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Dioxin Registry Report of Monsanto Company, Nitro, West Virginia

(U.S.) National Inst. for Occupational Safety and Health
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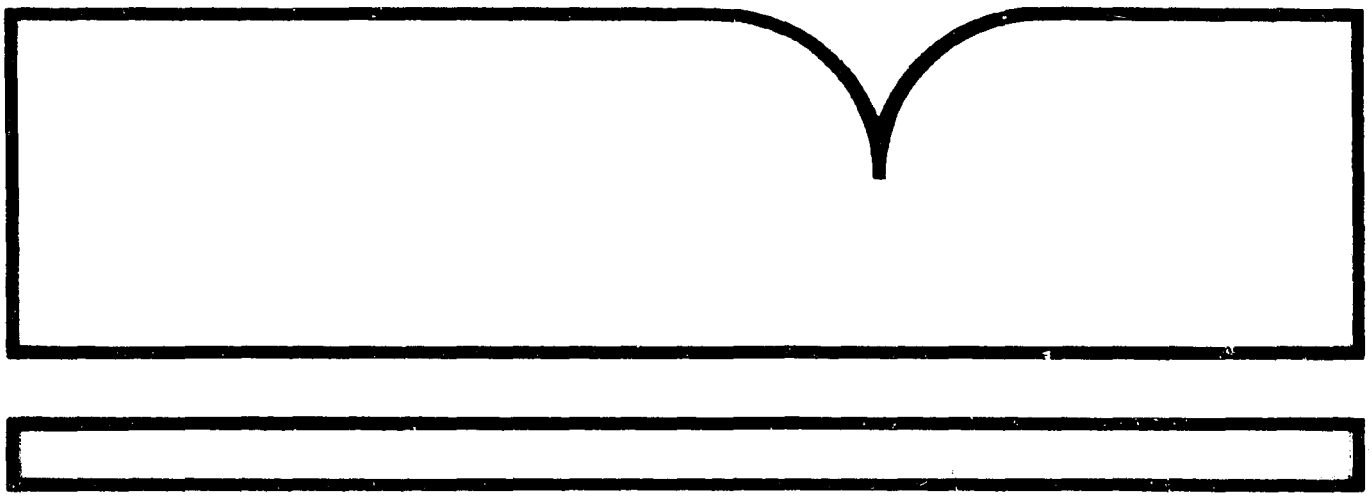

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16. Abstract (Limit: 200 words) Information was collected concerning the Monsanto Company, Nitro, West Virginia, for the purpose of evaluating the procedures and the data available to determine if this company would be suitable for inclusion in a study of the causes of death among workers exposed to products contaminated with 2,3,7,8-tetrachlorodibenzo-p-dioxin (1746016) (TCDD) or hexachlorodibenzo-p-dioxins (HxCDD). Sodium-2,4,5-trichlorophenate (Na-2,4,5-TCP) and 2,4,5-trichlorophenoxyacetic-acid (2,4,5-T-acid) were produced at the facility, and both compounds have been shown to be contaminated with TCDD. Based on the information gathered from Monsanto concerning Na-2,4,5-TCP and 2,4,5-T-acid production processes, the workers involved were suitable for inclusion in the NIOSH Dioxin Registry study. Work histories for these workers could be constructed. Descriptions of the tasks performed in the various processes through the years were available. Analytical data was available for the years 1958 through 1969 and could be combined with the work histories, the knowledge of the tasks performed, and the concentration of TCDD in the 2,4,5-T-acid.

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Dioxin Registry Report of Monsanto Company Nitro, West Virginia

Report Written By:
David A. Marlow
Marilyn A. Fingerhut
Laurie A. Piacitelli

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National Institute for Occupational Safety and Health
Division of Surveillance, Hazard Evaluations and Field Studies
Industrywide Studies Branch
Cincinnati, Ohio

Disclaimer

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health (NIOSH).

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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) and/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 in a retrospective cohort mortality study for which the comparison group is the U.S. male population. This study will evaluate the causes of death among the workers exposed to products contaminated with 2,3,7,8-TCDD and/or HxCDD.

The Monsanto Company has a facility in Nitro, West Virginia which produced sodium 2,4,5,-trichlorophenate (Na 2,4,5,-TCP) and 2,4,5-trichloro-phenoxyacetic acid (2,4,5-T acid). Na 2,4,5-TCP and 2,4,5-T acid have been shown to be contaminated with 2,3,7,8-TCDD. These two products were produced at Nitro from 1948 to 1969. Presented in this report is a historical compilation of information and data on the operations, personnel, and safety and health matters for these two production processes. This information was obtained mainly from documents received from Monsanto, plus interviews with Monsanto employees or former employees. Most of the figures and some of the tables are taken directly from Monsanto documents.

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 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) and hexachlorodibenzo-p-dioxin (HxCDD). The 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-TCDD and/or 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 a teratogen.[1-7] 2,3,7,8-TCDD is a contaminant 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 acid) and hexachlorophene. Currently, there are fourteen production facilities and approximately 7000 workers included in the Registry. The first use of this information will be a retrospective cohort 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 collected from the Monsanto Company and other sources for their facility in Nitro, West Virginia. Site visits to the Monsanto Company (Headquarters and/or Nitro facility) were made on Dec. 13, 1984; Jan. 2-3, 1985; June 24-25, 1987; and July 18-22, 1988. The Nitro plant produced Na 2,4,5-TCP which in turn was used to produce 2,4,5-T acid. Therefore, the workers involved in these processes are included in the Dioxin Registry.

The history and descriptions for the processes and personnel included in this report were obtained from Standard Manufacturing Process (SMP) descriptions, past studies conducted at the plant, information prepared for litigations, other company documents and interviews with company personnel or former company personnel. SMPs for 2,4,5-T acid production were provided for the years 1948, 1949, 1953, 1958, 1962-64, and 1966. SMPs for Na 2,4,5-TCP were provided for the years 1953, 1958, 1960, and 1962. The Na 2,4,5-TCP production process was a part of the 2,4,5-T acid production process from 1963-1969.

Description and History of the Facility

The Monsanto Nitro plant is located on the Kanawha River in Nitro, West Virginia. Nitro, West Virginia is located in Putman, County, 15 miles west of Charleston and received its name and beginning in 1917 when the U.S. Government built a large explosives complex in the area. In 1921, following the end of World War I, the complex was abandoned, divided up and sold to various organizations. One such organization was the Rubber Service Laboratories which purchased 30.7 acres of the complex in 1922. The Rubber Service Laboratories produced chemicals and additives used in the rubber

industry. In 1929, Monsanto purchased the plant from Rubber Service Laboratories. Over the years, the Nitro plant has diversified and grown such that as of 1986 the operating area of the plant occupied 69 acres and the waste treatment plant occupied 42 acres. Production included agricultural chemicals, nutrition chemicals, paper chemicals, plasticizers, and rubber chemicals. Figure's 1 & 2 show plant layouts for the Nitro plant for the years 1945 and 1970, respectively. The numbers on these layouts indicate the location of the various building located at the plant.

Through the years, the Monsanto Nitro plant has grown and diversified in the amounts and types of chemical products manufactured. Table 1, obtained from the Chemical Information Services of the Stanford Research Institute[8], list chemical products manufactured at Monsanto Nitro in 1970. Tables 2 and 3 list chemical products manufactured, building numbers, and departments where these products were manufactured and the raw materials used to manufacture these products for the years 1952 and 1960. Tables 4 and 5 list chemical products manufactured, building numbers and departments where these products were manufactured and the raw materials used to manufacture these products for the year 1968. These tables were constructed from information obtained from industrial hygiene surveys conducted by Monsanto on September 1952, March 1960, and April 1968.[9,10,11] In the 1952 industrial hygiene survey, the workforce was reported to have 804 employees while estimates of 450 and 400 employees were calculated as the workforce size for the years 1960 and 1968. The workforce size was reported to be 512 employees in 1986.

Monsanto Nitro processes of interest to the Dioxin Registry study are the Na 2,4,5,-TCP and the 2,4,5-T acid. Na 2,4,5-TCP and 2,4,5-T acid were produced at Nitro from 1948 to 1969. Na 2,4,5-TCP was used exclusively as a raw material to produce 2,4,5-T acid. From April 1948 to September 1948, Na 2,4,5-TCP and 2,4,5-T were produced on a pilot plant basis in Building 32. Beginning in October 1948, Na 2,4,5-TCP and 2,4,5-T acid was produced on a full scale basis in Buildings 41 and 34, respectively. The Na 2,4,5-TCP process was moved from Building 41 to Building 51 in July 1950. From October 1948 to July 1963 the 2,4,5-T acid process operated in Building 34. In November and December 1952, Building 34 was renovated such that all 2,4,5-T acid production activities were now done entirely in Building 34. Prior to this renovation from 1948 to 1952, 2,4,5-T acid was dried in Buildings 34 and 79, to a lesser extent in Building 16 and on some occasions Buildings 21 and 46. In August 1963, the 2,4,5-T acid process was consolidated with the Na 2,4,5-TCP process in Building 51 and designated Building 92. In Building 92, Na 2,4,5-TCP was a batch operation, while 2,4,5-T acid was produced in a semi-continuous operation. The 2,4,5-T acid operations in Building 34 were discontinued at this time. Production of Na 2,4,5-TCP and 2,4,5-T acid was discontinued at Nitro in August 1969 with some activity continuing in Building 92 until December 1969. The buildings used, the products manufactured and the years of production for the processes of interest are summarized in Table 6.

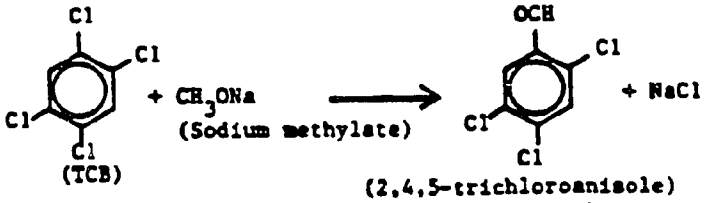
Production capacities for 2,4,5-T acid and Na 2,4,5-TCP are listed in Table 7. These capacities were obtained from Standard Cost Sheets in the SMPs for 2,4,5-T acid for the years 1948-49, 1953, 1958, and 1962-64 and in the

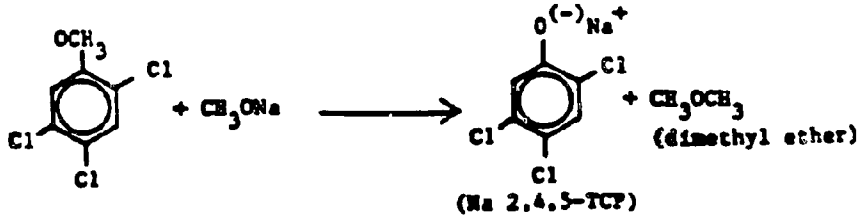
SMPs for Na 2,4,5-TCP for the years 1953, 1958, and 1960. The production capacities for 2,4,5-T acid increased from 25,000 pounds of 2,4,5-T acid per month in 1948 to 400,000 pounds of 2,4,5-T acid per month by 1965. Also included in Table 7 are the actual production levels for 2,4,5-T acid provided by Monsanto. Production levels for 2,4,5-T acid were slightly over 200,000 pounds of 2,4,5-T acid per month in 1961 and by 1968 had increased to over 600,000 pounds of 2,4,5-T acid per month. The production capacity for Na 2,4,5-TCP while the process was in Building 51 was between 225,000 and 260,000 pounds of Na 2,4,5-TCP per month. Na 2,4,5-TCP production capacities are not available for the years 1948 to 1950 when it was produced in Building 41 or for 1963 through 1969 when Na 2,4,5-TCP production was a part of the 2,4,5-T acid process in Building 92.

Description of the Process

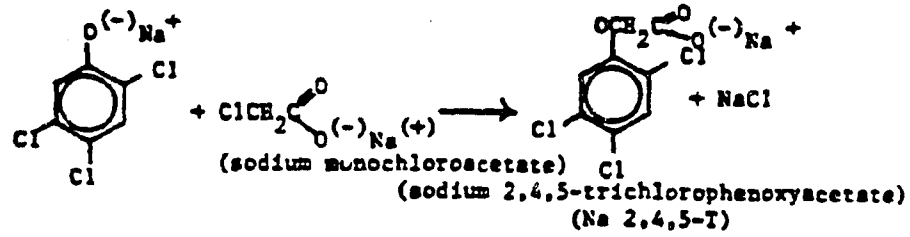
The processes used to produce Na 2,4,5-TCP and 2,4,5-T acid were located in several buildings and sites at the plant throughout the time they were operated. The following process descriptions are organized by buildings. Throughout the years of operation, the chemistry used to produce Na 2,4,5-TCP and 2,4,5-T acid remained unchanged. The chemical process for Na 2,4,5-TCP involved the hydrolysis of 1,2,4,5-tetrachlorobenzene (TCB) to form Na 2,4,5-TCP in a methanol-caustic-water solution as shown in the following mechanisms:

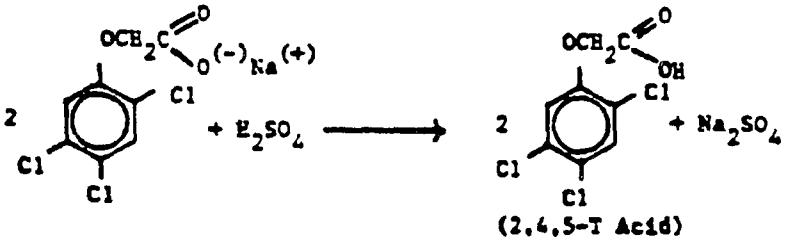
CH_3OH	+	NaOH		CH_3ONa	+	H_2O
(methanol)		(caustic)		(sodium metyhlate)		(water)





The Na 2,4,5-TCP produced was then used to produce 2,4,5-T acid. Na 2,4,5-TCP was reacted with sodium monochloroacetate (NaMCA) to form Na 2,4,5-T. The Na 2,4,5-T was in turn reacted with sulfuric acid to produce 2,4,5-T acid, by the following mechanisms:





While the chemistry of these production processes did not change through the years, the equipment, procedures, and operating conditions did change. The descriptions to follow will include changes made in the procedures and operating conditions as well as changes made from one building to another.

Process flow diagrams depicting the Na 2,4,5,-TCP, as well as the 2,4,5-T acid processes are shown in Figures 3 through 8. Figures 3 through 8 represent the processes for the eras 1948 through 1950, 1950 through 1951, 1951 through 1953, 1953 through 1957, 1958 through 1961, and 1962, respectively. The six figures illustrate the evolution of the Na 2,4,5-TCP and 2,4,5-T acid processes from their start in 1948 until they were consolidated into one process in 1963.

A. Na 2,4,5-TCP and 2,4,5-T Acid Pilot Process, Building 32.

Initial production of Na 2,4,5-TCP and 2,4,5-T acid was started in the Pilot Plant, Building 32, in April 1948. Very little information, descriptions or operating procedures were provided for the Pilot Plant operation. Presumably the initial operating procedures and conditions used when the Na 2,4,5-TCP and 2,4,5-T acid process were moved to Buildings 41 and 34, respectively, were used in the Pilot process. A 35-gallon autoclave reactor was used to produce Na 2,4,5-TCP using the raw materials of TCB, flaked caustic (NaOH), and

methanol (MeOH). The resulting Na 2,4,5-TCP (32% solution), 25% NaOH solution and monochloroacetic acid (MCA) were mixed cold, heated, and reacted in a condensation reactor. The crude Na 2,4,5,-T resulting from this reaction was filtered and washed, dissolved in water, and acidified with 93% sulfuric acid (H_2SO_4). The resulting 2,4,5-T acid slurry was filtered, washed, and the resulting cake was dried in tray dryers.

B. Na 2,4,5-TCP Process, Buildings 41 and 51

A full-scale Na 2,4,5-TCP process was started in October 1948 in Building 41. SMPs for the Na 2,4,5-TCP process for the years 1948, 1953, 1958, 1960, and 1962 were used to write the following process descriptions. The Na 2,4,5-TCP process was moved to Building 51 in the summer of 1950 and initially was essentially the same as the process in Building 41. A building layout of Building 51 is shown in Figure 10.

Na 2,4,5-TCP Process flow diagrams for the years 1948 through 1962 are shown in Figures 3 through 8. Inspection of these figures shows that no significant changes were made in the Na 2,4,5-TCP process between the years of 1958 through 1962.

TCB, excess flaked NaOH and 90% MeOH were charged to a 500 gallon fire heated agitated steel autoclave reactor and heated 5 to 7 hours at a temperature range between 165 and 175°C and a pressure range between 300 and 500 pounds per square inch gauge (psig). The autoclave contents were then cooled to 120°C and blown by residual pressure through pipes to a MeOH still in Building 34. In the still, excess MeOH was removed while water was added. Water was added to the Na 2,4,5-TCP solution until the desired 32% Na 2,4,5-TCP solution by weight was obtained.

This procedure of adding all the reactants to the autoclave and then heating the batch to the desired temperature by an open flame resulted in two incidents of runaway decomposition reactions. The first runaway reaction was a minor problem that was self-contained. The second of these decomposition reactions occurred on March 8, 1949 and was of such an order of violence that almost all of the batch was discharged from the autoclave into the work area. The batch had built up a pressure from 150 psig to greater than 1500 psig within ten minutes. This pressure build-up was inadequately relieved through a hand vent and emergency vent. One of the vents twisted off and allowed the batch to spray into the operating area. A fine black powder and a thick, sticky, dark brown substance coated the working surfaces throughout Building 41. This accident was to have severe consequences to the health of the workers involved with this process and will be discussed in detail in the Past Exposure section of this report. The Na 2,4,5-TCP process was shut down until August, 1949. During this time, Na 2,4,5-TCP used to produce 2,4,5-T acid was purchased from The Dow Chemical Company.

As a result of the March 1949 accident, several changes were made in the manner with which Na 2,4,5-TCP was produced. After the accident, MeOH and NaOH were charged into the autoclave and pre-heated to 170°C. TCB was then

gradually fed to the autoclave solution over a 4-1/2 to 5-1/2 hour time period. With respect to the TCB, a 50% molar excess of NaOH and 700% molar excess of MeOH were used. Prior to the accident, as stated previously, the raw materials were added to the autoclave and then heated. The new procedure allowed better control of the reaction and was less likely to result in runaway reactions. The final significant change made as a result of the accident was the installation and use of steam coils to heat the reactor rather than use of an open flame, again allowing better control of the reaction rate.

In the summer of 1950, the Na 2,4,5-TCP production process was moved to Building 51, where production procedures were essentially the same. Table 8 lists the major pieces of equipment used in the Na 2,4,5-TCP process housed in Building 51. A 2500-gallon steel autoclave reactor was installed in Building 51, increasing the production capacity for Na 2,4,5-TCP. The reaction procedures were the same as those in Building 41; the reaction temperatures ranged between 168 and 175°C and the pressures ranged between 300 and 500 psig. A batch charge was made up of 8200 lbs of MeOH, 3300 lbs of NaOH, 120 gallons of water and 6000 lbs of TCB. The TCB was gradually fed to the autoclave contents over a 4-1/2 to 5-1/2 hour period. A cooking time (hold time) of 3-1/2 hours was used. In October 1951, the Na 2,4,5-TCP filtration and distillation process (to recover excess MeOH) was moved to Building 51. Prior to this time, filtration and distillation were done in Building 34.

Distillation to recover excess MeOH from the Na 2,4,5-TCP reaction solution was accomplished using a four plate bubble cap distillation column and a still pot. The distillation was carried out with steam on the still pot jacket. The reflux ratio was set at 1:1 at the start and the vapor temperature at the top of the column was maintained under 66°C by increasing the reflux ratio as the distillation progressed. When the reflux ratio reached 9:1, a weak alcohol cut was made. After the pot temperature reached 110°C, 500 gallons of water were added and the distillation continued until the vapor temperature reached 90°C or the pot temperature reached 115°C. The finished Na 2,4,5-TCP batch was adjusted by the addition of water and a final sample was taken. The average assay of the Na 2,4,5-TCP solution was between 31 and 33% by weight Na 2,4,5-TCP.

From October 1948 to October 1951, the Na 2,4,5-TCP solution was filtered after MeOH removal in Building 34. From October 1951 to December 1957, Na 2,4,5-TCP was filtered in Building 51. The filter press was pre-coated with a water slurry of super-filtrol after clean filter papers were installed. The batch was filtered to the 10,000 gallon settling tank. When the settling tank was full, the contents were pumped to a 50,000 gallon storage tank.

By 1958, filtration of the Na 2,4,5-TCP solution had been eliminated and the solution went directly from the MeOH still to the settling tank. Four to five autoclave batches were accumulated in the settling tank after which they were transferred to the 50,000 gallon storage tank. The tanks were maintained at a temperature between 80 and 85°C. The undissolved salt and other solids which settled out in the settling tank were flushed out with hot water to the sewer after every transfer from the settling tank to the storage tank.

Time cycles for the various steps in the process are shown in Table 9. Time cycles for the operation of the Na 2,4,5-TCP process remained the same between the years of 1958 and 1962 with 15-1/2 hours needed per batch on the autoclave and 9 hours needed per batch on the MeOH still.

C. 2,4,5-T Acid Process, Building 34

Full scale 2,4,5-T acid production was started in October 1948 in Building 34. A building layout of Building 34 is shown in Figure 10. Building 34 also housed Santoflex B, AW, and DD (also known as Ajone C, AW and DD, respectively), Flectol H, DDK, mercaptan and other processes. SMPs for the 2,4,5-T acid process for the years 1948, 1949, 1953, 1958, and 1962 were provided by Monsanto and used to write the following process description. Process diagrams depicting the 2,4,5-T acid process are shown in Figures 3 through 8. These six figures illustrate when and what process changes took place while the 2,4,5-T acid process operated in Building 34. Significant process changes were made in the winter of 1953 and very few changes occurred from 1954 to 1962. Major pieces of equipment used to produce 2,4,5-T acid in Building 34 for the years 1948, 1949, 1953, 1958, and 1962 are listed in Table 10.

From 1948 until 1950, Na 2,4,5-TCP produced in Building 41 was distilled to remove excess MeOH and filtered in Building 34. The Na 2,4,5-TCP solution in the autoclave in Building 41 was cooled to 120°C. Residual pressure inside the autoclave was used to blow the autoclave solution through pipes to a 1200 gallon agitated, jacketed steel MeOH still. MeOH was removed from the still while water was added to keep the Na 2,4,5-TCP in solution. Once the excess MeOH was removed from the Na 2,4,5-TCP solution, which was approximately 32% Na 2,4,5-TCP by weight, it was pumped from the still through a 24" Sparkler clarifying filter to a 1200 gallon agitated, jacketed, steel condensation reactor. The MeOH distillation step was moved to Building 41 in 1950.

The Na 2,4,5-TCP solution was pumped to the condensation reactor where recovered 2,4,5-TCP was added to make up a batch. Steam was applied to the reactor jacket, agitation was started and the reactor was heated to 92-95°C. The batch was now ready for reaction with sodium monochloroacetic acid (NaMCA). NaMCA had been prepared previous to this step by reacting MCA with a 25% caustic solution. The NaMCA was fed slowly over a period of 1-1/2 to 2 hours to the Na 2,4,5-TCP solution. The Na 2,4,5-TCP reacted with NaMCA to form Na 2,4,5-T.

Periodically, throughout the NaMCA addition the pH of the reactant solution was checked. Initially the pH was checked using a dip rod and phenolphthalein paper. Starting in March 1961, the pH was monitored with a pH meter instead of the phenolphthalein indicator. If the batch became too thick water was added. After the final addition of the NaMCA solution, the contents of the reactor were agitated for 2-1/2 hours at 92-95°C, to complete the reaction (starting in 1958, the hold time was reduced from 2-1/2 hours to 1-1/2 hours). The batch was then diluted with water and cooled to a minimum of 50°C by circulated recovered water through the reactor jacket.

The Na 2,4,5-T salt slurry was either pumped from the condensation reactors and loaded directly into the centrifuges or pumped to the reactor storage tank and then to the centrifuges. Initially a 48", center slung, top unloading, Tolhurst centrifuge was used (see Figure 11). By 1953, a second centrifuge was added, a 48" suspended bottom unloading Fletcher centrifuge (see Figure 12). By 1958 the Tolhurst centrifuge had been replaced by a second Fletcher centrifuge. The Tolhurst was operated such that each charge was dewatered, washed with a solution made up of two parts water and one part 25% caustic, dewatered again and the cake was then cut down into small pieces and shoveled into a Redler hopper. A Redler conveyor was started and the material was punched from the hopper to the conveyor by means of a shovel or punch stick. The Fletcher was operated similarly to the Tolhurst except the cake was cut into pieces and discharged from the bottom of the centrifuge to the hopper. The Redler conveyor, shown in Figure 13, carried the wet Na 2,4,5-T cake to either a storage bin or to the dissolver. When filtration and dewatering of the Na 2,4,5-T cake became difficult, changing of the filter cloth in the centrifuges was required. Before the cloth was changed all material possible was removed from the centrifuge basket. The cloth was then washed with the centrifuge running, first with hot water until all solids were dissolved and then with cold water until cool. The cloths which had been removed were placed in metal containers with closed lids and twice weekly hauled to a disposal pit. The filtrate and wash water coming from the centrifuges were collected in the filtrate receiver and pumped to the filtrate storage tank where it was later used to recover unreacted 2,4,5-TCP.

The wet Na 2,4,5-T cake was either stored or directly dumped to the dissolver which contained hot water. The contents of the dissolver were then heated with agitation to 90-95°C and held at this temperature for 10-15 minutes or until the solution was complete. From 1948 through 1953, the Na 2,4,5-T solution in the dissolver was filtered through one of three Alsop filters either to storage or the acidifiers. Each filter was equipped with a No. 45 cartridge. One filter was used at a time and changed to a clean filter when filtration slowed. Cartridges were changed as required with the dirty cartridges being disposed of in closed metal containers which were hauled twice weekly to a disposal pit. After 1953, filtration of the Na 2,4,5-T solution from the dissolver was not done.

Initially, acidification of the Na 2,4,5-T solution took place in a 500 gallon, enamel lined, agitated, steel acidification tank. Na 2,4,5-T solution was pumped into the acidifier followed by a weighed amount of 93% sulfuric acid which was slowly added. The resulting solution's pH was periodically checked and sulfuric acid was added until the pH paper was dark red (pH=2). After the acidification was complete the acidifier contents were cooled to 40°C by introducing reclaimed water to the acidifier jacket.

As a result of the process improvements made to the 2,4,5-T acid process in late 1953, two 500 gallon acidification tanks were now used and the procedure for the formation of 2,4,5-T acid was altered. A weighed amount of sulfuric acid was pumped into each acidifier, followed by the Na 2,4,5-T solution. Additional sulfuric acid was added until the pH reached 2. The contents of

the acidifiers were agitated for 20 minutes and were then ready for filtration. Cooling water was kept on the acidifier jacket at all times. Acidification in this manner remained the same throughout the time that the 2,4,5-T acid process was in Building 34.

Filtration of the 2,4,5-T acid solution in the acidifiers was done in two ways when the process was in Building 34. From 1948 to 1953, the 2,4,5-T acid solution was filtered using a 3 foot by 6 foot filter box equipped with glass cloth covered with a large mesh stainless steel screen. From 1953 to 1963, the 2,4,5-T acid solution was filtered using a 48 inch, bottom discharge, Fletcher centrifuge with a stainless steel basket.

From 1948 to 1953, contents of the acidifier were cooled to 40°C and a vacuum was applied to the filter box by a three stage jet through the filtrate receiver tank. The 2,4,5-T acid slurry was dropped from the acidifier, with the agitator running, into the filter box, checking to make sure not to overflow the filter box. When the flow from the acidifier to the filter box decreased, the agitator was stopped and the acidifier was washed out with the wash water going to the filter box. The 2,4,5-T acid in the filter box was filtered fairly dry. Cracks that formed in the 2,4,5-T acid filter cake were smoothed out with a shovel and the cake was washed twice with water, after each washing the cake was filtered dry and the cracks smoothed out. The filter cake was then shoveled from the filter box into clean metal drums and weighed. The drums of damp 2,4,5-T acid were then moved to drying areas in Buildings 34, 79, 16, 21, and 46. The filtrate from the filter box was collected in the receiving tank and subsequently discharged to the sewer.

From 1953 to 1963, the 2,4,5-T acid solution was filtered using a 48 inch, bottom discharge Fletcher centrifuge with a stainless steel basket. The contents of two acidifiers were loaded into a Fletcher centrifuge operating at high speed, with the wash water spray on. During the loading of the centrifuge, which took between 10 and 20 minutes, a wash water spray was used. After the centrifuge was loaded, the spray wash was continued for another 20 minutes. The 2,4,5-T acid cake in the centrifuge was dewatered for 15 minutes and was then ready to be dug down. The Redler conveyor was started and the cake was slowly dug down with a digger while the centrifuge operated on slow speed. The damp 2,4,5-T acid was discharged from the bottom of the centrifuge into a hopper which discharged the material on to the Redler conveyor. At times it was necessary to punch the damp 2,4,5-T acid out of the hopper and onto the conveyor using a stick or a shovel. The heel was then dug out of the centrifuge. The Redler conveyor moved the material to the dryer feed hopper. The filtrate coming from the centrifuge was collected in a filtrate receiving tank and subsequently pumped to a filter box. The filter box operated the same as the filter box previously described.

The damp 2,4,5-T acid coming from the filtration step was dried by two methods while the 2,4,5-T acid process was in Building 34. From 1948 through 1953 the damp 2,4,5-T acid was dried using tray dryers primarily in Buildings 34 and 79 and to a lesser extent in Building 16, 21, and 46. From late 1953 until the process moved to Building 92, in 1963, the damp 2,4,5-T acid was dried using a rotary dryer.

