DISTILLATION, DEHYDRATION & EVAPORATION (DD&E) SYSTEM

FIELD MANUAL

PROJECT:

PROJECT NO.

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3	09/18/2007	Revised CIP Section	DML	
4	10/10/2007	Revised CIP Section	DML	

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1.0 SYSTEM NARRATIVE

1.1 INTRODUCTION

Thermal Kinetics Systems, LLC (TKS) has prepared a system configuration and material balance presented in drawings PF-4001, PF-4101, PF-4201 and PF-4301. These Process Flow Drawings present the flows for CIP as well as the Distillation, Evaporation and Dehydration systems. The scope of supply is for a “conventional” Thermal Kinetics’ DD&E design. The systems’ production rate is 38.09 MM gallons/year of undenatured ethanol based on 8,472 hours per year of operation. After denaturant is added the production is 40 mmgy of denatured ethanol. The overall system consists of an energy integrated system that reduces the calculated steam consumption to a level of less than 10.9 lb/gallon of denatured ethanol.

The distillation system consists of a 8’-6” diameter Stripping Column (‘Beer Column”) and a 6’-6” diameter Rectifying Column (“Alcohol Column”). The evaporation system comprises a double effect evaporator operating at a final pressure of 1.79 psia. Much of the evaporation occurs in the stripping column and whole stillage flash with a bottoms concentration of 14.73 wt% total solids compared to the beer concentration of 11.96 wt% total solids. The dehydration system consists of a two column system that contains molecular sieve type 3A. Dehydration systems operate in sequence through a dehydration, regeneration and re-pressurization cycle. A dehydration column system using accumulators is employed to establish a steady operating pressure to the stripping column reboiler, ET-4104.

The evaporative condenser unit eliminates the need for a cooling tower to service the system and can eliminate the need for waste water treatment or sewer discharge from a cooling tower and boiler blowdowns. The blowdown from these sources can be directed the condenser and further concentrated prior to feeding the evaporator with the thin stillage feed. For this system configuration in Canton, Il, no reduction of blowdown streams has been included.

Table 1: Overall System Balance

System Feed	"Beer" from corn feedstock	
	278,590 lb/hr	
	10.5% w/w Ethanol/11.96% TS	
Ethanol Produced	4,497 gallons/hour @ 99.5 wt%/199.5 proof	
		(8,472 hours/year)
Whole Stillage from Distillation	226,177 lb/hr @ 14.73 wt% TS after flash step to 185°F	
Syrup from Evaporation	25,815 lb/hr @ 35% TS and 127°F	
Process Water from Rectification	24,548 lb/hr @ 203°F	
Process Water from Evaporation Distillate	45,655 lb/hr @ 127°F (from TK-Condenser)	
Process Water from Evaporation Condensate	44,677 lb/hr @ 151°F	
Fusel Oils	From Decanter - blended back into anhydrous ethanol	
Evaporation Area Product Handled	Thin Stillage @ 8.02 wt% TS	
Evaporation Sytem Operating Pressure (1st Effect)	3.54 psia	
Evaporation Sytem Operating Pressure (2nd Effect)	1.79 psia	
Evaporator Feed Rate	112,443 lb/hr thin stillage (9,818 lb/hr added capacity	
	available for 4 hrs CIP/wk)	
Total Evaporation quantity from Evaporation Area	86,636 lb/hr	
Evaporation Area Discharge Rate	25,815 lb/hr @ 35% TS* and 127°F	
	(max 9% insoluble solids in syrup)	
*Based on typical corn stillage viscosity data, measurements taken in various plants.		
Design not to exceed 150 cps for 35% at 148°F		

1.2 OPERATIONAL INTRODUCTION

The Distillation, Dehydration, and Evaporation Systems are operations that share energy in order to produce fuel grade ethanol. The flow of energy through the entire DD&E unit are clarified below:

- STEAM PROVIDES ENERGY TO RECTIFIER COLUMN
- RECTIFIER COLUMN OVERHEAD VAPORS PROVIDE ENERGY TO BEER COLUMN REBOILERS
- VAPORS FROM THE BEER COLUMN REBOILERS PROVIDE ENERGY TO BEER COLUMN
- BEER COLUMN OVERHEAD VAPORS PROVIDE ENERGY TO EVAPORATORS
- WHOLE STILLAGE FLASH VAPOR PROVIDES ENERGY TO EVAPORATORS

The Rectifier Column and dehydration systems operate at pressures above atmospheric while the Beer Column and evaporation systems operate under vacuum supported by a total of two liquid ring vacuum pumps and one TK wet surface condenser. The 190 proof from the Rectifier Column is dehydrated via a pressure swing adsorption process using the Molecular Sieve Unit to generate 200 proof ethanol.

The system is designed for automatic analog control of PID loops (*see CIE Functional Controls Description*) with operator initiated, sequential operation of start-up, shut down, and cleaning. The PLC automation will control dehydration sequencing (*see CIE Molecular Sieve Sequencing Description*) and plant operations. The PLC automation will not control the CIP sequencing for the Evaporators and Beer Column Reboilers; changes in Reboiler control schemes will be administered during CIP operations and is clarified in the *CIE CIP Sequencing Description.* Operator intervention will be needed for a full shut-down as well as CIP of the Beer Column and Flash Tanks. Valve failure positions assure a fail-safe mode during power failures. Other alarms and interlocks help alert and avoid potential adverse conditions from getting worse (*see CIE Alarm and Interlocks List*).

1.3 DISTILLATION

Beer is introduced to the Beer Preheater (EP-4113A/B) which is operated using second stage cook flash vapor from Mash Flash Cooler #2 (TP-4113). Beer is then transferred to the CO_2 Flash Tank (TP-4105) by setting the flow controller located on the inlet of the Beer Preheater which regulates the flow control valve on the discharge of the Beer Preheater. CO_2 is removed from the beer in the Flash Tank at a controlled rate using a differential temperature controller to minimize ethanol leaving with the CO_2 and maximize temperature of the feed going to the Beer Column. The degassed beer is fed to the top of the Beer Column (TW-4101) based on level in the CO_2 Flash Tank (TP-4105) by the level controller using the control valve. Ethanol is stripped from the beer using the vapors from the two Beer Column Reboilers as well as from low pressure steam from Cook Flash and Rectifier Column Bottoms flash tanks. The bottoms from the Beer Column Reboilers are sent to the Decanters as whole stillage.

There are two Reboilers circulating the whole stillage from the bottom of the Beer Column that operate on level control before finally discharging to the Whole Stillage Flash Tank (TP-4207) on the way to the centrifuges. One Reboiler (RC Condenser / BC Reboiler: ET-4103) uses the 190 proof vapor discharged from the top of the Rectifier while the other (BC Reboiler / 200 Proof Condenser: ET-4104) uses 200 proof vapor from the Molecular Sieve Unit (MSU). Vapors from the Rectifier Bottoms Flash Tank (TP-4110) are combined with the vapors discharged from the Reboiler Separators (TP-4103 & TP-4104) and are then introduced to the bottom of the Beer Column where they provide energy used to strip the ethanol from the beer.

Steam is sent to the Rectifier Reboiler (ET-4102) using flow control to both strip ethanol from the feed, making the bottoms essentially ethanol free, and to raise the ethanol concentration to 92 wt% ethanol composition at the top of the Rectifying Column (TW-4102). The beer column overhead ethanol condensate feed from the evaporation area is preheated within ET-4111, which uses the condensate from the Rectifier Reboiler, and then is transferred to the Rectifying Column around tray 23.

The vapors leaving the top of the Rectifier Column are split by directing a portion to the Molecular Sieve 190 Proof Superheater (ET-4114) while the remaining vapors are directed to one Beer Column Reboiler (ET-4103) which also serves the purpose as the 190 proof condenser. The 190 Proof Superheater (ET-4114) elevates the temperature of the 190 proof ethanol vapors prior to being introduced to the molecular sieve unit (MSU). A portion of the Rectifier Column overhead vapor is transferred to and condensed within the shell-side of the Rectifier Column Condenser/Beer Column Reboiler (ET-4103) before it serves as a reflux and is transferred back to the Rectifier Column. The Rectifier Column overhead product which serves the function as a reflux back to the column provides the energy required for evaporation of Beer Column bottoms. The 190 proof condensate collects in the 92% Ethanol Receiver (TP-4106) and is returned to the Rectifier Column on level control. Density is checked to determine acceptable proof while flow is also measured before the liquid reflux is returned to the top of the column. The 190 proof ethanol vapors sent to the Superheater are flow controlled with set point correction based on column temperature at tray 21 (There is pressure control between the top of the Rectifier Column and the Molecular Sieve 190 Proof Superheater). Ethanol vapors are enriched in the first stage Evaporator prior to preheating and feeding to Rectifier Column.

Temperature and pressure profiles are monitored in the two columns. Temperatures in the Beer Column will range from 203° F at the bottom to 176°F at the top while the pressure ranges from 12.26 psia at the bottom to 10.17 psia at the top. The temperature in the Rectifier Column will range from 288°F at the bottom to 240°F at the top while the pressure ranges from 56.45 psia at the bottom to 53.45 psia at the top. Beer feed rates may require adjustment based on temperature profiles within columns. Beer feed rate must match the steam rate to the Rectifier Reboiler and is also dependent upon the ethanol feed temperature.

The pressure of the overhead vapors discharged from the Rectifier Column is controlled by a pressure control valve located between the MSU take-off and the 190 Proof Condenser. Control of the 190 proof ethanol concentration is achieved by means of a cascade computer controller which senses two variables and controls one variable. The primary set point is the flowrate of superheated 190 proof ethanol vapor feed to ET-4114 (Superheater 190 Proof to MSU) and the controller derives from this a set point for the temperature above stage 21 of TW-4102 (Rectifier Column) via temperature element and transmitter. This temperature is used as an indication of the composition of the liquid on tray 21 and, thus, as a measure of the separation produced. High temperature at Tray #21 can indicate poor quality due to inadequate reflux or the buildup of fusel oil. High temperature at the top of the column indicates poor quality, inadequate reflux. The reflux to the top of the column is set by the level control within the 190 Proof Condensate Receiver (TP-4106).

Fusel Oils are removed with ethanol and water, from one of the trays (#22, #23, or #24) of the Rectifying Column and are drawn using rate control, through the Fusel Oil Exchanger (EP-4108) and into the Fusel Oil Decanter (TP-4108) where they are mixed with water (which is also fed using rate control) and settled. The heavy, ethanol / water phase is removed from the bottom of the Fusel Oil Decanter on interface control and returned to the Rectifying Column by combining with the feed stream after passing through the Fusel Oil Exchanger. The light fusel oil phase is collected on one end of the Decanter after spilling over an internal baffle and is then transferred to the 200 Proof Receiver (TP-4107) using a positive displacement variable frequency drive pump (PD-4109) operated on level control. The density of the fusel oil is measured to confirm that water and ethanol have been sufficiently separated from the fusel oil before it is mixed with the dry product.

1.4 EVAPORATION

The evaporation system is a three stage, double effect evaporator that concentrates thin stillage feed into syrup. The stillage in the system flows in sequence: 1) first stage, 2) second stage and 3) third stage producing syrup. Overhead vapors from the Beer Column (TW-4101) are used in the First Effect Evaporator (Stage 1 – ET-4201) to drive the evaporator system. There is also flash steam added to stage 1 from the Whole Stillage Flash Tank (TP-4207). Vapors from the First Effect Separator (TP-4201) are used in the Second Effect Evaporator (Stages 2 and 3 – ET-4202) and the vapors from the second effect are sent to the Main TK Condenser (ET-4204). Vapors are driven from first effect, to second effect, to the TK Condenser, by a thermal / pressure gradient ending at the vacuum pump (PV-4201) operating between 1.8 and 2.0 psia.

The ~50% ethanol vapors discharged from the top of the Beer Column are condensed within the shell side of the First Effect Evaporator (ET-4201) and collected in the First Effect Condensate Collection Receiver (TP-4205). The vapors from the vents on the First Effect Evaporator jackets are condensed in the First Effect Vent Condenser (ET-4205) and combined with the ethanol condensate in TP-4205 (1st Effect Condensate Collection Tank). The non-condensables from the vent condenser are transferred to the Beer Column Vacuum Pump which is controlled using a pressure control valve that returns vapors from the vacuum pump separator with the controller set at about 10.2 psia based on the pressure at the top of the Beer Column. Vapors leaving the separator are sent to the CO_2 Scrubber while the excess condensate is combined in TP-4205.

Flow into each stage is controlled by the level in that stage. The feed rate in any stage equals the bottoms going to the next stage plus the vapors driven off. Beer Column overhead vapors fed to the jackets on the First Effect Evaporator (stage 1) along with the noncondensables (that includes significant CO_2) vent to the vacuum pump which is controlled by the pressure transmitter located where the vapor leaves the Beer Column by allowing vapor flow from the vacuum pump separator back into suction. The syrup rate leaving the bottom of the third stage is controlled by flow and cascaded to syrup density. The density of the product (syrup) is an indicator of final concentration. Therefore, the density controller controls the final concentration by cascading to the syrup flow controller and adjusting the rate of syrup withdrawal from the system.

The material flows out of the system include the product syrup (35% from stage 5 bottoms), ~50% ethanol condensate (from first effect stage 1), used as feed to the Rectifier, and process condensate from the Second Effect Evaporator (stages 2 & 3) sent to mash cooking. The first effect vaporizes water from the feed producing low-pressure steam for heating the second effect. The second effect vapor is sent to the Main TK Condenser with the noncondensables going on to the main vacuum system. The parameter controlling the capacity of the evaporation system is the energy from distillation. The capacity of the system, therefore, is set by the steam to the Rectifier Reboiler.

The pressure and temperature profiles for the evaporator are established naturally by the amount of surface in each effect, total heat load, and heat transfer rates in each effect. The second effect pressure sets the temperature in the last effect and the remaining effects balance to provide the temperature differential required to satisfy the heat load. Pressure in the second effect is set by the pressure in the TK Condenser that is determined by the operation of the distillation system and the vacuum pumps. Once the capacity of the system, concentration control of the product, and last effect pressure are established the only remaining issue is to control the levels of stillage throughout the system. Level requirements in each stage are satisfied by controlling the flow into each stage. The two condensate streams from the evaporator jackets are collected in three condensate receivers. Level requirements in each receiver are satisfied by controlling the flow out of each receiver.

Pressure in the ethanol and process condensate receivers is equalized by venting these vapors into system vent at various points. The evaporator jacket vents also provide venting of non-condensables. Pressure in the ethanol receiver is maintained to prevent excessive flashing. The 1st Effect Ethanol Condensate Collection Tank pressure is controlled by pressure controller that vents to the vacuum pump. The process condensate receivers and second effect evaporator jackets are vented to the Main Condenser that is then vented to the main vacuum pump and pressure controlled. The discharge temperature of Main Condenser Recirculation Pumps to the spray nozzles is measured and a signal is transmitted to a temperature indicating controller which sends a signal to condenser fan's variable speed drive to adjust fan speed depending upon the difference between the actual measured spray water temperature and the operator user-defined temperature.

1.5 DEHYDRATION

190 proof ethanol vapors discharged from the Rectifier Column are sent through the molecular sieve adsorption unit to remove the water and generate 200 proof ethanol for fuel grade blending. 190 proof ethanol vapors flow in the downward direction through one of two vertical packed towers of type 3A zeolite molecular sieves that work in cyclic semi-batch mode wherein 200 proof ethanol is produced via timed alternating cycles comprised of sequences which entail (1) dehydration (adsorption), (2) depressurization, (3) regeneration and (4 & 5) initial and final repressurization. When one bed is adsorbing, the other is undergoing a desorption process which is a means to recharge the packed bed for subsequent adsorption cycles. While one sieve dehydrates, the other depressurizes, regenerates and re-pressurizes according to a series of valve sequences and using a portion of the product 200 proof ethanol vapor controlled by flow controller using a control valve. 200 proof vapor leaving the MSU is sent to the Beer Column Reboiler / 200 Proof Condenser (ET-4104). The 200 proof condensate is collected in the 99.5 wt% Ethanol Receiver (TP-4107) and sent to storage on level control after cooling in the 200 Proof Ethanol Cooler (EP-8201). The pressure measured entering the adsorption unit controls pressure control valve on the sieve outlet. The temperature of 190 proof ethanol introduced to the dehydration area is adjusted by the steam flow to the shell-side of the Superheater 190 Proof to MSU which is regulated by a temperature control valve located on the Superheater's discharge.

The regeneration cycle is sequenced by a total of three block valves and one modulating control valve on each packed tower. The positions of each block valve are verified by dual limit switches that will cause an alarm if the proper position is not achieved within a specified time. The 200 proof ethanol purge during regeneration is held by the flow controller (FIC-4301-017) during that portion of the regeneration cycle. Refer to the *CIE Molecular Sieve Sequencing Description* for details on the operation of each instrument during the entire cycle.

Depressurization and regeneration vapors are transferred from the MSU to the Regen Condenser (ET-4301). The condensate from the Regen Condenser is split based on timing / composition, sending the initial, higher proof to TP-4304 (Depressurization Condensate Receiver), and the final, lower proof being sent to TP-4303 (Regeneration Condensate Receiver). The higher proof receiver condensate is combined with 190 proof reflux in TP-4106. The lower proof receiver condensate is combined with the 50.77% ethanol feed in TP-4205. The non-condensables from both receivers are vented through ET-4301 to the vacuum pump (PV-4301) which is designed to arrive at less than 2 psia at the end of each regeneration cycle. Each condensate receiver is operated by level control.

2.0 OPERATING PROCEDURES

2.1 START UP

As a preliminary check, the evaporation and distillation systems can be operated with water and a production run simulated. The procedure is simply to fill the system with water. DO NOT PRESSURIZE ABOVE THE DESIGN OF THE UNITS. Warm water should be used (85-90°F), since cold water can cause condensation, making minor leaks difficult to detect. All leaks should be taken care of before proceeding further. Operation on water can also allow continuous transition from CIP to production operation and back to minimize the total start-up time required. Whenever operating on water, use low level settings to minimize start-up time. NEVER OPERATE THE MOLECULAR SIEVE UNIT WITH WATER OR ANY LIQUID.

Water should be introduced to both the Rectifier Column and the Beer Column. The Rectifier Column bottoms level control valve should be closed to prevent water from being introduced to the Rectifier Column Bottoms Flash Tank (TP-4110). Water will transfer from the Beer Column to the Beer Column Reboilers. The evaporation area should also have water recirculating throughout its pipe-work. A water discharge flow rate from the evaporation area may be manually established via the flow controller on the Third Stage Evaporator discharge. Pumps should be operated, and instruments checked, keeping in mind the difference in specific gravity of water and product with reference to the level control instruments. During this period, all manually operated valves, and gages, can be checked and prepared for normal operation.

After recommended precautions are taken and water is present within the Rectifier Column, Beer Column, Beer Column Reboilers and evaporation area, a vacuum may be applied to the DD&E area and the steam source to the Rectifier Column Reboiler may be introduced at around ~1/3 to ~1/2 design rate. Do not wait until the system has reached full vacuum to introduce steam to the Rectifier Column Reboiler. The DD&E are pipe-work should contain only water and the Rectifier Column should be operated water and on total reflux.

It is important to ensure that a minimal steam supply is provided to the shell side of the 190 Proof Superheater (ET-4114) to prevent condensation of any fluid within the tube side. The flow control valve located on ET-4114 tube side discharge should be closed and nothing should be introduced the MSU until the point where 190 proof is discharged from the top of the Rectifier Column and proper temperature profiles equilibrate throughout the Beer and Rectifier Columns. No liquid or steam should ever be introduced to the MSU.

While steam is vaporizing liquid within the Rectifier Column, the level within the Column must be manually maintained. The pressure indicating controller located on the top of the Column must be manually adjusted to maintain an overhead vapor discharge temperature of about 240 – 250ºF. The Rectifier Column must operate at a lower pressure (~23 psia) to achieve the design condensing temperatures within the shell side of the 190 Proof Condenser / Beer Column Reboiler (ET-4103); water has a much higher condensing temperature than ethanol, if the Rectifier Column were to operate at pressures associated with continuous operation, the temperate of the vapors introduced to the 190 Proof Condenser / Beer Column Reboiler (ET-4103) would be in excess of design condensation temperatures.

Steam should be introduced to the Rectifier Column Reboiler which will vaporize water within the Rectifier Column which in turn will provide energy to draw vapor from the water circulating through the Beer Column Reboiler pipe-work. The vapors discharged from the 190 Proof Condenser / Beer Column Reboiler (ET-4103) will provide energy to vaporize water within the Beer Column. The Beer Column overhead vapors provide energy to vaporize water circulating throughout the evaporation area pipe-work.

At the point where water vapor is discharged from the Second Effect Evaporator and condensate has built up within the 1st Effect Condensate Collection tank, the water source located on the suction of the RC Feed pump may be exchanged for the condensate stream fed by the 1st Effect Condensate tank. Beer may be introduced to the Beer Column instead of water when the 1st Effect Condensate feed to the Rectifier Column replaces the water source initially used to fill the Rectifier Column. Rectifier Column Bottoms may be set on level control and the bottoms product may be transferred to the Rectifier Column Bottoms Flash Tank.

As the Beer Column and Rectifier Column begin to produce ethanol the pressure controller on top of the Rectifier Column must be manually increased to maintain an overhead vapor discharge temperature of about 240 – 250ºF. Samples should be taken from the Beer Column Bottoms every hour to ensure there is no ethanol present. Stability of cascade loops should be frequently checked. Flow discharged from the evaporation unit will increase in viscosity over time; an operator defined density should eventually be set on the density / flow cascade loop located on the evaporation area discharge.

When 190 proof ethanol is discharged from the top of the Rectifier Column and desired temperature profiles are achieved within the both distillation columns, the steam source to the 190 Proof Superheater may be increased to design rates and low flow rates may be introduced to the Molecular Sieve Unit. To avoid rapid pressurization of bed 1 caused by 190 proof feed flow to the MSU, bed 1 (TW-4301) outlet valve XV-4301-015 should be first opened followed by opening bed 1 inlet valve XV-4301-001; both inlet and outlet valves on bed 2 should be closed. The MSU pressure control should be set at 35 to 45 psia for start up (experience will dictate what is the most suitable start up pressure). Bed 1 should be heated until the bed and outlet are at the desired temperatures (bed temperatures TI-4301-009 through TI-4301-013). When Bed #1 (TW-4301) has achieved desired temperature profiles, switch to bed 2 (TW-4302); open the bed 2 outlet valve XV-4301-016 before opening bed 2 inlet valve XV-4301-003. Bed 2 should be heated until the bed and outlet are at the desired temperatures (bed temperatures TI-4301-022 through TI-

4301-026). When both beds are at desired temperatures the sieve sequence may begin (the MSU will now be cycling normal). Set the MSU pressure control between 50 and 55 psia. The sieve can now be slowly ramped up to plant rate using FIC-4101-014. As ethanol is produced the level within the 200 Proof Ethanol Receiver (TP-4107) should be confirmed; PC-4107 should be started and the manual 200 proof vapor desuperheat valve should be opened.

At this point, the beer feed rate to the Beer Column may have to be increased. The rate of 190 proof ethanol sent to the MSU is dependent upon the ethanol content within the beer fed to the Beer Column. Beer Column feed rate is proportional to the steam rate and the rate introduced to the MSU. High flow rates to the MSU can cause high temperature spikes which can destroy the adsorbent material within the adsorption towers. Short cycle times and low flow rates are initially recommended. After phasing in the 190 proof and reasonable MSU cycles are obtained, the steam rate to the Rectifier Column Reboiler as well as the beer feed rate to the Beer Column may be increased. Steam rate should always be increased before increasing the beer feed rate.

Further details related to start up, continuous operation and shut down are clarified in the following sections.

- Ensure that all permits are turned in.
- Ensure all drains are closed
- Make sure that manual valves are in correct position for normal operation.
- Check all manways, pump seal flushes, pump valves, tank recirculation valves all set at 50%, motor disconnects, pump switches in auto, non-condensable vents are slightly cracked open (1/4 approx).
- Make sure utilities (Cooling water supply, cooling water return, etc.) are introduced to proper equipment (CO2 Flash Condenser, Vacuum Pumps, TK Condenser).
- Notify steam house of DD&E area start-up.
- Fill Beer Column and Beer Column Reboilers and Evaporators with water.
- The Rectifier Column bottoms level control valve should be closed.
- Water should be introduced to fill the Rectifier Column through the water supply located on the suction of PC-4205 (1st Effect Condensate Pump).
- Establish flows within recirculation loops.
- Verify liquid levels within equipment.
- Establish a discharge flow rate from the Syrup Pump via FIC-4202-007.
- Start up vacuum pumps PV-4205 and PV-4201.
  Do not wait until reach vacuum to start up Rectifier Column.
  It will take less time to reach vacuum when steam is in system.
- Make sure that flow control valve located on 190 Proof Superheater (ET-4114) is closed.
- Make sure that the steam supply to the 190 Proof Superheater is introduced at 5 to 10 psia steam. This will vaporize, and prevent, condensation accumulating within the Superheater's tube side.
- Start up Rectifier Column (TW-4102) with ~½ steam rate & lower capacity – operate on water and total reflux. Verify level valve on RC Bottoms is closed. Manually maintain water level in Rectifier Column through feed system by overriding LV-4201-007 located before the Rectifier Column Preheater.
- Operate Rectifier Column at lower pressure so that top of column is between 240 – 250ºF. PV-4101-021 should be set at a lower pressure and manually adjusted (~23 psia).

- ET-4104 will not have an energy input – MSU is off-line.

- Steam provides energy to vaporize liquid within Rectifier Column. Overhead vapor from Rectifier Column will provide energy to the Beer Column Reboilers. Beer Column Reboiler vapors provide energy to drive vapors from the liquid within the tube-side of the RC Condenser / BC Reboiler (ET-4103). Beer Column overhead vapors provide energy to and are introduced to the Jackets of the 1st Effect Evaporator. 1st Effect condensate vapors provide energy to vaporize water from the 2nd Effect Evaporator (2nd & 3rd Stages). Beer Column overhead vapors introduced to the 1st Effect Evaporator will condense and will be transferred as liquid feed to the Rectifier Column. Whole stillage flash vapors provide additional energy as steam to the evaporation area.

- Make sure that the valve located above the CO_2 Flash Condenser is cracked open approximately 30%.

- When 1st Effect Condensate Collection Tank (TP-4205) reaches 75% level the water source located on the suction of the RC Feed pump may be shut off and condensate from the Evaporators may be introduced to the Rectifier Column. LV-4201-007 should be set for normal operation.

- Rectifier Column Bottoms should be set on level control and RC Bottoms should be transferred to the process condensate header.

- Introduce beer to and fill the Beer Column. If the steam rate is at 50% design rate, introduce beer feed at 40% design rate.

- Beer should pass through the Beer Column to the Reboilers and then transfer to the Whole Stillage Flash Tank.

- Take Beer Column bottoms samples every hour or so to make sure there is no ethanol present.

- Verify that steam supply valve to MSU Superheater is open enough to vaporize any condensation within the tube side of the exchanger. Steam supply to MSU Superheater (Rectifier Column still at low capacity) may be increased at the time 190 proof ethanol is introduced.

- When 190 proof ethanol is discharged from the top of the Rectifier Column **low flow rates** to the MSU may be established via FIC-4101-014.

- The MSU pressure control should be set at 35- 45 psia for start up (experience will dictate appropriate start up temperature for MSU)

- Keep track of the level within the 200 Proof Ethanol Receiver (TP-4107); PC-4107 should be started after the MSU has been started up and when 200 proof ethanol condensate is present. When PC-4107 is turned on the manual 200 proof vapor desuperheat valve should be opened.

- Heat the MSU: bed 1 (TW-4301) outlet valve XV-4301-015 should before opening bed 1 inlet valve XV-4301-001.

- Bed 1 should be heated until the bed and outlet are at the desired temperatures (bed temperatures TI-4301-009 through TI-4301-013).

- When bed 1 (TW-4301) has achieved desired temperature profiles, switch to bed 2 (TW-4302); close bed 1 (TW-4301) inlet valve XV-4301-001 before closing bed 1 outlet valve.

- Bed 2 should be heated until the bed and outlet are at the desired temperatures (bed temperatures TI-4301-022 through TI-4301-026).

- When both beds are at desired temperatures the sieve sequence may begin (the MSU will now be cycling normal).

- Set the MSU pressure control between 50 and 55 psia.

- The sieve can now be slowly ramped up to plant rate using FIC-4101-014.

- AVOID HIGH FLOWRATES TO THE MSU WHICH CAN CAUSE TEMPERATURE SPIKES. Watch temperature profiles – note key temperatures and proper profile.

- Continue ~½ steam rate to Rectifier Column Reboiler (ET-4102) until steady state conditions are obtained and 190 proof ethanol has been introduced to MSU and MSU cycles/sequences are reasonably attained.

- When temperature profiles within Rectifier Column reach desired design profiles and MSU cycles are reasonably attained, steam flow to ET-4102 and beer feed rate may be gradually increased. Steam flowrate should be increased before the beer feed rate is increased.

2.2 OPERATION

- Frequently check density of 190 proof ethanol condensate (~every few hours via PC-4106 discharge)
- Frequently check density of 200 proof ethanol condensate (~every hour via PC-4107 discharge)
- Frequently check fusel oil and syrup densities (every hour until process is at steady state – then less frequently)
- Check stability of cascade loops
- Check ethanol/water compositions on discharge of depressurization and regeneration condensate pumps

2.3 SHUT DOWN

Proper shut down of the DD&E area include first reducing steam input to the Rectifier Column Reboiler to approximately 50% design rate. Beer feed to the Beer Column and thin stillage feed evaporation unit should be substituted for water. CIP procedures should be started for the Beer Column and Flash Vessels noting that a steam source is required to realize CIP of these units; CIP is a once through procedure for these units (no recirculation of cleaning solution within pipe work is required) and should coincide with procedures clarified in the *CIE CIP Sequencing Description*.

MSU shut down procedures entail first stopping the 190 proof ethanol feed to the MSU from the 190 Proof Superheater via FIC-4101-014. The steam source to the 190 Proof Superheater should be stopped. The manual 200 proof desuperheat valve located on PC-4107 should be closed; this is the 200 proof liquid from the 200 Proof Ethanol Pump that injects after the sieve back pressure valve. With the feed to the MSU completely shut off, let the MSU continue to cycle <u>at least</u> one full cycle before shutting off the sequence or shutting off the Regen (this will ensure that the beds have been regenerated). Both adsorbers should remain under vacuum while off line. After each bed has adequately depressurized and regeneration of each bed has taken place, the MSU sequence and the Regen vacuum pump should be shut off. Make sure that the Regen and depress condensate pumps have been shut off.

- Stop feeding 190 proof to MSU.

- Shut off steam source to 190 Proof Superheater; continue to cycle MSU at least one full cycle to depressurize and regenerate beds. Both beds should remain under vacuum while off line.

- Reduce steam input to 50% to Rectifier Column Reboiler.

- Run system on water.

- Start CIP sequences for Reboilers, Evaporators and/or Beer Column & Flash Tanks. Note that cleaning of the Beer Column requires a steam input.

- Stop beer flow and replace with water – run system for ~15 minutes, rinse out Beer Column and Reboilers.

- Replace thin stillage for water into the Evaporation unit. Rinse Evaporators.

- Shut off steam source to Rectifier Column Reboiler.

2.4 ANALYSIS OF OPERATIONAL PROBLEMS

Failure to Build Vacuum

Incorrect seal water to the vacuum pump (check seal loop, separator, and cooler).

Excessive backpressures on the vacuum pump - check if exhaust lines are clear.

Insufficient water to the condenser or seal loop cooler.

Check for restriction in air inlet line, including evaporator vent lines too far closed or plugged or check valve is stuck.

Air leakage to system - check for valves left open, relief valve not seated; check sight glasses, all pipe flanges and pump seals.

Check for malfunction of pressure controls including that control valve is not full open.

Failure to maintain vacuum while operating same as above, plus:

Insufficient water to main condenser.

Water to condenser not cold enough.

Fouled condenser tubes.

Failure to remove condensate from Evaporator chest

Insufficient pressure differential between effects.

Malfunctioning condensate pumps or level controls on condensate tanks.

Decrease in evaporation

Evaporator chest fouled.

Product viscosity is increased (check density control loop and syrup pump output).

Malfunctioning circulating pumps (check discharge pressures).

Buildup of condensate in evaporators. Check sight glasses on evaporator jackets.

Improper venting of evaporators - either too much or too little.

Partially plugged liquid lines.

Inadequate steam supply to 1st effect.

Water leakage into system.

Insufficient water to condenser.

NOTE: Malfunctioning instruments can give indications of all of the above and should be checked first.

See molecular sieve sequencing description for adsorber troubleshooting

3.0 CLEAN IN PLACE (CIP)

Clean-in-place (CIP) is used to clean pipes and tanks or wherever the potential for stillage to foul heat transfer surfaces may exist. Cleaning the Beer Preheater, Reboiler and Evaporator surfaces is necessary to remove stillage solids left behind. It is extremely important to regularly clean the Beer Preheater as well as the tube sides of the Reboilers and Evaporators. Cleaning of the Beer Preheaters will have to occur more frequently than the Reboilers or Evaporators.

Table 2: DD&E Areas to Realize CIP Cleaning.

AREA TO BE CLEANED	FREQUENCY	NOTES
Beer Column Reboilers	**Frequent** Boil out H_2O weekly CIP w/ NaOH 1 x / month	Controls to be switched ON-LINE CLEANING
Evaporation Area	**More frequent** Boil out H_2O weekly CIP w/ NaOH 1 x / 2 weeks	ON-LINE CLEANING
Beer Preheater	**< 2 Days - Very frequent**	OFF-LINE CLEANING
Beer Column and Flash Tanks	**Bi-annually**	Only *during* shutting-down HEAT SOURCE NEEDED

The operation of CIP system requires knowledge of several factors:

Fluid Flow Rates
Temperatures
Pressures
Dilution & Cleaning Times
Concentrations of Process Fluids
    Percent Total Solids (%TS) → halogen moisture meter
    Sodium Hydroxide Concentration (%NaOH) → acid base titration (clean fluid) or pH (unclean fluid)
Tank Inventory / Capacity
    CIP Supply Tank

CIP Waste Tank
Thin Stillage Tank
Syrup Tank
Condensate Tank

Cleaning heat transfer surfaces is necessary to remove stillage solids left by evaporation. The high pressure CIP supply is used and the spent CIP returned to the CIP return header with other spent CIP. While cleaning takes place the spent solution is collected separately from the stillage concentrate. Spray Balls are installed in each Separator, one above and one below the mist eliminator. The lower spray balls provide the majority of the cleaning solution. While cleaning takes place, the spent solution is collected separately from the stillage concentrate.

Cleaning of the Beer Column Reboilers and Evaporators takes place when the system is left on-line. The best time to clean the Beer Column and Flash Tanks is while shutting down the DD&E area; a steam is required to clean these units and they can not realize CIP operations while the DD&E area remains functional. Refer to the *CIE CIP Sequencing Description* which covers CIP operations in detail.

