DIOXIN REGISTRY REPORT

REPORT PREPARED BY REVIEW OF
DOCUMENTS RECEIVED FROM:
SYNTEX (U.S.A.), INCORPORATED
Verona, Missouri
Springfield, Missouri

and
SITE VISITS:
September 30-October 1, 1980
June 24, 1986

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PURPOSE:	To gather personnel, medical and process data for the NIOSH Dioxin Registry.
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STANDARD INDUSTRIAL CLASSIFICATION:	2869 - Industrial Organic Chemicals

ABSTRACT

The National Institute for Occupational Safety and Health (NIOSH) Dioxin Registry is a compilation of demographic and work history information for all U.S. production workers who have synthesized products known to be contaminated with 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) or hexachlorodibenzo-p-dioxins (HxCDD). Currently, there are fourteen production facilities and approximately 7000 workers included in the Registry. The first use of this information is a mortality study for which the comparison group is the U.S. male population. This study will evaluate the causes of death among workers exposed to products contaminated with 2,3,7,8-TCDD and/or HxCDD.

A facility in Verona, Missouri, where two different companies produced products contaminated with 2,3,7,8-TCDD is included in the Dioxin Registry. Hoffman-Taff, Incorporated operated a process to produce the butyl ester of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T butyl ester) from May 1968 to January 1969, and North Eastern Pharmaceutical and Chemical Company (NEPACCO) operated a process to produce 2,2'-methylenebis (3,4,6-trichlorophenol) (hexachlorophene) from April 1970 to January 1972 at the site in Verona, Missouri, currently owned and operated by Syntex Agribusiness, Incorporated. Presented in this report is a compilation of historical information on the operations of these processes and personnel involved in these processes. This information was obtain from documents received from Syntex and from site visits made to the facility in October 1980 and June 1986. Included in this report are descriptions of the facility, workforce, processes, past exposures and personnel record systems.

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH), Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS), Industrywide Studies Branch (IWSB), is conducting an investigation of health effects resulting from occupational exposure to polychlorinated dibenzo-p-dioxins (PCDD) and in particular the 2,3,7,8-tetrachlorodibenzo-p-dioxin isomer (2,3,7,8-TCDD). This study, referred to as the Dioxin Registry, is a compilation of demographic and work history information for all U.S. production workers who have synthesized products known to have been contaminated with 2,3,7,8-TCDD or hexachlorodibenzo-p-dioxins (HxCDD). The Registry, initiated in 1979, was prompted by animal studies showing 2,3,7,8-TCDD to be acutely toxic and a chloracnegen, as well as a carcinogen and teratogen.[1,2,3,4,5,6,7] 2,3,7,8-TCDD is a contaminate found in 2,4,5-trichlorophenol (2,4,5-TCP) and/or its sodium salt, which are raw materials used to produce chemical compounds such as 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and 2,2'-methylenebis (3,4,6-trichlorophenol) (hexachlorophene). Currently, there are fourteen production facilities and approximately 7000 workers included in the Registry. The first use of this information is a mortality study for which the comparison group is the U.S. male population. This study will evaluate the causes of death among workers exposed to products contaminated with 2,3,7,8-TCDD and/or HxCDD.

Presented is a compilation of information and data from documents received from Syntex Agribusiness, Incorporated and from a site visit conducted September 30 and October 1, 1980 and June 24, 1986. The site in Verona, Missouri, currently owned and operated by Syntex, was operated by two companies, Hoffman-Taff, Incorporated and the North Eastern Pharmaceutical and Chemical Company (NEPACCO) during the times of interest to NIOSH for the Dioxin Registry. Hoffman-Taff produced 2,4,5-T butyl ester and NEPACCO produced hexachlorophene. Therefore the workers involved in these processes are included in the Dioxin Registry.

DESCRIPTION AND HISTORY OF THE FACILITY

The Hoffman-Taff plant in Verona, Missouri was opened in 1960. A layout of the plant is shown in Figure 1. Building V-11, which was later used for 2,4,5-T butyl ester production, was built in 1965. It was originally utilized to make arsenic-based paint additives for a short time. In 1967, the building was decontaminated and then half was used for 3-aminopropionic acid (ß-alanine) production from March 1968 to August 31, 1974, while the other half was used from May 1968 until January 1972 for 2,4,5-T butyl ester and hexachlorophene production. The ß-alanine section (southern section) was physically separated from the 2,4,5-T butyl ester section. Figure 2 shows a building layout of the 2,4,5-T butyl ester process (northern section). The numbers that appear in Figure 1 represent the different pieces of equipment used for 2,4,5-T butyl ester production and are defined in Figures 4 and 5. While the ß-alanine and 2,4,5-T butyl ester process

were physically separated Building V-11 was one room with no physical barriers separating the two processes. The 2,4,5-T butyl ester production and formulation operations began on May 6, 1968, and continued until January 29, 1969, during which time there was a strike which shut down operations from July 1, 1968, to September 16, 1968, and production resumed by October 16, 1968. Operations were shut down also between December 10, 1968, and January 6, 1969. From May 1968 to June 1968 and from October 1968 to January 29, 1969, a total of 57 batches of 2,4,5-T butyl ester were produced, formulated and drummed.

On November 18, 1969, NEPACCO leased the space that had been used for 2,4,5-T butyl ester production from Hoffman-Taff. NEPACCO supplemented, modified, and rearranged the 2,4,5-T butyl ester equipment and began production of hexachlorophene. Figure 3 shows the hexachlorophene process building layout. The numbers that appear in Figure 3 represent the different pieces of equipment used for hexachloroophene production and are defined in Figures 6, 7, and 8. NEPACCO operated the hexachlorophene production process from April 1, 1970, to January 9, 1972. During this time period, the B-alanine operation continued to be operated by Hoffman-Taff in the other half of the building. On December 12, 1969, Syntex Agribusiness, Incorporated purchased the Verona site from Hoffman-Taff including the lease to NEPACCO. The name of the Verona facility was changed from Hoffman-Taff to Syntex Agribusiness, Incorporated on November 30, 1973. For the period of December 1969 to November 1973, the facility was referred to as Hoffman-Taff, Incorporated.

Syntex provided NEPACCO with electricity, process water and steam. For the most part, NEPACCO used Hoffman-Taff workers to operate the hexachlorophene process. NEPACCO used their own supervisors, some of which were formerly with Hoffman-Taff. Based on utility bills provided by Syntex Agribusiness it is estimated that 328 batches of 2,4,5-TCP and 611 batches of hexachlorophene were produced by NEPACCO during the years it operated. There were times when no hexachlorophene was produced due to poor quality batches, technical problems and a fire (which caused the process operations to be shut down for approximately a month). Production of hexachlorophene ceased shortly after the Food and Drug Administration restricted the use of hexachlorophene.

Although NEPACCO considered eventually restarting the hexachlorophene process for export, this never occurred. The lease was terminated in June 1972 and the process equipment including a storage tank which was later found to contain approximately 4300 gallons of still bottoms from NEPACCO's 2,4,5-TCP and toluene distillation processes (containing 343 $\pm$ 17 ppm 2,3,7,8-TCDD) reverted to Hoffman-Taff, Incorporated.

Other products produced at the Verona facility included vitamins, "Rope", a mold inhibitor, pre-mix (feed additive) for poultry and swine, calcium and sodium propionate, chloride salts, ethylene diamine dihydroiodide (EDDI), Panoplex, and TAC (a quaternary ammonium salt).

DESCRIPTION OF THE WORKFORCE

Hoffman-Taff 2,4,5-T Butyl Ester Operations

Personnel in the 2,4,5-T butyl ester operation included four operators plus one supervisor per shift. The operators controlled the sodium 2,4,5-trichlorophenate (Na 2,4,5-TCP) reaction, recycled a 2,4,5-trichloroanisole (TCA)/n-heptane extraction, neutralized the Na 2,4,5-TCP, and performed a butyl esterification process. Hoffman-Taff did not distill its Na 2,4,5-TCP or the 2,4,5-T butyl ester. The finished 2,4,5-T butyl ester was then formulated with the butyl ester of 2,4-dichlorophenoxyacetic acid (2,4-D) to form the herbicide Agent Orange. Approximately 60-80% of the supervisor's time was spent in the production area. In addition, there was a central maintenance crew of nine men who were dispersed throughout the entire plant, as needed. Table 1 lists the job titles, duties, and location of duties for personnel associated with the 2,4,5-T butyl ester production process.

