III. WTU STEAM STRIPPERS

A. WTU Steam Stripper History

A brief discussion of the process effluent collection and treatment system in Plant B and its evolution from its original simple form into the present system is included in Section II.B. of this Report to provide a perspective on PPG's design standards and philosophy of operation for environmental compliance. Because changes made in 1987 to the physical system by which feed flow to the WTU stripper is equalized and stored were originally, but no longer are, thought to impact stripper performance, these changes are outlined here.

The API Separator used prior to 1987 was a dual-unit, acid-brick lined, above-ground, open-top phase separator. The basis for its design was the American Petroleum Institute's Manual on Disposal of Refinery Wastes, Chapter 5 (1969). Each separator bay had a capacity of about 14,000 gallons and could accommodate 1100 gpm of flow. The VCM II unit brought on-line in 1981 has its own separator. The API Separator is still used for the collection of emergency stripper overflows in the WTU area.

The WTU Surge Pond used prior to 1987 was a Bentonite clay-lined earthen pond with sloped sides. Its dimensions were 135' x 195' by 8' deep, with a capacity of 1.2 million gallons. It was sized for 24 hours of surge capacity at 500 gpm feed rates. It served to equalize the feed flow to the WTU Steam Stripper and to provide surge capacity during stripper outages. Pond level was monitored by the WTU Unit.

The API separator and surge pond were replaced in 1987 with two covered settling tanks and two covered storage (feed) tanks. The present system eliminates both potential groundwater contamination and fugitive air emissions.

The two WTU Settler Tanks currently in use are elevated, upright cylindrical tanks with conical roofs and 2:1 sloped bottoms. Both are lined with a 220 mil interior coating of FRP (Atlac 570 vinyl ester resin) applied to the A-36 carbon steel tank shell. The WTU Settler Tanks each provide 45,000 gallons of surge capacity and 2.5 hours retention time at 600 gpm feed rates. The two tanks are operated in parallel.

The two WTU Storage Tanks currently in use are upright cylindrical tanks with conical roofs and 10" crowned bottoms with a 220 mil interior coating of Atlac 570 vinyl ester resin applied to the A-36 carbon steel tank shell. A concrete slab is used as the tank foundation. The WTU Storage Tanks each provide 253,000 gallons storage capacity. Only one storage tank is normally used and the unused, empty storage tank provides 7 hours of surge capacity at 600 gpm system feed rates.

Contaminated pr cess wast water c llected in the segregated sewer system lift stations is pumped to the two covered WTU settler tanks, then overflows to the WTU Stripper Storage Tanks and is pumped to the WTU steam stripper system for treatment. A separate stream which is presettled in the VCM II Separator and commingled with Main Laboratory and South Terminal Groundwater Containment System water bypasses the Settler Tanks and is fed directly to the WTU Stripper Feed Tanks.

B. Basis and Evolution Of Design

As discussed in Section II.B. of this Report, the concept of steam stripping for the removal of chlorinated organics from acidic aqueous streams was investigated in a series of lab projects and pilot plant studies initiated in 1972. The results of laboratory tests with a 1", 20-tray glass Oldershaw column in 1972 were used to design a packed stripping column which was built and operated as a pilot plant at the Per-Tri Unit in 1973. The results of the laboratory investigations are presented in Appendix 3.

Several PPG internal reports detail the sequence of these investigations. These reports are listed in Appendix 8 and are available up n request.

Wastewater stream characterizations performed in the course of the sewer segregation project between 1972 and 1975 formed the basis of the original design flowrate of 500 gpm for the first WTU Steam Stripper. EDC was identified as the primary or key design compon nt for treatment by laboratory analysis.

The segregated sewer system installed in 1977 combined contaminated wastewater from the process units in operation in 1977 and included streams from the following units: Ethyl Chloride, EDC I and EDC II, OHC I, VCM I, HCl, VDCM, Per Tri, Tri-Ethane[R], and Organic Shipping. Only the process pad and trench run-off from the OHC I unit (and the OHC II unit after its start-up in 1979) were part of the combined WTU Steam Stripper feed stream.

As discussed in Section II.B. of this Report, steam stripper pil t plant operation in 1972 and 1973 provided the data to scale up to a commercial design and the basic WTU system configuration was proposed by 1974.

Experience gained from the operation of the OHC I aqueous phase steam stripper installed in 1974 was also applied to the design of the original WTU steam stripper. The OHC I feed stream differed from the WTU system feed in that it was alkaline, at pH 11 to 13, rather than acidic at pH 1.0 to 2.5.

The original WTU Steam Stripper was designed in 1975 to remove soluble chlorinated hydrocarbons (primarily EDC) from the contaminated wastewater streams generated in Plant B, the organics production area of PPG's Lake Charles complex. In the commercial design, an additional 5' of packing height was added to serve as a safety factor and to accommodate variations in the organic content of the system feed stream. The original design calculations are provided in Appendix 9.

The original design called for the reduction of total chlorinated organics in 500 gpm of feed from 2000 ppm total ClHC to < 75 ppm total ClHC in the stripper bottoms (effluent) resulting in a total loss of < 450 lbs/day of organics, mostly EDC, to the outfall system. Operating guidelines developed after start-up call for a bottoms concentration of < 25 ppm total ClHC.

A decision to use the WTU system feed stream as the cooling medium in the WTU steam stripper overhead vent condenser was the result of a lack of available water for this purpose in the area at the time of the initial WTU steam stripper design and installation. Feed economizers were specified as a method of saving steam that would have otherwise been required to provide sensible heat to the feed stream.

Confirmation of the original stripper design concept is provided in a comprehensive review of wastewater treatment technologies performed by T. R. Rogers of PPG Chemical's Corpus Christi R&D center in 1981. In his report, Rogers used the WTU Steam Stripper design as an example and based hypothetical stripper design calculations on actual WTU performance data from March - May, 1980. Rogers concluded that EDC concentrations of 5 ppm in the stripper effluent should be attainable at 700 gpm feed rates with an EDC feed concentration of 2000 ppm by operating a 4' diameter column with 14.5' of packing and using a 2% boilup rate. This report is identified as CD-4484 in Appendix 8.