Table 3: CIP Sequences

SEQUENCE #	SEQUENCE NAME	SEQUENCE DESCRIPTION
1	Normal Operation / Stillage Drain	During Normal Operation prepare for CIP procedures. Pump down levels within Reboiler or Evaporator liquid reservoirs to minimum level heights.
2	Water Flush	Flush stillage or syrup from processing system (Transfer to Syrup Tank, Thin Stillage Tank, Whole Stillage Tank or Process Condensate Tank) / Rinse with water. Details on where fluid is to be transferred in available in respective section.
3	Caustic Addition	Shut off system discharge. Charge recirculation pipe wortk with anti-foam agent. Introduce caustic CIP solution to processing system - Always use fresh caustic during a DD&E CIP Procedure.
4	Caustic Recirculation & Boil-Out	Recirculate caustic CIP Solution within processing system. Make-up for evaporation losses with water when desired caustic concentration within processing system is achieved (5% NaOH).
5	Caustic Dilution	Flush caustic from processing system: Step 1) Introduce lesser flush flow rate to concentrate caustic NaOH fluid and send to CIP Drain when NaOH is less than 1%. Step 2) Increase water flush flow rate and transfer dilute fluid to alternate location (Thin Stillage Tank, Whole Stillage Tank, etc.).
6	Stillage Fill / Normal Operation	Raise levels within Reboiler or Evaporator liquid reservoirs / Return to Normal Operation

		EVAPORATION CIP OPERATION						REBOILER CIP OPERATION						EP-4113A/B		DISTILLATION SYSTEM	
STREAM NUMBER		**C1**	**C2**	**C3**	**EVAP**	**C4**	**C5**	**C6**	**C7**	**C8**	**EVAP**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**
STREAM NAME		3% NaOH	RINSE WTR	MAKE UP		TO SYRUP	CIP RETURN	3% NaOH	RINSE WTR	MAKE UP		WHOLE STLG	CIP RETURN	3% NaOH	WATER	3% NaOH	RINSE WTR
RINSE CYCLE #1 - 60 MIN.																	
	FLOW (LB/HR):	0	160,000	40,000	117,213	82,787	82,787	0	88,000	40,000	51,298	76,702	0	0	75,000	0	100,000
	TEMPERATURE (F):	N/A	150	150	-	125	125	N/A	150	150	-	125	N/A	N/A	150	N/A	150
	PRESSURE (PSIA):	N/A	41.5	46	-	36	28.0	N/A	52	46	-	28	N/A	N/A	35	N/A	52
	DURATION (MINS)	0	60	60	60	15	45	0	60	60	60	60	0	0	20	0	30
	VOLUME/CYCLE (GALLONS)	0	19,200	4,800	14,066	2,484	7,451	0	10,560	4,800	6,156	9,204	0	0	3,000	0	6,000
CAUSTIC CIP CYCLE - SUPPLY, HOLD & RECYLCE																	
	FLOW (LB/HR):	80,000	0	37,213	117,213	0	0	44,000	0	7,298	51,298	0	0	75,000	0	100,000	0
	TEMPERATURE (F):	150	N/A	150	-	N/A	N/A	150	N/A	150	-	N/A	N/A	150	N/A	150	N/A
	PRESSURE (PSIA):	46	N/A	46	-	N/A	N/A	46	N/A	46	-	N/A	N/A	46	N/A	46	N/A
	DURATION (MINS)	60	0	60	60	0	0	60	0	60	60	0	0	5	0	90	0
	VOLUME (GALLONS)	9,600	0	4,466	14,066	0	0	5,280	0	876	6,156	0	0	750	0	18,000	0
RINSE CYCLE #2 - 60 MIN.																	
	FLOW (LB/HR):	0	160,000	40,000	117,213	0	82,787	0	88,000	40,000	51,298	0	76,702	0	75,000	0	100,000
	TEMPERATURE (F):	N/A	150	150	-	N/A	125	N/A	150	150	-	N/A	125	N/A	150	N/A	150
	PRESSURE (PSIA):	N/A	41.5	46	-	N/A	28.0	N/A	52	46	-	N/A	28.0	N/A	35	N/A	52
	DURATION (MINS)	0	60	60	60	0	60	0	60	60	60	0	60	0	20	0	30
	VOLUME/CYCLE (GALLONS)	0	19,200	4,800	14,066	0	9,934	0	10,560	4,800	6,156	0	9,204	0	3,000	0	6,000

NOTES:
1) PRESSURES REPORTED AT GRADE ELEVATION.
2) TOP CIP SPRAYS OVER THE DEMISTERS ARE ONLY FOR RINSE WATER. NO CAUSTIC IS USED ON THE TOP SPRAY BALLS.
3) VOLUMES ARE APPROXIMATE AND WILL BE VERIFIED AFTER START UP.
4) CIP RETURN OF C5 DURING THE FIRST RINSE IS TO THE THIN STILLAGE TANK.
5) CIP RETURN OF C5 DURING THE SECOND RINSE IS TO CAUSTIC RECOVERY AT THE BEGINNING THEN TO THE THIN STILLAGE TANK AT THE END.
6) C9 RETURNS DILUTE WHOLE STILLAGE TO THE BEER WELL OR WHOLE STILLAGE TANK.
7) C10 RETURNS CIP SOLUTION FROM CAUSTIC RINSE TO CAUSTIC RECOVERY AT THE BEGINNING THEN TO THE WHOLE STILLAGE TANK OR BEER WELL.
8) C11: WHEN A CAUSTIC FLUSH IS NEEDED, FLOW ONLY FOR FILLING THE UNIT IS USED AND THEN IT IS ISOLATED FOR RECIRCULATION.
9) C13: WHEN CAUSTIC IS INTRODUCED FOR CLEANING THE DISTILLATION AREA, IT IS SENT THROUGH THE SPRAY BALLS IN THE TP-4112, TP-4113, TP-4105 AND ET-4105.

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PFD LEGEND

Pounds/hr FLOW RATE: Divide by 2.2046 for Kg/hr

PSIA PRESSURE: Divide by 14.223 for Kg/sqcm

Deg F TEMPERATURE: (T-32)/1.8) = deg C

mm Hg ABSOLUTE PRESSURE (mm Hg)

NOTE:
1.) ALL PRESSURE TAGS/BUBBLES REFERENCED AT GRADE

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THERMAL KINETICS
Engineering, PLLC & Systems, LLC
Evaporation/Distillation/Chemical Reaction/Process Design & Energy Conservation
667 Tifft Street Buffalo, NY 14220

PROJECT NUMBER

SIZE D

REV	REVISION	DATE ISSUED	DWN BY	CHK BY	LPSI APPD
0	-	5-10-07	TJV	JML	

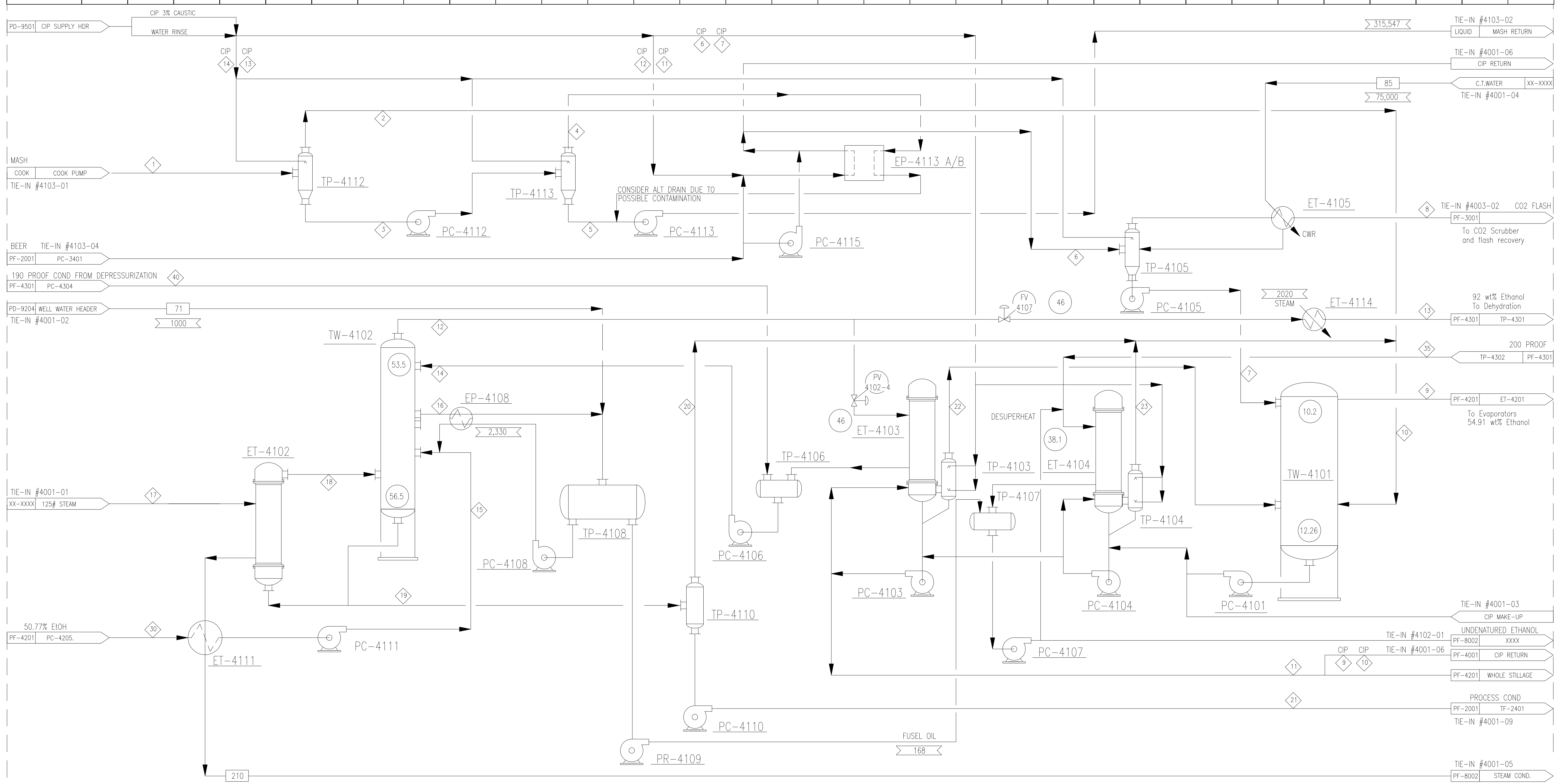
DISTILLATION, DEHYDRATION & EVAPORATION
PROCESS FLOW DIAGRAM
CIP FLOWS

Lurgi
Lurgi PSI, Inc.
A Lurgi AG Company

CAD Ref. No. 73338-PF-4001-01-0
DRAWN BY: TJV DATE: 2-23-07
CHECKED BY: — DATE: —
SCALE: NONE SHT. NO. 1 of 1
DRAWING NO.: 6018-PF-4001 REV. 0

D-SIZE (24x36)

STREAM NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
STREAM NAME	MASH	COOK FLASH	MASH 2	COOK FLSH 2	MASH RETURN	BEER	BC FEED	CO2 FLASH	BC OVHD	BC BOT VAP	BC BTMS	RC OVHD	MSU FEED	RC REFLUX	RC FEED	FUSEL OIL	STEAM	RC BOT VAP	RC BTMS	RC BTM FLSH	PROC COND	PROC VAP 1	PROC VAP 2
FLOW (LB/HR):	310,959	5,884	305,075	4,703	300,372	278,590	277,885	705	56,257	39,916	229,877	107,877	42,423	72,828	61,992	840	49,225	46,996	26,944	2,365	24,579	25,890	11,661
TEMPERATURE (F):	225	203	203	185	185	173.01	169.0	100	176.8	203	203	240	330	240	236.2	248	344	288.7	288.7	203	203	203	203
PRESSURE (PSIA):	18.91	12.26	12.26	8.39	8.39		10.2	14.8	10.17	12.26	42	53.45	45.6	53.45	55	54	125	56.45	56.45	12.26	109	12.26	12.26
TOTAL SOLIDS (LB/HR):	84,892	-	84,892	-	84,892	33,319	33,319	-	-	-	33,322	-		-	-		-	-					
ETHANOL (LB/HR):						29,252	29,252		29,206	6	46	98,168	38,605	66,273	31,523	403	0	14	6	6	0	0	0
CO_2 (LB/HR):						970		970															
WATER (LB/HR):	226,067	5,884	220,183	4,703	215,480	215,049	215,314		27,051	39,910	196,509	9,709	3,818	6,555	30,469	269	49,225	46,982	26,938	2,359	24,579	25,890	11,661
OTHER COMPONENTS:																FUSEL OILS							
(LB/HR):																168							
DENSITY (LB/CUFT):	70.89	0.031	71.07	0.02	71.20	61.76	61.85	0.748	0.048	0.031	66.89	0.310	0.234	44.17	49.02	53.91	0.279	0.131	57.63	0.031	60.05	0.031	0.031
HEAT CAP (BTU/LB F):	0.82	-	0.80	-	0.78	0.89	0.90	-	-	-	0.90	0.18	-	0.85	0.92	0.71	-	-	1.03	-	1.01	-	-
VISCOSITY (CPS):	15	-	25	-	35	3	3	-	-	-	4	-	-	0.26	0.23		-	-	0.19	-	0.30	-	-



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PFD LEGEND

Pounds/hr FLOW RATE: Divide by 2.2046 for Kg/hr	PSIA PRESSURE: Divide by 14.223 for Kg/sqcm
Deg F TEMPERATURE: (T-32)/1.8) = deg C	mm Hg ABSOLUTE PRESSURE (mm Hg)

NOTE:
1.) ALL PRESSURE TAGS/BUBBLES REFERENCED AT GRADE

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THERMAL KINETICS
Engineering, PLLC & Systems, LLC
Evaporation/Distillation/Chemical Reaction/Process Design & Energy Conservation
667 Tifft Street Buffalo, NY 14220

PROJECT NUMBER
SIZE D

REV	REVISION	DATE ISSUED	DWN BY	CHK BY	LPSI APPD
0	ISSUED FOR DESIGN	5-10-07	TJV	JML	

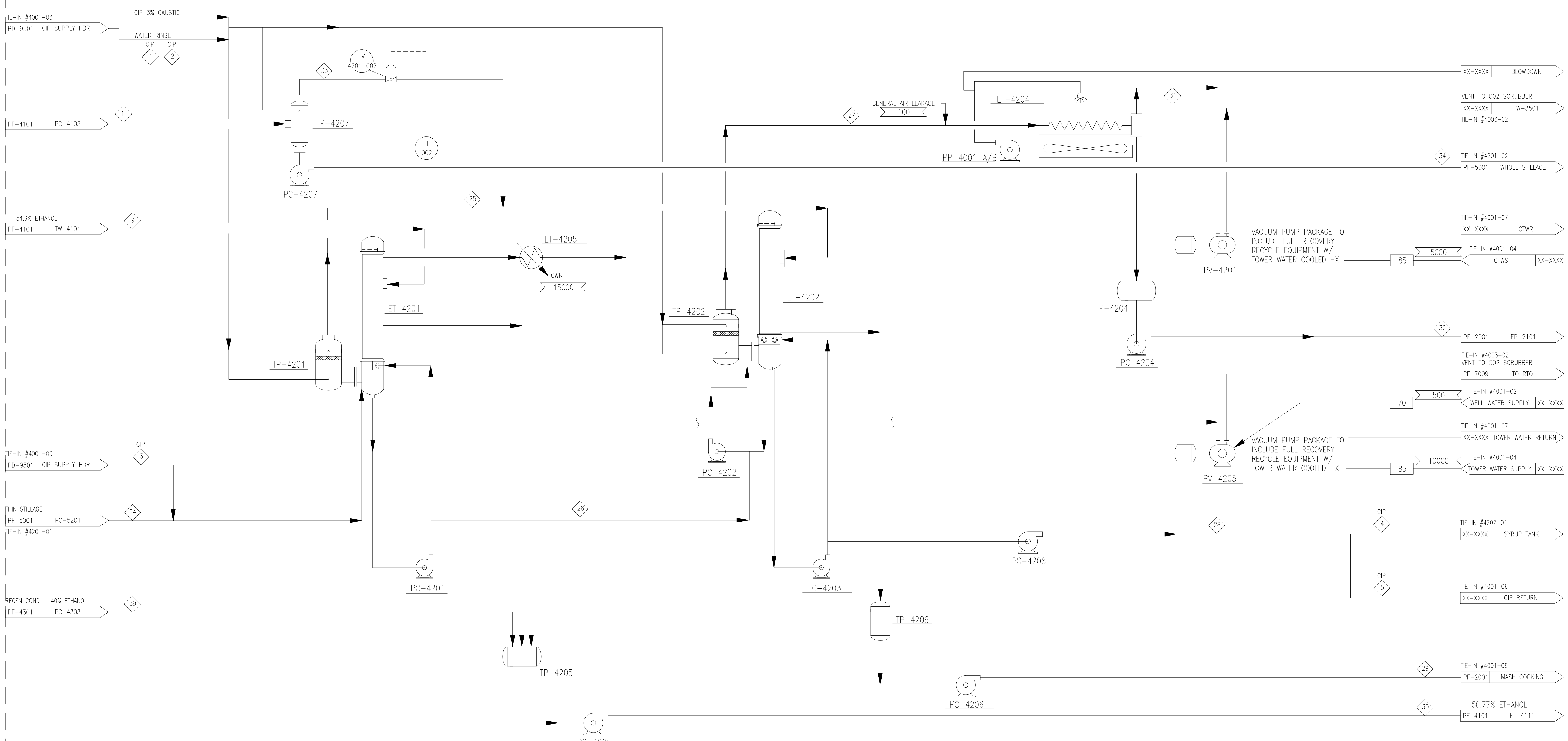
DISTILLATION, DEHYDRATION & EVAPORATION
PROCESS FLOW DIAGRAM
DISTILLATION

Lurgi
Lurgi PSI, Inc.
A Lurgi AG Company

CAD Ref. No. 73338-PF-4101-01-0
DRAWN BY: KAR DATE: 5-15-06
CHECKED BY: — DATE: —
SCALE: NONE SHT. NO: 1 of 1
DRAWING NO.: 6018-PF-4101 REV. 0

D-SIZE (24x36)

STREAM NUMBER	24	25	26	27	28	29	30	31	32	33	34
STREAM NAME	THIN STILL	1ST EFF VAP	1ST EFF LIQ	2ND EFF VAP	SYRUP	PROC COND1	RC FEED	VENT	PROC COND2	WHOLE FLASH	WHOLE STILL
FLOW (LB/HR):	112,445	40,967	71,478	45,642	25,836	44,664	61,992	219	45,642	3,697	226,180
TEMPERATURE (F):	184.5	147	151	122	122.0	151	157	110.0	120.0	185.0	185.0
PRESSURE (PSIA):	22.15	3.45	33.70	2.05	53.2	61.7	65.6	1.9	62.8	8.39	46.1
TOTAL SOLIDS %W/W:	8.0%	-	12.6%	-	35.0%	-	-	-	-	-	-
DENSITY (LB/CUFT):	63.65	0.010	66.45	0.005	71.76	61.20	52.30	0.009	61.71	0.022	66.90
HEAT CAP (BTU/LB F):	0.95	-	0.93	-	0.91	1.00	0.85	-	1.00	-	0.90
VISCOSITY (CPS):	3.3	-	4.5	-	102	0.44	0.48	-	0.6	-	3.5



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PFD LEGEND

Pounds/hr FLOW RATE: Divide by 2.2046 for Kg/hr

PSIA PRESSURE: Divide by 14.223 for Kg/sqcm

Deg F TEMPERATURE: (T-32)/1.8 = deg C

mm Hg ABSOLUTE PRESSURE (mm Hg)

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Engineering, PLLC & Systems, LLC
Evaporation/Distillation/Chemical Reaction/Process Design & Energy Conservation
667 Tifft Street Buffalo, NY 14220

SIZE D

REV	REVISION	DATE ISSUED	DWN BY	CHK BY	LPSI APPD
0	ISSUED FOR DESIGN	5-10-07	TJV	JML	

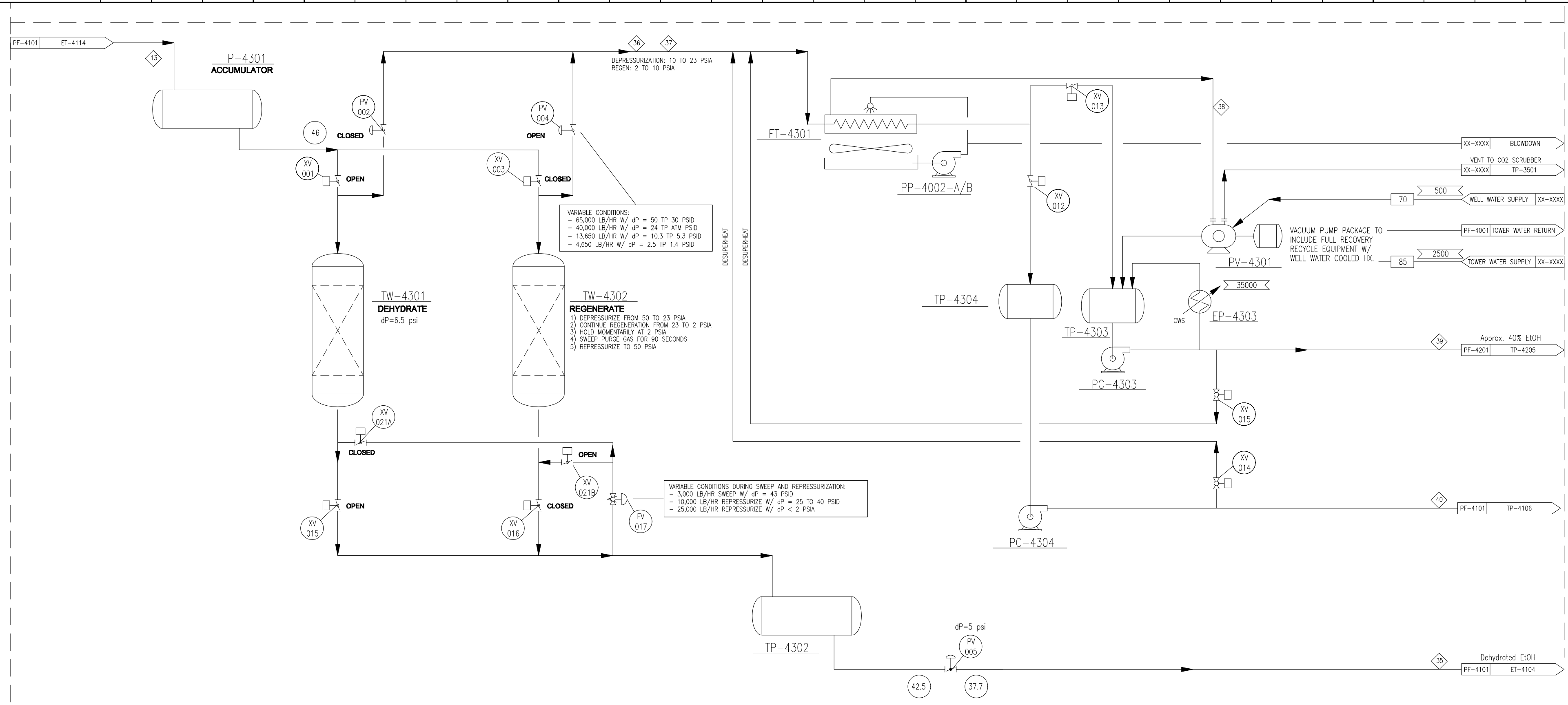
DISTILLATION, DEHYDRATION & EVAPORATION
PROCESS FLOW DIAGRAM
EVAPORATION

Lurgi
Lurgi PSI, Inc.
A Lurgi AG Company

CAD Ref. No. 73338-PF-4201-01-0
DRAWN BY: KAR DATE: 5-15-06
CHECKED BY: – DATE: –
SCALE: NONE SHT. NO: 1 of 1
DRAWING NO.: 6018-PF-4201 REV: 0

D-SIZE (24x36)

STREAM NUMBER	35	36	37	38	39	40
STREAM NAME	200 PR VAP	DEPRESS	MSU REGEN	VENT	REGEN COND	DEPRS COND
FLOW (LB/HR):	29,314	7,374	5,735	36	5,735	7,374
TEMPERATURE (F):	240	290	229	110	100	150
PRESSURE (PSIA):	37.7	23	1.93	1.9	27	62
DENSITY (LB/CUFT):	0.230	0.125	0.008	0.012	58.03	46.29
HEAT CAP (BTU/LB F):	-	-	-			
VISCOSITY (CPS):	-	-	-			
ETHANOL W/W:	99.5%	91.0%	39.8%	58%	40.4%	91.0%
COMMENTS:		AVG. FLOW	AVG. FLOW			



CONFIDENTIAL

PFD LEGEND

Pounds/hr — FLOW RATE: Divide by 2.2046 for Kg/hr

PSIA — PRESSURE: Divide by 14.223 for Kg/sqcm

Deg F — TEMPERATURE: (T-32)/1.8) = deg C

mm Hg — ABSOLUTE PRESSURE (mm Hg)

NOTE:
1.) ALL PRESSURE TAGS/BUBBLES REFERENCED AT GRADE

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Evaporation/Distillation/Chemical Reaction/Process Design & Energy Conservation
667 Tifft Street Buffalo, NY 14220

SIZE D

REV	REVISION	DATE ISSUED	DWN BY	CHK BY	LPSI APPD
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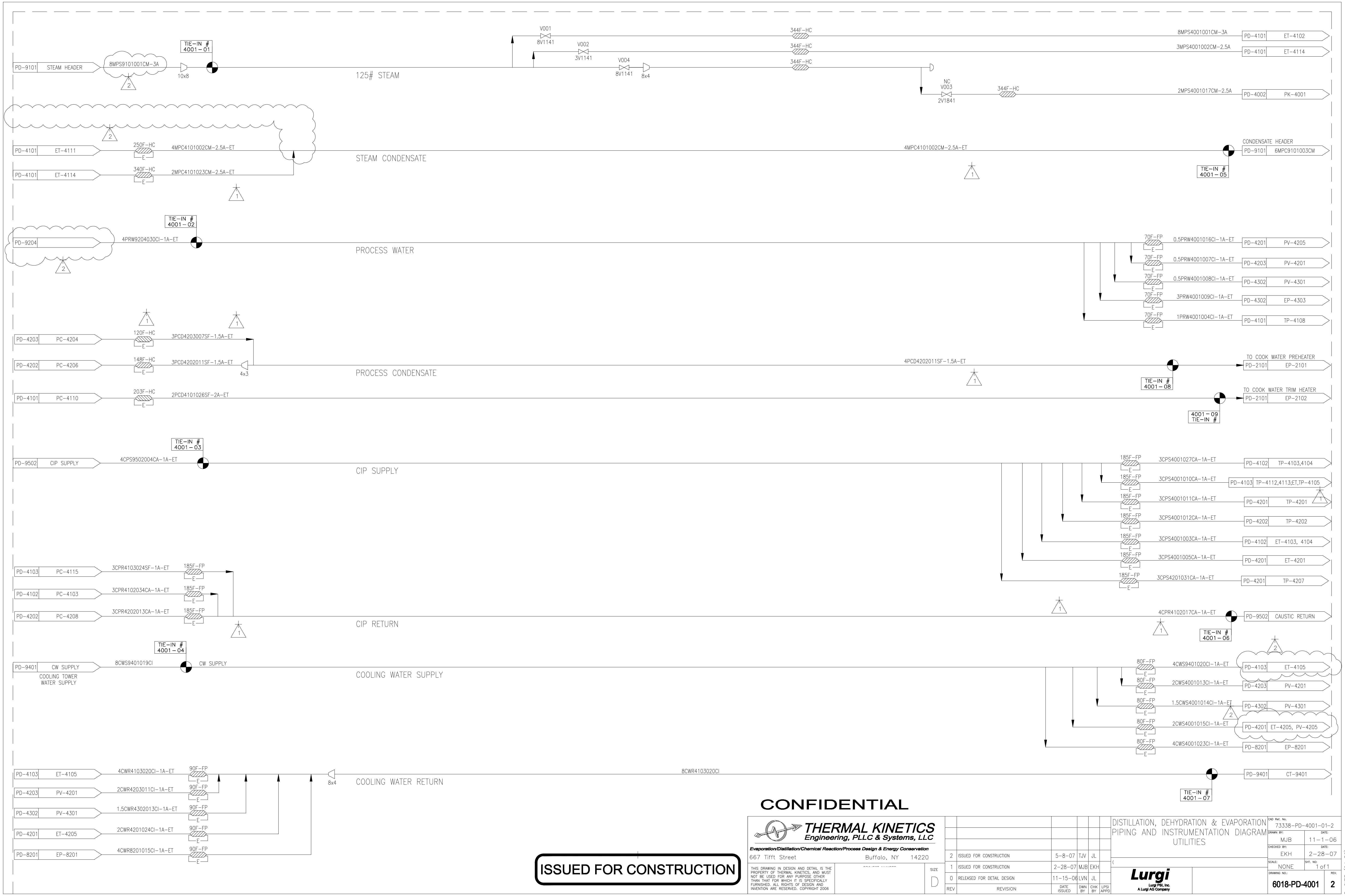
DISTILLATION, DEHYDRATION & EVAPORATION
PROCESS FLOW DIAGRAM
TWO BED DEHYDRATION

Lurgi — Lurgi PSI, Inc. A Lurgi AG Company

CAD Ref. No. 73338-PF-4301-01-0
DRAWN BY: KAR DATE: 5-15-06
CHECKED BY: – DATE: –
SCALE: NONE SHT. NO: 1 of 1
DRAWING NO.: 6018-PF-4301 REV. 0

D-SIZE (24x36)



PD-9101 STEAM HEADER
8MPS9101001CM-3A
TIE-IN # 4001-01
10x8
125# STEAM
V001 8V1141
V002 3V1141
V004 8V1141
8x4
344F-HC
8MPS4001001CM-3A PD-4101 ET-4102
3MPS4001002CM-2.5A PD-4101 ET-4114
NC V003 2V1841
2MPS4001017CM-2.5A PD-4002 PK-4001
PD-4101 ET-4111 250F-HC 4MPC4101002CM-2.5A-ET
PD-4101 ET-4114 340F-HC 2MPC4101023CM-2.5A-ET
STEAM CONDENSATE
4MPC4101002CM-2.5A-ET
CONDENSATE HEADER PD-9101 6MPC9101003CM
TIE-IN # 4001-05
PD-9204 4PRW9204030CI-1A-ET
TIE-IN # 4001-02
PROCESS WATER
70F-FP 0.5PRW4001016CI-1A-ET PD-4201 PV-4205
70F-FP 0.5PRW4001007CI-1A-ET PD-4203 PV-4201
70F-FP 0.5PRW4001008CI-1A-ET PD-4302 PV-4301
70F-FP 3PRW4001009CI-1A-ET PD-4302 EP-4303
70F-FP 1PRW4001004CI-1A-ET PD-4101 TP-4108
PD-4203 PC-4204 120F-HC 3PCD4203007SF-1.5A-ET
PD-4202 PC-4206 148F-HC 3PCD4202011SF-1.5A-ET 4x3
PROCESS CONDENSATE
4PCD4202011SF-1.5A-ET
TO COOK WATER PREHEATER PD-2101 EP-2101
TIE-IN # 4001-08
PD-4101 PC-4110 203F-HC 2PCD4101026SF-2A-ET
TO COOK WATER TRIM HEATER PD-2101 EP-2102
4001-09 TIE-IN #
PD-9502 CIP SUPPLY 4CPS9502004CA-1A-ET
TIE-IN # 4001-03
CIP SUPPLY
185F-FP 3CPS4001027CA-1A-ET PD-4102 TP-4103,4104
185F-FP 3CPS4001010CA-1A-ET PD-4103 TP-4112,4113;ET,TP-4105
185F-FP 3CPS4001011CA-1A-ET PD-4201 TP-4201
185F-FP 3CPS4001012CA-1A-ET PD-4202 TP-4202
185F-FP 3CPS4001003CA-1A-ET PD-4102 ET-4103, 4104
185F-FP 3CPS4001005CA-1A-ET PD-4201 ET-4201
185F-FP 3CPS4201031CA-1A-ET PD-4201 TP-4207
PD-4103 PC-4115 3CPR4103024SF-1A-ET 185F-FP
PD-4102 PC-4103 3CPR4102034CA-1A-ET 185F-FP
PD-4202 PC-4208 3CPR4202013CA-1A-ET 185F-FP
CIP RETURN
4CPR4102017CA-1A-ET PD-9502 CAUSTIC RETURN
TIE-IN # 4001-06
PD-9401 CW SUPPLY
COOLING TOWER WATER SUPPLY
8CWS9401019CI
TIE-IN # 4001-04
CW SUPPLY
COOLING WATER SUPPLY
80F-FP 4CWS9401020CI-1A-ET PD-4103 ET-4105
80F-FP 2CWS4001013CI-1A-ET PD-4203 PV-4201
80F-FP 1.5CWS4001014CI-1A-ET PD-4302 PV-4301
80F-FP 2CWS4001015CI-1A-ET PD-4201 ET-4205, PV-4205
80F-FP 4CWS4001023CI-1A-ET PD-8201 EP-8201
PD-4103 ET-4105 4CWR4103020CI-1A-ET 90F-FP
PD-4203 PV-4201 2CWR4203011CI-1A-ET 90F-FP
PD-4302 PV-4301 1.5CWR4302013CI-1A-ET 90F-FP
PD-4201 ET-4205 2CWR4201024CI-1A-ET 90F-FP
PD-8201 EP-8201 4CWR8201015CI-1A-ET 90F-FP
8x4
COOLING WATER RETURN
8CWR4103020CI
PD-9401 CT-9401
TIE-IN # 4001-07
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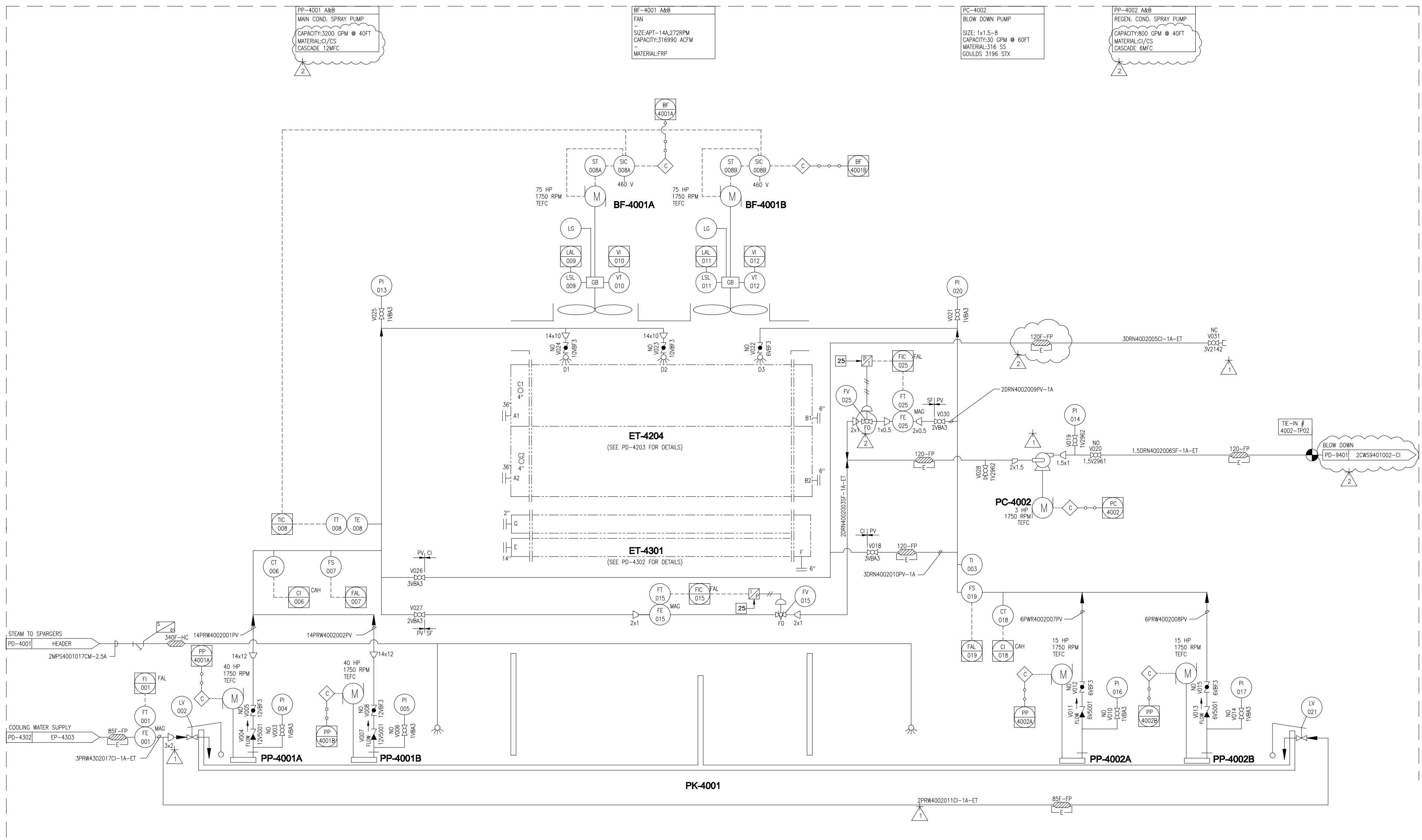
2 ISSUED FOR CONSTRUCTION 5-8-07 TJV JL
1 ISSUED FOR CONSTRUCTION 2-28-07 MJB EKH
0 RELEASED FOR DETAIL DESIGN 11-15-06 LVN JL
REV REVISION DATE ISSUED DWN BY CHK BY LPSI APPD
DISTILLATION, DEHYDRATION & EVAPORATION
PIPING AND INSTRUMENTATION DIAGRAM
UTILITIES
Lurgi
Lurgi PSI, Inc.
A Lurgi AG Company
73338-PD-4001-01-2
DRAWN BY MJB DATE 11-1-06
CHECKED BY EKH DATE 2-28-07
SCALE NONE SHT. NO. 1 of 1
DRAWING NO. 6018-PD-4001 REV 2
D-SIZE (24x36)



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1	ISSUED FOR CONSTRUCTION	2-28-07	MJB	EKH	
0	RELEASE FOR DETAIL DESIGN	11-15-06	LVN	JL	

DISTILLATION, DEHYDRATION, EVAPORATION
PIPING & INSTRUMENTATION DIAGRAM
EVAPORATION & REGEN
CONDENSER

Lurgi
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CAD Ref. No. 73338-PD-4002-01-2
DRAWN BY: MJB DATE: 11-1-06
CHECKED BY: EKH DATE: 2-28-07
SCALE: NONE SHT. NO: 1 of 1
DRAWING NO.: 6018-PD-4002 REV. 2

D-SIZE (24x36)

NOTE: UTILITY STATIONS, SAFTY SHOWERS, ETC. OUTSIDE TK SCOPE. LURGI TO ADDRESS.