In 1949, 6- and 12-stall tray dryers were located in Buildings 34 and 79, respectively. Each dryer was equipped with a pre-heater for air with a blower fan, temperature controller, dryer racks with wooden and metal trays, wooden boxes for dumping material prior to loading it in the tray driers, a paper cutter for cutting paper used in the trays and a micro-pulverizer with a bar screen. The 2,4,5-T acid, shoveled from the filter box into metal drums, was taken to the tray dryers and the material in the drums was dumped in wooden boxes. The tray dryer's trays were checked and all loose material was removed. New clean paper was placed in each dryer tray and the damp 2,4,5-T acid shoveled from the wooden boxes into the trays. Two scoops were loaded into each tray to a depth of approximately 2 inches thick. The dryer trays were loaded into the dryer from top to the bottom. After the dryers had been loaded, the doors were closed, the timer was set, and the steam was turned on in the dryers. The temperature of the dryers was raised as rapidly as possible to 100-105°C. The dryers were checked frequently, and when the 2,4,5-T acid was determined to be dry, the steam was turned off and the dryers were cooled down for 30 to 60 minutes using the blower fan. The trays were unloaded from the top to bottom of the dryer. The dried 2,4,5-T acid was dumped into either fiber drums or into large wooden boxes, which were then emptied into a hopper for the micro-pulverizer. A wooden stick was used to punch the 2,4,5-T acid into the micro-pulverizer where it was ground, and packed into fiber drums, 200 pounds net. Sweepings from the dryer room were collected, screened, and recycled. 100 pounds of screened sweepings were dissolved in 12 gallons of 25% caustic for reworking in the reactor.

With the renovation of the 2,4,5-T acid process in 1953 came the replacement of the tray dryers with a rotex dryer. The drying system installed in Building 34 replaced all the tray dryers and therefore Building 34 housed the entire 2,4,5-T acid process. The drying system consisted of a storage hopper equipped with a vibrator, a punch arm and a 6-inch screw feed; a 30-inch stainless rotary dryer equipped with inlet and outlet temperature controls; a feed shut-off control; three double banks of heating coils; a cyclone separator; a dust bag collector equipped with an exhaust blower fan and bag shaker; a Redler conveyor; and a rotex screener equipped with 8 mesh screen. The Redler conveyor fed damp 2,4,5-T acid from either the 2,4,5-T acid centrifuge or wet acid storage to the dryer hopper and from there into the rotary dryer. The wet 2,4,5-T acid was fed through the dryer to the rotex screen as fast as possible while maintaining an outlet temperature on the dryer at or above 45°C. The 2,4,5-T acid coming from the rotex screen was packaged in fiber drums, 200 pounds net. Each drum was marked with a code, a lot number, drum number, and the gross, tare and net weights. A sample of the 2,4,5-T acid was collected using a thief tube from each drum.

Filtrate coming from the Na 2,4,5,-T centrifuges was collected in filtrate storage tanks and contained unreacted Na 2,4,5,-TCP. The filtrate was pumped from storage to a monel recovery tank where agitation was started and 93% sulfuric acid was added until the contents in the recovery tank had a pH of 2 using pH paper until March 1961 and then using a pH meter until 1963. When the pH of 2 was reached agitation was stopped and the contents in the tank were allowed to settle into layers for one hour. After the settling period

the upper or water layer was discharged to the sewer through an adjustable siphon. After two batches had been processed, the recovered 2,4,5,-TCP was reacted with 25% caustic and diluted with water to form a thin slurry. The caustic was added until a pH between 9 and 11 was reached. Samples were collected and the batch of recovered 2,4,5,-TCP was pumped to a Na 2,4,5-TCP weigh tank to make up part of a batch.

No ventilation system was in place until the renovations to the 2,4,5-T acid process were made in 1953. At that time, the reactors, the Na 2,4,5,-T centrifuges, the dissolver, the dissolver storage tank, the acidifiers, the 2,4,5-T acid centrifuge, and the filtrate settling box were all operated under decreasing pressure as supplied from a Roto-Clone fume scrubber ventilation system equipped with an American Blower fan, Size 23, 1750 RPM, 15 HP. By July, 1962, the Roto-Clone had been replaced by a Schutte and Koerling venturi fume scrubber (Figure 14) and a Chemico scrubber. The Chemico scrubber ventilated the dissolver, the TCP recovery tank, the acidifiers, the 2,4,5-T acid centrifuge, the settling box, and the Na 2,4,5,-T centrifuges. The Schutte and Koerling venturi scrubber ventilated the reactors, the Na 2,4,5,-T filtrate receivers and storage tanks, and the MCA weigh tank.

D. Na 2,4,5-TCP and 2,4,5-T Acid Process, Building 92

In August 1963, the 2,4,5-T acid process was consolidated with the Na 2,4,5-TCP process, in Building 51. Building 51 had to be enlarged to accommodate the addition of the 2,4,5-T acid process and was designated as Building 92. The chemistry and the procedures for producing 2,4,5-T acid remained essentially the same but the equipment used in the Building 92 was somewhat different in order to make the process semi-continuous.

Figures 15A-15E are flow diagrams for the processes in Building 92. Figure 15A shows the Na 2,4,5-TCP process steps while Figures 15B-15D show the 2,4,5-T acid process steps. Figure 15E illustrates the support operations and the TCP recovery step in the 2,4,5-T acid process in Building 92. Figure 16 is a building layout for Building 92.

Two 2,500 gallon autoclave reactors were used to produce Na 2,4,5-TCP in the same manner previously described for Building 51. TCB was fed to the sodium methylate solution in the autoclave over a 4 hour period at a temperature between 170°C and 173°C and pressure of 150 psig. Following the TCB addition the autoclave contents were held for 3-1/2 hours with the pressure gradually rising to between 350 to 400 psig. Following the hold time the autoclave contents were cooled until the reactor pressure fell to 100 psig at which time the batch was blown through a well line to the methanol recovery still using the reactor's residual pressure.

Methanol recovery was accomplished in the same manner as was done in Building 51, which was previously described. The methanol recovery system in Building 92 was made up of a 2000 gallon steel jacketed tank with an agitator. Attached on top of the 2000 gallon tank was a 3 ft. 6 inch by 11 ft. 6 inch steel bubble cap column with four plates each containing 8 caps. The methanol

vapors coming from the still were condensed in a 16 inch by 18 ft. steel shell and tube condenser, collected in a 1,200 gallon alcohol receiver and stored in two 1,400 gallon alcohol storage tanks. The distillation was started with a reflux of 2 gallons per minute. When the temperature of the still reached 110°C, 500 gallons of water were added and the distillation was continued until the still temperature reached 115°C at which time it was diluted with water to a determined outage and transferred to a 50,000 gallon Na 2,4,5-TCP agitated storage tank maintained at 80-85°C.

Two 2000 gallon steel condensation reactors were used to produce Na 2,4,5,-T. Na 2,4,5-TCP was pumped from storage into a 500 gallon steel weigh tank and MCA was added to a 100 gallon glass-lined weigh tank. The Na 2,4,5-TCP charge was dropped by gravity into the reactors. Agitation was started and recovered 2,4,5,-TCP was added until the pH was adjusted to 8.5. The reactors were maintained at 92°C and over a 45 to 60 minute period the MCA and water charge were fed into the reactors. The pH of the two batches was maintained by automatic pH control and checked with litmus paper. After the MCA addition, the batches were held for 90 minutes maintaining a constant temperature of 90°C and a pH of 8.5. At the end of the hold period, 25% NaOH was added while the batches cooled. The batches were pumped to a surge tank and water was used to wash out the reactor. From the surge tank the Na 2,4,5,-T slurry was pumped to the filter feed tank maintaining a constant level in the filter feed tank. The temperatures of the surge tank and the filter feed tank were maintained at 60° to 70°C.

The Na 2,4,5,-T slurry was then fed by gravity from the filter feed tank to the filter pan in the Eimco belt filter, shown in Figure 17. The Na 2,4,5,-T slurry was maintained at a constant level in the filter pan and the Eimco belt rotated through the Na 2,4,5,-T slurry forming a cake on the outer surface of the belt. The cake on the belt surface was washed by three banks of cold water to remove residual Na 2,4,5-TCP and impurities. The Na 2,4,5,-T cake then rotated off the belt and fell through a chute into a Na 2,4,5,-T slurry tank where the Na 2,4,5,-T was redissolved in water and maintained at a temperature between 75° and 80°C. The concentration of the Na 2,4,5,-T slurry in the slurry tank was maintained at 10 to 12% Na 2,4,5,-T using automatic ratio controls. Wash water and Na 2,4,5,-T filtrate were pumped from the Eimco belt filter to the primary TCP recovery settler.

Sodium hypochlorite was added to the Na 2,4,5,-T solution in the slurry tank on a continuous ratio with the quantity of Na 2,4,5,-T cake coming from the Eimco belt filter. The rate of addition of the sodium hypochlorite was set on a ratio controller taking its signal from the Eimco cake thickness gauge. The sodium hypochlorite was added at a rate to give 4 to 6 pounds of sodium hypochlorite per 100 pounds of Na 2,4,5,-T cake. The sodium hypochlorite was added to the Na 2,4,5,-T solution in order to lighten the color of the final 2,4,5-T acid product. The Na 2,4,5,-T solution was then pumped from the slurry tank to a 2000 gallon glass-lined agitated jacketed acidification tank. While the Na 2,4,5,-T solution was charged, 93% sulfuric acid was also added at a ratio to give 300% excess acid and no residual Na 2,4,5,-T. The

temperature of the acidification tank was maintained between 80° and 85°C. The feed and discharge of the acidification tank were continuous with discharge coming from a bottom center nozzle on the acidifier.

The 2,4,5-T acid slurry coming from the acidifier was fed to a 300 gallon Haveg tank. From the Haveg tank the 2,4,5-T acid slurry was continuously fed at a controlled rate to a 6 foot diameter Carpenter 20 Dorr Oliver pan filter (Figure 18). The 2,4,5-T acid cake which collected in the pan filter was washed by four hot (70°C) water washes, dewatered and discharged by a screw type scroll into the dryer feed surge hopper. The wet 2,4,5-T acid was then fed from the surge hopper to a 4 foot by 20 foot stainless steel rotary dryer at a controlled rate to keep the outlet temperature at 60°C or higher in order to get a dry product. The dry 2,4,5-T acid coming from the dryer was discharged through a 6" screw conveyor to a link-belt bucket elevator through a 30 inch Sweco screener and into a 450 cubic foot steel product hopper. The 2,4,5-T acid flowed continuously from the product hopper into a 275 cubic foot ribbon blender until the blender was loaded. The ribbon blender was used to increase the density of the 2,4,5-T acid product. The 2,4,5-T acid product was then packaged using either a St. Regis fluidizing bag packer or the drum packaging station. Dust generated in the finishing and packaging steps of the process was collected in a Dustex primary dust collector. Air coming from the primary dust collector was again filtered by a Dustex backup dust collector. Dust collected in the primary dust collector was discharged to the product hopper while dust collected by the backup was collected in a drum which was checked twice per shift to detect primary collector leakage. A Mikro-Pulsair primary dust collector, shown in Figure 19, was also installed to backup the two Dustex collectors in case of failure. In addition, a Dracco dust collector was used to collect dust from the product hopper, the blender, the bucket elevator, the bagger, and the drumming station. Oversize 2,4,5-T product from the product screener was collected in a drum and reworked through the dryer. Packaging was done during the day shift and the 2,4,5-T acid was packaged in either 50 pound bags or 230 pound drums. One blender load was considered a finished lot and was sampled for final analysis.

Na 2,4,5,-T filtrate and wash water were collected from the Eimco belt filter in a 10 foot in diameter by 8 foot 6 inch tall Haveg 60 primary settler. The filtrate and wash water was mixed with 93% sulfuric acid using a mixing jet. The pH of the overflow acid stream was controlled at a pH of 1.5 $\pm$ 0.5 pH units. The filtrate and wash water were added to the primary settler only when the Eimco filter was running, but sulfuric acid was added as required to maintain overflow pH. The weak sulfuric acid containing some residual 2,4,5,-TCP was overflowed to a 5000 gallon Haveg secondary settler where the residual 2,4,5,-TCP was settled out. The recovered 2,4,5,-TCP from the secondary settler was pumped back to the primary settler either on a continuous basis or once per shift. The recovered 2,4,5,-TCP from the primary settler was pumped to the TCP weigh tank for recycling to the condensation reactor as needed.

Description of the Workforce

The workforce at the Monsanto plant in Nitro, West Virginia is organized into departments but is more clearly associated with buildings and production processes. Workers involved in the production of Na 2,4,5-TCP and 2,4,5-T acid are included in the Dioxin Registry study. The buildings associated with these two processes have changed over the years these processes were operated. Manufacturing changes which affected worker exposure are summarized in Table 11. As stated in the History and Description of the Facility section of this report and in Table 6, the buildings involved were Building 32 for Na 2,4,5-TCP and 2,4,5-T acid in the summer of 1948, Building 41 for Na 2,4,5-TCP for the time period of October 1948 to July 1950, Building 51 for Na 2,4,5-TCP for the time period of July 1950 to August 1963, Building 34 for 2,4,5-T acid for the time period of October 1948 to August 1963, and Building 92 for both Na 2,4,5-TCP and 2,4,5-T acid for the time period of August 1963 to August 1969.

Job titles and descriptions were obtained from industrial hygiene reports and SMPs. Additional workforce information came from three industrial hygiene survey reports for the years 1952[9], 1960[10], and 1968, and from SMPs for 2,4,5-T acid for the years of 1958 and 1962 and for Na 2,4,5-TCP for the year of 1960. Constructed from this information and listed in Table 12 are the job titles and descriptions for the Na 2,4,5-TCP and 2,4,5-T acid processes through the years they were operated. In Building 32, which was a pilot plant for the Na 2,4,5-TCP and 2,4,5-T acid processes, the job titles of operator, helper, and production utility were used. Operators were responsible for the operation of the autoclave, the methanol still, the 2,4,5-T acid reactor, and the 2,4,5,-TCP recovery. The helpers operated the Na 2,4,5-T and 2,4,5-T acid centrifuges and the drying and packaging operation. The production utility workers filled in for the operators and helpers.

When the Na 2,4,5-TCP and 2,4,5-T acid processes moved to Buildings 41 and 34, respectively, and became full scale processes, the workforce size increased as well as their responsibilities. In Building 34, the 2,4,5-T acid process had the job titles of head operator, operator, helper, and production utility associated with it. The head operators were responsible for the operation of the 2,4,5-T acid reactor, the 2,4,5-TCP recovery system, and preparation of the NaMCA. The operators assisted the head operators and operated the Na 2,4,5,-T centrifuges. The helpers also operated the Na 2,4,5,-T centrifuges as well as the acidification, 2,4,5-T acid centrifuges, drying and packaging operations. The 2,4,5-T acid process was operated for three, eight hour shifts per day, and there were one head operator, one operator, and three helpers per shift. Shown in Table 13 are time cycles for the 2,4,5-T acid process in Building 34. These time cycles obtained from the SMPs were associated with the job titles used in the 2,4,5-T acid process.

For the Na 2,4,5-TCP process in Building 41, from 1948 to 1950, and later in Building 51, from 1950 to 1963, the job titles of head operator, operator, and helper were used. The autoclave and the methanol still were operated by either the head operator or operator with the assistance of a helper. The

Na 2,4,5,-TCP process was operated for three eight-hour shifts per day with each shift having either a head operator or an operator and a helper. Shown in Table 9 are time cycles for the Na 2,4,5-TCP process in Building 51. The time cycles obtained from the SMP were associated with the job titles used in the Na 2,4,5-TCP process.

In 1963, when Building 51 was expanded and became Building 92, the Na 2,4,5-TCP batch process and the 2,4,5-T acid process were combined to make one semi-continuous process. Table 14 lists the major pieces of equipment used in the combined process. The job titles associated with the Na 2,4,5,-TCP/2,4,5-T acid process were head operator, operator, and helper. The head operators coordinated the process work activities and worked vacation relief. The operators ran the autoclaves, ethanol stills, 2,4,5-TCP recovery system and the 2,4,5-T acid reactors. The helpers operated the filtration equipment, drying, and packaging machines. The Na 2,4,5,-TCP/2,4,5-T acid process operated three eight-hour shifts per day with five workers per shift. Each shift was comprised of a head operator, two operators, and two helpers. Shown in Table 15 are time cycles which were associated with the Na 2,4,5,-TCP/2,4,5-T acid process. These time cycles, obtained from the SMP, were associated with the job titles in the Na 2,4,5,-TCP/2,4,5-T acid process.

Workers in these processes and operations were organized under the United Steelworkers of America, District 23, Local 12610.

Description of Medical, Industrial Hygiene and Safety Programs

Starting in the 1940's, part-time plant physicians attended to the medical needs of the workers at the Nitro plant. In 1946, Monsanto hired a corporate medical director who was responsible for the safety and health of Monsanto workers throughout the company, including the Nitro plant. A year later, an industrial hygienist was hired by the medical director. These two individuals began making annual inspections of all Monsanto plants. Also in 1946, the first safety director for the Nitro plant was hired. Prior to this time, the personnel manager handled the safety activities for the plant. A formal safety program was established with the arrival of the safety director in 1946. Also established at this time were four safety committees; a Plant Safety Committee, a Supervisor's Safety Committee, Departmental Safety Groups, and a Union Management Safety Committee. By 1952, a full-time nurse was hired at the Nitro plant while the plant physician remained part-time making periodic visits to the plant and being on call. Also about this time an assistant to the safety director was hired. The medical and safety personnel at the Nitro plant remained the same during the time the Na 2,4,5-TCP and 2,4,5-T acid processes were operated (until 1969). Industrial hygiene activities at the Nitro plant remained at the corporate level throughout the time the Na 2,4,5-TCP and 2,4,5-T acid processes operated and consisted of plant inspections (usually annually) and recommendations.

Description of Past Exposure

The first evidence of exposure to 2,3,7,8-TCDD to the Monsanto workers appeared in the form of chloracne in those workers involved in the clean-up and repair of the Na 2,4,5-TCP process in Building 41 after the March 8th, 1949 accident. Within hours after the accident in which the autoclave reactor contents had been sprayed into the operating area, workers began repairing and cleaning Building 41. The operating areas, including neighboring processes, were covered with a fine black powder and a thick, sticky, dark brown substance. In an effort to clean up Building 41 the evening after the accident, the building and equipment were cleaned with water and steam and the autoclave was boiled out with caustic and water. Within days of the accident, workers began to develop chloracne. On March 15, 1949, the contaminated areas of Building 41 were washed with trichloroethylene. With an increasing number of people contracting chloracne, Building 41 was sprayed with sodium hypochlorite on May 27th and 30th and June 24th, 1949. This was done with the hope that the sodium hypochlorite would oxidize the phenolic materials which had contaminated the building. On August 3 and 4, 1949, the entire interior of Building 41 was washed throughly with water and on August 6 and 7, 1949, the entire interior of the building and surfaces of the equipment were spray painted with an aluminum paint. By October 1949, the Na 2,4,5-TCP process in Building 41 was back in operation.

The development of chloracne cases from this accident marked the beginning of the medical activities involving workers assigned to the Na 2,4,5-TCP and 2,4,5-T acid processes. On April 1, 1949, the part-time physician for the Nitro plant reviewed a summary of 21 cases and personally observed three patients.[12,17] Doctors from the U.S. Public Health Service and an industrial hygienist from the West Virginia Department of Health visited the Nitro plant for consultation and observation of chloracne patients on August 5, 1949.[17] During October 1949, four workers with severe cases of chloracne were sent to the University of Cincinnati for examinations and laboratory tests.[12] The examinations, tests, and consultations were under the direction of Drs. William Ashe and Raymond Suskind of the Kettering Laboratory in the Department of Preventive Medicine, College of Medicine, University of Cincinnati.

Drs. Ashe and Suskind[12] wrote a report dated December 5, 1949 summarizing their findings from the examinations and tests on the four Monsanto workers sent to them. In the summary of their report they indicated that, "It is our opinion that these men are suffering from systemic intoxication from a common agent arising out of their employment. This intoxication is characterized by acneform skin lesions, hepatitis, disturbed lipid metabolism, peripheral neuropathy, and probably mild central nervous system involvement. From the point of view of the morphologic dermatologist, the type of exposure and the resultant skin lesions may justify the diagnosis of chloracne. In the cases

herein reported metabolic and systemic manifestation other than the skin were prominent." The doctors also noted in their report that, "when these men are in a closed room together, there is a strong odor which suggests a phenolic compound, but cannot be identified with certainty. This odor is definitely not the odor of sweat nor the odor of the rancid fat in their skin lesions. While we have been unable to prove it, we believe that these men are excreting a foreign chemical through their skin." This initial examination lead to further examinations by these doctors.

Reexamination of the four workers previously examined in October 1949, plus examination of other workers with the same conditions was done by Drs. Ashe and Suskind in April 1950[13]. Similar to the initial examination, the findings of this examination showed that these workers had suffered from an intoxication which affected their skin and central nervous system as well as their respiratory tract, peripheral nerves, hepatic tissue, and sexual aspects of their endocrine system. The skin manifestations were characterized by a variety of acneform lesions and in some cases melanosis and phrynoderma. The central nervous system symptoms were those of irritability, nervousness, and insomnia. The respiratory problems were dyspnea and wheezing. The neurological minifestations were characterized by local pain and weakness which were associated with the histopathologic findings of peripheral neuropathy. The workers examined were also found to have a loss of libido and some impotence.

Cases of chloracne began to occur in workers who were not involved in the 1949 accident in Building 41. To address this situation and to follow-up on the previous work, Dr. Suskind[14] and others from the University of Cincinnati in April 1953, went to the Nitro plant to study workers with chloracne. Workers were chosen to represent two situations: 1) chloracne cases arising from involvement with the 1949 accident in Building 41 and 2) chloracne cases arising from regular operations of the Na 2,4,5-TCP and 2,4,5-T acid processes. A total of 36 workers were given examinations, with 11 workers contracting chloracne as a result of the 1949 accident and 25 contracting chloracne as a result of working in Na 2,4,5-TCP and 2,4,5-T acid production operations. The report lists the distribution of the symptoms found among the 36 workers examined:

Clinical Symptoms	Number of Workers
Cutaneous lesions	35*
Fatigue	21
Aches and pains	27
Dyspnea	9
Nervousness and irritability	17
Loss or decrease of libido	13
Vertigo	4

* One subject complained of pains, fatigue, and irritability, but never developed acne.

The conclusions of this study were: "Our positive findings at this time are limited to the skin. Symptomatically, it would appear that the substance (or substances) is capable of exerting a toxic effect on nerves as well as certain of the endocrines and, perhaps, on the liver. No evidence of hepatic dysfunction was found in the 36 workers examined, but changes which may have occurred in the acute or severe phase of the syndrome, could have subsided completely by the time of these examinations." In conjunction with the medical examinations of these workers, industrial hygiene surveys of the Na 2,4,5-TCP and 2,4,5-T acid processes were conducted.

Industrial hygienists from the University of Cincinnati, Kettering Laboratory, Department of Preventive Medicine and Industrial Health, College of Medicine conducted industrial hygiene surveys in Buildings 34 and 51 on April 14, 1953 and January 10, 1956[15,16]. These surveys were conducted to ascertain exposure levels for the workers in these buildings to chemicals used in the Na 2,4,5-TCP and 2,4,5-T acid processes. Samples of air were collected at all locations where workers were stationed permanently or at equipment which required the frequent attention of the workers. Vapors of halogenated hydrocarbons were sampled by decomposing the vapor in a Wilson furnace and collecting the liberated chlorine and hydrogen chloride in a impinger containing 0.1 N sodium hydroxide and 0.005 gm/ml of arsenious oxide. The impinger solutions were returned to the university for analysis by a turbidimetric procedure following precipitation of the chloride by silver nitrate solution. Because of the hazard of fire from the methanol used in the Na 2,4,5-TCP process in Building 51, air samples were collected in Building 51 using a sintered glass impinger containing 95% ethanol. The alcohol solutions were analyzed by burning away a portion of the alcohol in a device similar to that used for the determination of sulfur in petroleum products, with combustion products being collected and analyzed for chloride as described previously.

The results of the two University of Cincinnati industrial hygiene surveys are listed in Tables 16, 17, and 18. Table 16 lists the organic chloride concentration for air samples collected in Building 51 on April 14, 1953. The concentrations of organic chloride in the four air samples collected in Building 51 ranged from <0.10 to 18.1 parts chloride per million parts air (ppm). The 18.1 ppm sample was collected in the control room where the operator spent a majority of his time and would represent a concentration of 4.5 ppm if the vapor was composed of TCB or a concentration of 6.0 ppm if the vapors were Na 2,4,5,-TCP.

Table 17 list the results of the organic chloride concentrations for air samples collected in Building 34 on April 14, 1953 and January 10, 1956. The organic chloride concentrations in the 20 air samples collected at the various operations throughout the 2,4,5-T acid process in Building 34 ranged from <0.10 to 7.50 ppm. Two of the higher organic chloride concentrations for both sampling dates were collected on the reactor platform while loading the reactor with Na 2,4,5-TCP and NaMCA solution and testing the solution pH. Results showed organic chloride concentrations of 5.60 and 2.25 ppm for the dates April 14, 1953 and January 10, 1956, respectively. The mean of the nine samples collected in 1953 was 1.18 ppm while the mean for the eleven samples collected in 1956 was 1.89 ppm.

Dust samples were also collected during the industrial hygiene surveys conducted by the University of Cincinnati industrial hygienist. The dust samples were collected using high volume (7 cubic feet of air per minute) air samples and a paper filter [Whatman 41, 105 millimeter (mm) diameter] in 1953 and a glass fiber filter (105 mm diameter) in 1956. The filters in both cases were digested with alcohol and the chloride was determined following combustion of the alcohol as described previously. The results of these samples are listed in Table 18, and ranged from 0.20 to 2.57 mg of 2,4,5-T acid per cubic meter of air (mg/m^3). Four dust samples were collected in the drying and packaging areas of the 2,4,5-T acid process in Building 34 in 1953 and gave a geometeric mean value of 1.26 mg/m^3. Five dust samples were collected in the drying and packaging areas of the 2,4,5-T acid process in Building 34 in 1956 as well as in the centrifuge and acidifier areas of the process. The results of these samples gave a geometric mean value of 0.79 mg/m^3.

Several observations, comments, and recommendations were made by the University of Cincinnati industrial hygienist in reports resulting from the survey conducted at the Nitro plant in the Na 2,4,5-TCP and 2,4,5-T acid processes in the years 1953 and 1956. In the 1953 report, the hygienists noted that the odors of halogenated hydrocarbons were always detected at all locations in both buildings (Buildings 34 and 51). The hygienists noted that the workers in these processes invariably wore gloves when working at locations where skin contact was possible and that rubber boots and aprons were also worn when suspected equipment was being cleaned (filter press, Building 51). The greatest opportunity for contact to process materials occurred when the operators dug down the suspended centrifuge (Figure 12) removing solid material from the sides of the centrifuge. The hygienist concluded that skin contact with process materials provided greater opportunities for exposure than the suspension of vapors and dust in the atmosphere.

A comparison of the findings in 1956 survey compared to those in the 1953 survey led the University of Cincinnati industrial hygienist to conclude that the concentrations of dust and vapors in Building 34, the 2,4,5-T acid process, had not changed appreciably during this time. Some changes made which the hygienist felt might reduce exposure to process materials were the replacement of the filter press in the Na 2,4,5-TCP process with a settling tank, the elimination of the Alsop filters, the addition of a mechanical clapper to the throat of the duct leading to the rotary dryer feed hopper in the 2,4,5-T acid process, and the addition of exhaust ventilation at the centrifuges, settling boxes and in the reactor room in the 2,4,5-T acid process.

The West Virginia State Department of Health, Bureau of Industrial Hygiene collected air samples for 2,4,5-T acid in the 2,4,5-T acid process area in Building 34 on June 8, 1954. These samples were collected using Greenburg-Smith impingers at a sampling rate of one cubic foot per minute. No information was available on the sampling media used in the impingers or the analytical procedures used to measure the concentrations of 2,4,5-T acid. The

results are listed in Table 19. The concentrations of ten 2,4,5-T acid air samples from various process areas ranged from 0.02 to 1.06 mg of 2,4,5-T acid per cubic meter of air (mg/m^3) with a geometric mean of value of 0.17 mg/m^3. The highest concentration was found near a centrifuge during unloading and the lowest concentration was found near a centrifuge during loading.

In September 1952, a corporate industrial hygienist and the plant safety director from Monsanto conducted a walk-through survey of the plant. A report[9], from November 1952, resulted from this survey and inventoried the chemicals used and produced in the various processes throughout the Nitro plant and reported the number of workers involved with the various processes. Remarks included in the report pertaining to 2,4,5-T acid and Na 2,4,5-TCP operations indicated that clothing changes, showers, gloves, and respirators were provided for the workers involved in the 2,4,5-T acid process.

A survey of the Na 2,4,5-TCP and 2,4,5-T acid process at the Nitro plant was conducted from November 12 through November 14, 1952 by Drs. Donald Birmingham and Cleveland Denton of the Division of Occupational Health, U.S. Public Health Service[17]. The survey consisted of walking through the processes of interest and dermatological examination of six workers with chloracne of varying severity. The cases were presented by the plant physician as representative of about 80 cases present in the plant. The authors concluded that all chloracne cases had, in common, exposure to the physical facility or to the operation of making the chlorinated hydrocarbon intermediate (sodium 2,4,5-TCP) for the herbicide.

From the walk-through the following observations were made as to where dermatologic hazards existed in the Na 2,4,5-TCP and 2,4,5-T acid processes:

1. Cleaning the filter press in the Na 2,4,5-TCP process.
2. Cleaning the Alsop filters.
3. Removing solid materials from the centrifuges.
4. Drying, grinding, and packaging the 2,4,5-T acid product.

From the dermatological examinations the investigators found those workers most severely afflicted had comedones, small yellow papules, and yellow colored cystic lesions about the face, neck, shoulders, and scattered papular and follicular lesions on the trunk and lower extermities. The workers less severely affected by chloracne showed comedones and small yellow papules in a typical symmetrical distribution in the skin overlying the lateral portions of the orbits and along each zygoma. Three of the workers with chloracne examined complained of malaise, weakness, weight loss, painful joints, and loss of libido.

Some of the recommendations made by the Public Health Service investigators included the following:

1. The entire operation involving chlorinated hydrocarbons should be isolated from those workers not directly concerned with these processes (Na 2,4,5-TCP and 2,4,5-T acid).