Additional evaluations of the WTU Steam Strippers performance have been performed through the years which also confirm the original stripper design. The original and current stripper design parameters are summarized in Appendices 10 and 11. A second steam stripper was added to the system in 1980. The original design calculations for the second stripper are attached in Appendix 12.

Treatment of OHC Aqueous Stream by WTU Steam Strippers

The aqueous process effluent from the OHC units producing EDC was part of the combined wastewater stream fed to the WTU steam strippers for treatment when diversion of the OHC aqueous stream from the OHC Steam Stripper occurred and no chloral treatment was accomplished. The original OHC Chloral Treatment System was not designed to operate when the OHC Steam Stripper was not operating. During these periods, the OHC aqueous stream was diverted to the Per-Tri acid pit.

Revisions to the OHC Chloral Treatment system in 1978 provided for chloral destruction during periods when the OHC aqueous stream was diverted to the acid pit. These revisions were incorporated in the OHC II unit design.

This OHC aqueous stream was recognized as a major source of chloral which could not be effectively removed by steam stripping and required separate treatment with NaOH for conversion of the chloral to sodium formate and chloroform. After chloral destruction, further treatment was provided by steam strippers located in the individual OHC units.

After the startup of the OHC Central Steam Strippers in 1981, the OHC aqueous process effluent from the OHC II and OHC III units was combined and treated in the OHC Central Steam Stripper unit. The OHC I unit had been decommissioned in 1983 and was subsequently demolished in 1985.

C. <u>Process/Equipment Description</u>

Sketch III in Appendix 2 is a simplified process flowsheet of the current WTU Steam Stripper system. The WTU Steam Stripper system is composed of two steam strippers. Identical and separate process equipment for the two strippers are the stripper feed pumps, stripper bottoms pumps, stripper column, stripper overhead condensers, phase separators, and feed economizers (the #1 system has six feed economizers, while the #2 system has three economizers). Three of the feed economizers (in the middle bank) from the #1 system can be used in the #2 system.

System geometry and restrictions on available feed economizers limit the total throughput of the WTU stripper area to 1100 gpm (700 gpm through one unit and 400 gpm through the other at any one time).

The feed preheaters were originally different in the two systems although both utilized live steam injection to preheat the feed stream. The #1 system used a 5' ID by 7' T/T vertical vessel as a preheater while the #2 system had a Pick preheater. Both systems now utilize Hastelloy C Pick preheaters.

Process equipment in the current Waste Treatment Unit area common to both stripper systems includes the two settling tanks and the two stripper feed tanks added in 1987. The #2 WTU Steam Stripper system also utilizes the #1 stripper product pumps and vent scrubber.

WTU STRIPPER SYSTEM DESCRIPTIONS

Feed from the WTU stripper feed tanks is pumped to the shell side of the stripper overhead condenser by the stripper feed pumps. A small

(5 gpm) stream splits off upstream of the stripper overhead condenser for use on the WTU vent scrubber. The effluent from the vent scrubber is returned to the settler tanks. The feed from the WTU feed tanks is flow controlled to the stripper(s). Feed temperature is increased 20 - 30°F in the condenser. This feed flow is recorded on a strip chart. There is a "low flow" alarm set at 100 gpm for the feed. Feed is used as the cooling medium on the stripper overhead condenser since cooling tower water is not available in the area and because the feed must be preheated.

A bypass around the stripper overhead condenser was installed in 1977 to increase feed rates to the stripper. The original Plant B design flow was 500 gpm. It is possible to flow more through the stripper overhead condenser, but increased flow causes tube vibration, that can be heard as a rapid knocking sound in the condenser. If this condition persists it will destroy the tubes. Under normal conditions the bypass valve is adjusted to give a 10°F temperature differential on the water side of the condenser. This ensures that enough water is being bypassed so the stripper overhead condenser tubes will not be damaged and that adequate condensing is being accomplished. At rates of less than 450 gpm, the bypass is not needed and is blocked in. With the bypass, the stripper is designed to treat a flow of 700 gpm.

The feed then passes from the stripper overhead condenser to the series economizers. At low rates it may be necessary to block in one bank of economizers to prevent water hammer in the system. The feed is heated to 170 - 190°F by exchange with the stripper bottoms (effluent) in the economizers. This heat recuperation step saves utility costs associated with both steam and cooling tower water. Feed is on the tube side and the steam stripper bottoms (effluent) is on the shell side. There are temperature and pressure indicators on the inlet and outlet of each economizer to adequately monitor their performance. The temperature of the feed stream after the last economizer is recorded. The feed leaves the economizers at about 185°F and enters the Pick preheater.

The feed enters the preheater and is heated with live steam by direct injection to around 200 - 215°F. The flow of steam is controlled based on the temperature of the feed leaving the preheater. Liquid is prevented from backing up the steam line by an 8' seal loop. A valve is provided at the top of the seal loop for N_2 addition should it become necessary to break a vacuum. The steam flow and the temperature of the feed leaving the preheater are recorded. The feed leaving the preheater flows by gravity through a 4' seal loop to two feed spargers at the top of the #1 WTU steam stripper column.

Live 50 psi steam is injected in the bottom of the steam stripper to give a small (2%) boilup. The steam is mass flow controlled and the flow is monitored on the control board. Liquid is prevented from backing up the steam line by a seal loop. The n rmal operation of the stripper calls for 2% boilup.

A steam pressure-reducing station taking steam from the #3 Incinerator 175# steam header serves both stripper systems. Condensate is added automatically to control the temperature of the steam. This is important because the spargers in the stripper are rated only up to 350°F and the available superheated steam temperature is above 500°F. There is a high temperature alarm on the steam supply to the stripper.

