TECHNICAL REPORT ON UREA FORMALDEHYDE

PREPARED BY:

ANEFCO, INC.
22? MAMARONECK AVENUE
WHITE PLAINS, NEW YORK 10605
(914) 946-4631

8007230483

INDEX

CHEMICAL REACTION (POLYMERIZATION)

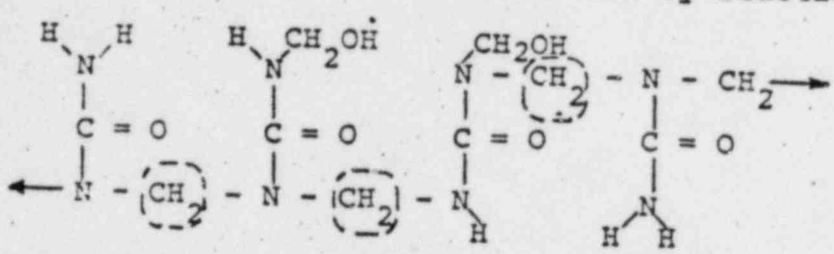
Urea has the formula CO (NH). It is produced by the reaction of ammonia and carbon dioxide. Formaldehyde has the basic formula of HCHO.

The first step of the reaction urea molecules link to the methylene bridge, marked on the schemitic drawing with red marks, (-CH_2-). These bridges form by the spliting off of molecules of water, the oxygen coming from the formaldehyde and the hydrogen atoms from each of two urea molecules.

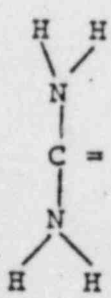
During the reaction, other formaldehyde adds on to various urea molecules to form dangling methylol, - CH_2OH, groups. Thus, the following urea-formaldehyde formula is derived.

Four molecules of urea condense and polymerize with six molecules of formaldehyde. The formaldehyde to urea ratio is 1.5:1 and typical of the amino group.

Additives are used to provide a wetting agent and form and azeotropic mixture with the alcohol groups (R-O-R[1]). This also affords additional strength to the compound and elimination of the water of condensation by reaction.



UREA FORMALDEHYDE



UREA

BRIDGE

ELECTRON MICROSCOPIC EXAMINATION

In order to demonstrate the cross linkage and bonding of U-F, ANEFCO, INC. retained Arthur D. Little to perform electron microscopic examination of U-F samples with resin (ion-exchange) materials solidified in the media.

Two distinctly different samples were prepared. One with proper pH control and the proper amount of hydrogen ion to produce the cross linkage and the second with insufficient quantities of hydrogen ion. The latter was done in order to show the two phase reaction and the bonding of the resin beads to the final phase.

The results may be seen in the photographs by observing the two shaded areas with the complete surrounding and coupling of the U-F and its tentacles to the resin beads. The various magnifications are shown on the back of each film.

Copies of these photographs are attached at the end of this section. Appendix A.

PHYSICAL PROPERTIES OF UREA FORMALDEHYDE

density, lb/ft^3	1.8
Mechanical properties	
compression strength, psi.	8
flexural strength, psi.	17
flexural modulus, psi. x 10^{-3}	0.7
Thermal properties	
flammability	SE
specific heat, Btu/lb.	0.40
Absorption	
water, lb/ft^2 (10 ft. head)	--
water, vol.%	--
moisture-vapor transmission rate, perin-in.	--

SE - self extinguishing

PHYSICAL PROPERTIES OF UREA FORMALDEHYDE

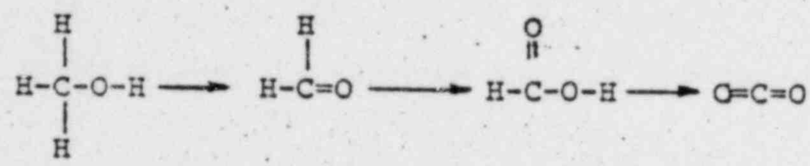
	ASTM test method	DATA
Compression ratio	--	2.1 - 4.4
Mold (linear) shrinkage, in./in.	--	.004 - 0.010
Specific gravity (density)	D792	1.5 - 1.7
Specific volume, cu.in./lb.	D792	20.9 - 17.8
Tensile strength, p.s.i.	D638	6000 - 8000
Elongation, %	D638	0.4 - 0.8
Tensile elastic modulus, 10^5 p.s.i.	D638	8.0 - 17.0
Compressive strength, p.s.i.	D695	26000 - 30000
Flexural yield strength, p.s.i.	D790	8000 - 10000
Impact strength, ft.lb./in. of notch (1/2 x 1/2 in. notch bar, izod test)	D256	0.27 - 0.38
Hardness, Rockwell	D785	E95 - 100
Flexural elastic modulus, p.s.i. x 10^5	D790	10.0 - 12.0
Compressive modulus, p.s.i. x 10^5	D695	--
Thermal conductivity, 10^{-4} cal/sec/ sq.cm.,/1 (°C./cm)	C117	4.0 - 7.0
Specific heat, cal/°C/gm	--	0.35 - 0.40
Thermal expansion, 10^{-5} in./in./°C	D696	1.0 - 4.0
Resistance to heat °F (continuous)	--	275 - 325
Deflection temp., °F		
@264 p.s.i. fiber stress		285 - 310
@ 66 p.s.i. fiber stress	D648	--
Volume resistivity, ohm-cm. (50% RH and 23°C)	D257	--
Dielectric strength, short-time, 1/8 in. thickness, volts/mil.	D149	220-325
Dielectric strength, step-by-step, 1/8 in. thickness, volts/mil.	D149	--
Dielectric constant, 60 cyc	D150	7.0 - 7.7
Dielectric constant, 10^3 cyc	D150	--
Dielectric constant, 10^6 cyc	D150	5.2 - 6.0
Dissipation (power) factor, 60 cyc	D150	0.02 - 0.04
Dissipation (power) factor, 10^3 cyc	D150	--
Dissipation (factor), 10^6 cyc	D150	0.04 - 0.06
Arc resistance, sec.	D495	130 - 180
Water absorp., 24 hr., 1/8 in. thick, %	D570	0.03
Burning rate (flammability), in./min.	D635	self ext.
Effect of sunlight	--	nil.
Effect of weak acids	D543	none
Effect of strong acids	D543	mild
Effect of strong alkalies	D543	none
Effect of organic solvents	D543	none
Effect of weak alkalies	D543	none

FIRE TEST

In order to categorically prove that U-F is not only fire proof, but self extinguishing, ANEFCO, INC. conducted a field fire test in a quarter scale polyethylene liner. The flammable material used was gasoline in order to simulate a maximum credible accident nominal to highway transport. The photographs and motion picture film demonstrate graphically that the material is not pyroforic.

The need to more dramatically demonstrate these facts, ANEFCO attempted to burn the U-F with an acetylene torch and again could not produce burning.

The chemical reason for the above is best explained by the following senus of reactions which show the production of carbon dioxide (CO_2) which extinguishes the flame and insulates the remaining mass.



Methyl Alcohol Formaldehyde Formic Acid Carbon Dioxide

$CH_3 + H_2O \rightarrow CH_3OH + 2H^+ + 2e^- - 0.58$ Volts 25°

$CH_3OH \rightarrow HCHO + 2H^+ + 2e^- - 0.24$ Volts 25°

$HCHO + H_2O \rightarrow HCOOH + 2H^+ + 2e^- + 0.01$ Volts 25°

$HCOOH \rightarrow CO_2 + 2H^+ + 2e^- + 0.14$ Volts 25°

The half reactions involved in these oxidation reactions and their approximate potentials in water solution are shown. The couples are not reversable at room temperature.

Thus, one may observe that the reaction in fire conditions shows the production of CO_2 making it a self extinguishing fire proof material.

DATA APPLICABLE TO STORAGE AND PUMPING OF

A-SET RESIN

PHYSICAL PROPERTIES (at time of manufacture):

pH	7.2-7.5
*Viscosity @ 25°C., cps	500-700
Specific Gravity #25/25°C.	1.295-1.300
Solids %	66 ± 1
Free Formaldehyde %	3 max.
Storage Life, Months	
@ 50°F	18
@ 70°F	2
@ 90°F	1

*Brookfield RVF, 1/10

* REMARKS:

The degree of reactivity of the resin can be controlled by varying the amount and makeup of a catalyst. This product ahs the desirable characteristic of being very stable.

* A-SET FOAM

PHYSICAL PROPERTIES

Density	0.8 lbs./cu-ft
Ash content	0.7 %
Free Formaldehyde	1 %
Setting Time	10-30 Seconds
Electric Resistivity	5.00 ohms/cm