NEPACCO Hexachlorophene Operations

All non-supervisory hourly labor and maintenance were leased from Hoffman-Taff, Incorporated to operate the 2,4,5-TCP and hexachlorophene production operations. Six operators were assigned to these processes per shift. The responsibilities and duties of these operators are not known. Hoffman-Taff, Incorporated personnel records do not indicate the chemical operators assigned to the hexachlorophene operation. However, salary records currently retained by Syntex Agribusiness, Incorporated identify all Hoffman-Taff, Incorporated personnel who worked for NEPACCO. Maintenance workers were supplied by Hoffman-Taff, Incorporated from their central maintenance crew for the process equipment and building. NEPACCO reimbursed Hoffman-Taff, Incorporated for the wages of these workers, plus a fee. Table 2 lists the job titles, duties, and location of duties for personnel associated with hexachlorophene production process.

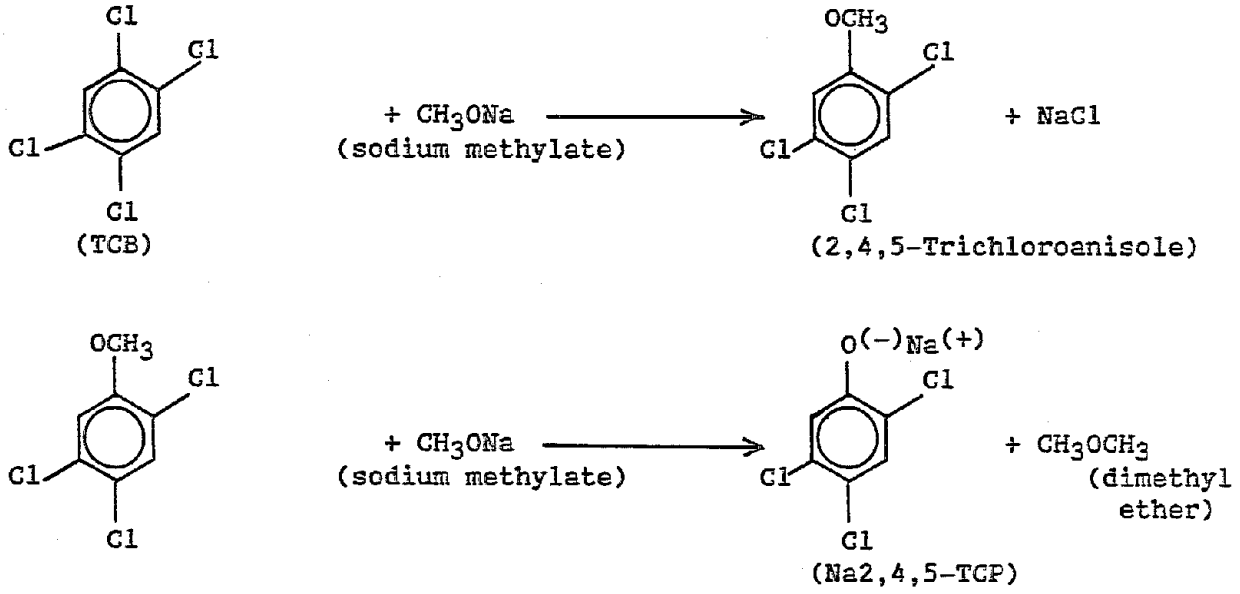
DESCRIPTION OF PROCESS

Hoffman-Taff 2,4,5-T Butyl Ester Process Description

The 2,4,5-T butyl ester process began with the synthesis of sodium 2,4,5-trichlorophenol (Na 2,4,5-TCP). Figure 4 shows a block flow diagram for Na 2,4,5-TCP synthesis. The first step was the dechlorination of 1,2,4,5-tetrachlorobenzene (TCB) to form Na 2,4,5-TCP. The raw materials used to produce Na 2,4,5-TCP were caustic (NaOH), methanol (MeOH), TCB and hydrochloric acid (HCl). NaOH and MeOH were combined in a pre-reactor, and the solution in the pre-reactor was then pumped to an agitated jacketed autoclave reactor. The solution was heated and sodium methylate was formed:

$$NaOH + CH_3OH \longleftrightarrow NaOCH_3 + H_2O$$

Molten TCB was gradually added to the reactor over a period of two hours. The major reaction mechanism was as follows:



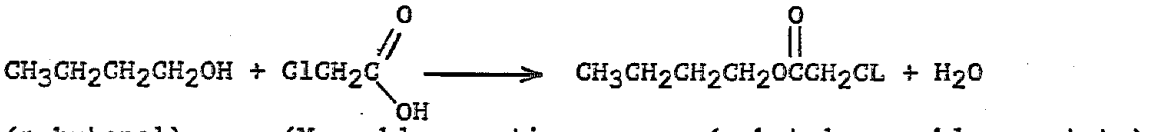
The reaction mixture was held at 165 ± 1°C for a five to six hour period. The pressure rose to approximately 350 pounds per square inch gauge (psig) during this time. It was during this step that 2,3,7,8-TCDD may have been formed as an unwanted by product. Then the reactor contents were cooled to 50°C and the pressure dropped to 20 to 50 psig.

Following the cool down, the mixture in the autoclave was pumped from the autoclave to a neutralization vessel followed by a methanol wash of the reactor to remove any remaining material. Recycled Na 2,4,5-TCP was then added to the neutralization vessel. HCl was added to quench the reaction and neutralize any remaining NaOH.

HCl was added until the mixture pH was between 10.4 to 10.6. Hyflo was then added to the mixture to facilitate separation of the fine sodium chloride (NaCl) particles formed. The NaCl/Hyflo was separated from Na 2,4,5-TCP and washed with MeOH in the centrifuge. The organics (e.g., 2,4,5-TCA) in MeOH were collected for extraction with n-heptane.

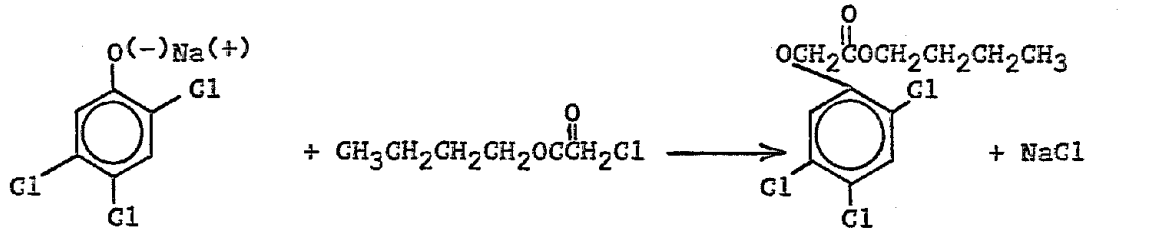
From the centrifuge the Na 2,4,5-TCP batch was transferred to an extraction vessel where samples were collected to determine the percent of 2,4,5-TCA. If more than 2% 2,4,5-TCA was found, a n-heptane extraction step was carried out. N-heptane was pumped into the extraction vessel and mixed with the Na 2,4,5-TCP. The contents in the extraction vessel were allowed to separate into layers, and the n-heptane layer containing 2,4,5-TCA was extracted and the 2,4,5-TCA was recycled. The other layer containing the Na 2,4,5-TCP was then pumped to a distillation vessel where the remaining n-heptane/MeOH azeotrope was removed. Following the removal of the n-heptane/MeOH azeotrope, butanol was added and water was removed. The finished batch of Na 2,4,5-TCP in butanol, containing less than 0.1% moisture was pumped from the distillation vessel to a heated holding tank ready for use as a raw material in the production of 2,4,5-T butyl ester.

Figure 5 shows a block flow diagram for 2,4,5-T butyl ester synthesis. In the production of 2,4,5-T butyl ester the first step involved the formation of butyl monochloroacetate (BCA). Butanol was reacted with monochloroacetic acid in a glass-lined reactor set for reflux with water removed from the azeotrope. The reaction to form butyl monochloroacetate was as follows:



(n-butanol) (Monochloroacetic acid) (n-butyl monochloroacetate)

In a condensation reactor, the Na 2,4,5-TCP in butanol was combined with a calculated amount of BCA and the reactor was set for reflux. The batch in the reactor was heated to 122°C and held at reflux for four hours. The following reaction to form 2,4,5-T butyl ester took place:



(2,4,5-T butyl ester)

Following the reaction to form 2,4,5-T butyl ester, the excess butanol was then distilled off at atmospheric pressure and a batch temperature of 130°C and then under vacuum to remove the last traces of butanol. The batch in the reactor was then cooled to approximately 50°C and n-heptane was added. The batch was then pumped through a filter press, which removed the NaCl formed, to a purification vessel. Several n-heptane washes were performed through the filter press to remove any residual 2,4,5-T butyl ester, and the press was sucked dry by vacuum. In the purification vessel, a previously prepared solution of NaOH and water was added. The aqueous and n-heptane phases were allowed to separate with the unreacted Na 2,4,5-TCP in the aqueous phase being recycled back to the neutralization vessel.