2. Workers associated in any way with the manufacture of Na 2,4,5-TCP should have a detailed work history record. If possible, the worker should be maintained at one specific job.
3. A complete daily change of work clothing, including underwear, coveralls, gloves, and caps should be given to each worker.
4. The company should continue its practice of laundering all the work clothes.
5. Two lockers should be provided; one for street clothes and the other for work uniforms.
6. Wash periods should be scheduled on company time. Workers must wash before lunch and before leaving work.
7. Workers should use the eating facilities away from the work area at all times.

In March 1960, a corporate industrial hygienist from Monsanto conducted a survey similar to the one Monsanto conducted in 1952[10]. The 2,4,5-T acid and Na 2,4,5-TCP process were in Buildings 34 and 51, respectively, at the time of this survey. Recommendations for corrective action made as a result of this survey and pertaining to the 2,4,5-T acid and Na 2,4,5-TCP processes are as follows:

1. Building 34-(2,4,5-T): The hand sticking of the sodium 2,4,5-T reactors must be stopped.
2. Building 34-(2,4,5-T): There are two Fletcher centrifugals on the sodium 2,4,5-T line that supposedly are ventilated. These centrifugals are ploughed and finished off by hand. It is recommended that automatic ploughed centrifugals be utilized in this operation.
3. Building 34-(2,4,5-T): The sodium 2,4,5-T slurry storage tank foams through the agitator packing gland. This foam and the dust from the dried foam contaminate the area. It is recommended that this packing gland be replaced with some material that will prevent this foaming out through the gland.
4. Building 34-(2,4,5-T): The bagging equipment is not exhaust ventilated. It is recommended that this be done.
5. Building 34-(2,4,5-T): When the final product centrifugal is in operation, vapors and mist are badly splashed and projected all over the department. This operation, along with the general dust conditions, is probably the major exposure in this department. It is recommended that this centrifugal be properly equipped to prevent misting and that provisions be made to eliminate the necessity for hand digging this machine.
6. Building 34-(2,4,5-T): The dust collection and handling facilities should be thoroughly checked for leaks and other dust sources and should be repaired to eliminate these sources as soon as possible.
7. Building 51-(Na 2,4,5,-TCP): The still autoclave is opened after the methanol has been flashed off. The contents of the vessel are checked and water is added to make a sodium 2,4,5-trichlorophenate of a certain concentration. When the reactor is open, there is very little fuming. No chloracne cases have been traced to this operation.

A similar survey was done by Monsanto in 1968[11]. The Na 2,4,5-TCP and 2,4,5-T acid process were housed in Building 92 at this time. Recommendations made as a result of this survey pertaining to these processes were to keep all filters closed and that the exhaust ventilation system be redesigned.

Three epidemiological studies have been conducted involving the workers from the Na 2,4,5-TCP and 2,4,5-T acid processes at the Nitro plant. In 1980, Zack and Suskind[18] conducted a standardized mortality analysis on workers exposed to 2,3,7,8-TCDD as a result of the Na 2,4,5-TCP accident in Building 41 in 1949. One hundred and twenty-one workers were included in this study with a follow-up of this group 100% complete. The conclusions of the investigators of this study were that since the size of the cohort was small and the number of deaths was relatively small, the results of the study could not be considered conclusive.

The second epidemiological study conducted on the 2,4,5-T acid and 2,4,5-T acid process workers was a clinical epidemiologic study conducted by Raymond Suskind and V.S. Hertzberg[19] in 1979. The clinical study was conducted to determine the long-term health effects of workplace exposure to the process of manufacturing 2,4,5-T acid including contaminants such as 2,3,7,8-TCDD. The population consisted of two cohorts: 204 clearly exposed workers and 163 workers not exposed. There were 176 workers with a history of or the presence of chloracne. Chloracne occurred more frequently in the exposed workers, 86.27%, as compared to the unexposed workers, 0.00%. Among 86.27% chloracne cases, clinical evidence of chloracne persisted in 55.7%. None of the unexposed workers experienced chloracne development. An association was found between the persistence of chloracne and the presence and severity of actinic elastosis of the skin. There was an association between exposure and the history of gastrointestinal tract ulcer. Pulmonary function values among those who were exposed and who currently smoked were lower than those workers who were not exposed and who currently smoked. The researchers concluded that the data assembled in the study indicated no evidence of increase risk for cardiovascular disease, hepatic disease, renal damage, or central or peripheral nervous system problems.

A third epidemiological study was conducted by Zack and Gaffey[20] in 1980. A standard mortality analysis was conducted on 844 workers at the Nitro facility between 1951 and 1977. A subset of 163 decedents exposed to 2,3,7,8-TCDD as a result of being assigned to an area of the Na 2,4,5-TCP and/or 2,4,5-T acid production processes was examined in a proportional mortality analysis. The authors concluded that although lung cancer was somewhat higher in the exposed group, the proportional mortality analysis of decendents by 2,4,5-T acid exposure indicated no unusual patterns of mortality in the 2,4,5-T acid exposed.

Descriptions of 2,3,7,8-TCDD Concentrations in 2,4,5-T Acid

Monsanto 2,4,5-T acid has been analyzed for 2,3,7,8-TCDD concentrations by Monsanto and others. Listed in Table 20 are the results of analyses of Monsanto 2,4,5-T acid obtained from Monsanto, Dow, the U.S. Air Force, and the U.S. Department of Agriculture. The results listed in Table 20 are summarized in Table 21.

From the documents and data received from the company, it appears Monsanto began to analyze their 2,4,5-T acid in 1965. The analytical procedures used to analyze 2,4,5-T acid for 2,3,7,8-TCDD concentration appear to have remained the same throughout the time the 2,4,5-T process was operated. Ten grams of 2,4,5-T acid product was weighed out and added to 10 ml of chloroform. This mixture was then shaken for ten minutes, filtered, and washed with 5 ml of chloroform. The filtrate coming from the filter was collected, 5 ml of 2 molar NaOH solution was added to it, and the mixture was shaken for ten minutes. The mixture was then diluted with 10 ml of water, centrifuged, and the organic layer was drawn off. The organic layer collected from the centrifuge was evaporated down to 2 ml and 40 microliters was injected into a gas chromatograph containing a 2 meter column packed with chromosorb and having an operating temperature of 250°C, an injector temperature of 330°C, a block temperature of 320°C, and retention time of 2.6 min for 2,3,7,8-TCDD using flame ionization detection.

Monsanto saved 2,4,5-T acid samples for the years 1958, 1959, 1960, 1961, 1962, 1963, and 1964 and analyzed them in 1965. These results as well as results of analyses conducted after 1965 by Monsanto and other investigators are summarized in Table 21. From 1958 to 1964, 2,3,7,8-TCDD concentrations in 2,4,5-T acid ranged from 5 to 12 micrograms (ug) 2,3,7,8-TCDD/gram (g) 2,4,5-T acid. Starting in 1965 and continuing until 2,4,5-T acid production stopped in 1969, Monsanto routinely analyzed their 2,4,5-T acid for it's 2,3,7,8-TCDD concentration. In 1965, 17 analyses of 2,4,5-T acid for 2,3,7,8-TCDD concentration were conducted and yielded results ranging from 5 to 55 ug/g with an arithmetic mean of 23.8 ug/g. Twenty-seven analyses of 2,4,5-T acid were analyzed in 1966 with results ranging from 3 to 28 ug/g and an arithmetic mean of 10.5 ug/g. In 1967, 117 samples were analyzed with 8 samples yielding non-detectable levels at a detection limit of 1 ug/g and 109 results ranging from 1 to 25 ug/g and an arithmetic mean of 9 ug/g. In 1968, 29 samples were analyzed. Twelve of the 29 analyses results were below the detection limit of 3 ug/g while 17 of the results ranged from 3 to 12 ug/g with an arithmetic mean of 3.4 ug/g. The last year that Monsanto produced 2,4,5-T acid at their Nitro plant was 1969. Eighty-two samples of 2,4,5-T acid produced in 1969 were analyzed and all were detectable, ranging from 0.3 to 22 ug/g and an arithmetic mean of 2.0 ug/g.

The Dow Chemical Company analyzed samples of Monsanto 2,4,5-T acid manufactured before 1965 and in 1969 for 2,3,7,8-TCDD concentration. Thirteen analyses of Monsanto 2,4,5-T acid by Dow in 1965 had results ranging from 6.5 to 11 ug/g. In 1970, Dow analyzed a sample of Monsanto 2,4,5-T acid for 2,3,7,8-TCDD concentration and found a concentration of 1.4 ug/g. In addition to these analyses, Dow also analyzed Monsanto Agent Orange (50% 2,4,5-T ester and 50% 2,4-D ester) for the U.S. Air Force in 1972. Six analyses of Monsanto Agent Orange were done by Dow and the results ranged from 6.9 to 9.3 ug 2,3,7,8-TCDD/g of 2,4,5-T acid and an arithmetic mean of 7.6 ug/g.

Monsanto 2,4,5-T acid and 2,4,5-T ester were analyzed for 2,3,7,8-TCDD concentration by the U.S. Department of Agriculture (U.S.D.A.)[21]. In three 2,4,5-T ester samples manufactured from Monsanto 2,4,5-T acid produced in 1967

the results ranged from 14.1 to 34 ug/g and an arithmetic mean of 20.8 ug/g. Three Monsanto 2,4,5-T acid samples manufactured in 1968 and analyzed by the U.S.D.A. had results ranging from 12 to 24 ug/g and an arithmetic mean of 16.3 ug/g. Six samples of Monsanto 2,4,5-T acid manufactured in 1969 were analyzed with results ranging from 1.9 to 6.8 ug/g and an arithmetic mean of 4.0 ug/g.

Description and Use of Personnel Records

Personnel records were the primary source for identifying exposed workers for inclusion in the NIOSH Dioxin Registry study. Monsanto supplied the records to NIOSH on computer tapes. The Nitro cohort consists of all hourly workers ever assigned to the production of 2,4,5-T or 2,4,5-TCP between October 4, 1948, and December 31, 1969. Salaried workers and maintenance workers from the central pool were not included, since it was not possible to identify which individuals worked in the relevant processes.

Additionally, as stipulated in the study protocol, all individuals identified by the company as having had exposure were included. This included individuals identified in studies published by the company[18-20], in unpublished studies,[12-17] and in several internal company documents.[22,23] Records of individuals who were identified as having chloracne not related to the 1949 accident[23] are being reviewed for evidence of exposure. Only those individuals with a record of exposure will be included in the cohort. Personnel records for all hourly employees who terminated after 1955 are maintained in the Personnel Office. Personnel files were located for all but 4 individuals of the Nitro cohort. The personnel folders contain application forms, job transfer forms, a service record containing a chronological listing of all jobs held, and miscellaneous additional information. Most folders have job transfer forms dating back to the date first employed. For active employees, the service card is maintained in the Personnel Office separate from the file. Records for active, retired, and terminated/deceased hourly employees are maintained in separate files. There are records for approximately 370 active employees, 320 retired employees, and 310 deceased and terminated employees. In addition, there is a separate file of approximately 450 folders for individuals with termination dates prior to 1955. Files for salaried employees are maintained in a separate personnel office. Similar information is present in the folders of salaried employees, except there is no chronological listing of job titles.

Payroll records maintained since 1955 were used by the plant epidemiologist to verify that the plant personnel records are complete for all persons ever employed at the plant. Personnel folders for the period 1955 to 1979 were missing only for approximately 13 people. Since this verification was not conducted for the 450 folders of individuals with termination dates prior to 1955, NIOSH staff reviewed the contents and concluded that based upon the small number of hourly workers ever employed at the Nitro facility after 1955 (about 1000), the variety of dates of hire and termination, and the presence of names beginning with all letters of the alphabet, that the boxes were possibly quite complete.

Monsanto has computerized the content of the service cards for all hourly workers who worked after 1955. Over the years, several computer tapes were sent to NIOSH containing the complete work history records for all individuals in the Nitro dioxin cohort. Much effort has gone into verifying the accuracy of the work history information and the identification of the individuals in the cohort. In 1985, the Monsanto plant epidemiologist conducted an audit of an 8% sample of the records computerized for all employees who worked between 1955 and 1977. In 1988, NIOSH staff scrutinized a 10% sample of the records of the dioxin cohort. No errors were found in transcription of information from the service cards to the computerized system. NIOSH staff also reviewed the job transfer slips in the folders of the 10% sample, and compared the content to the information on the service card. There were no errors, although one additional temporary assignment was found recorded on a job transfer slip. Records of 10% of the employees not in the cohort were also sampled, but no additional indication of a job assignment to a building contaminated with 2,3,7,8-TCDD was found.

Description and Use of Records With Medical Information

All medical and worker compensation records are located in the medical building. Medical records were found for all but 21 individuals in the Nitro cohort. The files are quite extensive and contain the employees' medical records (including pre-employment and interim physical reports). Separate files are maintained for each individual's worker compensation records and for records relevant to the para-aminobiphenyl monitoring program. Microfilmed copies of the medical records were sent to NIOSH by Monsanto for members of the cohort. In 1988, NIOSH staff reviewed the medical filesmaintained by Monsanto to obtain records for individuals for whom no records were received. Unpublished studies, described earlier in this report, also contained medical descriptions for some people[12-17].

The medical and worker compensation records are being reviewed for indications of chloracne. Monsanto provided a list of individuals who had chloracne associated with the 1949 accident[19], and also identified individuals with chloracne "not related to" the accident. The list was initially compiled by Monsanto staff in the late 1940's and 50's from safety memos and from the daily treatment log of the dispensary. The final list was compiled by a Monsanto epidemiologist in the 1970's.[23] In addition, another list was provided of maintenance men who were exposed following the accident but who did not develop chloracne.[22] Individuals who had choracne will be analyzed as a separate subcohort, as indicated in the study protocol.

A second (separate) utilization of records with medical information involved scrutiny for entries noting days of assignment to exposed departments, because such assignments appear on many worker compensation forms and accident records and in some medical reviews. This approach was used to identify assignments to TCP and 2,4,5-T buildings, and duration of exposure only for individuals identified as exposed by Monsanto, but for whom we had no other record of assignment. A unique NIOSH department code was used to code these assignments. In many instances the duration of assignment was probably greatly underestimated, since only the date of the accident report was coded.

Conclusions

Based on the information, documents and data collected from Monsanto on the Na 2,4,5-TCP and 2,4,5-T acid production process at the Nitro, West Virginia plant, the workers involved in these operations are suitable for inclusion in the NIOSH Dioxin Registry study. From the personnel and other records, work histories for those workers involved in Na 2,4,5-TCP and 2,4,5-T acid operations can be constructed. The SMPs and other process information provided descriptions of tasks performed in the various processes through the years they were operated. Analytical data measuring 2,3,7,8-TCDD concentrations in 2,4,5-T acid are available for the years 1958 through 1969. With the work history data, the knowledge of the tasks performed, and the 2,3,7,8-TCDD concentration in the 2,4,5-T acid, estimates of exposure to 2,3,7,8-TCDD to the Monsanto Nitro workers relative to the other workers included in the NIOSH Dioxin Registry will be made.

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Appendix A

Monsanto Company
Nitro, West Virginia

Figures 1 through 19

Figure 1
Plant Layout
Monsanto Company
Nitro, West Virginia
1945

Figure 2
Plant Layout
Monsanto Company
Nitro, West Virginia

1970

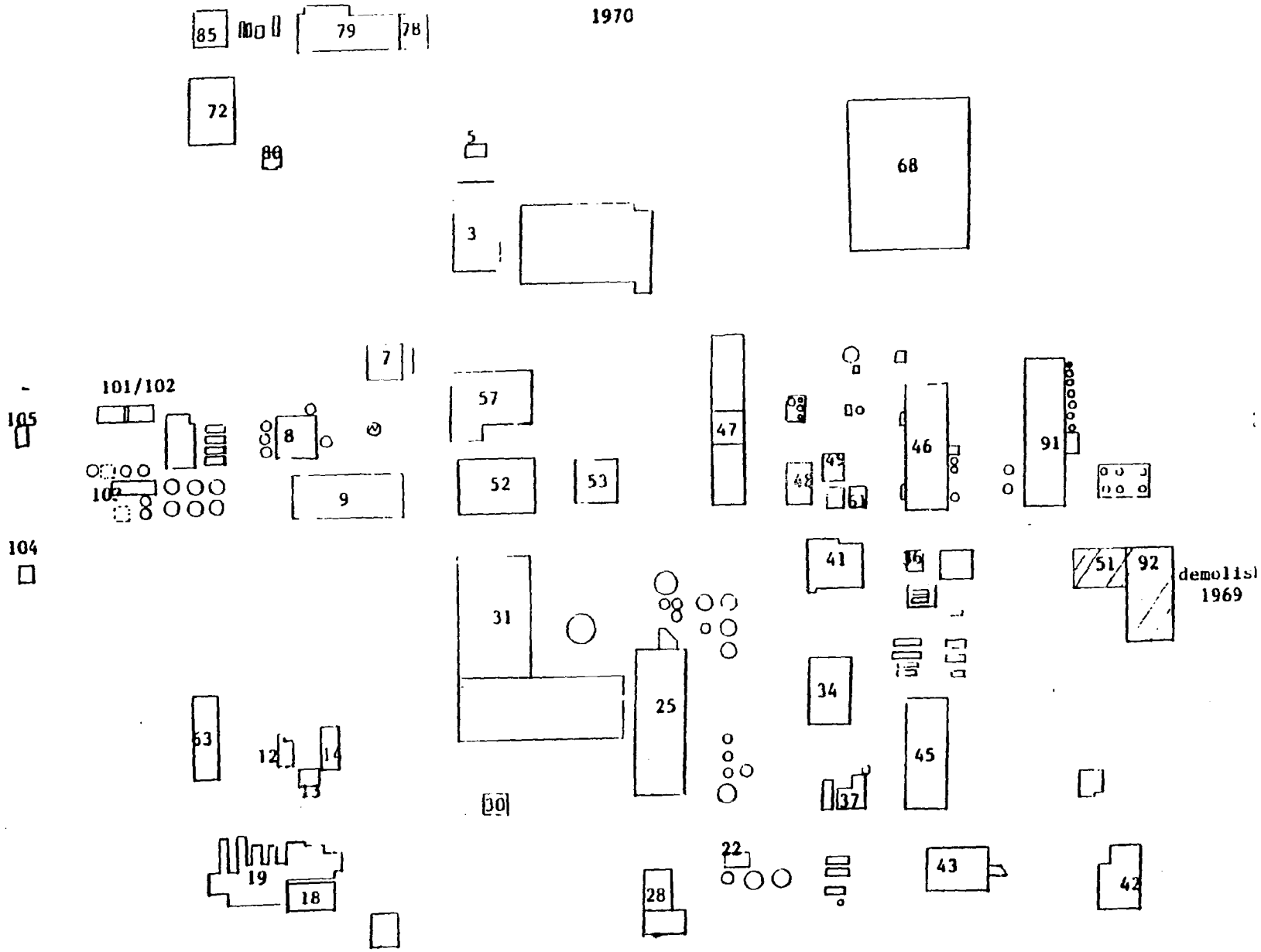
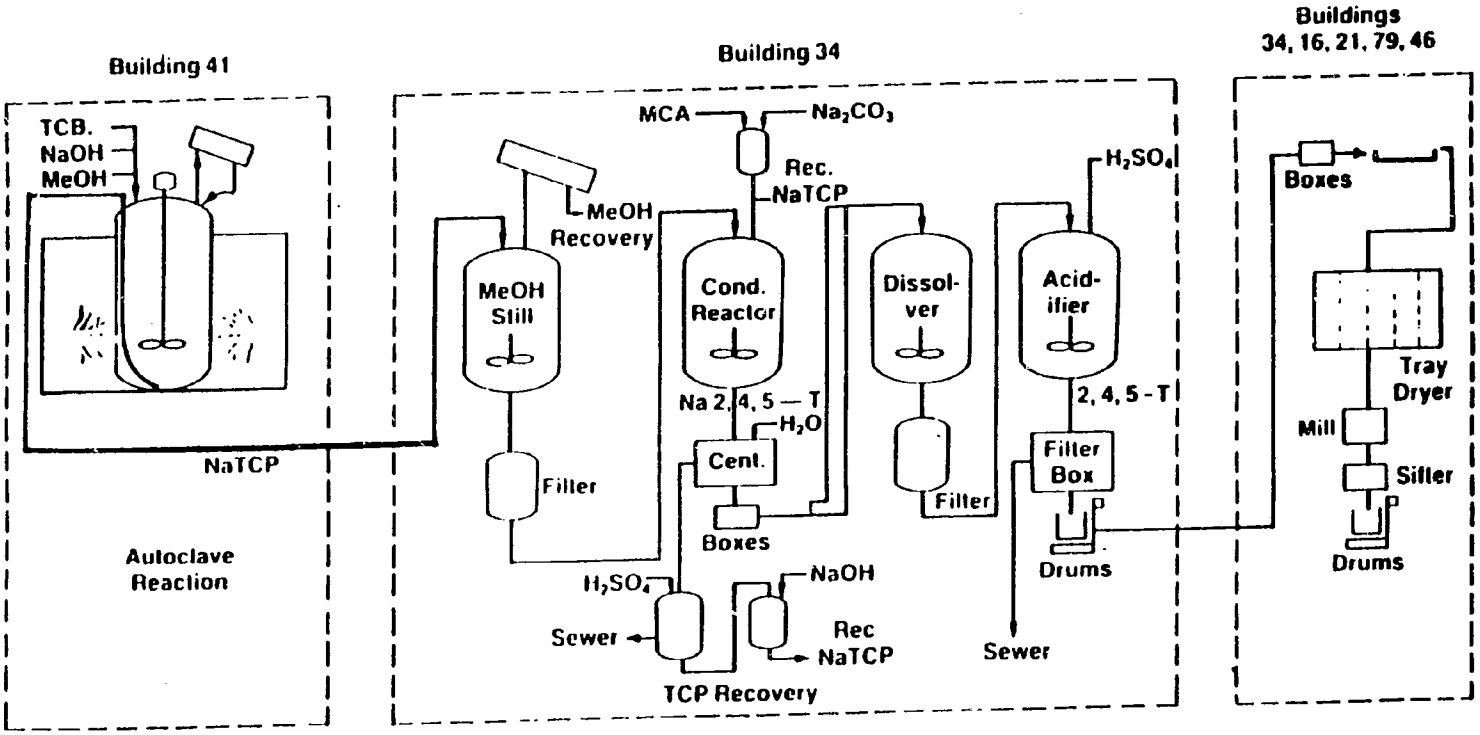
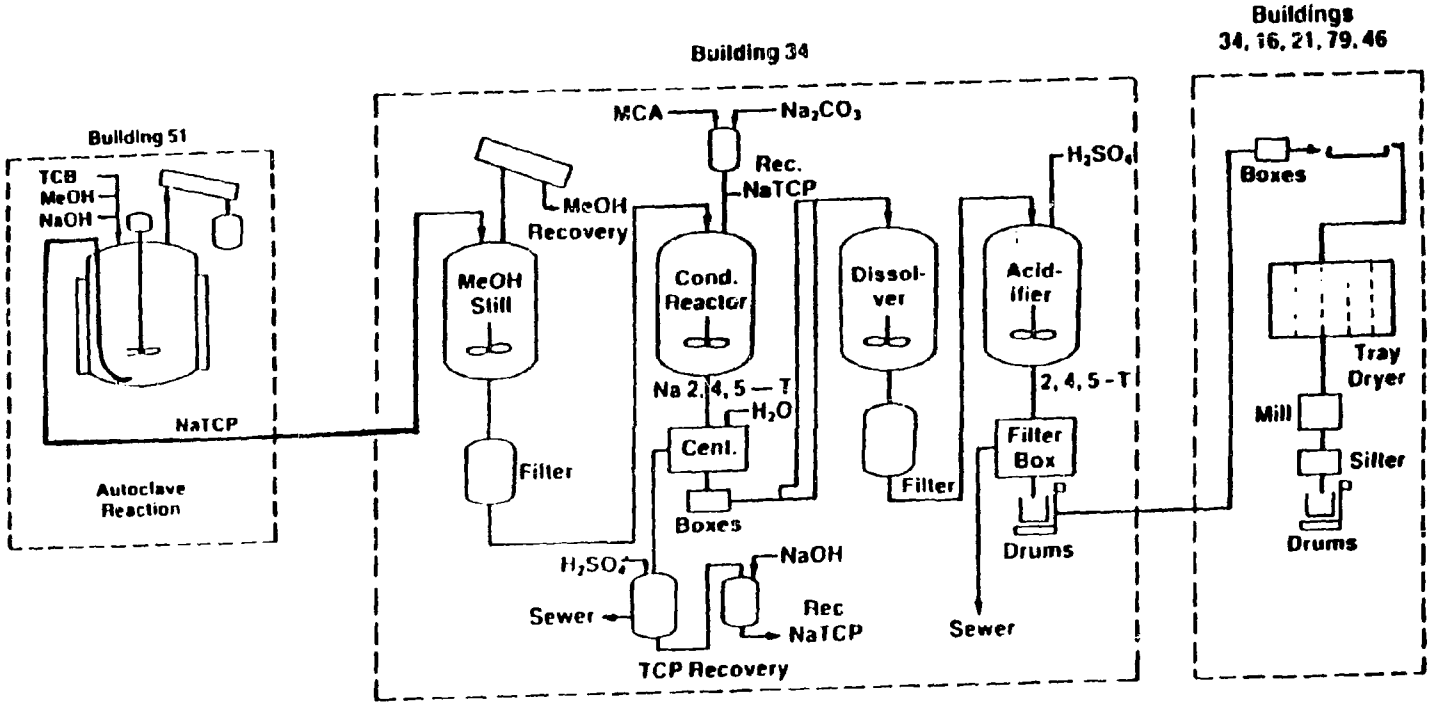


Figure 3
Na 2,4,5,-TCP and 2,4,5-T Acid Processes
Block Flow Diagram
Monsanto Company
Nitro, West Virginia
1948-1950 era



Na 2,4,5,-TCP and 2,4,5-T Acid Processes
Block Flow Diagram
Monsanto Company
Nitro, West Virginia
1950-1951 era



Na 2,4,5,-TCP and 2,4,5-T Acid Processes
Block Flow Diagram
Monsanto Company
Nitro, West Virginia
1951-1953 era

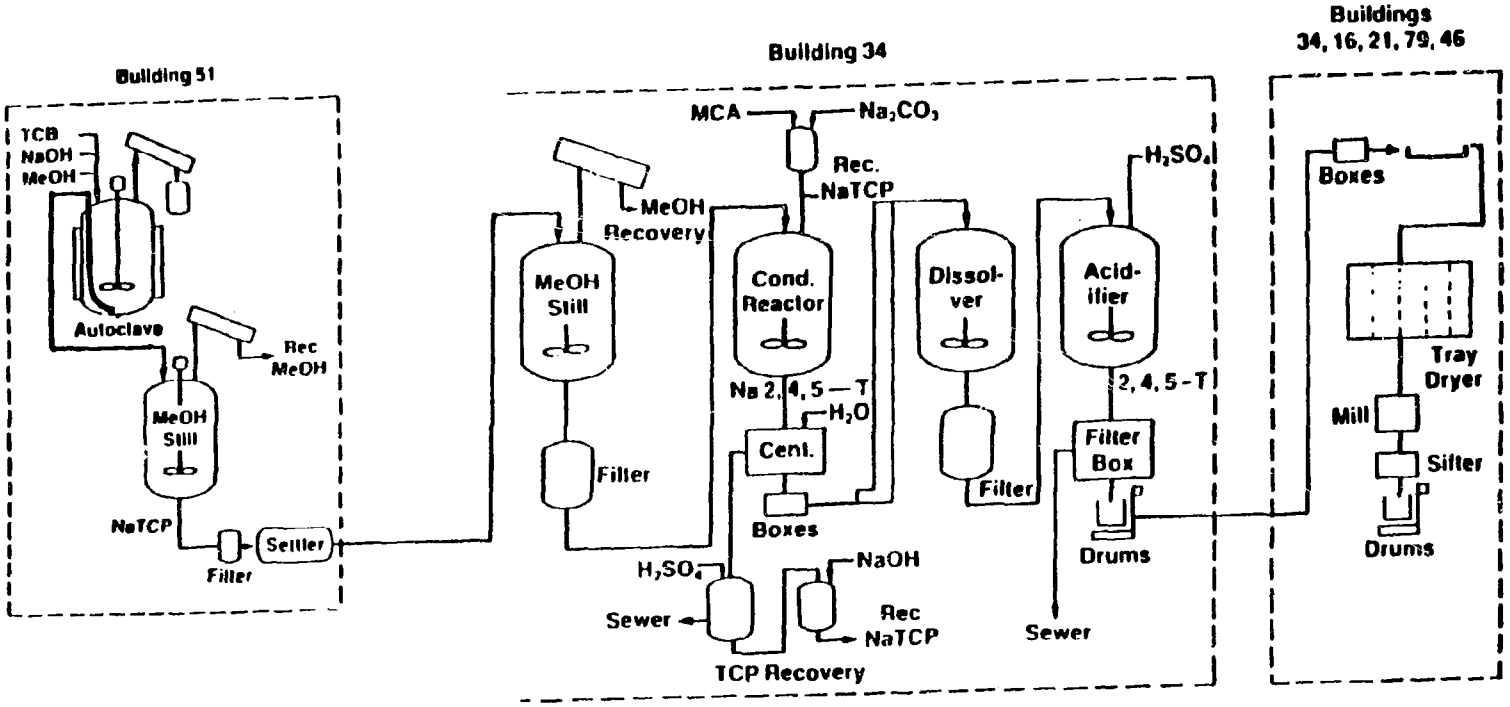


Figure
Na 2,4,5,-TCP and 2,4,5-T Acid Processes
Block Flow Diagram
Monsanto Company
Nitro, West Virginia
1953-1957 era