2

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REV	REVISION	DATE ISSUED	DWN BY	CHK BY	LPSI APPD
2	ISSUED FOR CONSTRUCTION	5-8-07	TJV	JL	
1	ISSUED FOR CONSTRUCTION	2-28-07	MJB	EKH	
0	RELEASED FOR DETAIL DESIGN	11-15-06	LVN	JL	

DISTILLATION, DEHYDRATION & EVAPORATION
PIPING AND INSTRUMENTATION DIAGRAM
UTILITY DISTRIBUTION

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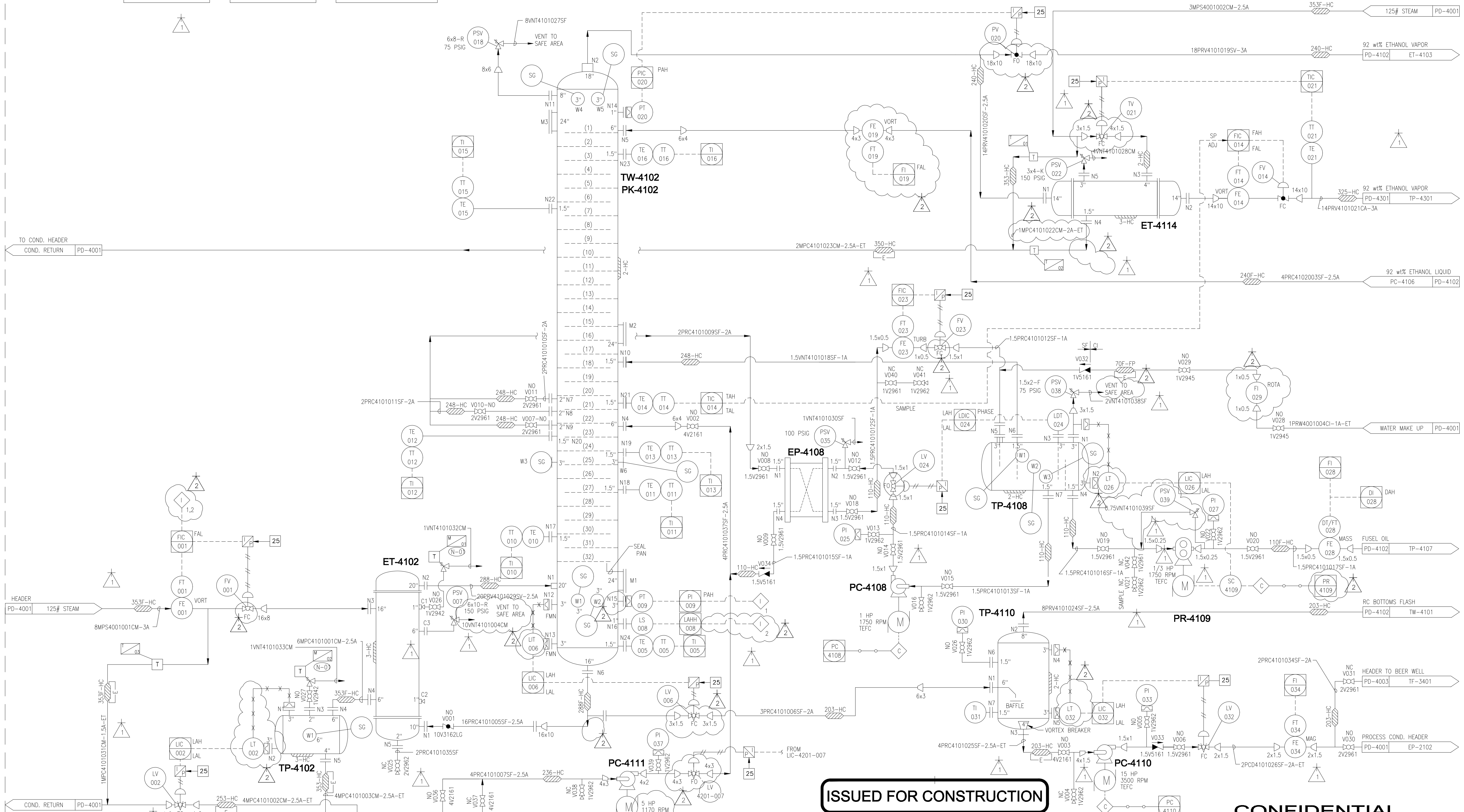
CAD Ref. No. 73338-PD-4003-01-2
DRAWN BY: MJB DATE: 11-1-06
CHECKED BY: EKH DATE: 2-28-07
SCALE: NONE SHT. NO: 1 of 1
DRAWING NO.: 6018-PD-4003 REV. 2

D-SIZE (24x36)

ET-4111	PC-4111	TP-4102	ET-4102	TW-4102	EP-4108	PC-4108	PK-4102	TP-4108	TP-4110	PC-4110	PR-4109	ET-4114
FEED PREHEATER SIZE:1'-2"ø x 10'-0" CAPACITY:4.5MM BTU/HR TS:100 PSIG @ 400°F 304L SS SS:150 PSIG @ 400°F CS	RC FEED PUMP SIZE: 2x3-13 CAPACITY:150 GPM@ 50FT MATERIAL: 316 SS GOULDS 3196 MTX	STEAM COND. RECEIVER SIZE: 2'-2"ø x4'-0" CAPACITY:130 GAL MATERIAL: C/S 150 PSIG @ 360°F	RC REBOILER 3'-6"ø x 12'-0" SIZE:2601 FT 2 CAPACITY:44.9MM BTU/HR SS:150 @ 360°F - C/S TS:75/FV @ 300°F - 304L SS	RECTIFIER COLUMN 32 SS TRAYS SIZE:6'-6"ø x 80'-6" MATERIAL:304L SS 75/FV @ 400°F	FUSEL OIL EXCHANGER SIZE:3.7 FT-2"x10"x22" CAPACITY:75463 BTU/HR MATERIAL:304L SS 100 PSIG @ 250° F	PUMP - DECANTER RETURN SIZE:1x1.5-8 CAPACITY:5 GPM @ 50 FT MATERIAL:316 SS GOULDS 3196LF MTX	RC INTERNALS MVG TRAYS w/ PUSH-VALVES SIZE:84"x32 TRAYS CAPACITY:257,601 #/HR VAP. MATERIAL:14 Ga. 304L SS 32TRAYS 24"SPACING	FUSEL OIL DECANTER SIZE: 5'øx7'-0" SS CAPACITY:1000 GALLONS MATERIAL:304L SS INTERNAL BAFFLES 75 PSIG/FV @ 300°F	RC BOTTOMS FLASH TANK SIZE:2'-0"ø x 5'-0" MATERIAL:304L SS CAPACITY:180 GALLONS 75/FV @ 300°F	RC BOTTOMS FLASH TANK PUMP SIZE:1x1.5-8 CAPACITY:55 GPM @ 230 FT MATERIAL:316 SS GOULDS 3196 MTX	FUSEL OIL PUMP SIZE:0.5x0.5 CAPACITY:1 GPM @ 40 FT MATERIAL:316 SS	SUPERHEATER 190 PROOF TO MSU SIZE:1189 FT 2-0"ø x 14' CAPACITY:1.8MM BTU/HR SS:150 PSIG @ 360°F-CS TS:75 PSIG @ 350°F-304L SS



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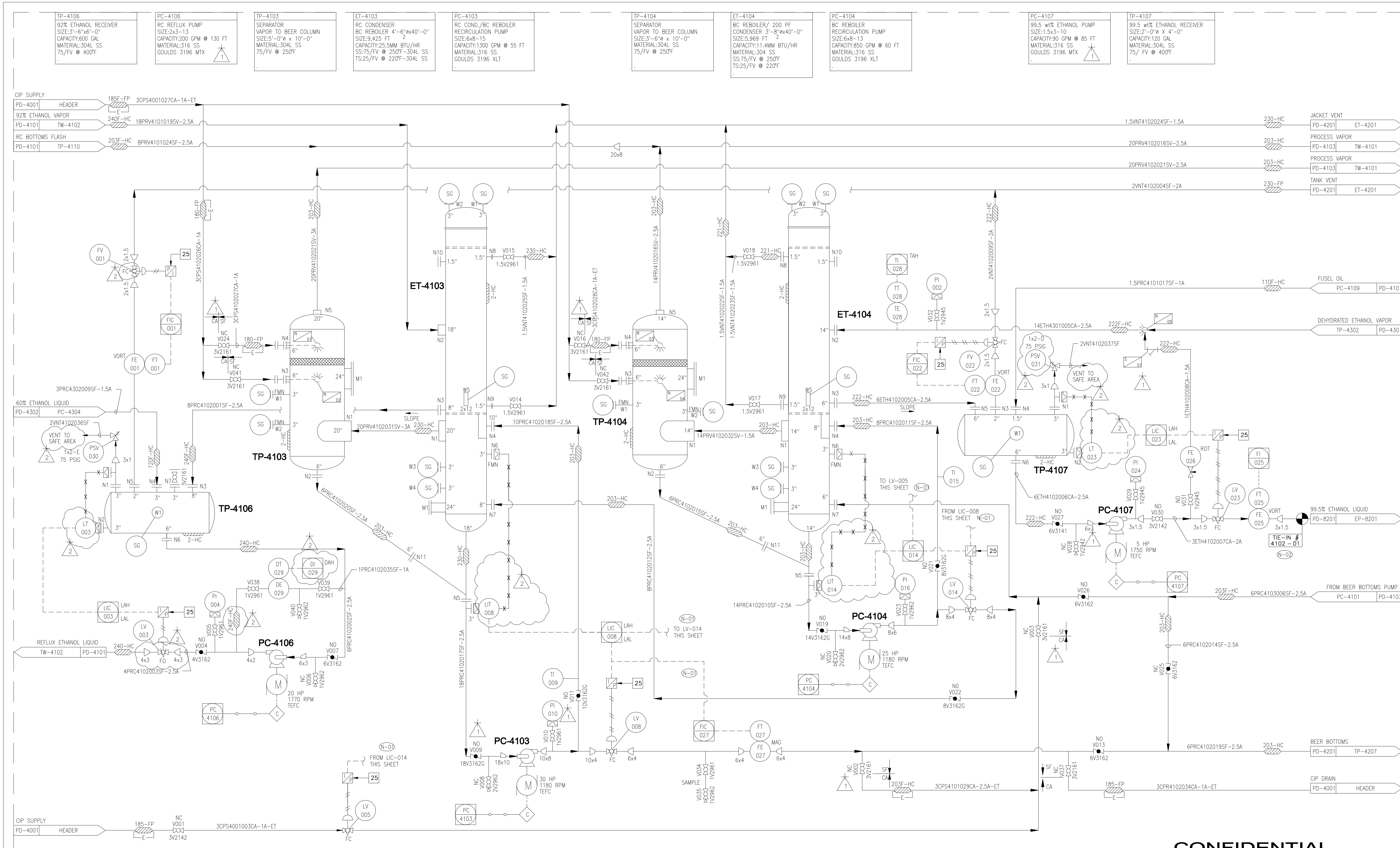
0	RELEASED FOR DETAIL DESIGN	11-15-06	LVN	JL	

DISTILLATION, DEHYDRATION & EVAPORATION
PIPING AND INSTRUMENTATION DIAGRAM
DISTILLATION
RECTIFIER COLUMN

Lurgi
Lurgi PSI, Inc.
A Lurgi AG Company

CAD Ref. No. 73338-PD-4101-01-2
DRAWN BY: MJB DATE: 11-1-06
CHECKED BY: EKH DATE: 2-28-07
SCALE: NONE SHT. NO. 1 of 1
DRAWING NO.: 6018-PD-4101 REV: 2

D-SIZE (24x36)



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NOTE:
1. ALTERNATE CONTROL SCHEME DURING CIP ONLY.
2. TIE-POINT IS DOWNSTREAM OF EP-8201 WHICH IS IN DD&E AREA.

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0	RELEASED FOR DETAIL DESIGN	11-15-06	LVN	JL	

DISTILLATION, DEHYDRATION & EVAPORATION
PIPING AND INSTRUMENTATION DIAGRAM
DISTILLATION
BEER COLUMN REBOILER

Lurgi
Lurgi PSI, Inc.
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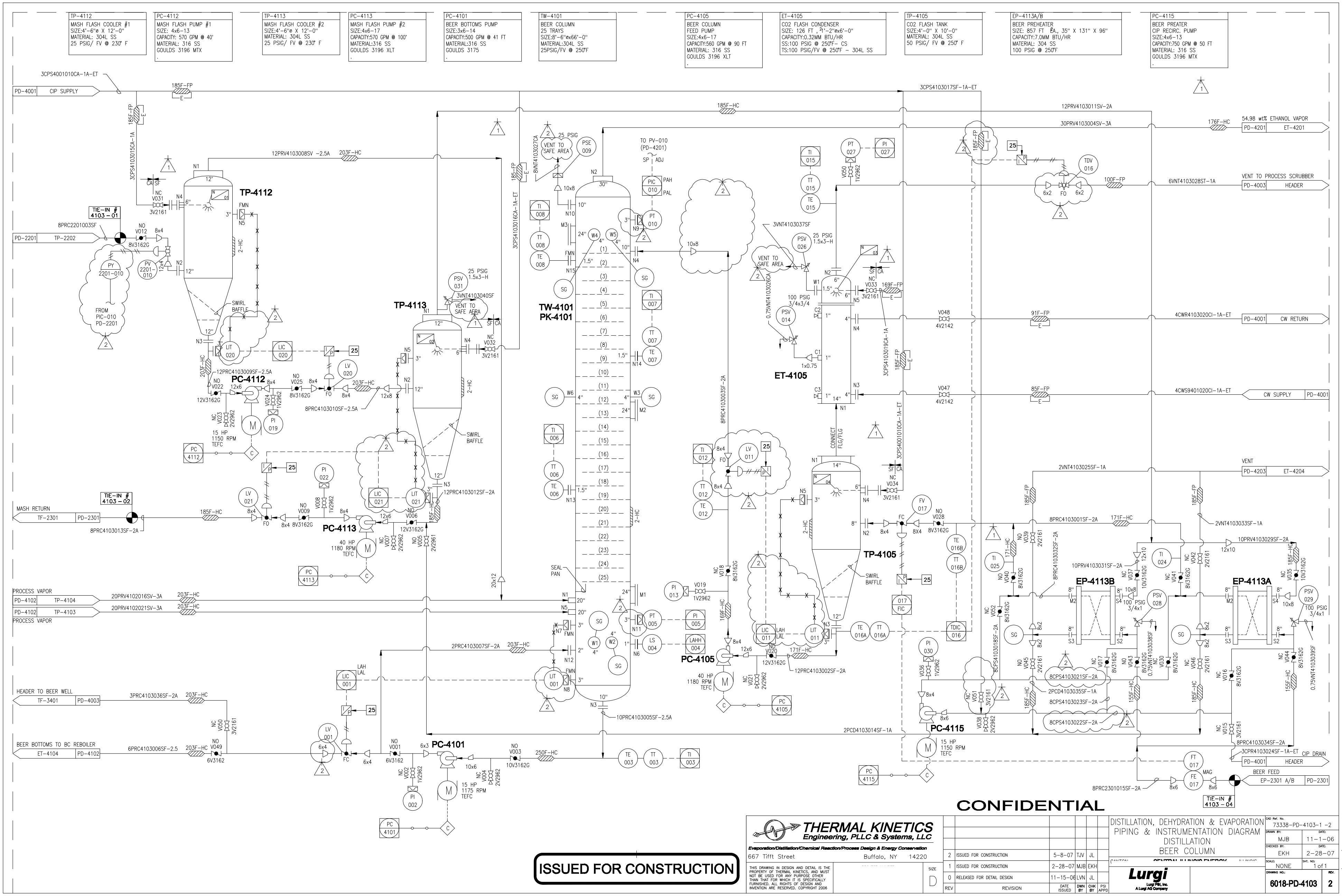
CAD Ref. No. 73338-PD-4102-1-2
DRAWN BY: MJB DATE: 11-1-06
CHECKED BY: EKH DATE: 2-28-07
SCALE: NONE SHT. NO. 1 of 1
DRAWING NO.: 6018-PD-4102 REV: 2

D-SIZE (24x36)



TP-4112 MASH FLASH COOLER #1 SIZE:4'-6"ø X 12'-0" MATERIAL: 304L SS 25 PSIG/ FV @ 230°F
PC-4112 MASH FLASH PUMP #1 SIZE: 4x6-13 CAPACITY: 570 GPM @ 40' MATERIAL: 316 SS GOULDS 3196 MTX
TP-4113 MASH FLASH COOLER #2 SIZE:4'-6"ø X 12'-0" MATERIAL: 304L SS 25 PSIG/ FV @ 230°F
PC-4113 MASH FLASH PUMP #2 SIZE:4x6-17 CAPACITY:570 GPM @ 100' MATERIAL:316 SS GOULDS 3196 XLT
PC-4101 BEER BOTTOMS PUMP SIZE:3x6-14 CAPACITY:500 GPM @ 41 FT MATERIAL:316 SS GOULDS 3175
TW-4101 BEER COLUMN 25 TRAYS SIZE:8'-6"øx66'-0" MATERIAL:304L SS 25PSIG/FV @ 250°F
PC-4105 BEER COLUMN FEED PUMP SIZE:4x6-17 CAPACITY:560 GPM @ 90 FT MATERIAL: 316 SS GOULDS 3196 XLT
ET-4105 CO2 FLASH CONDENSER SIZE: 126 FT², 1'-2"øx6'-0" CAPACITY:0.32MM BTU/HR SS:100 PSIG @ 250°F- CS TS:100 PSIG/FV @ 250°F - 304L SS
TP-4105 CO2 FLASH TANK SIZE:4'-0" X 10'-0" MATERIAL: 304L SS 50 PSIG/ FV @ 250°F
EP-4113A/B BEER PREHEATER SIZE: 857 FT² EA., 35" X 131" X 96" CAPACITY:7.0MM BTU/HR MATERIAL: 304 SS 100 PSIG @ 250°F
PC-4115 BEER PREATER CIP RECIRC. PUMP SIZE:4x6-13 CAPACITY:750 GPM @ 50 FT MATERIAL: 316 SS GOULDS 3196 MTX
PD-4001 CIP SUPPLY
PD-2201 TP-2202
TIE-IN # 4103-01
TIE-IN # 4103-02
TIE-IN # 4103-04
MASH RETURN TF-2301 PD-2301
PROCESS VAPOR PD-4102 TP-4104
PD-4102 TP-4103 PROCESS VAPOR
HEADER TO BEER WELL TF-3401 PD-4003
BEER BOTTOMS TO BC REBOILER ET-4104 PD-4102
54.98 wt% ETHANOL VAPOR PD-4201 ET-4201
VENT TO PROCESS SCRUBBER PD-4003 HEADER
PD-4001 CW RETURN
CW SUPPLY PD-4001
VENT PD-4203 ET-4204
CIP DRAIN PD-4001 HEADER
BEER FEED EP-2301 A/B PD-2301
TP-4112
PC-4112
TP-4113
PC-4113
TW-4101 PK-4101
PC-4101
ET-4105
TP-4105
PC-4105
PC-4115
EP-4113B
EP-4113A
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0 RELEASED FOR DETAIL DESIGN 11-15-06 LVN JL
REV REVISION DATE ISSUED DWN BY CHK BY PSI APPD
DISTILLATION, DEHYDRATION & EVAPORATION PIPING & INSTRUMENTATION DIAGRAM DISTILLATION BEER COLUMN
73338-PD-4103-1 -2
MJB 11-1-06
EKH 2-28-07
NONE 1 of 1
Lurgi
6018-PD-4103 2
D-SIZE (24x36)
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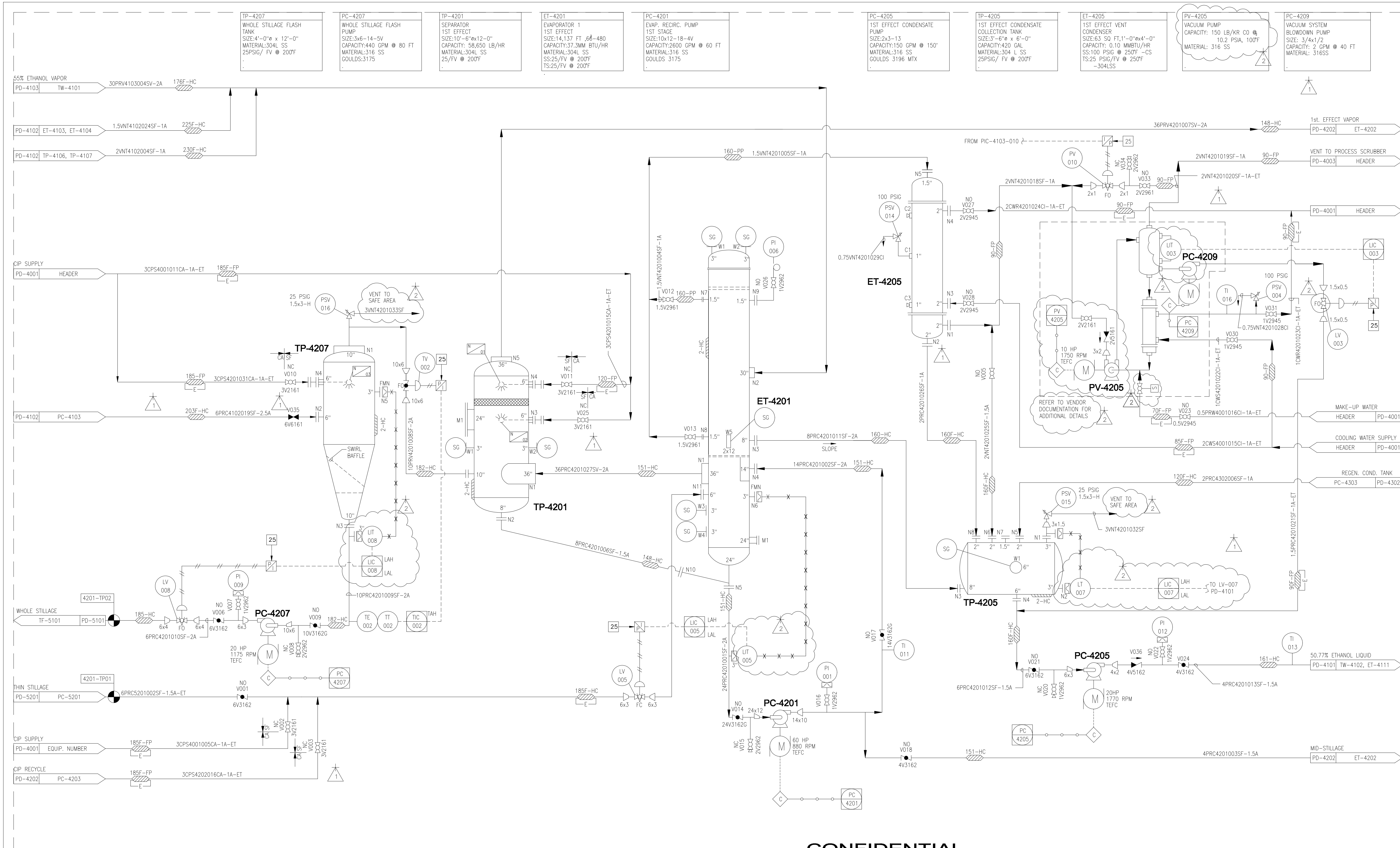

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DISTILLATION, DEHYDRATION, EVAPORATION
PIPING & INSTRUMENTATION DIAGRAM
EVAPORATOR
1st EFFECT

Lurgi
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A Lurgi AG Company

CAD Ref. No. 73338-PD-4201-01-2
DRAWN BY: MJB DATE: 11-1-06
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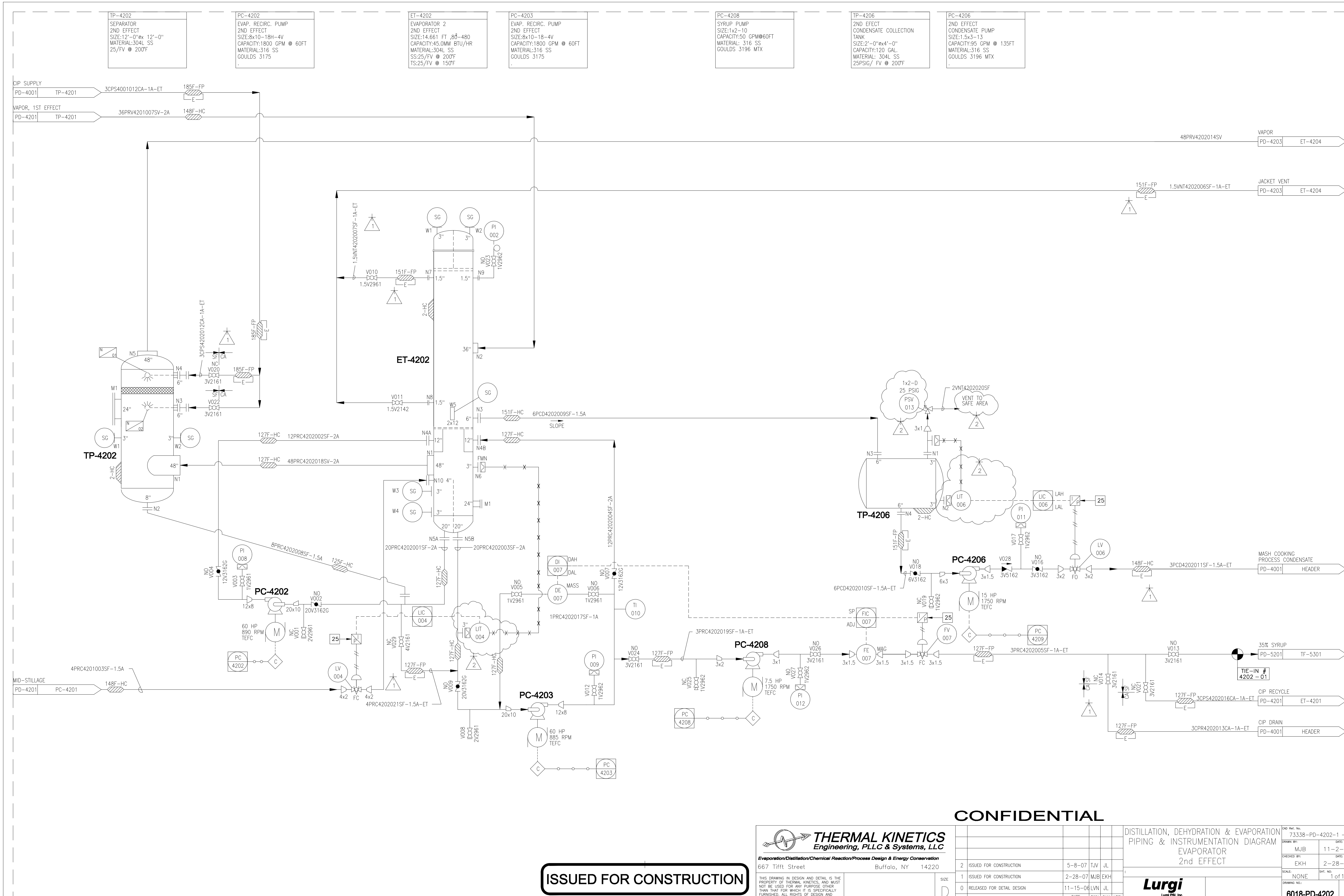
SCALE: NONE SHT. NO. 1 of 1
DRAWING NO.: 6018-PD-4201 REV: 2

D-SIZE (24x36)


TP-4202
SEPARATOR
2ND EFFECT
SIZE:12'-0"ø x 12'-0"
MATERIAL:304L SS
25/FV @ 200°F
PC-4202
EVAP. RECIRC. PUMP
2ND EFFECT
SIZE:8x10-18H-4V
CAPACITY:1800 GPM @ 60FT
MATERIAL:316 SS
GOULDS 3175
ET-4202
EVAPORATOR 2
2ND EFFECT
SIZE:14.661 FT, 80-480
CAPACITY:45.0MM BTU/HR
MATERIAL:304L SS
SS:25/FV @ 200°F
TS:25/FV @ 150°F
PC-4203
EVAP. RECIRC. PUMP
2ND EFFECT
SIZE:8x10-18-4V
CAPACITY:1800 GPM @ 60FT
MATERIAL:316 SS
GOULDS 3175
PC-4208
SYRUP PUMP
SIZE:1x2-10
CAPACITY:50 GPM@60FT
MATERIAL: 316 SS
GOULDS 3196 MTX
TP-4206
2ND EFFECT
CONDENSATE COLLECTION
TANK
SIZE:2'-0"ø x 4'-0"
CAPACITY:120 GAL.
MATERIAL: 304L SS
25PSIG/ FV @ 200°F
PC-4206
2ND EFFECT
CONDENSATE PUMP
SIZE:1.5x3-13
CAPACITY:95 GPM @ 135FT
MATERIAL:316 SS
GOULDS 3196 MTX
CIP SUPPLY
PD-4001 TP-4201
3CPS4001012CA-1A-ET
VAPOR, 1ST EFFECT
PD-4201 TP-4201
36PRV4201007SV-2A
48PRV4202014SV
VAPOR
PD-4203 ET-4204
1.5VNT4202006SF-1A-ET
JACKET VENT
PD-4203 ET-4204
ET-4202
TP-4202
TP-4206
PC-4202
PC-4203
PC-4208
PC-4206
6PCD4202009SF-1.5A
SLOPE
12PRC4202002SF-2A
48PRC4202018SV-2A
8PRC4202008SF-1.5A
20PRC4202001SF-2A
20PRC4202003SF-2A
12PRC4202004SF-2A
1PRC4202017SF-1A
4PRC4202021SF-1.5A-ET
3PRC4202019SF-1A-ET
3PRC4202005SF-1A-ET
4PRC4201003SF-1.5A
MID-STILLAGE
PD-4201 PC-4201
2VNT4202020SF
VENT TO SAFE AREA
1x2-D
25 PSIG
6PCD4202010SF-1.5A-ET
3PCD4202011SF-1.5A-ET
MASH COOKING PROCESS CONDENSATE
PD-4001 HEADER
35% SYRUP
PD-5201 TF-5301
TIE-IN # 4202-01
3CPS4202016CA-1A-ET
CIP RECYCLE
PD-4201 ET-4201
3CPR4202013CA-1A-ET
CIP DRAIN
PD-4001 HEADER
60 HP
890 RPM
TEFC
60 HP
885 RPM
TEFC
7.5 HP
1750 RPM
TEFC
15 HP
1750 RPM
TEFC
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DISTILLATION, DEHYDRATION & EVAPORATION
PIPING & INSTRUMENTATION DIAGRAM
EVAPORATOR
2nd EFFECT
Lurgi
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A Lurgi AG Company
CAD Ref. No. 73338-PD-4202-1-2
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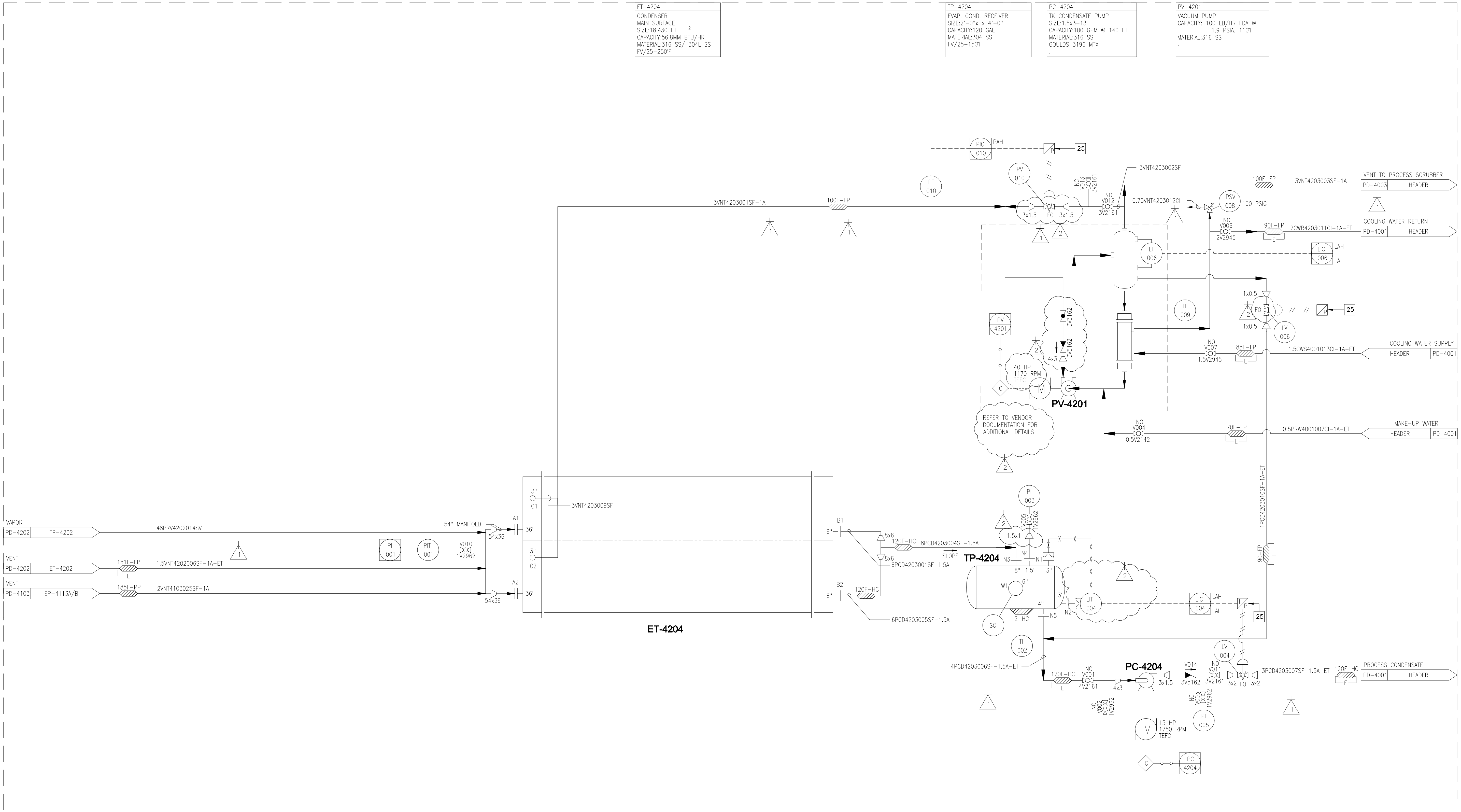
D-SIZE (24x36)



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667 Tifft Street Buffalo, NY 14220

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DISTILLATION, DEHYDRATION, EVAPORATION
PIPING & INSTRUMENTATION DIAGRAM
EVAPORATION
CONDENSER

Lurgi
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A Lurgi AG Company

CAD Ref. No. 73338-PD-4203-01-2
DRAWN BY: MJB DATE: 11-2-06
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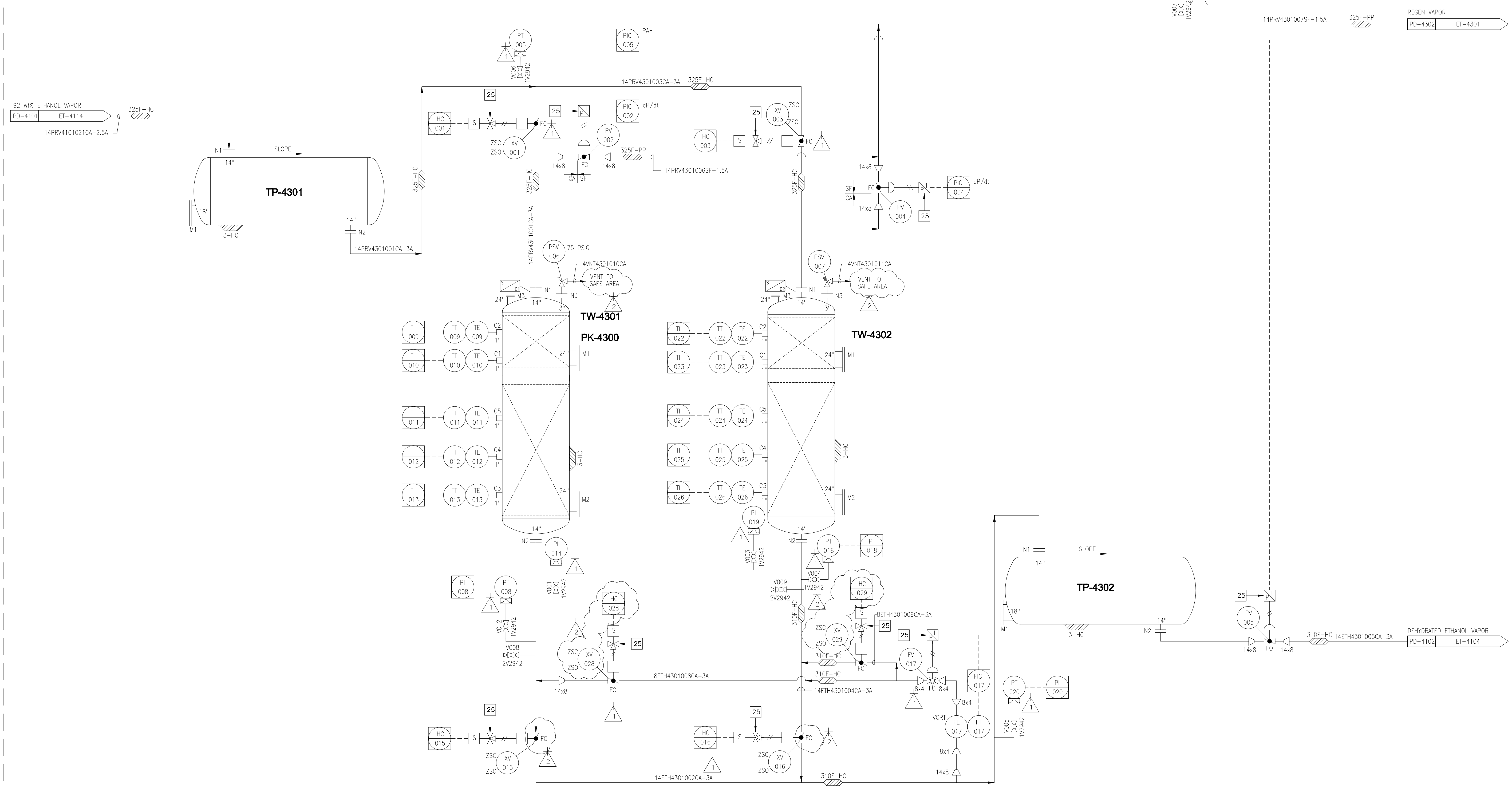
SCALE: NONE SHT. NO. 1 of 1
DRAWING NO.: 6018-PD-4203 REV: 2