* WICKING

Water Absorption	3.8 hrs. @ 15% by weight
ASTM Method	6.2/6.9

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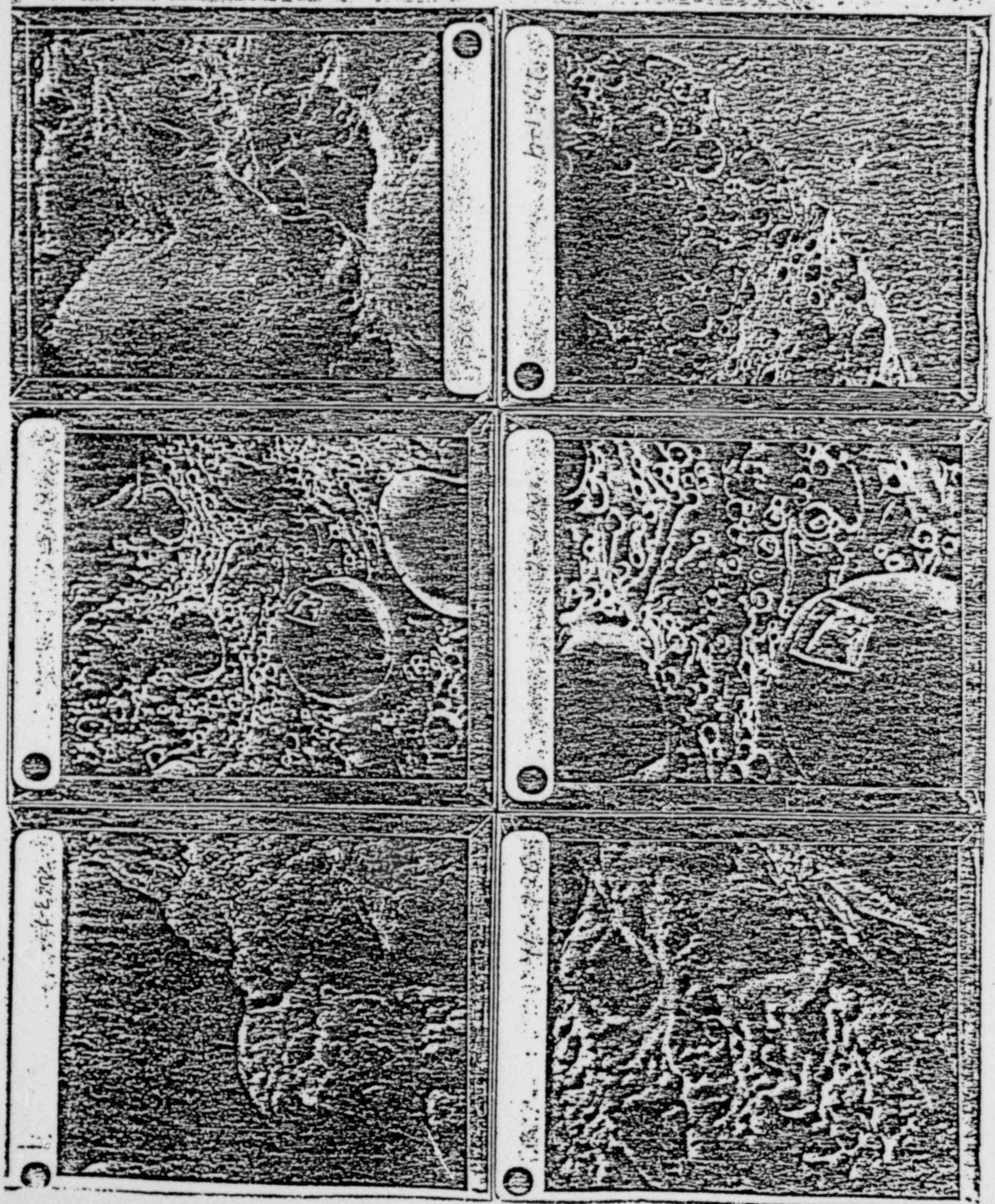
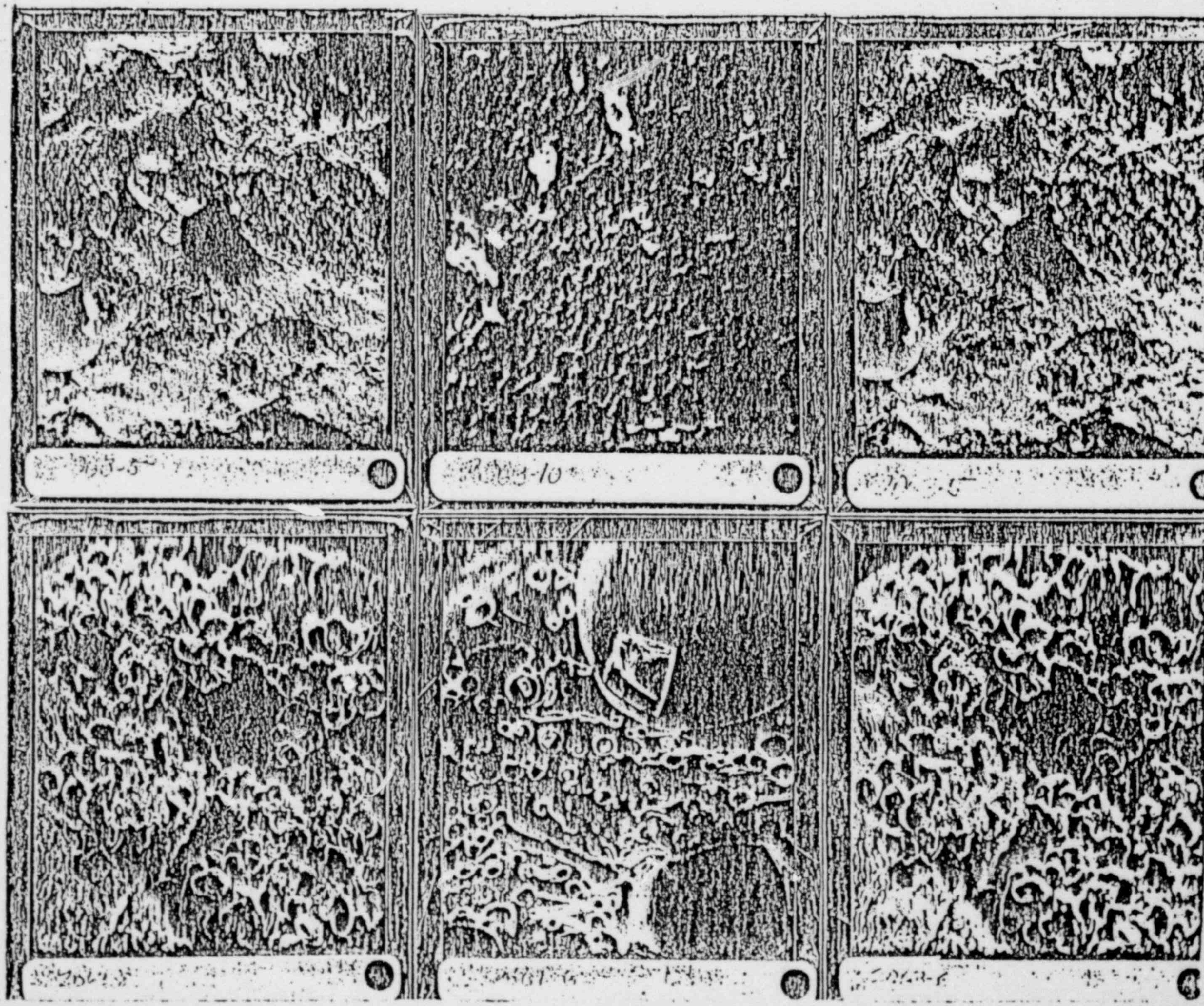
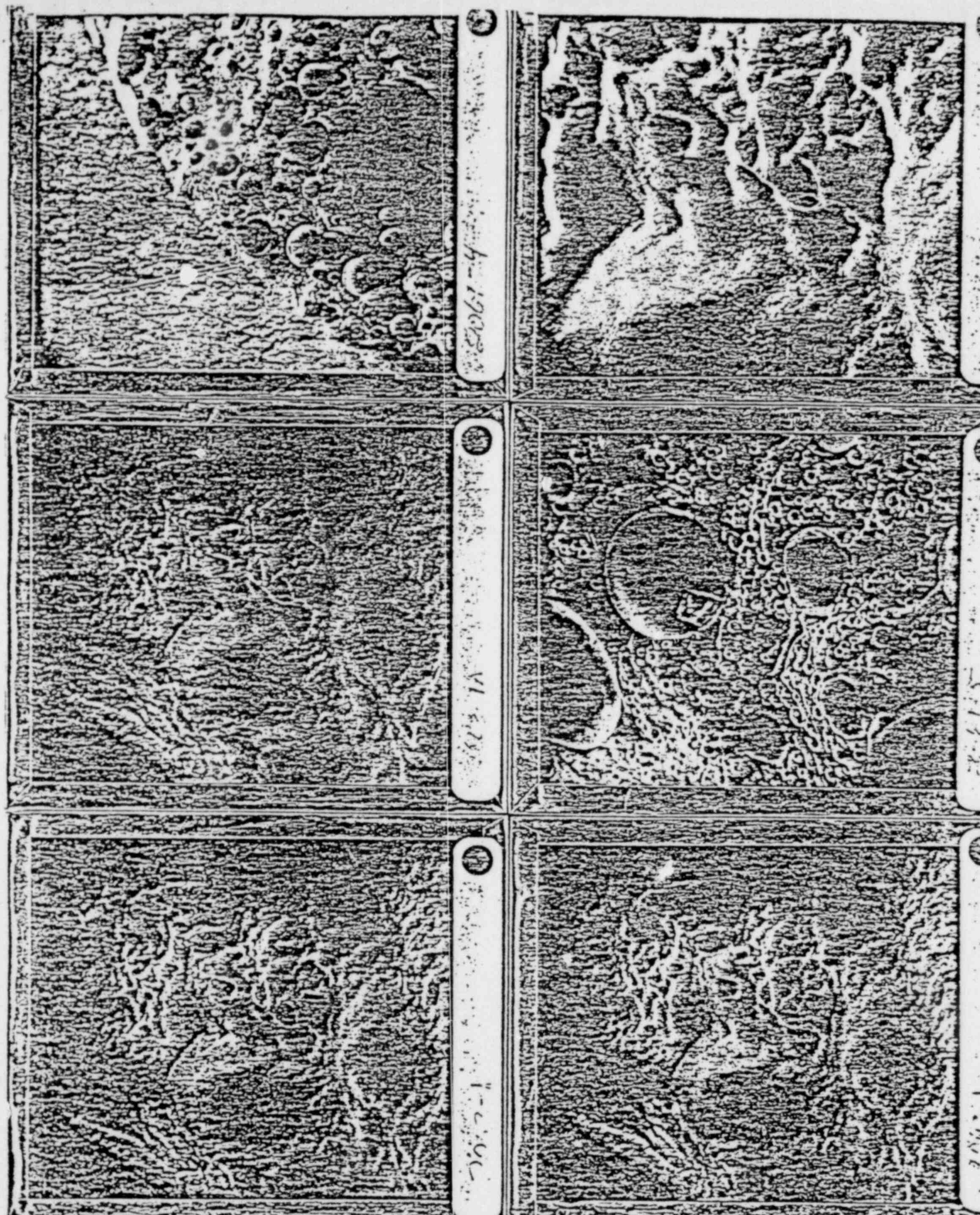
Storage of Urea Formaldehyde

Urea Formaldehyde is stable for at least six months under normal storage conditions. At 35°C (95°F) viscosity will increase rapidly upon storage. For this reason, storage tanks should not be exposed to direct summer sunlight. Extended storage at temperatures as low as -20°C (-4°F) has no permanent deleterious effect on Urea Formaldehyde, but to maintain the proper viscosity it is recommended that Urea Formaldehyde be stored at 20 to 30°C (68-86°F). If low ambient temperatures are anticipated, indoor or insulated storage tanks should be used, with provisions for heating and recirculation or agitation.

A heating coil is sometimes needed only near the outlet of small tanks; this can be used to avoid having to heat the entire contents of the tank. Water heated about 50°C (122°F) should be used instead of steam for heating stored Urea Formaldehyde, since localized overheating could deteriorate the material.







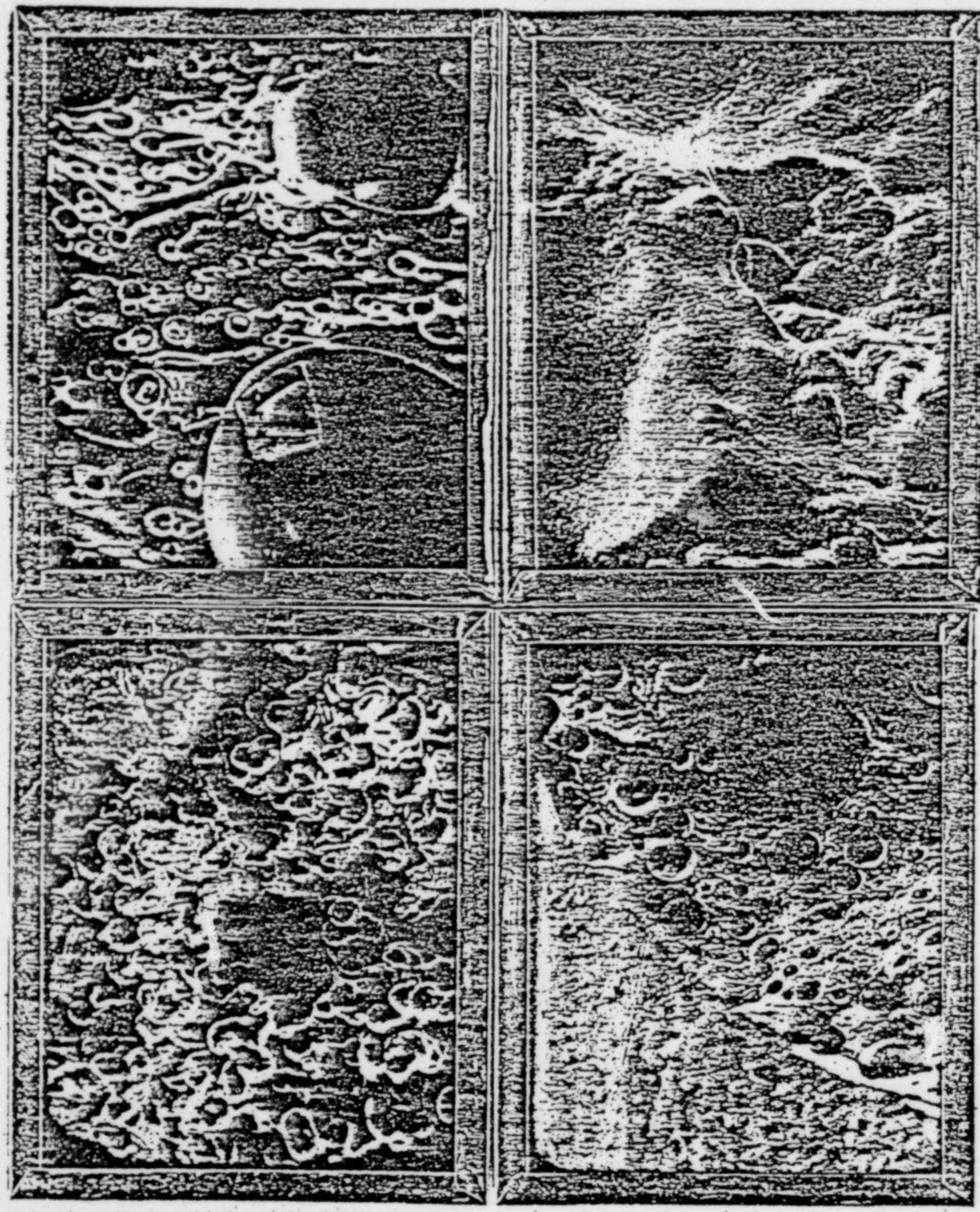


Table 1: pH Measurements by mls. of Catalyst for 200 ml. Slurries of Water/A-SET

X Ml. of 25% wt. Sodium Bisulfate	Y pH of Slurry @ 70°F.	Estimated pH
2	2.4	2.4
4	1.7	1.7
6	1.5	1.5
8	1.4	1.4
10	1.3	1.3

Equation for curvilinear fit of raw data. Shown in Figure 1.

$Y = 1.02522 + (.0415589X)$ Index of Determination = .99724

X Ml. of 3N H_2SO_4	Y pH of Slurry @ 70°F.	Estimated pH
1	2.7	2.7
2	1.9	1.9
3	1.6	1.6
4	1.4	1.5
6	1.4	1.3
10	1.2	1.2

Equation for curvilinear fit of raw data. Shown in Figure 1.

$Y = 1.05443 + (1.64827/X)$ Index of Determination = .99304

Table 2. 70° and 90°F. Gel Times by pH of Water/ A-SET Slurries Catalyzed with 25% Sodium Bisulfate

X Slurry pH @ 70°F. Using 25% wt. Sodium Bisulfate Solution	Y Gel Time @ 70°F. (mins.)	Estimated Gel Time @ 70°F.
2.4	19	19.4
1.7	11	9.3
1.5	5	5.7
1.4	4	5.0
1.3	4	3.5

Equation for curvilinear fit of raw data. Shown in Figure 2.

$Y = -15.2101 + (14.4304X)$ Index of Determination = .97226

X Slurry pH @ 70°F. Using 25% wt. Sodium Bisulfate Solution	Y Gel Time @ 90°F. (mins.)	Estimated Gel Time @ 90°F.
2.4	16	15.3
1.7	5	6.8
1.5	3	3.8
1.4	4	3.2
1.3	3	1.9

Equation for curvilinear fit of raw data. Shown in Figure 2.

$Y = -13.8506 + (12.1519X)$ Index of Determination = .94999

Table 3.

Table 3. 70° and 90°F. Gel Times by pH of Water/ A-SET Slurries Catalyzed with 3N Sulfuric Acid

X Slurry pH @ 70°F. Using 3N H_2SO_4	Y Gel Time @ 70°F. (mins.)	Estimated Gel Time @ 70°F. (mins.)
2.7	118	133.7
1.9	24	21.1
1.6	9	8.5
1.4	6	4.2
1.4	3.5	4.2
1.2	1.5	1.9

Equation for curvilinear fit of raw data. Shown in Figure 3.

$Y = .719384 (X^{5.26018})$ Index of Determination = .97931

X Slurry pH @ 90°F. Using 3N H_2SO_4	Y Gel Time @ 90°F. (mins.)	Estimated Gel Time @ 90°F. (mins.)
1.9	13	12.9
1.6	8	7.9
1.4	5	4.5
1.4	3.5	4.5
1.2	1.5	1.2

Equation for curvilinear fit of raw data. Shown in Figure 3.

