

Process Description

DO A 045289
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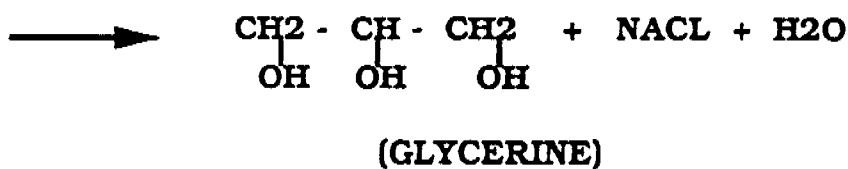
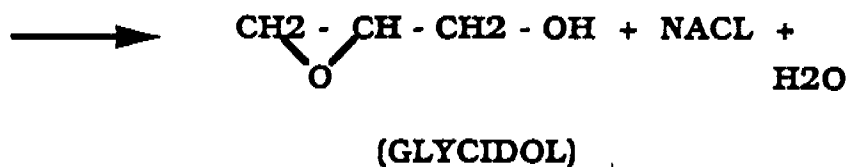
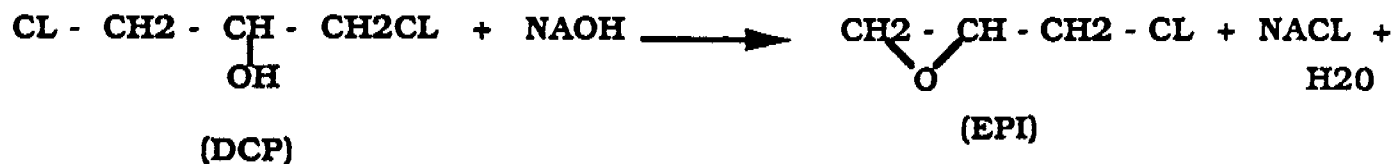
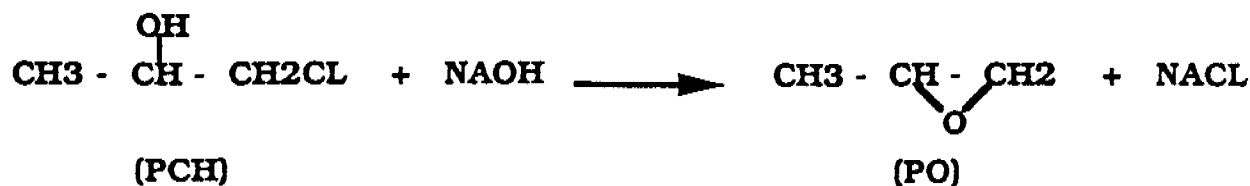
PCH REACTOR CHEMISTRY

<u>REACTIONS</u>	<u>ABBRV.</u>	<u>% YIELD</u>
$\text{Cl}_2 + \text{H}_2\text{O} \longrightarrow \text{HOCl} + \text{HCl}$		
$\text{HOCl} + \text{C}_3\text{H}_6 \longrightarrow \begin{array}{c} \text{OH} \\ \\ \text{CH}_3\text{-CH-CH}_2\text{-Cl} \end{array}$ (PROPYLENE CHLOROHYDRIN)	PCH	94%
$\text{C}_3\text{H}_6 + \text{Cl}_2 \longrightarrow \begin{array}{c} \text{Cl} \\ \\ \text{CH}_3\text{-CH-CH}_2\text{-Cl} \end{array}$ (PROPYLENE DICHLORIDE)	PDC	4%
$\text{C}_3\text{H}_6 + \text{Cl}_2 \longrightarrow \text{Cl-CH}_2\text{-CH=CH}_2 + \text{HCl}$ (ALLYL CHLORIDE)		
$\text{ALLYL CHLORIDE} + \text{HOCl} \longrightarrow \begin{array}{c} \text{Cl-CH}_2\text{-CH-CH}_2\text{-Cl} \\ \\ \text{OH} \end{array}$ (DICHLORO PROPANOL)	DCP	1%
$\text{PCH} + \text{HCl} \longrightarrow \begin{array}{c} \text{CH}_3\text{-CH-CH}_2\text{-Cl} + \text{H}_2\text{O} \\ \\ \text{O} \\ \\ \text{CH}_3\text{-CH-CH}_2\text{-Cl} \end{array}$ (DICHLOROISOPROPYL ETHER)	DCIPE	1%

CKS
2/25/90

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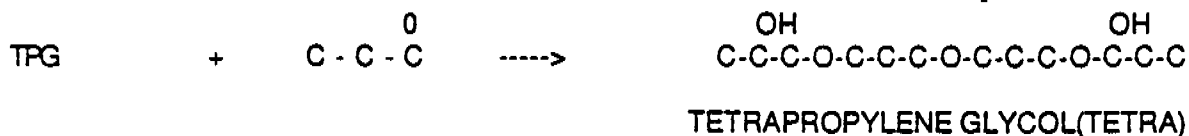
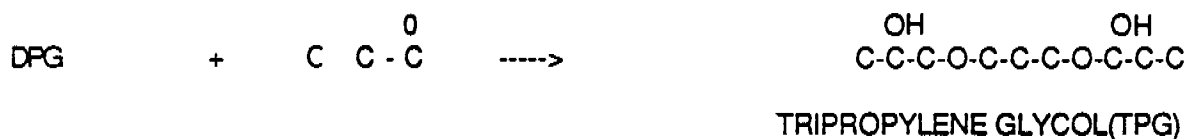
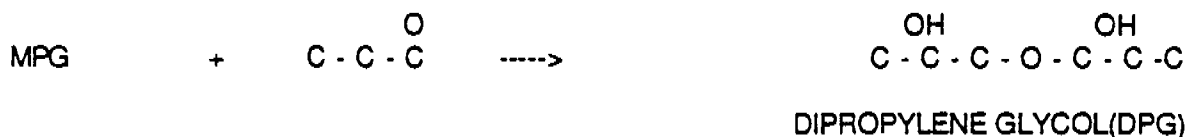
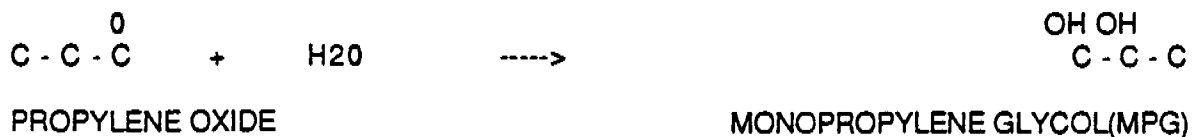
HYDROLYZER CHEMISTRY



* PDC AND DCIPE DO NOT REACT WITH NaOH *

PROPYLENE GLYCOL AREA CHEMISTRY

Propylene oxide is reacted with water in a 1:6 ratio in order to produce propylene glycols. Monopropylene, Dipropylene, Tripropylene, and Tetrapropylene glycol are formed by the reactions below.



The water left over after the reaction is removed by means of two trains of three stage evaporators. The glycols are then separated by rigorous distillation.

DO A 045292
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CHILLED WATER SYSTEM RESOURCES

I. Process Description

The chilled water system is a closed system. The normal operating temperature of chilled water is 5-12 degrees C. The chilled water is held in a drum, D-62, from which it is pumped by P-62 A/B to the refrigeration units. MRU-5 and MRU-7A/B cool the chilled water. After leaving the MRUs it is divided between three exchangers, E-4A, E-104A, and E-550. The first two are the third condensers in the overhead condensing train following the hydrolyzers. E-550 is an overhead condenser off of T-500 in the glycol plant. The chilled water leaving these exchangers is recycled back to D-62 where it begins the cycle again. Condensate from the high pressure condensate header is used as makeup for the drum. Corshield is added to the chilled water system to reduce corrosion to the equipment.

Chilled water is also used in the seal flush coolers on the P-27's which pump sweet water to glycol reactor, R-500.

II. Control Considerations

The chill water temperature transmitters on the MRUs are located on the outlet line. The flow to the MRUs can be controlled by restricting the manual outlet valve.

III. Description of How the Process Control System Addresses these Considerations

The controllers and transmitter indications for the MRUs, E-4, and E-104 are located on the TDC.