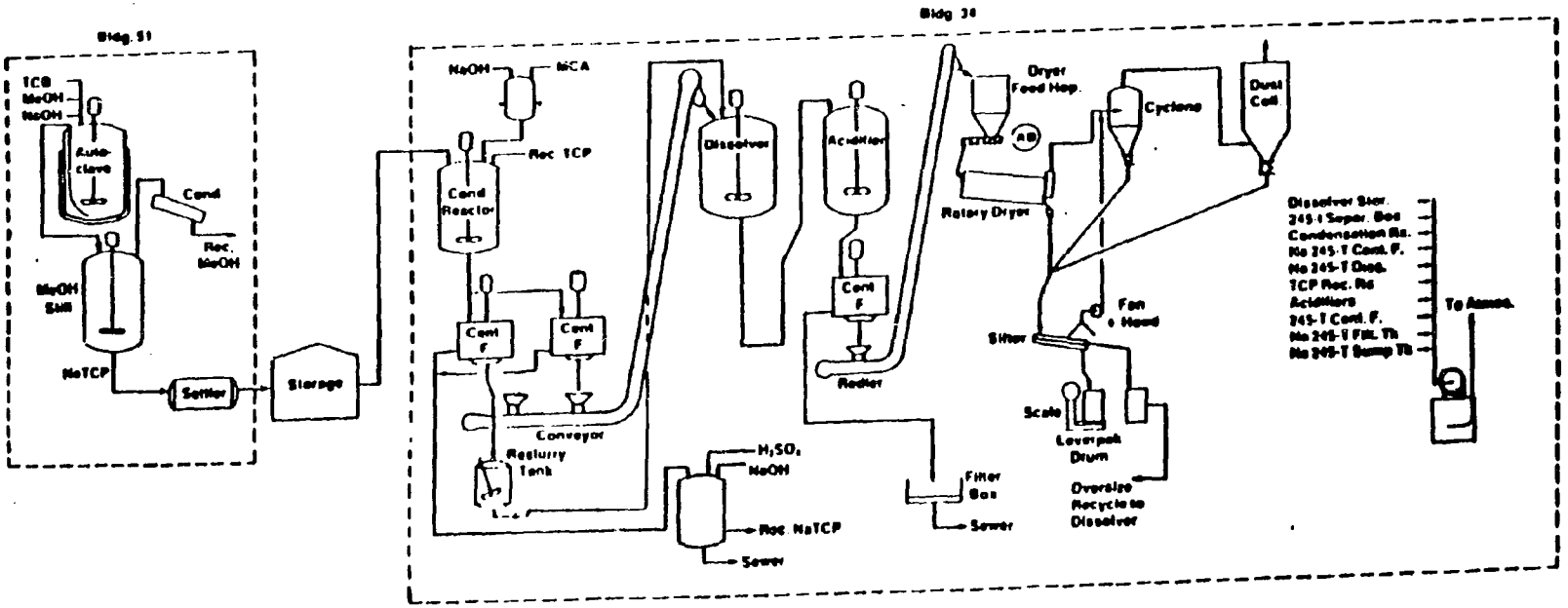
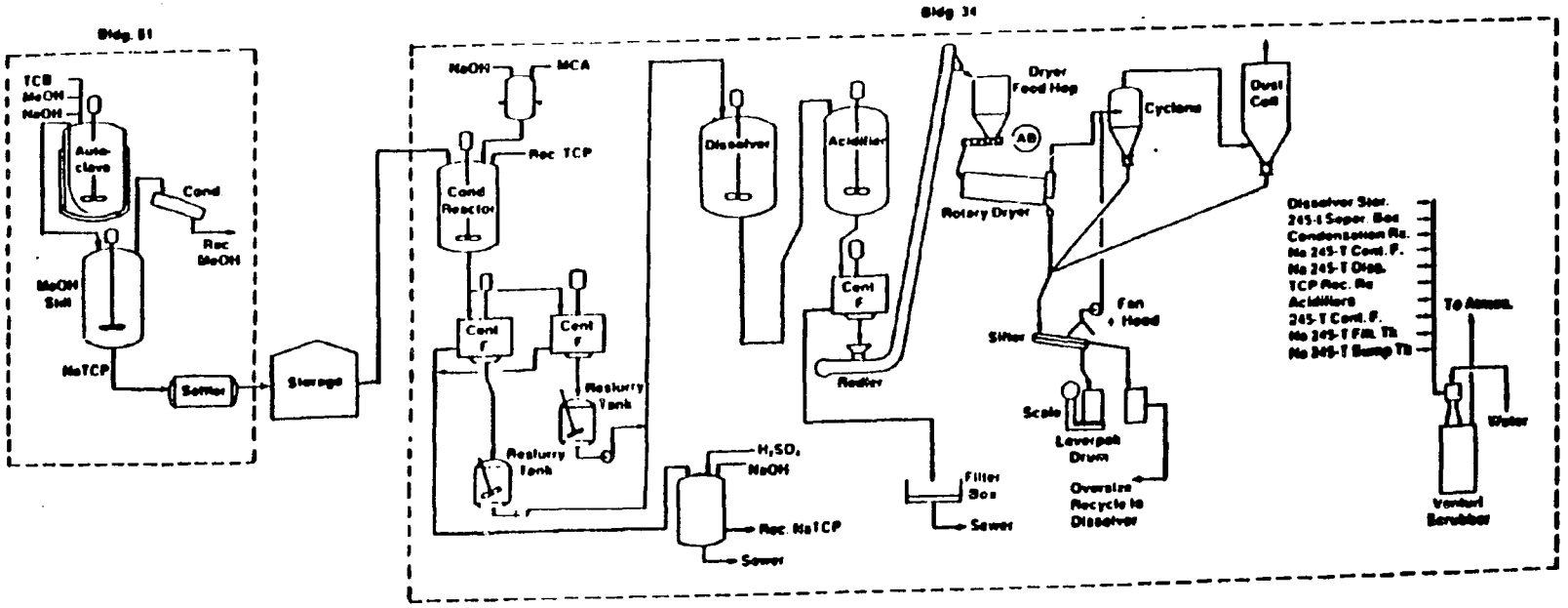


Figure 7
Na 2,4,5,-TCP and 2,4,5-T Acid Processes
Block Flow Diagram
Monsanto Company
Nitro, West Virginia
1958-1961 era



Na 2,4,5,-TCP and 2,4,5-T Acid Processes
Block Flow Diagram
Monsanto Company
Nitro, West Virginia
1962 era

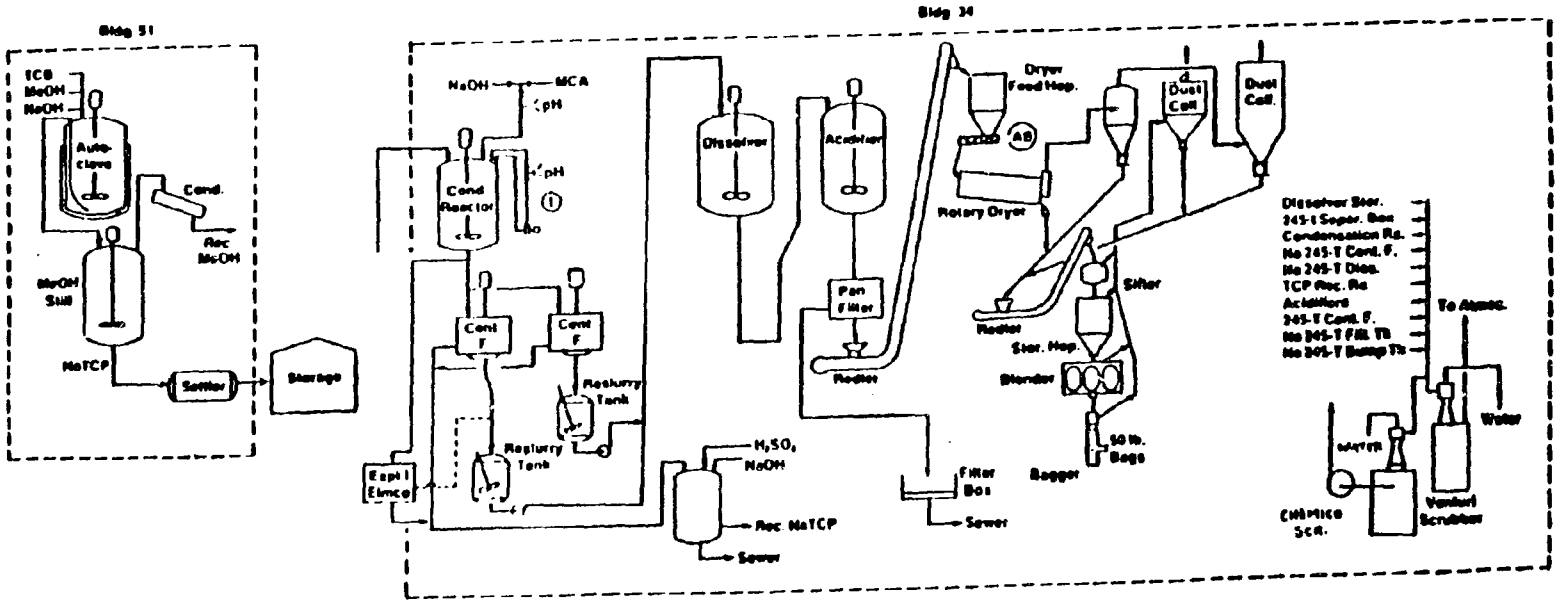


Figure 9
Building 51 Layout
Monsanto Company
Nitro, West Virginia
1950-1962

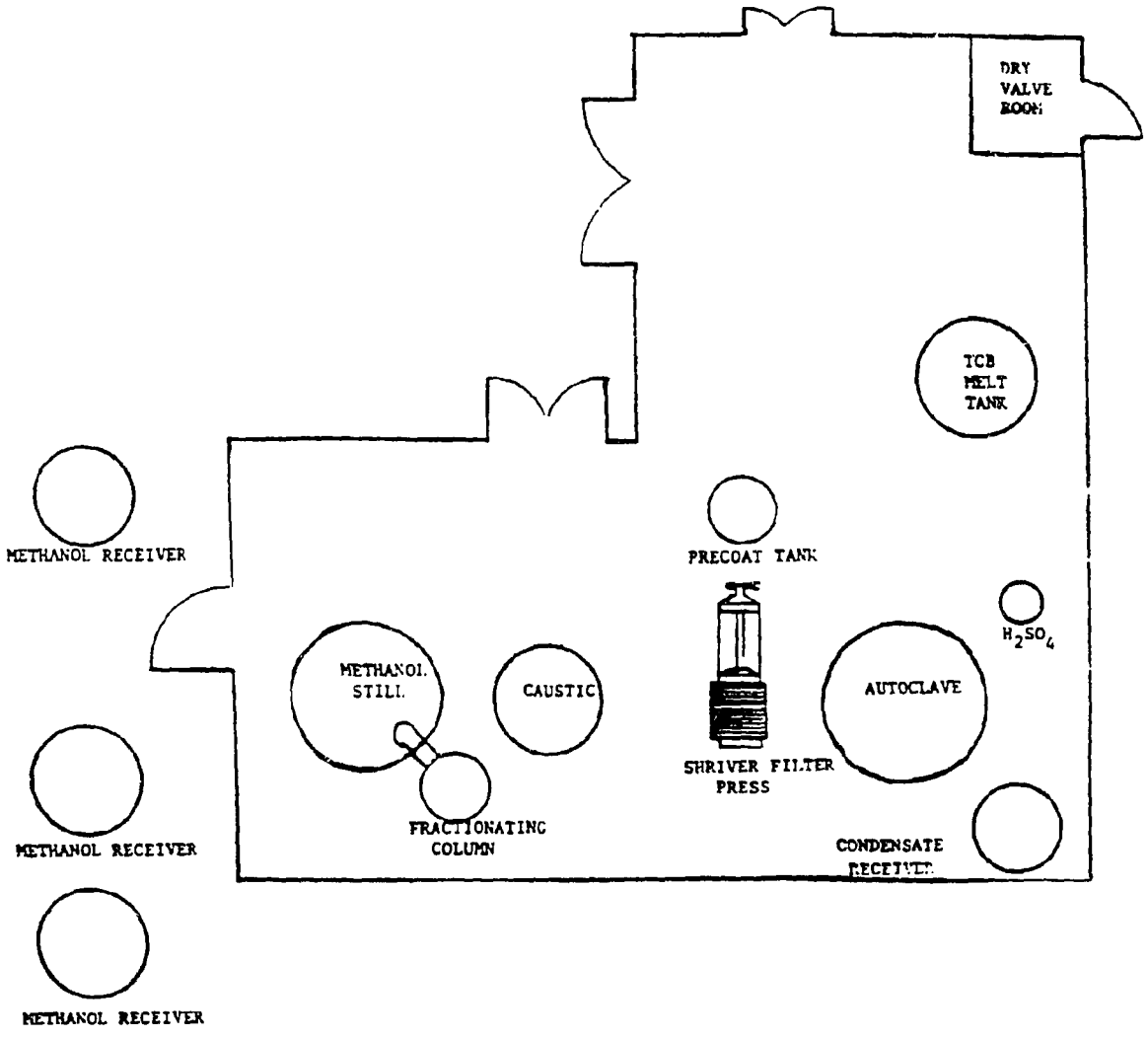


Figure 10
Building 34 Layout
Monsanto Company, Nitro, West Virginia
1948-1962

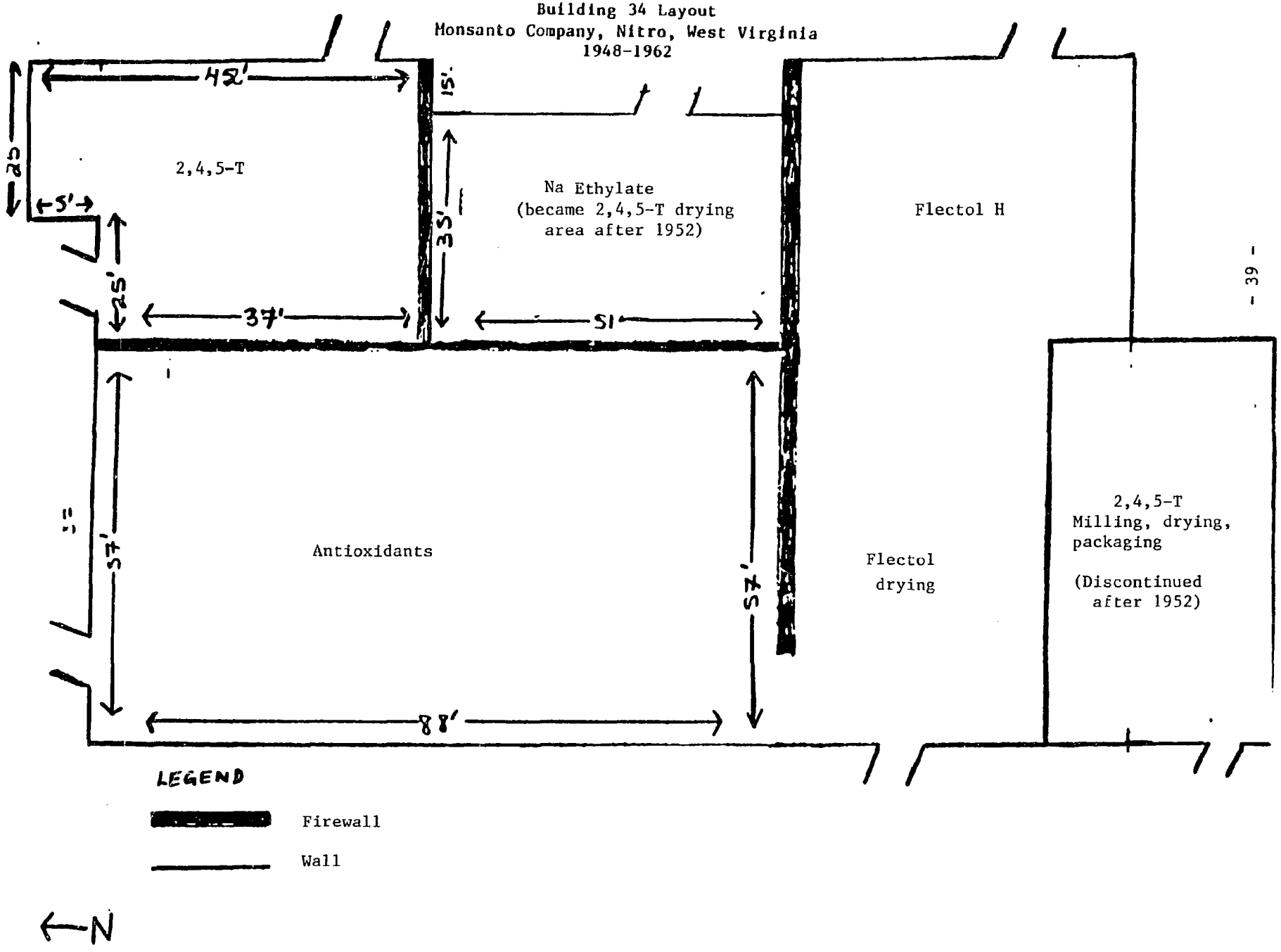
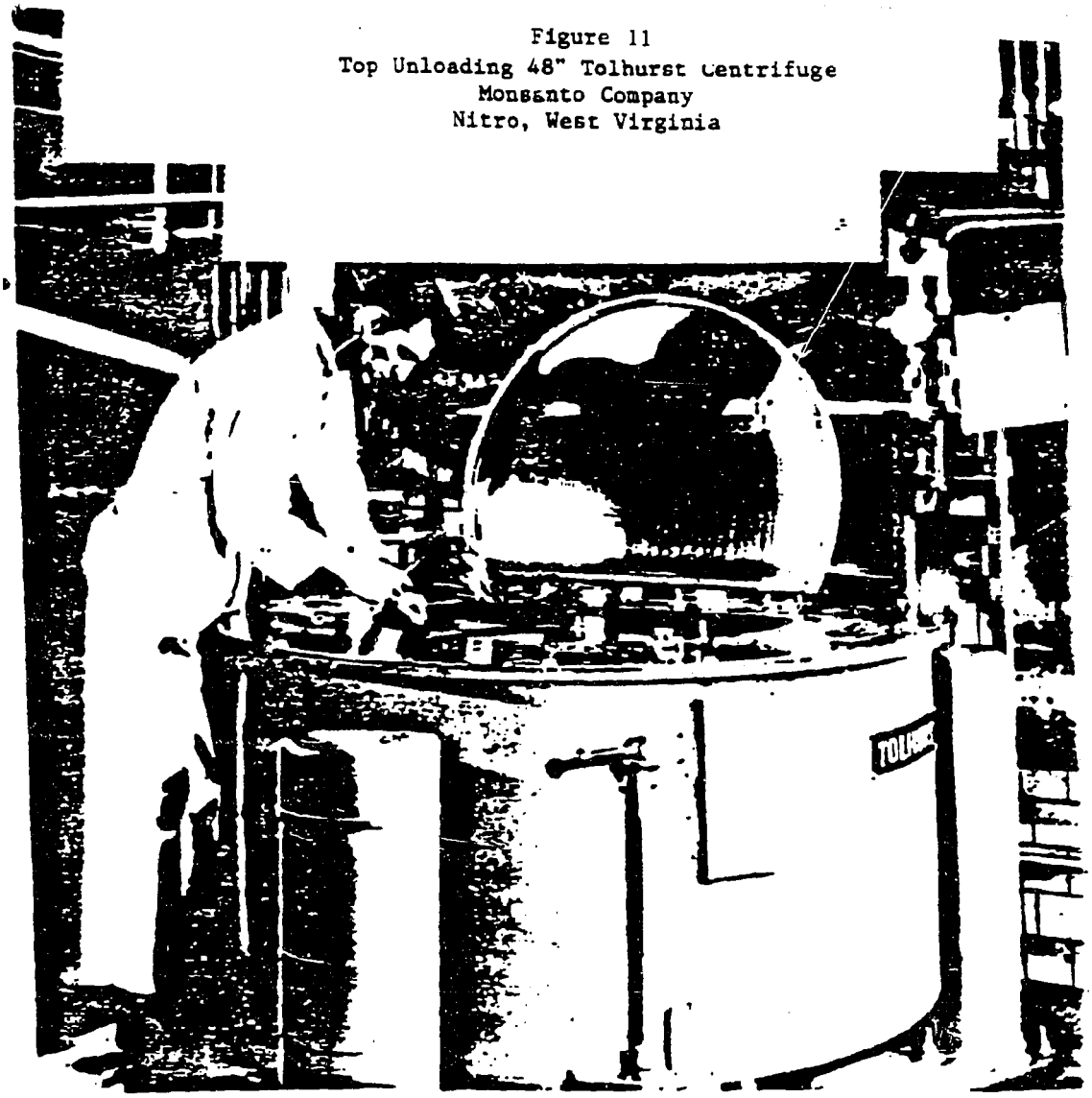
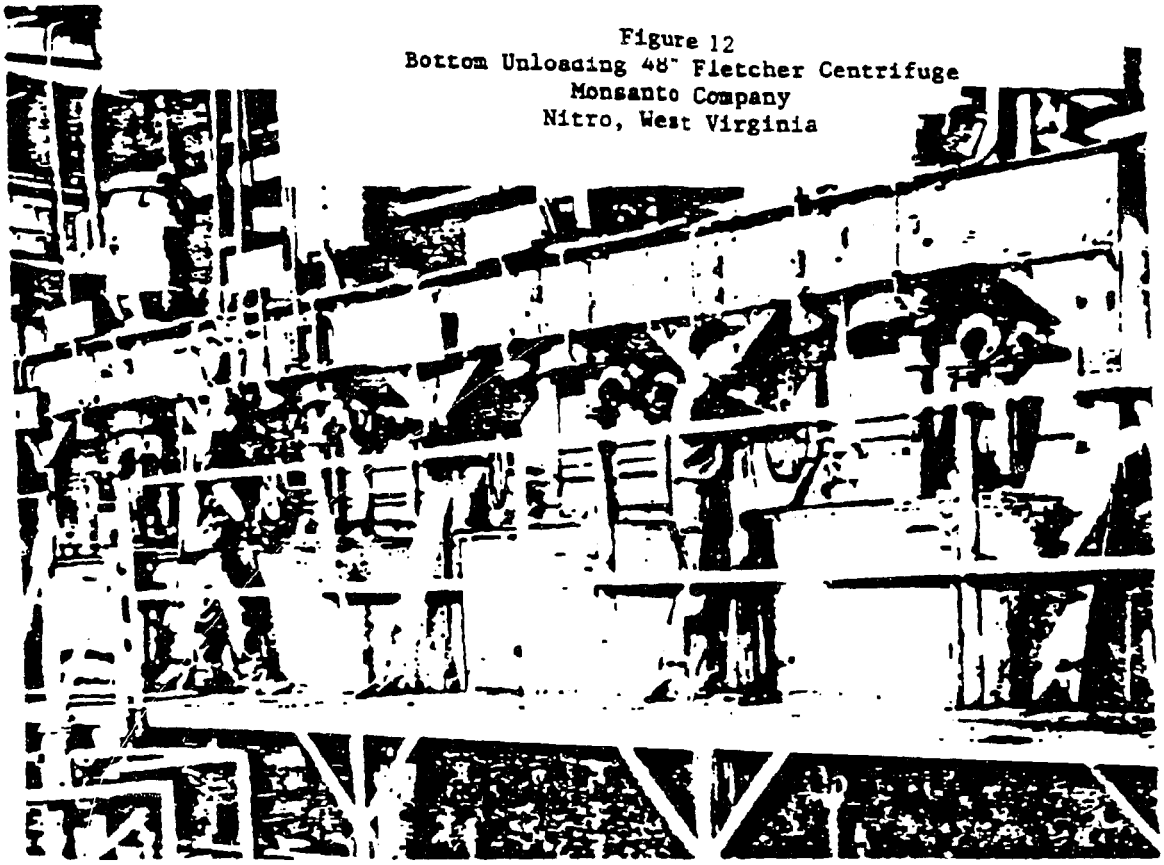


Figure 11
Top Unloading 48" Tolhurst Centrifuge
Monsanto Company
Nitro, West Virginia

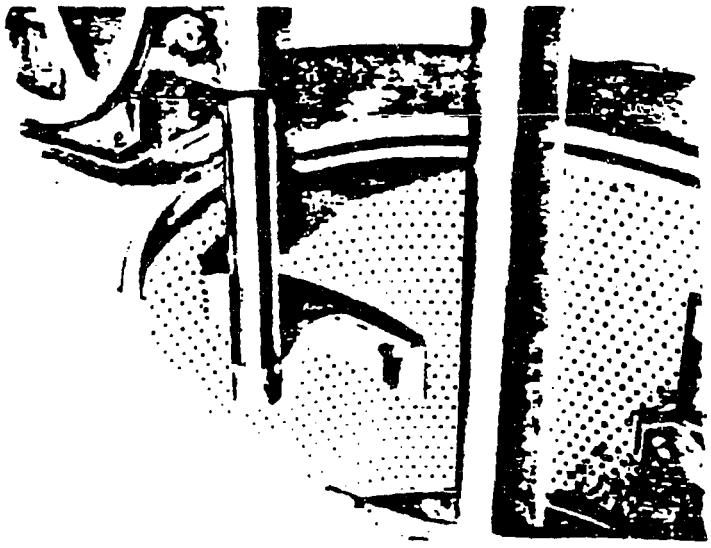


48" UNDERDRIVEN CENTRIFUGE TOP UNLOADED

Figure 12
Bottom Unloading 48" Fletcher Centrifuge
Monsanto Company
Nitro, West Virginia



EXAMPLE OF 48" SUSPENDED CENTRIFUGES
BOTTOM UNLOADED



CLOSE UP OF A PERFORATED BASKET
WITH VIEW OF THE
UNLOADING PLOW

Figure 13
Redler[R] Conveyor/Elevator 1000 Series
Monsanto Company
Nitro, West Virginia

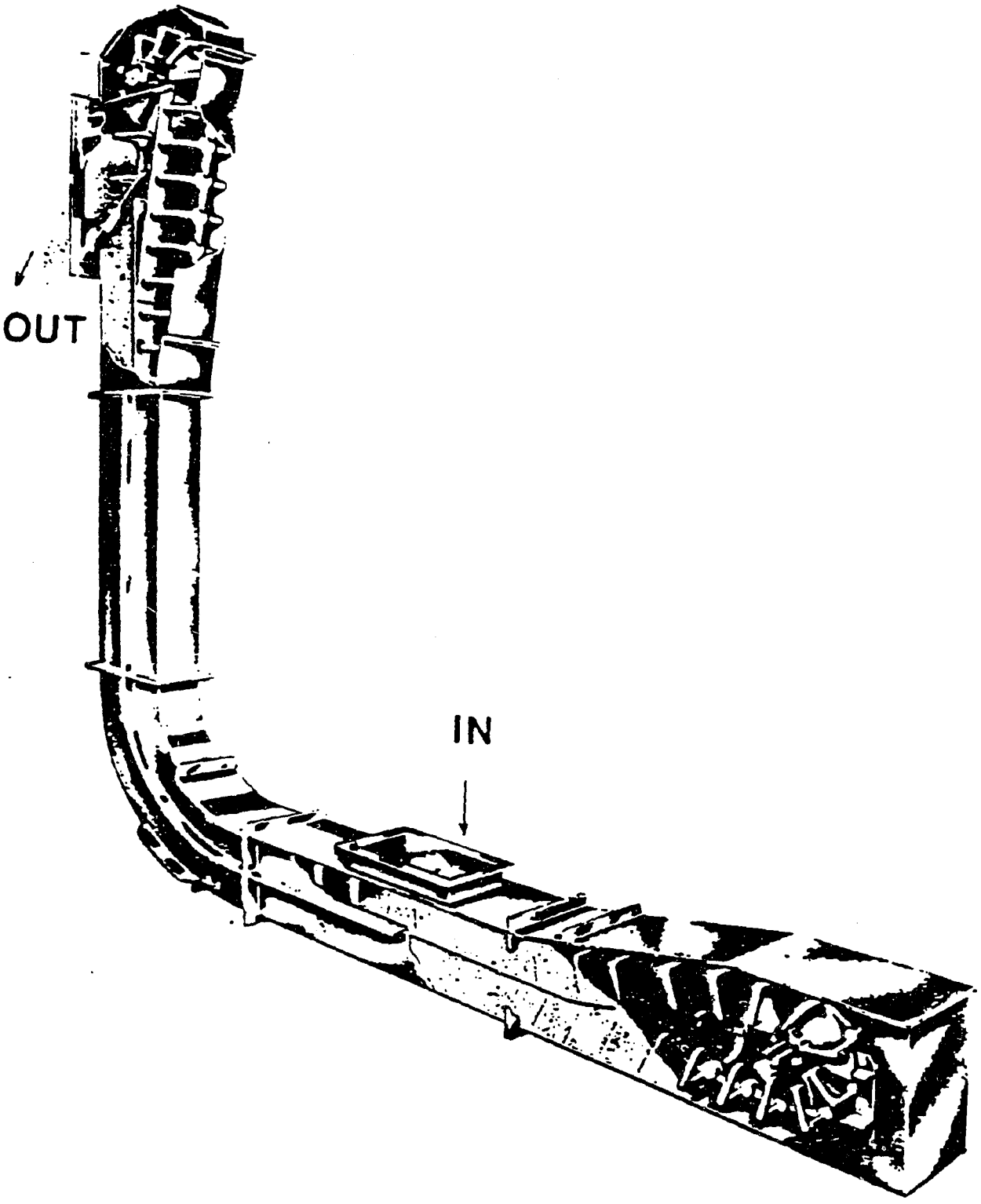


Figure 14
Schutte and Koerling Venturi Scrubber
Monsanto Company
Nitro, West Virginia