$Y = -18.9736 + (16.7857X)$ Index of Determination = .98243

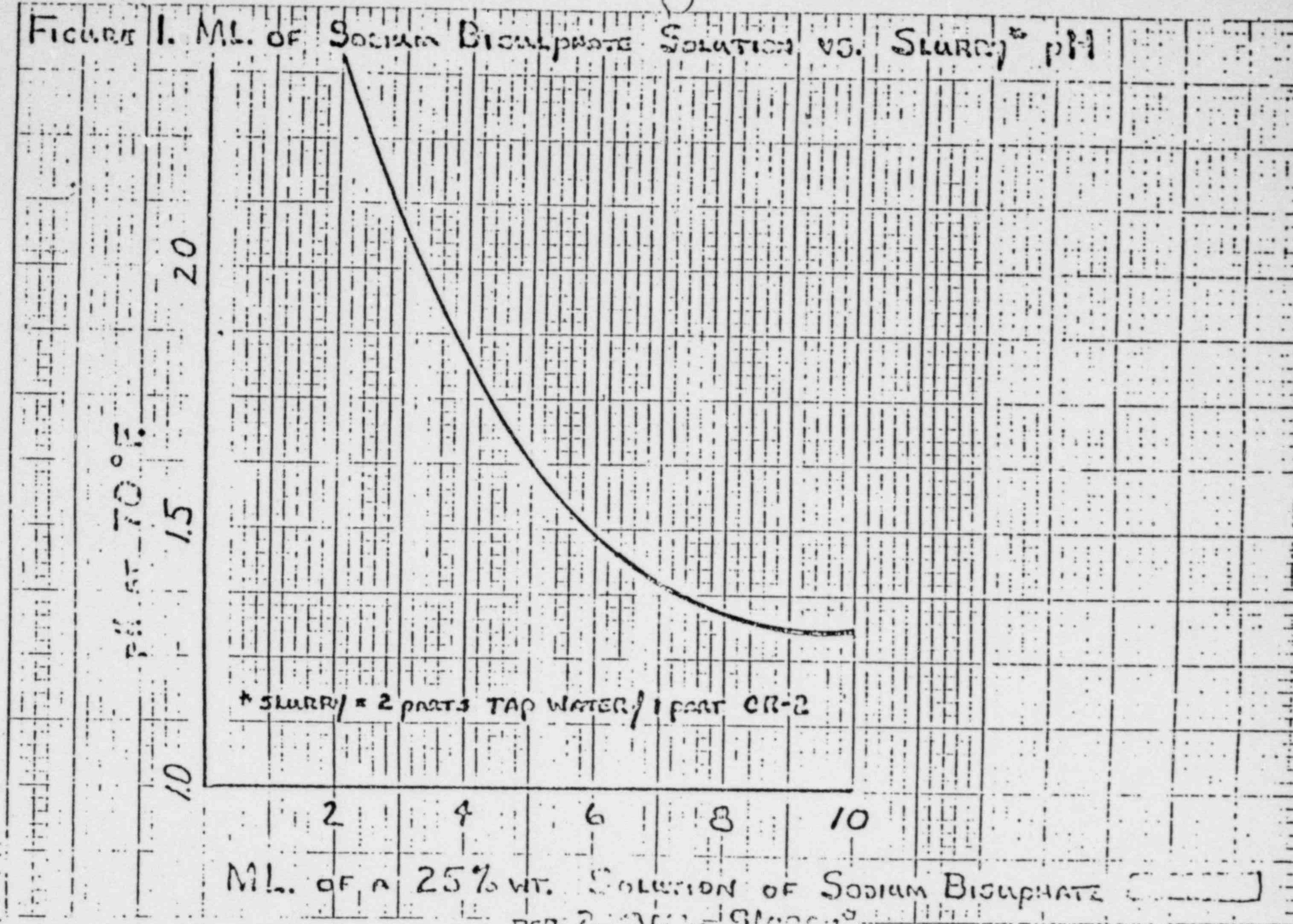


FIGURE I. ML. OF SODIUM BISULPHATE SOLUTION VS. SLURRY* pH

Figure 2. ML. of 3 Normal H_2SO_4 vs. Slurry* pH

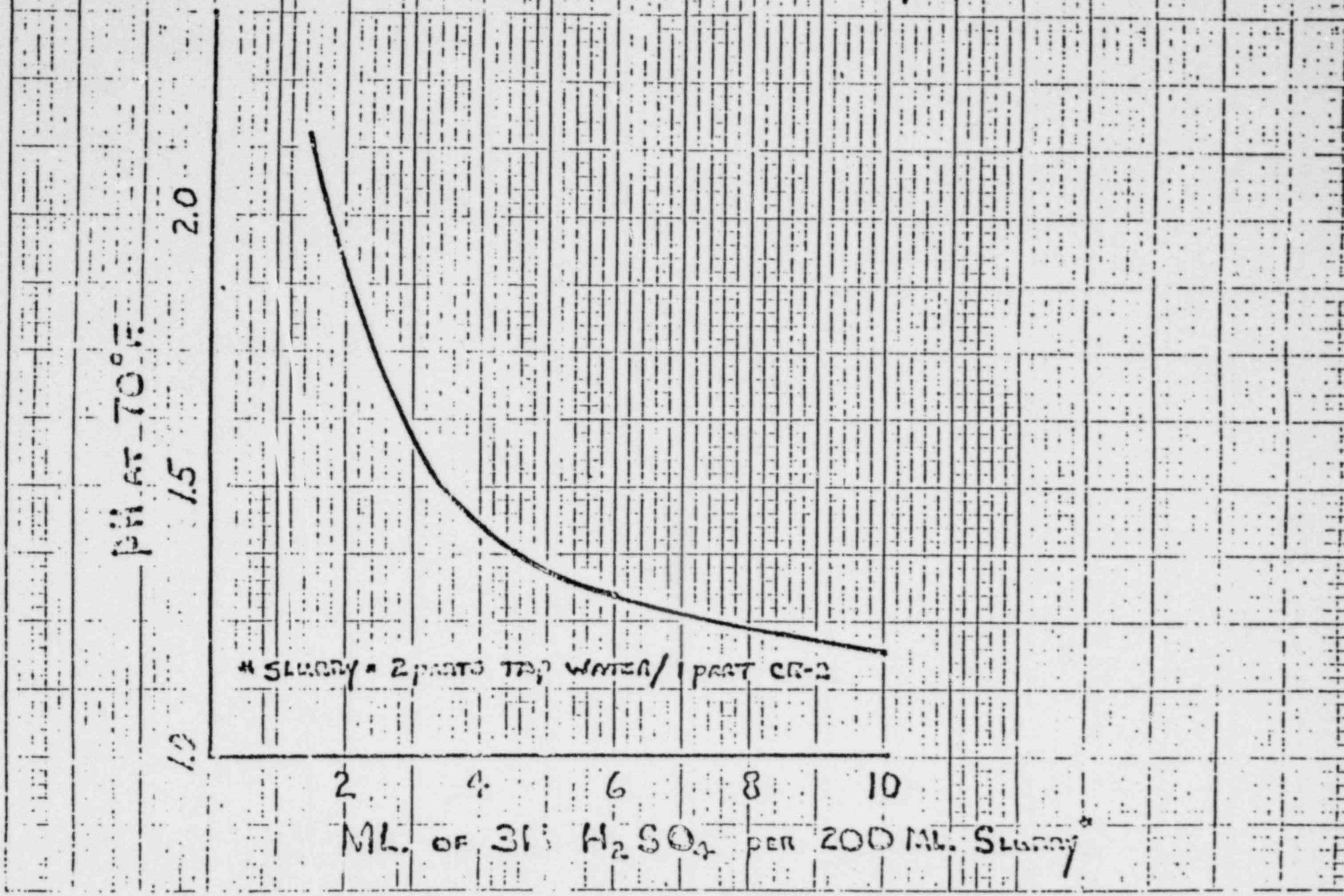
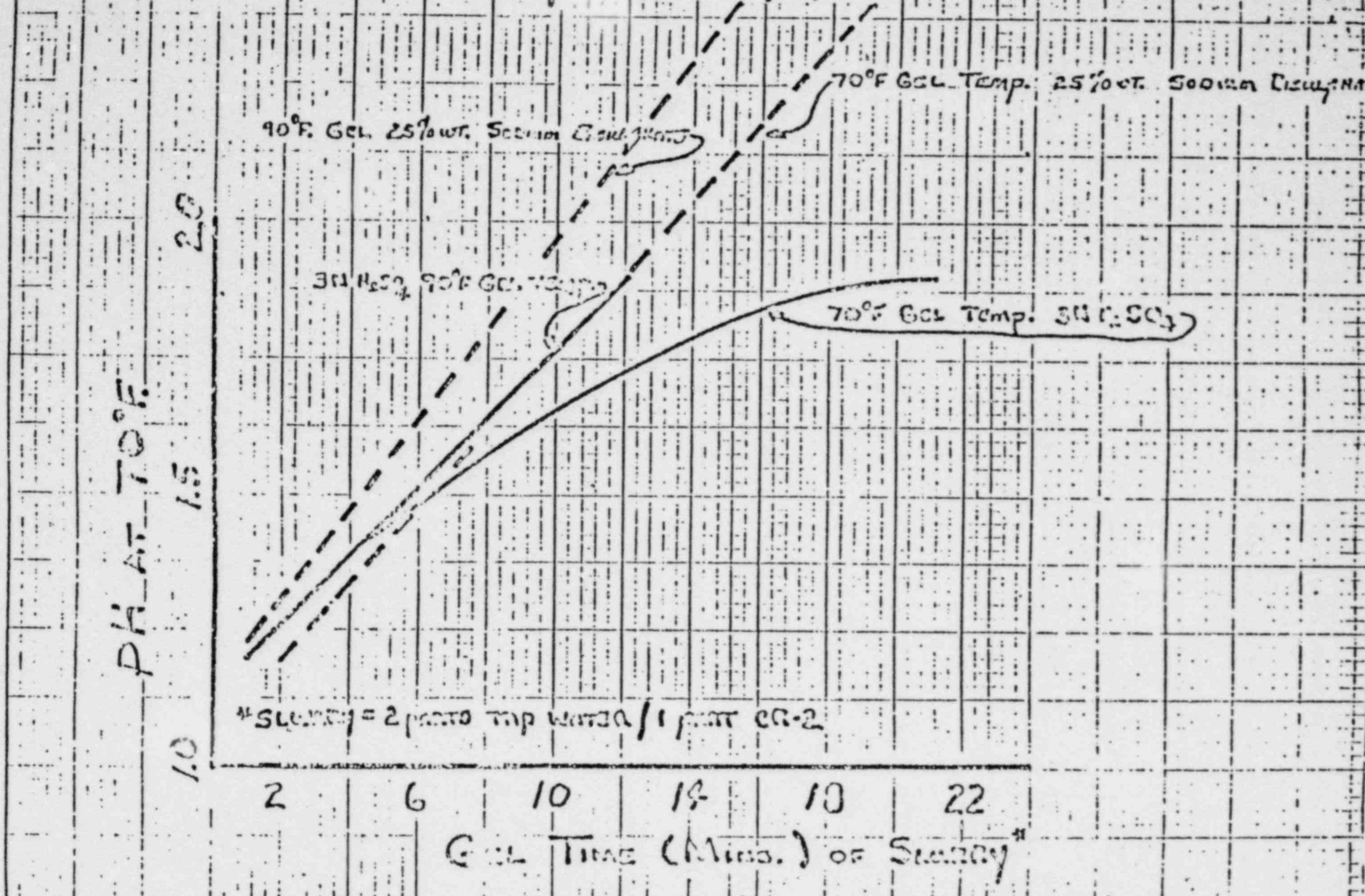


Figure 3. Gel Time of Slurry* vs. Slurry* pH



ANEFCO INC. ECOPAC SYSTEM
PROCEDURE FOR ON-SITE SOLIDIFICATION
OF LOW-LEVEL RADIOACTIVE WASTE
AT SEQUOYAH NUCLEAR PLANT

CONTRACT 80P68-161957

ANEFCO CODE B-123

This Procedure describes general operation of the ECOPAC system and the necessary interfacing with Sequoyah Nuclear Plant systems.

1/31/80 Rev. 0

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SCOPE:

1.0 The purpose of this procedure is to describe the general operations, precautions, and interfacing for the removal and packaging of resin and liquid radwaste from the Sequoyah Nuclear Plant (SNP).

PREREQUISITES:

2.0 All radiation protection standards will be in accordance with the Radiological Safety Policy and Program of Sequoyah Nuclear Plant, and Code of Federal Regulations, Title 10, ENERGY; Part 20, Standards for Protection Against Radiation.

2.1 All ECOPAC equipment will be checked prior to this operation by the ANEFCO field supervisor.

2.2 Radiation work permit must be completed.

PRECAUTIONS:

3.0 Traumatic safety is of primary concern throughout the entire operation.

3.1 Radiation limits established by Health Physics section and 10 CFR 20, will be monitored.

3.2 The limiting radiation factors, as applied to this procedure, are the readings on the side of the transfer vehicle. Dose rates on shielded container will be limited to DOT regulations for sole use vehicle, 200 mr/hr. contact and 10 mr/hr at six feet from truck body.

3.3 Area barriers (i.e. radiation signs) will be posted per 10 CFR 20.

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3.4 Wipe tests (i.e. smearable loose contamination) will be performed prior to work and at the finish of the job to establish that this area is within the limits as prescribed by the applicable regulation.