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HYDROLYZER AND CONDENSING TRAIN RESOURCES

I. Process Description

The purpose of the hydrolyzer and condensing train is to form Glycol 1's largest product, propylene oxide (PO), and to prepare it for product finishing. Propylene chlorohydrin (PCH) and caustic are combined in an epoxidation mixer to form PO, and the hydrolyzer and overhead condensers remove the PO and other organics from the water. The waste water is utilized in downstream exchangers for waste heat recovery.

The epoxidation mixers, MX-2 and MX-102, in which the PO is formed, were installed in 1994 to provide better mixing and resonance time, which improved the conversion of PCH from 84 to 94%. The housing is constructed of titanium and contains 61 zirconium tubes through which the PCH flows. The size of the tubes were carefully calculated to provide proper velocity of PCH and caustic to ensure thorough and uniform mixing. The mixer outlet is located at a close, but optimal, position to the hydrolyzer to provide adequate resonance time for PO formation without significant further hydrolysis to propylene glycol. The distance and resonance time are dependent upon the PCH and caustic temperatures.

The hydrolyzers, R-2D and R-102D, were converted from trays to a packed bed design in 1995 to handle the increased hydraulic load resulting from the PO incremental expansion. The vessels on each side are nearly identical, both 35' tall and 16' wide, constructed of carbon steel with a 13' packing height. The packing is Norton #40 IMTP Stainless Steel dump packing. To reduce fouling, Antiscalant is added in the feed stream. Both hydrolyzers operate under a vacuum, with R-102D running 1.5-2 pounds greater. This enables them to run in series with R-102D bottoms flashing into R-2D, thus decreasing steam requirements. The R-2D bottoms are used in E310, a reboiler on the T-300 finishing column. Not only does this minimize steam required to the reboiler, but it also cools the waste water stream before it reaches Environmental Operations. The stream passes through two more sets of exchangers, E-250 F/G and E-256A/B/C, for additional cooling. Overhead vapor from the hydrolyzers, containing mostly water, PO, and some propylene dichloride (PDC), enters the condensing train which recycles the water back to the hydrolyzers and the organics continue on to PO finishing.

The condensing train consists of five exchangers which are listed in the following table. Liquid from each partial condenser drops into a separation tank from which the overhead vapors are drawn off and fed to the next condenser. The first condenser operates at the highest temperature by using process water that has already been fed through the second condenser. Each of the subsequent condensers operate at a lower temperature than the previous one.

CONDENSER (70 SIDE)	CORRESPONDING DROPOUT TANK	CONDENSER (71 SIDE)	CORRESPONDING DROPOUT TANK	COOLANT
E-70	S-1	E-3C	S-101	Process Water
E-3A	S-4	E-103A	S-104	Process Water
E-4A	S-5	E-104A	S-105	Chilled Water
E-2D	S-2	E-102D	S-102	Propylene
E-5	S-3	E-105	S-103	River Water

E-70 and E-3C condense only water and a small amount of PO and PDC. The overhead vapor, consisting of mostly PO with some PDC and water, proceeds to the next condenser, E-3A or E-103A. The lower water layers in S-1 and S-101 are recycled back to the hydrolyzers and the vapor is fed to the next condenser. The condensed PO is collected from the separator bottoms and fed to the crude PO tank, DH-1251 or DH-1252A. The overhead vapor from the fourth tank is fed to the PO compressor. Process water used on the tube side of the first two condensers is sent back to the PCH reactors as preheated feed. The fourth condenser is cooled with liquid propylene, which is vaporized and later utilized as reactor feed.

The PO compressor keeps the crude PO vapors and non-condensables moving through the overhead train. The remaining PO is condensed from the compressed vapor and sent to DH-1251 and DH-1252A. The non-condensables are sent through a scrubber and finally burned in the Throx.

II. Control Considerations

One control consideration is maintaining the vacuum on the hydrolyzer and condensing train, which is essential in achieving an efficient separation. The vacuum can be controlled by decreasing the chilled water temperature used in the third condenser and by adjusting steam on the hydrolyzers. This must be done cautiously however due to fouling problems with the packing. The first partial condenser outlet temperature setpoint is dependent upon the hydrolyzer vacuum. Control of this temperature is crucial in order to condense as much water as possible, without dropping out PDC as well. The deeper the vacuum on the hydrolyzers, the lower the outlet temperature setpoint.

Another control consideration is the caustic flow to the hydrolyzers. It can be optimized to increase PO yield and decrease TOD excursions to Environmental Operations. An excess of caustic is used to ensure complete conversion of PCH to PO, but too much caustic can lead to other problems. High caustic concentrations will promote the formation of glycol, thus raising TOD. Also, the pH must be kept below 12 so that the waste water to EOP is not considered a characteristic hazardous waste.

III. Description of How the Process Control System Addresses these Considerations

The vacuum is controlled by manual inputs to the TDC by the operator. Caustic flow to the hydrolyzer is controlled using the PICSVAX. The TDC caustic flow controller setpoint is determined by the PICSVAX from an operator input of desired weight percent caustic in the hydrolyzer bottoms. A ratio of caustic/chlorine feed is used by the VAX to determine this setpoint. The control logic, including alarm and trip setpoints, can be found in the PICSVAX documentation.

PDC FINISHING RESOURCES

I. Process Description

The purpose of the PDC finishing area is to produce good, salable PDC from crude. PDC finishing consists of a phase separation tank, DV-1262, and two distillation towers, T-1000 and T-1200. DV-1262 functions to separate water and other contaminants from the crude PDC before it is distilled. The towers run in series and remove heavy contaminants such as ether, DCIPE, chlorides, and water to produce finished PDC.

Before the crude PDC feed can be distilled it is fed to DV-1262 where the oil layer containing PDC is allowed to settle below the water layer. Extra water is added to a static mixer in the line feeding DV-1262 to aid in removing the unreacted PCH and PO. The upper water layer flows over into an adjacent drum, DV-1261, from which it is pumped back to the degassers to go through the hydrolyzers once again to reclaim the PO and to react the PCH.

The purpose of T-1000 is to strip the crude PDC from ether, EPI, and PCH. This column is packed with stainless steel Nutter rings and was installed in 1996. It was originally made of carbon steel, which is easily corroded by PDC. The new column is constructed of Duplex stainless steel. PDC, water, and other light components are condensed and fed to the next column. Non-condensable vapor is sent back to the PO compressors in the hydrolyzer and overhead condensing area. Heavy impurities in the bottoms are pumped to the PCH wash tank to remove any left over PCH.

The finished PDC is separated from the water in T-1200. It is a 105 foot Duplex Stainless Steel trayed tower with an inside diameter of 2.5 feet. The 70 valve trays are grade 7 titanium. Water vapor containing any leftover impurities, is washed in the PCH liquid-liquid extraction column, T-400. Finished PDC is taken from the bottoms and cooled before it is sent to storage.

The PCH extraction column, T-400, strips any leftover PCH from the ether. Ether containing PCH is fed to the top of the tank and water flows into the bottom. As the heavy ether settles to the bottom, the PCH is extracted by the water rising upward. The water layer is taken off and recycled to the hydrolyzer where the PCH can be converted to PO. Ether is sent to DV-1210. From there, it is burned in the Throx, which utilizes waste heat to generate 235# steam. If the Throx should ever go down or be unable to keep up with production, ether can be pumped to Solvents for destruction in their TOX.

II. Control Considerations

T-400 is controlled at six parts water to one part ether. If this ratio is too low, ether can get in the overheads which could lead to chlorides in the finished PO and high TOD in the waste water leaving the hydrolyzers.

Finished PDC must contain less than 28 ppm water and 300 ppm oxygenated hydrocarbons. Moisture in the air can easily contaminate the PDC while it is in storage so the tanks are purged with nitrogen. If the water level exceeds 28 ppm, the tank must be flushed with product, losing time and valuable product.