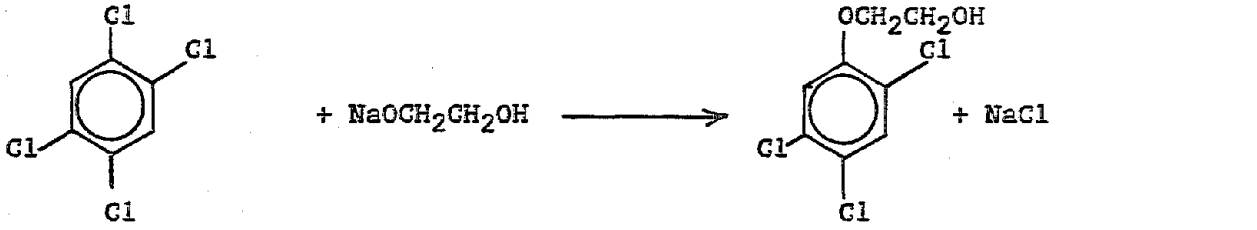
Following the extraction of unreacted Na 2,4,5-TCP, water washes were done to bring the batch pH to 8. The water extracts from this step were collected and used to prepare a NaOH solution for the next batch. The batch in the purification vessel was then pumped to a distillation vessel were n-heptane was removed from the 2,4,5-T butyl ester at a maximum batch temperature of 135°C. The n-heptane was recovered and reused. A vacuum was applied to the distillation vessel which removed the last traces of n-heptane. The 2,4,5-T butyl ester was pumped from the purification vessel to an assay tank to await release by Quality Control. Once released, the 2,4,5-T butyl ester was stored pending formulation with an equal amount of butyl ester of 2,4-dichloroacetic acid (purchased from Rhodia, Incorporated, Portland, Oregon) to form the herbicide Agent Orange.

NEPACCO 2,4,5-TCP and Hexachlorophene Process Descriptions

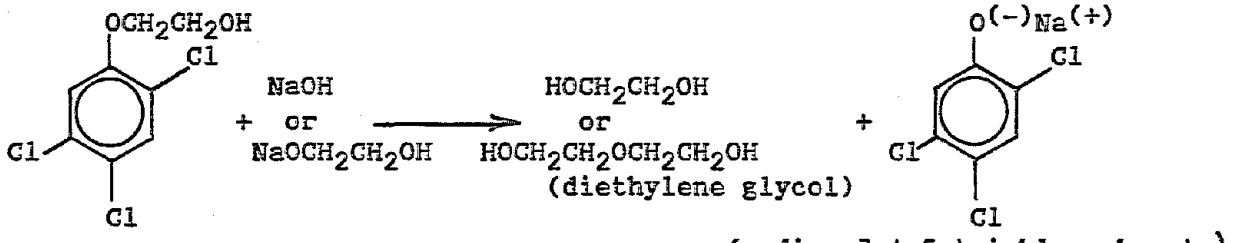
NEPACCO produced hexachlorophene by condensation of purified 2,4,5-TCP in the presence of an acid condensing agent and paraformaldehyde. The first step was the synthesis and purification of 2,4,5-TCP. Figure 6 shows a process flow diagram for 2,4,5-TCP synthesis and purification. The synthesis of 2,4,5-trichlorophenol began with dechlorination of TCB. A solution of NaOH in ethylene glycol (EG) was prepared in a drop tank and heated to 140-150°C. This solution was fed to an autoclave agitated jacketed reactor containing molten TCB and mineral spirits. Hot oil was circulated in the reactor jacket at 140°C, and this temperature was then increased to 190°C. The TCB was dechlorinated through a series of reactions as shown,

$$NaOH + HOCH_2CH_2OH \longrightarrow NaOCH_2CH_2OH + H_2O$$

(EG) (sodium ethylene glycolate)

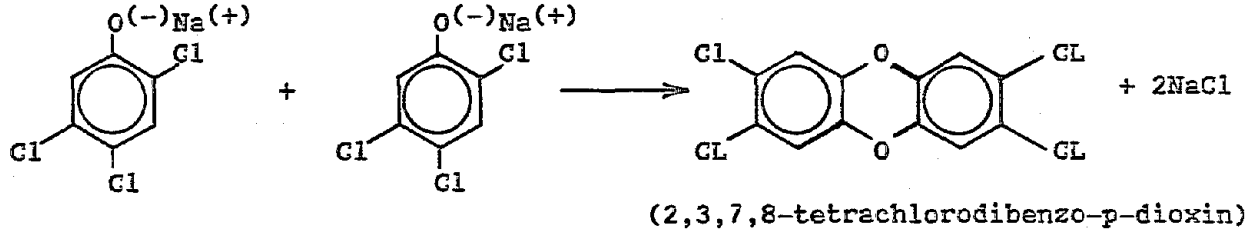


(2(2,4,5-Trichlorophenoxy)ethanol)



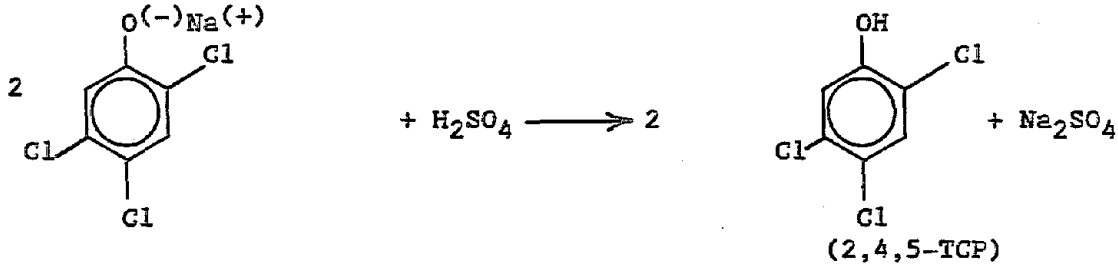
(sodium 7,4,5-trichlorophenate)

at a batch temperature of 170-175°C and reaction time of seven hours. During the seven hour reaction time the water produced was removed azeotropically. It is in this step and the following distillation where 2,3,7,8-TCDD may have been formed by the combination of Na 2,4,5-TCP at high temperature as follows:



(2,3,7,8-tetrachlorodibenzo-p-dioxin)

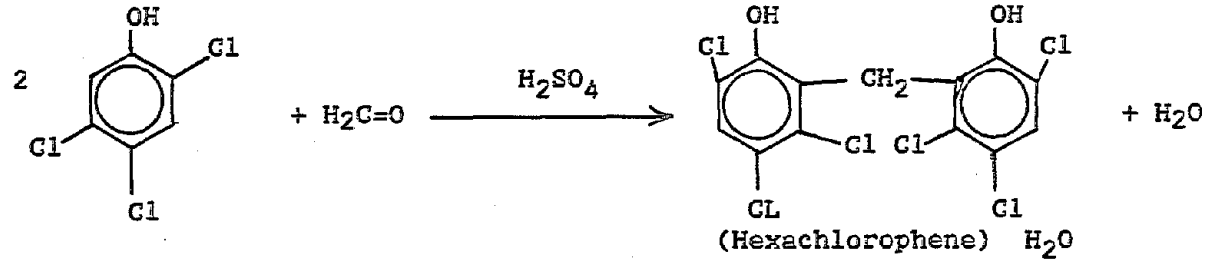
The batch temperature was allowed to cool to 140°C and a small amount of sulfuric acid (H_2SO_4) was added to remove excess NaOH and make the solution flow better. The resulting pH was approximately 10.5-11.9. A seven hour vacuum distillation was then performed at 190°C under a vacuum of 20 mmHg, the EG/water was distilled off, the EG and water separated, and the EG recovered for reuse. The batch was cooled to 65°C and pumped to another reactor (B-2). The H_2SO_4 reacted with the Na 2,4,5-TCP to form 2,4,5-TCP as shown.



(2,4,5-TCP)

Water, from the vacuum distillation which followed, and wash water were added to the vessel and throughly mixed. Phases were allowed to separate and the 2,4,5-TCP organic phase (including any 2,3,7,8-TCDD) was pumped to a holding tank (D-1). These washes were repeated several times. The organic phase was finally pumped from the holding tank to a vacuum distillation glass-lined reactor (D-3) where the 2,4,5-TCP was purified by distilling it off from the rest of the organic phase. The water removed was recycled back to the neutralization reactor (B-2) and 2,4,5-TCP pumped to a holding tank. The still wastes from the bottom of the vacuum distillation reactor (containing any 2,3,7,8-TCDD) were pumped to a waste storage tank. The next step in the process was the condensation of 2,4,5-TCP to form hexachlorophene.

Figure 7 shows a process flow diagram for hexachlorophene synthesis, purification, finishing, and packaging. 2,4,5-TCP, from the 2,4,5-TCP holding tank, was pumped to a condensation reactor (F-1). Paraformaldehyde and H_2SO_4 were added to the 2,4,5-TCP. The 2,4,5-TCP was condensed with formaldehyde in the presence of H_2SO_4 resulting in an exothermic reaction to form hexachlorophene, as shown.