If the #3 incinerator is down, steam will come from the powerhous 's 175 psi steam system, but will be at a higher temperature (up to 725°F). There is a high temperature alarm downstream of the st am desuperheater. A constant liquid level is maintained in the bottom of the steam stripper column by a level control valve on the stripper bottoms. High and low level alarms are provided for the column liquid level. [In addition, there is a 6" emergency overflow to the API Separator. Water from the API Separator is directed to the WTU settler tanks. This overflow has an 8 ft. seal loop.] The temperatures of both the stripper bottoms and stripper overhead are recorded.

seal loop deleted 6/91

The overhead from the steam stripper are fed to the stripper overhead condenser. These vapors consist of water and chlorinated hydrocarbons and are condensed in the stripper overhead condenser and collected in the phase separator. The water phases out on top of the more dense chlorinated hydrocarbons and is drained off to the ~~API Separator~~. #8 L.S.
This water is then directed to the #8 Lift Station sump which in turn is pumped to the WTU settler tanks.

The recovered chlorinated hydrocarbons are pumped from both WTU steam stripper systems phase separators to the Waste Recovery DH Still feed tanks. The effluent from the bottom of the steam stripper is pumped to the shell side of the economizers. After exiting the economizers, it discharges into the combination of sewers for neutralization (Outfall 201).

phase d not in u as of 8

The phase interface level on either phase separator can be used as the signal to the phase interface level controller governing the flow of stripped product from the phase separators. There is a selector switch allowing the operator to select which phase separator phase interface level is used for control. Valving allows either phase separator to be isolated.

The WTU steam stripper overhead vent condensers are vented to the stripper vent system. Vents are compressed and incinerated.

The effluent from the bottom of the #2 WTU steam stripper is pumped to the shell side of the economizers. After passing through the economizers, it discharges into Outfall 201.

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WASTE TREATMENT UNIT PROCESS EQUIPMENT PROFILE

Process Equipment Common to Both WTU Steam Stripper Systems

WTU Stripper Product Pumps, SAC # 55-2280 and 55-2281

These are DurcoMark II, FRP (Durcon 700), 1-1/2 x 1-6 pumps, designed for 2.5 gpm at 73' of head. The impeller diameter is 4-1/8." They are driven by 2 hp, 3500 rpm motors.

WTU Stripper Vent Scrubber, SAC # 67-115

The stripper vent scrubber is an 18" ID vertical, open-top vessel containing 4' of 1" ceramic Intalox packing. This scrubber is used for emergencies only. Vents are normally incinerated.

WTU Steam Desuperheater, SAC # 71-2105

The WTU desuperheater is a Copes-Vulcan 8"-300 psi, WCB VO-76 desuperheater designed to supply 30,000 lbs/hr of steam at 50 psi and 318°F.

Equipment Description for WTU #1 Steam Stripper System

Stripper Feed Pumps 1 and 2; SAC # 55-2560 and 55-2561

These are Durco Mark II 4 x 3-13 pumps, designed for 600 gpm at 144' of head. The material of construction is Hastelloy C. The impeller diameter is 13." They are driven by 50 hp, 1750 rpm motors.

#1 Steam Stripper Column, SAC # 67-150

The steam stripper column is a 4'-0" ID x 25'-3" T/F vertical vessel constructed of Furan. It was designed for 15 psig pressure and 10 psia vacuum and is protected by a 4" impregnated graphite rupture disc rated at 15 psi. The stripper contains one 15' section of Jaeger Tri-Paks #1 (2") packing. A 4" diameter sparger with one row of sixteen 3/4" diameter holes is used for live 50# steam injection at the bottom of the column.

#1 Stripper Bottoms Pumps, SAC # 55-2562 and 55-2563

These are Durco Mark II 443-13 pumps, designed for 600 gpm at 99' of head. The material of construction is Hastelloy C. The impeller diameter is 11-7/8." They are driven by 30 hp, 1750 gpm motors.

Feed Economizers, SAC # 71-1655 A - F

There are six horizontal, single-pass economizers arranged in two banks of three economizers each with the individual economizers arranged in series. Each economizer contains 88, 3/4" OD 20 BWG, 33'-2" long tubes of Ti-38A (Titanium). The shell is also constructed of Ti-38A. Ti-38A is a titanium alloy containing 0.3% molybdenum and 0.8% nickel and is suitable for boiling 5% HCl. Surface area per individual unit is 572.9 sq. ft.; total surface area is 3437.4 sq. ft. Design shell-side temperatures were 215°F in and 120°F out; design tube-side temperatures were 90°F in and 185°F out. Design pressure was 50 psig for both shell and tube sides.

#1 Stripper Condenser, SAC # 71-1656

The stripper condenser is a vertical downflow single pass condenser constructed of Ti-38A. There are 137, 3/4" OD 20 BWG, 15'-6" l ng tubes of Ti-38A. Surface area is 417.6 sq. ft. Design shell-side temperatures were 90°F in and 115°F out. Design pressure was 75 psig on the shell side and 30 psig on the tube side.

#1 Phase Separator, SAC # 60-1422

The phase separator is a 4'-0" ID x 8' T/T vertical vessel constructed of Furan. It was designed for 15 psig pressure and 10 psia vacuum at 350°F and is protected by a 2" impregnated graphite rupture disc rated at 15 psi.

Instrumentation for the #1 System

All of the controllers in the #1 WTU steam stripper area are board-mounted and located in the WTU control room. Indicators and alarms are also mounted on the control board in this control room.

Equipment Description for WTU #2 Steam Stripper System

Stripper Feed Pumps 3 and 4, SAC # 55-2933 and 55-2934

These are Durco Mark II 4 x 3-13 pumps, designed for 600 gpm at 144' of head. The material of construction is Hastelloy C. The impeller diameter is 13." They are driven by 50 hp, 1750 rpm motors.

WTU #2 Pick Preheater, SAC # 71-2104

The Pick preheater is an in-line steam injection heater providing direct contact of steam and the feed. The injection tube, rated at 15,000 lbs/hr steam, is constructed of Hastelloy C. It is housed in a teflon-lined 10" 150# ANSI tee.