DO A 045296
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III. Description of How the Process Control System Addresses These Considerations

The PDC finishing system is primarily controlled using the TDC-2000, with a few areas controlled by the PICSVAX. The tower temperatures and reflux are controlled by supervisory control schemes on the VAX. The logic is described in the documentation found on the microvax in the control room. All other areas of the PDC finishing system are controlled with the TDC.

PO FINISHING RESOURCES

I. Process Description

The purpose of the PO finishing area is to purify the crude PO to meet the specifications of Glycol 1's customers within and outside the division. Within LAD, Glycol 1 provides PO to Dowanols, Cellulose, Chlorinated Methanes, and to the propylene glycol plant. PO finishing consists of three distillation towers operating in series, of which the first and last are trayed and the middle is packed. The first tower, T-102B removes light impurities and provides feed to the propylene glycol plant. Heavier impurities are then removed by T-300 and T-102C. Finished PO is taken off of these two towers and crude PDC is taken from the bottoms of T-102C.

T-102B, which contains 70 trays, strips light impurities, such as aldehydes, chlorides, and light hydrocarbons, from the PO that will be finished. The overhead vapor is condensed and fed to the PG plant. Non-condensables from all three towers are vented to the PO vent system to get rid of impurities and to improve the overhead condenser efficiency. One of the two reboilers on T-102B uses overhead from PG columns, T-5 and T-105 when available. If this vapor is not sufficient, 30# steam is used.

T-300, packed with No. 2 Cascade mini rings, is the main PO stripper. There are four packing beds, each 28-30 feet in height. The finished PO is taken from the condensed overheads and the heavier impurities, such as water, PO (20-30%), EPI, DCIPE, and PDC, remain in the bottoms. One of T-300's reboilers, E-310, utilizes waste heat from the hydrolyzer bottoms, while the other reboiler uses 30# steam.

T-102C, containing 70 bubble cap trays, is the deoiler. The condensed overhead vapor is fed to the finished PO tanks and the bottoms is the crude PDC feed. As on T-102B, vapor from T-5 and T-105 is used in one reboiler.

II. Control Considerations

As with any product finishing system, one of the primary goals in PO finishing is to maximize production and quality. This goal is the focus of several control considerations. First, in order to increase PO load on T-300 and T-102C, the forward flow from T-102B, containing light impurities, is maximized. However, to avoid overloading the tower, the forward flow may not exceed 17.5 klb/h, and the total aldehyde level must be below 35 ppm for PG quality reasons. To reduce PO losses out of the bottom of T-102C, the bottoms are controlled at <1% PO. This is also done to prevent inversion of the crude PDC phase separation tank, DV-1262. To keep the crude PDC flowing to T-1000, the light water layer must remain above the PDC layer. Any PO in the tank will stay in the PDC, and at higher concentrations, will cause it to rise above the water. If the tank were to invert, water fed to T-1000 would plug the packing, and PDC would be pumped back to the hydrolyzers. All of these controls are done using the PICSVAX, which will be addressed in the next section.

Another control consideration is the level of water in the crude PO feed. Greater than 30% water may stimulate a PO-water hydrolysis reaction in the tank. This reaction produces great pressure, and could lead to PO release and explosion. A water percent of 8 - 11% is desired. If too high, T-300 and T-102C may fill up with water due to the extra load. The water content is controlled in the PO condensing train.

Finally, the pH of T-102C bottoms must be controlled at 7-9. Caustic is injected into crude PO feed entering T-102B. The addition of caustic protects the metallurgy of the equipment, and minimizes aldehyde formation. However, excessive caustic must be avoided as well. At high pH, chlorides will begin to form in T-102C, and the water layer in DV-1262 will become heavier than the PDC layer, and invert.

III. Description of How the Process Control System Addresses these Considerations

The PO columns are controlled using the PICSVAX and TDC. For example, to increase T-102B forward flow, the VAX will increase steam while staying within the reflux, pressure, forward flow, or aldehyde constraints. The complete logic controlling all the columns, including alarms, trips, and constraints, is described in the PICSVAX documentation available in the control room.

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PO STORAGE RESOURCES

I. Process Description

The PO storage area consists of two tanks, DV-6201 and DV-7401. Finished PO from the holding tanks, DH-1252B and DH-1253, is pumped across the road to the tank farm where DV-6201 and DV-7401 are located. PO flowing to DV-6201 is cooled via an MRU unit and filtered through an adsorber prior to storage. PO in both tanks is maintained at five degrees celcius by recycling liquid PO through the MRU unit located at each tank.

The purpose of the adsorber, AD-6201, is to remove any Poly-PO that has formed. Poly-PO can cause quality problems for Glycol 1's Polyurethane foam customers. The PO first passes through the MRU unit to minimize further Poly-PO formation. Carbon steel, which makes up much of the piping and equipment in the plant, catalyzes polymerization of PO. Diatomaceous earth within AD-6201 traps the large Poly-PO molecules, allowing the finished PO to pass through to DV-6201.

PO is very volatile and flammable, therefore a nitrogen padding system is used on the tanks. The padding system adds nitrogen while liquid PO is removed and the de-pad system removes vapor while the tank is being filled. The de-pad flow is passed through the vent scrubber where it is washed with process water, which is then recycled back to S-1 and S-101, the first drop out tanks in the overhead condensing train for recovery of PO.

PO from DV-6201 and DV-7401 is shipped by tank car, tank truck, ship, and occasionally barge.

II. Control Considerations

Many PO storage area control considerations relate to storage conditions and safety. The padding system described above is necessary to maintain pressure in the tank to prevent the PO from vaporizing and the tank from collapsing in. Each tank is equipped with a combustible gas detector which will signal an alarm in the event of a leak. Sprinkler systems are also located at each tank. These can all be activated from the control room, which will be discussed in the next section.

Protection of the storage equipment is also a consideration. The temperature of the PO must be kept above one degree centigrade or the slab below the tank could freeze and crack. Finally, when loading PO to be shipped, the tanks must never be pumped empty. This would allow the pumps to cavitate which could cause damage. Also, some liquid is always needed to circulate through the MRU to keep the tanks cool.

The air permit for the tank farm determines the process water flow rate on the vent scrubbers. VS-6201 must maintain 10-15 GPM and VS-7401 must maintain 15-20 GPM. Flows less than these limits would result in a noncompliance.

Any changes made in the storage area must be reviewed and confirmed by an engineering consulting firm to ensure compliance with Coast Guard certification for vapor recovery. The firm utilized, which has been Babet Engineering, must be approved by the Coast Guard.

DO A 045300
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III. Description of How the Process Control System Addresses these Considerations

The PO storage area is controlled by use of the TDC-2000 and the MODV. AD-6201 is controlled using the MOD. The pad/de-pad control, temperature control for the MRUs, and level control are all on the TDC. The sprinklers can be activated from the MODV can 300 for DV-6201 and from the hand switch below the wall mounted intercom for DV-7401.

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PROCESS WATER RESOURCES

I. Process Description

Process water is water that has been clarified at the water treatment plant to remove suspended solids. Glycol 1 uses process water as a coolant, extractive agent, vapor scrubber, and as a seal flush on some pumps. Process water enters the block through P-100 from where it is pumped to E-3A/103 A and continues to E-70/3C. This process water stream is further heated by the E-250's, and finally fed to R1 and R101 as preheated feed.

The PCH extraction column, T-400, uses process water to remove PCH from the ether that has not yet reacted. The water containing PCH is recycled back to the hydrolyzers where it can be converted to PO.

The vapor scrubbers at the end of the PO compressors, VS-3/103, use process water to remove PO from the non-condensable vapor before it is burned. The water is recycled back to the first dropout tank of the condensing train, S-1/101.

II. Control Considerations

The discharge pressure of P-100 is controlled at 100 pounds. Lower pressures may not get enough water to the reactors, and pressures exceeding 100 pounds may blow the gaskets on the E250's and overhead exchangers.

High mineral content in the process water due to low river level can cause excessive carbonate in the reactors. To minimize carbonate buildup during these times, process water can be diluted with Demin and extra Antiscalent may be added to the hydrolyzers.

III. Description of How the Process Control System Addresses These Considerations

The process water system is controlled using the TDC system. The P-100 discharge pressure transmitter and control valve are located on the TDC.