(Hexachlorophene) H_2O

The reaction temperature started out at 65°C and gradually rose to 100°C over a two-hour period. A water quench followed, which raised the temperature to a maximum of 110°C. At this temperature any excess formaldehyde present was steamed off. Toluene was then added to the reactor. The hexachlorophene was extracted with the toluene at 100 to 105°C from the reactor solution. A second hexachlorophene extraction using toluene was performed on the solution remaining in the reactor, after which the spent acid solution was extracted again and then sent to storage for disposal. The hexachlorophene solution in toluene was pumped from the condensation reactor to a glass-lined reactor (F-2) set for azeotropic removal of water and decolorization with clay, which was added directly to the batch. The reactor contents were cycled through a sparkler filter, which removed the clay, to a cooling vessel. The clay was removed from the filter and drummed for disposal. In the cooling vessel the hexachlorophene was cooled and crystallized. The hexachlorophene slurry was pumped into a cloth filter centrifuge where the toluene containing any unreacted 2,4,5-TCP was removed and recovered. The toluene damp hexachlorophene cake was transferred to a rotary vacuum dryer where it was dried. The dried hexachlorophene was transferred to a hammer mill where it was ground into fine crystals followed by packing where the finished hexachlorophene was drummed.

The toluene removed and recovered from the centrifuge was pumped to a holding tank where it was treated with ammonia to precipitate the ammonia salt of hexachlorophene for recovery and recycle. The recovery of hexachlorophene from the toluene was referred to as a "second crop." This second crop of hexachlorophene was then filtered and washed in a filter press and held for recycle in reactors. The toluene was recovered from the filter press and pumped to a neutralization vessel (G-4) where NaOH solution was added to adjust the pH and form water-soluble sodium salts from the organic compounds and phenols present. The mixture was decanted and split, and the NaOH wash water was discarded. From the neutralization vessel the toluene phase was pumped to a monel distillation unit (G-6) where the toluene was distilled off and recovered and the still bottoms were sent to the waste storage tank. The recovery of toluene and the "second crop" of hexachlorophene are illustrated in Figure 8.

DESCRIPTION OF PAST EXPOSURES

No industrial hygiene or environmental monitoring was conducted while either the Hoffman-Taff's 2,4,5-T butyl ester or NEPACCO's hexachlorophene processes were operated. The workers involved in the Hoffman-Taff 2,4,5-T butyl ester operation were less likely to be potentially exposed to dioxins than the workers involved in NEPACCO's hexachlorophene operation. Hoffman-Taff was making technical grade Agent Orange, where purity of the product was not of primary importance, consequently any dioxins formed during the production of 2,4,5-TCP would have gone forward with the product in an unconcentrated form, and very little waste was created. As for the NEPACCO's hexachlorophene, high purity 2,4,5-TCP was required in order to

produce practical yields of hexachlorophene. Therefore this required purification of 2,4,5-TCP which meant that the impurities formed such as 2,3,7,8-TCDD were isolated and concentrated by distillation making the levels for potential dioxin exposure much greater.

Hoffman-Taff Agent Orange was analyzed for dioxin content as part of the Gulf Port Agent Orange stocks analyses.[8] The result of this analysis showed that Hoffman-Taff Agent Orange contained less than 1.0 part per million (ppm) 2,3,7,8-TCDD. NEPACCO's purified 2,4,5-TCP and hexachlorophene have been analyzed by the Food and Drug Administration.[9] The results of these analyses showed that the purified 2,4,5-TCP contained 67 parts per billion (ppb) 2,3,7,8-TCDD and the hexachlorophene contained less than 20 ppb 2,3,7,8-TCDD. The following statement was written by Dr. Firestone based on the analysis results, "The presence of chlorodioxins in the firm's 2,4,5-trichlorophenol as well as in extracts isolated from the product was confirmed by chicken embryo assay, whereby edema and terata were observed. In addition, extracts from the hexachlorophene also produced edema and terata symptoms suggestive of dioxin contamination."

DESCRIPTION OF RECORD SYSTEMS

Four sources were used to identify and locate demographic and work history information for workers employed in the Hoffman-Taff and NEPACCO processes of interest: 1) payroll sheets which list workers assigned to Area VI or Area VIII during the periods of interest, 2) plant memos which described the startup period for 2,4,5-T at Hoffman-Taff and named many of the workers assigned to the process, 3) a bi-weekly assignment sheet for Hoffman-Taff workers employed in the NEPACCO hexachlorophene process and 4) personnel files for the workers identified in the first three sources.
All records are located at the Syntex plant in Springfield, Missouri. Some records were copied during the 1980 site visit and additional records were microfilmed during the June 1986 visit by NIOSH personnel.

These sources also permitted the identification of some workers employed in the beta-alanine process, which was located in the same process building, V-11.

Worker's compensation records were obtained for the period 1968-1972 and all medical records were obtained for the workers employed in the Hoffman-Taff and NEPACCO processes. Copies of Health Surveillance records of physical examinations and medical histories were sent to NIOSH by the company for all workers still employed during the years 1979-1985.

CONCLUSIONS

Production workers and supervisors can be identified who made 2,4,5-T for Hoffman-Taff and/or hexachlorophene for NEPACCO. Maintenance workers from the Hoffman-Taff and NEPACCO periods can also be identified. These individuals are appropriate for inclusion in the NIOSH Dioxin Registry.

Workers who have not been identified may have had potential exposure to dioxin-contaminated wastes after NEPACCO ceased production.

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Verona Plant Layout
Syntex, Inc.
Verona, Missouri