D-SIZE (24x36)

ISSUED FOR CONSTRUCTION

TP-4301	TW-4301	PK-4300	TW-4302	TP-4302
ACCUMULATOR – INLET	MOLE SIEVE #1	MSU INTERNALS	MOLE SIEVE #2	ACCUMULATOR – OUTLET
SIZE:6'-0"øx24'-0"	SIZE:8'-0"øx36'-0"	BEAD PACKAGE	SIZE:8'-0"øx36'-0"	SIZE:6'-0"øx24'-0"
CAPACITY:680 FT^3	CAPACITY:2000 FT^3	SIZE:8' DEEP @ 1/16"	CAPACITY:2000 FT^3	CAPACITY:680 FT^3
MATERIAL:CS	MATERIAL:CS	SIZE:20' DEEP @ 1/8"	MATERIAL:CS	MATERIAL:CS
75 PSIG/FV 450°F	FV/75–450°F	MATERIAL: CERAMIC	FV/75–450°F	FV/75–450°F
		GRACE 562, 564		



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DISTILLATION,DEHYDRATION & EVAPORATION
PIPING & INSTRUMENTATION DIAGRAM
DEHYDRATION
MOLECULAR SIEVE UNIT

Lurgi
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CAD Ref. No. 73338-PD-4301-1 -2
DRAWN BY: MJB DATE: 11-2-06
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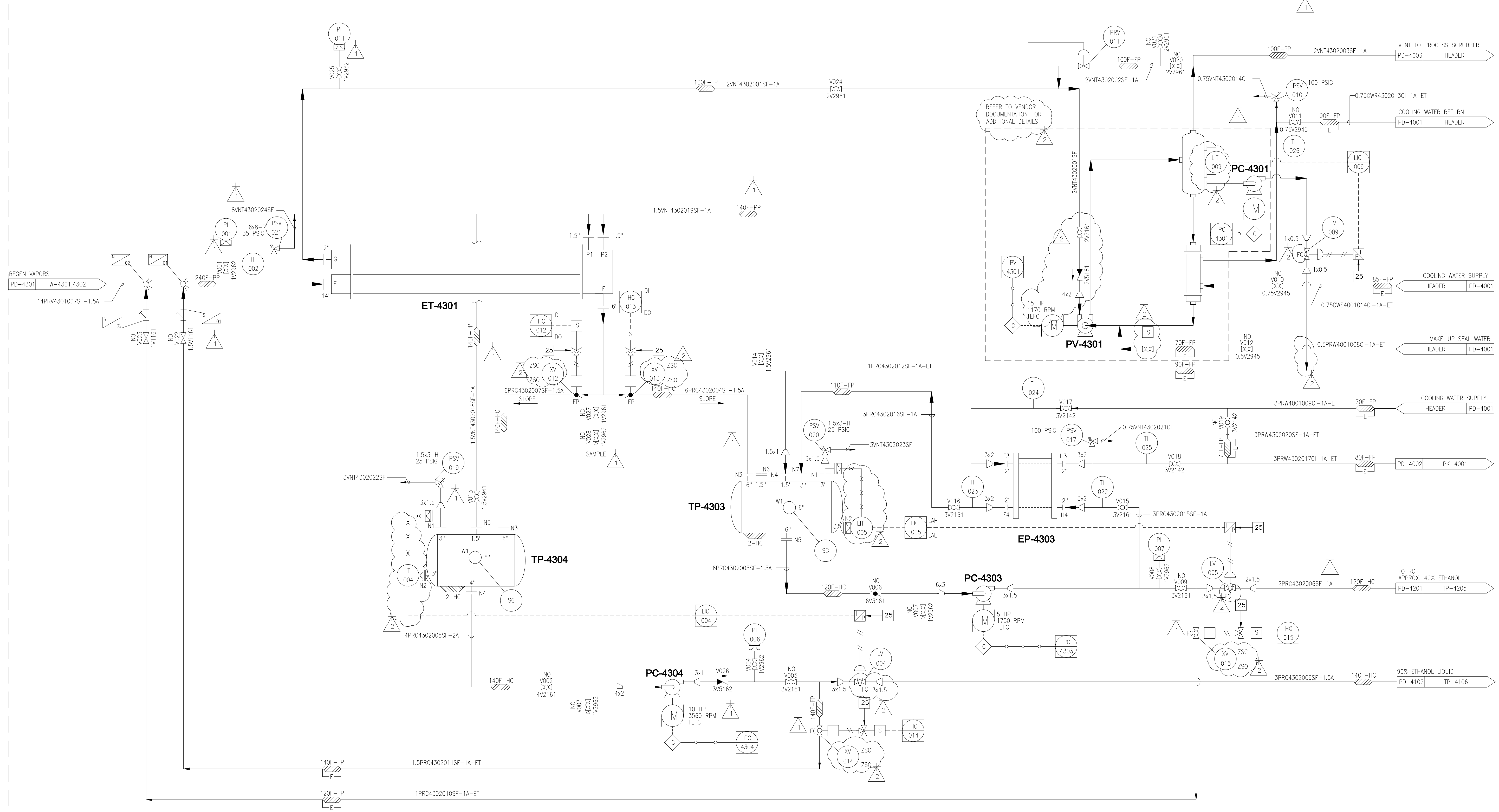
DRAWING NO.: 6018-PD-4301 REV. 2

D-SIZE (24x36)

ET-4301	TP-4304	PC-4304	TP-4303	PC-4303	EP-4303	PV-4301	PC-4301
REGENERATION CONDENSER	DEPRESS. COND. RECEIVER	DEPRESS. COND PUMP	REGEN. COND. RECEIVER	REGENERATION PUMP	REGENERATION COOLER	VACUUM PUMP	VACUUM SYSTEM BLOWDOWN PUMP
SIZE:2160 FT 2	SIZE:3'-6"ø x 6'-0"	SIZE: 1x2-10	SIZE:3'-6"ø x 6'-0"	SIZE:1.5x3-10	SIZE:146 FT 2	CAPACITY: 240 CFM @ 1.9 PSIA, 120°F	SIZE: 3/4x1/2
CAPACITY:11.6MM BTU/HR	CAPACITY:400 GALLONS	CAPACITY:50 GPM @ 180 FT	CAPACITY:400 GALLONS	CAPACITY:100 GPM @ 60 FT	CAPACITY: 0.32 MM	MATERIAL:316 SS	CAPACITY: 2 GPM @ 40 FT
MATERIAL:304/316 SS	MATERIAL:304L SS	MATERIAL:316 SS	MATERIAL:304L SS	MATERIAL:316 SS	MATERIAL:304LSS		MATERIAL:316SS
25 PSIG/ FV @ 250°F	25 PSIG/ FV @ 220°F	GOULDS 3196LF LTX	25PSIG/ FV @ 220°F	40% ETHANOL TO TW-4102	100 PSIG @ 250 °F		
				GOULDS 3196 MTX			



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Evaporation/Distillation/Chemical Reaction/Process Design & Energy Conservation
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DISTILLATION, DEHYDRATION & EVAPORATION
PIPING & INSTRUMENTATION DIAGRAM
DEHYDRATION
CONDENSER

Lurgi
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CAD Ref. No. 73338-PD-4302-01-2
DRAWN BY: MJB DATE: 11-2-06
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SCALE: NONE SHT. NO: 1 of 1
DRAWING NO.: 6018-PD-4302 REV. 2

D-SIZE (24x36)

MOLECULAR SIEVE SEQUENCING DESCRIPTION

Thermal Kinetics
Engineering, PLLC & Systems, LLC
Evaporation, Distillation, Chemical Reaction, Process Design & Energy Conservation
667 Tifft Street
Buffalo, New York 14220
(716) 826-3836 Fax 826-3853

APPROVAL

Name	Title	Date of Approval
		24 May 2007

REVISION HISTORY

Revision	Date	Description of Revision	Revised By	Approved By
0	05/24/2007	Original Issue	DML	GCG
1	08/09/2007	Revised MSU Operation Matrix, included MSU Operation Matrix Description and trouble shooting section	DML	JML
2	09/12/2007	Included: Instructions on Installation of TK Adsorption Vessel Internal Components, detailed adsorber schematic	DML	KD
3	10/10/2007	Revised Instructions on Installation of TK Adsorption Vessel Internal Components	DML	

CONTENTS:

ATTACHED:

Instructions on Installation of TK Adsorption Vessel Internal Components

ADSORBER INTERNALS DETAILS SCHEMATIC

Grace Davison Technical Information: SYLOBEAD Spherical Molecular Sieves for Process Applications – Configuration of Vessel Internals

Grace Davison Technical Information_UNLOADING OF ADSORBENT

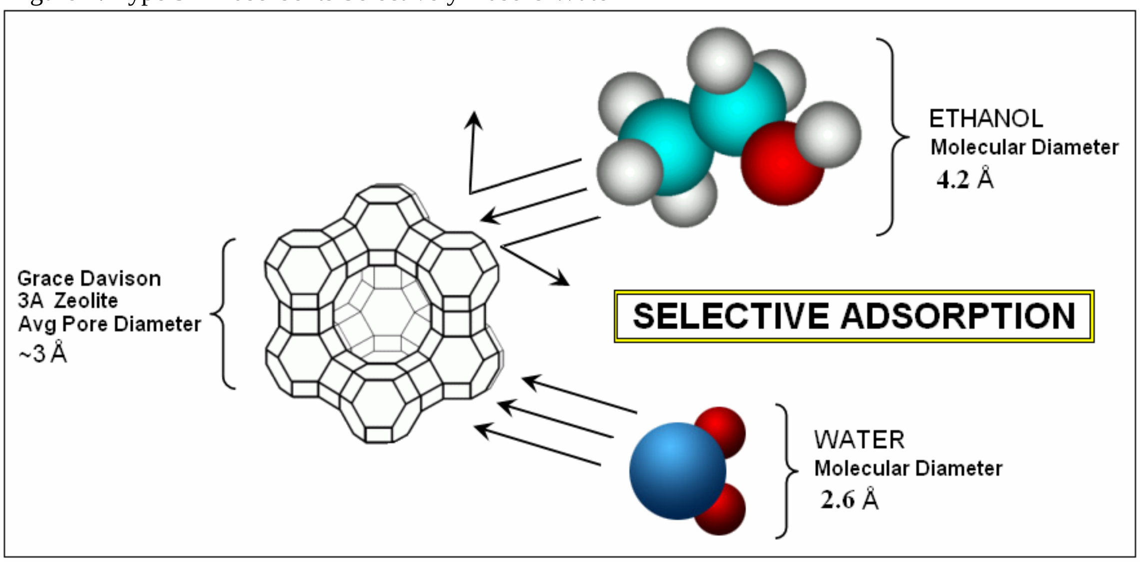
INTRODUCTION

This document is intended as an introduction to Thermal Kinetics' Molecular Sieve Vacuum Pressure Swing Adsorption (VPSA) Unit. Section 1 includes a brief section on the theory of molecular sieves and how they are used in practice. Section 2 provides a detailed molecular sieve area overview; this section includes a detailed description of the operation of TK's VPSA unit as well as discussing in detail how TK's adsorption unit acts in communication with the rest of TK's Distillation, Dehydration & Evaporation (DD&E) alcohol recovery process.

MOLECULAR SIEVES

The dehydration of ethanol vapors can be accomplished by using type 3A molecular sieve zeolites. Zeolites provide a separation based upon differences in molecular size. Water molecules preferentially diffuse into these material and ethanol molecules are excluded. Type 3A adsorbents preferentially adsorb water molecules as opposed to selectively adsorbing larger ethanol molecules. The molecular diameters of water and ethanol are 2.6Å and 4.2Å, respectively.

Figure 1: Type 3A Adsorbents Selectively Adsorb Water



More on adsorption is explained in Section 2: Dehydration

MOLECULAR SIEVE AREA OVERVIEW

The following text refer to process diagrams provided in Appendix 2 through 4 which illustrate how the PSA unit is integrated with TK's DD&E area.

190 proof ethanol vapor leaves the top of the Rectifier Column (TW-4102) at a rate of 107,877 lb/hr with a pressure of 53.45 psia and a temperature of 240°F. This 190 proof ethanol vapor discharged from TW-4102 is diverted to two separate locations: 42,423 lb/hr is introduced into the tube-side of the 190 proof Superheater (ET-4114) which superheats the ethanol vapors elevating the temperature to approximately 332°F prior to being introduced to the molecular sieve unit (MSU); 65,454 lb/hr of the 190 proof ethanol vapor discharged from TW-4102 acts as a reflux which is ultimately transferred back to the rectifying column after it is condensed within the shell-side of the Rectifier Column Condenser/Beer Column Reboiler (ET-4103). The rectifying column overhead product which serves the function as a reflux back to the column provides the energy required for evaporation of Beer Column (TW-4101) bottoms product within the tube side of ET-4103.

Pressure transmitter PT-4101-020, located at the top of the TW-4102 (Rectifier Column), monitors the pressure above tray 1 within the rectifying column and transmits a signal to a pressure indicating controller (PIC-4101-020) which modulates a pressure control valve (PV-4101-020) placed on the overhead discharge of TW-4102 to attain a set point pressure within both TW-4102 and the tube-side of ET-4114 (190 Proof Superheater). The flow rate of steam into the shell-side of the 190 Proof Superheater is regulated by a temperature control valve (TV-4101-021); Temperature element and transmitter TE/TT-4101-021 placed on the 190 Proof Superheater's tube-side discharge monitors the temperature of superheated 190 proof ethanol vapor and transmits a signal to a temperature indicating controller (TIC-4101-021) which instructs TV-4101-021 to open or close depending upon the difference of the actual temperature of the ethanol vapor discharged from the Superheater's tube-side and the desired operator defined design discharge temperature.

The quality of TW-4102 (Rectifier Column) overhead is controlled by setting a take-off rate of 190 proof alcohol (this is the feed to the mole sieves) that matches the alcohol feed to the column and by monitoring the temperature at a lower point in the column that is sensitive to a change in composition. The flow is established by setting the rate using FIC-4101-014 that is controlled by FV-4101-014. The flow is then adjusted using cascade control from a temperature set point above tray 21 with the flow increasing when the process value is below the established set point at TIC-4101-014 and vice versa. The remaining portion of the overhead from the column is condensed in ET-4103 (Rectifier Condenser and Beer Column Reboiler) and returned to the top of the column as reflux using level control. Flow and proof of the reflux steam is monitored by the DCS.

Superheated ethanol vapors discharged from ET-4114 are introduced to an Inlet Accumulator (TP-4301) within the Molecular Sieve (Dehydration) area. The pressure of the superheated ethanol vapors discharged from the Inlet Accumulator is monitored and controlled by pressure transmitter PT-4301-005 and controller PIC-4301-005 which act in communication to modulate pressure control valve PV-4301-005 placed on the MSU Outlet Accumulator (TP-4302) discharge; the operator set-point for the PSA unit is approximately 50 to 60 psia. The Molecular Sieve Unit or Vacuum Pressure Swing Adsorption (VPSA) process is essentially a batch process. Inlet and Outlet Accumulators serve the purpose of temporarily storing ethanol vapors, while also creating a high pressure reservoir which dampens pressure fluctuations created by cyclic operation and, thus, ultimately facilitates integration of the semi-batch VPSA process with the rest of the continuous distillation and evaporation alcohol recovery process.

190 proof ethanol vapors discharged from the Inlet Accumulator flow in the downward direction through one of two molecular sieve adsorption towers: TW-4301 or TW-4302. These two vertical cylindrical packed columns of type 3A molecular sieves work in cyclic batch mode wherein timed alternating cycles are comprised of sequences which entail (1) dehydration (adsorption), (2) depressurization, (3) regeneration and (4 & 5) initial and final repressurization. 190 proof ethanol passes through one of two cylindrical backs beds of zeolite molecular sieves to obtain pure ethanol; when one bed is adsorbing, the other is undergoing a de-sorption process which is a means to recharge the packed bed for subsequent adsorption cycles. The feed rate to the Molecular Sieve Unit (MSU) is determined by ethanol vapor requirements in the evaporator and system capacity.

DEHYDRATION (ADSORPTION)

Vacuum Pressure Swing Adsorption (VPSA) involves passing an ethanol and water vapor mixture through a pressurized vertical cylindrical packed bed of molecular sieves to obtain pure ethanol. It is common practice to employ the use of type 3A molecular sieves in ethanol VPSA processes due to the fact that these materials possess a high affinity for water molecules which preferentially diffuse into their network of cavities. These adsorbents allow a separation based on the physical size differences in the molecules by allowing the water molecules to diffuse within cavities of the zeolitic adsorbent, while excluding the larger ethanol molecules. The molecular diameter of an ethanol molecule is much larger than the average pore entrance of a 3A zeolite and resultantly their adsorption onto the zeolite material is often considered negligible.

When water molecules diffuse onto the zeolite surface, energy in the form of heat is released into the bed and vapor passing through the bed. During an adsorption sequence, a temperature front will progress through the bed of molecular sieve material raising the temperature to between 300 and 345 ^{o}F in the active dehydration zone. Moreover, the packed bed of adsorbent material will decrease in temperature during a regeneration sequence as the heat retained within the bed is released with the evaporation of water from the zeolite. This temperature front is indicative of where the dehydration is occurring within the bed. The pressure will remain relatively constant at 50 psia inlet and 46 outlet. Although the temperature of the bed indicates progress of dehydration and regeneration, it will not be used to control the switching process between dehydration and regeneration but could be used to reset cycle timing. Cycle timing is used to determine the point of changing from one sequence to the next. Multiple block valves are used to change between adsorption and de-sorption; these block valves are each provided with dual position switches to verify the valves reach the desired position within a specified time limit. As references values, adsorption will proceed until the end of 8 minutes whereas latter sequences (depressurization, regeneration (de-sorption) and repressurization) will take an additional 8 minutes (cycle times subject to change). Once an adsorption vessel has completed its adsorption sequence, it will automatically engage in a depressurization period followed by a regeneration sequence and finally two separate sequences of repressurization. Refer to the operation matrix (Appendix 1) for valve position through the adsorption and de-sorption cycles.

The superheated 200 proof vapor leaving the MSU is de-superheated to a temperature between 235 and 260 ^{o}F using 200 proof condensate discharged from PC-4107 (99.5 wt% Ethanol Pump); FE-4102-021 (rotameter) indicates the flow rate of ethanol flowing to de-superheating nozzle (N-4102-05). The 200 proof ethanol vapor is introduced into the shell side of ET-4104 (Beer Column Reboiler/200 Proof Condenser) where it is used as the energy source to vaporize the beer column bottoms within the tube side. Temperature and pressure of de-superheated ethanol vapor are indicated by TE-4102-028 and PI-4102-030, respectively; the pressure within the shell-side of ET-4104 is approximately 38 psia. 200 proof shell-side condensate is directed to TP-4107 (99.5 wt% Ethanol Receiver) and ethanol liquid is removed from this vessel by level control (LV-4102-023) and sent to EP-8201.

DEPRESSURIZATION, REGENERATION AND REPRESSURIZATION (DESORPTION)

Depressurization, regeneration and repressurization occur after an adsorption sequence is completed. Depressurization ensues immediately after an adsorption sequence is finished. The depressurization sequence entails simultaneously closing the feed and discharge block valves (XV-4301-001 and XV-4301-015) of the bed that is to be de-sorbed (TW-4301). XV is a prefix for a pneumatic ON/OFF valve. At this time a modulating butterfly valve (PV-4301-002) located on the top of the bed to be de-sorbed will ramp open from 50% to 100% (modulation and time ranges to be adjusted) within the first minute to allow the adsorption column to depressurize from 50 to 25 psia. The latter half of the depressurization sequence is accomplished by applying a vacuum to the bed which lowers the pressure within the bed from 25 to 1.95 psia. Initial and final depressurization take a total of approximately 4 minutes (time ranges to be adjusted). A high vacuum is employed to remove water from the molecular sieves within the bed. Regeneration lasts approximately 2 minutes (time ranges to be adjusted). Regeneration is an endothermic process and generates a thermal wave which travels upwards in the bed, opposite the direction that the heat front travels during the exothermic adsorption sequence. The physical process of adsorption occurs more readily at elevated pressures; the adsorbed water may be removed from the zeolite by lowering the absolute pressure. The regeneration sequence begins only after a low vacuum within the regenerating bed is realized. At this time, a small percent of the superheated 200 proof ethanol vapor product stream from the bed which is undergoing adsorption is introduced through the bottom of the de-sorbing bed. This ‘slip stream’ or ‘purge’ flow stream coupled with a low pressure serve the purpose in aiding the removal of water which has accumulated within the zeolite’s pores during the subsequent adsorption sequence. During regeneration, the flow rate set-point for the 200 proof ethanol ‘purge’ stream passing through FV-4302-017 may be subject to change based on optimal operation. While TW-4302 is adsorbing and during the regeneration sequence of TW-4301 both FV-4302-017 and XV-4301-028 are open; xv-4301-029 is closed.

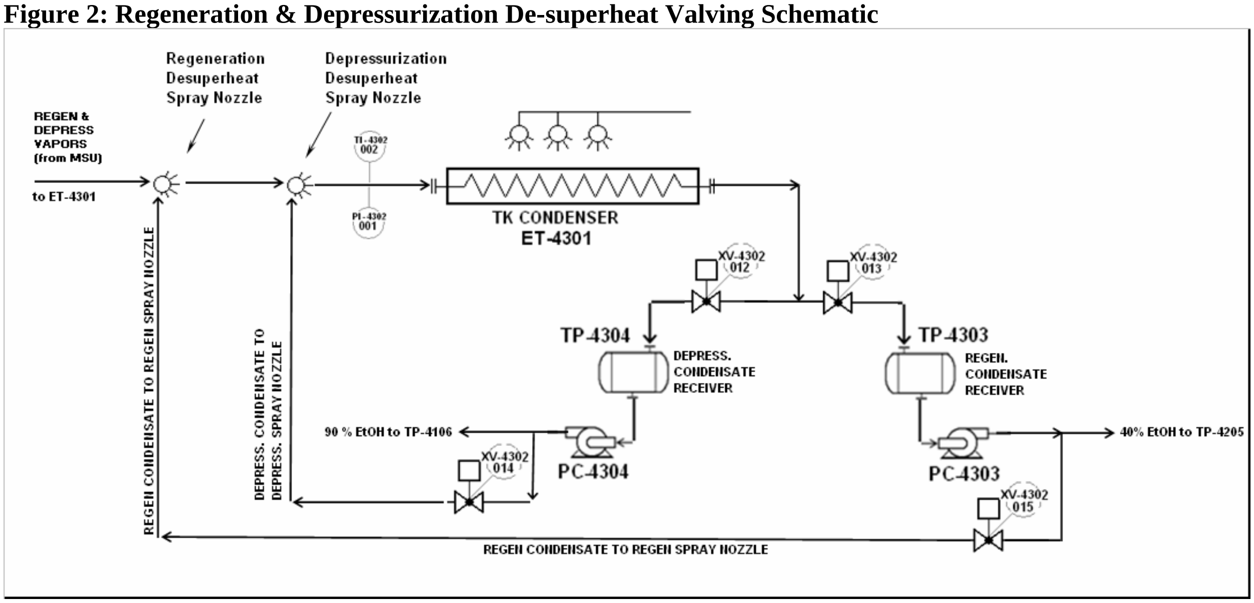
Repressurization of the de-sorbing bed is required to prepare it for the next adsorption sequence. The first repressurization sequence of TW-4301 entails closing PV-4301-002 while ramping opening FV-4302-017 to 100% (modulation rages to be adjusted) while at the same time XV-4301-028 remains open; it is preferred to first repressurize by this arrangement from 1.95 to 25-40 psia. Regeneration rates must be controlled to avoid sudden and significant changes in the process. Final repressurization occurs approximately 5-10 seconds (time ranges to be adjusted) before the desorbing MSU switches to an adsorption sequence; this step entails opening XV-4301-029 (bypasses FV-4301-017) so that a pressure of 50 psia may be realized within the MSU for the proceeding cycle. Final repressurization may also be realized by opening top (XV-4301-001) or bottom (XV-4301-015) feed and discharge valves (or both) on the desorbed bed; this may be an appropriate alternative to opening the block valves located on the regeneration purge stream pipe work (XV-4301-028 and/or XV-4301-029) to equilibrium pressures between both beds. Rapid depressurization or repressurization could both, damage the zeolite pellets within the bed and also may result in poor performance due to channeling and uneven vapor flow distribution within the adsorber. It is absolutely crucial that these steps are controlled to prevent pressure from changing more than 25 psi per minute.

Ethanol/water vapors discharged from the bed during de-sorption travel in the countercurrent direction of the adsorption feed flow and are introduced to the TK Condenser (ET-4301) which operates under vacuum; PV-4301 (Dehydration Area Vacuum Pump) provides a low pressure driving force so that depressurization or regeneration vapors may enter the TK Condenser and exit as a liquid. Condensate exiting ET-4301 may be transferred to either TP-4304 (Depressurization Condensate Receiver) or TP-4303 (Regeneration Condensate Receiver) via alternating pneumatic ON/OFF valves (XV-4302-012 and XV-4302-013) which open or close with respect to scheduled MSU cycle times. During depressurization XV-4302-012 is open (XV-4302-013 is closed) allowing depressurization condensate to enter TP-4304; the depressurization ethanol/water composition is approximately 90% ethanol and is roughly the same alcohol concentration of that which is fed to the MSU from the Rectifier Column. During regeneration XV-4302-013 is open (XV-4302-012 is closed) permitting regeneration condensate to enter TP-4303; Regeneration vapors are comprised of a lesser ethanol concentration (approximately 40%).

Refer to Figure 2 for the following text. Depressurization and regeneration vapors are transferred from the MSU to the Regen Condenser (ET-4301). The condensate from the Regen Condenser is split based on timing / composition, sending the initial, higher proof to TP-4304 (Depressurization Condensate Receiver), and the final, lower proof begin send to TP-4303 (Regeneration Condensate Receiver). The higher proof receiver condensate is combined with 190 proof reflux in TP-4106. The lower proof receiver condensate is combined with the 50.77% ethanol feed in TP-4205. The non-condensables from both receivers are vented through ET-4301 to the vacuum pump (PV-4301) which is designed to arrive at less than 2 psia at the end of each regeneration cycle. Each condensate receiver is operated by level control.

TP-4304 (Depressurization Condensate Receiver) 90% ethanol (depressurization) condensate is transferred to TP-4106 (92% ethanol receiver) via PC-4304 (Depressurization Condensate Pump) where it is then refluxed back to the top of the rectifying column (TW-4102). TP-4303 (Regeneration Condensate Receiver) 40% ethanol regeneration condensate is transferred to TP-4205 (1st Effect Condensate Collection Tank) via PC-4303 (Regeneration Condensate Pump) where it is eventually transferred to the feed tray of the rectifying column (TW-4102). It is advantageous to separate higher and lesser concentrated de-sorption ethanol/water condensate to reduce both the steam input and ultimately the reflux ratio to the Rectifier Column. Moreover, vapors discharged from each bed during de-sorption are superheated and must be de-superheated before being introduced to the TK Condenser tube bundle. Desuperheating de-sorption vapors is accomplished by transferring a small amount of either depressurization or regeneration condensate to their respective de-superheat spray nozzles (N-4302-01 or N-4302-02, respectively) which are located prior to the TK Condenser inlet. XV-4302-014 located on the discharge of PC-4304 (Depressurization Condensate Pump) opens only during the MSU depressurization sequence and serves the function to de-superheat only depressurization vapors; XV-4302-014 and XV-4302-012 simultaneously (sampling may determine to lag this sequence) open and close so that MSU depressurization condensate may de-superheat MSU depressurization vapors. XV-4302-015 placed on PC-4303 (Regeneration Condensate Pump) discharge only opens during the MSU regeneration sequence to de-superheat regeneration vapors; XV-4302-015 and XV-4302-013 simultaneously (sampling may determine to lag this sequence) open and close so that MSU regeneration condensate may de-superheat the MSU regeneration vapors. Refer to the operation matrix (Page 4) for valve position through the adsorption and de-sorption cycles.

Figure 2: Regeneration & Depressurization De-superheat Valving Schematic



APPENDIX 1: MSU OPERATION MATRIX

8/9/2007
by DML

MOLECULAR SIEVE OPERATION MATRIX

OPERATION MATRIX	TW-4301 DEHYDRATION					TW-4302 DEHYDRATION				
	TW-4302 DEPRESS.	TW-4302 DEPRESS. 2ND HALF	TW-4302 REGEN.	TW-4302 REPRESS. INITIAL	TW-4302 REPRESS. FINAL	TW-4301 DEPRESS.	TW-4301 DEPRESS. 2ND HALF	TW-4301 REGEN.	TW-4301 REPRESS. INITIAL	TW-4301 REPRESS. FINAL
XV-4301-001	OPEN	OPEN	OPEN	OPEN	OPEN	CLOSED	CLOSED	CLOSED	CLOSED	OPEN (1)
XV-4301-003	CLOSED	CLOSED	CLOSED	CLOSED	OPEN (1)	OPEN	OPEN	OPEN	OPEN	OPEN
PV-4301-002	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	RAMP OPEN	OPEN	OPEN	CLOSED	CLOSED
PV-4301-004	RAMP OPEN	OPEN	OPEN	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED
XV-4301-015	OPEN	OPEN	OPEN	OPEN	OPEN	CLOSED	CLOSED	CLOSED	CLOSED	OPEN (1)
XV-4301-016	CLOSED	CLOSED	CLOSED	CLOSED	OPEN (1)	OPEN	OPEN	OPEN	OPEN	OPEN
XV-4301-028	CLOSED	CLOSED	CLOSED	CLOSED	OPEN (1)	CLOSED	OPEN	OPEN	OPEN	OPEN
XV-4301-029	CLOSED	OPEN	OPEN	OPEN	OPEN	CLOSED	CLOSED	CLOSED	CLOSED	OPEN (1)
XV-4302-012	OPEN	OPEN	CLOSED	CLOSED	CLOSED	OPEN	OPEN	CLOSED	CLOSED	CLOSED
XV-4302-013	CLOSED	CLOSED	OPEN	OPEN	OPEN	CLOSED	CLOSED	OPEN	OPEN	OPEN
XV-4302-014	OPEN	OPEN	CLOSED	CLOSED	CLOSED	OPEN	OPEN	CLOSED	CLOSED	CLOSED
XV-4302-015	CLOSED	CLOSED	OPEN	OPEN	OPEN	CLOSED	CLOSED	OPEN	OPEN	OPEN
PV-4301-005	CONTROL	CONTROL	CONTROL	CONTROL	CONTROL	CONTROL	CONTROL	CONTROL	CONTROL	CONTROL
TI-4301-009	290°F	310°F	325°F	330°F	335°F	330°F	315°F	305°F	295°F	290°F
TI-4301-010	330°F	325°F	330°F	335°F	350°F	345°F	340°F	335°F	330°F	330°F
TI-4301-011	325°F	325°F	330°F	330°F	330°F	330°F	330°F	325°F	325°F	325°F
TI-4301-012	330°F	330°F	333°F	333°F	333°F	333°F	333°F	333°F	330°F	330°F
TI-4301-013	333°F	335°F	335°F	335°F	335°F	335°F	335°F	335°F	333°F	333°F
TI-4301-022	330°F	315°F	305°F	295°F	290°F	290°F	310°F	325°F	330°F	335°F
TI-4301-023	345°F	340°F	335°F	330°F	330°F	330°F	325°F	330°F	335°F	350°F
TI-4301-024	330°F	330°F	325°F	325°F	325°F	325°F	325°F	330°F	330°F	330°F
TI-4301-025	333°F	333°F	333°F	330°F	330°F	330°F	330°F	333°F	333°F	333°F
TI-4301-026	335°F	335°F	335°F	333°F	333°F	333°F	335°F	335°F	335°F	335°F
FV-4301-017	CLOSED	CLOSED	REGEN RATE	RAMP TO FULL OPEN	CLOSED	CLOSED	CLOSED	REGEN RATE	RAMP TO FULL OPEN	CLOSED
FE-4301-017	INDICATES NO FLOW	INDICATES NO FLOW	REGEN RATE	REPRES RATE	INDICATES NO FLOW	INDICATES NO FLOW	INDICATES NO FLOW	REGEN RATE	REPRES RATE	INDICATES NO FLOW
MAX. MINUTES INTO CYCLE	0 - 1	1 - 4	4 - 6	6 - 7.75	7.75 - 8	0 - 1	1 - 4	4 - 6	6 - 7.75	7.75 - 8
MAX. SECONDS INTO CYCLE	0 - 60	61 - 240	241 - 360	361 - 465	466 - 480	0 - 60	61 - 240	241 - 360	361 - 465	466 - 480
PT-4301-008	55 PSIA	55 PSIA	55 PSIA	55 PSIA	55 PSIA	55 TO 30 PSIA	30 TO 1.93 PSIA	1.93 PSIA	1.93 TO 45 PSIA	45 TO 55 PSIA
PT-4301-018	55 TO 30 PSIA	30 TO 1.93 PSIA	1.93 PSIA	1.93 TO 45 PSIA	45 TO 55 PSIA	55 PSIA	55 PSIA	55 PSIA	55 PSIA	55 PSIA
PT-4301-020	MONITORS PRESSURE BEFORE TP-4302 (OUTLET ACCUMULATOR), NORMAL BETWEEN 42 AND 50 PSIA									
PI-4301-001	MONITORS PRESSURE OF DEPRESSURIZATION AND REGENERATION FLOWS TO ET-4301 (TK CONDENSER) HIGH PRESSURE ALARM AT **69 PSIA**									
PT-4301-005	CONTROLS PRESSURE OF VAPOR GOING TO VAPORIZER USING PRESSURE CONTROL VALVE ON SIEVE DISCHARGE, VALVE FAILS OPEN									
TT-4201-028	MONITORS TEMPERATURE LEAVING SIEVE, AFTER DESUPERHEATER, NORMAL BETWEEN 235 AND 260 F (ADJUST FI-4102-026 ACCORDINGLY) - MANUAL SOME EXCESS NOT AN ISSUE									
FIC-4101-014 (FV-4101-014)	CASCASDING CONTROL LOOP: PRIMARY SET-POINT: ET-4114 190 PROOF VAPOR DISCHARGE, CONTROLLER DERIVED SET-POINT: TEMPETURE ABOVE STAGE 21 TW-4102 (Rectifier Column)									
TT-4101-021	MONITORS TEMPERATURE LEAVING ET-4114 (190 PROOF SUPERHEATER) TO MOLECULAR SIEVE UNIT BY ADJUSTING STEAM FLOW TO ET-4114 SHELL-SIDE									

(1) - FINAL REPRESSURIZATION TAKES PLACE BY OPENING EITHER THE TOP OR BOTTOM BLOCK VALVES (OR BOTH) ON THE DEHYDRATED BED (i.e. - FOR TW-4301 DEHYDRATION (DURING FINAL TW-4302 REPRESS.) XV-4301-016 AND XV-4301-003 MAY BE OPENED FOR FINAL REPRESSURIZATION OF TW-4302 - as long as the pressure within TW-4302 is within 10 pounds of final desired repress. pressure) - **no more than 25 psi per minute**

ALL TEMPERATURES IN THE SIEVES ARE HYPOTHETICAL AND WILL BE EVALUATED IN THE INITIAL OPERATION

THIS MATRIX TAKES INTO ACCOUNT IF REGEN PURGE FLOW BEGINS AT FULL VACUUM AFTER DEPRESS. (REGEN)

CYCLE TIMES SUBJECT TO CHANGE REV 2

APPENDIX 2: MSU OPERATION MATRIX DESCRIPTION

NARRATIVE

8/9/2007 **MSU VALVE SEQUENCING**

There are four valves on each molecular sieve adsorption vessel and one regen flow control valve and flow controller which introduces regeneration sweep flow to either vessels during regeneration

The initial total cycle time shall be 16 minutes (960 seconds), 8 minutes of dehydration for each vessel (cycle time subject to change).