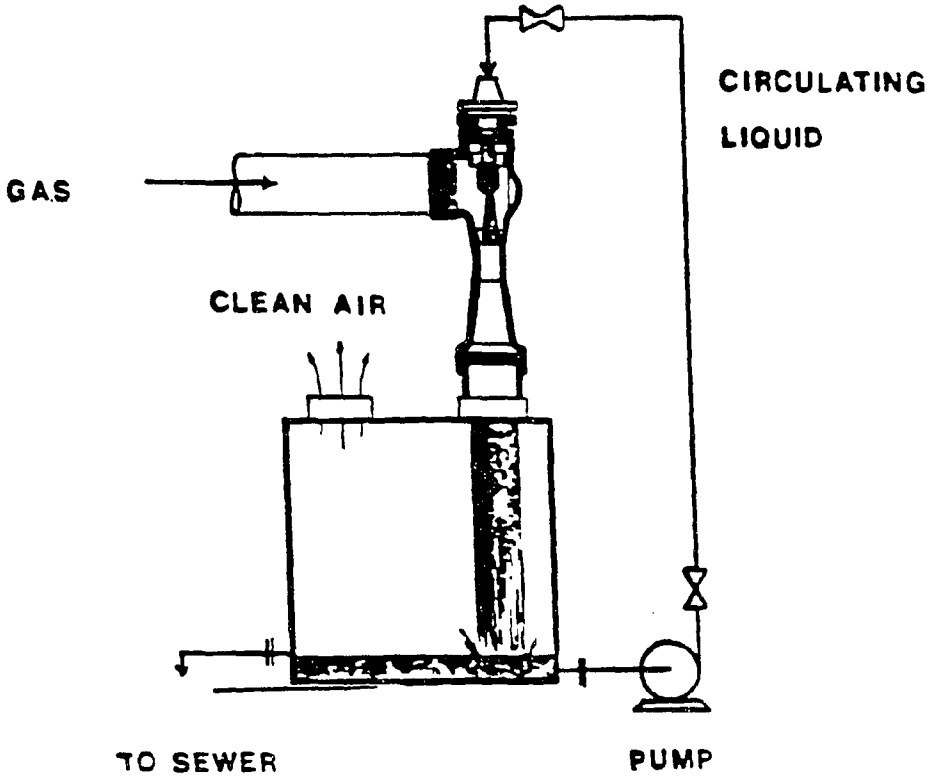
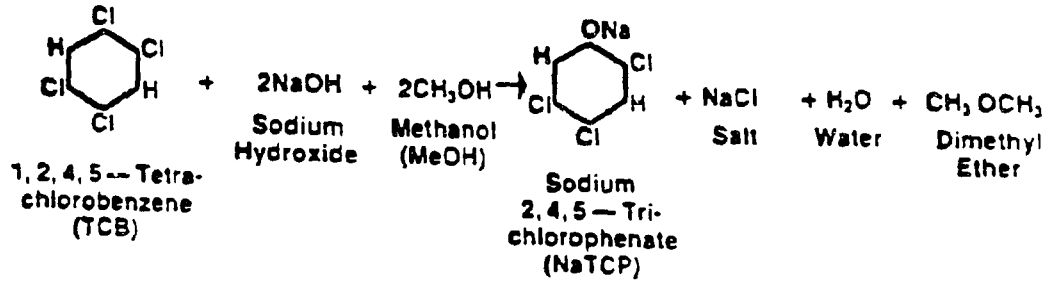


Figure 15A
Na 2,4,5,-TCP and Process Block Flow Diagram
Building 92
Monsanto Company
Nitro, West Virginia
1963-1969 era



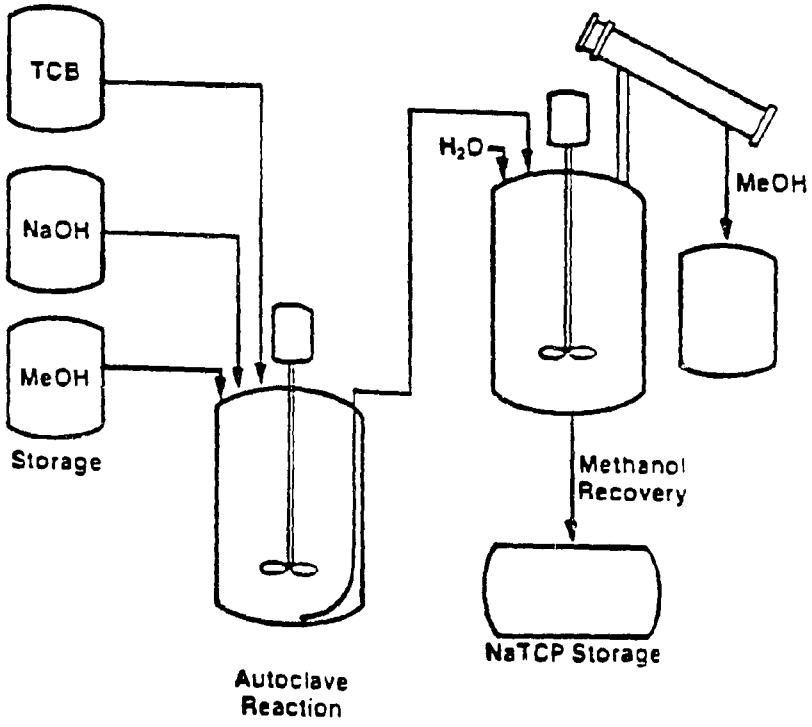
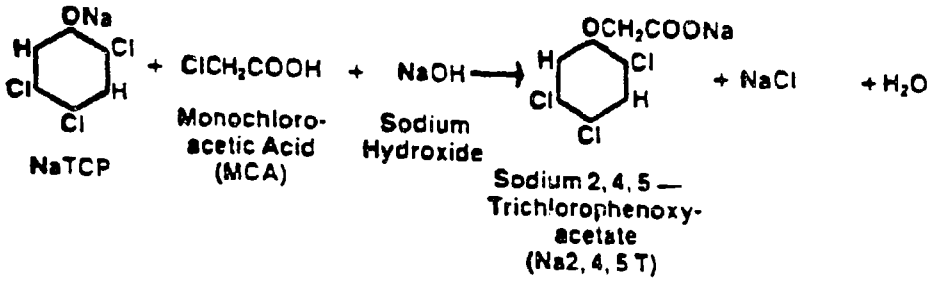


Figure 15B
2,4,5-T Acid Process Condensation Reaction
Block Flow Diagram
Building 92
Monsanto Company
Nitro, West Virginia
1963-1969 era



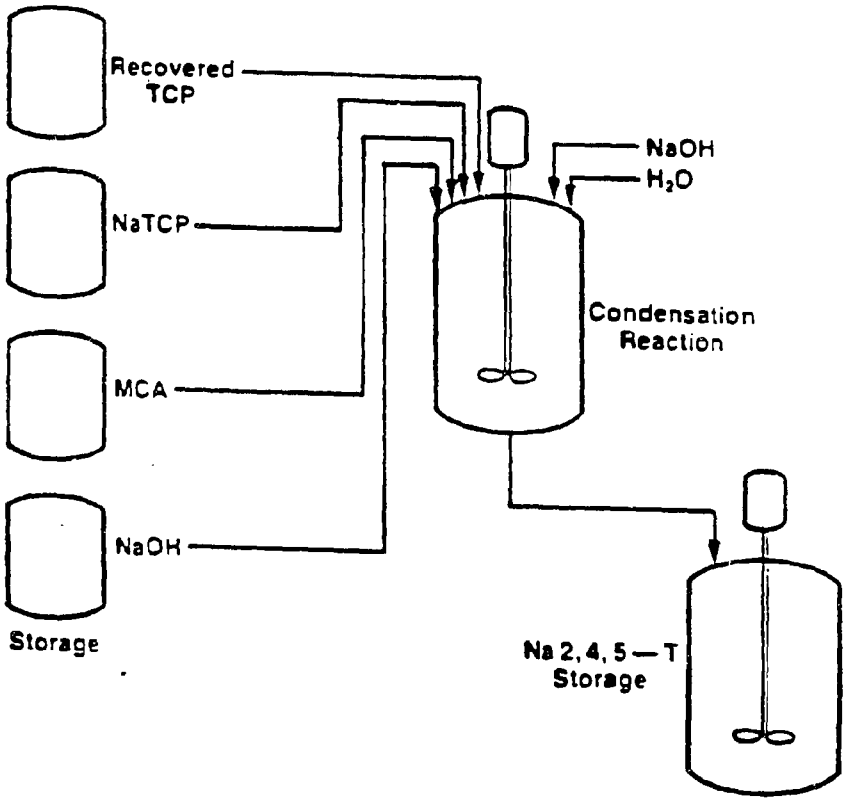
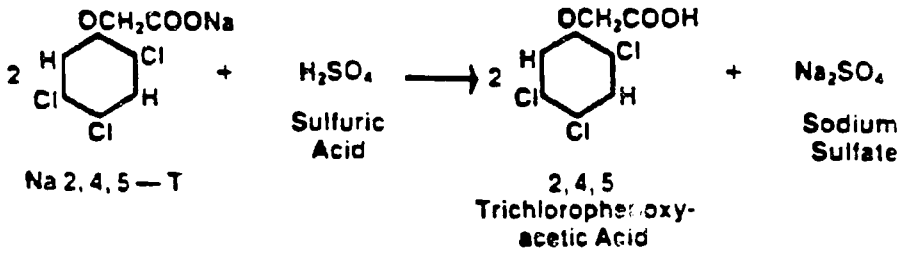


Figure 15C
2,4,5-T Acid Process Purification
Block Flow Diagram
Building 92
Monsanto Company
Nitro, West Virginia
1963-1969 era



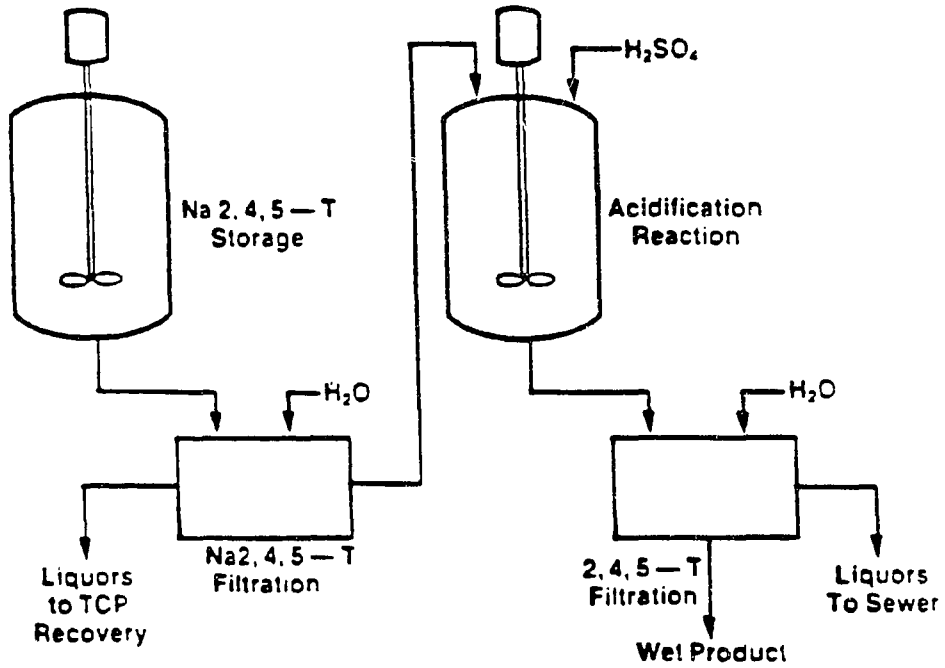


Figure 15D
2,4,5-T Acid Process Drying and Packaging
Block Flow Diagram
Building 92
Monsanto Company
Nitro, West Virginia
1963-1969 era

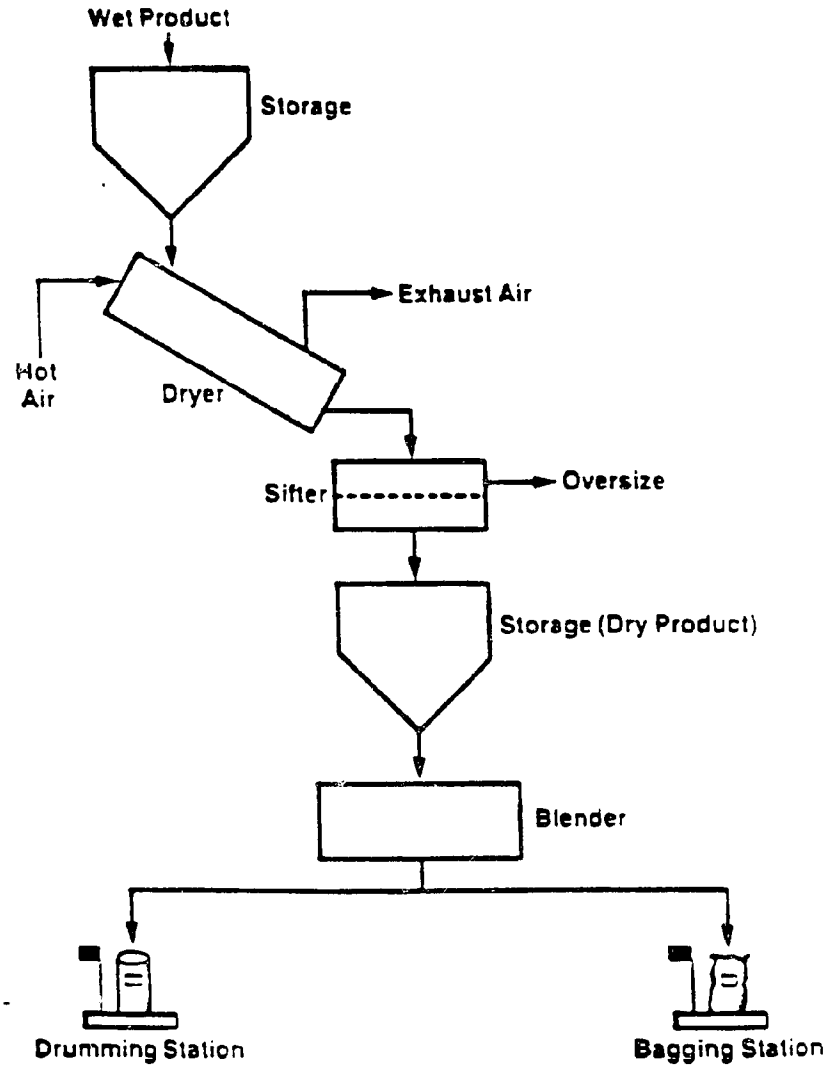


FIGURE 15E
2,4,5-T Acid Process Support and TCP Recovery
Block Flow Diagram
Building 92
Monsanto Company
Nitro, West Virginia
1963-1969 era

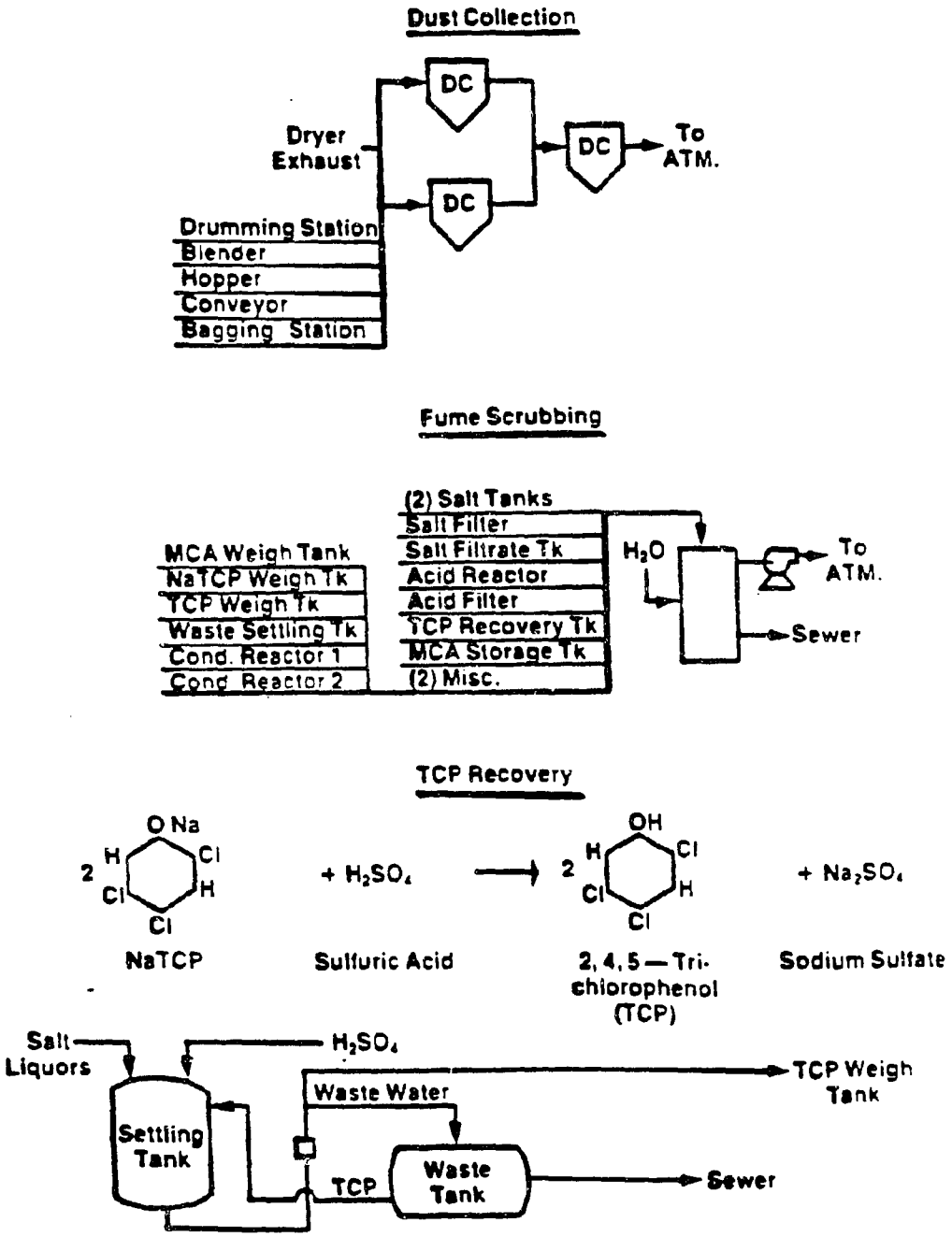


Figure 16
Building 92 Plant Layout
Monsanto Company
Nitro, West Virginia
1963-1969

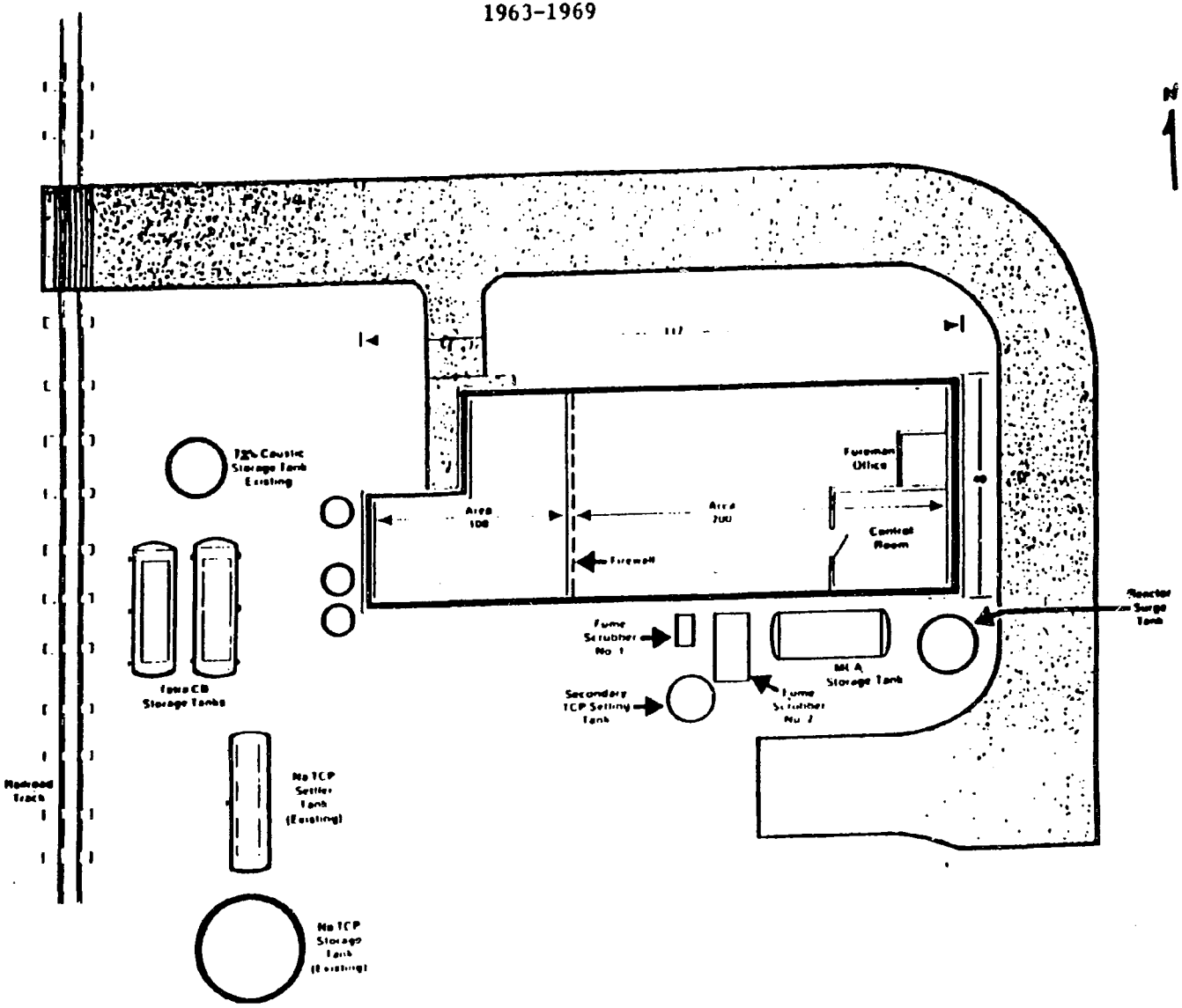


Figure 17
Eimco Belt Filter
2,4,5-T Acid Process
Monsanto Company
Nitro, West Virginia

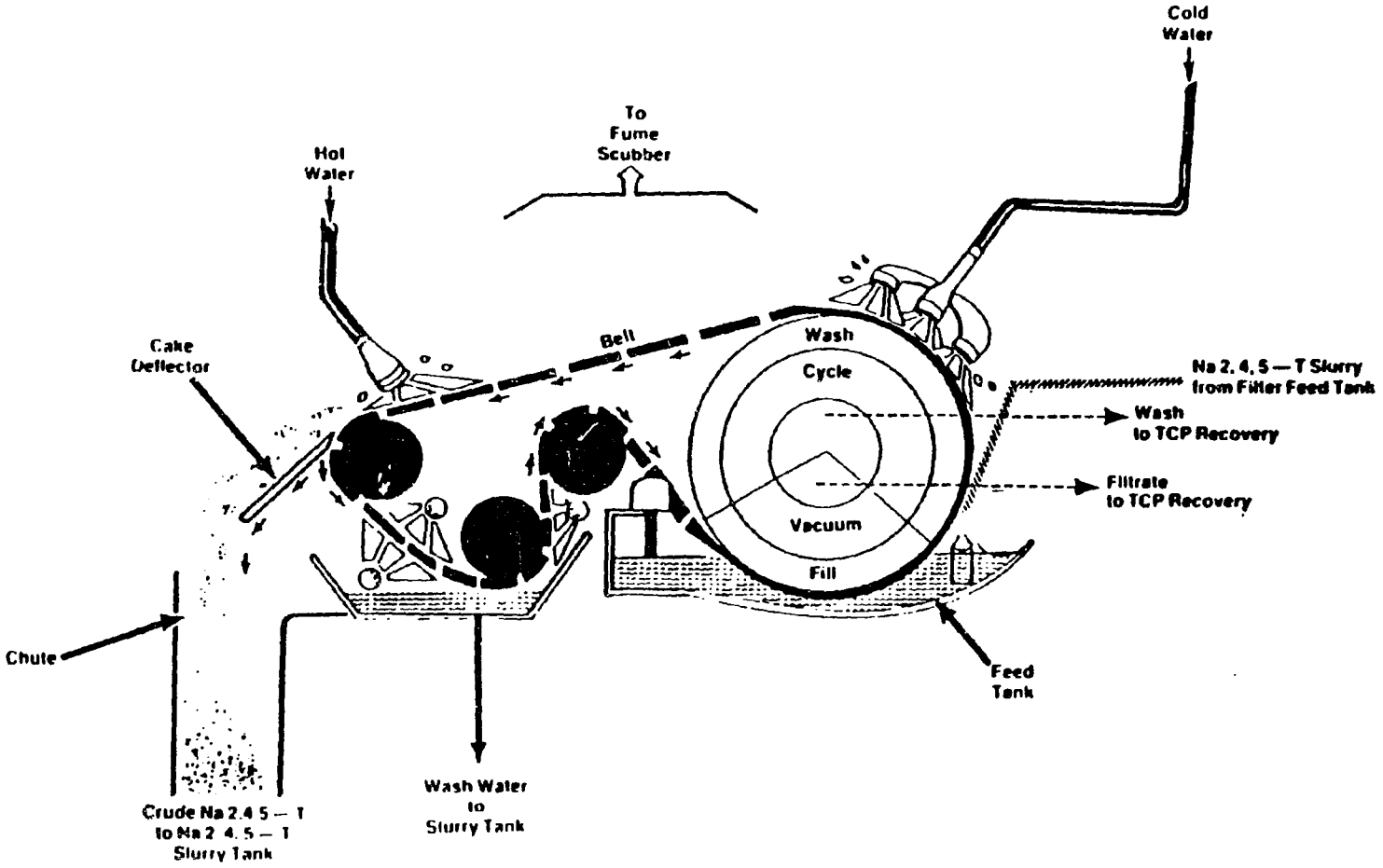


Figure 18
Dorr-Oliver Pan Filter
2,4,5-T Acid Process
Monsanto Company
Nitro, West Virginia

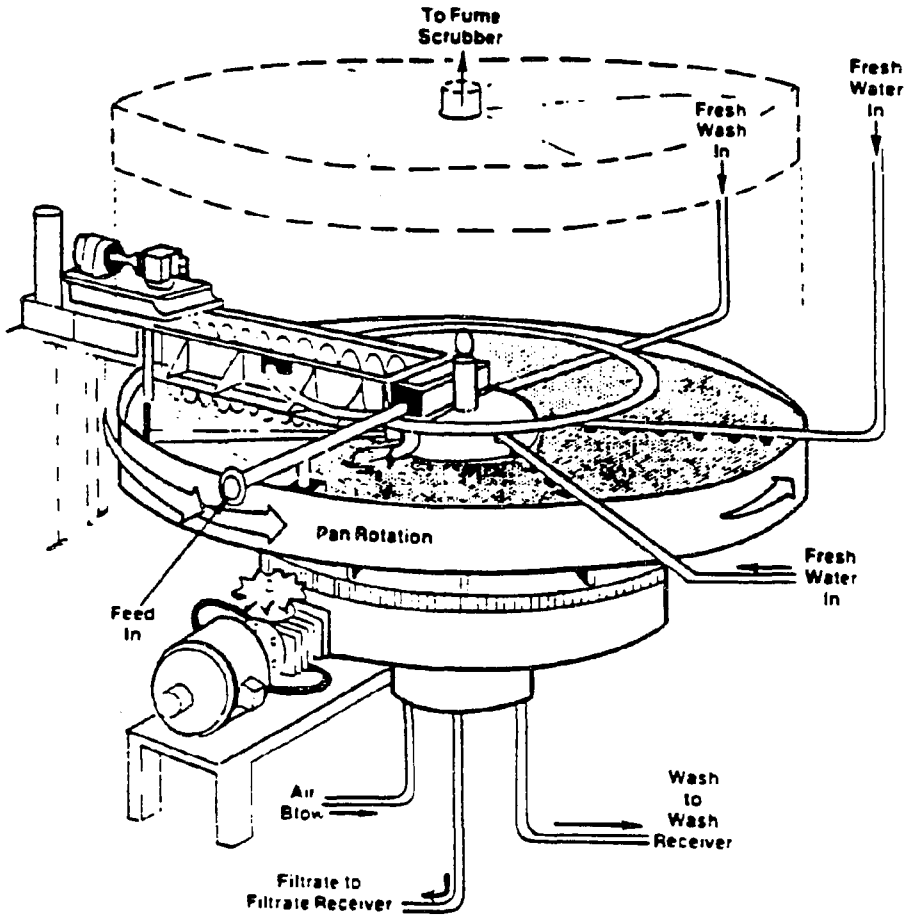
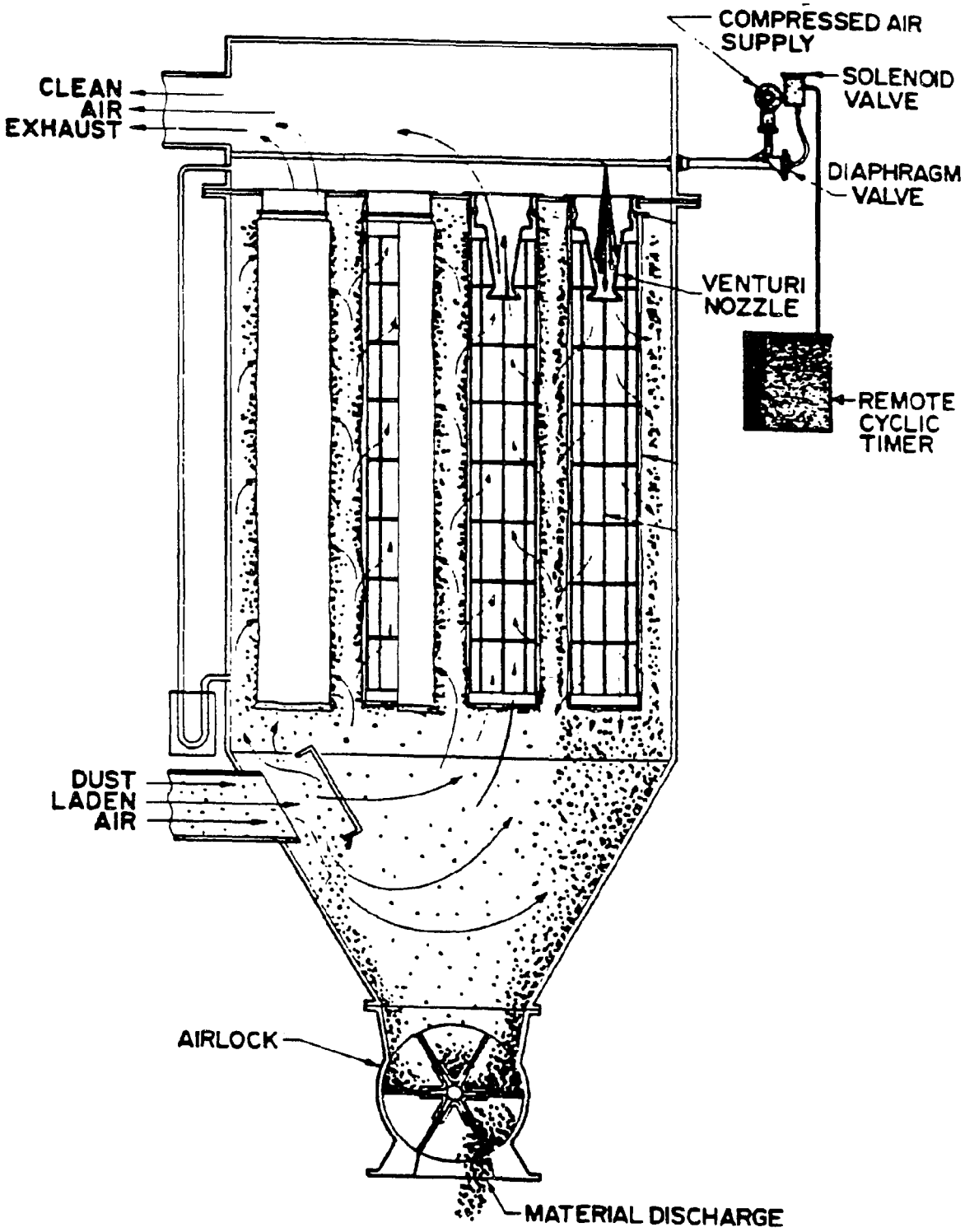


Figure 19
Mikro-Pulsaire Dust Collector
Monsanto Company
Nitro, West Virginia



Appendix B

Monsanto Company
Nitro, West Virginia

Tables 1 through 21

Monsanto Chemical Products

Monsanto Company

Nitro, West Virginia

1970

Divison	Chemical Products
Agricultural	2-Chloroallyl diethyldithiocarbamate
	S-2,3-Dichloroallyl diisopropylthiocarbamate
	Ethoxyquin
	2,3,3-Trichloroallyl N,N-diisopropylthiolcarbamate
	Methionine hydroxy analogue
Inorganic Chemicals	Decylbenzenesulfonic acid, sodium salt
	Dodecylbenzenesulfonic acid, sodium salt
Organic Chemicals	2-Benzothiazolethiol, sodium salt
	1,3-Diphenyl-2-thiourea
	1,3-Bis (2-benzothiazothiazolylmercaptomethyl) urea
	Bis (dimethylthiocarbamoyl) disulfide
	N,N'-Bis (1-ethyl-3-methylpentyl) p-phenylenediamine

Divison	Chemical Products
Organic Chemicals cont.	N,N'-Bis (1-methylheptyl) p-henylenediamine
	N-tert-Butyl-2-benzothiazolesulfenamide
	6-tert-Butyl-m-cresol and sulfur dichloride condensate
	4,4'-Butylidenebis (6-tert-butyl-m-cresol)
	Butyraldehyde-acetaldehyde-aniline condensate
	n-Butyraldehyde-aniline condensate
	Butyraldehyde-butylideneaniline condensate
	Carbon disulfide and 1,1'-methylenedipiperidine condensate
	N-Cyclohexyl-2-benzothiazolesulfenamide
	2,5-Di (tert-amyl) Hydroquinone
	1,2-Dihydro-6-dodecyl-2,2,4-trimethylquinoline
	1,2-Dihydro-6-ethoxy-2,2,4-trimethylquinoline
	1,2-Dihydro-2,2,4-trimethylquinoline
	1,2-Dihydro-2,2,4-trimethylquinoline, polymerized
	Dimethyldithiocarbamic acid, zinc salt
	N-(2,6-Dimethylmorpholino)-2-benzothiazole-sulfenamide
	1,3-Diphenylguanidine

Table 1 (cont.)