#2 Steam Stripper Column, SAC # 67-189

The #2 WTU steam stripper column is a 4'-0" ID x 25'-3" T/T vertical vessel constructed of Derakane 470. It was designed for 15 psig pressure and 10 psia vacuum and is protected by a 6" impregnated graphite rupture disc rated at 15 psi. The stripper contains one 15' packed section of Jaeger Tri-Pak #1 (2") packing. A 4" diameter sparger with one row of sixteen 3/4" diameter holes is used for live steam injection into the bottom of the column.

Stripper Bottoms Pumps 3 and 4, SAC # 55-2931 and 55-2932

These are Durco Mark II GP II 4 x 3-13 pumps, designed for 600 gpm at 99' of head. The material of construction is Hastelloy C. The impeller diameter is 11-7/8". They are driven by 30 hp, 1750 gpm motors.

Economizers, SAC # 71-2100, 71-2101, and 71-2102

There are three horizontal, single-pass economizers aligned in series (one bank of three economizers, each individual economizer in series). Each economizer contains 88, 3/4" OD 20 BWG, 33'-2" long tubes of Ti-code 7 or Ti-code 12 titanium. The shell is also constructed of Ti-code 7 titanium. Surface area per individual unit is 572.9 sq. ft.; total surface area is 1718.7 sq. ft. Design shell-side temperatures were 215°F in and 120°F out; design tube-side temperatures were 90°F in and 185°F out. Design pressure was 50 psig for both shell and tube sides.

#2 Stripper Condenser, SAC # 71-2103

The #2 WTU steam stripper overhead vent condenser is a vertical downflow, single-pass condenser constructed of Ti-code 7 and Ti-code 12 titanium tubes and Ti-code 7 titanium shell. There are 137, 3/4" OD 20 BWG, 15'-6" long tubes of Ti-38A. Surface area is 417.6 sq. ft. Design shell-side temperatures are 90°F in and 115°F out; design tube-side temperatures were 215°F in and 115°F out. Design pressure was 75 psig on the shell side and 30 psig on the tube side. Revisions to process piping in 1989 now allow water to be used on this condenser to facilitate true series operation of the two stripper columns.

#2 Phase Separator, SAC # 60-1889

The #2 WTU phase separator is a 4'-0" ID x 8' T/T vertical vessel constructed of Furan. It was designed for 15 psig pressure and 10 psia vacuum at 350DF and is protected by a 2" impregnated graphite rupture disc rated at 15 psi.

Instrumentation for the #2 System

All of the controllers in the #2 WTU steam stripper system are board-mounted in the WTU control room. Indicators and alarms are also on the control board in this control room.

UTILITIES IN THE WTU STRIPPER AREA

The WTU Steam Stripper area is supplied with well water, steam instrument air, and nitrogen.

Well Water

Well water is supplied to the area with a 2" line from the incinerator area. Well water is used for safety showers and utility stations.

Steam

Nominal 50 psi steam is supplied to both stripper systems via an 8" insulated line from the #3 incinerator area. Nominal 175 psi steam recovered from the # 3 Incinerator Waste Heat Boiler is pressure reduced and desuperheated to 50 psi and 318°F. If the #3 incinerator is down, superheated 175 psi steam from the powerhouse header is pressure-reduced and desuperheated by direct condensate injection.

Instrument Air

Instrument air is supplied to the area via a 1-1/2" line from th incinerator area. It is used on the instruments and at the utility stations.

Nitrogen

Nitrogen is supplied to the area via a 1-1/2" line from the incinerator area. It is used at the utility stations.

D. <u>Modifications and Improvements</u>

The original WTU Steam Stripper design concept in 1975 was to accommodate a 500 gpm feed rate. The first WTU Steam Stripper (67-114) was started up in May, 1977.

WTU Steam Stripper System P st-Startup Modifications

High shell-side pressure drop and lower than design heat transfer performance experienced in the WTU feed titanium economizers during and after start-up in May, 1977 was traced back to a design error made by Futura Titanium Corporation, the engineering and design company that had supplied the feed economizers.

This condition severely limited feed flow (to 320 gpm) until February 1978, when economizers Nos. 1 and 2 were removed and pipe spool pieces were installed to increase maximum feed flow from 430 to 520 gpm using only three economizers in series.

Modifications To Increase System Capacity

By July, 1977 it was obvious that the design maximum feed rate of 500 gpm was too low. The flowrate for wastewater requiring treatment was estimated at 650 gpm in February, 1978. The WTU system capacity remained slightly below 550 gpm until modifications were made to the feed economizers. This bottleneck resulted in poor compliance with the NPDES permit until after November, 1977 at which time wastewater reduction efforts became effective in reducing feed flows to the system.

Temporary measures also included further modifications in late 1977 to accommodate 700 gpm feed rates by installing a feed bypass ar und the overhead vent condenser. The stripper overhead vent condenser was designed to use feed as the cooling medium since cooling water was not available in the area in 1975. Although it was possible to flow m re than 500 gpm through the overhead vent condenser, this practice was found to cause undesirable and potentially damaging vibration in the exchanger tube bundle.

The bypass flow of feed around the overhead vent condenser is adjusted to maintain a 10°F temperature differential on the feed side of the vent condenser. At rates below 450 gpm, the bypass is blocked.

Later permanent corrective action included:

1. rearrangement of feed piping to provide the ability to bypass some or all of the economizers and to provide a 3x2 flow arrangement for the existing five economizers in 10/78;

2. reorientation of existing five economizers to place flow over tube baffles in a horizontal rather than vertical orientation in 10/78;

3. the addition of a sixth identical economizer in 3/79 after protracted negotiations with Futura Titanium Corporation.

This allowed for greater shellsid flow (800 gpm) and higher heat transfer at all flowrates with the increased transfer area.

After revision #3, the WTU system was capable of routinely feeding 700 gpm to the steam stripper.

A design review in August, 1978 indicated that the maximum feed rate with operation at 2% boilup was 685 gpm. This calculation is provided in Appendix 13.

Factors limiting system capacity after these modifications were process line pressure drops, overhead condenser pressure drop, and column hydraulics.