During dehydration, both the inlet and outlet valves on the adsorbing vessel (XV-4301-001 & XV-4301-015) or (XV-4301-003 & XV-4301-016) are open.

The bottom regen valve (XV-4301-028 or XV-4301-029) opens on the dehydrating vessel during regeneration and during the last minute of dehydration for final repressurization of regenerating vesse

Final repressurization may also be realized by opening top (XV-4301-001 or XV-4301-003) or bottom (XV-4301-015 or XV-4301-016) feed and discharge valves (or both) on the desorbed bed

during the last 15 seconds of final depressurization to increase the desorbing bed pressure from 45 to 55 psia.

The first stage in desorbing a spent vessel is initial depressurization which takes place in two steps using PV-4301-002 or PV-4301-004.

For the first minute of desorbing a spent vessel (1 to 60 seconds), PV-4301-002 or PV-4301-004 ramps open so at the end of the first depressurization period the vessel pressure is 30 psia.

The first depressurization period should decrease the vessel pressure from 55 psia to 30 psia with a pressure decrease of 25 psi per minute.

The second depressurization period takes a total of three minutes (61 to 240 seconds) and should realize a pressure decrease from 30 to 1.93 psia.

Final pressure at 240 seconds into desorption cycle should be approximately 1.93 psia.

At 241 seconds into desorbing a spent vessel, the 200 proof sweep valve opens (XV-4301-028 or XV-4301-029) and regen flow control valve and flow controller (FV-4301-017 & fic-4301-017) set the r

Ramp FV-4301-017 during the two minutes of regeneration (240 to 360 seconds) from 0 to 2,500 pph (regeneration flow rates subject to change).

Regeneration continues at these settings until 6 minutes (360 seconds) into the cycle (lasting 2.0 minutes).

Repressurization starts at 6 minutes (361 seconds) by closing regen valve to vacuum pump (PV-4301-002 or PV-4301-004) and modulating FV-4301-017 so that the desorbing vessel repressurizes from

1.93 psia to 45 psia in the time interval allowed for the initial repressurization which is 6 to 7.75 minutes into desorption cycle (repressurize at 25 psi per minute).

Final repressurization begins at 466 seconds into desorption cycle and can be realized in several different valving schemes already discussed in narrative.

The regenerated sieve goes on dehydration at eight minutes (481 seconds) by closing XV-4301-001 and XV-4301-015 an opening XV-4301-003 and XV-4301-016.

The pressure will increase to 55 psia shortly after dehydration starts.

PRESSURE AND TEMPERATURE INPUTS

Any adjustment must be given several cycles to fairly determine the impact and before and additional adjustment is made.

Changes occur only once in ten cycles, using only the last five as a basis for change.

The temperature profile of the beds indicates the utilization of the potential available in that the heat is generated by adsorption.

The initial set point for tuning cycle times will be 300 deg F.

Changes must be small in proportion to the total cycle, limited to a total cycle of 20 to 40 minutes (initial 30).

Failure of the 'adsorption front' to reach the end of the useful portion of the bed indicates less than full utilization.

Increase cycle time to increase bed utilization. The segment to increase is the regen portion.

Should the 'adsorption front' reach the end of the useful portion prematurely, the potential for wet product exists.

Decrease cycle time to assume dry product (assumes regen is adequate). Decrease the regen portion.

The temperature profile also indicates the effectiveness of the regeneration by the temperature front similar to adsorption, above.

Failure of the 'regeneration front' to reach the top of the bed indicates less than fully regenerated.

Increase regen flow setting (FV-4301-017) to increase water removal rate.

Should the 'regeneration front' reach the top of the bed prematurely, some 200 proof ethanol is being recycled unnecessarily.

Decrease regen flow setting (FV-4301-017) to match water removal rate with cycle time allowing removal.

The rate of pressurization and depressurization is controlled to minimize the damage to the beds while allowing time for regeneration.

At the end of the first minute of depressurization, the pressure should be close to 25 psia.

Higher pressure will not allow time to complete the depressurization, PV-4301-002 OR PV-4301-004 must ramp open more quickly.

Lower pressure is not good practice for bed life and PV-4301-002 OR PV-4301-004 must ramp open more slowly or over a longer duration of time.

APPENDIX 3: ADSORBER TROUBLESHOOTING

The purpose of this section is to provide information regarding:

Records that should be maintained for ease in troubleshooting
Troubleshooting to identify and correct problems

RECORDS

A log of the following should always be maintained on a daily or weekly basis. A change in any of these parameters will affect the performance of the dehydration system.

FEED CONDITIONS
Flow rate
Temperature
Pressure
Impurity (water) concentration
Pressure drop
Cycle Time to Water break through

REGENERATION CONDITIONS
Vacuum level attained
Rate of pressure decrease
Temperature at end of regeneration purge

POOR WATER CONTENT
The most significant factor affecting outlet water content is the regeneration conditions. If the dehydration unit suddenly goes bad then the regeneration scheme is suspect. Check that the pressure indicators are correct and that the vacuum system is operating as specified. Since a liquid seal pump is used for the vacuum check the liquid temperature; as the liquid seal temperature goes up, the attainable vacuum gets worse. A small vacuum change can drastically affect the outlet proof. Valve leakage can be the cause of poor vacuum but it can also allow bypassing during the adsorption cycle. If a purge is used check the flow rate and pressure. Also check that the purge gas is really dry.

EARLY BREAKTHROUGH
Early water breakthrough can often send water to the product tanks to significantly lower the product proof. Obviously shortening the adsorption time can help but it is important to determine the reason for malfunction. Early breakthrough is usually associated with the following factors:

A) Inlet water content is higher that design
B) Flow rate has increased (check if flow indicator is defective).
C) Inlet temperature has increased. The capacity of molecular sieves is a strong function of temperature; the lower the temperature, the more water the zeolite can adsorb - the higher the temperature the less the zeolites can adsorb.

SHORT ADSORBENT LIFE
The adsorbent life in a well-designed alcohol plant has an average life of five years. The ability and capacity for water to preferentially diffuse into the zeolite within the packed bed deteriorates resulting in early breakthrough with the consequent water content in the product tank. Obviously the cycle times can be reduced until you reach an impractical time where a bed can not be depressurized and repressurized in the allotted time; then the adsorbent must be replaced.

The life of the adsorbent primarily depends upon the feed composition. Degradation of molecular sieves is due to many factors. The thermal and physical stresses of each regeneration can eventually destroy the delicate properties of the molecular sieves much like bending of a wire will cause it to break. An obvious way to increase the adsorbent's life cycle is to run longer cycles, i.e., to water breakthrough each cycle thus minimizing the number of regenerations. In many cases you will find that the adsorbent is simply dying of old age and must eventually need to be replaced but this is normally a slow gradual decay and should not cause unplanned shutdown if good data and records are kept.

BED BUMPING

A rapid depressurization possibly from a sticking valve can lift the bed and even fluidize it. This will most certainly reduce the molecular sieve beads to a powder. Normally a bed should not be depressurized or repressurized at a rate greater than 25 psi per minute. The only sure fix here after the cause of bed bumping has been fixed is to dump and screen or replace the adsorbent.

The importance of keeping records on the performance of the dehydrator can not be overemphasized. It is also valuable to sample the adsorbent (near the inlet) at least once per year and have the adsorbent vendor run an analysis to check for sieve poisoning (fouling) and retained water capacity. These analyses allow the operator to extrapolate the adsorbent decay curve to predict when it needs to be replaced. The cost saving of a planned versus unplanned shut down can be staggering. If there are any suspicions that the dehydrators are malfunctioning then the adsorbent vendor's technical service group should be contacted.

Instructions on Installation of TK Adsorption Vessel Internal Components

The internals of a typical TK molecular sieve vessel in an adsorption unit are as follows:

Internal Adsorbent Configuration:
A typical Thermal Kinetics adsorption bed contains two separate usable bed length sections each containing different size molecular sieve beads. The upper section of each adsorption bed contains smaller diameter 1/16" beads and the lower section of the bed contains larger, 1/8" molecular sieve beads.

Bed Support Systems:
See Grace Davison Technical Information: SYLOBEAD Spherical Molecular Sieves for Process Applications – Configuration of Vessel Internals (Page 2).

Two separate elevated support systems are provided in each TK adsorption vessel. These elevated support systems utilize a system of aligned Johnson Screen grids above a support structure and provide support for each usable bed length. When installing each Johnson Screen grid, it is extremely important to ensure there are no gaps between the support grid and the vessel wall. The grid is provided in sections that will fit through the loading manways and are fastened together at regular intervals. The perimeter is supported by a ring welded to the inside of the vessel and held down with 'j-bolts'. The perimeter gap must be properly sealed with an asbestos-free fireproof ceramic rope material, so that the adsorbent particle cannot fall through.

Ceramic Balls:
Two separate layers of different size ceramic balls (6 inches total and 3 inches of each ceramic material per layer) should be placed beneath the molecular sieve material and above the Johnson Screen support grid within each usable bed section.

See Grace Davison Technical Information: SYLOBEAD Spherical Molecular Sieves for Process Applications – Configuration of Vessel Internals (Page 3).

A wire mesh should be installed between the support grid and the first layer of ceramic to prevent sieve bead fines from passing through the system. The screens start with the coarser mesh at the grid and the finer mesh following. The larger ceramic (1/2" for the bottom section, 1/4" for the top section) is placed on top of the screen and leveled at about 3" depth and the smaller ceramic (1/4" for the bottom section, 1/8" for the top section) follows above with another 3" that is leveled prior to closing the manway and preparing to load the sieve media. The ceramic is denser than the sieve beads so that little migration is anticipated into the ceramic layers.

Loading the Vessel:
See Grace Davison Technical Information: SYLOBEAD Spherical Molecular Sieves for Process Applications – Vessel Loading (Page 5).

The lower portion of the bed must be filled before loading upper portion of the bed. Ensure that the ceramic balls and lower screen are inserted prior to loading the bottom of the vessel with molecular sieves. The ceramic balls for each section of the bed should be loaded through the side manway located just above each bed section's support grid.

The lower usable bed length may be filled with 1/8" molecular sieves once the ceramic ball support layers have been loaded and the lower manway closed. After the adsorbent has been loaded, the top of the bed layer should be leveled. There should be minimal space remaining above the top of the adsorbent and the support grid for the upper bed. The bed depth should be ~24'.

Previously, a layer of ceramic, protected by a stainless screen, was used to hold the bed down but the more recent approach has been to allow the beads to 'float' and prevent them from leaving the sieve container using an 'inlet screen' or in this case the support grid for the upper bed. Loading of the upper portion of the bed takes place in a similar manner to that of the lower portion. This upper bed depth is much smaller (~8')

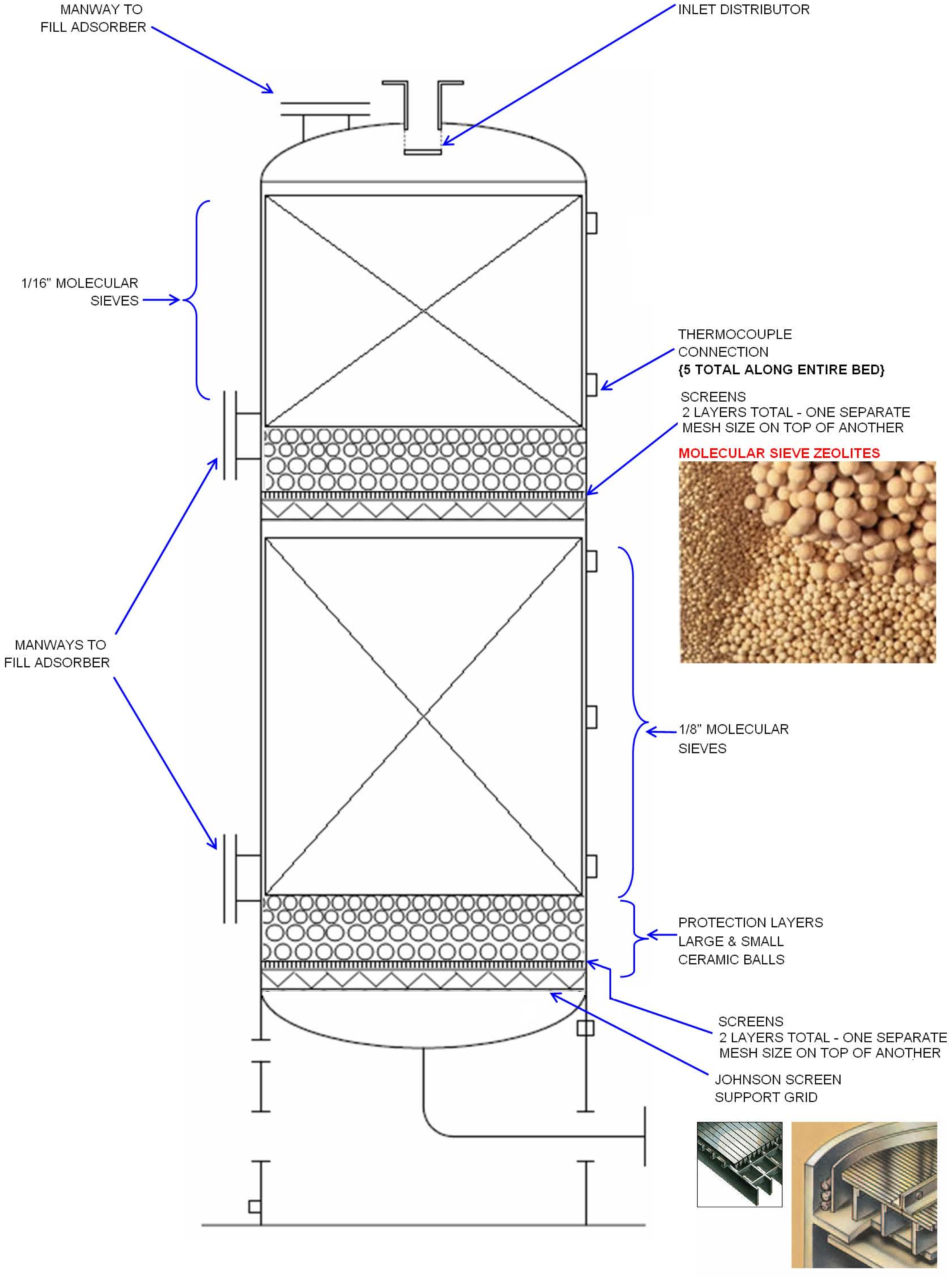
Notes:

1. **Read all materials prior to loading beds.**
2. **The team to perform the loading has to be informed about the nature of the molecular sieves and should be equipped with the appropriate personal protective equipment. These included but are not limited to gloves, long sleeves, pants or coveralls, safety glasses and dust masks.**
3. **Completely load lower portion of bed before loading the upper section.**
4. **Do not walk on molecular sieves once in column.**

Adsorption Vessel Loading Overview:

1. Install Lower Johnson Screen support grid above support beams within vessel
2. Fill gaps around the perimeter of support grid with ceramic rope
3. Insert screens which separate ceramic balls from the support grid
4. Load larger ceramic balls (1/2") through the manway located above the lower portion's support grid (3" depth)
5. Load smaller ceramic balls (1/4") above layer of larger ceramic ball support media (3" depth)
6. Load 1/8" molecular sieves into vessel, level off top of bed (~24' depth)
7. Install upper Johnson Screen support grid above support beams within vessel
8. Fill gaps around the perimeter of support grid with ceramic rope
9. Insert screens which separate ceramic balls from the support grid
10. Load larger ceramic balls (1/4") through the manway located above the upper portion's support grid (3" depth)
11. Load smaller ceramic balls (1/8") above layer of larger ceramic ball support media (3" depth)
12. Load 1/16" molecular sieves into vessel, level off top of bed (~8' depth)

Warning: Adsorbants exposed to water can become very hot and alkaline (due to heat of adsorbtion). Any contact with moist skin, eyes or mucous membranes should be avoided. See MSDS for additional information.


MANWAY TO FILL ADSORBER
INLET DISTRIBUTOR
1/16" MOLECULAR SIEVES
THERMOCOUPLE CONNECTION
{5 TOTAL ALONG ENTIRE BED}
SCREENS
2 LAYERS TOTAL - ONE SEPARATE MESH SIZE ON TOP OF ANOTHER
MOLECULAR SIEVE ZEOLITES
MANWAYS TO FILL ADSORBER
1/8" MOLECULAR SIEVES
PROTECTION LAYERS
LARGE & SMALL
CERAMIC BALLS
SCREENS
2 LAYERS TOTAL - ONE SEPARATE MESH SIZE ON TOP OF ANOTHER
JOHNSON SCREEN SUPPORT GRID

Technical Information

GRACE Davison®

Reg. No. 0924

SYLOBEAD®

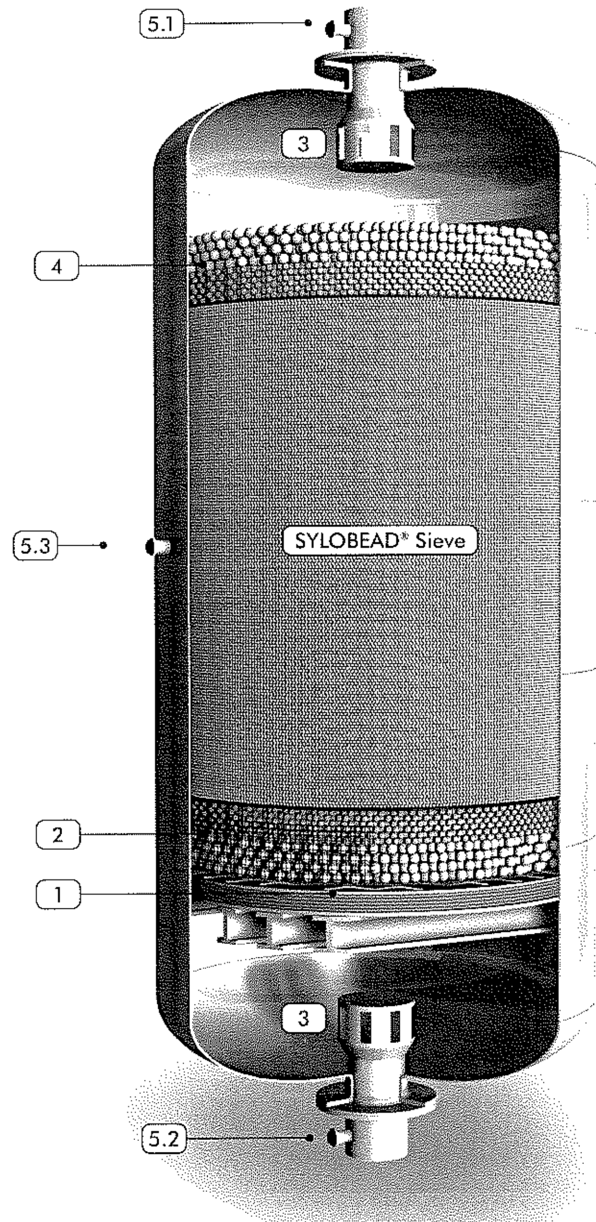
Spherical Molecular Sieves for Process Applications

Configuration of Vessel Internals

The following information regarding the internals of an adsorption unit represents the experience of Grace Davison and is believed to be reliable. However it is not intended to replace the design philosophy of the engineering company, which is responsible for the application of the valid engineering standards and codes. The purpose of the information is to provide the client with a minimum of information, in order to direct his attention to the importance of certain construction details for a trouble-free operation of the unit.
The information is a service to our customers, it is free of charge and with no warranty of any kind.

The internals of a typical molecular sieve vessel in an adsorption unit are as follows:

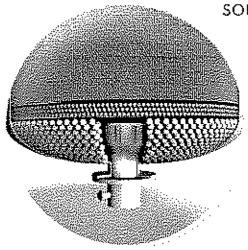
Note: The following numbers correspond to the number on the vessel model shown on the right.



Schematic of typical molecular sieve vessel elevated support system

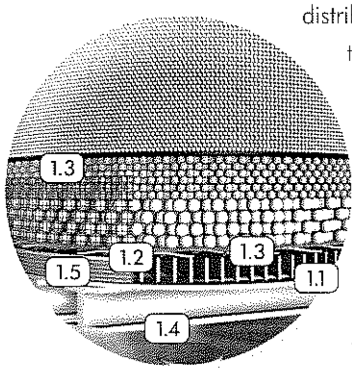
1 Bed support systems

In principal two types of bed support are used in adsorption units, the **elevated support system** and the **bottom head support** system. Typically the **bottom head support** is used in lined or internally insulated vessels, where an elevated support is difficult to design. In such cases ceramic balls of gradually decreasing sizes are stacked, beginning from the bottom up to the desiccant bed. The bottom distributor is usually protected from plugging by using a mesh basket within the distributor nozzle or by covering the distributor with mesh.



Bottom head support

As the bottom head support is used rather rarely in adsorption units the following description refers to the **elevated support system**.
The elevated support system utilizes a system of aligned screens (1.2, 1.3) of decreasing mesh-size above a support grid (1.1).



Elevated support system

In order to withstand static load and the dynamic load caused by the pressure drop over the bed, the grid and screen system is usually supported by beams (1.4) that are connected to the vessel wall. A different fine mesh size is recommended for each adsorbent bead size, as shown in the following table.

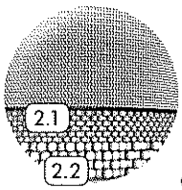
Adsorbent bead size mm	US Mesh Range	Max. fine mesh size (1.3) mm	inch	Max. fine mesh size (1.3) in Tyler
0.8 – 2	10 x 20	0.59	0.022	28
1.6 – 2.5	8 x 12	0.84	0.033	20
2.5 – 5	4 x 8	2.0	0.079	9

The fine mesh (**1.3**) should be positioned so that its edge runs 150 mm (6") up the vessel and fits snugly against the vessel wall (ideally it should be clamped against the vessel wall).

The coarse mesh (**1.2**) should be selected to provide sufficient support to the fine mesh (**1.3**).Typical openings for coarse meshes are 3-5 mm (Tyler 7- Tyler 4).

An alternate to grid and screen type support is the Vee-wire screen or Johnson screen, which is also used for this purpose in adsorption units.

It is extremely important to ensure that there are no holes in the meshes or gaps between the support grid/screen and the vessel wall. Holes have to be patched with the appropriate mesh while the gaps must be properly sealed, with an asbestos-free fireproof ceramic rope material (**1.5**), so that adsorbent particles cannot fall through.

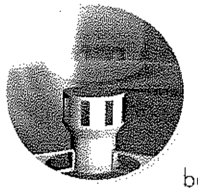


2 Ceramic balls

The use of ceramic balls above the screen not only minimizes the possibility of adsorbent breakage and dust formation but also significantly improves the gas distribution over the adsorber bed. Two layers of ceramic balls, each 100 mm (4") high, are normally placed above the screen.

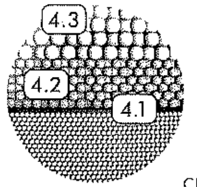
The ceramic balls should be selected such that their size is no larger than twice the size of the material being supported (e.g. in case we have to support a bed of a molecular sieve with a bead size of 1.6-2.5 mm then the upper layer (**2.2**) of inert balls would have the diameter of 3 mm (1/8") while the lower layer (**2.1**) would have a diameter of 6 mm (1/4").

The ceramic balls should not contain any toxic or hazardous material, which might have any impact on the health of the operating personnel. Further, they should not contain any materials which could contaminate the supported molecular sieve. In addition, inert balls should have a high thermal shock resistance to withstand adsorption, regeneration, depressurising. They should have low attrition tendency and high crush strength. Grace Davison can offer ceramic balls fulfilling all the above criteria.



3 Inlet and outlet distributors

These are strongly recommended to ensure proper distribution of the process fluid or the regeneration gas before it reaches the bed. If distributors have not been or cannot be installed, top layers of ceramic balls are mandatory. The distributors or the piping opening should be covered with the same size mesh as recommended above under section 1 to prevent molecular sieve leaving the vessel in the case of support failure or bed lifting.

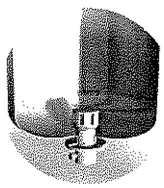


4 Top ceramic ball layers with wire mesh.

The wire mesh (**4.1**) above the molecular sieve is usually used to prevent a mixing of the molecular sieve with the inert balls above it. The size of the mesh is the same as the fine mesh (**1.3**) of the bottom section.

Heights of the two ceramic ball layers (**4.2**, **4.3**) as well as the size selection follow the rules outlined under section 2.

The top ceramic ball layers are mandatory when the clearance between the top inlet nozzle and the top of the adsorber bed is lower than 0.5 m (20"). Their main purpose is the improvement of the downflow fluid distribution.

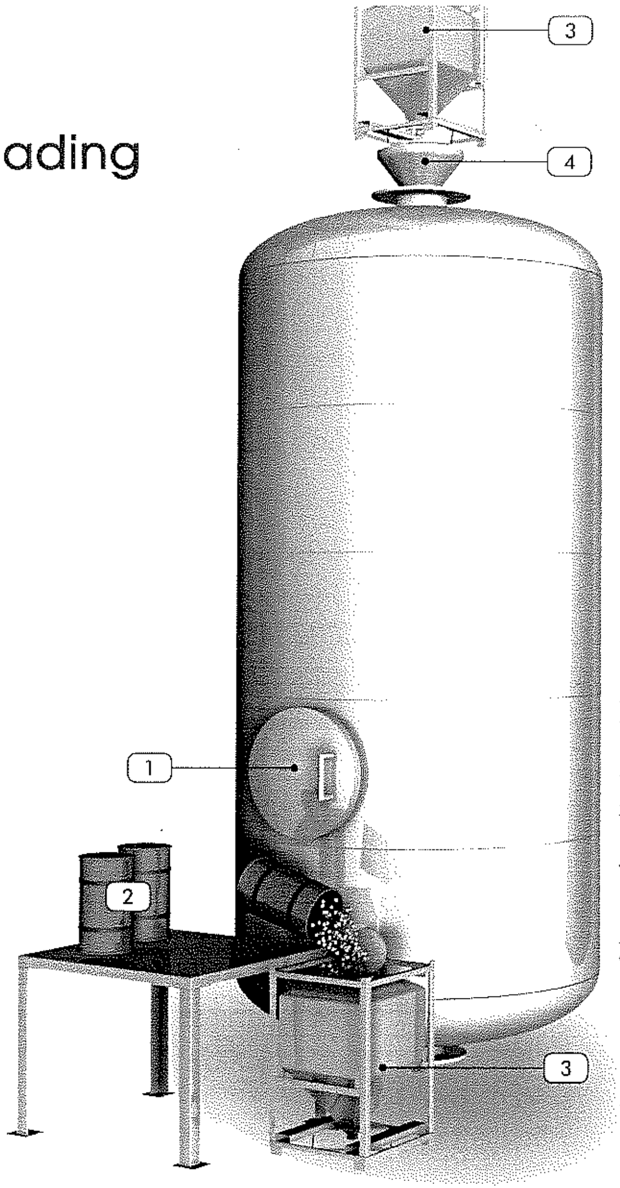


5 Sample points

Inlet (**5.1**) and outlet (**5.2**) sample points are better located at the inlet and outlet piping connected to the adsorber vessel. At least one additional sample point (**5.3**) is always located on the vessel within the adsorbent bed and should be covered inside with wire mesh.

For adsorbers with a second guard bed section this sample point or an additional sample point should be installed in the vessel space between the two beds. In case no space has to be considered between main und guard bed the sample point can be installed within the bed. For the definition of the position please contact our Technical Customer Service.

Vessel Loading



Schematic of vessel loading with drums

1. There are three common methods of loading: from pneumatic truck, drums, and big bags.

Pneumatic loading is covered in a separate leaflet. The loading needs to be carried out by properly trained personnel in full compliance with all safety regulations and loading procedures of the site.

2. The plant manager and the safety engineer are responsible for the following of all local and plant safety regulations. Also within their responsibility is the isolation of the vessel from sources of hazardous materials or energy by installing blind flanges to all inlet and outlet nozzles and decoupling the related pumps and compressors and instrumentation. Furthermore the vessel should be adequately punged and ventilated.

The team to perform the loading has to be informed about the nature of molecular sieves and to be equipped with the appropriate protective equipment including gloves, long sleeves and pants or coveralls, safety glasses or face shields, dust masks or respirators. Adsorbents exposed to water, due to heat of adsorption, can become very hot and alkaline (pH>7) **therefore any contact with moist skin, with eyes or any mucous membranes should be avoided** (refer also to the Technical Information "Unloading of adsorbent").

3. Before loading the vessel the plant supervisor or unit manager is responsible for ensuring that the bottom mesh and ceramic ball layers are in a satisfactory condition, and installed correctly so that no molecular sieve or ceramic balls can fall into the bottom of the vessel *(see Technical Information: Configuration of Vessel Internals)*.

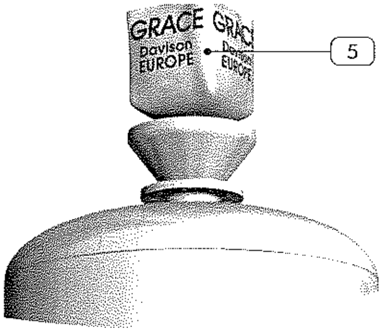
If a change to a smaller particle size is made, the bottom mesh should be checked to ensure that it is the correct size. When installing a new mesh it is advisable to check that it has the correct opening by placing a small amount of adsorbent on it and observing if any particles fall through. If they do, a smaller mesh size must be used.

4. Once the ceramic balls have been checked or installed, the bottom manhole (1) can be closed and secured. The loading can now begin.

5. When carrying out a loading with drums (2), the ventscrew on the drum lid should be loosened to equalise any pressure differential to atmosphere in the drum before trying to remove the lid. A hopper (3) is normally used with a bottom outlet pipe fitted with a sliding plate closure, when loading from drums.

A platform is erected that is slightly higher than the top of the hopper. The drums are then emptied directly into the hopper. If there is a possibility of rain the hopper should have a top cover and the hopper loading site roofed over with tarpaulin.

6. The hopper is then lifted with a crane over the top manhole and the sliding plate removed (4) to allow the adsorbent to run into the vessel. Unless the manhole is small no funnel is required. Due to the high mechanical stability of the spherical form of Grace Molecular Sieves, no sock is needed inside the vessel. The beads can be allowed to freefall from the top manhole. Where rain is possible the manhole should be kept covered when the



Schematic of vessel loading with big bags

hopper is not directly over it. If the vessel has a side man hole a sock should be attached to the hopper discharge long enough to guide the molecular sieve into the vessel.

7. For big bag loading (5), before lifting the bag, the inner liner should be fastened to the outer bag. This can be done by opening the Velcro or string fastening at the top of the bag, and pulling the inner liner through. The fastening should then be retied below the knot in the inner bag. In this way the inner liner should not slip through when the molecular sieve is removed from the bag. The big bag can then be lifted by crane.

Care must be taken to ensure that the crane lifting gear is securely attached to the bag and cannot slip. The bag is then positioned over the top manhole. The bottom Velcro or string attachment is unfastened, and the two wire fasteners removed. The inner lining is pulled through the opening and its end cut, to allow the molecular sieve to free-flow into the vessel directly, or via a hopper. In adverse weather it may be necessary to delegate more personnel to help with the loading or a decision should be made to halt the loading until the weather improves.

8. A responsible person should be delegated to count the number of drums or bags to ensure that the correct amount is loaded and in the correct order if more than one type of adsorbent is to be loaded in a vessel.

9. It is NOT allowed for someone to be inside the vessel during the loading. If several types of adsorbent are to be loaded in one vessel, each layer of adsorbent should be levelled after it has been loaded. The operator performing the levelling should NOT go into the vessel WITHOUT safety harness and rope (anchored to the vessel nozzle). The operator should also follow site safety guidelines regarding breathing apparatus. Two additional operators have to watch him during the levelling process. Also, after the final layer of adsorbent has been loaded the top of the bed should be levelled. The top screen and ceramic balls can then be installed where necessary. The vessel must then be put in a safe and correct condition for start-up or stand-by.

Start-Up

Check with the responsible client safety engineer whether all client safety issues have been considered.

1. Check that all manholes are securely closed, all sample valves are shut and that all blinds have been removed.

2. If the unit is not to be put on stream immediately, the vessel should be purged and then isolated.

3. Purge if necessary. For dehydration units a preliminary regeneration is not normally necessary (even when pneumatic loading has been used) unless ppm levels of the constituents of air in the product stream (CO_2/N_2/O_2) will interfere with downstream processes.

For sweetening or CO_2 removal units a preliminary regeneration should always be carried out.

4. Check the liquid level in the upstream separator and if required drain the vessel before start-up.

5. Bring the required vessel on stream and monitor the product quality. Note that on dehydration units it will take some time for downstream pipework and sample lines to dry out. If the regeneration circuit is wet, the adsorbent bed may not be fully regenerated until this has dried out.

Normally, units meet specification on the first cycle, but in exceptional cases several adsorption/regeneration cycles may be required before the specification is reached.

On cryogenic units where low dewpoints are required it may take more than a day before the hygrometer registers correctly.

6. Set adsorption, heating and cooling times according to the design.

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→ Unloading of Adsorbent

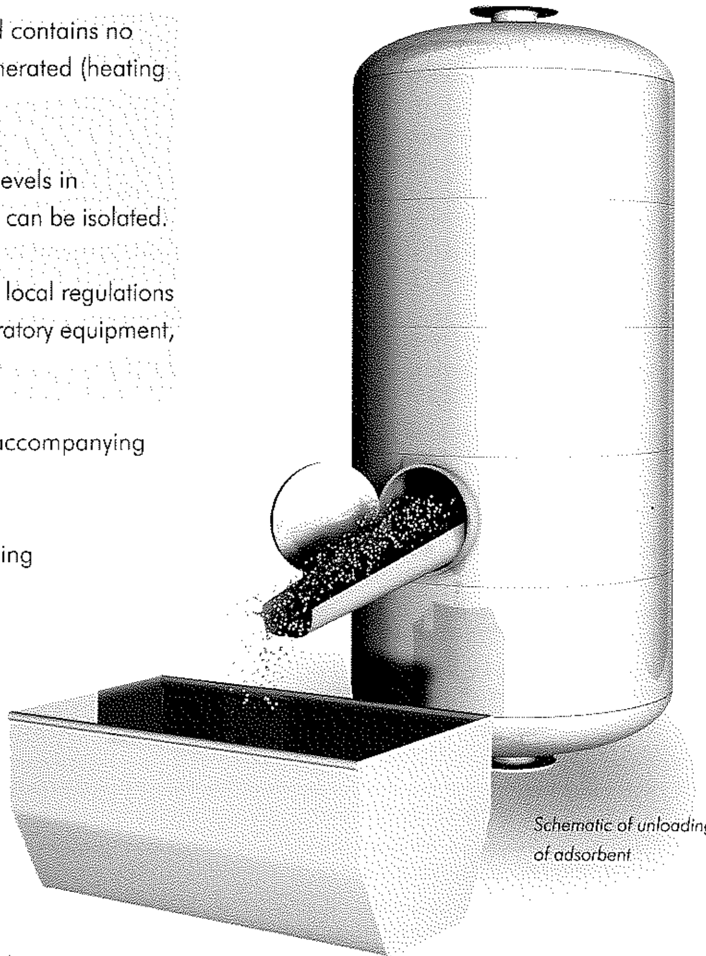
1. Unless the user is absolutely sure that the adsorber bed contains no hazardous components, the adsorbents bed must be regenerated (heating and cooling) thoroughly before purging.

2. The vessel is then purged with inert gas to permissible levels in accordance with local safety regulations. After this the vessel can be isolated.

3. If vessel entry is required this must be in accordance with local regulations (personnel protective equipment including appropriate respiratory equipment, safety harness etc.).

4. If a top layer of ceramic balls is installed, this and the accompanying mesh must be removed first.

5. There are two commonly employed methods for removing adsorbents. In the first method, a suitable open container or hopper is placed under the bottom manhole and the manhole opened to allow the adsorbent to flow out into the hopper. In case the adsorbent free flow stops do not enter the vessel without consulting the local safety officer on how to proceed.