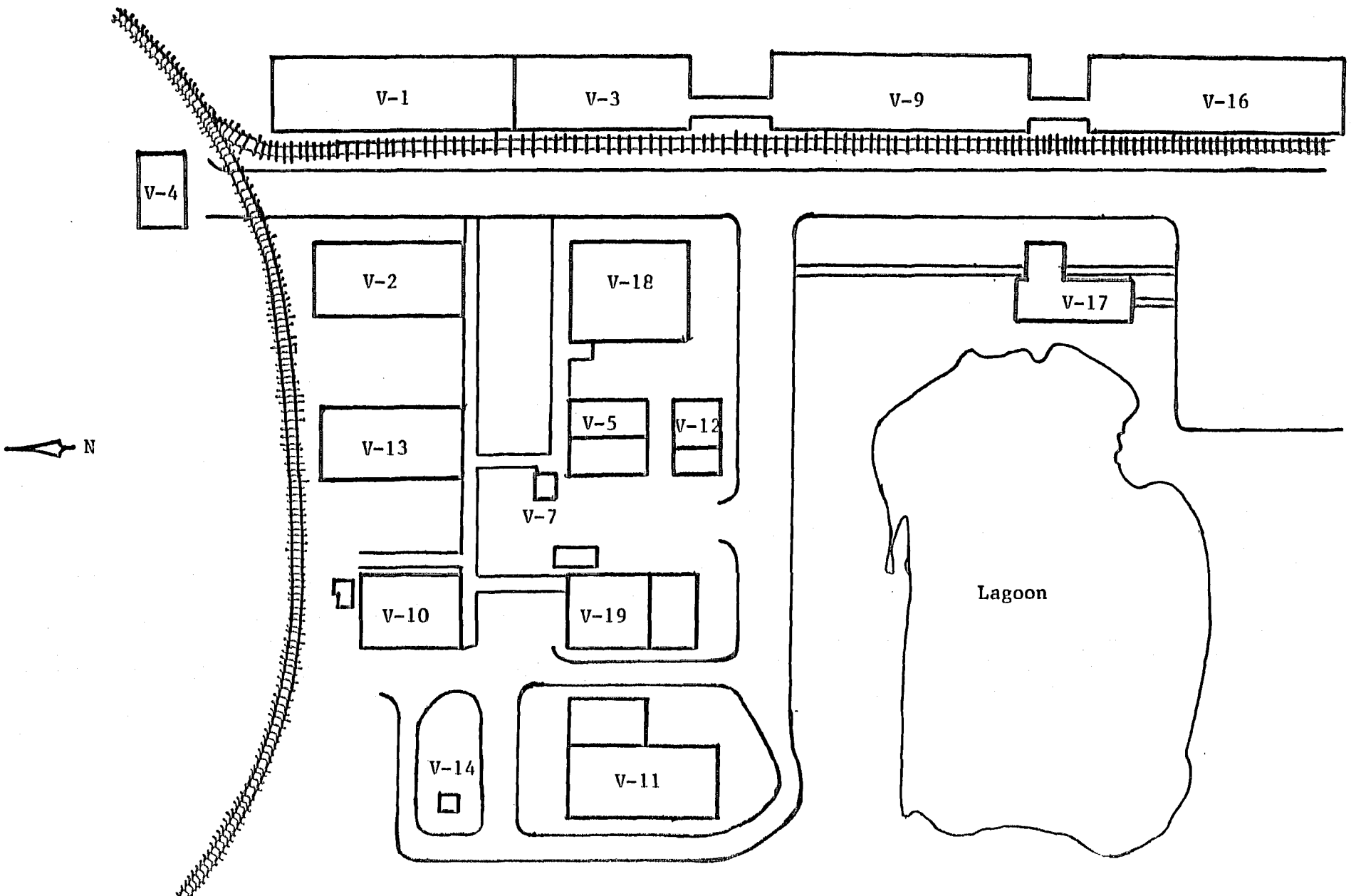
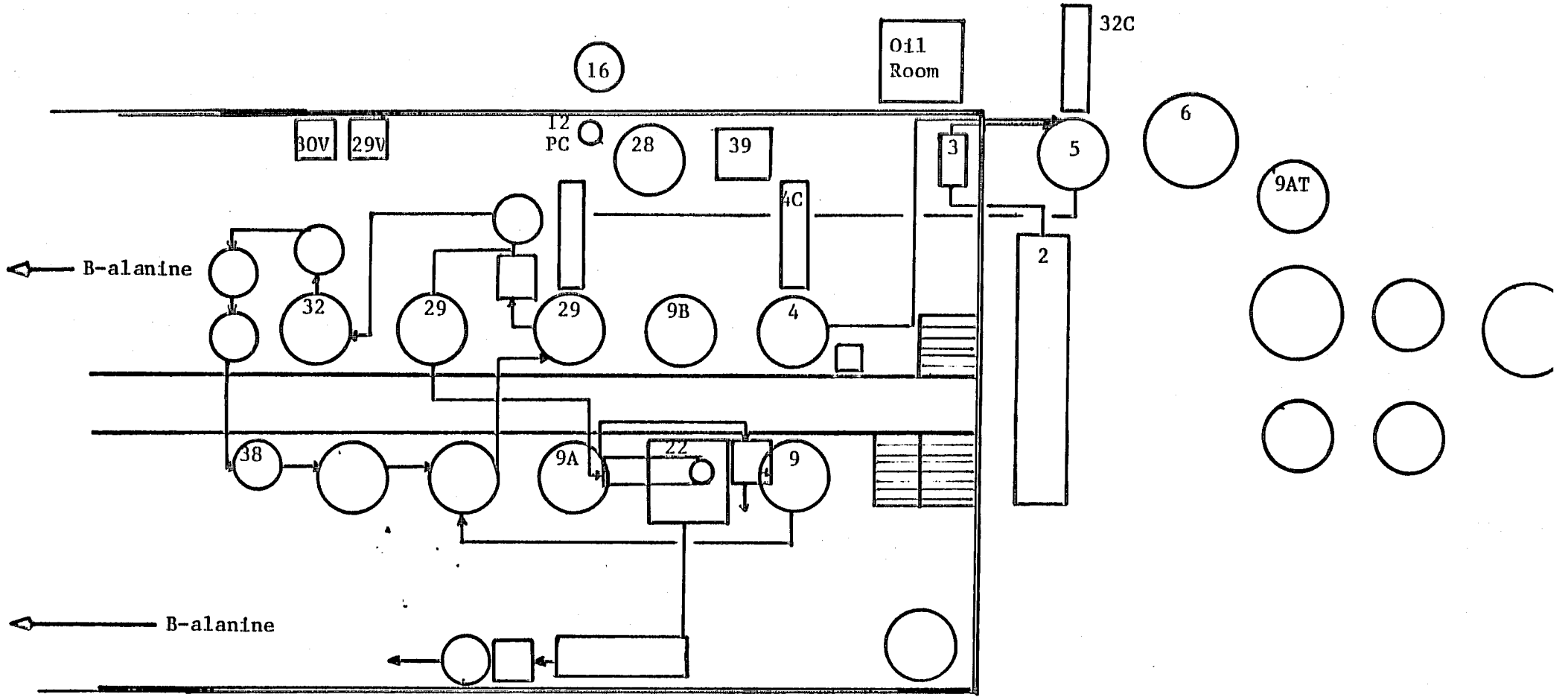


Figure 1 Cont.
Verona Plant Layout
Syntex, Inc.
Verona, Missouri

Building Number	Building Produce or Use
V 1	dry choline chloride feed grade
V 2	calcium and sodium proprioate
V 3	dry choline chloride feed grade
V 5	maintenance shop
V 9	warehouse
V11	arsenic paint additives; 2,4,5-T butylester; beta alanine, and hexachlorophene
V14	decontamination shower
V16	warehouse
V17	office building
V18	warehouse
V19	calcium and sodium proprionate