Division	Chemical Products
Organic Chemicals cont.	2-Mercaptobenzothiazole
	1,3-Diphenylguanidine phthalate
	2,2'-Dithiobis (benzothiazole)
	4,4'-Dithiodimorpholine
	N-Oxydiethylene-2-benzothiazolesulfenamide
	4,4'-Thiobis (6-tert-butyl-m-cresol)
	2-Thiurad-1-thiotax mixture
	o-Tolybiguanide
	Defoamer PC 1244 and 1344
	Sythetic resin antioxidant
	Paper sizing agent

Reference: SRI International 1971 Directory of Chemical Producers, USA.

Table 2
Chemical Products, Departments,
Building Numbers and Raw Materials
Monsanto Company
Nitro, West Virginia
1952

Dept. No.	Bldg. No.	No. of Hourly Workers	No. of Salaried Workers	Total No. of Workers	Products	Materials Handled
1	3	4	—	4	A-1-Thiocarbanilide, A-22-Cond. Prod. of CS2 & orthotoluidine & Acetaldehyde ammonia	Aniline, CS2, Ortho-toluidine, Acetaldehyde & Ammonia
3	3 15 (grinding)	12	—	9	Diphenylguanidine (DPG)	NaCN, HCN, Aniline, DPG&HCl, H2SO4, NaOH, tirchloroethylene & DPG
38A	8	12	—	12	Santomerse (Drying)	Santomerse slurry, Santomerse powder & Diethylene glycol
7, 20, 26, 31 & part of 54	16(Tray drying) 17(Grinding Screening & Packaging)	13	—	13	Several Products	Plastic sulfur, Soconox, Santowhite, Thiotax, Santocure, SA 326, Thiurad, Santomerse 3 & D, Areskaps, Santovar U & A, Thiocarbanilate, SV-175, 2,4,5-T & Clay
33	21	13	—	13	Niran	PSCl3, Sodium ethylate paranitrophenol, Soda ash & Filter aid
9	25	4	—	4	PSCl3 & Polyglycerol	PCl3, Sulfur (powder & molten), AlCl3, Glycerine & NaOH
33	30	4	—	4	Sodium ethylate	Metallic sodium & ethyl alcohol
Pilot Plant	32	9	6	15	Miscellaneous	Numerous chemicals
41	34	16	—	16	Ajone C Ajone P Santoflex AW	Acetone & para-amino-biphenyl Ajone C & N,N'-diphenyl-para-phenylene-diamine Acetone & Parabenetadine
42	34	13	—	13	Flectol H	Acetone, Aniline, HCl & NaOH
57	34 D & F	17	—	17	2,4,5-T	Na 2,4,5-TCP, MCA, H2SO4,

Table 2 cont.

Dept. No.	Bldg. No.	No. of Hourly Workers	No. of Salaried Workers	Total No. of Workers	Products	Materials Handled
						NaOH & Soda ash
11, 13 & 14	40	16	—	16	Oil Additives	Chlorine, Kerosene, Isopropoanol, Isopropoyl xanthate, CS2, Abatol, P2O5 in alcohol, Phosphate Maltes, NaOH, Ocenol, Ditertiary amyl phenol & Hydrobetyl alcohol
6	41	22	—	22	Mercaptobenzothiazol, Sodium MBT & Thiotax	Aniline, CS2, Sulfur, NaOH & H2SO4
60	45	29	—	29	Santocure	Sodium MBT, Cyclohexyl-amine, NaOH, Cl2, Na sulfite & Santocure
32 & 62	46	8	—	8	Santowhite	Monotertiarybutyl-meta-cresol, Sulfur dichloride & Skellysolve C
					Actamer	2,2'-thiobis-(4,6-dichloro-phenol), CCl4, AlCl3, 2,4-dichlorophenol & Monochlorobenzene
32	46	13	—	13	Small Products	Acetaldehyde, Butyraldehyde, Creosote oil, Dimethylamine, 2-ethyl hexanol, Ocenol, Toluene, p-toluene sulfon-chloride, Methanol, Trichlorobenzene, NaOH & Acids
64	51	8	—	8	Na 2,4,5-trichlorophenate	Tetrachlorobenzene, NaOH, Methanol & Na 2,4,5-TCP
53	54	26	—	26	Thiourea	Thiourea, Calcium cyanamide, Lime, Na sulfohydrate, H2SO4 & H2S
54	60 70(grinding & packaging)	9	—	9	Plastic Sulfur	Sulfur, Sulfur mono-chloride & Br2

Table 2 cont.

Dept. No.	Bldg. No.	No. of Hourly Workers	No. of Salaried Workers	Total No. of Workers	Products	Materials Handled
Research, Rubber & ontrol Labs	6A	52	36	88	Many and varied	Group leaders, chemists, nontechnical and students handle the gamut of materials encountered in research and control labs.
38, 51	71	9	—	9	Santomerses (Detergents)	Alkyl benzene, H2SO4, NaOH, Na sulfate, Isopropanol, Na hypochlorite, SOT & Butylamine
55	72	9	—	9	Spray-dried Santomerse	Santomerse slurry and dried product
30	75A	8	—	8	Sa-326, Soanox & Santovar A &D	Orthotoluidine, Ortho-aminodiphenyl, Tertiary amyl alcohol, H2SO4, HCl, Skellysolve K, Dicyandiamide, Hydroquinone, Orthobiphenyl, Biguanide & Alkylated polyhydroxyl phenol
10	750	8	—	8	Alkyl benzene & Dodecyl benzene	Benzol, Skellysolve S, Cl2, AlCl3 & NaOH
56	78 79 (Tray Drying)	16	—	16	Thiofide	Na mercaptobenzothiazole, Cl2, NaOH, Tall oil & Stearic acid
Mechanical & Service	—	259	44	302	Services & Crafts	—
	Totals	608	86	694		

Table 3
Chemical Products, Departments,
Building Numbers and Raw Materials
Monsanto Company
Nitro, West Virginia
1960

Dept. No.	Bldg. No.	No. of Hourly Workers	No. of Salaried Workers	Total No. of Workers	Products	Materials Handled
B17.35 B17.47	51 34	21	2	23	Na 2,4,5-TCP 2,4,5-T Acid	TCB, MeOH & Flaked NaOH Na 2,4,5-TCP, MCA, 93% H_2SO_4 & 25% NaOH
B17.45	17, 60 & 70	12	—	12	Insoluble Sulfur 60	Sulfur (polished, dry & melted) & Sulfur Monochloride
B17.02	17	9	1	10	Misc. Grinding Plant Products	Elastocar, Whitex, Santowhite Crystals, Thiotax, Santocure, Thiurad, Accelerator B & Process Mineral Oil
B17.37	34	18	2	20	Flectol H	para-Phenetidine Dodecylaniline
B18.22 B18.05 B18.25	34				Santoflex AW	Aniline Acetone Diphenyl-para-phenylenediamine
B18.25	34				Santoflex DD	Toluenesulfonic Acid HCl (32 Be)
B17.68	34				Santoflex 75	Dow Corning Defoamer 25% NaOH Solution
B17.50	45	15	2	17	Santocure	tertiary-Butylamine Cyclohexylamine
B17.61	45				Santocure NS	NaOH (25% soulution) H_2SO_4 (93%)
B23.60	45				Santocure 26	Chlorine Sodium Hypochlorite 2,6-Dimethylmorpholine Na Mercaptobenzothiazole Sodium Sulfite Victoria blue base dye
B17.51	75A	12	2	14	Soxanox	ortho-Toluidine, Dicyandiamide, HCl (22 Be), 25% NaOH & Na Sulfite
B17.58	75A				Santovar A	Hydroquinone, tertiary-Amyl Alcohol, 93% H_2SO_4, Na_2HPO_4 & Na_2SO_3
B23.37	75A				Santowhite Powder	MeOH, Butyraldehyde, Clensolene, tertiary-

Table 3 cont.

Dept. No.	Bldg. No.	No. of Hourly Workers	No. of Salaried Workers	Total No. of Workers	Products	Materials Handled
						Butyl meta Cresol & HCl
823.48	75A				Sulfasan R	Morpholene, Sulfur monochloride, Clensolene, 25% NaOH & Sterox CD
817.83	B	9	2	11	Mersize	Tall oil rosin, para-formaldehyde, Toluene-sulfonic Acid, Fumaric Acid, 25% NaOH & NaCl
817.86	71C				Calcium MHA (methionine hydroxy analogue)	MHA Acid & Lime
Tall Oil Fractionation	Control Room - 100 Otherwise open structure	12	2	14	Rosin Acids Fatty Acids	Crude Tall Oil
821.32	32	9	1	10	Elastopar (N-Methyl-N-dinitroso-aniline)	N-Methylaniline, HCl, Na Nitrite & 25% NaOH
823.54	46	18	2	20	MHA Acid	HCH, Acrolein, Methyl mercaptan, Pyridine, Acetic Acid & HCl
823.50	46				CDEC (Vegadex active)	Dichloropropene Diethylamine 25% NaOH & CS2
823.64	46				Avadex Concentrate	NH4SCN, Trichloropropene, Diisopropyl amine, H2SO4 & 25% NaOH
817.21	46				Santowhite Crystals	Sulfur dichloride Skellysolv-C tertiary-Butyl mets-Cresol NH4OH
823.69	46				PC 1244 (defoamer)	Kerosene, Ethyl acrylate
823.70	46				PC 1344 (defoamer)	2-Ethylhexyl acrylate, Benzoyl peroxide & Toluene
825.12	71	15	2	17	Santoperse S	Liquid SO3

Table 3 cont.

Dept. No.	Bldg. No.	No. of Hourly Workers	No. of Salaried Workers	Total No. of Workers	Products	Materials Handled
						Decylbenzene
825.50	71				Santoaerse SX	Monsanto aromatic naphtha Ethylene glycol
825.51	71				Santoaerse 3 Paste	Chlorine
825.52	71				Santoaerse E Dry	
825.56	71				Santoaerse E 30% Solution	
823.44	79				Vegadex	CDEC Heavy aromatic naphtha Emcol Ad 420
823.67	79				Avadex	Crude Avadex
817.46	79				Thiofide	Mercaptobenzothiazole Chlorine 25% NaOH Lt. weight Petroleum oil Steric Acid Sterox SK
823.35	79				Guantal	Phthalic Anhydride Diphenylguanidine
817.01	79				A-1 Thio (Thiocarbanilide)	Same as Thiofide
Maintenance	71 (Main Shop) 76 (Paint Shop) 73 (Area Shop)	96	—	96		
905.09 Quality Control Laboratory	66A	16	4	20		
	41	22	—	22	Mercaptobenzothiazole	Aniline, CS2, Sulfur NaOH & H2SO4
823.55 823.58	40	16	—	16	Santopoid S Santolene CP Oil Additives	
	Total	300	22	322		

Table 4
Chemical Products, Departments,
Building Numbers and Raw Materials
Monsanto Company
Nitro, West Virginia
1968

Dept. No.	Bldg. No.	No. of Hourly Workers	No. of Salaried Workers	Total No. of Workers	Products
89501	92	22	2	24	2,4,5-T Acid
Bldg. 71	71 & 71C	22	2	24	Santomerse S Santomerse SX Santomerse 3 Paste Santomerse E Avadex Avadex BW Vegadex Stabolized CDEC
Mersizes	8 & 17	6	1	7	Mersizes Santowhite Crystals
Tall Oil	Tall Oil	12	2	14	Various Tall Oil Fraction
91 Products	91	38	4	42	Santocure MOR, MOR90 & 26 Defoaser PC1244 &PC1344 Defoaser M 530 Rubber Chem. A 32 & 100 Santowhite Powder Sanfasan R, Santonox R Thiotax, Accelerator B
B1721	46	9	1	10	Santowhite Crystals Santowhite MP
89507	46	12	1	13	TDTC Avadex BW DDTC Avadex CDEC Vegadex
89504	46	21	1	22	2, Hydroxy-4-Methyltnio- Butyric Acid
89512	12 & 13	11	2	13	1,1,2,3-Tetrachloropropene
B-75	75	16	2	18	Soxanox, Santovar A Santowhite
B-79	B-79	12	2	14	Thiotax AP, Thioxor Thiofide, EL 60, Guantal
MBT (Mercapto Benzol Thiazole)	41	17	2	19	MBT, Na MBT, Thiotax

Table 4 cont.

Dept. No.	Bldg. No.	No. of Hourly Workers	No. of Salaried Workers	Total No. of Workers	Products
45	45	16	2	18	Santocure, Santocure NS
34	B-34	13	1	14	Santoflex DD, AW & 75 Santoquin, Flectol A 503 A, A-85
37	B-37	8	1	9	Flectol H & DDP
25		1	0	1	Central Drumming Station
B-40	B-40	16	2	18	Oil Additives, Santopoid 5 Rust Inhibitors Phosphate & Malate Esters
	Totals	252	28	280	

Table 5
Chemical Products, Raw Materials, Departments,
Intermediats and Building Numbers
Monsanto Company
Nitro, West Virginia
1968

Building Number	Products	Raw Materials	Intermediates
92	2,4,5-T Acid	TCB, NaOH3, H2SO4, MCA & NaOH	2,4,5-TCA, NaCl, Na 2,4,5-TCP & dimethyl ether
71 & 71C	Santomerse S	Decyl Benzene, Sulfur Trioxide, Ethylene Glycol Chlorine, 25% NaOH & Filter Aid	
71 & 71C	Santomerse SX	Olefin Dodecyl Benzene, Ligth Aromatic Naphtha, Sulfur Trioxide, Ethylene Glycol, Chlorine, 25% NaOH & Filter Aid	
71 & 71C	Santomerse 3 Paste	Same as Santomerse SX	
71 & 71C	Santomerse E	Ligth Aromatic Naphtha, 100% H2SO4, Di Sodium Phosphate, 25% NaOH, Chlorine & Filter Aid	
71 & 71C	Avadex	Heavy Aromatic Naptha, Avadex Technical & Agrimul A & N100	
71 & 71C	AvadexBW	Avadex BW Technical, Agrimul A & N100, Solvent Xylene & Heavy Aromatic Naptha,	
71 & 71C	Vegadex	Heavy Aromatic Naptha, Vegadex Concentrate Emcal AD 420 (Witco)	
71 & 71C	Stabolized CDEC	Vegadex - Technical Isodecyl Alcohol	
8	Mersizes	Rosin, Toluene Sulfonic Acid, 50% Formaldehyde, Fumaric Acid, Potassium Hydroxide, NaCl & Pot Ash	
17	Santowhite Crystals	4, 4'-thio-bis-(6 tertiary meta Cresol)	

Table 5 cont.

Building Number	Products	Raw Materials	Intermediates
Tall Oil (open air)	Pitch Rosin Fatty Acids Unsaturated Saturated	Crude Tall Oil	
Tall Oil (open air)	High Viscosity Distilled Tall Oil	50-50 Rosin Fatty Acid	Super Filtrol Activated Carbon 75% Phosphoric Acid
91	Santocure MOR Santocure MOR 90	Morphline, Chlorine, NaOH, Isopropanol & Thiomor MBT Disulfide	
91	Santocure 26	Thiomor, Chlorine, NaOH, Monochlorobenzene & 2,6-Dimethyl Morpholine	
91	Defoamer PC1244 &PC1344 Defoamer M 530	Defoamers, Kerosene, Ethyl Acrylate, 2 Ethyl Hexyl Acrylate, Benzyl Peroxide & Toluene	
91	Rubber Chem. A 32	Aniline, Butryl Aldehyde & Acetic Acid	
91	Rubber Chem. A 100	Aniline, Acetaldehyde, Butyric Acid, Cresote Oil & Rubber Chem. A 32	
91	Santowhite Powder	Muriatic Acid, Tertiary Butyl meta Cresol, Butyraldehyde & Stoddard Solvent	
91	Sanfasan R	Morpholine, Sulfur Monochloride, NaOH & Stoddard Solvent	
91	Santonox R	Tertiary Butyl Meta Cresol, Sulfur Dichloride Trichloroethylene & Stoddard Solvent	
91	Accelerator B	Mercapto Benzol Thiozole, Tetra Methyl Thuram Di	

Table 5 cont.

Building Number	Products	Raw Materials	Intermediates
		Sulfide & Texas Oil # 511	
91	Thiotax	Mercapto Benzol Thiozole, & Texas Oil # 511	
46	Santowhite Crystals (4,4'-Thio-bis-(6-tert-butyl-meta-Cresol))	Tert Butyl meta Cresol, Sulfur Dichloride, n-Heptane & Aqua Ammonia	
46	Santowhite MK (Folmer Santowhite Crystals)	Same as Santowhite Crysta	Calcium Chloride
46	TDTC Avadex BW	Ammonium Thiocyanate, Sulfuric Acid, NaOH, Diisopropyl Amine, Tetrachloropropene & Carbonyl Sulfide	
46	DDTC Avadex	Same as Avadex BW except trichlorpropene for the tetrachloropropene	
46	CDEC Vegadex	NaOH, Diethyl Amine, Carbon Disulfide & Dichloropropene	Calcium Chloride
46	2, Hydroxy-4-Methylthio-Butyric Acid	Hydrogen Cyanide, Acrolein, Methyl Mercaptan, Muriatic Acid, Pyridine & Acetic Acid	Calcium Chloride
12-Tetra 13-Control	1,1,2,3-Tetrachloropropene	1,2,3-Trichloropropene, Chlorine, NaOH & Sulfuric acid	
75	Soapanox (O-Tolybiguanide)	Muratic Acid, Orthotoluidine, Dicyandiamide, Sodium Sulfite & NaOH	
75	Santovar A (2,5,D-Tertiary Amyl Quinone)	Hydroquinone, Tertiary Amylalcohol, Sulfuric Acid & Sodium Sulfite	
75	Santowhite Powder	Muratic Acid, Butryl-	

Table 5 cont.

Building Number	Products	Raw Materials	Intermediates
	(4,4'-Butyldienen-bis-(6-tert-butyl-m-Cresol))	aldehyde, Tertiary Butyl meta Cresol & Stoddard Solvent	
B-79	Thiotax - MBT	Sodium, Mercaptobenzo-thiazole, Texas Oil #5 & Muratic Acid	
B-79	Thiomor (Benzothiazole Disulfide)	Sodium MBT, Chlorine & NaOH	
B-79	Thiofide	Thiomor, Texas Oil & Steric Acid	
B-79	EL 60	MBT, Paraformaldehyde & Urea	Tardex
B-79	Guantal	Diphenyl Guanidine & Phthalic Anhydride	
41	MBT (Mercaptobenzol Thiazole)	Molten Sulfur, Aniline & Carbon Bisulfide	Hydrogen Sulfide Sulfur Recovery
41	Na MBT	MBT & NaOH	
41	Thiotax	MBT	
45	Santocure (N-Cyclo-Hexylbenzothiazole Sulfanamide)	Na MBT, Sulfuric Acid, Cyclohexamine, Sodium Hypochlorite & Sodium Sulfite	
45	Santocure NS (N-Tert-Butylbenzothiazole Sulfanamide)	Same as Santocure except tertiary butyl amine is used for Cyclohexylamine	
B-34	Santoflex DD (Dodecyl 1,2-Dihydro-2,2,4-Tri-methyl Quinoline)	Dedecyl Aniline, Acetone, Paratoluene Sulfonic Acid Dow Corning Antifoam A	
B-34	Santoflex AW (6 Ethoxy 1,2-Dihydro-2,2,4-Tri-methyl Quinoline)	Paraphenetidine, Acetone, Toluene Sulfonic Acid & Dow Corning Antifoam A	
B-34	Santoflex 75	Diphenyl Paraphenylene	Blend

Table 5 cont.

Building Number	Products	Raw Materials	Intermediates
		Diamine & Santoflex DD	
B-34	Flectol A	Aniline, Acetone, Toluene Sulfonic Acid & Dow Corning Antifoam A	
B-34	Santoquin	Santoflex AW	Purify
B-34	Santoflex A-85	Santoflex AW & Santoquin Residue	Blend
B-34	Santoflex 500 A	Santoflex A 85 & Santoflex 13	Blend
B-37	Flectol H (1,2-Dihydro-2,2,4- trimethyl Quinoline - polymerized)	Flectol A, Muratic Acid, Aqua Ammonia, Xylene & Steric Acid	
B-37	Flectol ODP (P,P' Di-tert-octyl-diphenyl Amine)	Diphenyl Amine, Diisobutylene, Aluminum Chloride & Muratic Acid	
25	Central Drumming Station	(All finished products from Depts. 34 & 40)	
B-40	Santopoic S	Isopropanol, Carbon Bisulfide, Flaked NaOH, Chlorine & Kerosene	Muratic Acid
B-40	RT 53A	Ditertamylphenol & Phosphorus Pentoxide	Phosphate Esters
B-40	M541	Mixture of N-Octyl & N-Decyl Alcohol & Phosphorus Pentoxide	
B-40	RT 28AA & RT33A	Adol 80 (Ocenol) & Phosphorus Pentoxide	
B-40	RT 52A	Abitol & Malic Acid	Malate
B-40	RD 18-500	Ocenol & Malic	
B-40	Santolene CF	Kerosene, Dimer Acid, Process Oil & Tricresylphosphate	Rust Inhibitors Blend

Table 5 cont.

Building Number	Products	Raw Materials	Intermediates
B-40	Santolene C	Kerosene, Dimer Acid, Process Oil & RT 53A	Blend
B-40	Santolene CX	Dimer Acid & Kerosene	Blend
B-40	PA 1260	Dimer Acid, Kerosene, Process Oil & T.C.P.	
B-40	Santolube 70	Benzene, Dibutyl-p-cresol Process Oil, Oleic Acid, Triethyl-tert-amine & Tetrapropenyl-succinic Anhyride	Reaction
B-40	Santolube 70A	Santolube 70 & Santolene C	

Table 6
Na 2,4,5,-TCP and 2,4,5-T Acid Building
Numbers and Start and End Dates
Monsanto Company
Nitro, West Virginia

Building Number	Production Product	Start Date	End Date
32	Na 2,4,5-TCP / 2,4,5-T acid (pilot plant)	01-Apr-48	30-Sep-48
34	2,4,5-T acid	01-Oct-48	31-Jul-63
41	Na 2,4,5-TCP	01-Oct-48	30-Jun-50
51	Na 2,4,5-TCP	01-Jul-50	31-Jul-63
92	Na 2,4,5-TCP / 2,4,5-T acid	01-Aug-63	31-Aug-69

Na 2,4,5-TCP = sodium 2,4,5-trichlorophenate
2,4,5-T acid = 2,4,5-trichlorophenoxyacetic acid

Table 7
Production Capacities and Levels for
2,4,5-T Acid and Na 2,4,5,-TCP Production Process
Monsanto Company
Nitro, West Virginia

Date	Product	Production Capacity* (pound per month)	Number of Workers	Date	Production Level ** (pound per month)
Oct-48	2,4,5-T acid	25,000	10		?
Jun-49	2,4,5-T acid	50,000	10		?
Jan-54	2,4,5-T acid	200,000	16		?
Feb-58	2,4,5-T acid	200,000	16		?
Jan-61	2,4,5-T acid	130,000	16	May-61	214,500
Jan-61	2,4,5-T acid	160,000	14		
Jan-61	2,4,5-T acid	110,000	10	May-62	249,430
Aug-63	2,4,5-T acid	333,000	12	Jan-63	255,744
				Mar-63	276,521
Jan-65	2,4,5-T acid	400,000	16		?
				Oct-67	629,050
				Oct-68	658,995
Jan-54	Na 2,4,5-TCP	225,000	8		?
Apr-58	Na 2,4,5-TCP	260,000	8		?
Apr-58	Na 2,4,5-TCP	170,000	6		
Jan-60	Na 2,4,5-TCP	240,000	8		?
Jan-60	Na 2,4,5-TCP	157,000	6		

2,4,5-T acid = 2,4,5-trichlorophenoxyacetic acid
Na 2,4,5-TCP = sodium 2,4,5-trichlorophenate
? = production level not provided
* = data from S.M.P.
** = data provided by company

Table 8
Na 2,4,5,-TCP Process Equipment
Building 51
Monsanto Company
Nitro, West Virginia
1958, 1960, 1962

Process	Building	Year	Quanity	Equipment Description	Process Step
Na 2,4,5-TCP	51	1958			
			1	12,000 gal. TCB storage tank	
			1	10,000 gal. MeOH storsge tank	
			1	800 gal. TCB melt tank	
			1	2,500 gal. autoclave reactor	1
			1	2,000 gal. MeOH still	2
			2	6' x 7'6" MeOH receivers	
			1	5' x 6' MeOH weak cut receiver	
			1	10,000 gal. settling tank	3
Na 2,4,5-TCP	51	1960			
			1	12,000 gal. TCB storage tank	
			1	10,000 gal. MeOH storsge tank	
			1	800 gal. TCB melt tank	
			1	2,500 gal. autoclave reactor	1
			1	2,000 gal. MeOH still	2
			2	6' x 7'6" MeOH receivers	
			1	5' x 6' MeOH weak cut receiver	
			1	10,000 gal. settling tank	3
Na 2,4,5-TCP	51	1962			
			1	12,000 gal. TCB storage tank	
			1	10,000 gal. MeOH storsge tank	
			1	800 gal. TCB melt tank	
			1	2,500 gal. autoclave reactor	1
			1	2,000 gal. MeOH still	2
			2	6' x 7'6" MeOH receivers	
			1	5' x 6' MeOH weak cut receiver	
			1	10,000 gal. settling tank	3

Na 2,4,5-TCP Process steps

1. Autoclave reactor
2. MeOH still
3. Na 2,4,5-TCP settling tank

Table 9

Time Cycles for Na 2,4,5,-TCP Process
Building 51
Monsanto Company
Nitro, West Virginia

Na 2,4,5-TCP Time Cycle 1958, 1960 & 1962 Bldg. 51

Unit	No. of Unit	Cycle/Unit (hours)	Capacity (lbs/hour)
Autoclave	1	15.50	372
Still	1	9.00	641

Cycles in Detail

Autoclave		Still	
Load	1.00 hr.	Load	1.50 hr.
Heat up	2.75 hrs.	Distill	6.75 hrs.
Feed TCB	4.50 hrs.	Adjust	0.25 hr.
Hold period	3.50 hrs.	Transfer	0.50 hr.
Cool	2.25 hrs		
Transfer	1.50 hrs.		9.00 hrs.
	15.50 hrs.		