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PROPYLENE/CHLORINE SYSTEM RESOURCES

I. Process Description

Propylene is supplied to Glycol 1 by LHC 2 and LHC 3. It enters the block as a liquid with a header pressure of 225-275 psig. The propylene is vaporized in exchangers E-150C, E-2D, and E-102D. E-150C controls the propylene pressure at 73 psig. The vaporized propylene enters E-152A which superheats the propylene to 75-85 degrees C before it enters the reactors.

Chlorine enters the block as a saturated vapor at 65-75 psig. It is superheated to 55 degrees C by E-210 before it is fed to the reactors.

II. Control Considerations

E-150C alone controls the propylene pressure. If more than one exchanger were allowed to control, they would work against each other, and cause the propylene system to become unstable. This could lead to a reactor shutdown.

E-2D and E-102D are maintained at 40-50% level. The higher the level, the more vapor is condensed and the greater vacuum is produced. However, this level may not exceed 85% to prevent liquid propylene from reaching the reactors.

E-210 maintains a minimum incoming chlorine temperature of 55 degrees C. This guarantees no liquid chlorine will reach the reactors. The maximum temperature of E-210 is 150 degrees C. At this high temperature, chlorine could react with the steel in the exchanger. It is also important to note that dry chlorine must never be used with titanium. The dry chlorine and titanium reaction can lead to fire.

III. Description of How the Process Control System Addresses These Considerations

The propylene and chlorine system controls and alarms are located on the TDC system. E-150C is controlling the propylene pressure when it is in auto mode. E-2D and E-102D are on level control, but either can be put on pressure control if E-150C is taken off.

UTILITIES RESOURCES

Air Dryers and Air System Control

I. Process Description

The purpose of the air dryers is to dry wet air from Solvents for use as instrument air in the block and for export to the division header. The purpose of the block air pressure control scheme is to maintain the block at a constant pressure, importing from or exporting to the division header as needed, and to protect the block from potential shutdown in the event of a drop in division pressure.

Air from the discharge of Solvents' air compressor first passes through E-215, a process water cooler, which cools the air and knocks out some of the water. The air then passes through a knockout pot, F-201, where the water is discharged, then into the top of the on-line dryer (AD-10A or B) through a four-way valve. The incoming air passes through the on-line dryer's desiccant bed, which absorbs the remaining water. Air exits the bottom of the dryer and passes through a filter, F-202, before going to the air distribution header, from which point it supplies the plant and can be exported to the division header.

There are two dryer beds of regenerable desiccant which take turns drying the incoming air. The "on-line" dryer is the one through which the incoming wet air flows. The "off-line" dryer goes through a regeneration cycle to dry out the desiccant before it is ready to be put back in service. The regeneration cycle begins with depressuring of the bed. Then a slip stream of dry air from the outlet of the on-line dryer passes through E-216, where it is heated by 235 psig steam, and enters the bottom of the wet bed. The air passes upward through the bed, drying the desiccant, and is then vented to atmosphere. The progress of the regeneration is monitored by a bed outlet temperature located on the vent line. When this temperature reaches 150°C, the bed is dry and cool down begins. In this step the slip stream from the outlet of the on-line dryer bypasses E-216 and cools the bed to below 65°C, at which time the vent valve to atmosphere closes, allowing the bed to pressure up before dryers are swapped. Dryer swap occurs based on dew point analysis of the dryer outlet stream; when the dew point reaches -30°C, the air is considered wet and the dryers will swap.

The block air pressure control scheme allows the block to maintain a minimum pressure, while protecting the block from sudden drops in division pressure. CV-2471 operates off of a high select between the block pressure, PT-2465, and the division pressure, PT-2468. The block will export to the division header as long as PT-2465 is at or above setpoint and greater than PT-2468. The block will import when PT-2468 is greater than PT-2465. If for some reason division pressure starts dropping, CV-2471 will close to prevent the block from exporting all of its air and dropping the internal block pressure.

The dryers are 3' in diameter, 6' tall. The dryer beds contain Sorbeid R and Sorbeid WS (water resistant) desiccant. The top of the bed is approximately 21" from the face of the top 4" flange. Dryer capacity is approximately 2600 scfm.

E-215, the air dryer pre-cooler, is a one pass exchanger. It contains 68 ¾" Cu-Ni tubes.

II. Control Considerations

The primary control objective for the air dryers is to maintain dry instrument air for the block. The block definition of "dry" is less than -30°C dew point. Another objective of the air dryer

control is to operate the equipment so as to minimize breakdown of the desiccant, making the system more efficient and reliable.

The primary control objective for the block air pressure control scheme is to maintain a minimum block pressure (operator setpoint), exporting to the division header when pressure exceeds setpoint and division pressure. The control scheme ensures that the block is protected from sudden drops in the division pressure.

Reference the one-line drawing for this area located on the operating discipline PC for a graphic process overview.

III. Description of How the Process Control System Addresses These Considerations

The air dryer control is accomplished via a PLC. The control strategy is documented in the air dryer equipment file. The air system pressure control (import / export) is accomplished via TDC-2000. The control valve operates off a high select between the plant pressure and division pressure, opening when (1) the division pressure is greater than block pressure and (2) block pressure is greater than division pressure and block setpoint. The control valve closes when block pressure is at setpoint and is greater than division pressure.

GLYCOL PLANT RESOURCES

Dehydrator

I. Process Description

The purpose of the dehydrator is to dry the crude glycol effluent from the triple effect evaporators to the part per million level before the stream is processed in the finishing section of the plant. Dehydration is accomplished in a single vessel, T-500, which is 70' 10" tall. The top 28' is 66" in diameter and has a 15' bed of structured packing. The bottom section is 84" in diameter and has a 20' packed bed (also structured). The column was constructed with different diameters in part to minimize load on foundation supports. The vessel is of carbon steel construction. The reboiler, E-530, is a falling film driven by 235 psig steam. The column is operated at approximately 150 mmHg, achieved by vacuum pumps VP-800 A/B. The overhead condenser, E-540, uses river water as its condensing medium. A small overheads stream (typically less than 10 gpm) has the capability of going to Environmental Operations or back to D-9, the sweet water drum. This stream should always be routed to Environmental Operations since it is a purge for impurities (such as aldehydes) which cause quality problems (carbonyls) in the heavier glycols. The MPG content of this stream is typically less than 200 ppm.

II. Control Considerations

The primary specification for the dehydrator is less than 350 ppm water in the bottoms stream. Finished USP has a water specification of 2000 ppm; to achieve this, the dehydrator must provide feed to the MPG columns with a water content less than 350 ppm. The pressure relief valve on the system is set for 100 psig to protect the vessel (its MAWP is 132 psig). Water analysis is provided via an onstream analyzer to minimize the hazards (temperature) of exposure to the process.

The temperature setpoint is set using feedback from the bottoms water analyzer and is achieved by manipulating the 235 psig steam. This unit operation was oversized for the production objective of the PG Quality Expansion; it handles upsets from the evaporators well. The evaporator / dehydrator steam usage has the greatest impact on overall Glycol plant conversion energy.

Reference the one-line drawings for this area located on the operating discipline PC for a graphic process overview.

III. Description of How the Process Control System Addresses These Considerations

The dehydrator control is accomplished via MODV. The control strategy, including alarms and trips, is defined in the MODV English Language.

GLYCOL PLANT RESOURCES

DPG FINISHING

I. Process Description

The purpose of T-106 is to separate DPG from TPG and heavier glycols. Its feed is the combined bottoms stream from T-6 and T-115, the MPG finishing towers. The finished DPG is taken as a sidedraw stream off the column. All of the DPG finished at Glycol I is Low Odor Grade DPG, but can also be sold as Regular Grade DPG. The capability exists to swap to a Regular Grade cut, which involves taking forward flow and no sidedraw. On a sidedraw cut, the forward flow is minimized and is high in MPG and water. This stream is recycled to the dehydration section of the plant. T-106 is 48' 1½" tall with a diameter of 60". The vessel is constructed of carbon steel with a stainless steel clad. It contains three beds of stainless steel structured packing. The reboiler, E-119C, is a falling film reboiler driven by 235 psig steam. The column is operated at 25 - 35 mmHg, achieved by vacuum pumps VP-800 C/D. The overhead condenser, E-120C, is a kettle exchanger. It uses condensate as the condensing medium, and the flash steam produced on the shell side is utilized as stripping steam in the hydrolyzers, displacing 30 psig steam.