Schematic of unloading of adsorbent

Because some dust can be generated during unloading, dust masks should be worn. If access is difficult it may be necessary to use a chute to channel the adsorbent into the hopper. The manhole cover should be left hanging from its davit so that it can be pushed too, in order to stop the flow of adsorbent when necessary. When the free flow of adsorbent stops the remaining material in the vessel is raked or vacuumed out.

6. An alternative method is to vacuum the adsorbent out. This requires that a man be in the vessel the whole time, which involves specific site safety considerations. These safety regulations must be adhered to with regards to correct personal protection and working methods when performing this type of unloading.

7. Please note that the unloaded material can be active and will generate significant amounts of heat when brought into contact with liquid water. Moreover, liquid water in contact with molecular sieve will be alkaline (pH > 7) and therefore direct skin contact should be avoided. In addition, liquid water can also cause the release of hazardous compounds from the adsorbent.

Note:

The above guidelines contain safety recommendations. These are not meant to be exhaustive and local safety regulations should always be implemented. *If in doubt consult the local safety officer.*

CLEAN-IN-PLACE (CIP)
VALVE SEQUENCING DESCRIPTION

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APPROVAL

Name	Title	Date of Approval
		24 May 2007
		24 May 2007
		18 September 2007

REVISION HISTORY

Revision	Date	Description of Revision	Revised By	Approved By
0	05/25/2007	Original Issue	DML	GCG & TC
1	06/26/2007	Revised CIP Capacities & Pinning Chart	DML	GCG
2	09/19/2007	Revised Format, Procedures & Pinning Charts	DML	KD, CJB
3	10/10/2007	Minor revisions	DML	

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Table 1: Summary of CIP Sequences

SEQUENCE #	SEQUENCE NAME	SEQUENCE DESCRIPTION
1	Normal Operation / Stillage Drain	During Normal Operation prepare for CIP procedures. Pump down levels within Reboiler or Evaporator liquid reservoirs to minimum level heights.
2	Water Flush	Flush stillage or syrup from processing system (Transfer to Syrup Tank, Thin Stillage Tank, Whole Stillage Tank or Process Condensate Tank) / Rinse with water. Details on where fluid is to be transferred in available in respective section.
3	Caustic Addition	Shut off system discharge. Charge recirculation pipe wortk with anti-foam agent. Introduce caustic CIP solution to processing system - Always use fresh caustic during a DD&E CIP Procedure.
4	Caustic Recirculation & Boil-Out	Recirculate caustic CIP Solution within processing system. Make-up for evaporation losses with water when desired caustic concentration within processing system is achieved (5% NaOH).
5	Caustic Dilution	Flush caustic from processing system: Step 1) Introduce lesser flush flow rate to concentrate caustic NaOH fluid and send to CIP Drain when NaOH is less than 1%. Step 2) Increase water flush flow rate and transfer dilute fluid to alternate location (Thin Stillage Tank, Whole Stillage Tank, etc.).
6	Stillage Fill / Normal Operation	Raise levels within Reboiler or Evaporator liquid reservoirs / Return to Normal Operation

CLEAN FREQUENTLY TO PREVENT BUILDUP OF FOAM FORMING DEPOSITS

USE ONLY CLEAN CAUSTIC

KEEP LIQUID LEVELS LOW DURING CLEANING

ALWAYS DILUTE THE EVAPORATOR CONTENTS TO WELL BELOW **1%** TOTAL SOLIDS

SECTION 1

Introduction

Clean-in-place (CIP) is used to clean pipes and tanks or wherever the potential for stillage to foul heat transfer surfaces may exist. Its chief advantage is that it assures clean surfaces without disassembly. A typical CIP process involves dissimilar solutions traveling through vessels and pipe-work of the processing system in a deliberate and sequential manner. It is important to regularly perform CIP operations to limit the time and expense of cleaning.

TK DD&E (Distillation, Dehydration and Evaporation) Units employ the use of an integrated CIP design which combines both circulation and spray clean-in-place methods; this concept can accomplish CIP at minimal cost and is highly effective. Certain vessels and piping within the DDE require cleaning in place. TK CIP operation may be performed while the units are functional. The following narrative describes recommended TK CIP operations which covers highly manual and interactive procedures including valving, bypassing, and defining of process variables.

Cleaning of heat transfer surfaces is necessary to remove stillage solids left by evaporation. A high pressure CIP supply is used and the spent CIP returned to the CIP return header with other spent CIP. While cleaning takes place, the spent solution is collected separately from the stillage concentrate. Spray Balls are installed in each Separator, one above and one below the mist eliminator.

The operation of CIP system requires knowledge of several factors:

- Fluid Flow Rates
- Temperatures
- Pressures
- Dilution & Cleaning Times
- Concentrations of Process Fluids
    - Percent Total Solids (%TS) → halogen moisture meter
    - Sodium Hydroxide Concentration (%NaOH) → acid base titration (clean fluid) or pH (unclean fluid)
- Tank Inventory / Capacity
    - CIP Supply Tank
    - CIP Waste Tank
    - Thin Stillage Tank
    - Syrup Tank
    - Condensate Tank

The concentration of clean sodium hydroxide solution can be determined by an acid-base titration. This method will not work for contaminated caustic solution that has been introduced to the processing system since acid base titration requires a nearly transparent solution. Litmus paper may be also be used to measure the pH (which is related to the sodium hydroxide concentration) of an unclean liquid containing caustic solution.

CIP overview

The table below clarifies the DD&E areas that require cleaning with caustic solution.

Table 2: DD&E Areas to Realize CIP Cleaning

AREA TO BE CLEANED	FREQUENCY	NOTES
Beer Column Reboilers	**Frequent** Boil out H_2O weekly CIP w/ NaOH 1 x / month	Controls to be switched
Evaporation Area	**More frequent** Boil out H_2O weekly CIP w/ NaOH 1 x / 2 weeks	
Beer Preheater	**< 2 Days**	
Beer Column and Flash Tanks	**Bi-annually**	Only *during* shutting-down

How To Know When To Perform CIP Procedures

When to perform CIP procedures is determined by monitoring the system operating parameters. The fouling of heat transfer surfaces is accompanied by an increase in differential pressure or temperature across a heat transfer surface. It is essential to accurately monitor this delta P or T via electronic instrumentation.

BEER PREHEATERS:

TEMPERATURE OF FEED TO BEER COLUMN DECREASES
If the heat transfer surface of a Beer Preheater is fouled, the temperature of the beer fed to the Beer Column will decrease. If the Beer Column feed temperature decreases, it will require more steam (introduced to the Rectifier Column Reboiler) to strip out the ethanol from the beer. Inadequate separation of ethanol from the beer within the Beer Column may be indicated via the pressure transmitter located at the bottom of the Beer Column. If all of the ethanol within the beer feed is not stripped out, then the pressure within the bottom of the Beer Column will drop slightly.

CO_2 IN BEER COLUMN
Consequences → Gas in the condensers. Foaming in the Beer Column feed zone trays. CO_2 will increase vapor traffic and thus increase the pressure drop for the same boil-up rate. CO_2 carries over to the Rectifier Column with similar consequences. The capacity of the system is reduced by the increase of CO_2 in the beer feed.

REBOILERS & EVAPORATORS:

LARGER DELTA T AND P FOR THE SAME ENERGY INPUT
Usually this is seen by an increase in condensing pressure on the heating side of the heat exchanger. The vapor flow from the Reboilers will not drop and the energy level will remain about the same, but the delta T and P will increase. Indicates fouling of the heat transfer surfaces since a larger temperature difference is required to provide the same rate of heat transfer.

HIGHER SHELL SIDE VAPOR CONDENSATE TEMPERATURE
This could also indicate fouling exchanger surfaces or a corresponding rise in the process side due to an increase in the pressure at the bottom of the column.

DD&E Area Energy Integration Overview

The following text aims to clarify how the Beer Column Reboilers and Evaporators interact with the entire DD&E process and how it is possible for these separate components to maintain CIP operations while the entire DD&E Unit remains functional.

As part of the ethanol process, water, enzymes, and corn are cooked and combined into large fermentation tanks. When the fermentation part of the process is complete these tanks are first pumped out to the beer well and then transferred to the distillation system to separate the ethanol from stillage, or by-product. Spent solids (whole stillage) are discharged from the bottom of the first distillation column (Beer Column). The slurry is transferred to the tube-side of the Beer Column Reboilers (ET-4104 and ET-4103). Whole stillage is typically de-watered to produce animal feed; a preliminary step in the de-watering of whole stillage takes place within the Beer Column Reboilers. Vapors from a second distillation column (Rectifying Column) as well as uncondensed 200 proof ethanol discharged from the Molecular Sieve Area are directed to the shell-side of the first and second Beer Column Reboilers, respectively; the heat recovered from these two vapor streams provides the energy to evaporate water from the whole stillage within the tube-side of both reboilers. The operation of the first distillation column (Beer Column) is dependent upon the water vapor evaporated from the whole stillage.

To continue the de-watering process, the concentrated tube-side Beer Column Reboiler discharge is first transferred to a Whole Stillage Flash Tank to recover any available heat (which is recovered by the evaporators) and then introduced to a solid bowl decanter centrifuge which separates the feed stream according to density into a decanted cake (the “heavier” substances) and thin stillage. The thin stillage (or centrate) is then transferred to the tube-side of an arrangement of Evaporators which concentrate the solids into a distiller’s syrup (the syrup is subsequently added to the decanted cake and sent to a dryer). Heat from the Beer Column overhead vapors is recovered to Evaporators; the overhead vapors are condensed within the shell-side of these evaporators before being fed to the Rectifying Column.

Summary of DD&E Areas to Be Cleaned

The following are details of the various cleaning procedures that are required for TK DDE systems. The CIP time will depend on the degree of fouling in the vessels and exchangers. If cleaning is neglected, the product has the potential to be burnt on hard to heat transfer surfaces which may require mechanical cleaning. The efficiency of the entire ethanol production process relies upon effective heat transfer surfaces to realize the benefits of TK’s highly integrated energy management system.

Beer Preheaters EP-4113 A & B

Two units are supplied so that one can realize CIP operations while the other is operational. The unit to be cleaned should be isolated from the process fluid and the steam supply. The exchanger can then cleaned using the CIP circulating pump and appropriate CIP valving procedures clarified in the Beer Preheater section of the appendix.

Reboiler Cleaning

Cleaning will be achieved in the aforementioned CIP sequences (Table 1). With steam and process recirculation maintained on all heat exchangers, the beer bottoms flow from the Beer Column will be diverted directly to the Whole Stillage Flash Tank (TP-4212). The Stillage Drain sequence entails lowering liquid levels within all the Reboilers to expedite cleaning. At the time liquid levels are at minimum heights, rinse water will be introduced to the spray balls on the Separators and to the recirculation pipe work. Liquid containing whole stillage and water will be flushed from the pipe work and will be discharged to the Whole Stillage Flash Tank. When the percentage of total solids within the processing fluid is at minimal level (less than 1% total solids), the Caustic Addition sequence will begin which entails first introducing an anti-foaming agent to the processing sytem, followed by introducing **clean caustic CIP solution** to the system while recirculating instead of discharging liquid from the Reboiler area (anti-foam addition will be optimized during start up or initial CIP procedure). Caustic CIP solution will be added to the processing system at a low NaOH concentration (~3% NaOH) and will concentrate within the processing system. The Reboilers will remove water from the caustic cleaning fluid, via vaporization, which results in the NaOH concentration to increase within the evaporation area. When the NaOH concentration has equilibrated to a desired caustic concentration (5% NaOH), the Caustic Recirculation sequence will begin and the recirculation pipe work will continue to circulate the processing fluid throughout the Reboiler area and water will be introduced to the processing system to make up for evaporation losses and prevent over concentration of NaOH within the evaporation area. After a certain duration of time, the Caustic Recirculation sequence will end and the Caustic Dilution sequence will begin. The Caustic Dilution sequence involves opening the liquid discharge from the Reboiler area and transferring the caustic CIP solution within the pipe work to discharge to the CIP Drain for a duration of time followed by discharging the dilute caustic CIP solution to another location after the NaOH concentration is low (less than 0.5% NaOH). The Caustic Dilution sequence includes two steps: 1) First, introducing a lesser water flush flowrate to the system to concentrate the caustic NaOH while transferring the fluid to the CIP Drain for a duration of time until the NaOH has reached <0.5% NaOH; and 2) increasing the water flush flowrate to further dilute the NaOH within the cleaning fluid all while transferring the diluted fluid to a separate location (Whole Stillage Flash Tank, for the Reboilers). **All spent caustic from the Reboiler system should be sent to the fermentor CIP operation and only fresh caustic should be used.** When the Reboiler pipe work is sufficiently flushed with water, level heights may be raised and preparation for normal operation may begin.

Double Effect Evaporator

Cleaning will be achieved in the aforementioned CIP sequences (Table 1). With steam flow and process recirculation maintained on all heat exchangers, the thin stillage feed to the Evaporators will be bypassed back to the Thin Stillage Tank. The Stillage Drain sequence entails lowering liquid levels within all the Evaporators to expedite cleaning of the area. At the time liquid levels are at minimum heights, rinse water will be introduced to the spray balls on the Separators and to the recirculation pipe work. During rinsing, it will be possible for a time to chase out solids while at the same time producing an acceptable syrup concentration. Water will be flushed from the pipe work and processing fluid will be discharged to the Syrup Tank for a given amount of time and then the dilute mixture will be introduced to the Thin Stillage Tank for duration of time. When the amount of total solids within the processing fluid is at minimal level (less than 1% total solids), the Caustic Addition sequence will begin which entails first introducing an anti-foaming agent to the processing sytem, followed by introducing **clean caustic CIP solution** to the system while recirculating instead of discharging liquid from the Evaporation area (anti-foam addition will be optimized during start up or initial CIP procedure). Caustic NaOH should never be introduced to the spray balls located above the mist eliminators within the Separators; only water should ever be transferred through these spray balls. Caustic CIP solution will be added to the processing system at a low NaOH concentration (~3% NaOH) and will concentrate within the processing system. The Evaporators remove water from the caustic cleaning fluid, via vaporization, which results in the NaOH concentration to increase within the evaporation area. When the NaOH concentration has equilibrated to a desired caustic concentration

(5% NaOH), the Caustic Recirculation sequence will begin and the recirculation pipe work will continue to circulate the processing fluid throughout the Evaporation area and water will be introduced to the processing system to make up for evaporation losses. After a certain duration of time, the Caustic Recirculation sequence will end and the Caustic Dilution sequence will begin. The Caustic Dilution sequence entails opening the liquid discharge from the evaporation area and transferring the caustic CIP solution within the pipe work to discharge to the CIP Drain for a duration of time followed by discharging the dilute caustic CIP solution to another location after the NaOH concentration is low (<0.5% NaOH). The Caustic Dilution sequence includes two steps: 1) First, introducing a lesser water flush flowrate to the system to concentrate the caustic NaOH while transferring the fluid to the CIP Drain for a duration of time until the NaOH has reached <0.5% NaOH; and 2) increasing the water flush flowrate to further dilute the NaOH within the process fluid all while transferring the diluted fluid to a separate location (Thin Stillage Tank). **<u>All spent caustic from the evaporation system should be sent to the fermentor CIP operation and only fresh caustic should be used.</u>** When the evaporator pipe work is sufficiently flushed with water, level heights may be raised and preparation for normal operation may begin.

<u>It is necessary to open the drain/bypass vale that connects the two sumps within the vessel prior to the start of cleaning; this valve should only be closed after cleaning after levels are raised to heights associated with normal operating conditions.</u>

Distillation Columns and Flash Vessels Cleaning

It is not anticipated that the Rectifier Column will ever need to be cleaned, and it is probably best not to deliberately introduce caustic into this column. There may of course be some carryover of caustic from the beer still during cleaning.

Vessels TP-4112 and TP-4113 each have one spray ball. There is no recirculation. At shut down the vessels should be rinsed using the spray balls. Since there is very little hold up and no recirculation in these vessels, the rinse time will be relatively short (estimated 30 minutes). The rinse would then be followed by a caustic rinse CIP probably for about 30 minutes. This would be followed by a water rinse. CIP liquids will be returned in the mash return line, since there is no liquid outlet connection to the TK DDE system.

Vessel TP-4207 should be cleaned at the time of a general shut down. CIP fluid return should through the 2 effect evaporator.

The cleaning of the TP-4105, TP-4212 and ET-4105 should be performed in conjunction with the cleaning of the Beer Column. In order to improve the cleaning of the Beer Column, it is necessary to operate the column with about 40% of steam on the Rectifier Column Reboiler; this can be done during shut down. An initial rinse of the system is need with water going to the spray balls on TP-4105, TP-4212 and ET-4105, as well as additional water supplied through the beer feed line. The discharged rinse water should be returned to the Thin Stillage Tank via the centrifuges to remove large particles. The rinse time is predicted to be in the range of 30 to 60 minutes. After rinsing, CIP solution should be sent to the three spray balls as well as to the beer feed line. The CIP solution would then be a one pass flow through the flash vessels before being returned to the CIP system for filtration and recirculation. The cleaning time estimate is 60 minutes on caustic. CIP return can be through the reboiler CIP return piping. A final rinse of 60 minutes is estimated.

Note all rinse time will eventually have to be established as part of the plant start up. It will be necessary to sample and evaluate the rinse water over a period of time. For the first rinse the requirement would be to visually see low solids in the outlet liquid. For caustic rinse it will be necessary to evaluate the ph of the liquid. This will indicate when it will be safe to feed forward into the system rather than return to CIP. The times required for these rinses would then be used for future cleanings.

Important Considerations: Foaming

If caustic cleaning solution is introduced into the processing system before the ‘Water Flush’ sequence is completed, foaming may occur. It is necessary to always dilute the heat exchanger contents to well below 1% total solids before introducing sodium hydroxide to the system. An anti-foam agent may be introduced to the processing system after the “water Flush’(prior to introduction of caustic to the system) and before the ‘Caustic Dilution’ sequence which will reduce the amount of foam produced within the heat exchanger. Anti-foam addition will be optimized during start up or the first CIP procedure.

Foaming happens due to a saponifaction reaction which is the same chemical reaction used in the manufacturing of soap. During operation, the proteins within beer, whole stillage or thin stillage concentrate and adhere to the hot evaporator tube surfaces. With time, the proteins and oils (fatty acids) tend to polymerize and degrade. An amorphous type of crystallization and/or condensation buildup grows on the deposits. In the presence of NaOH these solids form sodium salts of esters and fatty acids. This type of compound is very foamy and is retained in the spent caustic in solution. All spent caustic from the DD&E area should be sent to the fermentor CIP operation and only fresh caustic should be used. Foaming will occur more with evaporators that are not frequently cleaned.

SECTION 2

BEER COLUMN REBOILER CIP PROCEDURE

Introduction

Cleaning of the Beer Column Reboilers is achieved by the following sequences:

- **Sequence 1: Normal Operation / Stillage Drain**
- **Sequence 2: Water Flush**
- **Sequence 3: Caustic Addition**
- **Sequence 4: Caustic Recirculation**
- **Sequence 5: Caustic Dilution**
- **Sequence 6: Stillage Fill / Normal Operation**

NOTE:

Please refer to –

Appendix 1: CIE Reboiler CIP Capacities

Appendix 3: CIE Reboiler Area CIP Pinning Chart

Sequence 1: Normal Operation / Stillage Drain

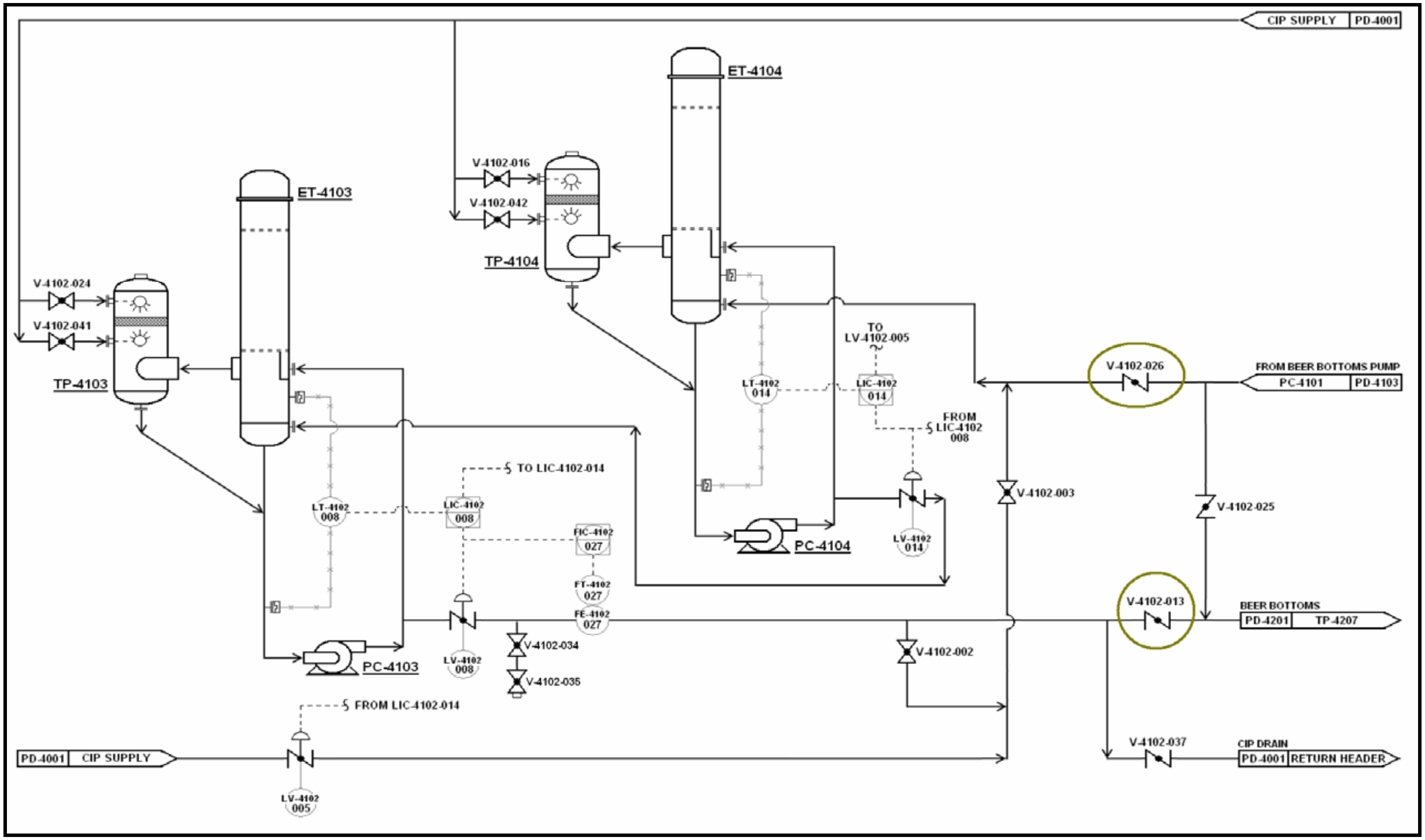


Figure 1: Reboilers – Normal Operation / Stillage Drain – Sequence 1.

Normal Operation

All valves located above and below the mist eliminators on each Separator should be closed. V-4102-002 is closed because stillage should not be recirculated back to ET-4104. V-4102-013 is open to allow whole stillage to be transferred from PC-4103 (RC Condenser / BC Reboiler Recirculation Pump) to the Whole Stillage Flash Tank (TP-4207). V-4102-025 is closed because beer does not normally bypass the Reboilers. V-4102-026 is open to permit whole stillage to be transferred from the Beer Bottoms Pump (PC-4101) to the tube side of ET-4104 (Beer Column Reboiler / 200 Proof Condenser). V-4102-037 is closed because nothing is to be sent back to the CIP drain.

During continuous Normal Operation both Reboilers operate on level control. Level transmitter (LT-4102-008) located on ET-4103 (RC Condenser/BC Reboiler) transmits a signal to level indicating controller (LIC-4102-008) which modulates level control valve (LV-4102-008) to maintain a constant level within the ET-4103 (RC Condenser/BC Reboiler) fluid reservoir. Feed to ET-4103 is controlled by level control in ET-4104. Level transmitter (LT-4102-014) located on ET-4104 (BC Reboiler) transmits a signal to level indicating controller (LIC-4102-014) which modulates level control valve (LV-4102-014) to maintain a constant level within the ET-4104 (BC Reboiler) fluid reservoir.

Stillage Drain

To expedite the cleaning cycle for all applications, it is best to reduce all levels in all Reboilers to the lowest operating level prior to, and during rinsing operations. Levels within ET-4104 and ET-4103 are to be reduced to minimal heights. Minimum levels are to be determined at start-up or at the first CIP procedure. Minimum level heights are to be defined at the first sign of pump cavitation. Noise is one of the indications that a centrifugal pump is cavitating. A cavitating pump can sound like a can of marbles being shaken. Other indications that can be observed from a remote operating station are fluctuating pressure, flowrate, and pump motor current.

Sequence 2: Water Flush

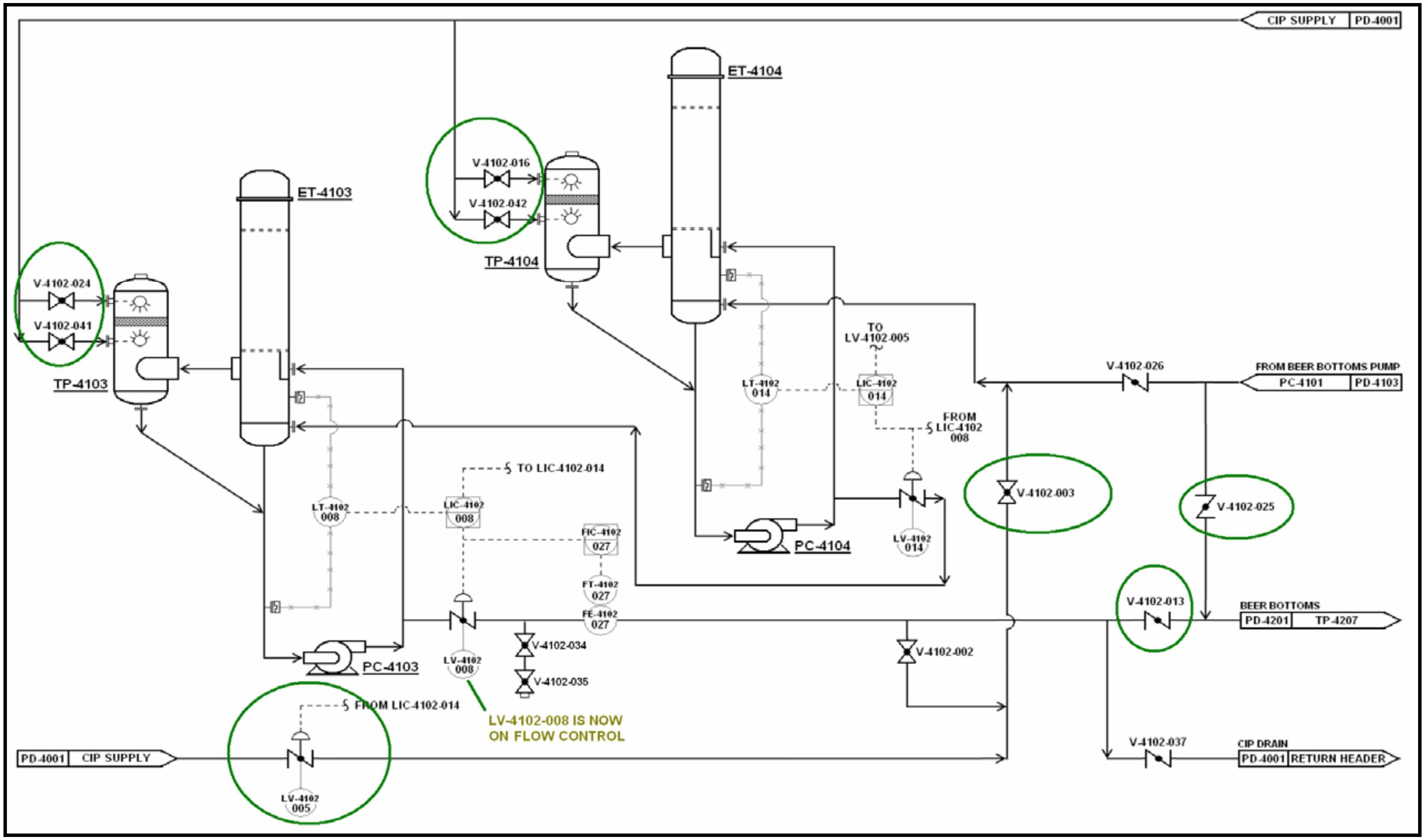


Figure 2: Reboilers – Water Flush – Sequence 2

The purpose of the 'Water Flush' sequence is to adequately remove most of the whole stillages before introducing caustic fluid to the system. The liquid level within both Reboilers should remain at minimum heights as previously described.

All manual valves (V-4102-024, 041, 016 and 042) located on each of the Separators (TP-4104 and TP-4103) should be open. V-4102-002 is closed because stillage and water should not be recirculated back to ET-4104. V-4102-003 is open to allow water to enter the tube-side of both Reboilers. V-4102-025 is to be opened to bypass whole stillage transferred from Beer Bottoms Pump (PC-4101) to the Whole Stillage Flash Tank (TP-4212). V-4102-026 is closed. V-4102-037 is closed because nothing is to be sent back to the CIP drain. Caustic solution is never to pass through manual valves above each Separator's mist eliminator because problems can occur if caustic carries over and contaminates the final product.

Alternate controls are to be administered via the DCS at the beginning of this CIP sequence. Refer to Table 3 which describes the controls that are to be changed at the beginning of 'Sequence 2: Water Flush.'

Table 3: Alternate Controls for Reboiler CIP.

ALTERNATE CONTROL FOR CIP ONLY		
CONTINUOUS OPERATION		**CIP OPERATION**
LV-4102-008 & LIC-4102-008	⟶	LV-4102-008 & FIC-4102-027
	⟶	LV-4102-005 & LIC-4102-014
LV-4102-014 & LIC-4102-014	⟶	LV-4102-014 & LIC-4102-008

Level control valve (LV-4102-014) located on ET-4104 recirculation discharge is modulated by the level transmitter and indicating controller (LT/LIC-4102-008) that is located on ET-4103 (RC Condenser / BC Reboiler). During this CIP sequence level transmitter and indicating controller (LT/LIC-4102-014) communicate with LV-4102-005 which permits the feed flow of CIP or Water Flush to be controlled by the liquid level in ET-4104 liquid reservoir. Level control valve LV-4102-008 is switched to flow control which acts in communication with flow element, transmitter and indicating controller (FE/FT/FIC-4102-027) located on PC-4103 recirculation pump discharge. At the start of this sequence, the operator is to set FIC-4102-027 and monitor the clarity of the water/stillage mixture via sample valves (V-4102-034 & 035). The duration of time recommended for this sequence is provided in Appendix 1. Samples of the process fluid may be taken through sample valves which can be used to monitor the amount of suspended solids within solution and which will be used to validate the duration of this sequence.

Sequence 3: Caustic Addition

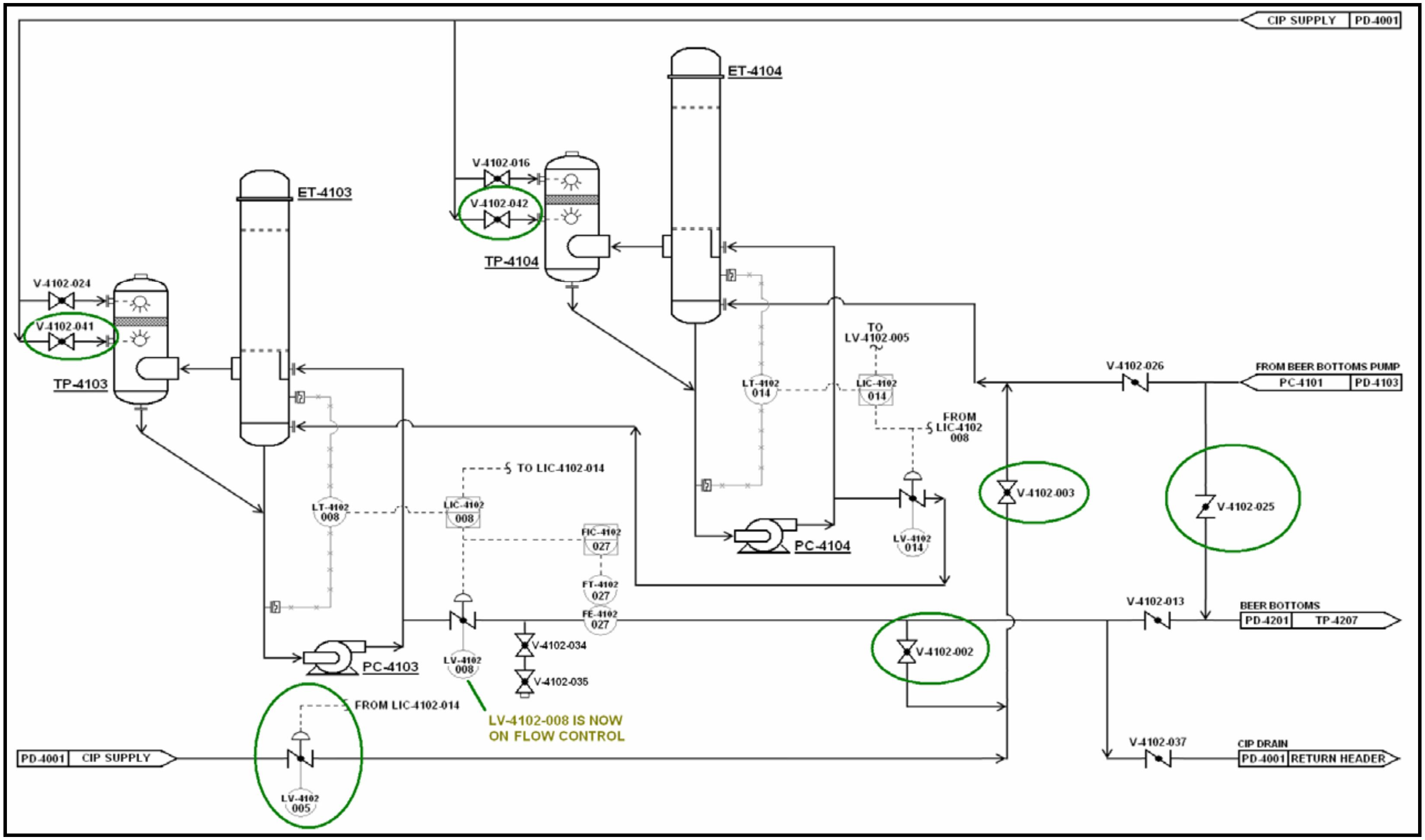


Figure 3: Reboilers – Caustic Addition – Sequence 3

After 'Sequence 2: Water Flush' is complete and the process fluid is reasonably clear of dissolved and suspended solids, Sequence 3: Caustic Addition will begin. The purpose of the 'Caustic Addition' Sequence is to charge the processing system with a low NaOH caustic concentration (~3% NaOH) while recirculating the cleaning fluid within the pipe work. No liquid is to be discharged from the system during this sequence. At the same time, the Reboilers will evaporate water from the caustic cleaning solution traveling throughout its pipe work which will increase the NaOH concentration within the system. When the NaOH concentration has reached a desired NaOH concentration (~5% NaOH), Sequence 3: Caustic Addition sequence will end.

Caustic CIP solution may be introduced to the Reboiler tube sides and to both manual valves located below each Separator's mist eliminators (V-4102-041 & V-4102-042) to transfer caustic to lower spray nozzles. Make sure upper spray ball valves V-4102-024 and V-4102-016 are closed whenever introducing caustic to processing system. V-4102-002 should be open to recirculate caustic while additional caustic is added. V-4102-003 remains open because caustic solution is to be introduced to the tube-side of ET-4104 through the same pipe work as the flush water. V-4102-013 should be closed. V-4102-025 remains open. V-4102-026 remains closed. V-4102-037 is closed to prevent caustic solution from entering the CIP Drain. The sodium hydroxide concentration within the processing system may be determined by litmus paper (determines caustic pH). The liquid level within both Reboilers' reservoirs should be at a minimum height. The duration of time recommended for this sequence is provided in Appendix 1.