Na 2,4,5-TCP = sodium 2,4,5-trichlorophenate

Table 10
2,4,5-T Acid Process Equipment
Building 34
Monsanto Company
Nitro, West Virginia
1948, 1949, 1953, 1958, and 1962

Process	Building	Year	Quanity	Equipment Description	Process Step
2,4,5-T acid	34	1948			
			1	1,200 gal. condensation reactor	1
			1	42" Fletcher centrifuge	2
			1	700 gal. TCP recovery tank	8
			1	18" Shriver filter press	2A
			1	500 gal. acidification tank	4
			1	3' x 6' fitler box	5
			1	tray dryer	6
			1	Type F Oyratory Sifting Machine	7
			1	recovered alcohol storage tank	
			1	centrifuge filtrate storage tank	2B
			1	Na 2,4,5-T storage tank	2C
2,4,5-T acid	34	1949			
				Dryers	6
			1	5' x 6' alcohol receiver	
			1	30" x 36" alcohol receiver	
			1	6'6" x 8' dissolver	2A
			1	6' x 6'7" dissolver storage tank	2B
			1	6' x 6' wringer storage tank	2C
			1	6' x 3' x 3' wooden filter box	2D
			1	5' x 6'6" wringer filtrate storage tank	2E
			1	1,200 gal. condensation reactor	1
			1	500 gal acidifier	4
			1	micro-pulverizer	7
			1	48" Tolhurst centrifuge	2
			1	3'3" x 10' TCP recovery tank	8
2.4,5-T acid	34	1953			
			1	10,000 gal. settling tank (Na 2,4,5-TCP)	
			1	50,000 gal. Na 2,4,5-TCP storage tank	
			1	500 gal. Na 2,4,5-TCP weigh tank	
			3	1,200 gal. condensation reactors	1
			1	500 gal. NaMCA preparation tank	
			1	1,000 gal. crude Na 2,4,5-T storage tank	
			1	48" Tolhurst centrifuge (Na 2,4,5-T)	2
			1	48" Fletcher centrifuge (Na 2,4,5-T)	2
			1	Redler conveyor	2A
			1	1,700 gal dissolver	3
			1	filtrate storage tank	2B
			1	caustic wash water storage tank	2C
			1	2,000 gal. Na 2,4,5-T storage tank	3A
			3	Alsop filter	3B
			2	500 gal. acidification tanks	4
			1	48" Fletcher centrifuge (2,4,5-T acid)	5
			1	Redler conveyor to dryer hopper	5
			1	Storage Hopper (wet 2,4,5-T acid)	6A

Table 10 cont.

Process	Building	Year	Quanity	Equipment Description	Process Step
			1	30" rotary dryer	6
			1	cyclone separator	6B
			1	dust bag collector	6C
			1	rotex with 8 mesh screen	7A
			1	1,000 gal. Recovered TCP storage tank	8A
			1	1,000 gal. TCP recovery tank	8
			1	Roto-Clone ventilation system	
2,4,5-T acid	34	1958			
			1	8,000 gal. MCA storage tank	
			1	50,000 gal. Na 2,4,5-TCP storage tank	
			1	200 gal. MCA weigh tank	
			1	500 gal. MCA neutralizer tank	
			2	3'6" x 4' NaMCA feed tank	
			1	4' x'4' Na 2,4,5-TCP weigh tank	
			3	1,200 gal. condensation reactor	1
			1	6' x 6'6" slurry storage tank	1A
			2	48" Fletcher centrifuge (Na 2,4,5-T)	2
			1	2'6" x 3'3" caustic wash tank	2A
			1	3' x 6' salt filtrate receiver	2B
			2	200 gal. crude Na 2,4,5-T slurry tank	3
			1	6'6" x 8' Na 2,4,5-T slurry storage tank	3A
			2	500 gal. acidifier	4
			1	3' x 5'6" x 4' filtrate settling box	4A
			1	2' x 4' sulfuric acid weigh tank	4B
			1	48" Fletcher centrifuge	5
			1	5" wet 2,4,5-T acid Redler conveyor	5A
			1	3'6" x 6' dryer feed hopper	6A
			1	2-1/2 x 20' Hersey rotary dryer	6
			1	Dracco dust collector 1750 RMP, 1/2 HP	6B
			1	5" dry 2,4,5-T acid Redler conveyor	7A
			1	#11 Rotex screener	7B
			1	6' x 6' salt filtrate storage tank	2C
			1	5'6" x 6' recovered TCP reactor	8
			1	Roto-clone fume scrubber 1750 RPM, 15 HP	
2,4,5-T acid	34	1962			
			1	8,000 gal. MCA storage tank	
			1	50,000 gal. Na 2,4,5-TCP storage tank	
			1	200 gal. MCA weigh tank	
			1	500 gal. MCA neutralizer tank	
			2	3'6" x 4' NaMCA feed tank	
			1	4' x'4' Na 2,4,5-TCP weigh tank	
			3	1,200 gal. condensation reactor	1
			1	7' x 8' slurry storage tank	1A
			2	48" Fletcher centrifuge (Na 2,4,5-T)	2
			1	2'6" x 3'3" caustic wash tank	2A

Table 10 cont.

Process	Building	Year	Quanity	Equipment Description	Process Step
			1	3' x 6' salt filtrate receiver	2B
			2	200 gal. crude Na 2,4,5-T slurry tank	3
			1	6'6" x 8' Na 2,4,5-T slurry storage tank	3A
			2	500 gal. acidifier	4
			1	3' x 5'6" x 4' filtrate settling box	4A
			1	2' x 4' sulfuric acid weigh tank	4B
			1	48" Fletcher centrifuge	5
			1	5" wet 2,4,5-T acid Redler conveyor	5A
			1	3'6" x 6' dryer feed hopper	6A
			1	2-1/2 x 20' Hersey rotary dryer	6
			1	Dracco dust collector 1750 RMP, 1/2 HP	6B
			1	5" dry 2,4,5-T acid Redler conveyor	7A
			1	#11 Rotex screener	7B
			1	6' x 6' salt filtrate storage tank	2C
			1	5'6" x 6' recovered TCP reactor	B
			1	Roto-clone fume scrubber 1750 RPM, 15 HP	

2,4,-T acid Process Steps

1. condensation reactor
2. Na 2,4,5-T filtration
3. Na 2,4,5-T dissolver
4. Acidification reactor
5. 2,4,5-T acid filtration
6. 2,4,5-T acid drying
7. 2,4,5-T acid packaging
8. TCP recovery

Table 11

Changes in 2,4,5-T Acid Manufacture Which Affected Worker Exposure

Monsanto Company

Nitro, West Virginia

Initial Production - Oct. 1948 - March 1949

Na 2,4,5-TCP in Bldg 41. Methanol recovery and 2,4,5-T acid in Bldg 43.

Exposures

1. Handling flake caustic (NaOH), Handling drum methanol (MeOH).
2. Drum handling sodium monochloroacetate (NaMCA), drum melting and handling 1,2,4,5-tetrachlorobenzene (TCB).
3. Opening MeOH still for pH checks and samples (dipped).
4. Clarification filtration Na 2,4,5-TCP; cleaning and changing filter cloths.
5. Inspection of MeOH still inner wall for caking, each batch. Clean if needed.
6. Opening condensation reactor to check slurry thinkness and after each batch cleaning cake off the sides of the reactor if needed.
7. Opening condensation reactor for dip pH checks and dip lab samples.
8. Opening Na 2,4,5-T centrifuge to check loading, shoveling cake out into transfer boxes, cleaning basket and changing cloths.
9. Sampling Na 2,4,5-T centrifuge filtrate for solids.
10. Shoveling Na 2,4,5-T from boxes to elevator for transfer to disolver.
11. Na 2,4,5-T decolorizing filtration to acidifier - changing cloths.
12. Acidifier opened for pH and sample dips and level measurements.

Table 11 cont.

13. 2,4,5-T acid pan filter opened, smoothed, washed and shoveled out cake.
14. Changed pan filter cloth.
15. Drying conducted in about four locations. Bldg.s 16, 21, 34, 46, and 79. Using tray dryer steps were: (1) scooping wet 2,4,5-T acid orto tray and spreading; (2) moving cart of wet trays in and dried product out of the drier; (3) dumping dry products into 2,4,5-T boxes; (4) moving boxes to mill (Bldgs. 17 and 34); (5) manually feeding mill and; (6) packing out containers (Bldg. 34).
16. Wiping off containers, sweeping up area for 2,4,5-T rework.
17. Screening sweepings, then dissolving in 25% NaOH for rework.
18. Opening acidifier for 2,4,5-TCP recovery for level dips, pH dip checks and sampling.
19. Drumming off recovered 2,4,5-TCP.
20. Sewering of any filtrates, washes, washdown and steam off of area facilities, handling spills, line leaks and preparation for repairs.

March 8, 1949 Massive exposure after autoclave over pressurized and relieved.

March 1949 - Summer 1950

7/49 Changed autoclave processing conditions to avoid overreaction.

11/49 Moved Na 2,4,5-TCP manufacture to Bldg. 51; same process

Summer 1950 - December 1952

3/51 TCB received in tank cars rather than drums

10/51 Operating Process change eliminated filtration of Na 2,4,5-TCP in B-34 and moved it to B-51.

Table 11 cont.

11/51 Expansion of Bldg. 51, equipment for MeOH distillation & dissolving flake NaOH was added.

Fall/52 Shut down Bldg. 34 to install new 2,4,5-T facilities.

1/6/53 Startup of 2,4,5-T acid process after new equipment addition in Bldg. 34

This new facility reduced manual labor, workforce exposed dropped from 32 to approximately 23 workers.

Exposures Eliminated (see above for description)

A. TCB drum melting & handling (Elim. 2)

B. One filtration of Na 2,4,5-TCP (Elim. 4)

C. Na MCA in drums (Elim. 2)

D. Inspection of MeOH still for residue per each cycle (Elim. 5)

E. Inspection of condensation reactor for slurry thickness (Elim. 6)

F. Cleaning cake off condensation reactor walls (Elim. 6)

G. Shoveling Na 2,4,5-T into bucket elevator (Elim. 10)

H. Open box filter operation (Elim. 13 & 14)

I. Box transfer of Na 2,4,5-T (part of 8)

J. Handling of 2,4,5-T to and from drier and manual mill feeding (Elim. 15)

K. Screening & dissolving sweeping for rework (Elim. 17)

L. Drum off of recovered 2,4,5-TCP (Elim. 19)

New Equipment Bldg. 34

TCB storage tank and pump

NaMCA feed tanks (2)

Table 11 cont.

MeOH storage tank and pump

Na 2,4,5-TCP weigh tank

NaOH dissolver and pump

MCA neutralizer and pump

Complete MeOH distillation system, tanks and pumps

Slurry storage tank

Dissolver storage tank

Three condensation reactors

Fletcher Centrifuge (bottom discharge) for 2,4,5-T

Fletcher Centrifuge (bottom discharge) for Na 2,4,5-T

Tolhurst Centrifuge (Manual dig) (above discharge Na 2,4,5-T)

Redler Conveyor and Screw Conveyor to dissolver (Na 2,4,5-T)

Redler Conveyor to move wet 2,4,5-T acid to drier feed hopper

Alsop filter

Wet 2,4,5-T acid hopper and feed screw

Rotary drier, dust cyclone, Dracco dust collector

Na salt filtrate storage tank and Na 2,4,5-TCP recovery tank

Dry 2,4,5-T Redler Conveyor, Rotex screener, packout drums

Roto-clone dust control system

Fan on Rotex vent hood and on drier feed hopper

Fan on Tolhurst Centrifuge and Alsop filter hood

Old Exposures Continuing

1-3-7-8-9-11-12-16-18-20

Table 11 cont.

New Exposures Added as a Result of Equipment Additions

21. Stick measurement of TCB melt tank, weighing and charging flake NaOH to caustic dissolver.
22. Manual charge MCA & Na2CO3 to MCA neutralizer
23. pH check of MCA neutralizer
24. Punch Na 2,4,5-T cake from hopper into Redler Conveyor from bottom discharge. Fletcher Centrifuge and manual cut down of cake.
25. Punch Na 2,4,5-T from hopper to Redler, existing Tolhurst Centrifuge.
26. Punch Na 2,4,5-T into feed screw to dissolver
27. Alsop filter for Na 2,4,5-T changing cartridges (dissolver to acidifier).
28. Punch 2,4,5-T into drier feed screw; break arches in drier feed hopper.
29. Clean out and change bags in Dracco dust collector
30. Rework oversize from sifter; Check weighing on packout scales.

January 1953 - August 1963

4/53 2,4,5-T Acid Process Description modified NaOH/MeOH ratio, designed to minimize chloracnegen formation, following Mellon's identification of 2,4,5-trichloroanisole (2,4,5-TCA) as a chloracnegen

12/53 Began tank car delivery of MeOH (eliminated exposure 1)

4/55 Completed arch breaker in wet 2,4,5-T acid drier feed hopper. (minimized expoure 29)

8/56 Installed larger exhaust fan in roof of reactor room.

8/56 Acidification carried out 20°C higher at 90°C (increased exposure 12)

7/57 Acidification temperature dropped back to 70°C (decreased exposure 12)

Table 11 cont.

7/57 Fletcher centrifuge was equipped with a salt slurry tank and pump to receive cake, transferred directly to dissolver. (segment of Redler conveyor eliminated, minimizing exposure)

10/57 Fletcher centrifuge installed to replace Tolhurst. Eliminated shoveling from centrifuge, new machine had bottom discharge to Redler conveyor. (modified 8)

10/57 Began using molten MCA from Krummrich plant; Sauget, Illinois

10/57 25% NaOH used in preparation of Na MCA, eliminated Na_2CO_3 (exposure 23)

11/57 Na 2,4,5-TCP solution diluted to 22% before pH adjusted, less fumes.

12/57 Water meter put on Na 2,4,5-T dissolver & slurry tanks (dissolver now operated closed).

12/57 Corrosion resistant fume ducts installed Bldg. 34. At this point there was no longer filtration between dissolver and acidification.

1/58 Eliminated discharging filtrate from 2,4,5-TCP batches (slight exposure increase).

2/58 Feed screw to dissolver improved

2/58 New dissolver storage tank

2/58 Mechanical ploughing of cake from centrifuges.

Spring/58 Bag packer replaced container packout (generally considered an exposure increase).

10/59 Venturi fume scrubber also tied to MCA neutralizer.

10/59 80°C wash water on centrifuge to improve washing.

12/59 Roto-clone replaced with Venturi fume scrubber (improved venting).

1960 Second Fletcher Centrifuge equipped with reslurry tank and pump (all Na 2,4,5-T Redler Conveyors eliminated).

Table 11 cont.

4/60 pH measure and control installed on one condensation reactor (#3 unit), allowed closed kettle operation.

5/60 Polishing filter put on acid centrifuge filtrate (increased exposure; due to need for cleaning).

6/60 Na 2,4,5-TCP began to be pumped from weighing tank rather than by blowing (minimized venting).

7/60 Began receiving 72% NaOH solution rather than flake.

7/60 Dracco dust collector put on drier feed hopper and packout system (minimized exposure).

1/61 Continuous system - 2,4,5-TCP recovery from Na 2,4,5-T filtrate (minimized exposure).

1/61 Fume collector Bldg. 34 tied into acidifier and 2,4,5-T centrifuge.

1/61 Dracco collector replaced with (Corden) corrosion resistant unit for drier.

2/61 pH meter on Na MCA reactor allowed closed, direct neutralization of MCA.

1961 Installed new hot water spray nozzles to improve 2,4,5-T centrifuge washing.

9/61 Began continuous neutralization of MCA directly in the condensation reactor.

1/62 Dry product handling revisions completed.

1/62 Test on Eimco Belt Filter successful.

2/62 Experimental Eimco Belt Filter placed on order.

4/62 Installed new drier feed hopper with vibratory feeder (decreased dust exposure)

Table 11 cont.

4/62 Dry product blender installed (decreased dust exposure).

4/62 Sweco screener replaced Rotex (decreased dust exposure).

4/62 Improved bagger added (decreased dust exposure).

4/62 Chemico scrubber installed (decreased dust exposure).

10/62 Polypropylene filter cloth replaced cotton for 2,4,5-T centrifuges. Increased life of cloth from 1 day to 4 days. (reduced exposure).

10/62 Tests on Dorr Oliver pan filter were successful for 2,4,5-T; new unit retained in service (eliminated high exposures during centrifuge operations).

6/62 Hot water heaters operating on all condensation reactors (minimized opening).

2/63 Fume removal hood and blower put on Dorr Oliver pan filter (minimized exposure).

5/63 Improvement made in pumping filtrate from pan filter (reduced maintenance exposure).

August 1963 - August 1969

New Plant - Na 2,4,5-TCP and 2,4,5-T Acid both in Bldg. 92

Bldgs. 51 and 34 were shutdown and idled. New facilities were designed to eliminate most of the exposure points experienced in the previous manufacturing equipment.

Auto sequence controls of condensation - 2 autoclaves, not automatic.

Semi-continuous operations; Na 2,4,5-T filtration, acidification of 2,4,5-T acid filtration, 2,4,5-T acid drying and 2,4,5-TCP recovery.

Bulk handling of raw materials with closed weighing tanks or limited entry measuring tanks

Table 11 cont.

Two Venturi scrubbers used to backup filter and solid settler on Eimco Packaging on day shift only

Late/63 Second dust collector put on rotary dryer.

4/64 Internal spray rings installed to prevent lump formation in condensation reactors

8/64 Complete vacuum drop indicator accross dust collector.

9/64 Auto feed valve and level control put on pan filter.

9/64 Auto cutoff water meters installed to prevent overfills.

10/64 Second parallel dust collector installed.

11/64 Side agitator put in Na 2,4,5-TCP storage tank (prevented solids from settling and made cleanouts easier, less boil outs).

1/65 Auto water level valve & dip probe on dilution of Na 2,4,5-TCP in MeOH still installed (maintained closed operation - minimized exposure).

5/65 Load accelerator installed on blender to allow restart under load (minimized cleanout of blender - minimized exposure).

6/65 A new, larger & more effective settler installed for 2,4,5-TCP recovery (minimized operator & maintenance exposure).

2/66 Surge bin was put in between pan filter and drier.

4/66 Auto temperature, pressure control and alarm systems put on Na 2,4,5-TCP autoclaves.

6/66 Level probe was put on 2,4,5-TCP weigh tank to prevent overflowing (minimized exposure).

6/66 Installed water flow meter on MCA mixer (eliminated overflowing - minimized exposure).

8/66 Cleaned Venturi fume scrubber ducts and rerouted pan filter wash and filtrate outside building (minimized operator exposure).

Table 11 cont.

11/66 Replaced #2 primary dust collector with a larger unit.

7/67 Added automatic batch hold cycle timers on the two Na 2,4,5-TCP autoclaves to minimize hold period after TCB addition (minimized exposure).

12/67 Weigh tanks and pumps for MeOH and 72% NaOH to add RMs under pressure (ed cycle time and significant reduction in Mid/68 of 2,3,7,8 -TCDD in Na 2, ,5-TCP).

10/68 Temperature control put on one of the Na 2,4,5-TCP autoclave (minimized 2,3,78-TCDD).

11/68 Agitator installed in Na 2,4,5-TCP weigh tank to prevent crystal deposition.

12/68 Better hot water system to eliminate wash nozzle plugging and to lengthen filter cloth life (minimized operator and mainteance exposures).

11/68 GL chromatograph methods issued for:

2,3,7,8-TCDD

2,4,5-TCA

TCB in Na 2,4,5-TCP or recovered 2,4,5-TCP

1/69 U.S. Government ended contract.

Table 12
Job Titles and Description for
2,4,5-T Acid and Na 2,4,5,-TCP Production Process
Monsanto Company
Nitro, West Virginia

Building Number	Job Title	Job Description	Effective Years
32	Helper, 1st & 2nd Class	Operated centrifugals, drying & packaging	1948
32	Operator	Operated autoclave, MeOH still, reactor & 2,4,5-TCP recovery	1948
32	Production Utility	Relieved Operator & Helpers	1948
34	Helper, 1st & 2nd Class	Operated Na 2,4,5-T centrifugal, acidification, 2,4,5-T centrifugal, drying & packaging	1948 - 1963
34	Operator	Assisted the Head Operator & operated Na 2,4,5-T centrifugal	1948 - 1963
34	Head Operator	Operated reactors and 2,4,5-TCP recovery system, some time spent preparing sodium monochloracetate	1948 - 1963
34	Production Utility	Relieved Head Operator, Operator & Helpers	1948 - 1963
41	Helper, 1st Class	Assisted and relieved Operator	1948 - 1950
41	Operator	Operated autoclave and methanol still	1948 - 1950
41	Head Operator	Oversaw Na 2,4,5-TCP process and relieved Operator	1948 - 1950
41	Production Utility	Relieved Operator & Helper	1948 - 1950
51	Helper, 1st Class	Assisted and relieved Operator	1948 - 1950
51	Operator	Operated autoclave and methanol still	1948 - 1950
51	Head Operator	Oversaw Na 2,4,5-TCP process and relieved Operator	1948 - 1950
92	Supervisor	Was responsible for Bldg. 92 operations	1963 - 1969

Table 12 cont.

Building Number	Job Title	Job Description	Effective Years
92	Foreman	Was responsible for production in Bldg. 92	1963 - 1969
92	Head Operator	Coordinated activities in Bldg. 92 and worked vacation relief	1963 - 1969
92	Operator	Operated autoclaves, methanol still 2,4,5-TCP recovery & reactors	1963 - 1969
92	Helpers	Operated filtration equipment, drying & packaging machines	1963 - 1969
92	Production Utility	Relieved Operators and Helpers	

2,4,5-TCP = 2,4,5-trichlorophenol
Na 2,4,5-TCP = sodium 2,4,5-trichlorophenate
2,4,5-T Acid = 2,4,5-trichlorophenoxyacetic acid
Na 2,4,5-T = sodium 2,4,5-trichlorophenoxyacetate

Table 13
Time Cycles for 2,4,5-T Acid Process
Building 34
Monsanto Company
Nitro, West Virginia

2,4,5-T Acid Time Cycles 1958 Bldg. 34

Unit	No. of Unit	Cycle/Unit (hours)	Capacity (lbs/hour)
Reactor	3	6.00	400
Na Salt Centrifuge	2	1.50	400
Dissolver	1	1.50	400
Acidifier	2	1.50	400
Acid Centrifuge	1	1.58	347
Dryer	1	continuous	417

2,4,5-T Acid Time Cycles 1962 Bldg. 34

Unit	No. of Unit	Cycle/Unit (hours)	Capacity (lbs/hours)
Reactor	3	5.50	500
Na Salt Centrifuge	2	1.50	500
Acidifier	2	1.30	450
Acid Centrifuge	1	1.30	450
Dryer	1	continuous	450

2,4,5-T Acid = 2,4,5-trichlorophenoxyacetic acid

Table 14
Na 2,4,5,-TCP/2,4,5-T Acid Process Equipment
Building 92
Monsanto Company
Nitro, West Virginia
1966

Process	Building	Year	Quanity	Equipment Description	Process Step
Na 2,4,5-TCP/2,4,5-T acid	92	1966	1	Ruggles & Coles Rotary Dryer	15
			1	6' x 6' Recover Alcohol Receiver #1	
			1	Na 2,4,5-TCP settling tank	3
			2	7' x 16'6" Autoclave reactor	1
			2	7' x 7' MeOH still	2
			1	108" x 25' TCB storage tank	
			1	50,000gal. Na 2,4,5-TCP storage tank	4
			1	10,000 gal. 72% NaOH storage tank	
			1	12,000 gal. TCB storage tank	
			1	800 gal. TCB feed tank	
			1	470 gal. Na 2,4,5-TCP weigh tank	5
			2	7' x 7' condensation reactor	6
			2	3,000 gal.Na 2,4,5-T filter feed tank	8
			1	2,000 gal. filtrate hold tank	
			1	Dryer feed hopper	14
			1	Haveg pan filter receiver	13
			1	Eimco vacuum receiver	10
			2	10'6" x 12' reactor surge tank	7
			1	Eimco filter	9
			1	Eimco vacuum receiver	
			1	Haveg primary settling tank	
			1	2,000 'gal. acidifier	11
			1	Pan filter	12
			1	Multi-bag Dracco filter	
			1	Eimco filter	9
			1	Mikro dust collector	21
			1	Bagger feed hopper	17
			1	Horizontal blender	18
			1	S & K Haveg fume scrubber	
			1	Sweco separator	16
			1	Dustex dust collector	22
			1	St. Regis packer	19
			1	Vibrax drum packer	20

Table 14 cont.

Na 2,4,5-TCP/2,4,5-T acid Process Steps

1. Autoclave reaction
2. MeOH recovery
3. Na 2,4,5-TCP settling
4. Na 2,4,5-TCP storage tank
5. Na 2,4,5-TCP weigh tank
6. Condensation reactor
7. Reactor surge tank
8. Filter feed tank
9. Eimco Na 2,4,5-T belt filter
10. Na 2,4,5-T slurry tank
11. Acidification reactor
12. 2,4,5-T acid pan filter
13. Haveg vacuum receiver
14. Dryer feed surge hopper
15. Rotary dryer
16. Sweco screener
17. Product hopper
18. Ribbon blender
19. Bag packaging station
20. Drum packaging station
21. Primary dust collector
22. Back-up dust collector

Table 15
Time Cycles for Na 2,4,5,-TCP/2,4,5-T Acid Processes
Building 92
Monsanto Company
Nitro, West Virginia

Na 2,4,5-TCP/ 2,4,5-T Acid Time Cycle 1966 Bldg. 92

Unit	No. of Unit	Cycle/Unit (hours)	Capacity (lbs/hour)
Autoclave	2	13.50	827
Still	1	7.00	770
Reactor	2	4.00	852

Filtration and acidification are considered to have 900 lbs/hr. capacity continuous operation.

Cycles in Detail

Autoclave		Still	
Load	1.00 hr.	Load	1.00 hr.
Heat up	2.50 hrs.	Distill	5.00 hrs.
Feed TCB	4.00 hrs.	Pump out	1.00 hr.
Hold period	3.50 hrs.		7.00 hrs.
Cool	1.50 hrs.		
Transfer	1.00 hrs.		
	13.50 hrs.		

Reactor	
Load	0.25 hr.
Adjust pH	0.25 hr.
MCA feed	1.00 hr.
Hold period	1.50 hrs.
Adjust pH	0.25 hr.
Pump out	0.75 hr.
	4.00 hrs.

Na 2,4,5-TCP = sodium 2,4,5-trichlorophenate
2,4,5-T Acid = 2,4,5-trichlorophenoxyacetic acid
TCB = 1,2,4,5-tetrachlorobenzene
MCA = monochloroacetic acid

Table 16
Concentrations of Organic Chloride and
Methyl Alcohol in Building 51
Monsanto Company
Nitro, West Virginia
April 14, 1953

Sample Description‡	Organic Chloride (ppm)	Methyl Alcohol (ppm)
Control room	18.1	1.06
At still (adding water)	<0.10	<0.04
At Filter while filtering	4.5	<0.02
Cleaning Filter Press	3.78	----

Organic Chloride = vapors of halogenated hydrocarbons were collected by passing the air through 95% ethyl alcohol in gas absorption bottles provided with sintered glass dispersers. Portions of the alcohol were burned, the combustion products trapped, and the chloride analyzed following precipitation of the chloride by silver nitrate solution.