II. Control Considerations

The primary production specifications for T-106 are < 100 ppm TPG in the sidedraw and < 0.1% DPG in the bottoms stream. Also critical are the percentages of the five isomers of DPG in the sidedraw (isomer 1: 33 - 43%; isomers 2 & 3: 42 - 56%; isomer 4: 5 - 9%; isomer 5: 3 - 8%). Manipulating the amount of forward flow shifts the isomer ratio. The lightest isomer is #1, and the heaviest #5. By increasing the sidedraw (decreasing forward flow) the isomer ratio will tend to shift to the lighter end. By decreasing the sidedraw (increasing the forward flow) the opposite will occur - the isomer ratio will shift to the heavier end. The pressure relief valve for T-106 is set for 50 psig to protect the vessel (the MAWP is 50 psig and full vacuum).

The temperature setpoint, which controls the 235 psig steam flow, is increased or decreased depending on the bottoms analysis. Reflux, sidedraw, and forward flow rates are manipulated in response to other lab analyses (TPG, UV, isomers, etc.).

Reference the one-line drawing for this area located on the operating discipline PC for a graphic process overview.

III. Description of How the Process Control System Addresses These Considerations

The DPG finishing column control is accomplished via MODV. The control strategy, including alarms and trips, is defined in the MODV English Language.

GLYCOL PLANT RESOURCES

Triple Effect Evaporators

I. Process Description

The purpose of the triple effect evaporators is to remove the bulk of the free water contained in the effluent from the glycol mixtube reactor. There are two parallel trains of evaporators; the 70 train vessels are T-3, T-4 (both 54" ID, 25'2" tall), and T-5 (84" ID, 46' tall), and the 71 train vessels are T-103, T-104 (both 42" ID, 30'7" tall), and T-105 (84" ID, 40'7" tall). Originally EG was dried on the 71 side (higher pressure) while PG was dried on the 70 side. The vessels are of carbon steel construction with trayed internals. Each column on the 70 side has two thermosyphon reboilers while the 71 vessels have one each. The first stage operates at approximately 120 psig and the last stage at 5 psig. The last stage is refluxed to minimize glycol losses in the overhead, which would ultimately result in yield losses and excess TOD to Environmental Operations. The condensate from the second and third effect reboilers is recycled back to the glycol reactor as feed water (it is referred to as "sweet" water since it contains some glycol). Aldehydes (which enter the process in the PO feed) are purged through D-9 and E-60 to ABS-810, a permitted discharge point. The purge stream comes from the second and third effects' reboiler vents. The evaporators are driven by 235 psig steam. The number of effects is a result of a trade-off between steam efficiency and quality - while multiple effects are more energy efficient, fewer are often utilized to produce higher quality crude (the more effects, the more impurities/lights produced).

The overhead from the last effect is not normally condensed, but is utilized in the PO plant in E-330 to produce stripping steam ("flash steam") from the condensate in S-10. This flash steam displaces 30 psig steam in the hydrolyzers, and helps to minimize overall plant conversion energy. By condensing the overhead of the last effect, the triples can be operated at a lower pressure, but the front end pays the energy penalty due to the loss of flash steam.

II. Control Considerations

The primary specification for the evaporators is to provide a feed to the dehydrator with a water content less than 20%, since it is more efficient to remove water in the evaporators than in the dehydrator. The pressure relief valves on the system are set as follows: T-3 150 psig; T-4 125 psig; T-5 35 psig; T-103 190 psig; T-104 160 psig; T-105 60 psig. Water analysis is provided via onstream analyzers to minimize the hazards (temperature) of exposure to the process and also to provide feedback to the control scheme.

The absolute pressure at which the evaporators are controlled determines the amount of 235 psig steam required to achieve the water concentration setpoint in the outlet. An overall PO / PG conversion energy economic evaluation is necessary to determine the optimum pressure control setpoint; some of the "flash" steam sent to the hydrolyzers could be condensed using river water to lower the pressure setpoint. The evaporator / dehydrator steam usage has the greatest impact on overall Glycol plant conversion energy.

Reference the one-line drawings for this area located on the operating discipline PC for a graphic process overview.

III. Description of How the Process Control System Addresses These Considerations

The evaporator control is accomplished via MODV. The control strategy, including alarms and trips is defined in the MODV English Language.

GLYCOL PLANT RESOURCES

TPG HYDROGENATION

I. Process Description

The purpose of R-7 is to hydrogenate the aldehydes in finished TPG to lower the color, thus making it salable acrylate grade TPG. Color in propylene glycols is due to impurities that form in the process, mainly aldehydes (propionaldehyde and longer chain conjugated aldehydes). This unit actually hydrogenates these double bonded aldehydes in the TPG (double bonds are the root of most of the color problem), not TPG itself. Hydrogenation reverses the side reactions that formed the impurities in the process by reacting the aldehydes back to a non-color causing compound. That is why if the color problem is caused by iron, hydrogenation will not affect it.

Hydrogenator feed is the finished TPG stream from T-700. The feed is preheated in EH-7, then zero grade hydrogen gas is dissolved in this stream in a static in-line mixer. This stream then flows up through R-7, where the aldehydes and the hydrogen react at normal operating conditions with the help of the nickel catalyst. Pressure is achieved through the feed pump and maintained via the back pressure control valve. Temperature is achieved with the preheater, EH-7, then maintained by 30# steam in the vessel jacket. The effluent from R-7 then flows into the top of S-7, a packed degasser, where it is contacted with nitrogen bubbling up from the bottom of the vessel. The nitrogen displaces the unreacted hydrogen, and the gases are vented. The hydrogen is removed from the product to prevent a flammable mixture in the vapor space of the storage tank. The TPG effluent from S-7 passes through very small mesh strainers to remove any catalyst fines that may be entrained.

The preheater EH-7 consists of a stainless steel tube inside a casing. Glycol flows through the tube, with either 30# or 235# steam on the shell side. R-7 is 24" OD, 16' flange to flange (bed height), with a 28" OD jacket. The vessel and the hydrogen-TPG mixer are both constructed of stainless steel. The jacket is constructed of carbon steel. The degasser, S-7, is approximately 23 ft high, with a 14' long, 8 5/8" OD packed section (stainless steel dump packing). The two sections above and below the packed section are 1' 2" OD.

There are some safety and loss prevention concerns associated with the hydrogenation catalyst. The catalyst is Ni 3266E 1/8" black extrudate, manufactured by Engelhard. It contains approximately 50% Ni on an inert support of alumina and amorphous silica. Many of the incidents with hydrogenation catalysts have occurred during startup and catalyst removal. During startup of the entire system, a nitrogen purge for air exclusion is critical before hydrogen is introduced. Exothermic heat from reaction with excess moisture and air, combined with an external heat source, could conceivably raise the catalyst temperature to the critical range (catalyst may be induced to kindle at temperatures over 175°F). It is also critical to keep activated catalyst wet, as this material is pyrophoric. Special, detailed, critical procedures for activating and removing the catalyst for regeneration and replacement exist on plant operating discipline.

II. Control Considerations

The primary production specification for R-7 is <10 color. Other specifications are water, acidity, DPG, MPG, Tetra, chlorides, and basicity. Composition should not change from finished TPG, since the hydrogenator unit op does no separation. However, a shift in composition may indicate that the catalyst is degrading the glycol, and operating conditions need to be adjusted. The pressure relief valve for EH-7, the TPG preheater, is set for 150 psig (MAWP is 150 psig). The pressure relief valves for R-7 and the jacket are set for 175

and 50 psig, respectively, to protect the vessels (the MAWP of the vessel is 175 psig, and that of the jacket is 50 psig).