3.5 Waste transfer piping and hose will be blown free when transfer is completed to prevent subsequent plugging, contamination buildup within the lines, and to reduce area background radiation levels.

3.6 All ECOPAC connecting hoses will be disconnected and stored when operations are completed.

OPERATIONAL PROCEDURE (Utilize 4.0 thru 4.8 for both Resin and Boric Acid solidification)

4.0 Position cask with empty disposable liner inside auxiliary building access bay alongside the ANEFCO ECOPAC solidification system.

4.1 Attach ECOPAC loading arm to the liner 2" male dry-break connector. Verify that the ultra-sonic level detector fits properly into liner port and seal OPW quick disconnect.

4.2 Connect the loading arm acid line to the liner 1/2" male dry-break connector.

4.3 Connect the dewatering system hose to the ECOPAC system air compressor outlet.

4.4 Connect two air hoses from plant service air to the ECOPAC system.

4.5 Connect both electrical supplies to ECOPAC system. (110 VAC, 60 hz; 220 VAC 3 phase, 60 hz).

4.6 Couple U-F tank to the 1 1/2" Sandpiper pump using 4' double OPW female quick-disconnect hose.

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4.7 Couple U-F Sandpiper pump to ECOPAC system using 25' double OPW female quick-disconnect hose.

4.8 Attach air supply from ECOPAC system outlet to the U-F Sandpiper pump.

RESIN SOLIDIFICATION

5.0 Slide hose containment over resin-transfer hose prior to attaching hose to SNP discharge fitting FCV-77-400.

5.0.1 Tape hose containment to hose, add (3) three absorbant pads into the containment, then tape and seal the containment to SNP pipe (refer to drawing SNP-1).

5.1 Connect the SNP resin outlet hose to the catch tank top inlet quick-disconnect and contain per drawing SNP-1.

5.2 Connect the resin catch tank discharge pump outlet (Moyno) to the ECOPAC system utilizing the 25' female quick disconnect flanged hose and contain per drawing SNP-1.

5.3 Connect the resin catch tank well point to the dewatering pump and contain per drawing SNP-1.

5.4 Attach dewatering pump discharge hose to SNP valve number FCV-77-40

5.5 ANEFCO will indicate when ~~gallon~~ one complete batch of resin can be pumped by SNP to the catch tank.

5.6 SNP should flush/clear resin hose prior to step 5.7 to lower the dose rate as low as reasonably achievable.

5.7 Supply 110 vac to the dewatering pump and dewater resin through SNP valve #FCV-77-401 Water recovered by dewatering system from catch tank will be pumped to SNP receiving line.

5.8 Supply 220 vac, 3 phase 60 hz. to resin forwarding Moyno pump from ECOPAC system.

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5.9 Connect air sparge hose from ECOPAC system to resin catch tank and sparge for a minimum of 30 minutes prior to transfer for solidification.

5.10 ANEFCO personnel to solidify the dewatered resin according to the ANEFCO ECOPAC process control plan. When resin solidification is completed, disconnect the SNP resin outlet hose to the catch tank top inlet and contain per drawing SNP-1. Store hose in assigned location.

5.11 Disconnect the catch tank discharge pump (Moyno) outlet hose to the ECOPAC system and contain per drawing SNP-1. Store hose in proper location.

5.12 Disconnect loading arm waste dry-break connector, acid dry-break connector, and ultra-sonic level detector. Contain opening with safety drip bags.

5.13 Health Physics Technician will monitor radiation levels and condition of solidified waste in the liners.

5.14 Seal full liners. Paint one liner cap with temporary sealed cap for indentification at burial site for subsequent inspection. Seal other liner caps with lock-cement (permanent).

5.15 Seal cask cover.

BORIC ACID/EVAPORATOR BOTTOMS (Liquid Wastes)

6.0 Slide hose containment over boric acid-transfer hose prior to attaching hose to SNP discharge line number

6.1 Tape hose containment to hose, add (3) three absorbant pads into the containment then tape and seal the containment to SNP pipe (refer to drawing SNP-1).

6.2 Connect the boric acid transfer hose to the ECOPAC system waste inlet and contain per drawing SNP-1.

6.3 ANEFCO will notify SNP when ECOPAC system is ready to receive liquid wastes.

6.4 SNP to open valve number FCV-77-402 for transfer of waste to ECOPAC system.

6.5 ANEFCO personnel will solidify the liquid wastes according to the ANEFCO ECOPAC Process Control ~~Plan~~. Program.

6.6 ANEFCO will verbally notify SNP upon receipt of one complete batch of boric acid so that SNP can terminate pumping waste by closing valve number FCV-77-402.

6.7 After notifying SNP operator, ANEFCO will flush ECOPAC system using SNP demin water ~~to~~ through SNP valve number FCV-77-402.

6.8 Disconnect the boric acid transfer hose from both the ECOPAC waste inlet and the SNP discharge line valve number FCV-77-402 using the containment method illustrated in drawing SNP-1. Store hoses in proper location.

6.9 Disconnect loading arm waste dry-break connector, acid dry-break connector, and ultra-sonic level detector. Contain openings with safety drip bags.

6.10 Health Physics technicians will monitor radiation levels.

6.11 Seal full liners. Paint one liner cap with temporary seal for identification at the burial site for subsequent inspection. Seal other liner caps with lock-cement (permanent).

6.12 Seal cask cover.

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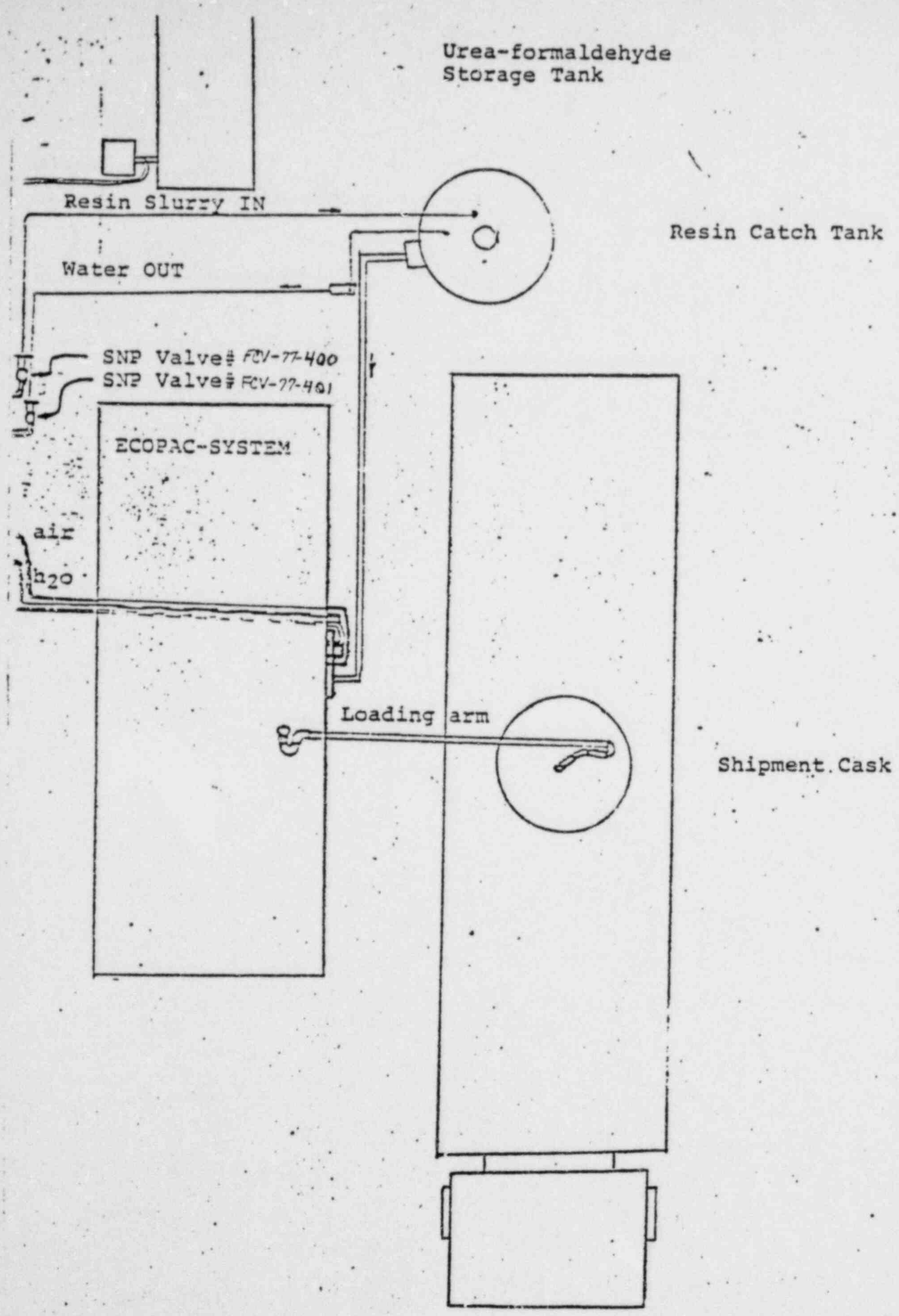
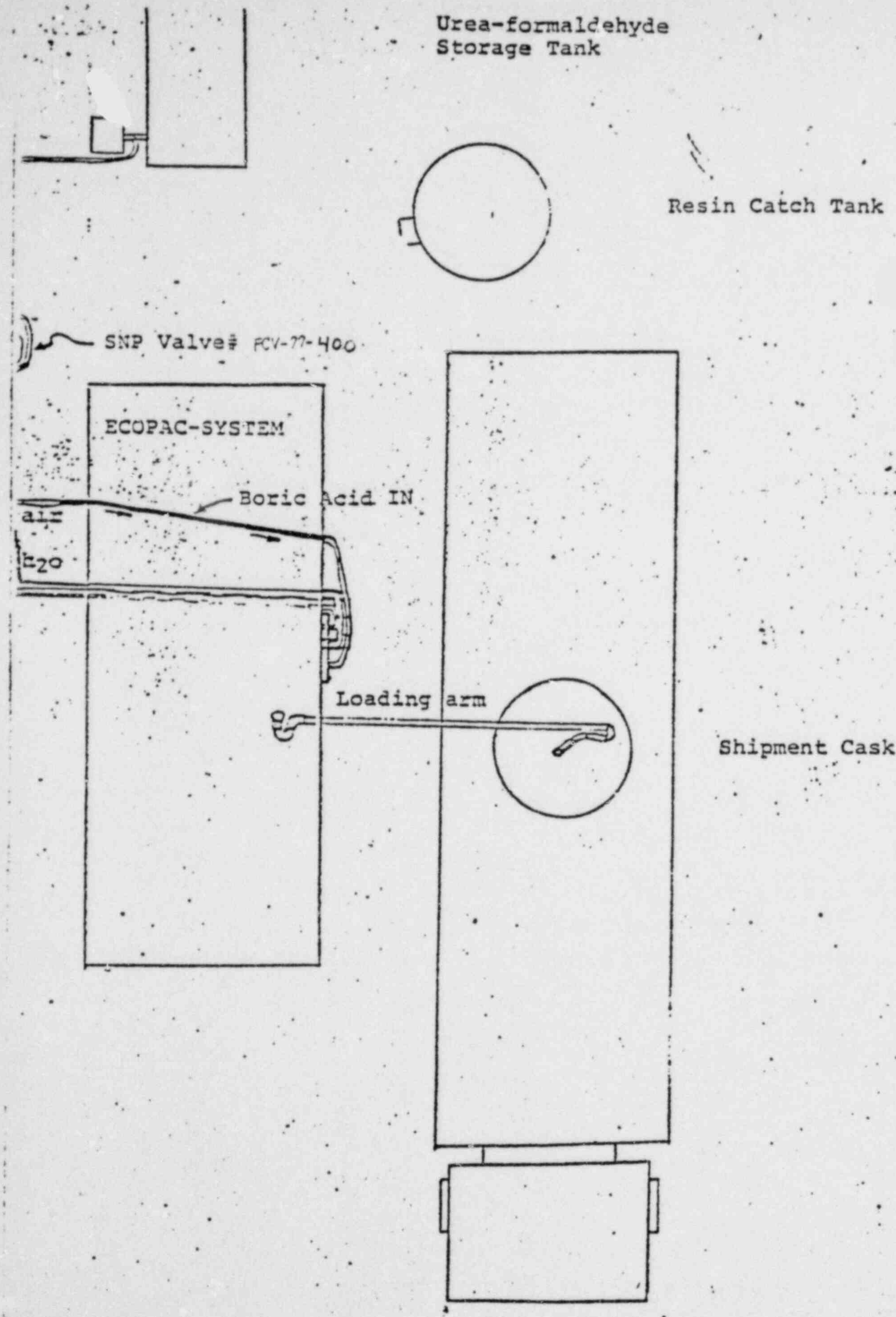
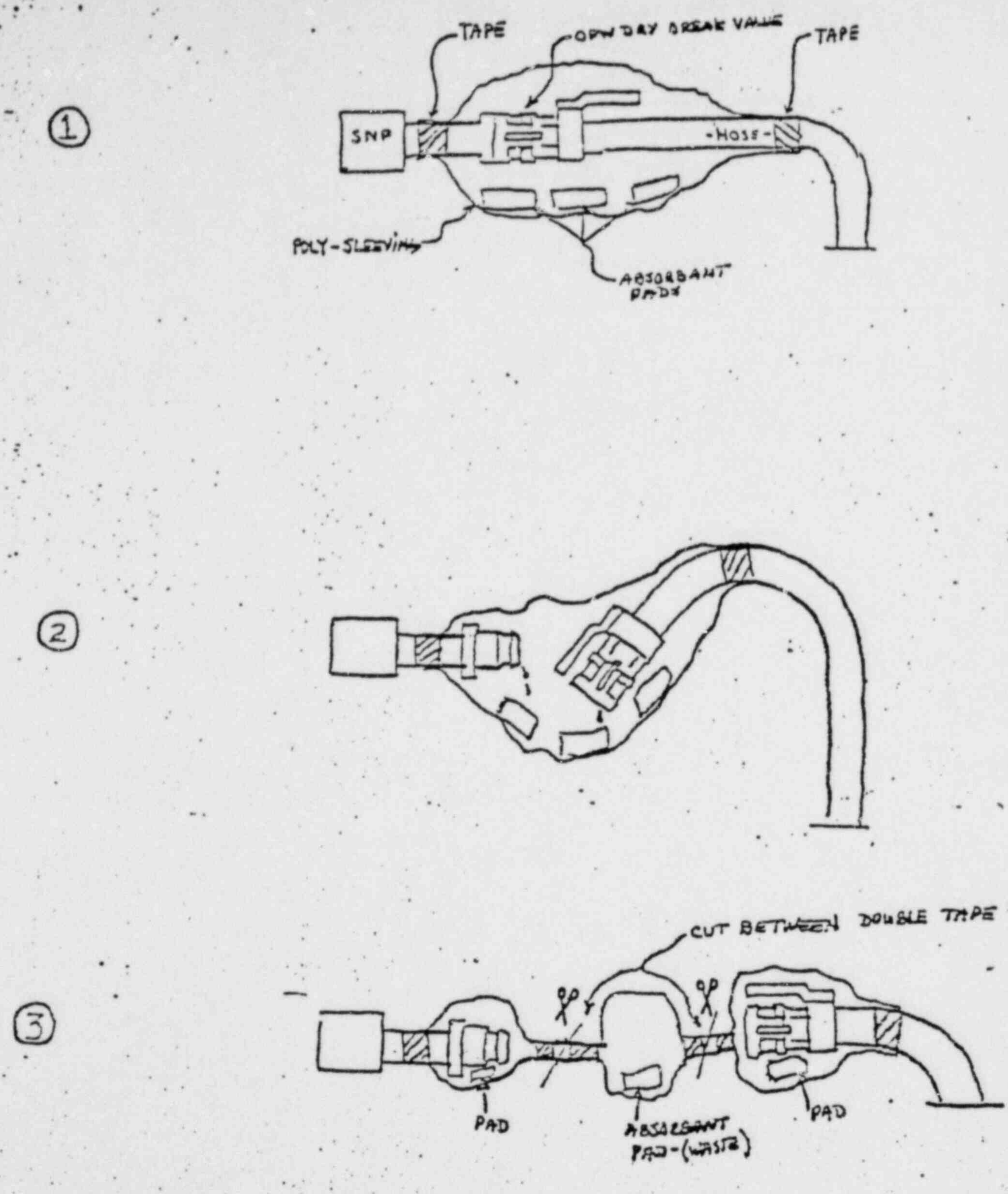