Sequence 4: Caustic Recirculation

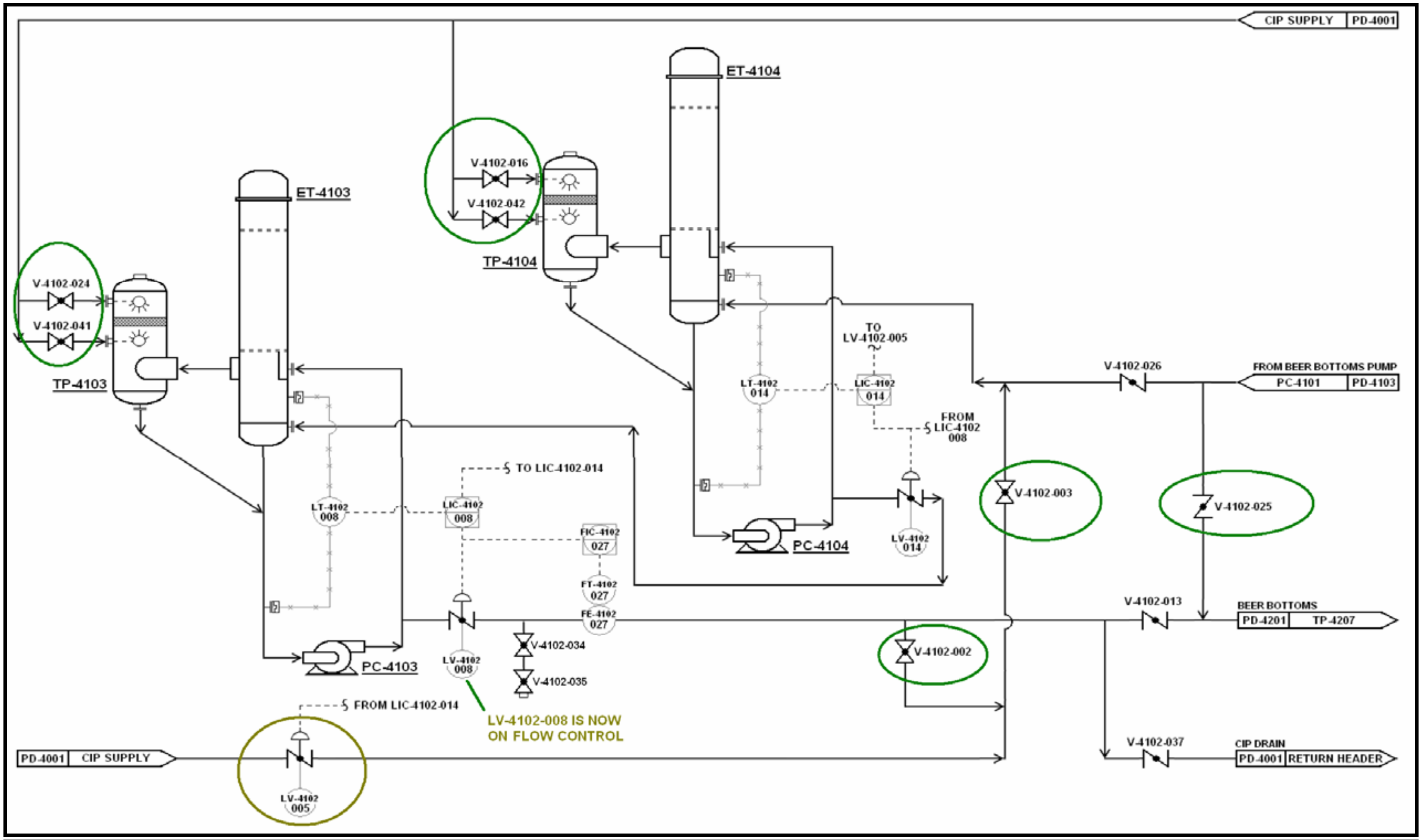


Figure 4: Reboilers – Caustic Recirculation – Sequence 4

During the Caustic Recirculation sequence, the Reboilers are already filled with caustic solution and water will then be used to make up for evaporation losses. The manual valves located above each Separator demister to upper spray balls (V-4102-024 & V-4102-041, V-4102-016 & V-4102-042) should be opened. **It is important to delay the opening of the upper spray-ball valves 5 minutes** after the time water enters the processing system in place of CIP solution; this lag time is crucial to assure that no caustic solution remains in the pipe work before introducing rinse liquid to the upper spray balls above each mist eliminator in each separator. It is important not to use caustic solution to 'make-up' for the evaporation from the Reboilers because the caustic will over-concentrate which can negatively impact the life-span of the chemical equipment due to corrosion. V-4102-037 is to be closed to divert caustic from draining out of the system. All other valve positions are identical to 'Sequence 3: Caustic Addition'. The duration of time recommended for this sequence is provided in Appendix 1.

Sequence 5: Caustic Dilution

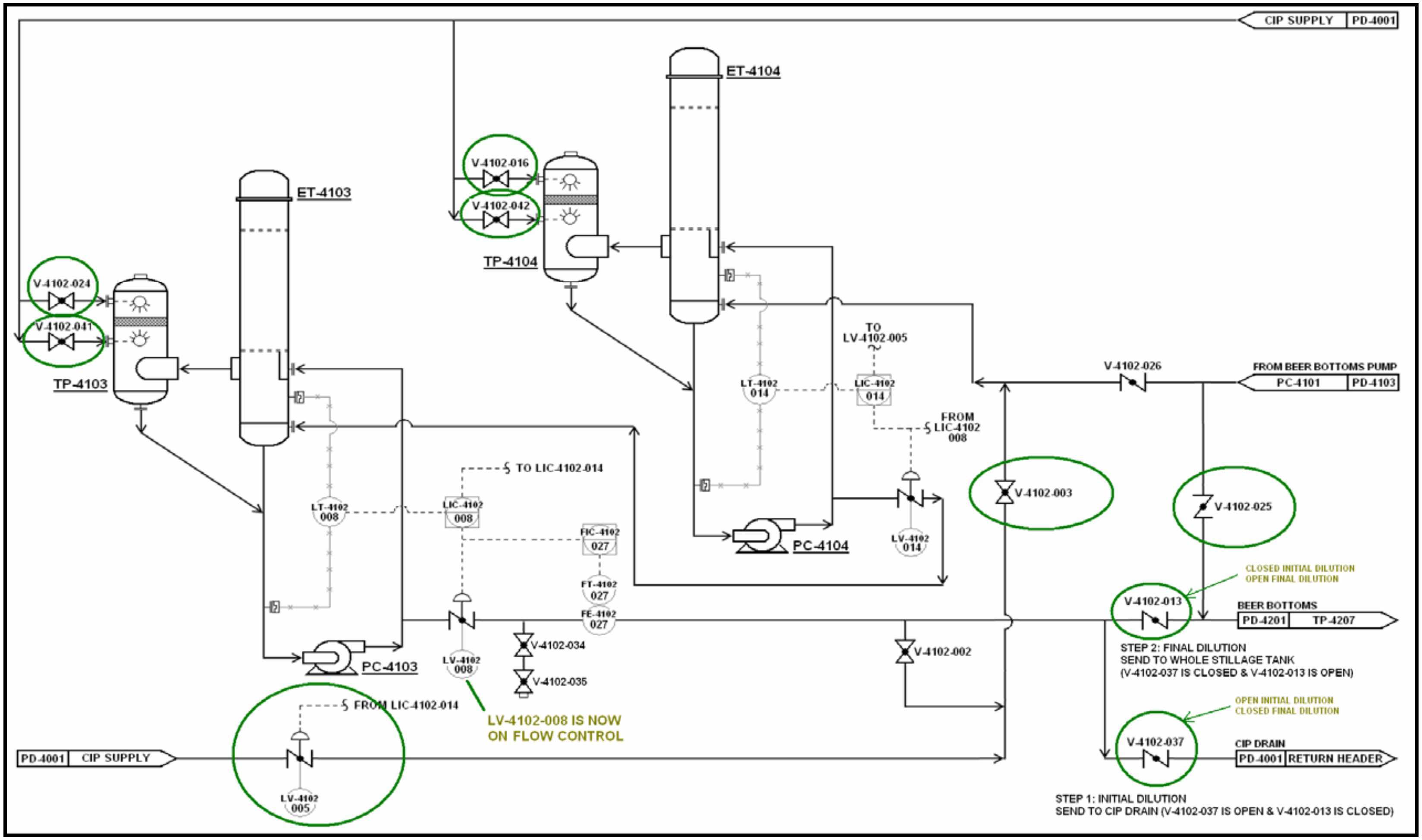


Figure 5: Reboilers – Caustic Dilution – Sequence 5

The purpose of Sequence 5: Caustic Dilution is to flush the caustic CIP solution from the system. The Caustic Dilution sequence involves opening the liquid discharge from the Reboiler area and transferring the caustic CIP solution within the pipe work to discharge to the CIP Drain for a duration of time followed by discharging the dilute caustic CIP solution to another location after the NaOH concentration is low (<0.5% NaOH); The Caustic Dilution sequence includes two steps:

1) Introducing a lesser water flush flowrate to the system to concentrate the caustic NaOH while transferring the fluid to the CIP Drain for a duration of time until the NaOH has reached <0.5% NaOH. When the solution pH is approximately 9.5 the cleaning fluid may be transferring to the Whole Stillage Flash Tank.

2) Increasing the water flush flowrate to further dilute the NaOH within the cleaning fluid all while transferring the diluted fluid to a separate location (Whole Stillage Flash Tank for the Reboilers).

V-4102-002 is to be closed to prevent CIP from recirculating through the Reboiler pipe-work. V-4102-013 remains closed for the first dilution time duration and open for the second dilution time interval. V-4102-025 should remain open. V-4102-026 remains closed to bypass beer to TP-4207. V-4102-037 is to be opened for the first dilution time interval and is closed for the second time interval. The duration of time recommended for each step within this sequence is provided in Appendix 1.

Sequence 6: Stillage Fill / Normal Operation

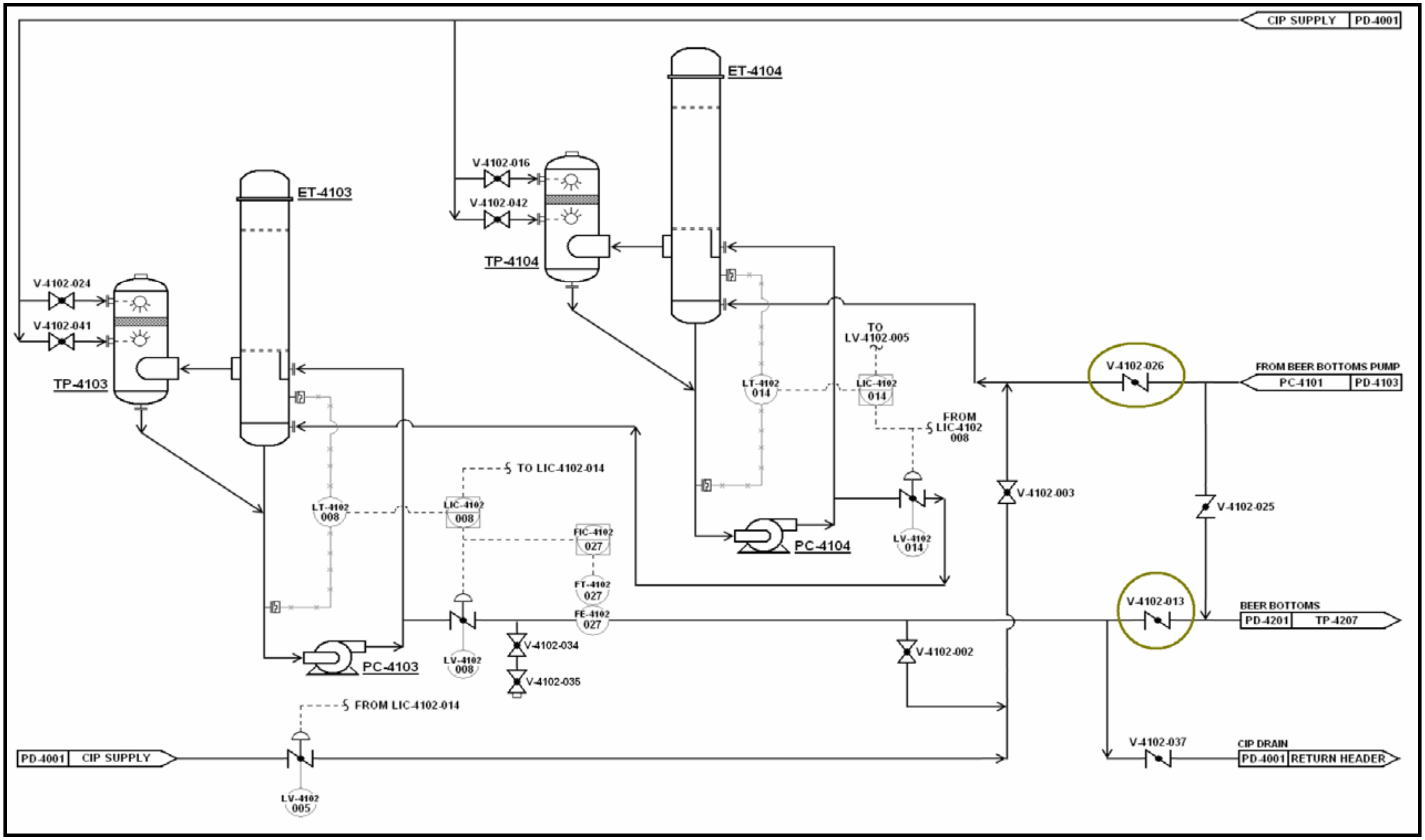


Figure 6: Reboilers – Stillage Fill / Normal Operation – Sequence 6

At the end of the CIP Dilution sequence, Sequence 6: Stillage Fill / Normal Operation may begin. Controls should be switched over from flow control to normal level control.

V-4102-002 should be closed. V-4102-003 should be closed. V-4102-013 should be opened. V-4102-025 should be closed because the Whole Stillage Pump discharge should not be bypassed to the Whole Stillage Flash Tank. Level heights are to be raised to Normal Operating levels. V-4102-026 is to be opened. CIP drain valve V-4102-037 should be closed. All valve arrangements are exactly the same as ‘Sequence 1: Normal Operation / Stillage Drain.’

SECTION 3

Evaporation Area CIP Procedure

Introduction

The following text explains how the cleaning of the Evaporator Area is achieved. CIP valve sequencing occurs in the following sequences:

- **Sequence 1:** **Normal Operation / Stillage Drain**
- **Sequence 2:** **Water Flush**
- **Sequence 3:** **Caustic Addition**
- **Sequence 4:** **Caustic Recirculation**
- **Sequence 5:** **Caustic Dilution**
- **Sequence 6:** **Stillage Fill / Normal Operation**

NOTE:

Please refer to –

Appendix 2: CIE Evaporation CIP Capacities

Appendix 4: CIE Evaporation Area CIP Pinning Chart

Sequence 1: Normal Operation

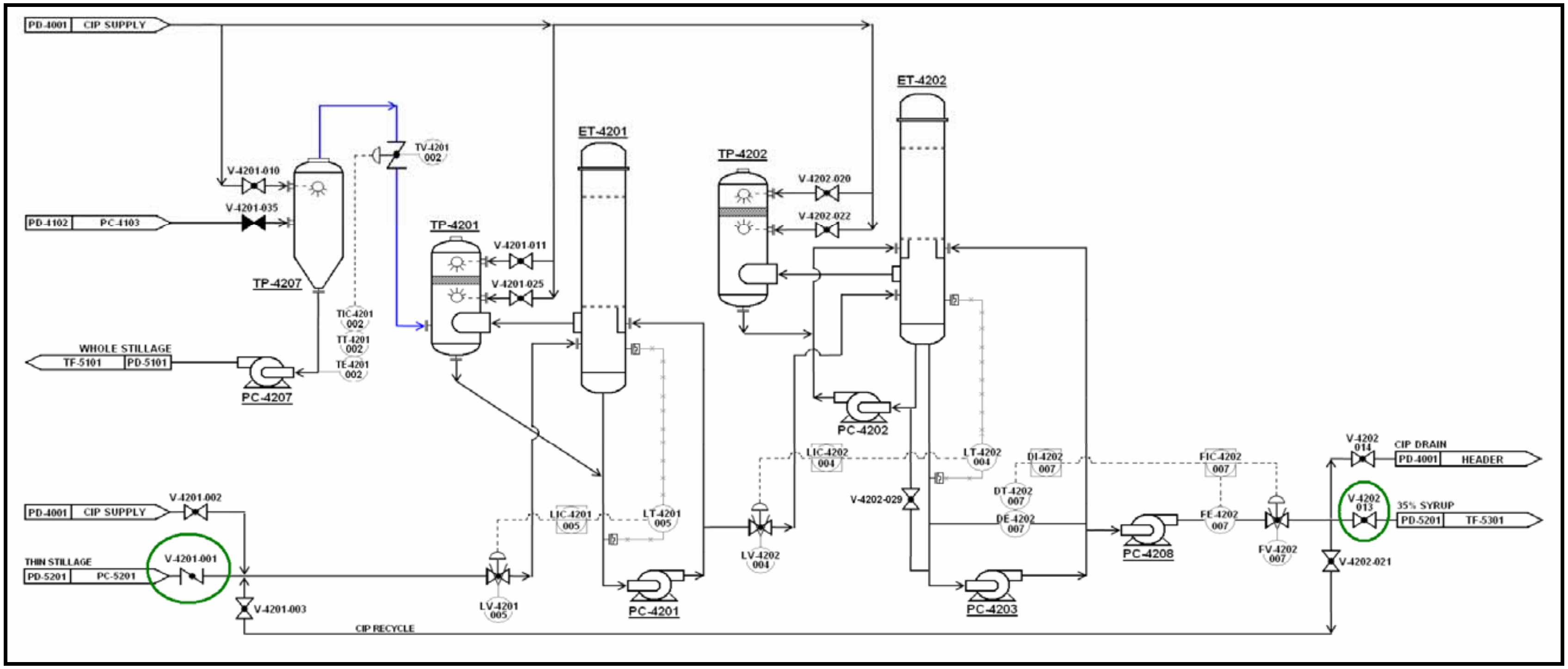


Figure 7: Evaporators – Normal Operation / Stillage Drain – Sequence 1

During Normal Operation V-4201-001 is open to permit thin stillage to be transferred from PC-5201 to ET-4201 (Evaporator 1, 1st Effect, 1st Stage). CIP supply valve V-4201-002 is closed. V-4201-003 and V-4202-021 are closed during this sequence because caustic material is not to be recirculated. These two valves are located on the same pipe line however since they are located far away from each other two valves are required. V-4201-010 is to remain closed during Evaporation Area CIP because the Whole Stillage Flash Tank (TP-4212) is to be cleaned separately. V-4202-013 is open to permit syrup to leave the Evaporation Area. CIP Drain valve V-4202-014 should be closed. V-4202-029 should be closed. All valves located on the Separators should be closed during normal operation.

Stillage is concentrated within the Evaporators to produce distiller's syrup via the Second Effect Evaporator (ET-4202) to an operator defined density and PC-4208 discharges it from the system via cascading flow control valve FV-4202-007 in communication with density element transmitter and controller DE/DT/DIC-4202-007.

Stillage Drain

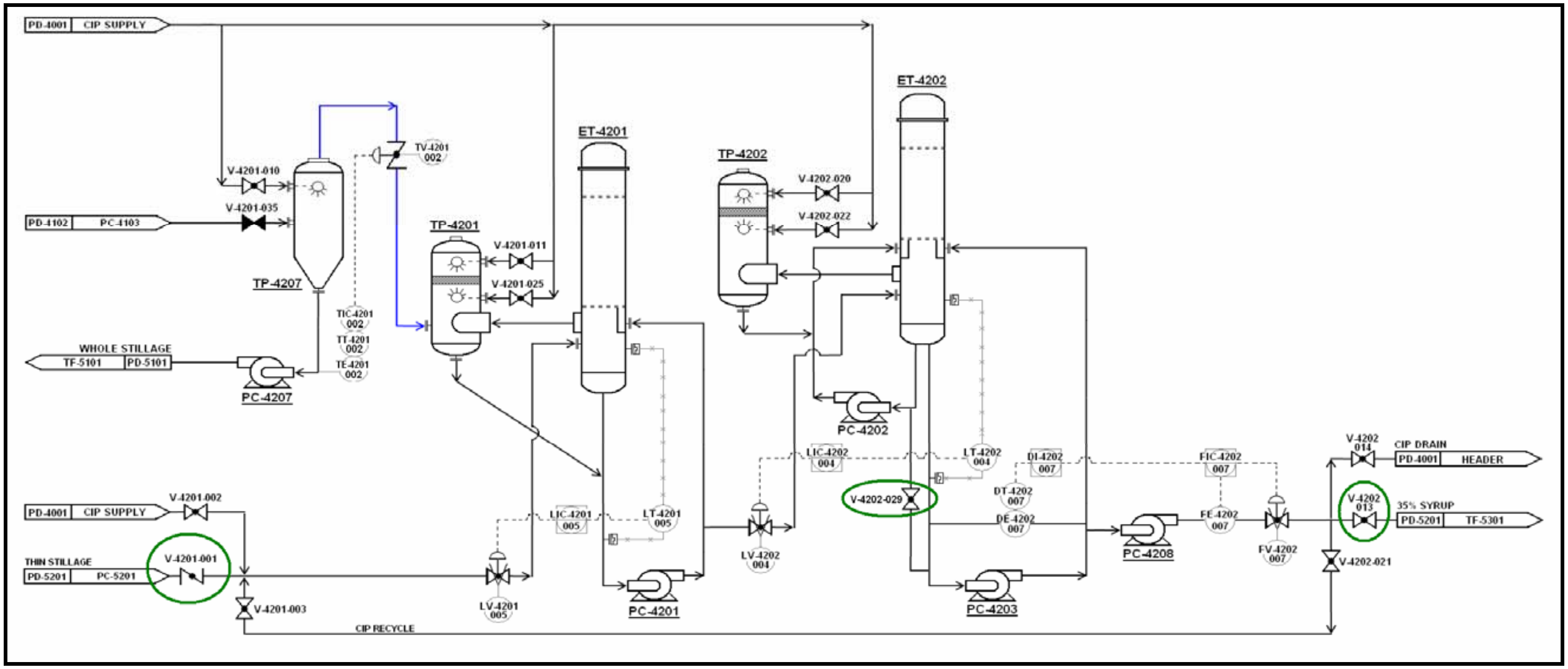


Figure 8: Evaporators – Normal Operation / Stillage Drain – Sequence 1

V-4202-029 is to be opened before reducing levels. Levels within all Evaporators (ET-4201 & ET-4202) are reduced to minimal heights to expedite the cleaning cycles. Actual levels are to be determined at start-up in the control room. Minimum level heights are to be defined at the first sign of cavitation. Noise is one of the indications that a centrifugal pump is cavitating. A cavitating pump can sound like a can of marbles being shaken. Other indications that can be observed from a remote operating station are fluctuating pressure, flowrate, and pump motor current.

Sequence 2: Water Flush

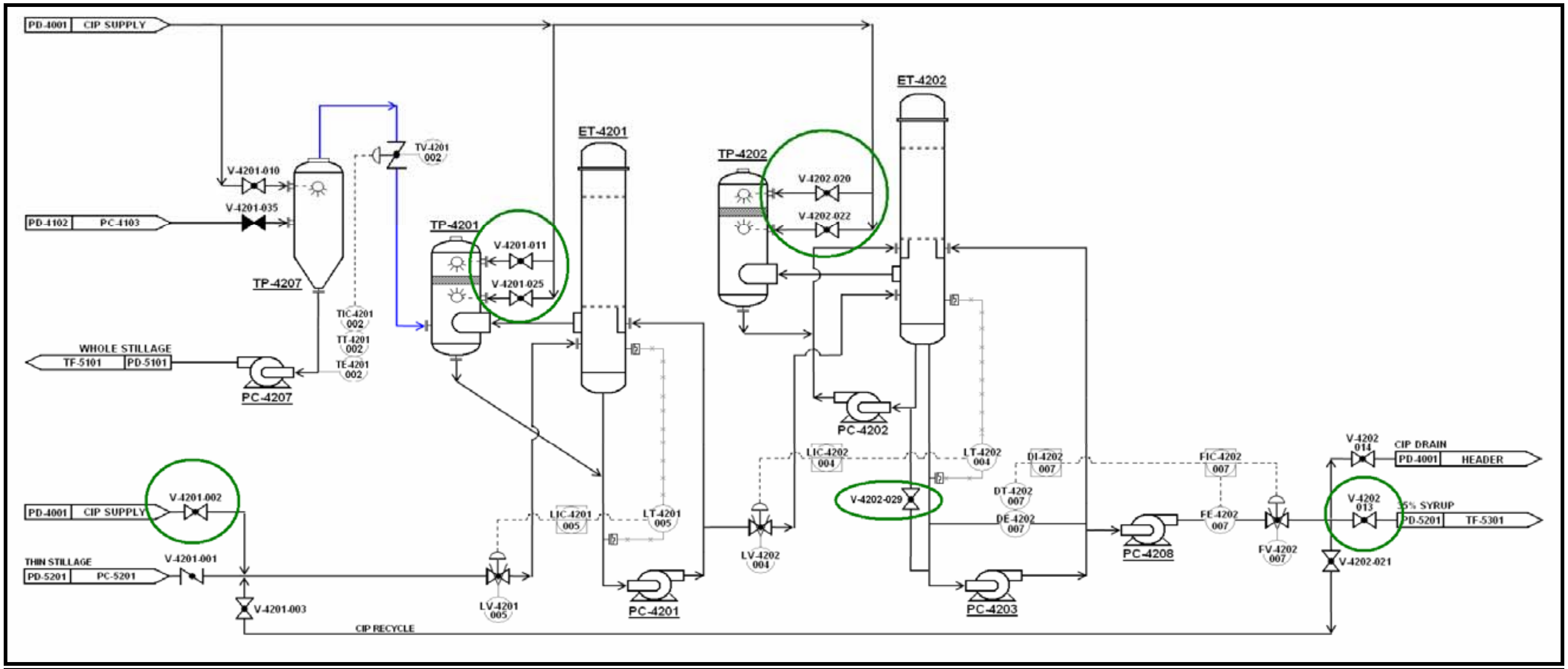


Figure 9: Evaporators – Stillage Drain / Water Rinse – Sequence 2

The purpose of the 'Water Flush' sequence is to flush out the solids before introducing caustic fluid to the system. The liquid level within each Evaporator must remain at a minimum height. During rinsing it will be possible for a time to chase out the solids while at the same time producing an acceptable syrup concentration. Water will be flushed from the pipe work and processing fluid will be discharged to the Syrup Tank for a given amount of time and then the dilute mixture will be introduced to the Thin Stillage Tank for duration of time.

All valves on each of the Separators (TP-4201, TP-4202) should be open. Only water is to be introduced to each upper spray ball valve located above the mist eliminators (V-4201-011 & V-4202-020). V-4201-001 is to be closed to bypass thin stillage from Evaporators. CIP supply valve V-4201-002 is to be opened to permit the transfer of flush water to the Evaporators. V-4202-013 is to remain open and the syrup/flush water mixture is to be sent to the Syrup Tank for a specific interval of time and then to the Thin Stillage Return for a designated time interval. CIP drain valve V-4202-014 should remain closed. V-4202-029 should remain open. The duration of time recommended for this sequence is provided in Appendix 2.

Sequence 3: Caustic Addition

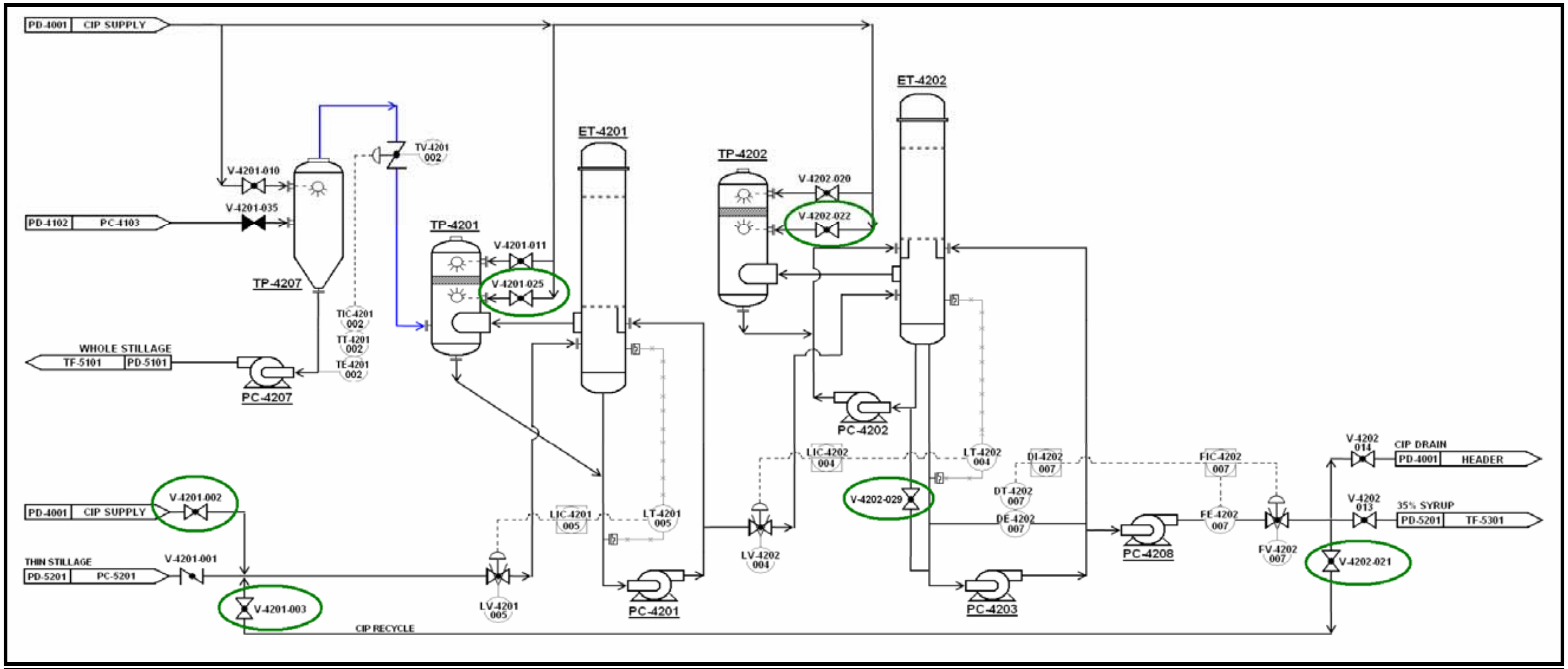


Figure 10: Evaporators – Caustic Addition – Sequence 3

After 'Sequence 2: Water Flush' is complete and the process fluid is reasonably clear of stillage, Sequence 3: Caustic Addition will begin. Caustic CIP solution may be introduced to the Evaporator tube sides and to each manual valve located below each Separator's mist eliminators to transfer caustic to lower spray nozzles.

The purpose of the 'Caustic Addition' Sequence is to charge the processing system with a low NaOH caustic concentration (~3& NaOH) while recirculating the cleaning fluid within the pipe work. At the same time, the Evaporators will vaporize water from the caustic cleaning solution traveling throughout its pipe work which will increase the NaOH concentration within the system. When the NaOH concentration has reached a desired NaOH concentration (~5% NaOH), Sequence 3: Caustic Addition sequence will end.

V-4201-001 remains closed. Caustic solution should enter the process through V-4201-002 and lower spray ball valves (V-4201-025 & V-4202-022). V-4201-003 and V-4202-021 should be opened to allow processing fluid to be recirculated throughout the evaporator area pipe work. No caustic solution should be drained from the evaporation area during this sequence. V-4202-013 should be closed to divert fluid from the Thin Stillage Tank. V-4202-029 should remain open. The caustic flow rate through the Evaporator pipe-work is controlled by level. The liquid level within each Evaporator must remain at a minimum height. The duration of time recommended for this sequence is provided in Appendix 2.

Sequence 4: Caustic Recirculation

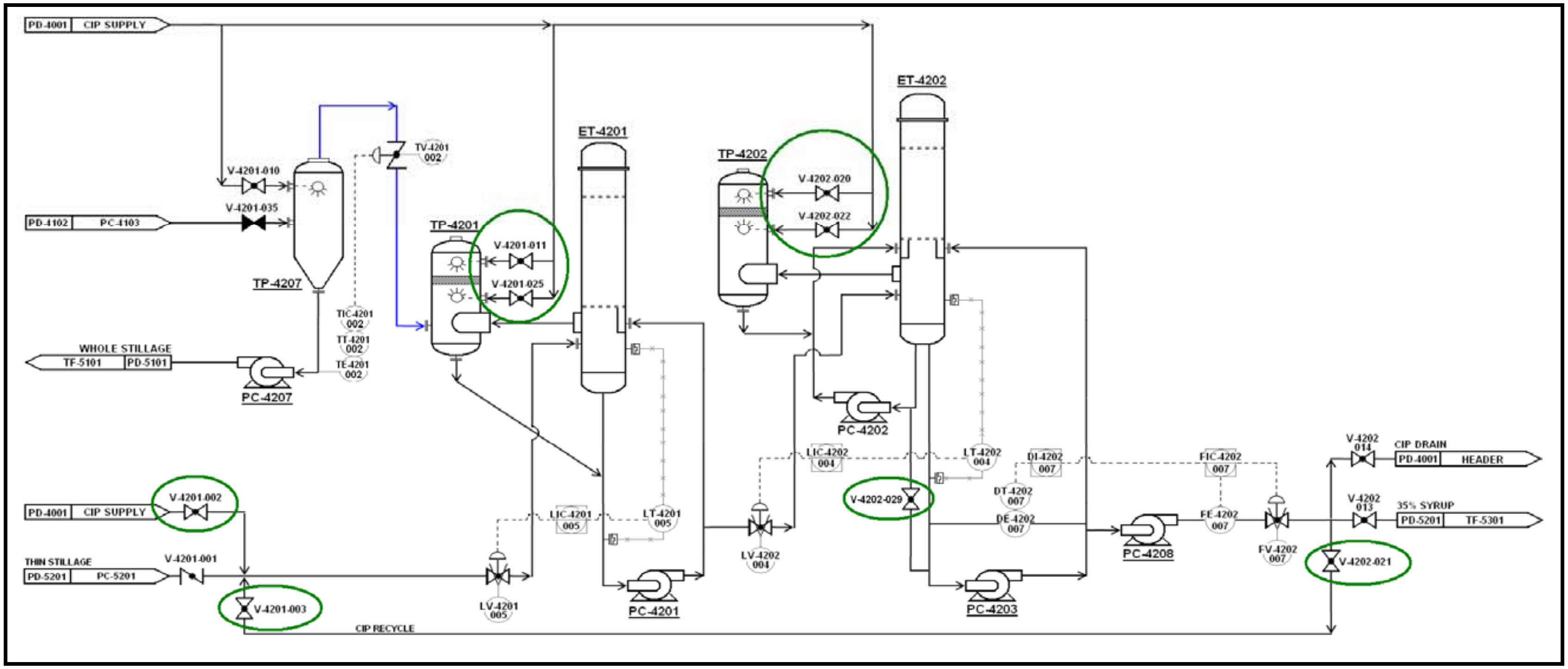


Figure 11: Evaporators – Caustic Recirculation – Sequence 4

During the Caustic Recirculation sequence, the processing system is already filled with caustic solution and water will then be used to make up for evaporation losses.

Lower and upper spray ball valves (V-4201-025 & V-4201-011, V-4202-020 & V-4202-022) located on each Separator should be opened. **It is important to delay the opening of the upper spray-ball valves 5 minutes** after the time water enters the processing system in place of CIP solution; this lag time is crucial to assure that no caustic solution remains in the pipe work before introducing rinse liquid to the upper spray balls above each mist eliminator in each separator. When the Evaporator's pipe-work has reached the desired sodium hydroxide concentration, V-4201-003 and V-4202-021 should be opened to recirculate CIP throughout the system. All other valve positions are identical to the preceding sequence 'Caustic Addition'. The duration of time recommended for this sequence is provided in Appendix 2.