Methyl Alcohol = vapors of methyl alcohol were collected with water in a in a gas wash bottle. Formaldehyde was produced and estimated in terms of intensity of the violet color it produced with chromotropic acid.

ppm = parts analyte per million parts of air

---- = no sample taken

‡ = Samples were collected and analyzed by investigators from the Kettering Laboratory in the Department of Preventive Medicine and Industrial Health, College of Medicine, University of Cincinnati, Cincinnati, Ohio

Table 17

Concentrations of Organic Chloride in Building 34
Monsanto Company
Nitro, West Virginia
April 14, 1953 and January 10, 1956

Sample Description‡	Organic Chloride (ppm) (4/14/53)	Organic Chloride (ppm) (1/10/56)
While loading Fletcher Centrifuge #2	1.11	0.455
While loading Tolhurst Centrifuge #1	0.42	0.910
Corner of first level under TCP recovery reactor	----	1.09
On recovered TCP reactor platform while loading reactor - Manhole open	----	1.26
While loading Centrifuge #3	0.41	0.81
Over settling tank while loading Centrifuge #3	----	0.45
On acidifier platform near Acidifier #1 - Manhole open	0.68	0.63
On reactor platform while loading reactor & testing pH	0.90 0.82 5.60	2.25
General air in reactor room near Alsop filter	0.59	0.57
In inlet duct (elbow) to Rotoclone	----	7.5
In outlet duct from Rotoclone	----	4.7
General air of drying room	<0.10	----

Organic Chloride = vapors of halogenated hydrocarbons sampled by decomposing the vapor in a Wilson furnace and trapping the liberated chlorine & hydrochloric acid in 0.1 N NaOH solution. The NaOH solution was analyzed by a turbidimetric procedure following preciptation of the chlorine by silver nitrate solution.

ppm = parts organic chloride per million parts of air

---- = no sample taken

‡ = Samples were collected and analyzed by investigators from the Kettering Laboratory in the Department of Preventive Medicine and Industrial Health, College of Medicine, University of Cincinnati, Cincinnati, Ohio

Table 16

Concentrations of 2,4,5-T Acid Dusts in Building 34
Monsanto Company
Nitro, West Virginia
April 14, 1953 and January 10, 1956

Sample Description*	2,4,5-T Acid (mg/M3) (4/14/53)	2,4,5-T Acid (mg/M3) (1/10/56)
In dryer room, 5 ft. from Rotex feeder and near the scale	1.38 0.93	2.57
At the feed hopper on top of dryer	0.71 2.00	0.35
Near stairway to acidifier platform	----	0.20
While unloading Centrifuge #1	----	0.76
On plant premises, 100 ft. downwind from Building 34	----	0.07

2,4,5-T Acid = Dust samples were collected by means of a large volume sampler fitted with filter paper (4/14/53) or glass fiber filters. The filters were desorbed with alcohol and the chloride determined by a turbidimetric procedure following precipitation of the chloride by silver nitrate solution.

mg/M3 = milligrams of 2,4,5-T Acid as measured as chloride per cubic meter of air

---- = no sample taken

* = Samples were collected and analyzed by investigators from the Kettering Laboratory in the Department of Preventive Medicine and Industrial Health, College of Medicine, University of Cincinnati, Cincinnati, Ohio

Table 19

2,4,5-T Acid Air Concentrations in Building 34
Monsanto Company
Nitro, West Virginia
June 8, 1954

Sample Description*	2,4,5-T Acid (mg/M3)
Vicinty of top of the reactor	0.39
Vicinity of recovery kettles	0.18
Loading No. 2 centrifuge	0.02
Vicinity of No. 1 centrifuge, centrifuge running	0.07
Vicinity of acid tanks	0.12
At No. 1 centrifuge during unloading	0.11
On platform at hopper while No. 3 centrifuge was unloading	0.66
Vicinity of No. 3 centrifuge during unloading	0.16
Vicinity of No. 3 centrifuge during unloading	1.06
Vicinity of drumming operation	0.18

2,4,5-T Acid = Samples collected with Greenburg-Smith impingers at a sampling rate of one cubic foot of air per minute.

mg/M3 = milligrams of 2,4,5-T Acid per cubic meter of air

* = Samples collected by the State Health Department of West Virginia, Bureau of Industrial Hygiene

Table 20
2,3,7,8-TCDD Concentrations in Monsanto 2,4,5-T Acid
Monsanto Company
Nitro, West Virginia
1958 - 1969

Date	Sample Description	2,3,7,8-TCDD Conc. (ug/g)	Source
1958	2,4,5-T acid	11	Monsanto
1959	2,4,5-T acid	11	Monsanto
1960	2,4,5-T acid	8	Monsanto
1961	2,4,5-T acid	5	Monsanto
1962	2,4,5-T acid	10	Monsanto
1963	2,4,5-T acid	11	Monsanto
1964	2,4,5-T acid	12	Monsanto
Jan-65	2,4,5-T acid	5	Monsanto
Feb-65	2,4,5-T acid	8	Monsanto
Dec-65	2,4,5-T acid Lot NE12-026	12	Monsanto
Apr-65	2,4,5-T acid	12	Monsanto
Apr-65	2,4,5-T acid	15	Monsanto
Apr-65	2,4,5-T acid	16	Monsanto
Apr-65	2,4,5-T acid	16	Monsanto
Mar-65	2,4,5-T acid	17	Monsanto
Apr-65	2,4,5-T acid	22	Monsanto
May-65	2,4,5-T acid	22	Monsanto
Apr-65	2,4,5-T acid	23	Monsanto
Jul-65	2,4,5-T acid	31	Monsanto
May-65	2,4,5-T acid	32	Monsanto
Apr-65	2,4,5-T acid	34	Monsanto
Apr-65	2,4,5-T acid	41	Monsanto
Apr-65	2,4,5-T acid	44	Monsanto
Apr-65	2,4,5-T acid	55	Monsanto
Nov-66	2,4,5-T acid Lot NH11-060	3	Monsanto
Sep-66	2,4,5-T acid Lot NH09-011	3	Monsanto
Apr-66	2,4,5-T acid Lot NH04-028	3.5	Monsanto
Sep-66	2,4,5-T acid Lot NH09-051	4	Monsanto
Nov-66	2,4,5-T acid Lot NH11-010	5	Monsanto
Aug-66	2,4,5-T acid Lot NH08-016	5	Monsanto
Dec-66	2,4,5-T acid Lot NH12-009	5	Monsanto
Jan-66	2,4,5-T acid Lot NH01-024	6	Monsanto
Oct-66	2,4,5-T acid Lot NH10-102	7	Monsanto
Dec-66	2,4,5-T acid Lot NH12-051	7	Monsanto
Mar-66	2,4,5-T acid Lot NH03-054	7.5	Monsanto
Sep-66	2,4,5-T acid Lot NH09-085	8	Monsanto
Apr-66	2,4,5-T acid Lot NH04-004	8	Monsanto
Feb-66	2,4,5-T acid Lot NH02-036	10	Monsanto
Aug-66	2,4,5-T acid Lot NH08-024	11	Monsanto
Oct-66	2,4,5-T acid Lot NH10-092	11	Monsanto
May-66	2,4,5-T acid Lot NH05-033	11	Monsanto

Table 20 cont.

Date	Sample Description	2,3,7,8-TCDD Conc. (ug/g)	Source
Sep-66	2,4,5-T acid Lot NH09-100	12	Monsanto
May-66	2,4,5-T acid Lot NH05-029	12	Monsanto
Oct-66	2,4,5-T acid Lot NH10-022	12.5	Monsanto
Jun-66	2,4,5-T acid Lot NH06-020	13	Monsanto
Oct-66	2,4,5-T acid Lot NH10-052	15	Monsanto
Jun-66	2,4,5-T acid Lot NH06-067	17	Monsanto
Oct-66	2,4,5-T acid Lot NH10-082	18	Monsanto
Jul-66	2,4,5-T acid Lot NH07-052	21	Monsanto
Jul-66	2,4,5-T acid Lot NH07-016	21	Monsanto
Jul-66	2,4,5-T acid Lot NH07-038	28	Monsanto
Feb-67	2,4,5-T acid Lot NI02-001	<3	Monsanto
Feb-67	2,4,5-T acid Lot NI02-025	<3	Monsanto
Feb-67	2,4,5-T acid Lot NI02-010	<3	Monsanto
Oct-67	2,4,5-T acid Lot NI10-050	<5	Monsanto
Oct-67	2,4,5-T acid Lot NI10-080	<5	Monsanto
Oct-67	2,4,5-T acid Lot NI10-090	<5	Monsanto
Oct-67	2,4,5-T acid Lot NI10-060	<5	Monsanto
Oct-67	2,4,5-T acid Lot NI10-070	<5	Monsanto
Mar-67	2,4,5-T acid Lot NI03-030	1	Monsanto
Feb-67	2,4,5-T acid Lot NI02-040	1	Monsanto
Mar-67	2,4,5-T acid Lot NI03-001	1	Monsanto
Mar-67	2,4,5-T acid Lot NI03-010	3	Monsanto
Jan-67	2,4,5-T acid Lot NI01-031	3	Monsanto
Jan-67	2,4,5-T acid Lot NI01-041	3	Monsanto
Jan-67	2,4,5-T acid Lot NI01-051	3	Monsanto
Dec-67	2,4,5-T acid Lot NI12-010	3	Monsanto
Nov-67	2,4,5-T acid Lot NI11-020	3	Monsanto
Nov-67	2,4,5-T acid Lot NI11-070	3	Monsanto
Nov-67	2,4,5-T acid Lot NI11-040	3	Monsanto
Nov-67	2,4,5-T acid Lot NI11-060	3	Monsanto
Feb-67	2,4,5-T acid Lot NI02-020	3	Monsanto
Jan-67	2,4,5-T acid Lot NI01-021	3	Monsanto
Nov-67	2,4,5-T acid Lot NI11-080	3	Monsanto
Nov-67	2,4,5-T acid Lot NI11-090	3	Monsanto
Jun-67	2,4,5-T acid Lot NI06-060	4	Monsanto
Aug-67	2,4,5-T acid Lot NI08-070	4	Monsanto
Dec-67	2,4,5-T acid Lot NI12-080	4	Monsanto
Jan-67	2,4,5-T acid Lot NI01-004	4	Monsanto
May-67	2,4,5-T acid Lot NI05-070	5	Monsanto
Feb-67	2,4,5-T acid Lot NI02-070	5	Monsanto
Sep-67	2,4,5-T acid Lot NI09-030	5	Monsanto

Table 20 cont.

Date	Sample Description	2,3,7,8-TCDD Conc. (ug/g)	Source
Sep-67	2,4,5-T acid Lot NI09-060	5	Monsanto
Sep-67	2,4,5-T acid Lot NI09-010	5	Monsanto
Sep-67	2,4,5-T acid Lot NI09-070	5	Monsanto
Sep-67	2,4,5-T acid Lot NI09-020	5	Monsanto
Dec-67	2,4,5-T acid Lot NI12-050	5	Monsanto
Jul-67	2,4,5-T acid Lot NI07-100	5	Monsanto
Jun-67	2,4,5-T acid Lot NI06-070	5	Monsanto
Jun-67	2,4,5-T acid Lot NI06-010	6	Monsanto
Jun-67	2,4,5-T acid Lot NI06-050	6	Monsanto
Sep-67	2,4,5-T acid Lot NI09-080	6	Monsanto
Aug-67	2,4,5-T acid Lot NI08-060	6	Monsanto
Jun-67	2,4,5-T acid Lot NI06-090	6	Monsanto
Jun-67	2,4,5-T acid Lot NI06-001	6	Monsanto
Jun-67	2,4,5-T acid Lot NI06-080	7	Monsanto
Feb-67	2,4,5-T acid Lot NI02-060	7	Monsanto
Oct-67	2,4,5-T acid Lot NI10-001	7	Monsanto
Sep-67	2,4,5-T acid Lot NI09-090	7	Monsanto
Apr-67	2,4,5-T acid Lot NI04-020	7	Monsanto
May-67	2,4,5-T acid Lot NI05-100	7	Monsanto
Mar-67	2,4,5-T acid Lot NI03-040	7	Monsanto
Oct-67	2,4,5-T acid Lot NI10-040	7	Monsanto
Jul-67	2,4,5-T acid Lot NI07-001	7	Monsanto
Jun-67	2,4,5-T acid Lot NI06-030	7	Monsanto
Nov-67	2,4,5-T acid Lot NI11-050	7	Monsanto
Jul-67	2,4,5-T acid Lot NI07-020	7	Monsanto
Jul-67	2,4,5-T acid Lot NI07-010	7	Monsanto
Jun-67	2,4,5-T acid Lot NI06-110	7.5	Monsanto
Oct-67	2,4,5-T acid Lot NI10-010	8	Monsanto
May-67	2,4,5-T acid Lot NI05-080	8	Monsanto
Apr-67	2,4,5-T acid Lot NI04-015	8	Monsanto
Jun-67	2,4,5-T acid Lot NI06-040	8	Monsanto
Mar-67	2,4,5-T acid Lot NI03-045	8	Monsanto
Sep-67	2,4,5-T acid Lot NI09-110	8	Monsanto
Dec-67	2,4,5-T acid Lot NI12-060	8	Monsanto
Feb-67	2,4,5-T acid Lot NI02-035	8	Monsanto
Oct-67	2,4,5-T acid Lot NI10-020	8	Monsanto
Jul-67	2,4,5-T acid Lot NI07-060	8	Monsanto
Sep-67	2,4,5-T acid Lot NI09-050	8	Monsanto
May-67	2,4,5-T acid Lot NI05-040	9	Monsanto
Oct-67	2,4,5-T acid Lot NI10-030	9	Monsanto
May-67	2,4,5-T acid Lot NI05-090	9	Monsanto

Table 20 cont.

Date	Sample Description	2,3,7,8-TCDD Conc. (ug/g)	Source
Feb-67	2,4,5-T acid Lot NI02-030	9	Monsanto
Jul-67	2,4,5-T acid Lot NI07-030	10	Monsanto
Jun-67	2,4,5-T acid Lot NI06-020	10	Monsanto
Apr-67	2,4,5-T acid Lot NI04-005	10	Monsanto
Nov-67	2,4,5-T acid Lot NI11-030	10	Monsanto
Dec-67	2,4,5-T acid Lot NI12-040	10	Monsanto
Mar-67	2,4,5-T acid Lot NI04-001	10	Monsanto
Aug-67	2,4,5-T acid Lot NI08-010	10	Monsanto
Aug-67	2,4,5-T acid Lot NI08-030	10	Monsanto
Dec-67	2,4,5-T acid Lot NI12-070	10	Monsanto
Jul-67	2,4,5-T acid Lot NI07-080	10	Monsanto
Jun-67	2,4,5-T acid Lot NI06-100	10	Monsanto
Jul-67	2,4,5-T acid Lot NI07-050	11	Monsanto
Jul-67	2,4,5-T acid Lot NI07-090	11	Monsanto
Dec-67	2,4,5-T acid Lot NI12-020	12	Monsanto
Sep-67	2,4,5-T acid Lot NI09-100	12	Monsanto
Nov-67	2,4,5-T acid Lot NI11-010	12	Monsanto
Apr-67	2,4,5-T acid Lot NI04-050	12	Monsanto
May-67	2,4,5-T acid Lot NI05-060	13	Monsanto
Apr-67	2,4,5-T acid Lot NI04-060	13	Monsanto
Dec-67	2,4,5-T acid Lot NI12-030	13	Monsanto
Jul-67	2,4,5-T acid Lot NI07-110	13	Monsanto
Aug-67	2,4,5-T acid Lot NI08-050	13	Monsanto
Mar-67	2,4,5-T acid Lot NI03-020	14	Monsanto
Mar-67	2,4,5-T acid Lot NI03-060	15	Monsanto
Mar-67	2,4,5-T acid Lot NI03-050	15	Monsanto
May-67	2,4,5-T acid Lot NI05-050	15	Monsanto
Apr-67	2,4,5-T acid Lot NI04-010	15	Monsanto
Jul-67	2,4,5-T acid Lot NI07-040	17	Monsanto
Feb-67	2,4,5-T acid Lot NI02-050	17	Monsanto
May-67	2,4,5-T acid Lot NI05-010	17	Monsanto
Sep-67	2,4,5-T acid Lot NI09-040	18	Monsanto
Aug-67	2,4,5-T acid Lot NI08-100	18	Monsanto
Apr-67	2,4,5-T acid Lot NI04-030	18	Monsanto
Jul-67	2,4,5-T acid Lot NI07-070	19	Monsanto
May-67	2,4,5-T acid Lot NI05-020	20	Monsanto
Apr-67	2,4,5-T acid Lot NI04-040	20	Monsanto
May-67	2,4,5-T acid Lot NI05-001	22	Monsanto
Aug-67	2,4,5-T acid Lot NI08-040	22	Monsanto
Aug-67	2,4,5-T acid Lot NI08-020	22	Monsanto
Aug-67	2,4,5-T acid Lot NI08-120	23	Monsanto

Table 20 Cont.

Date	Sample Description	2,3,7,8-TCDD Conc. (ug/g)	Source
May-67	2,4,5-T acid Lot NI05-030	24	Monsanto
Oct-67	2,4,5-T acid Lot NI10-110	25	Monsanto
Nov-67	2,4,5-T acid Lot NI11-001	25	Monsanto
Aug-67	2,4,5-T acid Lot NI08-110	25	Monsanto
Sep-68	2,4,5-T acid Lot NK09-059	<3	Monsanto
Oct-68	2,4,5-T acid Lot NK10-030	<3	Monsanto
Nov-68	2,4,5-T acid Lot NK11-023	<3	Monsanto
May-68	2,4,5-T acid Lot NK05-050	<3	Monsanto
Aug-68	2,4,5-T acid Lot NK08-022	<3	Monsanto
Oct-68	2,4,5-T acid Lot NK10-038	<3	Monsanto
Jul-68	2,4,5-T acid Lot NK07-011	<3	Monsanto
Mar-68	2,4,5-T acid Lot NK03-040	<3	Monsanto
Nov-68	2,4,5-T acid Lot NK11-018	<3	Monsanto
Sep-68	2,4,5-T acid Lot NK09-042	<3	Monsanto
Aug-68	2,4,5-T acid Lot NK08-005	<3	Monsanto
Apr-68	2,4,5-T acid Lot NK04-010	<3	Monsanto
Apr-68	2,4,5-T acid Lot NK04-020	3	Monsanto
Feb-68	2,4,5-T acid Lot NK02-010	3	Monsanto
Jul-68	2,4,5-T acid Lot NK07-002	3	Monsanto
Mar-68	2,4,5-T acid Lot NK03-030	3	Monsanto
Jan-68	2,4,5-T acid Lot NK01-060	3	Monsanto
Feb-68	2,4,5-T acid Lot NK02-020	3	Monsanto
Jan-68	2,4,5-T acid Lot NK01-050	3	Monsanto
Apr-68	2,4,5-T acid Lot NK04-030	3	Monsanto
Jun-68	2,4,5-T acid Lot NK06-010	3	Monsanto
Feb-68	2,4,5-T acid Lot NK02-030	3	Monsanto
Jan-68	2,4,5-T acid Lot NK01-040	3	Monsanto
May-68	2,4,5-T acid Lot NK05-040	5	Monsanto
May-68	2,4,5-T acid Lot NK05-060	5	Monsanto
Jun-68	2,4,5-T acid Lot NK06-020	7	Monsanto
Jan-68	2,4,5-T acid Lot NK01-001	8	Monsanto
Jan-68	2,4,5-T acid Lot NK01-020	12	Monsanto
Jan-68	2,4,5-T acid Lot NK01-010	12	Monsanto
Jun-69	2,4,5-T acid Lot NL06-028	0.3	Monsanto
May-69	2,4,5-T acid Lot NL05-032	0.5	Monsanto
Jun-69	2,4,5-T acid Lot NL06-006	0.5	Monsanto
Jun-69	2,4,5-T acid Lot NL06-038	0.5	Monsanto
Apr-69	2,4,5-T acid Lot NL04-029	0.6	Monsanto
Jul-69	2,4,5-T acid Lot NL07-023	0.7	Monsanto
Jun-69	2,4,5-T acid Lot NL06-023	0.7	Monsanto
Jul-69	2,4,5-T acid Lot NL07-012	0.7	Monsanto

Table 20 cont.

Date	Sample Description	2,3,7,8-TCDD Conc. (ug/g)	Source
Jul-69	2,4,5-T acid Lot NL07-012	0.7	Monsanto
May-69	2,4,5-T acid Lot NL05-014	0.7	Monsanto
Jun-69	2,4,5-T acid Lot NL06-024	0.8	Monsanto
Jun-69	2,4,5-T acid Lot NL06-020	0.8	Monsanto
May-69	2,4,5-T acid Lot NL05-010	0.8	Monsanto
May-69	2,4,5-T acid Lot NL05-036	0.8	Monsanto
Jun-69	2,4,5-T acid Lot NL06-020	0.8	Monsanto
Jul-69	2,4,5-T acid Lot NL07-009	0.8	Monsanto
Jul-69	2,4,5-T acid Lot NL07-013	0.9	Monsanto
Jul-69	2,4,5-T acid Lot NL07-012	0.9	Monsanto
May-69	2,4,5-T acid Lot NL05-003	0.9	Monsanto
Jun-69	2,4,5-T acid Lot NL06-013	0.9	Monsanto
Jun-69	2,4,5-T acid Lot NL06-034	0.9	Monsanto
Jul-69	2,4,5-T acid Lot NL07-011	0.9	Monsanto
May-69	2,4,5-T acid Lot NL05-013	1	Monsanto
Aug-69	2,4,5-T acid Lot NL08-026	1	Monsanto
Aug-69	2,4,5-T acid Lot NL08-012	1	Monsanto
May-69	2,4,5-T acid Lot NL05-009	1	Monsanto
Jun-69	2,4,5-T acid Lot NL06-015	1.1	Monsanto
Jun-69	2,4,5-T acid Lot NL06-030	1.1	Monsanto
Aug-69	2,4,5-T acid Lot NL08-030	1.1	Monsanto
Jul-69	2,4,5-T acid Lot NL07-010	1.1	Monsanto
Jul-69	2,4,5-T acid Lot NL07-013	1.1	Monsanto
Aug-69	2,4,5-T acid Lot NL08-029	1.1	Monsanto
Jul-69	2,4,5-T acid Lot NL07-024	1.2	Monsanto
Jun-69	2,4,5-T acid Lot NL06-026	1.2	Monsanto
Jul-69	2,4,5-T acid Lot NL07-029	1.2	Monsanto
Jul-69	2,4,5-T acid Lot NL07-031	1.2	Monsanto
Aug-69	2,4,5-T acid Lot NL08-033	1.3	Monsanto
Aug-69	2,4,5-T acid Lot NL08-031	1.3	Monsanto
Aug-69	2,4,5-T acid Lot NL08-003	1.4	Monsanto
Aug-69	2,4,5-T acid Lot NL08-006	1.4	Monsanto
Aug-69	2,4,5-T acid Lot NL08-021	1.4	Monsanto
Aug-69	2,4,5-T acid Lot NL08-019	1.4	Monsanto
Apr-69	2,4,5-T acid Lot NL04-019	1.4	Monsanto
Jul-69	2,4,5-T acid Lot NL07-028	1.5	Monsanto
Jul-69	2,4,5-T acid Lot NL07-021	1.5	Monsanto
Jul-69	2,4,5-T acid Lot NL07-019	1.5	Monsanto
Jul-69	2,4,5-T acid Lot NL07-024	1.6	Monsanto
Aug-69	2,4,5-T acid Lot NL08-027	1.6	Monsanto
Jun-69	2,4,5-T acid Lot NL06-003	1.6	Monsanto

Table 20 cont.

Date	Sample Description	2,3,7,8-TCDD Conc. (ug/g)	Source
Jun-69	2,4,5-T acid Lot NL06-012	1.6	Monsanto
Apr-69	2,4,5-T acid Lot NL04-013	1.6	Monsanto
Aug-69	2,4,5-T acid Lot NL08-006	1.6	Monsanto
Jul-69	2,4,5-T acid Lot NL07-020	1.6	Monsanto
Aug-69	2,4,5-T acid Lot NL08-028	1.7	Monsanto
Jul-69	2,4,5-T acid Lot NL07-028	1.7	Monsanto
Aug-69	2,4,5-T acid Lot NL08-003	1.7	Monsanto
Jun-69	2,4,5-T acid Lot NL06-007	1.8	Monsanto
May-69	2,4,5-T acid Lot NL05-005	1.8	Monsanto
Aug-69	2,4,5-T acid Lot NL08-004	1.8	Monsanto
Jun-69	2,4,5-T acid Lot NL06-015	1.9	Monsanto
Aug-69	2,4,5-T acid Lot NL08-001	2	Monsanto
Jun-69	2,4,5-T acid Lot NL06-011	2.1	Monsanto
Jun-69	2,4,5-T acid Lot NL06-014	2.1	Monsanto
Jun-69	2,4,5-T acid Lot NL06-022	2.2	Monsanto
Aug-69	2,4,5-T acid Lot NL08-025	2.2	Monsanto
Aug-69	2,4,5-T acid Lot NL08-005	2.4	Monsanto
Aug-69	2,4,5-T acid Lot NL08-020	2.5	Monsanto
Aug-69	2,4,5-T acid Lot NL08-022	2.6	Monsanto
Aug-69	2,4,5-T acid Lot NL08-007	2.7	Monsanto
Jul-69	2,4,5-T acid Lot NL07-018	2.7	Monsanto
Aug-69	2,4,5-T acid Lot NL08-029	2.7	Monsanto
Jul-69	2,4,5-T acid Lot NL07-016	2.7	Monsanto
Jul-69	2,4,5-T acid Lot NL07-030	2.8	Monsanto
Aug-69	2,4,5-T acid Lot NL08-027	2.8	Monsanto
Aug-69	2,4,5-T acid Lot NL08-023	2.9	Monsanto
Aug-69	2,4,5-T acid Lot NL08-018	3	Monsanto
Aug-69	2,4,5-T acid Lot NL08-034	3.8	Monsanto
Mar-69	2,4,5-T acid Lot NL03-007	4.4	Monsanto
Jan-69	2,4,5-T acid Lot NL01-006	9	Monsanto
Jul-69	2,4,5-T acid Lot NL07-016	9.7	Monsanto
Jan-69	2,4,5-T acid Lot NL01-005	10	Monsanto
Jul-69	2,4,5-T acid Lot NL07-015	22	Monsanto
Apr-67	Amchem A-95744 (Monsanto) 2,4,5-T ester	14.1	Woolson
Mar-67	Amchem A-94722 (Monsanto) 2,4,5-T ester	14.4	Woolson
Jan-67	Amchem A-81701 (Monsanto) 2,4,5-T ester	34	Woolson
Sep-68	Amchem QC-519 (Monsanto) 2,4,5-T acid	12	Woolson
Apr-68	Amchem QC-579 (Monsanto) 2,4,5-T acid	13	Woolson
May-68	Amchem NK05-036 (Monsanto) 2,4,5-T acid	24	Woolson
Jul-69	Amchem NL06-019 (Monsanto) 2,4,5-T acid	1.9	Woolson
May-69	Amchem NL04-032 (Monsanto) 2,4,5-T acid	2.3	Woolson

Table 20 cont.

Date	Sample Description	2,3,7,8-TCDD Conc. (ug/g)	Source
Mar-70	Monsanto 2,4,5-T acid, 07-020	2.3	Woolson
Mar-70	Amchem NL07-018 (Monsanto) 2,4,5-T acid	3.7	Woolson
Mar-69	Amchem NL03-013 (Monsanto) 2,4,5-T acid	4	Woolson
Jan-70	Amchem NL07-018 (Monsanto) 2,4,5-T acid	5.4	Woolson
Mar-70	Amchem NL07-131 (Monsanto) 2,4,5-T acid	6.8	Woolson
Feb-65	Monsanto 2,4,5-T acid	10	Dow
Jan-65	Monsanto 2,4,5-T acid (12 samples)	6.5 - 11	Dow
Mar-70	Monsanto 2,4,5-T acid, Lot NL07-020	1.4	Dow
Nov-72	Monsanto Agent Orange, Gulfport, Miss.	6.9	Dow*
Nov-72	Monsanto Agent Orange, Gulfport, Miss.	7	Dow*
Nov-72	Monsanto Agent Orange, Gulfport, Miss.	7.2	Dow*
Nov-72	Monsanto Agent Orange, Gulfport, Miss.	7.4	Dow*
Nov-72	Monsanto Agent Orange, Gulfport, Miss.	7.9	Dow*
Nov-72	Monsanto Agent Orange, Gulfport, Miss.	9.3	Dow*
Feb-67	Still TCP	5	Monsanto

2,4,5-T acid = 2,4,5-trichlorophenoxyacetic acid
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
ug/g = micrograms of 2,3,7,8-TCDD per gram of sample

Agent Orange = 50% 2,4,5-T butyl ester & 50% 2,4-D butyl ester
Monsanto = Correspondence from Marcie Strauss of Monsanto to Marilyn Fingerhut of NIOSH, November 24, 1986.
Woolson = Woolson, E.A. et. al.: Survey of Polychlorodibenzo-p-dioxin Content in Selected Pesticides. J. Agr. Food Chem., Vol. 20(2),1972,pp. 351-354
Dow = Correspondence from E.Micheal Seidel of The Dow Chemical Company to David Marlow of NIOSH, July 23, 1986.
Dow* = Analyses conducted by The Dow Chemical Company for the US Air Force under contract No. F 41608-73-C-1629
Still TCP = recovered 2,4,5-trichlorophenol

Table 21
Summary of 2,3,7,8-TCDD Concentrations
in Monsanto 2,4,5-T Acid
Monsanto Company
Nitro, West Virginia

Year	Sample Description	Analyte	Number of Samples	Number of NDs	Sample Result Range (ug/g)	Mean ND=LOD/2 (ug/g)	S.D. ND=LOD/2	Analysis Source
1958*	2,4,5-T acid	2,3,7,8-TCDD	1	0	11	---	---	Monsanto
1959*	2,4,5-T acid	2,3,7,8-TCDD	1	0	11	---	---	Monsanto
1960*	2,4,5-T acid	2,3,7,8-TCDD	1	0	8	---	---	Monsanto
1961*	2,4,5-T acid	2,3,7,8-TCDD	1	0	5	---	---	Monsanto
1962*	2,4,5-T acid	2,3,7,8-TCDD	1	0	10	---	---	Monsanto
1963*	2,4,5-T acid	2,3,7,8-TCDD	1	0	11	---	---	Monsanto
1964*	2,4,5-T acid	2,3,7,8-TCDD	1	0	12	---	---	Monsanto
1965	2,4,5-T acid	2,3,7,8-TCDD	17	0	5 - 55	23.8	13.7	Monsanto
1965	2,4,5-T acid	2,3,7,8-TCDD	13	0	6.5 - 11	---	---	Dow
1966	2,4,5-T acid	2,3,7,8-TCDD	27	0	3 - 28	10.5	6.2	Monsanto
1967	2,4,5-T acid	2,3,7,8-TCDD	3	0	14.1 - 34	20.8	11.4	Woolson
1967	2,4,5-T acid	2,3,7,8-TCDD	117	8	1 - 25	9.0	6.0	Monsanto
1968	2,4,5-T acid	2,3,7,8-TCDD	3	0	12 - 24	16.3	6.6	Woolson
1968	2,4,5-T acid	2,3,7,8-TCDD	29	12	3 - 12	3.4	2.8	Monsanto
1969	2,4,5-T acid	2,3,7,8-TCDD	82	0	0.3 - 22	2.0	2.8	Monsanto
1969-70	2,4,5-T acid	2,3,7,8-TCDD	6	0	1.9 - 6.8	4.0	1.8	Woolson
1970	2,4,5-T acid	2,3,7,8-TCDD	1	0	1.4	---	---	Dow
1972	Agent Orange	2,3,7,8-TCDD	6	0	6.9 - 9.3	7.6	0.9	Dow+

* Samples collected between 1958 - 1964 were analyzed in 1964
2,4,5-T = 2,4,5-trichlorophenol
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzodioxin
ug/g = micrograms of 2,3,7,8-TCDD per gram of sample
Agent Orange = 50% 2,4,5-T butyl ester & 50% 2,4-D ester
Monsanto = Correspondence from Marcie Strauss of Monsanto
to Marilyn Fingerhut of NIOSH, November 24,1986
Woolson = Woolson, E.A. et.al.: Survey of Polychlorodibenzo
Content in Selected Pesticides. J. Agr. Food Chem., Vol.20(2),1972 pp.351-354
Dow = Correspondence from E. Michael Seidel of The Dow Chemical Company
to David Marlow of NIOSH, July 23, 1986
Dow+ = Analyses conducted by The Dow Chemical Company for the US Air Force
under contract No. F 41608-73-C-1629