RESIN SOLIDIFICATION SCHEMATIC



BORIC ACID SOLIDIFICATION SCHEMATIC



DRAWING SNP-1

(Hose Coupling Containment)

EXPERIMENTAL SIMULATIONS OF RADIOACTIVE WASTE AND A-SET RESIN* FORMULATIONS

Experimental formulations for the solidification of selected simulated wastes with A-Set Resin has been determined. These formulations, [redacted], attempt to incorporate a relatively maximum quantity of waste while consistently producing a solidified product. Solidified products were obtained for all waste types tested although some difficulties were encountered at high waste to solidification agent ratios for sulfate wastes to UF. The addition of sufficient acid catalyst to waste-UF mixtures to achieve a pH of 1.5± 0.5 was found to produce a more rapid and consistent polymerization and also permit a higher waste to UF ratio for most wastes. Care should be exercised to assure that a thorough homogeneous blend is achieved. Mixing equipment must be kept free from foreign matter and cured adhesive build-up.

The free standing water in simulated wastes solidified with UF was measured and found to vary from zero to 25.4 wt.%. Adjustment of the waste to UF mixture pH to 1.5± 0.5 by the addition of sufficient acid catalyst resulted in a significant reduction in the quantity of free standing water. The free standing water was found to have a pH approximating that of the water to UF mixture after addition of the catalyst.

The polymerization reaction is acid catalyzed and is both temperature and pH dependent. Low waste to UF mixture pH and high ambient temperature decrease the time required for solidification. A pH of 1.5± 0.5 in the waste-UF mixture is desirable; however, the amount of catalyst needed must be determined for each type of waste. Such mixtures will begin to gel in several minutes and are generally well solidified within thirty minutes. Dilute solutions of strong acids maybe used to adjust the pH of highly buffered waste-UF mixtures. The use of strong acid solutions must be done with care to avoid premature gelling of the mixture.

Concentrated soduim sulfate wastes may cause erratic setting in UF. Additions of less than ten weight percent sodium sulfate or small amounts of calcium chloride are reported to eliminate this problem.[1] The addition of 2 wt.% calcium chloride to UF containing sodium

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[1] Heacock, H.W. and Riches, J.W., Waste Solidification-Cement or Ureaformaldehyde, American Society of Mechanical Engineers, 74-WA/NE-9, 1974.

*Registered Trademark

sulfate wastes was found to increase the permissible waste/A-set Resin ratio.. The addition of sufficient catalyst to produce a pH of 1.5± 0.5 in the waste-UF mixture allows an increase in the waste/UF ratio for most wastes.

TABLE 1

Simulated Waste Types Included in the Experimental Program

1. Bead Resin Waste

2. BWR Precoat Filter Cake

   a. Powdered Resin
   b. Diatomaceous Earth

3. Forced Recirculation Evaporator Concentrates

   a. BWR Chemical Regenerative Waste
   b. PWR Chemical Regenerative Waste
   c. Boric Acid Waste
   d. Decontamination Waste

4. Thin Film Evaporator Concentrates

   a. BWR Chemical Regenerative Waste
   b. PWR Chemical Regenerative Waste
   c. Boric Acid Waste
   d. Decontamination Waste

TABLE 2

Simulated Waste Formulations

1. BEAD RESIN WASTE

Material	Weight Percent, %
Water	50.
Bead Resin (IRN-150)[a]	50.
Temperature	70°F
pH	7

2a. BWR PRECOAT FILTER CAKE (WITH POWDERED RESIN)

Material	Weight Percent in Filter Cake, %
Water	50.
Anion Powdered Resin (PAO)[b]	20.
Cation Powdered Resin (PCH)[b]	20.
Crud[c]	5.
Sodium Chloride	5.
Temperature	70°F
pH	7

2b. BWR PRECOAT FILTER CAKE (WITH DIATOMACEOUS EARTH)

Material	Weight Percent in Filter Cake, %
Water	50.
Diatomaceous Earth	40.
Crud[c]	10.
Temperature	70°F
pH	7

3a. BWR CHEMICAL REGENERATIVE WASTE OF A FORCED RECIRCULATION EVAPORATOR

Material	Weight Percent in Evaporator Bottoms, %
Water	75.
Sodium Sulfate	22.9
Sodium Chloride	2.0
Crud[c]	0.1
Temperature	170°F
pH	6

3b. PWR CHEMICAL REGENERATIVE WASTE OF A FORCED RECIRCULATION EVAPORATOR

Material	Weight Percent in Evaporator Bottoms, %
Water	73.4
Sodium Sulfate	14.9
Ammonium Sulfate	9.6
Sodium Chloride	2.0
Crud[c]	0.1
Temperature	170°F
pH	2.5 to 4.0

3c. BORIC ACID WASTE OF A FORCED RECIRCULATION EVAPORATOR

Material	Weight Percent in Evaporator Bottoms, %
Water	87.9
Boric Acid	12.0
Crud[c]	0.1
Temperature	170°F
pH	3.5

3d. DECONTAMINATION WASTE OF A FORCED RECIRCULATION EVAPORATOR

Material	Weight Percent in Evaporator Bottoms, %
Water	80.
NUTEK-700[d]	9.4
EDTA	5.
Citric Acid	5.
Crud[c]	0.2
Hydraulic Oil No. 2	0.2
Lubricating Oil No. 20	0.2
Temperature	170°F
pH	5

4a. BWR CHEMICAL REGENERATIVE WASTE OF A THIN FILM EVAPORATOR

Material	Weight Percent in Evaporator Bottoms, %
Water	50.
Sodium Sulfate	45.8
Sodium Chloride	4.0
Crud[c]	0.2
Temperature	150 to 250°F
pH	6

4b. PWR CHEMICAL REGENERATIVE WASTE OF A THIN FILM EVAPORATOR

Material	Weight Percent in Evaporator Bottoms, %
Water	50.
Sodium Sulfate	29.
Ammonium Sulfate	16.8
Sodium Chloride	4.0
Crud[c]	0.2
Temperature	150 to 250°F
pH	1.8 to 4.0

4c. BORIC ACID WASTE OF A THIN FILM EVAPORATOR

Material	Weight Percent in Evaporator Bottoms, %
Water	50.
Boric Acid	49.8
Crud[c]	0.2
Temperature	150 to 250°F
pH	2.5 to 3.5

4d. DECONTAMINATION WASTE OF A THIN FILM EVAPORATOR

Material	Weight Percent in Evaporator Bottoms, %
Water	50.
NUTEK-700[d]	20.
EDTA	9.8
Citric Acid	19.
Crud[c]	0.2
Hydraulic Oil No. 2	0.5
Lubricating Oil No. 20	0.5
Temperature	150 to 250°F
pH	5

---

[a] Rohm and Haas Co., Philadelphia, Pa. 19105

[b] Ecodyne Corp., Union, N.J. 07083

[c] fine air cleaner test dust no. 1543094, AC Spark Plug Division, General Motors Corp., Flint, Michigan 48556

[d] compound for the dissolution of calcium sulfate scale, Nuclear Technology Corp., Amston, Conn. 06231

TABLE 5

Formulations for the Solidification of BWR and PWR Wastes Using A-Set Resin. Sufficient 25 Wt.% Sodium Bisulfate (Anhydrous) Aqueous Catalyst Solution Added to Achieve pH = 1.5±0.5 in the Waste-UF Mixture

Waste Type	Weight Ratio Waste to UF	Approximate Solidification Time	Volume % $NaHSO_4$ Solution Added
1. Bead Resin	2.2	15 minutes	1.8
2. BWR Precoat Filter Cake			
a. Powdered Resin	2.0	15 minutes	1.9
b. Diatomaceous Earth	2.0	15 minutes	3.0
3. Forced Recirculation Evaporator Concentrates			
a. BWR Chemical Regenerative Waste	1.3	15 minutes	3.1
b. PWR Chemical Regenerative Waste	1.3	15 minutes	2.9
c. Boric Acid Waste	1.2	10 minutes	0.8
d. Decontamination Waste	1.2	30 minutes	10.5
4. Thin Film Evaporator Concentrates			
a. BWR Chemical Regenerative Waste	1.5	20 minutes	1.5
b. PWR Chemical Regenerative Waste	1.0	20 minutes	1.7
c. Boric Acid Waste	1.2	20 minutes	[illegible]
d. Decontamination Waste	1.5	30 minutes	13.3

<u>Data and Discussion</u>: Tables 1 through 3 as described below show the raw data obtained in these catalyst studies of A-Set Resin 2 as well as their conversion to a curvilinear fit in graphing.

Table 1: pH measurements by mls. of Catalyst for 200 ml. Slurries of Water/CASCO-RESIN 2

Table 2: 70° and 90°F. Gel Times by pH of Water/A-Set Resin 2 Slurries Catalyzed with 25% Sodium Bisulfate

Table 3: 70° and 90°F. Gel Times by pH of Water/A-Set Resin 2 Slurries Catalyzed with 3N Sulfuric Acid

Figures 1 through 3 attached are graphical portrayals of Tables 1 through 3 and need no further description.

Table 1: pH Measurements by mls. of Catalyst for 200 ml. Slurries of Water/A-Set Resin 2

X Ml. of 25% wt. Sodium Bisulfate	Y pH of Slurry @ 70°F.	Estimated pH
2	2.4	2.4
4	1.7	1.7
6	1.5	1.5
8	1.4	1.4
10	1.3	1.3

Equation for curvilinear fit of raw data. Shown in Figure 1.

$Y = 1.02522 + (.0415589X)$ Index of Determination = .9972[illegible]

X Ml. of 3N H_2SO_4	Y pH of Slurry @ 70°F.	Estimated pH
1	2.7	2.7
2	1.9	1.9
3	1.6	1.6
4	1.4	1.5
6	1.4	1.3
10	1.2	1.2

Equation for curvilinear fit of raw data. Shown in Figure 1.

$Y = 1.05443 + (1.64827/X)$ Index of Determination = .99304

Table 2. 70° and 90°F. Gel Times by pH of Water/A-Set Resin 2 Slurries Catalyzed with 25% Sodium Bisulfate

X Slurry pH @ 70°F. Using 25% wt. Sodium Bisulfate Solution	Y Gel Time @ 70°F. (mins.)	Estimated Gel Time @ 70°F.
2.4	19	19.4
1.7	11	9.3
1.5	5	5.7
1.4	4	5.0
1.3	4	3.5

Equation for curvilinear fit of raw data. Shown in Figure 2.

$Y = -15.2101 + (14.4304X)$ Index of Determination = .97226

X Slurry pH @ 70°F. Using 25% wt. Sodium Bisulfate Solution	Y Gel Time @ 90°F. (mins.)	Estimated Gel Time @ 90°F
2.4	16	15.3
1.7	5	6.8
1.5	3	3.8
1.4	4	3.2
1.3	3	1.9

Equation for curvilinear fit of raw data. Shown in Figure 2.