The original stripper column (67-114) was replaced with one of identical design (67-150) in May, 1979 after a mechanical failure of the Furan vessel's corrosion barrier layer.

Addition of the Second WTU Steam Stripper

The second WTU Steam Stripper (67-171) added in May, 1980 was identical in design to the original stripper with the exception that it had only three titanium Futurs economizers, had a Pick preheater, and shared the existing stripper bottoms pumps and vent scrubber with the #1 system.

With its economizer configuration, the second stripper was limited to only 400 gpm of feed flow.

The inequity in capacity of the two identical stripper columns was due to the nature of the unit expansion which required that the two stripper columns share certain equipment in common; notably the stripper bottoms pumps, steam desuperheater, and vent scrubber. The #1 WTU Steam Stripper system has six feed economizers while the #2 WTU Steam Stripper system has three. The piping arrangement between the two systems allows either system to be operated as the "lead" system and to utilize six of the available nine feed economizers (two of the three bays, of three economizers each, may be utilized by only one stripper at a time).

A combined WTU system capacity of 1100 gpm is now possible with both strippers operating (700 gpm through one unit and 400 gpm through the other at any one time). The rationale for installing the second stripper column beyond providing capacity for the VCM II expansion was to significantly reduce the possibility of overflowing the surge pond during periods of heavy rainfall and to allow for proper maintenance of the strippers.

This system was sized as part of the ffsites quipment for the VCM II unit which started up in 1981.

The original #2 WTU Steam Stripper column (67-171) was replaced with an identical column, but of Derakane 470 rather than Furan, (67-189) in June of 1985.

Improvements for Reliability of Operation

Various projects were pursued to improve the reliability of system operation. Among the more significant of these were:

1. Provision of backup steam supplies for the WTU area.

2. Spill control and collection for the WTU area - concrete pad.

3. Pump and process piping materials of construction improvement.

4. Instrumentation upgrades.

5. Wastewater reduction in Plant B.

6. Solids removal from WTU stripper feed - sand and scum removal from separator.

7. Lift station pump and piping upgrades for enhanced performance.

8. Improvements to the vent scrubber followed by the vent scrubber being replaced by incineration of WTU area vents with startup of the WTU Vent Compressor in September, 1987.

The system enhancements allowed the WTU System to be debottlenecked and operate at 1100 gpm feed rates. The strippers were not the bottleneck; excessive pressure drop across the feed preheaters was the major problem.

Modifications to Improve ClHC Removal Efficiencies

Various methods to improve system performance were tried through the years.

1. Packing Changes

One method attempted was the replacement of the 2" ceramic Intalox stoneware saddles with more efficient packing styles. More efficient packings were sought to provide increased system capacity, lower pressure drop, and more efficient separation.

A history of the packing studies is presented below:

7/82 -#1 WTU stripper repacked with 2" ceramic intalox saddles
-#2 WTU stripper repacked with 2" ceramic intalox saddles

4/83 -#1 WTU stripper repacked with 2" ceramic intalox saddles

9/83 -#2 WTU stripper repacked with 2" ceramic intalox saddles

2/84 -KIMRE structured Kynar packing installed in #2 WTU stripper, packing collapsed and plugged with solids

-#2 WTU stripper repacked with 2" ceramic intalox saddles

11/84 -2" Super Intalox Kynar Saddles installed in #1 WTU stripper

5/85 -#2 WTU stripper repacked with 2" ceramic intalox saddles

8/85 -#2 WTU stripper repacked with 2" Kynar Super Intalox saddles

9/85 -#1 WTU stripper repacked with 2" ceramic intalox saddl s

3/87 -#1 WTU stripper repacked with Jaeger Tri-Paks #1

8/87 -#2 WTU stripper repacked with Jaeger Tri-Paks #1

Performance studies conducted in the past with different packings in place did not demonstrate any significant difference in overall removal efficiency. Packing differences did improve stripper column hydraulic performance.

E. <u>Characterization Of The Source Streams</u>

The WTU Steam Stripper feed stream is the composite stream formed by process wastewater, process pad runoff, rainwater, and other intermittent water sources that come in contact with chlorinated organics. See diagram in Appendix 14.

A typical analysis of the WTU feed stream is also found in Appendix 14.

The WTU Stripper system feed typically contains 57 ppm TSS. The pH of the feed is typically 1 - 2.5. The pH of the incoming feed is monitored as is the pH of the two WTU Stripper Feed Tanks.

A typical organic analysis of the WTU Stripper feed based on samples analyzed in 1989 is given below:

WTU STRIPPER FEED *

Component		Concentration
Chloroethene	(VCM)	2 ppm
Chloroethane	(EC)	nil
Methylene Chloride	($MeCl_2$)	4
1,1-Dichloroethene	(VDCM)	nil
1,1-Dichloroethane	(DCE)	1.5
1,2-Dichloroethene	(Cis/Trans)	7
Chloroform	($CHCl_3$)	14 - 350
1,2-Dichloroethane	(EDC)	450 - 2000
1,1,1-Trichloroethane	(MC)	nil
Tetrachloroethane	(CCl_4)	nil
Trichloroethene	(Trichlor)	20
1,1,2-Trichloroethane	(TCE)	80
Tetrachloroethene	(Perchlor)	10
TOTAL ClHC		350 - 2500 ppm

F. **Operating Parameters**

The stripper columns are normally operated at 2% boilup rates. WTU historical operating data for 1986-88 are provided in Appendix 15. Current operating guidelines, including checklists and start-up and shutdown procedures, are provided in Appendix 16.

Parameters normally monitored and controlled by operations include the following:

Parameter	Normal Value	Control
stripper feed rate	350 to 700 gpm	FCV
stripper overhead temp	212 to 215°F	
stripper bottoms temp	215 to 217°F	Btms steam
preheater outlet temp	> 215°F	Prhtr steam
column pressure drop	< 1.5 psi	
bottoms pressure	< 2 psi	

Column operating profile changes are made in response to changing system conditions and are based upon bottoms analyses performed every four hours in the WTU control lab.