The temperature and pressure are set, typically 100 - 105°C and 120 psig. Nitrogen and hydrogen flows are based on ratios to the feed flow.

Reference the one-line drawing for this area located on the operating discipline PC for a graphic process overview.

III. Description of How the Process Control System Addresses These Considerations

TPG hydrogenation control is accomplished via MODV. The control strategy, including alarms and trips, is defined in the MODV English Language.

GLYCOL PLANT RESOURCES

MPG FINISHING

I. Process Description

The purpose of T-6 and T-115 is to separate MPG from the heavier glycols. Its feed is the dry crude glycol effluent from the dehydrator. The MPG is finished as two grades: Propylene Glycol USP is taken as a sidedraw on both columns, and its production is continuous; Propylene Glycol Chemical Grade is an overheads product which can also be recycled to the dehydration section of the plant, depending on its demand. T-6, the larger of the two towers, is 60' 6" tall with a diameter of 84". T-115 is 59' 10" tall, and its diameter is 78". Both vessels are of stainless steel construction and contain stainless steel structured packing. The reboilers, E-19C and E-146C, are falling film reboilers driven by 235 psig steam. The columns are operated between 70 - 80 mmHg, achieved by vacuum pumps VP-800 A/B. The overhead condensers, E-20B and E142B, use condensate as the condensing medium; the flash steam produced is utilized as stripping steam in the hydrolyzers, displacing 30# steam.

II. Control Considerations

The primary production specifications for T-6 and T-115 are < 239 ppm DPG in the sidedraw and < 400 ppm MPG in the bottoms stream. Finished USP has a water specification of 2000 ppm. Most of the water comes out in the forward flow streams at 1000 - 6000 ppm (sales specification for this product is < 8000 ppm). Minimizing the amount of forward flow by keeping the water concentration high is critical to maximizing USP production and unloading the glycol system. The pressure relief valves on T-6 and T-115 are set for 35 psig and 74 psig, respectively, to protect the vessels (the MAWPs are 35 and 74 psig). DPG in the sidedraw and MPG in the bottoms analyses are provided via onstream analyzers to minimize the hazards (temperature) of exposure to the process and to aid in reduction in column variability via control programming.

The temperature setpoint is set using feedback from the bottoms analyzer and is achieved by manipulating the 235 psig steam. Reflux, sidedraw, and forward flow rates change in response to feedback from the sidedraw analyzer and other lab analyses.

Reference the one-line drawings for T-115 and T-6 located on the operating discipline PC for a graphic process overview.

III. Description of How the Process Control System Addresses These Considerations

The MPG finishing column control is accomplished via MODV. The control strategy, including alarms and trips, is defined in the MODV English Language.

GLYCOL PLANT RESOURCES

Glycol Raw Materials, Preheaters, and Reactor

I. Process Description

The purpose of R-500 and associated equipment is to provide heat, pressure, and residence time to allow the raw materials, PO and water, to react and form glycol. The glycol plant is primarily fed chemical grade PO; salable grade is fed as needed due to high glycol rates. Both are produced at Glycol I. The other raw material is "sweetwater," or condensate with less than 2% glycol, from D-9, the sweetwater collection drum. Condensate comes to D-9 from several sources: from the second and third effect reboilers (see evaporator resource for more information); from D-520 (condensate from the PO columns' free steam reboilers and E-330); from S-10 (plant low pressure condensate collection drum). The amount of water flow to the reactor is determined by a set ratio, typically between 4.4 and 6.0. The larger the ratio, the more MPG is formed in relation to DPG, TPG, and heavier glycols. The smaller the ratio, the more DPG, TPG, and heavier glycols are produced in relation to MPG.

The PO and condensate are combined in a static in-line mixer, MX-500, which is a sparger with baffles. The stream is then preheated to 125°C in two U-tube exchangers, E-500 and E-510. E-500 cross exchanges the feed with sweetwater from the triples, and E-510 uses 235 psig steam to maintain the reactor feed temperature setpoint. Feed pressure is maintained between 240 and 255 psig, typically. From E-510 the stream enters R-500, the glycol reactor. Flow is upward through the reactor, where there are baffles every four inches. Reactor temperature profile is monitored with ten thermocouples on the vessel - reaction is complete when the last two temperature points are the same or differ less than 1°C. These temperature points are monitored and alarmed on deviation. The value of this outlet temperature depends on the water ratio. A lower ratio results in a higher outlet temperature; low water ratio at high PG plant rates results in 195 - 197°C. Higher water ratio results in outlet temperatures of 182 - 185°C. At outlet temperatures greater than 200°C, there is a potential for quality problems from the generation of other impurities. Upon leaving R-500, the flow is split and goes to the triple effect evaporators.

D-9, the sweetwater drum, is a vertical carbon steel tank. The bottom part of the vessel is 90" ID and 16' seam to seam. The top of the vessel is a scrubber, 24" OD, 16' high, with 9'9" of structured stainless steel packing.

E-500, the first preheater, is 20" in diameter with a 16' 4 1/2" long stainless shell (originally was carbon steel, replaced with 304L stainless due to internal erosion from flashing condensate). It contains 108 3/4" U-tubes.

E-510, the second preheater, is 17 1/4" in diameter with a 14' 4 1/2" long carbon steel shell. It contains 99 3/4" stainless U-tubes (14' long). 235# stm is used on the shell side.

R-500 is 54" ID, 47' 8" tall, constructed of carbon steel. The vessel contains 135 baffles, each 4" apart.

II. Control Considerations

The primary concerns in the reactor system are to maintain inlet temperature and pressure setpoints and to monitor the exit temperature points to ensure completion of reaction. The pressure relief valves on D-9 are set at 50 psig to protect the vessel. E-500 and E-510 are set at 300 and 500 psig, respectively, to protect the vessels. R-500 is set at 480 psig, sized for a PO fire scenario.

Reference the one-line drawings for this area located on the operating discipline PC for a graphic process overview.

III: Description of How the Process Control System Addresses These Considerations

The preheat and reactor control is accomplished via MODV. The control strategy, including alarms and trips, is defined in the MODV English Language.

THERMAL TREATMENT RESOURCES

THERMAL HEAT RECOVERY OXIDIZER AND DOWNSTREAM EQUIPMENT

I.. Process Description

The purpose of R-4, a thermal heat recovery oxidizer or thermal treatment unit (THROX or TTU), is to incinerate process vents and process waste liquids and to produce 235 psig steam from high pressure condensate for use in the plant. There are two columns and a vent stack (termed the "downstream equipment") that are associated with the THROX. The purpose of T-200, the acid absorber, is to contact the flue gas from the TTU with process water to quench the hot gases and absorb chlorine as HCl. The liquid effluent from the bottoms of T-200 is pumped to Environmental Operations. The overhead gas goes to T-201, the chlorine scrubber, where it is contacted with cell effluent mixed with demineralized or process water. The liquid effluent from the bottoms is pH controlled and is pumped to Environmental Operations. The scrubbed gases are pulled through BL-101, the tail blower, and discharged through VS-1, a permitted vent stack.

Methane is used as support fuel because of its extremely high BTU value. It enters the unit through a ring of nozzles at the very edge of the burner. Methane is used alone on startup until the unit has stabilized, at which time vent streams can be added. It is also used to raise the combustion chamber temperature to the minimum required before liquid feed can be put on. The fuel gas remains on at all times at a base-loaded amount to ensure that the unit will stay on line should all other feeds cut off. Vent feeds to the TTU include process vents from the PCH reactors, R-1 and R-101, compressor vents from VS-3 and VS-103 (includes PO and PDC tank vents in addition to PO vapors from the process), and a process vent from the Solvents plant. The vent feeds enter through four nozzles which are centered around the liquid nozzle. The liquid feed is called ether, which typically is heavies from the PDC system, but can contain varying percentages of the following components, along with traces of numerous other components: PDC, dichloroisopropyl ether (dcipe), epichlorohydrin (epi), and PCH. Ether enters in the very center of the burner, through an air atomizing nozzle.