$Y = -13.8506 + (12.1519X)$ Index of Determination = .94999

Figure 1. ML. of Sodium Bisulphate Solution vs. Slurry* pH.

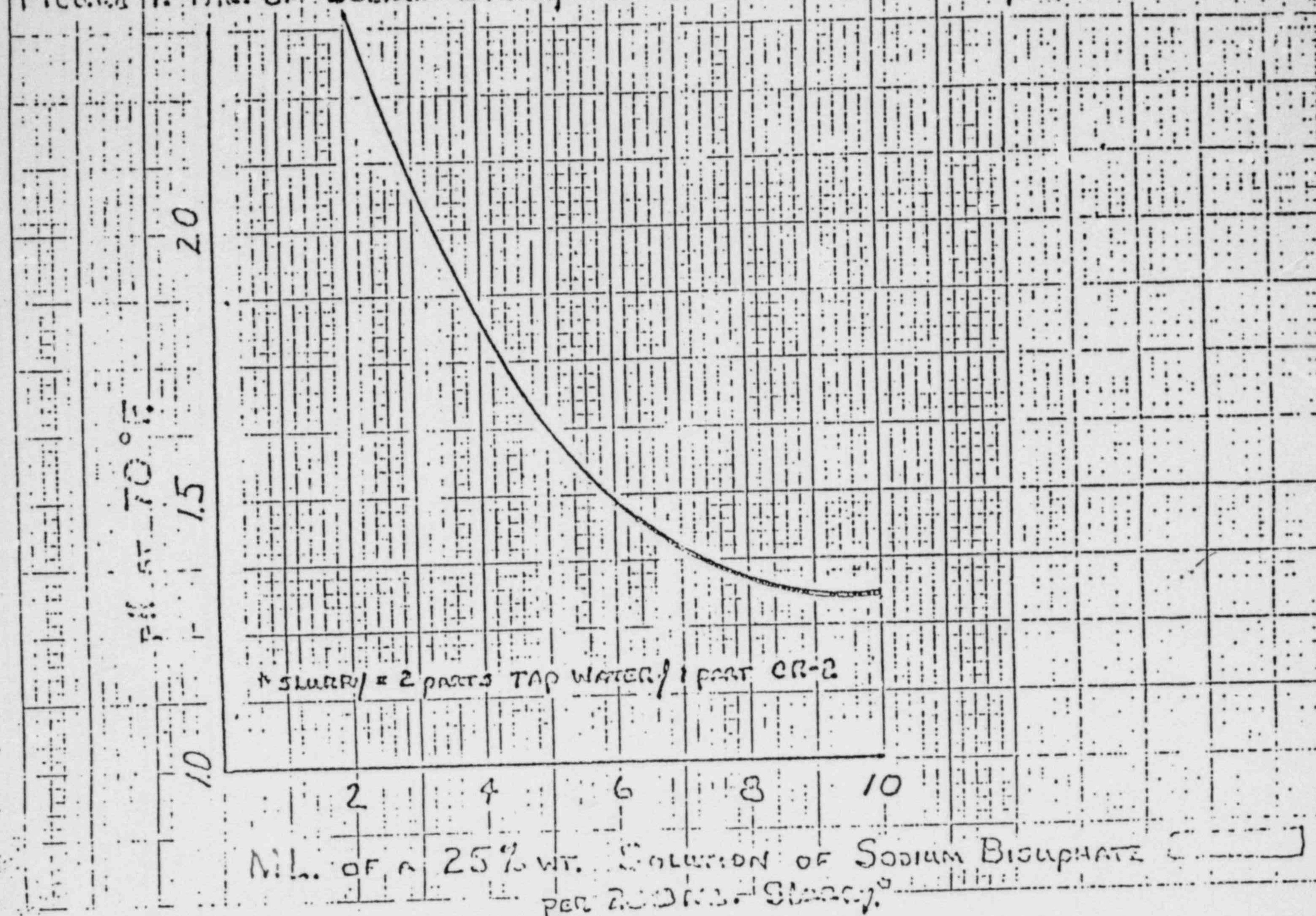


Figure 2. ML. of 3 Normal H_2SO_4 vs. Slurry* pH

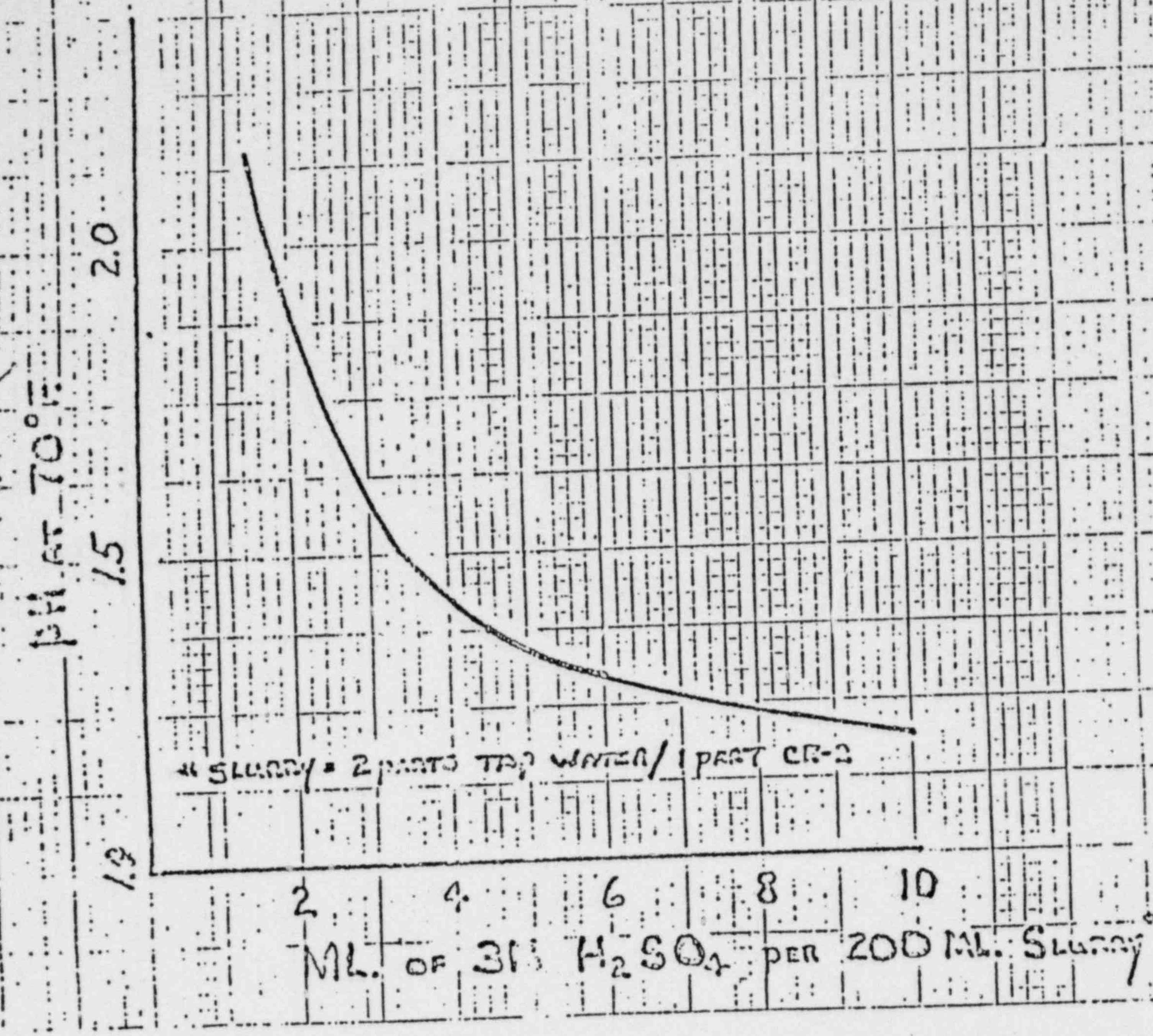
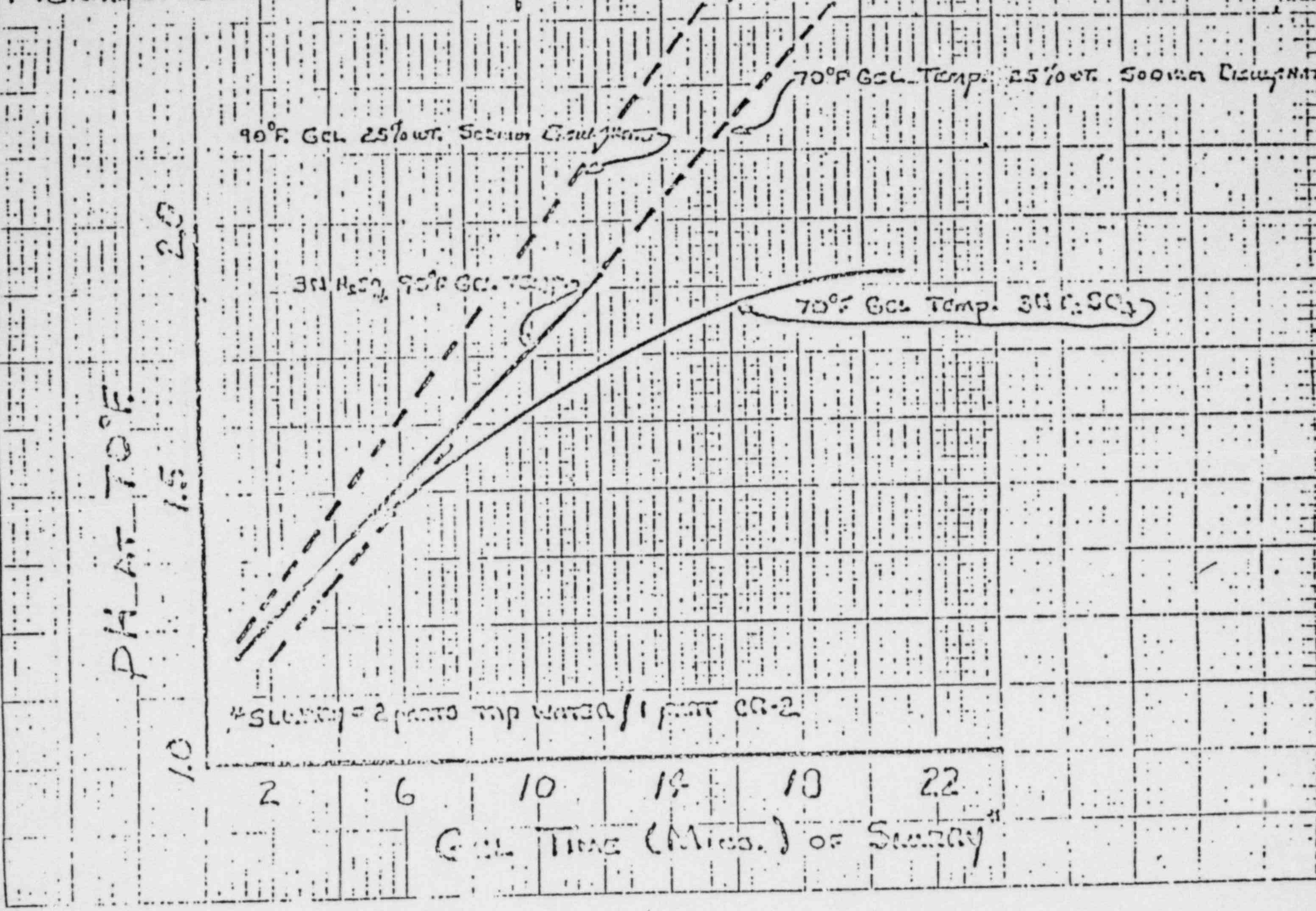