Stripper column level is controlled by a combination of feed flow, volume of bypass flow around feed economizers, LCV setpoint and LCV bypass valve position.

It must be noted that high pH (above 7.0) cannot be tolerated in the unit. High pH will attack the titanium equipment and eventually destroy it.

Abnormal Operating Conditions

The most common operating problem that might adversely affect stripper performance is screen plugging. There are ten screens located in the unit. The purpose of the screens is to keep solids from collecting inside the economizers. The locations of these screens are:

- Two at the feed pumps
- Two at the vent condenser
- Two on the feed inlet to the economizers
- Two on the bottoms inlet to the economizers
- Two on the stripper bottoms pump

Inability to obtain feed flow is most often due to screens b ing plugged. By considering pressures and position of the feed valve it is possible to tell if the plug is before or after the feed valve. Most often the problem will be located in the feed screens. By noting temperature differential and position of the vent condenser bypass valve it is possible to estimate the condition of the screens at th vent condenser.

If one of the feed inlet screens is plugged more than the other and the bottoms flow is equivalent on both sides then it is possible to distinguish the plugged screen by outlet temperatures on the feed side of each row of economizers.

When the stripper bottom screens plug it will be evident due to high level in the stripper and cavitating pumps. Since there screens are on the suction, it is advisable to shut one pump down and let the remaining pump run. This may back flush enough solids away from the screen on one pump that it will no longer cavitate when running. The other pump can then be shut down and the screen cleaned.

G. <u>Significant Differences from Design Parameters for Operation</u>

Current operation of the WTU Steam Strippers has not changed significantly.

H. Performance Reviews and Analyses Conducted After Promulgation of the OCPSF Limitations

A performance test to determine whether the WTU steam strippers could comply with the OCPSF guidelines was conducted during the period of May 22 through May 26, 1989. The packing in the stripper was Jaeger Tripakn #1 (2"). The Ultramax statistical optimization software was used during this test period to generate valid predictive models for EDC and Chloroform concentrations in the stripper effluent and to attempt optimization of the system. This data set contains 43 points. See the spreadsheet "WTUX0589.WK1" and graphs in Appendix 17 for estimated HTU and stripping factors for EDC, Chloroform, TCE, Perchl r and Trichlor.

The Huang-Farenthold Equation and Edmister Equation were applied t the data from May, 1989 and an HTU of 1.91 ft for EDC was calculated indicating that the different packing did little to alter stripper removal efficiency for EDC. The HTU value for Chloroform was estimated to be 3.58 ft. This value seems higher than would be expected for chloroform in comparison to the other chlorinated hydrocarbons present in the WTU Steam Stripper feed matrix.

A complete description of the Ultramax statistical optimization software package is provided in Appendix 18.

PURPOSE OF THE STUDY:

The objective of this study was to optimize the operation of the WTU Steam Stripper system to meet the OCPSF guidelines.

This test was designed to study two of the compounds of interest, namely chloroform and EDC. Both EDC and chloroform are present in the WTU Steam Stripper feed stream. Previous studies have shown these two compounds to be the most difficult to strip from Plant B wastewater streams.

PROCESS DESCRIPTION AND DEFINITION OF ULTRAMAX VARIABLES:

The WTU Steam Strippers are packed columns using direct steam injection to remove chlorinated hydrocarbons in a wastewater stream from the Plant B segregated sewer system.

This wastewater stream includes process water, spills, water from equipment cleaning, and rainwater which falls on process pads. The inherent nature of the stream allows variation in both the feed rate to the strippers and in the concentration of the chlorinated hydrocarbon compounds contained in the stream. The stripper volumetric feed rate and feed composition were treat d as external variables beyond the control of the system under study.

Two steam flows are fed to a stripper. One steam flow is used to preheat the feed and the second is injected into the bottom of the stripper column. The first steam preheats the wastewater feed to its boiling point to more effectively utilize the second steam flow fed directly to the stripper column to provide boil-up for the stripping action. A better understanding of their effect on stripper performance was sought to help optimize the performance of the strippers.

The amount of steam fed to the preheater depends on the wastewater feed flow, the wastewater inlet temperature and the desired stripper feed (preheater) outlet temperature. Since the feed preheater inlet temperature depends on several upstream variables, it was treated as an external variable. The preheater feed outlet temperature can be controlled and was treated as a controlled variable. This variable treatment will provide information on what preheater outlet temperature setting provides the best stripping results. This treatment also defines the preheater steam flow as a "result of interest" rather than a "controlled input" allowing Ultramax to provide advice on the required steam flow.

The steam flow fed directly to the bottom of the stripper is a controlled input for which Ultramax will also provide advice.

The feed concentrations of both EDC and chloroform have been defined as external variables.

The concentration of both compounds in the stripper bottoms str am are defined as "result variables of importance." Constraints have been placed on the bottoms concentrations of both compounds to define a level of consistent stripper performance required to meet, on a daily basis, the OCPSF guidelines for monthly average and daily maximum limits.

The bottoms concentrations of the two compounds are used to calculate the TPL, or a "measure of performance loss." This method of combining information about the two variables of interest into a single variable allows a single result variable to be optimized (minimized) by Ultramax. Additional variables such as stripper pressure and temperatures are defined as either fixed inputs or results of interest in the Ultramax problem formulation. The effect of such variables is difficult to assess at the present time.

PRIOR INFORMATION AND ANALYSIS:

Performance studies have been made on the WTU Strippers for the past five years. The data from 34 previous test runs were used to set up and validat the current Ultramax stripper problem formulation prior to its use in this study.

The historical test data provided an excellent basis for the determining the system's best "prior region" for Ultramax.

Past changes in stripper operation were based on engineering judgments about how each variable affected the desired results. Although system changes were made in a logical manner prior to Ultramax application, a definite improvement plan or strategy could not be implemented due to the inability of operators to control and track the many variables which were thought to have an impact on system performance.

The advantage of the Ultramax method is the software's ability to simultaneously track the many system variables, dynamically model the system, and to recommend advice (control variable setting change) to operations.