Hoffman-Taff 2,4,5-T Butyl Ester Process
Building Layout
Verona, Missouri



NEPACCO Hexachlorophene Process Building Layout
Verona, Missouri

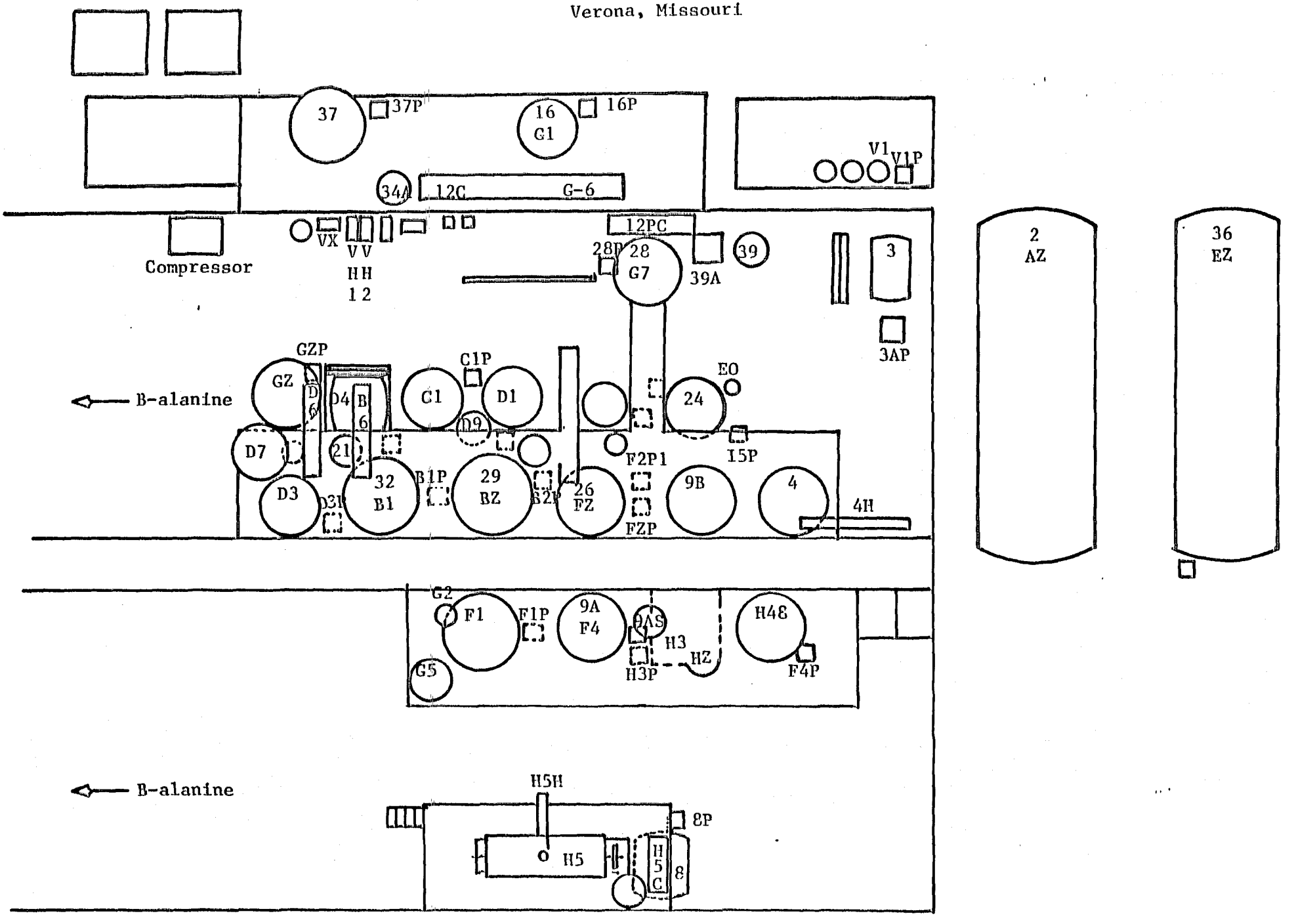
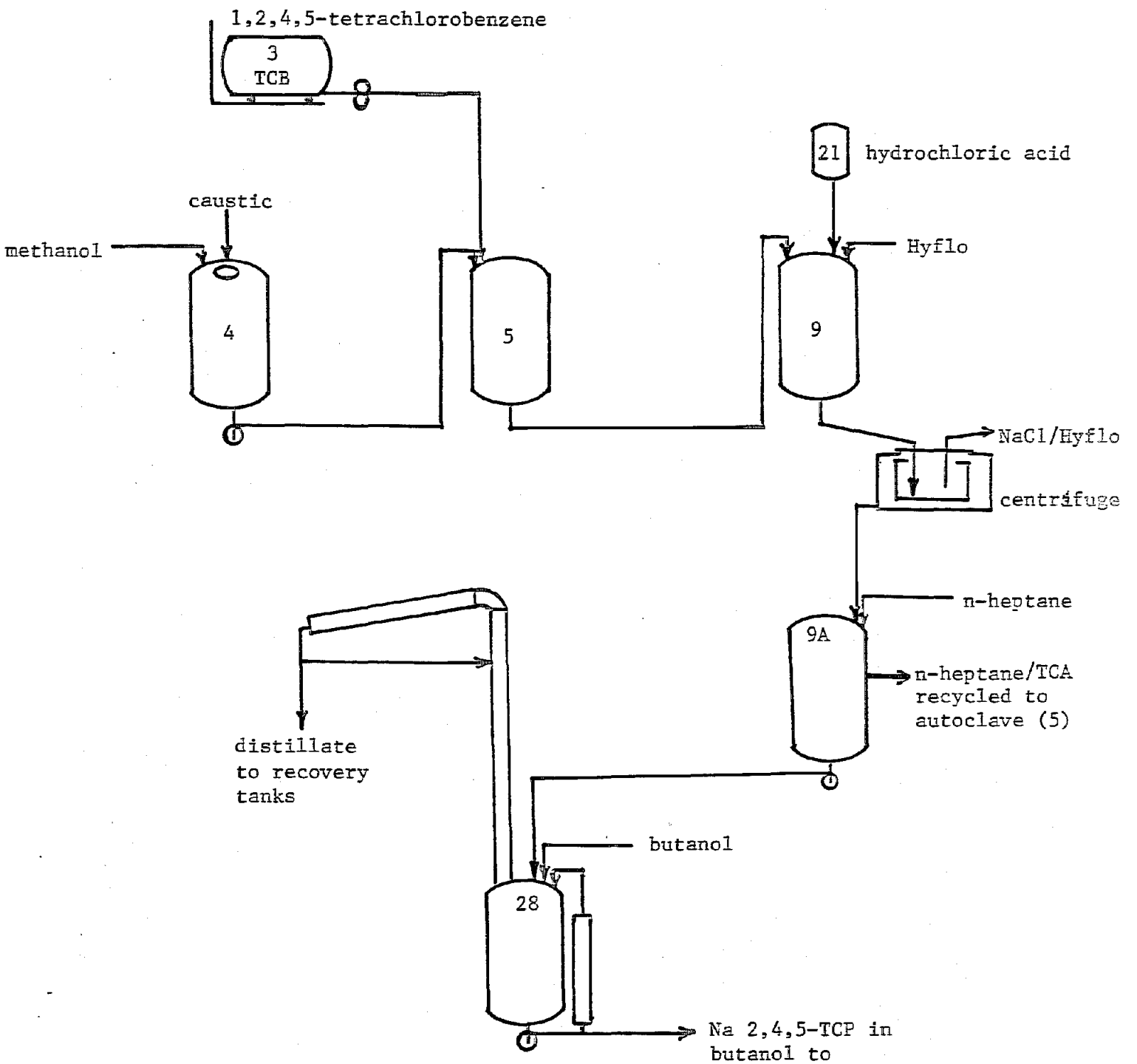
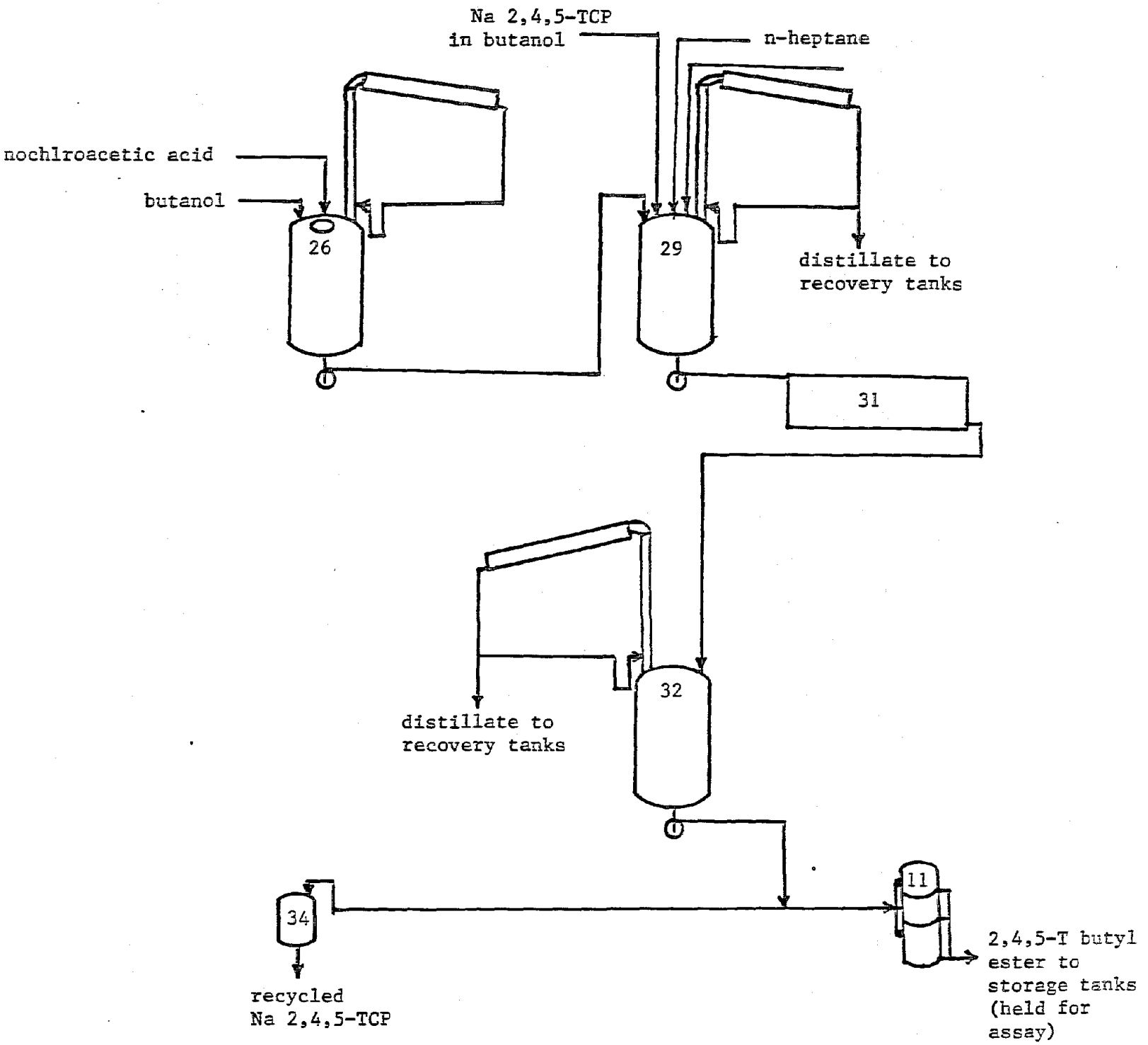