Air enters the burner, pulled by the tail end blower, BL-101. The vapor and liquid feed rates dictate a certain air flow that is required to complete combustion. The air enters around the feeds and passes through either an inner or outer set of vanes, which causes the air to swirl and mix with the feeds. Which set of vanes the air passes through is dependent upon the setting of the damper, which is dependent upon the unit's mode of operation. The outer set of vanes is used in a primarily vent burn or when only methane is being fed, because the majority of the BTU loading is with the methane, at the outer edge. The inner set is used when liquid is being burned because of the high BTU loading and air requirement of the liquid feed; the liquid requires atomization and good air mixing, so it is important to have all the air routed through the middle.

The unit is three pass, the first pass being the fire tube. At the end of the fire tube is the "backdoor," where the combustion chamber temperature is monitored with three thermocouples. There is a maximum backdoor temperature, 1150°C, set by metallurgical constraints; as with most of the constraints, the control program will shed the ether feed prior to a unit trip in order to restore the process conditions to normal ranges. In the case of the backdoor temperature, the ether will trip if the instantaneous backdoor temperature reaches 1110°C, and the entire unit will trip at 1150°C. The flame is monitored at all times using UV flame scanners. The boiler second and third passes are through tubes, with condensate on the shell side. The boiler feed water is treated with a phosphate / sulfite additive to control pH and scale. Gas exits the third pass through the flue, where temperature is normally 225°C. The temperature must stay above the acid dew point to prevent condensation and corrosion of the carbon steel. There are three oxygen probes in the flue, two insitu and one extractive. Excess O2 indication here is for combustion control

purposes. Typically the % excess O₂ is 4 - 5. The liquid feed trip is set at 1%, and the total unit shutdown is at 0.5%. Gas enters T-200 at a 45° angle below the vessel's packed section. Process water enters the top of the vessel, quenches the gas, and absorbs most chlorine as HCl. The column bottoms is typically 6 - 8% HCl. Overhead gas is scrubbed in T-201 by a mixture of process or demineralized water and cell effluent over a packed bed. There are redundant pH probes on the bottoms pump discharge, which provide feedback and control the cell effluent addition. Vapor is pulled through the tail end blower and discharged out of the vent stack, VS-1. At the vent stack there are two sets of Horiba analyzers for CO and O₂ monitoring (environmental regulation). With full ether rates on the THROX, the CO should average below 10 ppm (typically 5 - 6). The rolling hourly average trip for CO is 100 ppm. High CO is indicative of incomplete combustion and free chlorine as hypochlorite in the effluent water; hypochlorite, when combined with the organics in the effluent from the front end of the plant, forms chloroform, which can be a problem for Environmental Operations.

R-4 is a RCRA unit since it incinerates hazardous waste; there are numerous requirements and regulations associated with the unit, spelled out in Burner Management. Compliance Testing must be performed every three years until the DEQ calls for a Trial Burn to prove conditions for burning hazardous waste. During Compliance Testing, the trip conditions are proven, verifying that the unit operates within permitted limits on chlorine and CO emissions. Chlorine emissions are calculated, not analyzed. The chlorine in the feed is calculated by summing the chlorine content in all of the feed streams.

R-4 contains a Dow-designed burner retrofitted to a Johnston boiler. The refractory is lined with castable refractory cement. The firetube is constructed of corrugated carbon steel. The burner is rated for 40MM BTU/hr.

T-200 and T-201 are both derakane vessels, each 6' in diameter with a single 15' packed bed. The bottom of T-200 is brick-lined due to the hot flue gas and the acid environment. T-200's packed section contains a ceramic packing support and 2" ceramic intalox saddles. T-201's packed section contains a titanium packing support and kynar rings.

VS-1, the vent stack, is also constructed of derakane. The bottom section has a 5' diameter and is 8' tall. The top section has a 30" diameter and is 40' tall.

BL-101, the tail blower, was manufactured by Buffalo Forge Co. and is rated for 12,500 scfm. Its housing is constructed of hastelloy C22.

The liquid atomizing nozzle is manufactured by Ripco.

II. Control Considerations

The primary consideration for the THROX control is to reliably burn process vents and liquids while complying with all Burner Management requirements.

Reference the one-line drawing for this area located on the operating discipline PC for a graphic process overview.

III. Description of How the Process Control System Addresses These Considerations

R-4, vent system, liquid feed, and downstream equipment control is accomplished via MODV. The control strategy, including alarms and trips and all Burner Management requirements, is defined in the MODV English Language.

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GLYCOL PLANT RESOURCES

TPG FINISHING

I. Process Description

The purpose of T-700 is to separate TPG from Tetra and heavier glycols. Its feed is the bottoms stream from T-106, the DPG finishing tower. TPG is the final glycol product finished in the block. The bottoms stream from this column, called crude tetra or TPG bottoms, is stored and sold by the truckload. T-700 column capacity is much greater than what it needs to be to keep up with normal production rates; therefore, crude is accumulated in a large storage tank and TPG finishing is campaigned. The finished TPG is taken as an overheads stream off the column. T-700 is 65' 2 1/4" tall with a diameter of 3'. The vessel is constructed of stainless steel and contains three beds of stainless steel structured packing. The reboiler, E-700, is a falling film reboiler driven by 475 psig steam. The column is operated at 15 - 20 mmHg, achieved by vacuum pumps VP-800 C/D. The overhead condenser, E-710, is a kettle exchanger. It uses condensate as the condensing medium, and the flash steam produced on the shell side is utilized as stripping steam in the hydrolyzers, displacing 30 psig steam.

All the TPG produced at Glycol I at the current time is made in R-500, the glycol reactor, either as part of the normal product mix based on water ratio or through DPG recycle. The ability to recycle DPG to R-500 is dependent upon DPG column loading, which has been identified as a plant bottleneck. DPG is recycled to the suction of the sweetwater pumps and combines with the PO in the mixer to produce more TPG.

All the TPG produced at Glycol I is hydrogenated, a process whereby the TPG is preheated then contacted with hydrogen over a catalyst bed to remove color-producing bodies (see the glycol resource covering TPG hydrogenation for more details). The hydrogenated TPG meets Acrylate grade TPG specifications.

II. Control Considerations

The primary production specifications for T-700 are < 0.09 ppm tetra in the overheads and < 20% TPG in the bottoms stream. The pressure relief valve for T-700 is set for 100 psig to protect the vessel (the MAWP is 100 psig and full vacuum).

The temperature setpoint, which controls the 475 psig steam flow, is increased or decreased depending on the bottoms analysis. Reflux is manipulated in response to the amount of tetra in the overhead.

Reference the one-line drawing for this area located on the operating discipline PC for a graphic process overview.

III. Description of How the Process Control System Addresses These Considerations

The TPG finishing column control is accomplished via MODV. The control strategy, including alarms and trips, is defined in the MODV English Language.

GLYCOL PLANT RESOURCES

Vacuum Pumps

I. Process Description

The purpose of the vacuum pumps is to pull the glycol columns under a vacuum and to maintain their set pressures. There are two sets of vacuum pumps. One set, VP-800A/B, controls the higher pressure columns (>60 mmHg), T-500, T-6, and T-115. The other set, VP-800C/D, controls the lower pressure columns (<30 mmHg), T-106 and T-700. In each set, one is run as primary and the other is backup (but both can run at the same time in special circumstances, such as environmental sampling). The pumps are identical Nash liquid ring vacuum pumps that use dry crude glycol as the liquid sealing material.

The vacuum pumps can be started in one of four modes. 1. Start up as primary – this applies when no pump is running. 2. Pull down to atmosphere – this allows the vacuum pump to discharge to atmosphere before being swapped to ABS-810. The pump will pull down to set point more quickly than if it were discharging to ABS-810, because of the absence of back pressure. 3. Pull down to ABS-810 – in this mode the pump vapor discharge is routed to ABS-810. 4. Replace primary pump with the one being started – in this mode the MOD will indicate (once the new pump is on line) that the pump originally running can be shut down, and all vents should be swapped to the new pump.

