		
a) Licensing to manufacture innovative equipment developed by the American Gas Association, aerospace firms, etc.		
b) Internal development.		
c) Acquisition of companies with unique air conditioning product lines.	2	4
Totals	20	31

Richard Davis

PROFILES OF ESTABLISSEMENTS WANSON AND KONUS KESSEL

1968

	Wanson	Konus Kessel
Location:	Brussels, Belgium	Hockenheim, Germany
Growth Rate:	High	High
Sales:	$10M*	$2.5M
Cap. Employed:	$9M	$0.4M
Heater Sales:	$3-5M	$2.5M
Other Products:	Air Heaters, Burners, Boilers, Incinerators	None
Income (A.T.):	0.7M	-
R.O. CAP. Employed: (A.T.)	8%	-
No. Employees:	750	150
Countries Served:	Most Except USA	Europe and some ROW areas
Industries Served:	All except basic chemistry	Wood, Textiles Metal, Misc.
Ownership:	1 Family -87% (L. Wanson-69 Yrs. of Age)	1 Man (N. Rychen-31 Yrs. of Age)
Technical:	Good	Good
Manufacturing:	Very Good	Good
Marketing:	Very Good	Very Good
Main Competitors:	Konus, Geka, Beverly	Geka, Wanson
Misc:	Part Own Co.'s In: France, Germany, U. K., Lic. in Japan, Australia, etc.	One Plant Export and sell mostly through agents. High long-term debt.

*Wanson sales from Brussels plant $10M
Wanson sales from share of part-owned companies $8M
Total sales of Wanson products including those of licensees is joint ventures $30-50M.

DSW 176830

STLCOPCB4050717