Figure 3. Gel Time of Slurry* vs. Slurry* pH



VII. APPENDIX

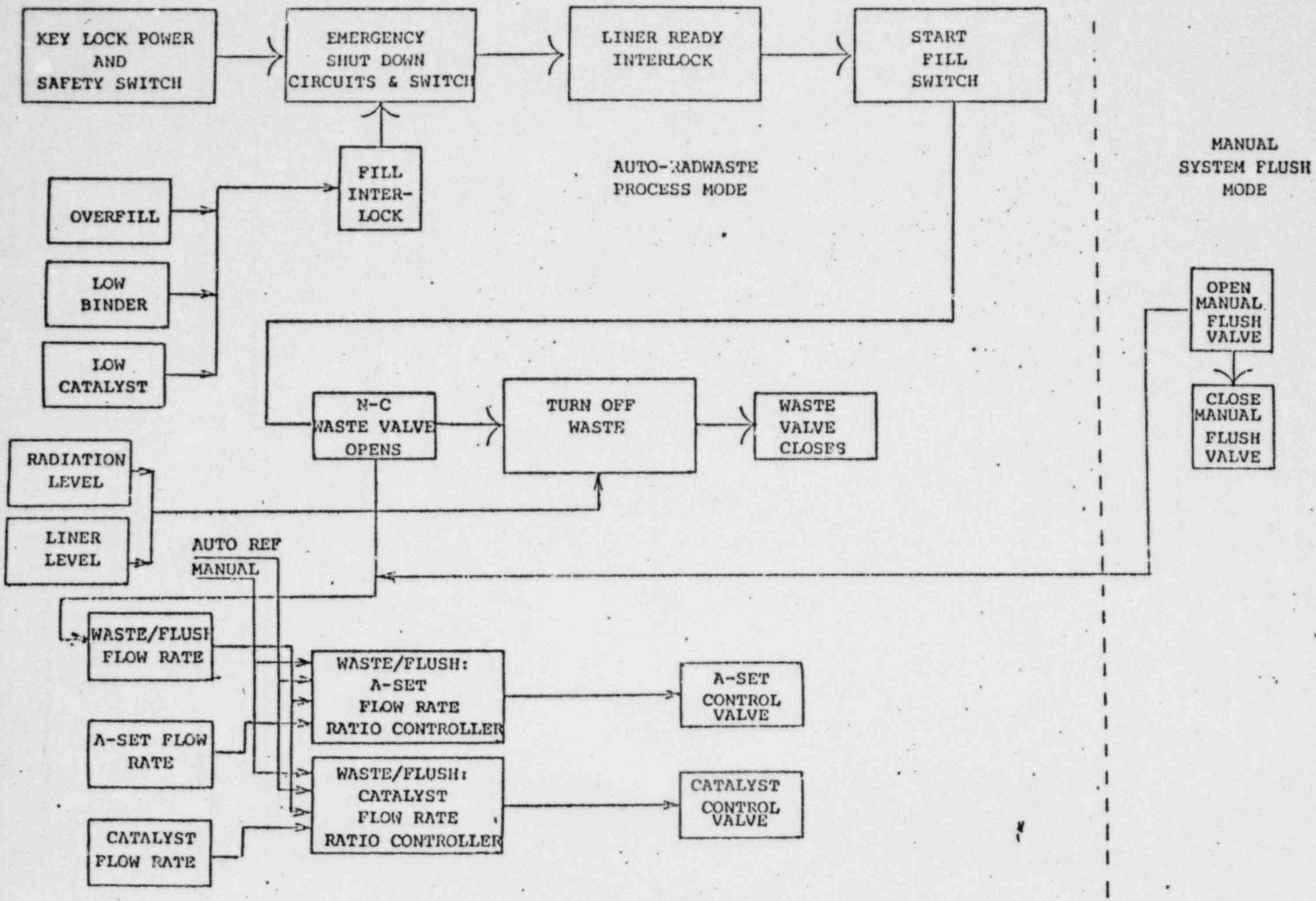


Figure 2.1 System Control Schematic

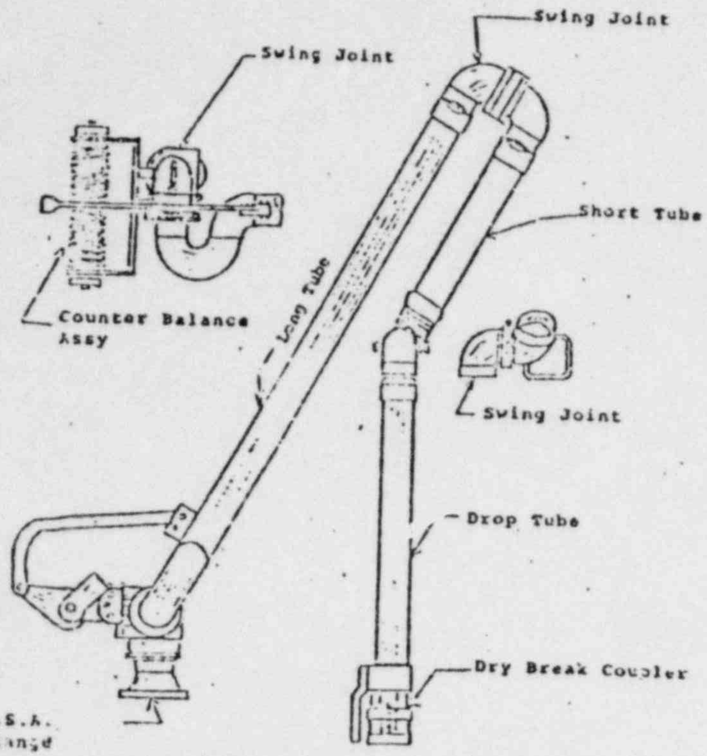


Figure 2.2 Waste Loader

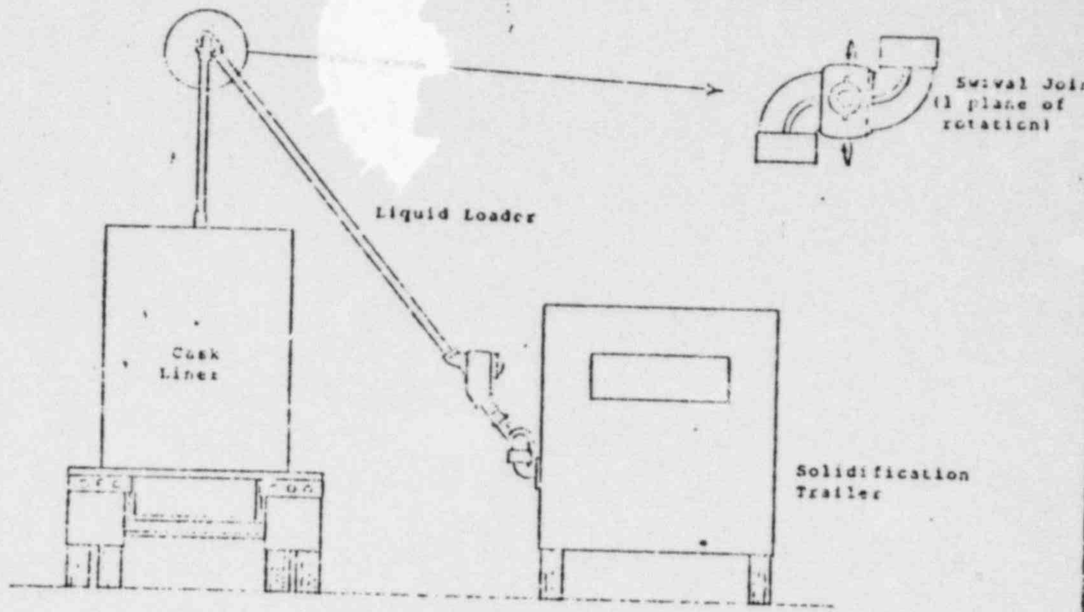
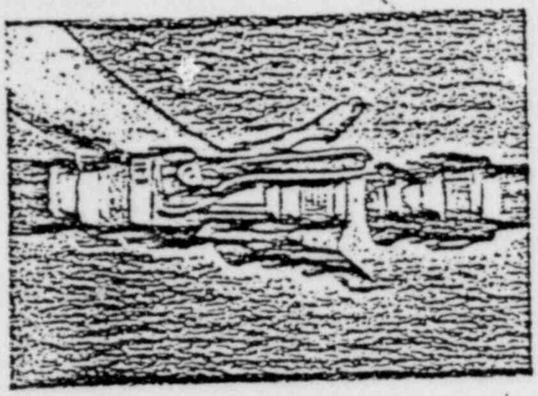


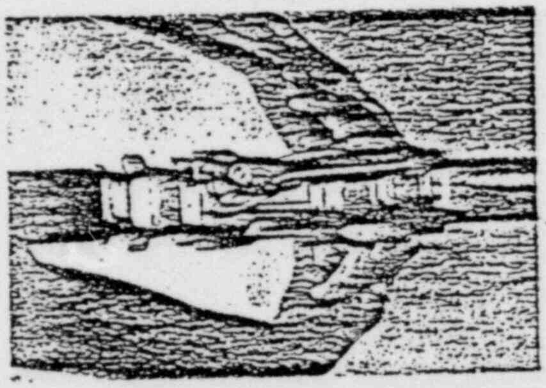
Figure 2.3 Dry Disconnect Coupler

operation:

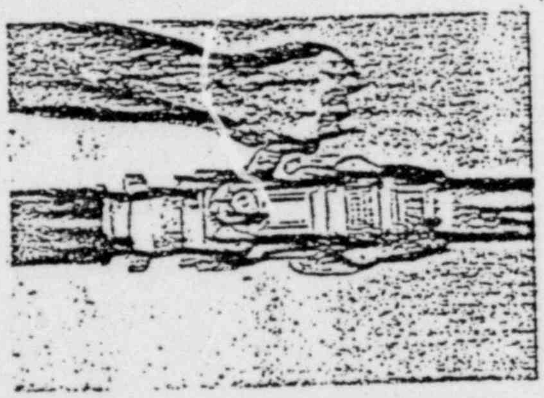
IT ONLY TAKES 4 SECONDS TO START FLOW.



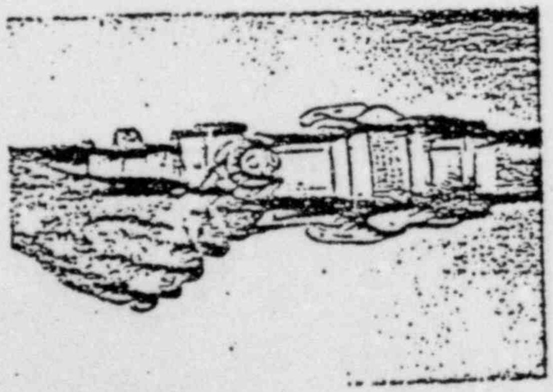
1. COUPLE IN ANY POSITION



2. CAM ARMS LOCK COUPLER AND ADAPTOR TOGETHER



3. LEVER OPENS VALVE



4. FULL FLOW STARTS

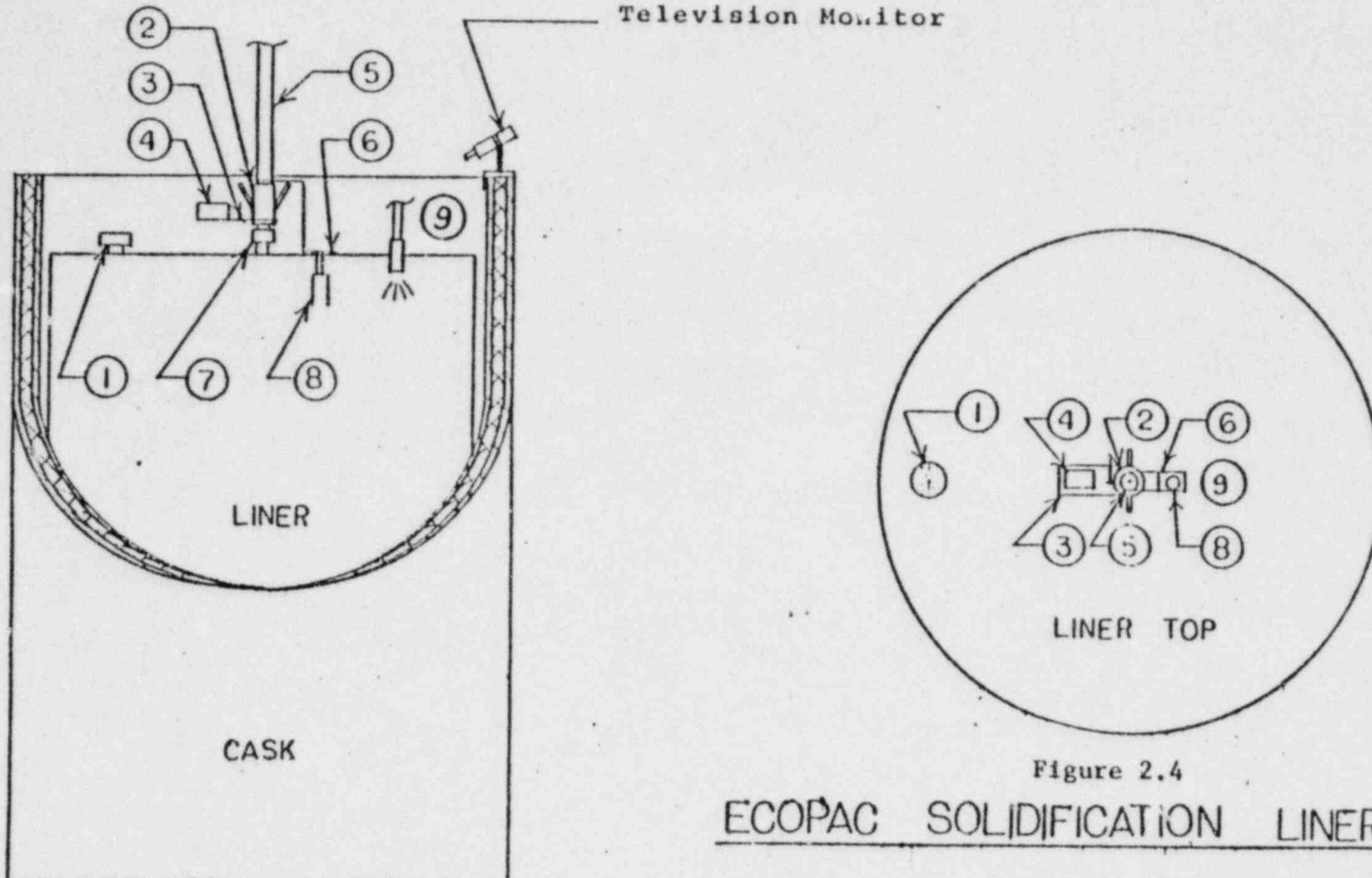


Figure 2.4

ECOPAC SOLIDIFICATION LINER DIAGRAM

1. Exhaust Vent HEPA Filter
2. Dry Break Manifold
3. R.A.M. Support Bracket
4. Remote Area Monitor
5. Waste Loader Drop Tube
6. Liquid Level Probe L Bracket Support
7. Liner Dry Brake Coupling
8. Liquid Level Probe and Limit Switch
9. Acid Catalyst Coupling

KEY

11-7-79

914-946-463

ANEFCO INC.