STUDY REQUIREMENTS - GETTING IMPROVEMENTS WITH ULTRAMAX:

To achieve the benefits of the Ultramax method, the advice of the software must be implemented, the results of system changes monitored, and the software allowed to "learn" from the new data to provide another set of advice. Advice sets generated by Ultramax follow a designed sequence of experimentation which lead to performance improvement.

In order to get timely improvement, process samples need to be taken and analyzed as rapidly as the lab instruments will permit. It was estimated that sampling, analysis, and system adjustments could occur on a two-hour cycle. To take samples and perform analyses to meet this cycle schedule, lab personnel were assigned on a 24-hour basis for the duration of the test run.

System adjustments were made by operators according to the advice of the Ultramax software. The advice was to be followed unless it was obvious from the operators' experience that a bad recommendation had been made that could lead to a violation of the plant's current NPDES permit.

The ideal situation was to have the Ultramax software installed on a personal computer to which the operators had access. Additional engineering help was required to provide shift coverage.

The test was conducted during the period of 5/22 -5/26/89.

SUMMARY OF WTU STEAM STRIPPER STUDY, 5/22 - 5/26/89

ULTRAMAX ANALYSIS AND CONCLUSIONS

As illustrated by the data and graphs in Appendix 17, the Response Surface Diagrams in Appendix 19, and the expert interpretations of the data in Appendix 20, the Ultramax study produced the following information:

1. Optimization of the WTU Steam Stripper is possible in some aspects of performance. The system has not been completely optimized as yet.

2. The constraints on stripper performance (i.e., the OCPSF limitations for EDC and Chloroform) cannot be met simultaneously.

3. Acceptable regression models for predicting TPL and stripper bottoms concentrations of $CHCl_3$ and EDC in the area of interest were produced by Ultramax, but are not significantly improving the performance of the system.

   Ultramax's value for R sqr for TPL was 94.6% indicating an excellent fit. R sqr for EDC concentration in the stripper bottoms was 97.4% indicating an excellent fit. R sqr for $CHCl_3$ concentration in the stripper bottoms was 98.0% indicating an excellent fit. This indicates that a good predictive model for TPL has been constructed.

   On occasions PPG did not follow the Ultramax advice. This occurred when, in PPG operators' judgement, the Ultramax advice, if followed, would have produced operating conditions that could have caused PPG to violate its current NPDES permit limitations.

4. The magnitude of the effect of unknown variables is equal or greater than the magnitude of the target values for the optimization or result variable, TPL. Variables with significant effects on TPL may be missing from the model. A better understanding of the process is needed to identify these variables.

5. Further optimization to minimize $CHCl_3$ concentration in the stripper bottoms stream seems highly unlikely. The OCPSF limit of 0.111 ppm for $CHCl_3$ concentration in the stripper bottoms stream cannot be met by the WTU Steam Stripper.

ULTRAMAX OBSERVATIONS

During the 4-1/2 day test period 43 data points were collected. The minimum and maximum values for the three result variables are reported below:

Variable	Minimum	Maximum
EDC, Btms Conc.	0.03 ppm	3.32 ppm
$CHCl_3$, Btms Conc.	0.08	2.17
TPL	8	383

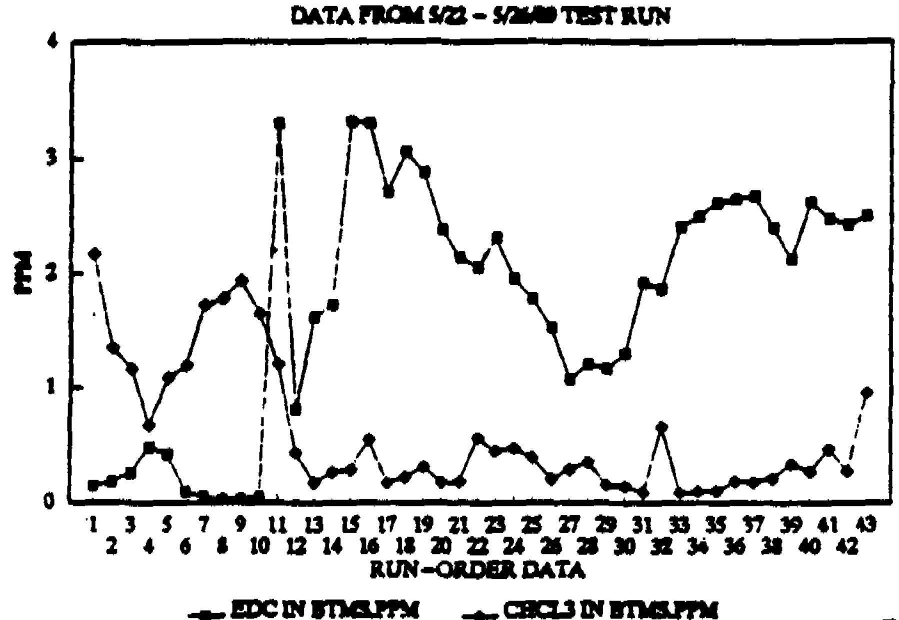
TPL never dropped below the desired upper limit of 2 during the test period. EDC and $CHCl_3$ were never below their target maximum concentrations simultaneously, but each was below its target maximum at some point during the test.