Figure 4
Na 2,4,5-TCP Flow Diagram
Hoffman-Taff
Verona, Missouri



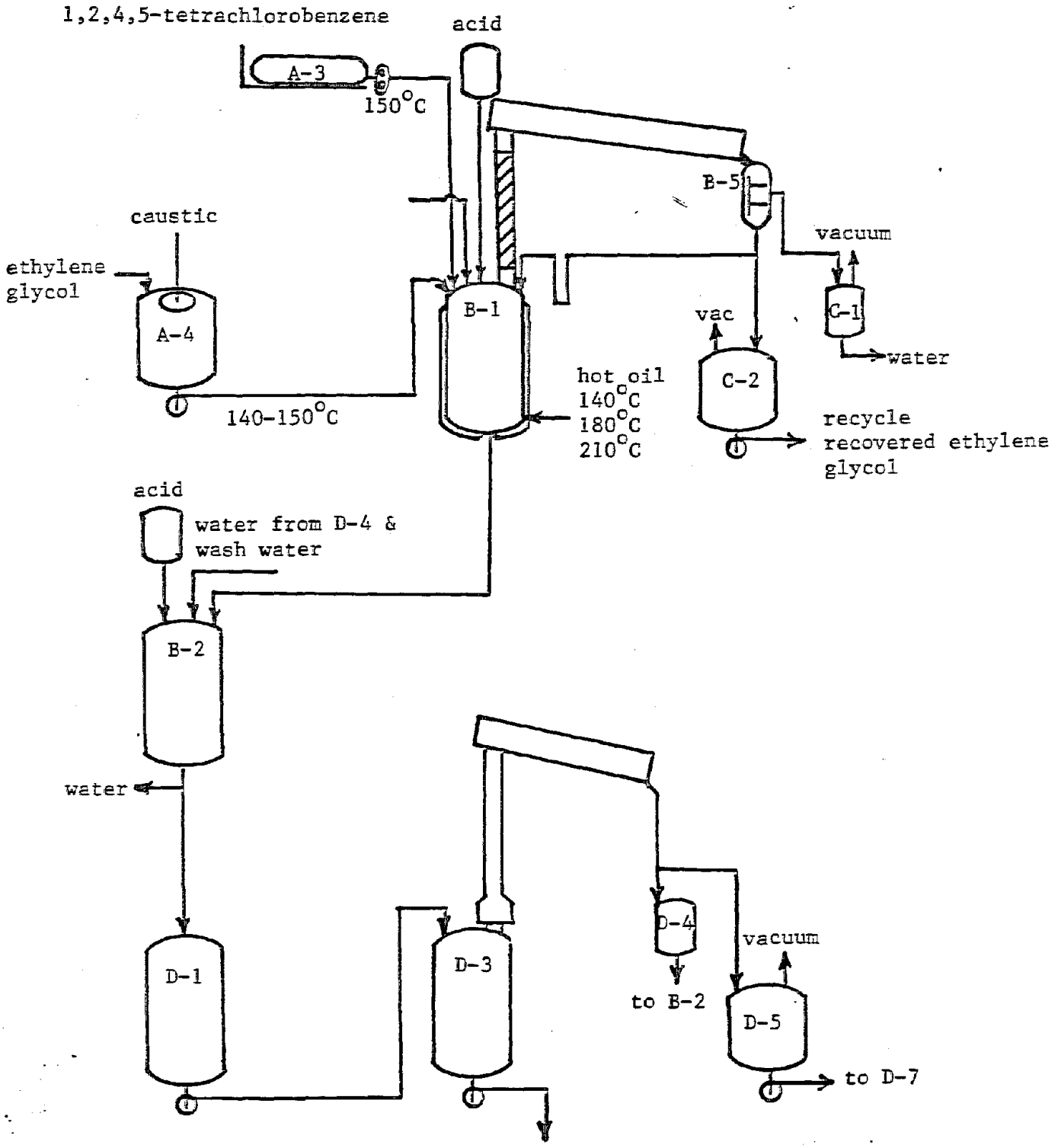
3 = tetrachlorobenzene storage tank
4 = sodium methylate pre-reactor
5 = autoclave reactor
9 = neutralization vessel
9A = extraction vessel
21 = hydrochloric acid storage tank
28 = distillation vessel

Figure 5
2,4,5-T Butyl Ester
Flow Diagram
Hoffman-Taff
Verona, Missouri



= 2,4,5-T butyl ester assay holding tank
= butyl monochloroacetate (BCA) reactor
= 2,4,5-T butyl esters condensation reactor
= filter press
= purification vessel
= recycle 2,4,5-TCP storage tank

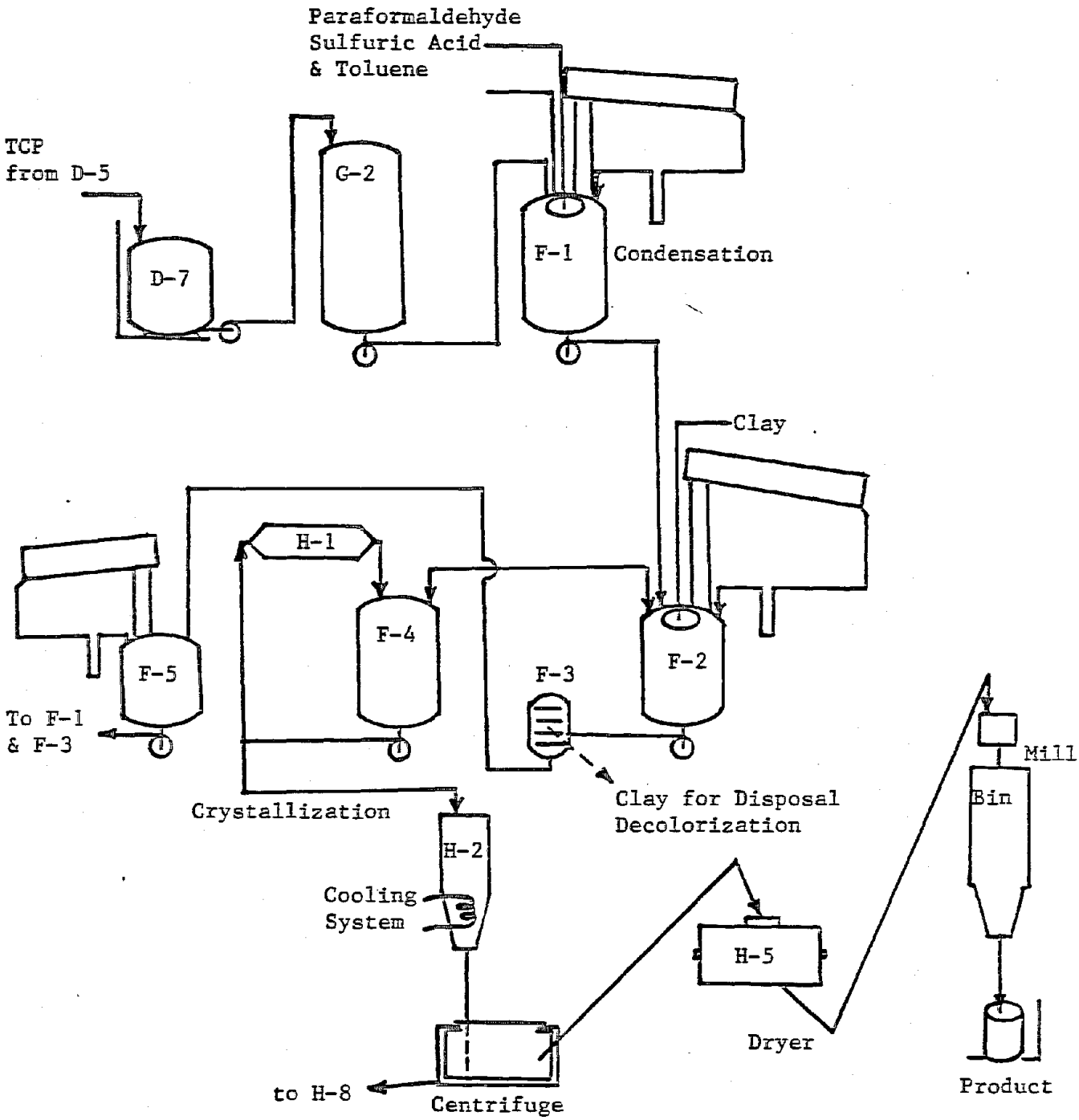
Figure 6
2,4,5-TCP Process Flow Diagram
NEPACCO
Verona, Missouri



= 1,2,4,5-tetrachlorobenzene storage tank
= ethylene glycol/caustic pre-heater drop tank
= Na-2,4,5-TCP autoclave reactor
= neutralization reactor
= ethylene glycol/water distillation column