At each distillation column vacuum control loop there are two automated valves for the vent stream; one will go fully open (or closed) and the other will act as trim to achieve and maintain the set pressure. At the vacuum pumps there is a suction control valve that maintains a constant suction pressure, with the help of a false load valve on a cross-tie to the discharge. The suction valve is normally wide open but will close back to prevent a shutdown if the vacuum pump is experiencing high discharge pressure problems (see MOD V English Language for more information on the control program). High discharge pressure can result from a number of things, such as liquid in the discharge line to the absorber or absorber level problems.

The vacuum pump discharges into a vapor / liquid separator pot, S-800, where any seal liquid drops out. The level in the seal pots is made up from MPG column feed (because of the low vapor pressure of MPG), and the wet seal liquid returns to the process as dehydrator feed. From the seal pot, the liquid is either recycled to the vacuum pump or is refreshed with drier material. The seal liquid is pumped from the pot, through a shell and tube river water exchanger (E-800) if the temperature setpoint on the stream is not met, then to the vacuum pump, where it provides the liquid ring for vapor compression. Hot seal liquid is indicative of a high water content, and could cause liquid to carry over (and condense) in the discharge line; if the temperature is high and the exchanger bypass valve is closed, the seal pot material should be refreshed.

The vacuum pumps discharge to ABS-810, the vent scrubber. ABS-810 is a process water absorber (the top section is packed) used to absorb any organic inerts discharged from the vacuum pumps. Vents from E-60, the D-9 vent condenser, are also scrubbed in ABS-810. Vacuum pump discharge pressure problems in the past have stemmed from plugged packing in ABS-810 (from mud, trash, and algae in the process water). A liquid level is maintained, and the pressure inside the vessel as well as the water flow is monitored and alarmed. The process water supply has an emergency backup line; this valve will open to a specified position upon loss of primary water flow to the absorber. After the vapors are scrubbed, they vent directly to atmosphere out of the top of ABS-810. This is the permitted discharge point for glycol emissions.

The S-800s are constructed of stainless steel and are rated for full vacuum and 75 psig. S-800A/B are 14" OD and 3'9" tall. S-800C/D are 18" OD, 5'2" tall.

The E-800s are horizontal shell and tube exchangers with a stainless shell, MAWP 75 psig. The tubes are 3/4" OD. E-800A/B have a 6 5/8" OD and are 7'10" long overall. E-800C/D have a 10 3/4" OD and are 9' 9.375" long.

The VP-800s are 2-stage liquid ring vacuum pumps manufactured by Nash. VP-800A/B were designed for 20 mmHgA with 2.0 psig discharge pressure. VP-800C/D were designed for 8 mmHgA with 2.0 psig discharge pressure.

The process water absorber, ABS-810, is constructed of carbon steel. The overall vessel height is 22' 6". The bottom part is 24" OD, 5' 6" tall (vessel diameter reduces to 6" in the top 2' of the vessel just underneath the packed section). The absorber section is 6" OD with an eight foot bed of stainless steel high efficiency structured packing. Above the packed section is an additional 7' 5" of pipe (water nozzle and sampling nozzle are here) which extends through the grating and allows vents to discharge above all process equipment.

II. Control Considerations

The primary control objective for the vacuum pumps is to achieve and reliably maintain their pressure setpoints so that the glycol distillation columns are provided with a constant vacuum source.

Reference the one-line drawings for this area located on the operating discipline PC for a graphic process overview.

III. Description of How the Process Control System Addresses These Considerations

The vacuum pump control is accomplished via MODV. The control strategy, including alarms and trips, is defined in the MODV English Language.

GLYCOL PLANT RESOURCES

Vacuum Pump

I. Process Description

The purpose of the vacuum pumps is to pull the glycol columns under a vacuum and to maintain their set pressures. There are two sets of vacuum pumps. One set, VP-800A/B, controls the higher pressure columns (>60 mmHg), T-500, T-6, and T-115. The other set, VP-800C/D, controls the lower pressure columns (<30 mmHg), T-106 and T-700. In each set, one is run as primary and the other is backup (but both can run at the same time in special circumstances, such as environmental sampling). The pumps are identical Nash liquid ring vacuum pumps that use dry crude glycol as the liquid sealing material.

The vacuum pumps can be started in one of four modes. 1. Start up as primary – this applies when no pump is running. 2. Pull down to atmosphere – this allows the vacuum pump to discharge to atmosphere before being swapped to ABS-810. The pump will pull down to set point more quickly than if it were discharging to ABS-810, because of the absence of back pressure. 3. Pull down to ABS-810 – in this mode the pump vapor discharge is routed to ABS-810. 4. Replace primary pump with the one being started – in this mode the MOD will indicate (once the new pump is on line) that the pump originally running can be shut down, and all vents should be swapped to the new pump.

At each distillation column vacuum control loop there are two automated valves for the vent stream; one will go fully open (or closed) and the other will act as trim to achieve and maintain the set pressure. At the vacuum pumps there is a suction control valve that maintains a constant suction pressure, with the help of a false load valve on a cross-tie to the discharge. The suction valve is normally wide open but will close back to prevent a shutdown if the vacuum pump is experiencing high discharge pressure problems (see MOD V English Language for more information on the control program). High discharge pressure can result from a number of things, such as liquid in the discharge line to the absorber or absorber level problems.

The vacuum pump discharges into a vapor / liquid separator pot, S-800, where any seal liquid drops out. The level in the seal pots is made up from MPG column feed (because of the low vapor pressure of MPG), and the wet seal liquid returns to the process as dehydrator feed. From the seal pot, the liquid is either recycled to the vacuum pump or is refreshed with drier material. The seal liquid is pumped from the pot, through a shell and tube river water exchanger (E-800) if the temperature setpoint on the stream is not met, then to the vacuum pump, where it provides the liquid ring for vapor compression. Hot seal liquid is indicative of a high water content, and could cause liquid to carry over (and condense) in the discharge line; if the temperature is high and the exchanger bypass valve is closed, the seal pot material should be refreshed.

The vacuum pumps discharge to ABS-810, the vent scrubber. ABS-810 is a process water absorber (the top section is packed) used to absorb any organic inerts discharged from the vacuum pumps. Vents from E-60, the D-9 vent condenser, are also scrubbed in ABS-810. Vacuum pump discharge pressure problems in the past have stemmed from plugged packing in ABS-810 (from mud, trash, and algae in the process water). A liquid level is maintained, and the pressure inside the vessel as well as the water flow is monitored and alarmed. The process water supply has an emergency backup line; this valve will open to a specified position upon loss of primary water flow to the absorber. After the vapors are scrubbed, they vent directly to atmosphere out of the top of ABS-810. This is the permitted discharge point for glycol emissions.

The S-800s are constructed of stainless steel and are rated for full vacuum and 75 psig. S-800A/B are 14" OD and 3'9" tall. S-800C/D are 18" OD, 5'2" tall.

The E-800s are horizontal shell and tube exchangers with a stainless shell, MAWP 75 psig. The tubes are 3/4" OD. E-800A/B have a 6 5/8" OD and are 7'10" long overall. E-800C/D have a 10 3/4" OD and are 9' 9.375" long.

The VP-800s are 2-stage liquid ring vacuum pumps manufactured by Nash. VP-800A/B were designed for 20 mmHgA with 2.0 psig discharge pressure. VP-800C/D were designed for 8 mmHgA with 2.0 psig discharge pressure.

The process water absorber, ABS-810, is constructed of carbon steel. The overall vessel height is 22' 6". The bottom part is 24" OD, 5' 6" tall (vessel diameter reduces to 6" in the top 2' of the vessel just underneath the packed section). The absorber section is 6" OD with an eight foot bed of stainless steel high efficiency structured packing. Above the packed section is an additional 7' 5" of pipe (water nozzle and sampling nozzle are here) which extends through the grating and allows vents to discharge above all process equipment.

II. Control Considerations

The primary control objective for the vacuum pumps is to achieve and reliably maintain their pressure setpoints so that the glycol distillation columns are provided with a constant vacuum source.

Reference the one-line drawings for this area located on the operating discipline PC for a graphic process overview.

III. Description of How the Process Control System Addresses These Considerations

The vacuum pump control is accomplished via MODV. The control strategy, including alarms and trips, is defined in the MODV English Language.