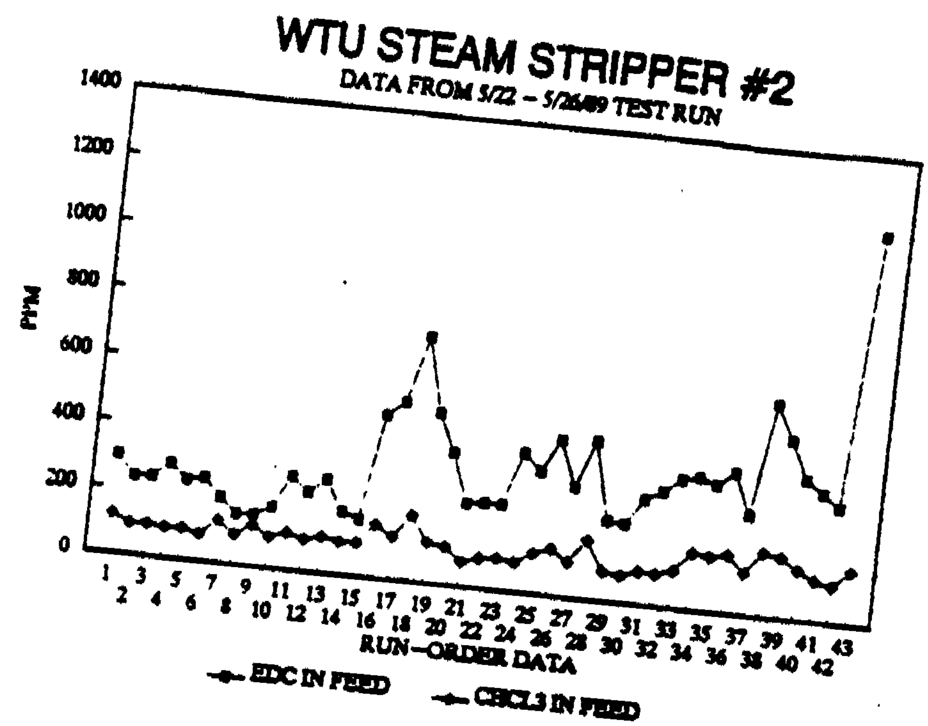
Indeed, as is shown in the following graphs, chloroform and EDC reacted in an opposite manner to the changes in operations suggested by Ultramax. Changes in operations that resulted in increased removal of EDC led to decreased removal of chloroform, while changes in opertions that resulted in increased removal of chloroform led t decreased removal of EDC. This result is contrary to all accepted principles regarding steam stripper design and operation, including those upon which the OCPSF guidelines were based and is the basis of PPG's FDF application.

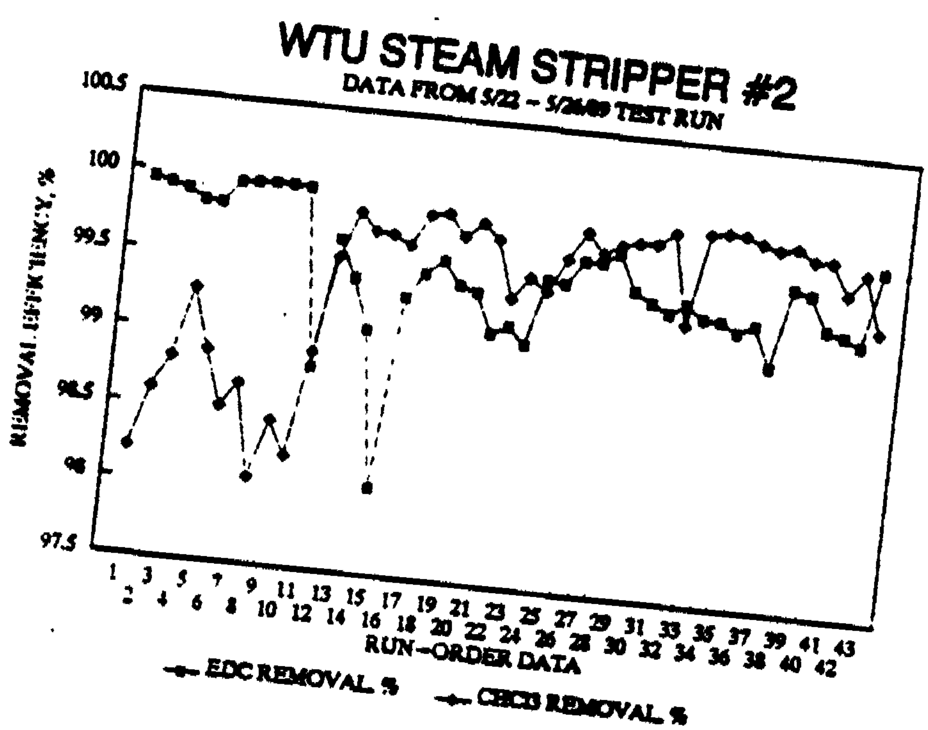
At no time during the study were acceptable simultaneous removal efficiencies of both EDC and chloroform achieved.

WTU STEAM STRIPPER #2

DATA FROM 5/22 – 5/26/89 TEST RUN




WTU STEAM STRIPPER #2
DATA FROM 5/22 – 5/26/89 TEST RUN
PPM
RUN–ORDER DATA
EDC IN FEED
CHCL3 IN FEED


WTU STEAM STRIPPER #2
DATA FROM 5/22 – 5/26/89 TEST RUN
REMOVAL EFFICIENCY, %
RUN–ORDER DATA
EDC REMOVAL, %
CHCl3 REMOVAL, %

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SPSS (STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES) ANALYSIS AND CONCLUSIONS

A statistical analysis of the data from the test run conducted in May, 1989 produced the following information:

1. The WTU Steam Stripper has only a minimum likelihood (approximately 1%) of meeting the OCPSF guideline for chloroform.

2. SPSS regression analysis produced a model for TPL prediction with an R sqr of 93%. This indicates that a good predictive model for TPL has been constructed and is very close to the value for R sqr produced by the Ultramax model.

3. Total steam to the stripper (preheater plus bottoms steam fed) has little influence on chloroform removal efficiency at high r chloroform feed concentrations.

4. EDC removal can be improved by the addition of more total steam to the stripper.

5. Chloroform bottoms concentrations are lower with higher feed preheater temperatures (with best results above 215°F), and with less steam fed to the bottom of the stripper column.

   EDC bottoms concentrations are lower with lower feed preheater temperatures (with best results below 215°F), and with more steam fed to the bottom of the stripper column.

   Thus, chloroform and EDC seem to react in the opposite mann r with respect to feed preheater temperature and the quantity of steam injected at the bottom of the stripper column.