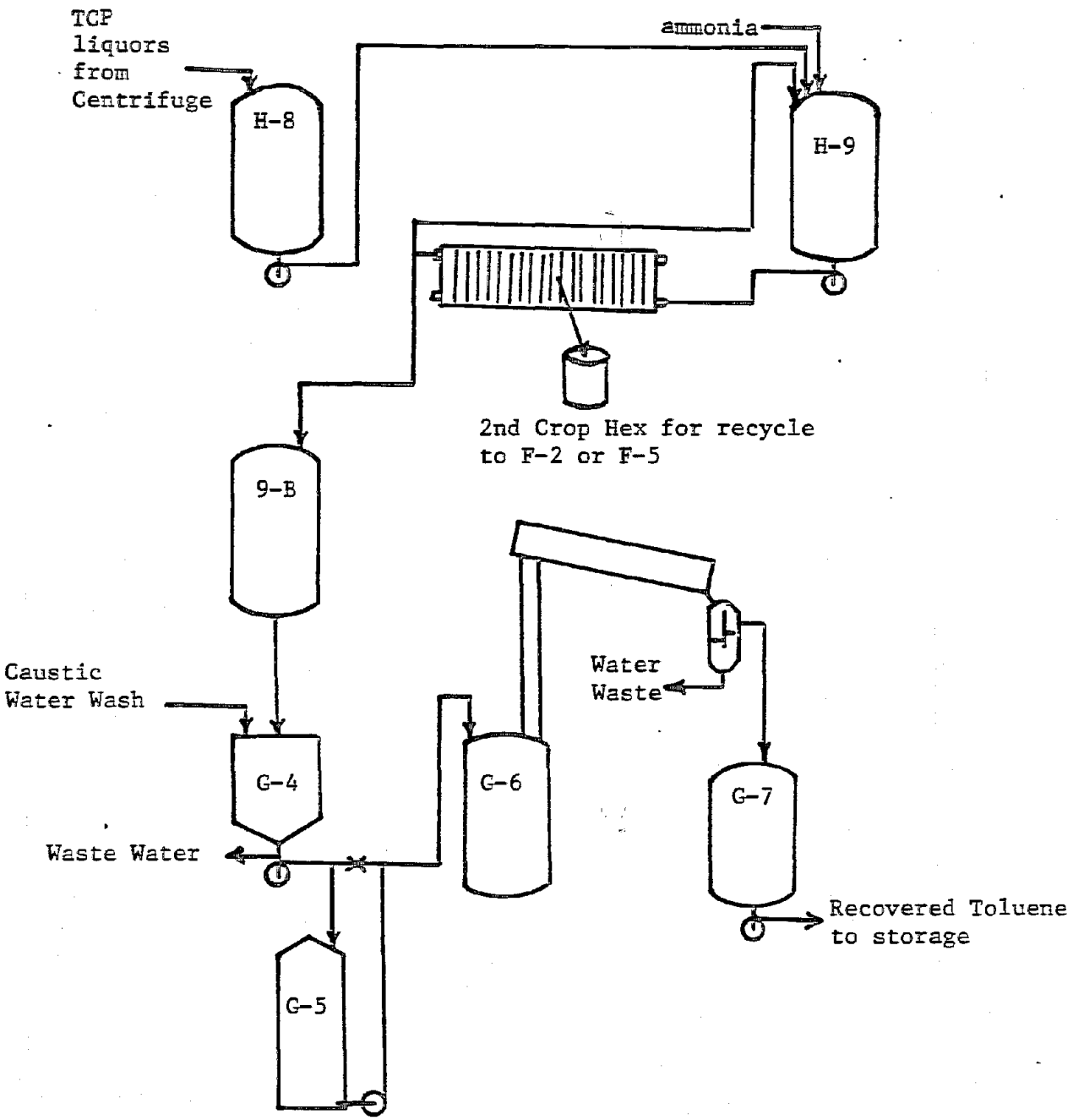
C-1 = water recovery tank
C-2 = ethylene glycol recovery tank
D-1 = crude 2,4,5-TCP holding tank
D-3 = 2,4,5-TCP vacuum distillation reactor
D-4 = water recovery tank
D-5 = purified 2,4,5-TCP assay tank

Figure 7
Hexachlorophene Process Flow Diagram
NEPACCO
Verona, Missouri



7 = purified 2,4,5-TCP holding tank
1 = condensation reactor
2 = azeotropic distillation reactor
3 = sparkler filter
4 = cooling vessel
5 = toluene recovery distillation reactor
2 = loading tank
1 = hexachlorophene recycle tank
2 = cooling system
5 = hexachlorophene dryer

Figure 8
Toluene/Hexachlorophene Recovery Flow Diagram
NEPACCO
Verona, Missouri



-4 = NaOH wash water
-5 = monel distillation unit
-6 =
-7 = purified toluene storage tank
-8 = raw toluene holding tank
-9 = second crop precipitation tank
9B = recovered toluene holding tank

TABLE 1*

JOB DESCRIPTIONS FOR HOFFMAN-TAFF
TCP AND BUTYL 2,4,5-T PROCESSES (AUGUST 1967 - DEC. 1968)

Job Title	Duties	Location[1]
Process Engineer	(Aug. 1967-April 1968) a. Built equipment for 2,4,5-T plant	Exclusively in non-production area
	(April 1968-July 1, 1968) a. Supervised shift operators in plant during start-up	Primarily in production area
	(Strike: July 1-Oct. 11) a. Involved in designing and improving existing process	Exclusively in non-production area
	(Oct. 11 to Dec. 1968) a. Involved in designing and improving existing processes	Exclusively in non-production area
	(Aug. 1967-Dec. 1968) b. Lunch and breaks	Exclusively in non-production area
Supervisor	a. In-plant supervision of chemical operators (primary duty)	Primarily in production area
	b. Paperwork related to manufacturing (secondary duty)	Exclusively in non-production area
	c. Lunch and breaks	Not in production area
Chemical Operator	a. Monitor equipment temperature and pressure. Packaging of intermediates and finished goods; Transfer of materials (pumping, etc.); Purification processes; Housekeeping and paperwork	Primarily in production area
	b. Lunch and breaks	Not in production area
Chemical Operator Trainee	a. Same duties as Chemical Operator Note 1: Trainees were promoted to chemical operators after 12-18 months	Primarily in production area

[1] The designation of "production area" refers to area VI for the period May 6, 1968, through January 29, 1968, and to area VIII after that time. The designation of "non-production area" refers to areas other than the production area.

* Table 1 provided by Syntex.

TABLE 1* (continued)

JOB DESCRIPTIONS FOR HOFFMAN-TAFF
TCP AND BUTYL 2,4,5-T PROCESSES (AUGUST 1967 - DEC. 1968)

Job Title	Duties	Location[1]
Supervisor	a. Responsible for supervision of in-plant activities; Helped out when process didn't function properly (primary duties)	Primarily in production area
	b. Paperwork (secondary duty)	Primarily in non-production area
	c. Lunch and breaks	Not in production area
Maintenance Operator	a. Disassemble and assemble process equipment, repair pumps, heat exchangers, filters, etc. Involved in welding, light electrical work, pipefitting, and sheet metal work.	Small amount of time spent in production area
	b. Lunch and breaks	Not in production area
Lead Man	a. Senior chemical operator and same duties as chemical operator. Note: Essentially a working foreman who reported to the supervisor (used only by Hoffman-Taff)	Primarily in production area
Blender/Premix Operator	Note 1: Persons in this job class had nothing to do with the manufacture of 2,4,5-T. This job title was used in the area where agrichemicals were mixed to make feed additives for pigs, chickens, and cows.	
	Note 2: Some chemical operators in the 2,4,5-T process spent 1 hr per week blending 2,4-D and 2,4,5-T, but they were still classified as chemical operators	

[1] The designation of "production area" refers to area VI for the period May 6, 1968, through January 29, 1968, and to area VIII after that time. The designation of "non-production area" refers to areas other than the production area.

* Table 1 provided by Syntex.

TABLE 2*

JOB DESCRIPTIONS FOR NEPACCO
TCP AND HEXACHLOROPHENE PROCESSES (1969-1971)

Job Title	Duties	Location [1]
Process Engineer	a. Provide process design; work with process development chemists; provide support for both; trouble shoot process; and devise process improvements.	Primarily in non-production area
	b. Lunch and break	Exclusively in non-production area
Warehouseman/ Dockworker; Shipping Clerk; Maintenance Operator; and Lead Man	Nepacco did not have this type of job designation in their organization.	
Supervisor	a. In-plant supervision of chemical operators; and paperwork related to manufacturing.	Primarily in production area
	b. Lunch and breaks	Exclusively in non-production area
Chemical Operator	a. Monitor temperature and pressure of process; package intermediates and final products; perform transfer of materials; conduct purification of process (filter, centrifuge, and separate); and follow written procedures; housekeeping and paperwork	Primarily in production area
	b. Lunch and breaks	Exclusively in non-production area

[1] The designation of "production areas" refers to area VIII. The designation of "non-production areas" refers to areas other than area VIII.

* Table 2 provided by Syntex.

TABLE 2*

JOB DESCRIPTIONS FOR NEPACCO
TCP AND HEXACHLOROPHENE PROCESSES (1969-1971)

Job Title	Duties	Location[1]
Chemical Operator Trainee	Same duties as Chemical Operator	
	a. Monitor temperature and pressure of process; package intermediates and final products; perform transfer of materials; conduct purification of process (filter, centrifuge, and separate); follow written procedures; and housekeeping and paperwork.	Primarily in production area[1]
	b. Lunch and breaks	Exclusively in non-production area
Blender/Premix Operator	Note 1: Persons who had this job classifications had nothing to do with the manufacture TCP or hexachlorophene. This job title was used in the area where agri-chemicals were mixed to make feed additives for pigs, chickens, and cows.	

1 The designation of "production areas" refers to area VIII. The designation of "non-production areas" refers to areas other than area VIII.

* Table 2 provided by Syntex.