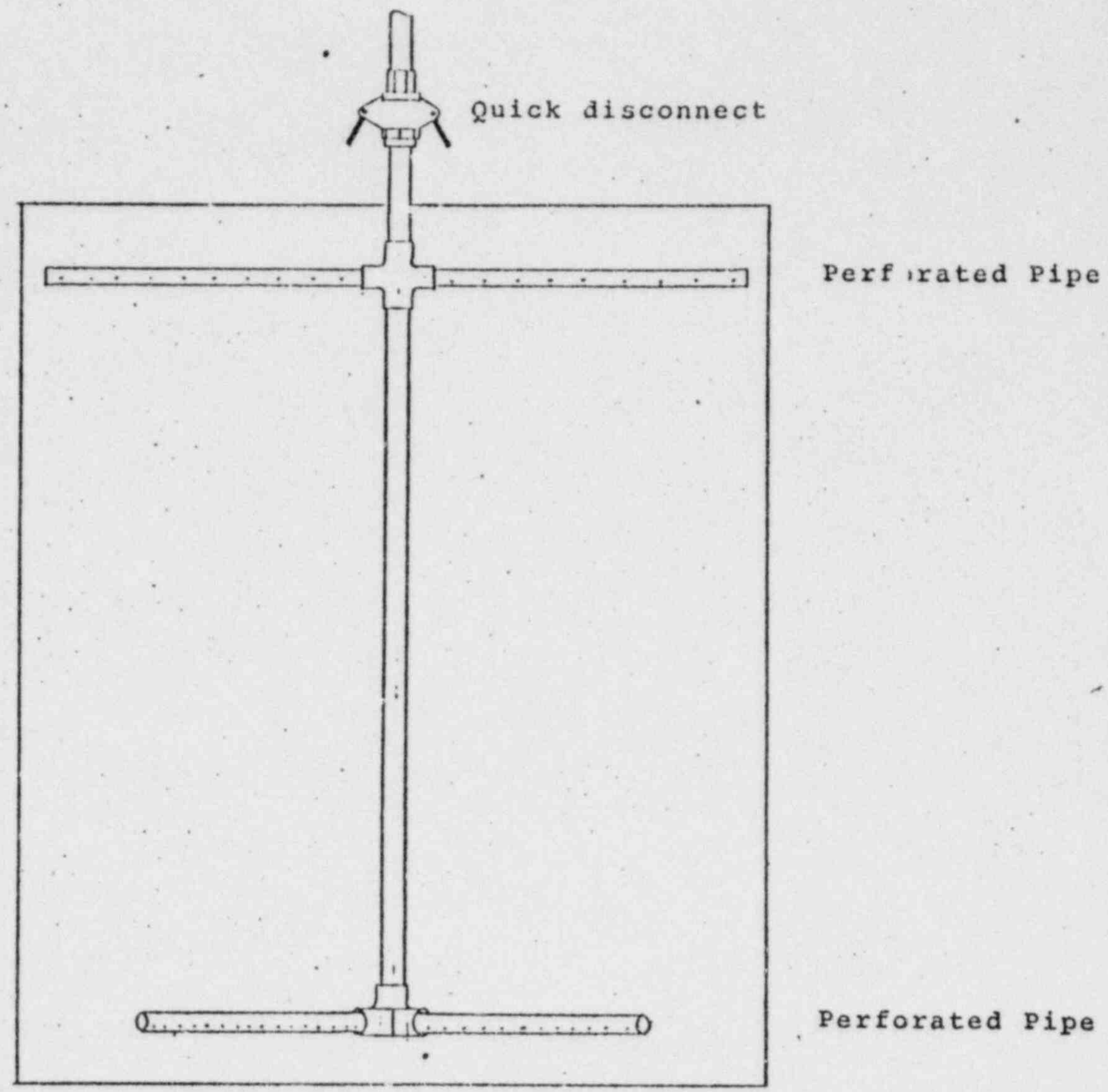


Figure 2.5 Dewatering System

ANEFCO
914-946-4631
ANEFCO INC.
222 Mamaroneck Avenue
White Plains, New York 10605

PSS-039

KEY

10-27-79

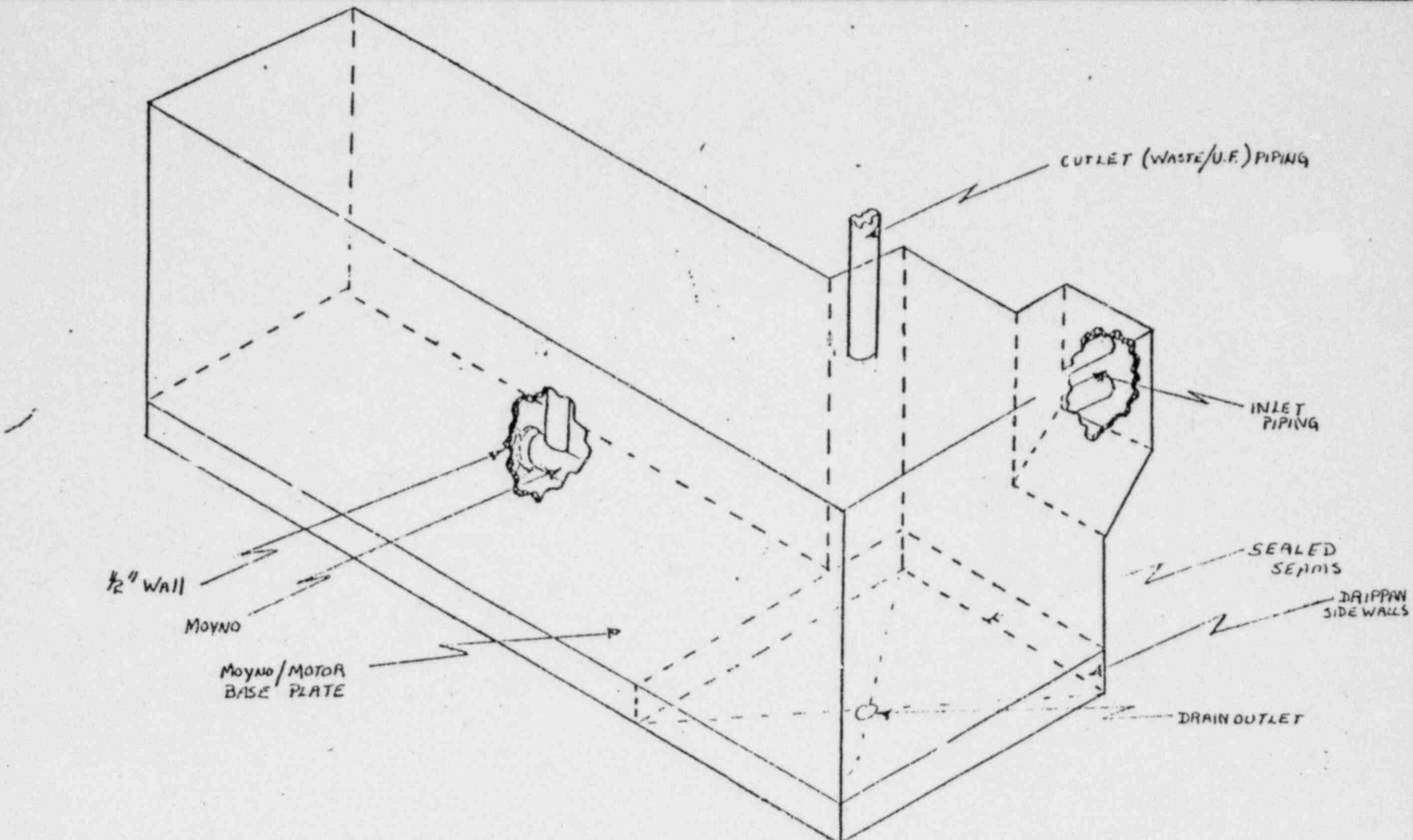
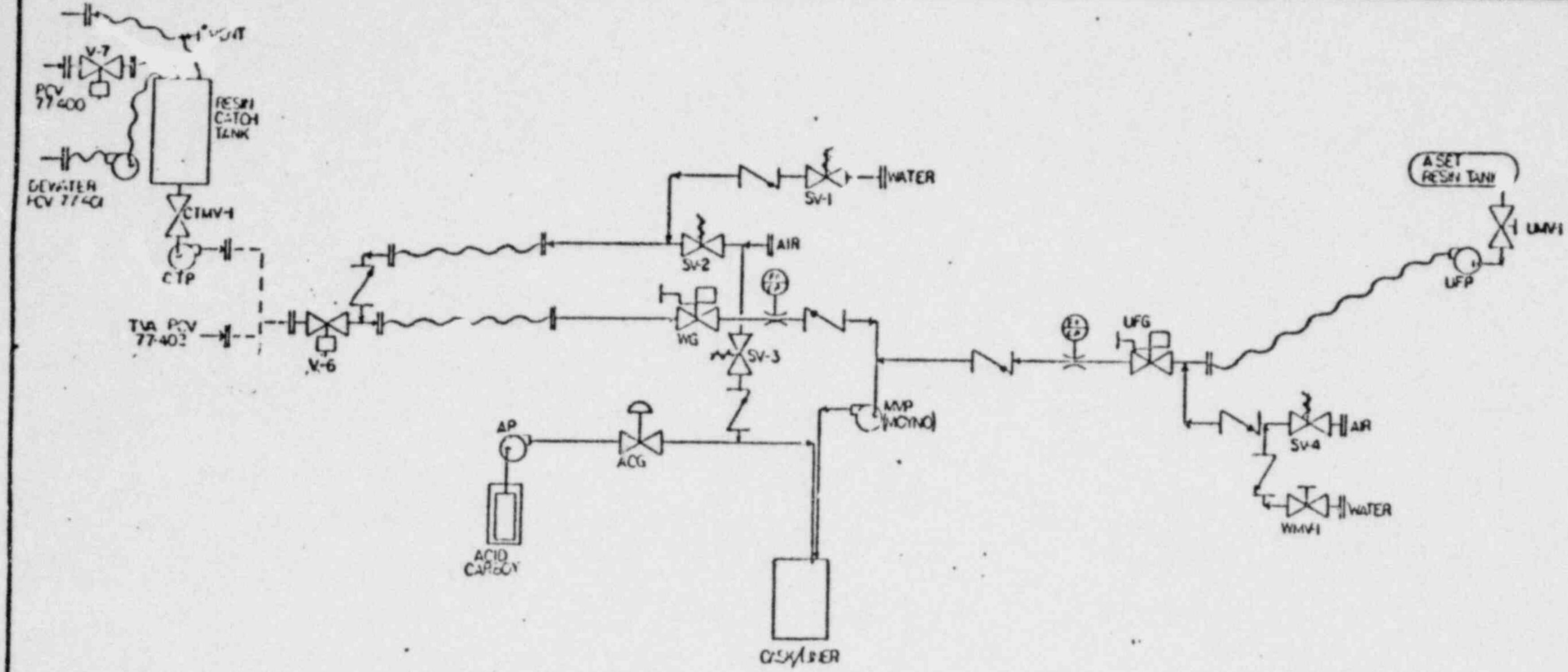
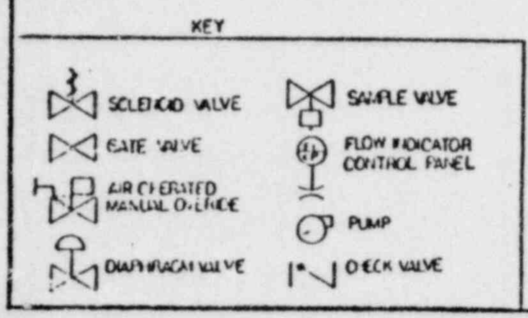


Figure 2.6

ANEFCO INC. 222 MAMARONECK AVE. WHITE PLAINS, N.Y. 10605		
DATE 4-9-80	DRAWN BY JDM JR	APPROVED BY
SCALE NONE DO NOT SCALE	REVISED	
RENDITION - CONTAINMENT AND SHIELDING ENCLOSURE - PIPING + PUMP		
ECOPAC II		DRAWING NUMBER 15169-02





PROPRIETARY

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Figure 2.7

ECOPAC II FLOW DIAGRAM		
DATE 3-20-80	DRAWN BY MM	APPROVED BY [signature]
SCALE N/A	REVISED 5-10-80	
ANEFCO INC. 222 MAMARONECK AVE WHITE PLAINS, N.Y. 10605		
		DRAWING NUMBER B123-07

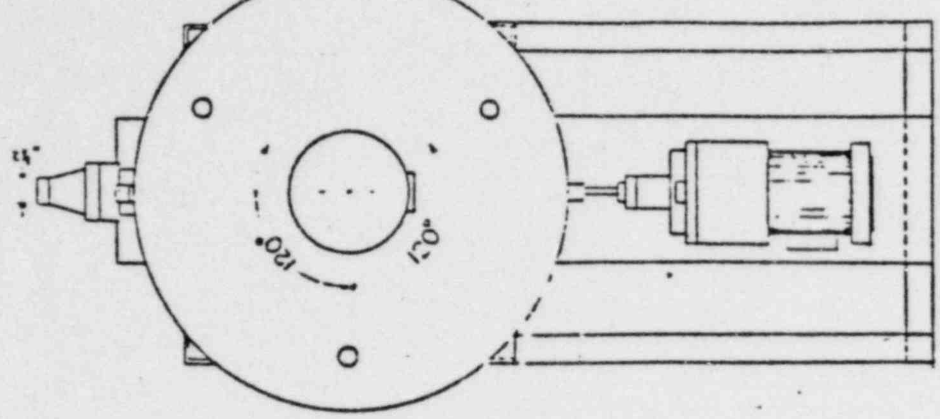

Figure 2.8 - Resin Catch Tank