Sequence 5: Caustic Dilution

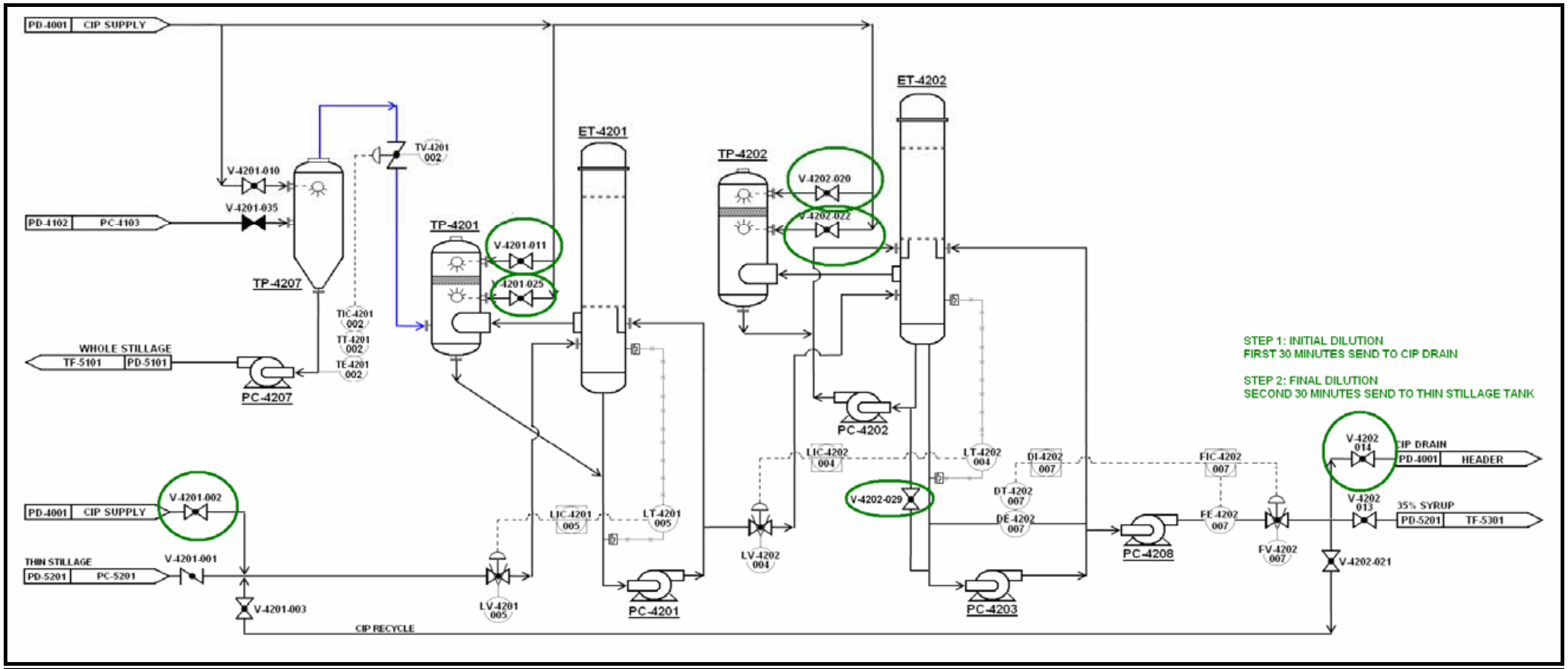


Figure 12: Evaporators – Caustic Dilution – Sequence 5

The purpose of Sequence 5: Caustic Dilution is to flush the caustic CIP solution from the system. The Caustic Dilution sequence involves opening the liquid discharge from the evaporation area and transferring the caustic CIP solution within the pipe work to discharge to the CIP Drain for a duration of time followed by discharging the dilute caustic CIP solution to another location after the NaOH concentration is low (<0.5% NaOH); The Caustic Dilution sequence includes two steps

1) Introducing a lesser water flush flowrate to the system to concentrate the caustic NaOH while transferring the fluid to the CIP Drain for a duration of time until the NaOH has reached <0.5% NaOH. When the solution pH is approximately 9.5 the cleaning fluid may be transferring to the Thin Stillage Tank.

2) Increasing the water flush flowrate to further dilute the NaOH within the cleaning fluid all while transferring the diluted fluid to a separate location (Thin Stillage Tank for the Evaporators).

All 4 spray ball valves located on Separators TP-4201 and TP-4202 should be opened. V-4201-001 should remain closed. V-4201-002 should remain open and water should continue to pass through the CIP pipe-work. V-4201-003 and V-4202-021 should be closed to prevent recirculation of CIP throughout the system. V-4202-013 is to remain closed because nothing is to be sent back to the Syrup Tank (or to the Thin Stillage Return) during this sequence. The mixture of caustic and water should be sent through the pipe work that contains the CIP Drain valve and V-4202-014 should be opened. The water rinse flow rate through the evaporator and finisher pipe work is determined by level control. The duration of time recommended each step within this sequence is provided in Appendix 2.

Sequence 6: Stillage Fill / Normal Operation

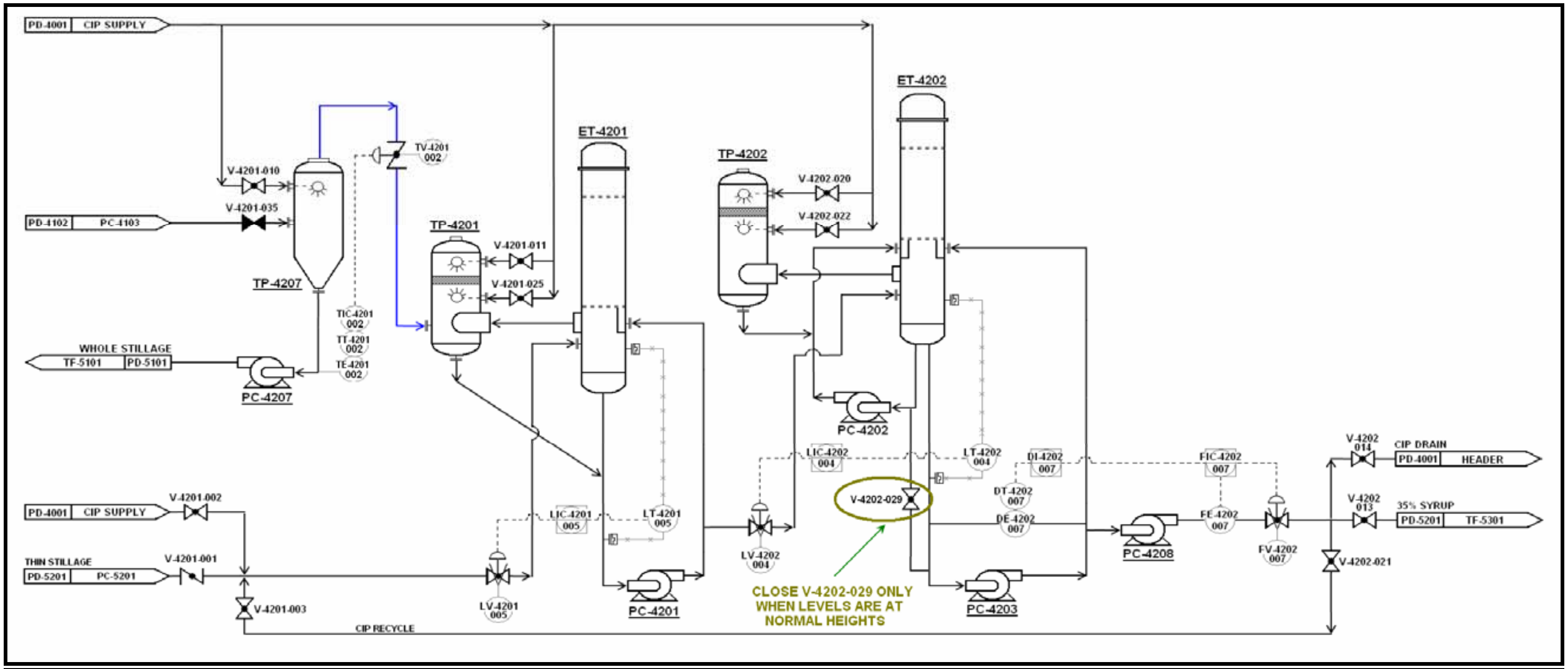


Figure 13: Evaporators – Rinse Water Drain / Stillage Fill – Sequence 7

At the end of the 'Caustic Dilution' sequence normal operation continues. All valve arrangements are exactly the same as 'Normal Operation' sequence. V-4202-029 SHOULD BE CLOSED ONLY WHEN LEVELS WITHIN EVAPORATORS ARE AT NORMAL OPERATING LEVELS.

Appendix 1: Reboiler CIP Capacities

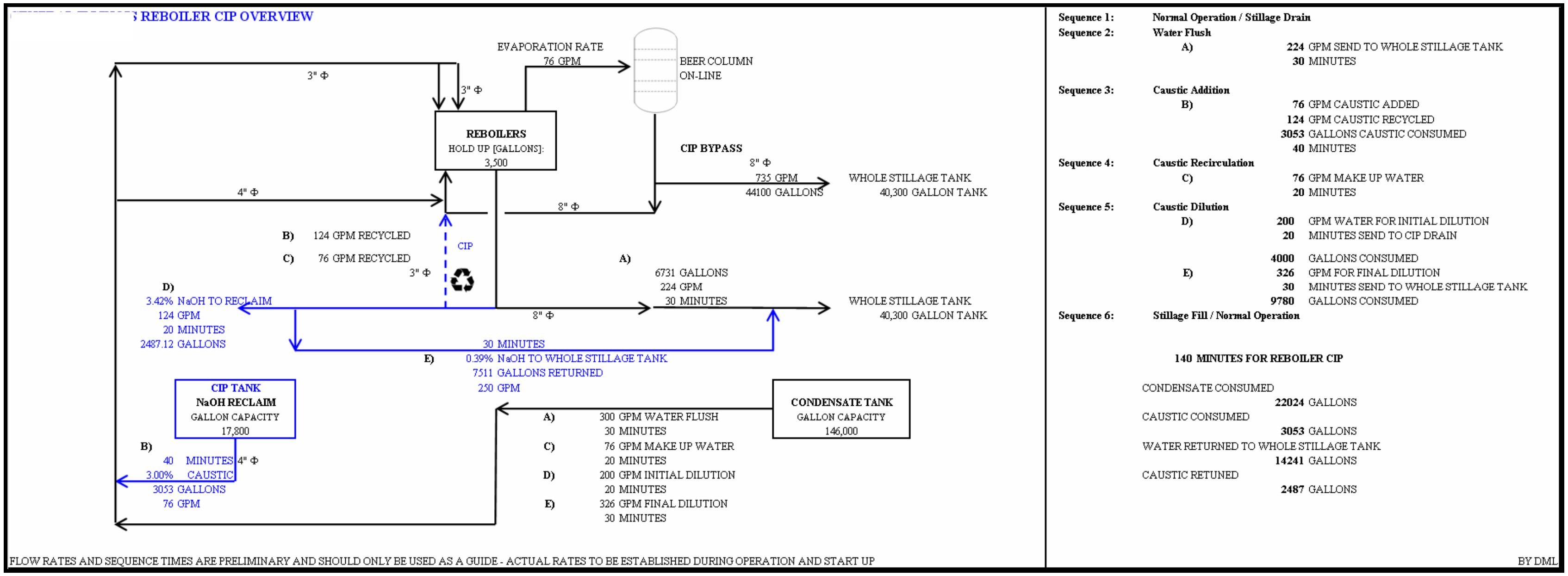


Figure 14: Reboiler CIP Capacities

Appendix 2: Evaporation CIP Capacities

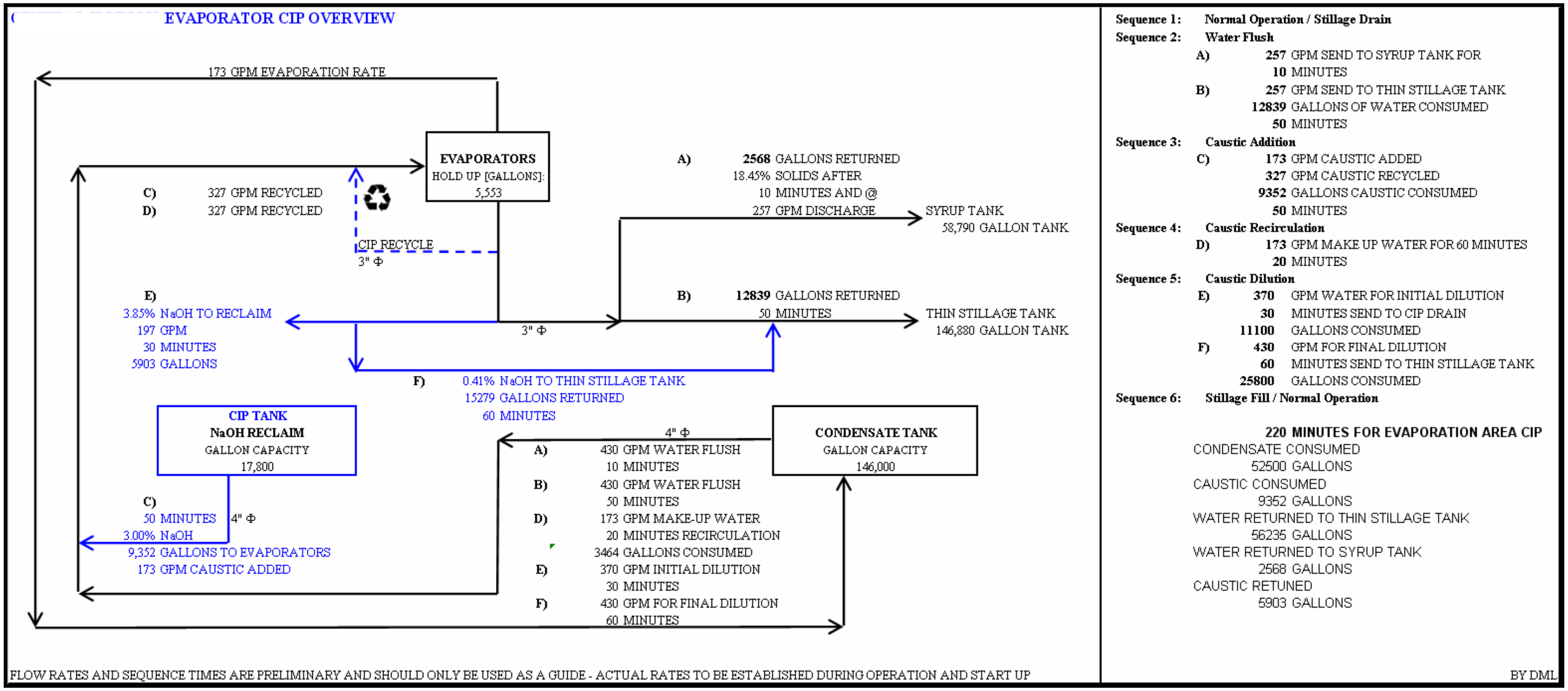


Figure 15: Evaporation Area CIP Capacities

Appendix 3: Reboiler Area CIP Pinning Chart

REBOILER CIP PINNING CHART

BY DML
REVISED 09/18/2007

Sequence #:	Sequence Name:	OPEN V-4102-002	OPEN V-4102-003	OPEN V-4102-013	OPEN V-4102-025	OPEN V-4102-026	OPEN V-4102-037	OPEN V-4102-024	OPEN V-4102-041	OPEN V-4102-016	OPEN V-4102-042	CLOSE V-4102-002	CLOSE V-4102-003	CLOSE V-4102-013	CLOSE V-4102-025	CLOSE V-4102-026	CLOSE V-4102-037	CLOSE V-4102-024	CLOSE V-4102-041	CLOSE V-4102-016	CLOSE V-4102-042	LOWER LIQ LEVELS	INCREASE LIQ LEVELS	DCS TO CIP CONTROLS	DCS TO NORMAL CIP CONTROLS	MAKE-UP WATER TO LV-4102-005	CAUSTIC TO LV-4102-005
1a	Normal Operation			X		X						X	X		X		X	X	X	X	X						
1b	Stillage Drain			X		X						X	X		X		X	X	X	X	X	X		X			
2	Water Flush		X	X	X			X	X	X	X	X				X	X									X	
3	Caustic Addition	X	X		X				X		X			X		X	X	X		X							X
4	Caustic Recirculation	X	X		X			X	X	X	X			X		X	X									X	
5a	Caustic Dilution **(INITIAL DILTUION)**		X		X		X	X	X	X	X	X		X		X										X	
5b	Caustic Dilution **(FINAL DILUTION)**		X	X	X			X	X	X	X	X				X	X									X	
6a	Stillage Fill			X		X						X	X		X		X	X	X	X	X		X				
6b	Normal Operation			X		X						X	X		X		X	X	X	X	X				X		

EQUIPMENT / LINE NO.						VALVE DESCRIPTION	VALVE TAG NO.
SIZE	SERVICE	P&ID NO.	SEQ. NO.	MAT'L	INSUL.		
3	CPS	4102	029	CA	2.5HC	BEER BOTTOMS PC-4107 DISCHARGE BYPASS TO ET-4104	**V-4102-002**
3	CPS	4001	003	CA	1FP/ET	BYPASSED BEER BOTTOMS TO ET-4104 FROM PC-4107 DISCHARGE	**V-4102-003**
8	PRC	4102	019	SF	2.5HC	BEER BOTTOMS PC-4107 DISCHARGE TO TP-4207	**V-4102-013**
8	PRC	4102	014	SF	2.5HC	BEER BOTTOMS PC-4101 DISCHARGE BYPASS TO TP-4207	**V-4102-025**
8	PRC	4103	006	SF	2.5HC	BEER BOTTOMS PC-4101 DISCHARGE TO ET-4104	**V-4102-026**
3	CPR	4102	034	CA	1FP/ET	CAUSTIC PC-4107 DISCHARGE TO CIP DRAIN	**V-4102-037**
3	CPS	4102	027	CA	1FP/ET	TP-4103 (SEPARATOR) ABOVE MIST ELIMINATOR	**V-4102-024**
3	CPS	4102	026	CA	1FP/ET	TP-4103 (SEPARATOR) ABOVE BELOW ELIMINATOR	**V-4102-041**
3	CPS	4102	028	CA	1FP/ET	TP-4104 (SEPARATOR) ABOVE MIST ELIMINATOR	**V-4102-016**
3	CPS	4001	027	CA	1FP/ET	TP-4104 (SEPARATOR) ABOVE BELOW ELIMINATOR	**V-4102-042**

ALTERNATE CONTROL FOR CIP ONLY

CONTINUOUS OPERATION		CIP OPERATION
LV-4102-008 & LIC-4102-008	→	LV-4102-008 & FIC-4102-027
	→	LV-4102-005 & LIC-4102-014
LV-4102-014 & LIC-4102-014	→	LV-4102-014 & LIC-4102-008

Figure 16: Reboiler CIP Pinning Chart

Appendix 4: Evaporation Area CIP Pinning Chart

EVAPORATION AREA CIP PINNING CHART

BY DML
REVISED 09/18/2007

Sequence #:	Sequence Name:	OPEN V-4201-001	OPEN V-4201-002	OPEN V-4201-003	OPEN V-4202-013	OPEN V-4202-014	OPEN V-4202-021	OPEN V-4201-011	OPEN V-4201-025	OPEN V-4202-020	OPEN V-4202-022	OPEN V-4202-029	CLOSE V-4201-001	CLOSE V-4201-002	CLOSE V-4201-003	CLOSE V-4202-013	CLOSE V-4202-014	CLOSE V-4202-021	CLOSE V-4201-011	CLOSE V-4201-025	CLOSE V-4202-020	CLOSE V-4202-022	CLOSE V-4202-029	LOWER LIQ LEVELS	INCREASE LIQ LEVELS	INTRODUCE WATER	INTRODUCE CAUSTIC	RECIRCULATE TO EVAP AREA	SEND TO CIR DRAIN	SEND TO SYRUP TANK	SEND TO THIN STILLAGE TANK
1a	Normal Operation	X			X									X	X		X	X	X	X	X	X	X							X	
1b	Stillage Drain	X			X							X		X	X		X	X	X	X	X	X		X						X	
2a	Water Flush (INITIAL FLUSH)		X		X			X	X	X	X	X	X		X		X	X								X				X	
2b	Water Flush (FINAL FLUSH)		X		X			X	X	X	X	X	X		X		X	X								X					X
3	Caustic Addition		X	X			X		X		X	X	X			X	X		X		X						X	X			
4	Caustic Recirculation		X	X			X	X	X	X	X	X	X			X	X									X		X			
5a	Caustic Dilution (INITIAL DILUTION)		X			X		X	X	X	X	X	X		X	X		X								X			X		
5b	Caustic Dilution (FINAL DILUTION)		X			X		X	X	X	X	X	X		X	X		X								X					X
6a	Stillage Fill	X			X							X		X	X		X	X	X	X	X	X			X						X
6b	Normal Operation	X			X									X	X		X	X	X	X	X	X	X							X	

6	PRC	5201	002	SF	1.5HC/ET	THIN STILLAGE FROM PC-5201 TO ET-4201; TIE IN# 4201-01	**V-4201-001**
3	CPS	4001	005	CA	1FP/ET	CIP SUPPLY FROM HEADER TO ET-4201	**V-4201-002**
3	CPS	4202	016	CA	1FP/ET	CIP RECYCLE FROM PC-4203 TO ET-4201	**V-4201-003**
3	PRC	4202	005	SF	1.5HC/ET	35% SYRUP FROM PC-4208 (PD-4202) TO TF-5301; TIE IN# 4202-01	**V-4202-013**
3	CPR	4202	013	CA	1FP/ET	CIP DRAIN FROM PC-4108 (PD-4202)	**V-4202-014**
3	CPS	4202	016	CA	1FP/ET	CIP RECYCLE TO ET-4201	**V-4202-021**
3	CPS	4201	015	CA	1FP/ET	TP-4201 (SEPARATOR) ABOVE MIST ELIMINATOR	**V-4201-011**
3	CPS	4001	011	CA	1FP/ET	TP-4201 (SEPARATOR) ABOVE BELOW ELIMINATOR	**V-4201-025**
3	CPS	4202	012	CA	1FP/ET	TP-4202 (SEPARATOR) ABOVE MIST ELIMINATOR	**V-4202-020**
3	CPS	4001	012	CA	1FP/ET	TP-4202 (SEPARATOR) ABOVE BELOW ELIMINATOR	**V-4202-022**
4	PRC	4202	020	SF	2HC	SECOND EFFECT FINSIHER STAGE BYPASS VALVE - WHEN OPEN: 2 STAGES = 1	**V-4202-029**

NOTE: When completing CIP procedure, V-4202-029 should be closed only when normal operating levels are obtained

Figure 17: Evaporation Area CIP Pinning Chart

Appendix 5: CIE Beer Preheater CIP Pinning Chart

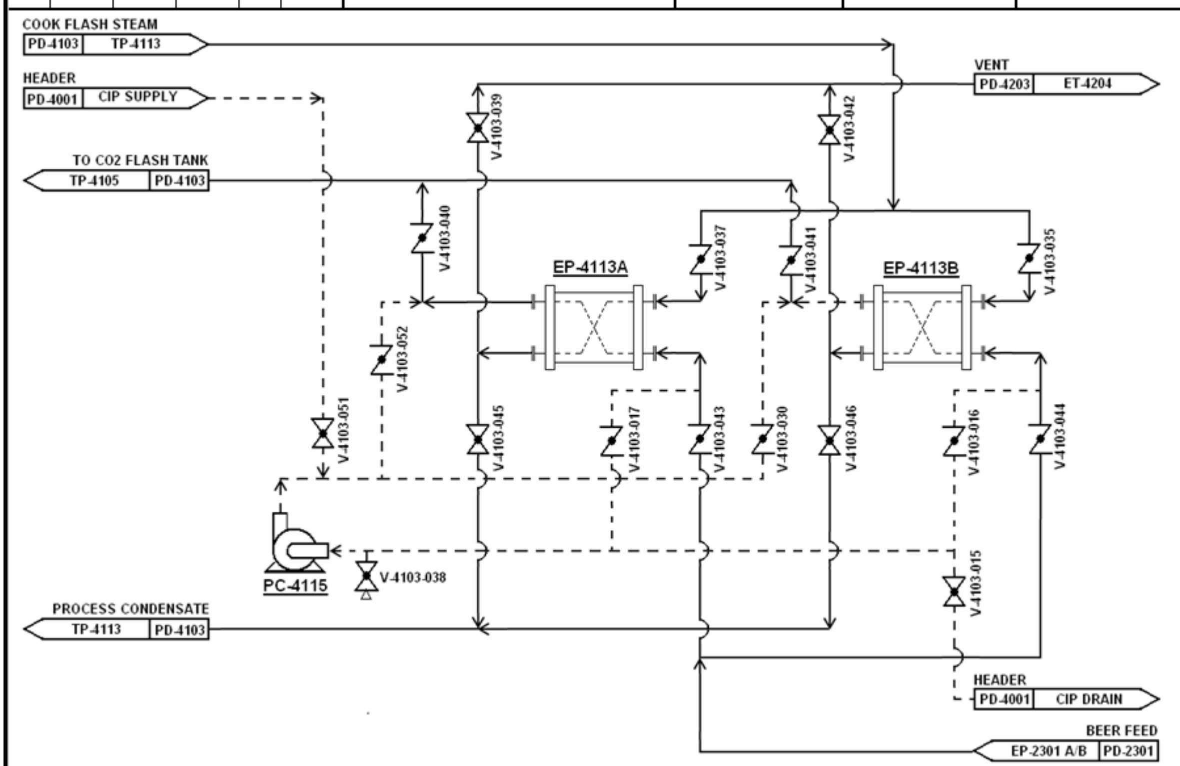
CLEAN-IN-PLACE (CIP) VALVE SEQUENCING: BEER PREHEATERS

Thermal Kinetics
Engineering, PLLC & Systems, LLC

Project Name:	CIE	**Project Number:**	[illegible]
Project	DACKSON	**Location:**	[illegible]
Revision	1	**Date:**	6/22/2007

667 Tifft Street
Buffalo, New York 14220
(716) 565-9191 Fax 823-7745

EQUIPMENT / LINE NO.						VALVE DESCRIPTION	VALVE TAG NO.	EP-4113A ON-LINE [CLEANING EP-4113B]	EP-4113B ON-LINE [CLEANING EP-4113A]
SIZE	SERVICE	P&ID NO.	SEQ. NO.	MAT'L	INSUL.				
10	PRV	4103	029	SF	2HC	STEAM TO EP-4113B	V-4103-035	CLOSED	OPEN
10	PRV	4103	031	SF	2HC	STEAM TO EP-4113A	V-4103-037	OPEN	CLOSED
8	PRC	4103	032	SF	2HC	EP-4113A BEER DISCHARGE	V-4103-040	OPEN	CLOSED
8	PRC	4103	001	SF	2HC	EP-4113B BEER DISCHARGE	V-4103-041	CLOSED	OPEN
8	PRC	2301	015	SF	2HC	BEER FEED TO EP-4113A	V-4103-043	OPEN	CLOSED
8	PRC	4103	034	SF	2HC	BEER FEED TO EP-4113B	V-4103-044	CLOSED	OPEN
3	CPS	4103	017	SF	1FP/ET	CIP SUPPLY TO EP-4113A&B	V-4103-051	OPEN	OPEN
3	CPR	4103	024	SF	1FP/ET	CIP DRAIN	V-4103-015	OPEN	OPEN
8	CPS	4103	022	SF	2HC	EP-4113B CIP RECIRC. / DRAIN	V-4103-016	OPEN	CLOSED
8	CPS	4103	023	SF	2HC	EP-4113A CIP RECIRC. / DRAIN	V-4103-017	CLOSED	
8	CPS	4103	021	SF	2HC	CIP SUPPLY TO EP-4113B	V-4103-030	OPEN	CLOSED
8	CPS	4103	018	SF	2HC	CIP SUPPLY TO EP-4113A&B	V-4103-052	CLOSED	OPEN
2	PCD	4103	014	SF	1HC	STEAM CONDENSATE FROM EP-4113A	V-4103-045	OPEN	CLOSED
2	PCD	4103	035	SF	1HC	STEAM CONDENSATE FROM EP-4113B	V-4103-046	CLOSED	OPEN
2	VNT	4103	033	SF	1FP	EP-4113A VENT	V-4103-039	OPEN	CLOSED
2	VNT	4103	045	SF	1FP	EP-4113B VENT	V-4103-042	CLOSED	OPEN



WATER RECIRCULATION – BOIL OUT:

It is recommended to frequently flush Reboilers or Evaporators out with water and it is possible to skip the 'Caustic Addition' & 'Caustic Recirculation' and 'Caustic Dilution' sequences. The table below states what sequences are necessary for only flushing processing systems out with water.

Table 4: Summary of Water Recirculation/Boil Out Sequences

SEQUENCE #:	SEQUENCE NAME	SEQUENCE DESCRIPTION
1	Normal Operation / Stillage Drain	Normal operation - prepare for CIP operations. Pump down levels within Reboiler or Evaporator liquid reservoirs to minimum heights
2	Water Flush	Flush stillage from processing system (send to Thin Stillage Return or Process Condensate Return) / Rinse with water
3	Water Recirculation – Boil Out	Recirculate water throughout processing system instead of recirculating caustic.
4	Stillage Fill / Normal Operation	Raise levels within Reboiler or Evaporator liquid reservoirs / Return to Normal Operation

Thermal Kinetics
Engineering, PLLC & Systems, LLC
, Distillation, Chemical Reaction, Process Design & Energy Conservation
667 Tifft Street
Buffalo, New York 14220
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FUNCTIONAL CONTROL DESCRIPTION

Prepared By: DML		Project No: 73338
Reviewed By: TC & GCG		Issue Date: 5/25/2007
Approved By: TC & GCG		Revision: 1 (5/25/2007)

FUNCTIONAL CONTROL DESCRIPTION:

MAIN CONDENSER CIRCULATION WATER TEMPERATURE **LOOP 4002-008**	**LOOP ELEMENTS:** TE-4002-008 TT-4002-008 TIC-4002-008 ST-4002-008A SIC-4002-008A ST-4002-008B SIC-4002-008B	Temperature of PP-4001A&B (Main Condenser Recirculation Pumps) discharge to ET-4301 spray nozzles is measured (TE-4002-008) and signal is transmitted (TT-4002-008) to temperature indicating controller (TIC-4002-008) which sends a signal to condenser fan's variable speed drive (ST/SIC-4002-008A and ST/SIC-4002-008B) to adjust fan speed depending upon the difference between the actual measured spray water temperature and the operator user-defined temperature.
MAIN CONDENSER WATER WATER/BLOW DOWN FLOW **LOOP 4002-015**	**LOOP ELEMENTS:** FE-4002-015 FT-4002-015 FIC-4002-015 FV-4002-015	Flow element (FE-4002-015) and transmitter (FT-4002-015) measures the actual flow and transmits a signal to a flow indicating controller (FIC-4002-015) which regulates the position of flow control valve (FV-4002-015) so that FE-4002-015 may equilibrate to and indicate a desired operator set flowrate
REGEN CONDENSER WATER WATER/BLOW DOWN FLOW **LOOP 4002-025**	**LOOP ELEMENTS:** FE-4002-025 FT-4002-025 FIC-4002-025 FV-4002-025	Flow element (FE-4002-025) and transmitter (FT-4002-025) measures the actual flow and transmits a signal to a flow indicating controller (FIC-4002-025) which regulates the position of flow control valve (FV-4002-025) so that FE-4002-025 may equilibrate to and indicate a desired operator set flowrate.
STEAM TO RC REBOILER (ET-4102) FLOW **LOOP 4101-001**	**LOOP ELEMENTS:** FE-4101-001 FT-4101-001 FIC-4101-001 FV-4101-001	125# steam is flow controlled (FE/FT-4101-001, FIC-4101-001 & FV-4101-001) and then introduced into the shell-side of ET-4102 (RC Reboiler) to provide energy to maintain continuous vaporization of rectifying column bottoms within the tube-side of ET-4102. INTERLOCK – See Alarm & Interlock List CIE
STEAM CONDENSATE RECEIVER LEVEL **(FROM TP-4102)** **LOOP 4101-002**	**LOOP ELEMENTS:** LT-4101-002 LIC-4101-002 LV-4101-002	Steam condensate from the shell-side of ET-4102 (RC Reboiler) is introduced into TP-4102 (Steam Condensate Receiver) where it then flows into the shell side of ET-4111 (Feed Preheater); a level control valve (LV-4101-002) located on the shell-side discharge of ET-4111 in communication with a level transmitter/controller located on TP-4102 (LT-4101-002 & LIC-4101-002) maintains a relatively constant flow of condensate through the shell-side of ET-4111 while maintaining a constant level of condensate within TP-4102.
RECTIFIER COLUMN BOTTOMS LEVEL **LOOP 4101-006**	**LOOP ELEMENTS:** LT-4101-006 LIC-4101-006 LV-4101-006	Level transmitter & controller (LT-4101-006 & LIC-4101-006) located on the bottom of the TW-4102 (Rectifier Column) regulate a level control valve (LV-4101-006) which influences how much fluid is sent to TP-4110 (RC Bottoms Flash Tank) in order to maintain a constant fluid level within the bottom of TW-4102.

RECTIFIER COLUMN TEMPERATURE AND 190 PROOF SUPERHEATE FEED FLOW **LOOP 4101-014**	**LOOP ELEMENTS:** TE-4101-014 TT-4101-014 TIC-4101-014 FV-4101-014 FIC-4101-014 CASCADE LOOP IF PV<SP CLOSES FV IF PV>SP OPENS FV	Control of the 190 proof ethanol concentration is achieved by means of a cascade computer controller which senses two variables and controls one variable. The primary set point is the flowrate of superheated 190 proof ethanol vapor feed to ET-4114 (Superheater 190 Proof to MSU) and the controller derives from this a set point for the temperature above stage 21 of TW-4102 (Rectifier Column) via temperature element and transmitter (TE/TT-4101-014). This temperature is used as an indication of the composition of the liquid on tray 21 and, thus, as a measure of the separation produced. This "cascade" loop is advantageous in that it automatically adjusts the 190 proof ethanol flowrate to ET-4114 for possible variations in the temperature above stage 21 within TW-4102. Need to set up so changes will be slow; start up will need operator setting for FIC-4101-014.
190 PROOF RECTIFIER COLUMN OVERHEAD PRESSURE **LOOP 4101-020**	**LOOP ELEMENTS:** PT-4101-020 PIC-4101-020 PV-4101-020	PT-4101-020, located at the top of the TW-4102 (Rectifier Column), measures pressure above tray 1 within the column and transmits a signal to a pressure indicating controller (PIC-4101-020) which regulates a pressure control valve (PV-4101-020 – FLOW TO ET-4103 [RC REBOILER/BC CONDENSER])) on the overhead discharge of TW-4102 to attain a set point pressure within TW-4102. INTERLOCK – High pressure closes FV-4101-001
190 PROOF ETHANOL SUPERHEATER TEMPERATURE **LOOP 4101-021**	**LOOP ELEMENTS:** TE-4101-021 TT-4101-021 TIC-4101-021 TV-4101-021	Steam flow to the shell-side of ET-4114 (Superheater 190 Proof to MSU) is regulated by a temperature control valve (TV-4101-021). TE/TT-4101-021 located on the Superheater's discharge transmits a signal to a temperature indicating controller (TIC-4101-021) which instructs TV-4101-021 to attain the set point temperature. INTERLOCK -
FUSEL OIL EXCHANGER DISCHARGE FLOW **LOOP 4101-023**	**LOOP ELEMENTS:** FE-4101-023 FT-4101-023 FIC-4101-023 FV-4101-023	Fusel oil is drawn from one of the three draw points from the Rectifier Column at a rate through the Fusel Oil Exchanger (EP-4108) measured and set by the flowmeter/controller (FE/FT/FIC-4101-023) and control valve FIC-4101-023 prior to being diluted and additionally cooled with water before entering the Fusel Oil Decanter (TP-4108).
FUSEL OIL DECANTER LEVEL **LOOP 4101-024**	**LOOP ELEMENTS:** LDT-4101-024 LDIC-4101-024 LV-4101-024	An interface transmitter (LDT-4101-024) located on TP-4108 (Fusel Oil Decanter) transmits a signal to level indicating controller (LDIC-4101-024) which regulates flow through level control valve (LV-4101-024) to maintain an interface at the desired point within the Fusel Oil Decanter by controlling the rate the heavier ethanol/water phase is removed.
FUSEL OIL DECANTER LEVEL **LOOP 4101-026**	**LOOP ELEMENTS:** LT-4101-026 LIC-4101-026 PD-4109	A level transmitter (LT-4101-026) located on TP-4108 (Fusel Oil Decanter) transmits a signal to level indicating controller (LIC-4101-026) which regulates flow from variable speed metering pump PD-4109 (Fusel Oil Pump) to maintain a constant level of fluid within the light phase Fusel Oil Decanter. *(Note: consider cascade to flow control to Flow/Density LOOP #4101-028)*

FLASHED RC BOTTOMS LEVEL **LOOP 4101-032**	**LOOP ELEMENTS:** LT-4101-032 LIC-4101-032 LV-4101-032	A level transmitter (LT-4101-032) located on TP-4110 (RC Bottoms Flash Tank) transmits a signal to level indicating controller (LIC-4101-032) regulates flow through level control valve (LV-4101-032) to maintain a constant level of fluid within the RC Bottoms Flash Tank.
92% ETHANOL RECEIVER VENT FLOW **LOOP 4102-001**	**LOOP ELEMENTS:** FE-4102-001 FT-4102-001 FIC-4102-001 FV-4102-001	Flow element (FE-4102-001 located on PD-4201) and transmitter (FT-4102-001) located on TP-4106 (92% Ethanol Receiver) measures the inert CO_2 vent flow (to ET-4201; PD-4201) and transmits a signal to a flow indicating controller (FIC-4102-001) which regulates the position of flow control valve (FV-4102-001) so that FE-4102-001 may equilibrate to and indicate a desired operator set flowrate. Flow set point is determined by regulating the acidity in the measured in samples of 190 proof ethanol.
92% ETHANOL RECEIVER LEVEL **LOOP 4102-003**	**LOOP ELEMENTS:** LT-4102-003 LIC-4102-003 LV-4102-003	A level transmitter (LT-4102-003) located on TP-4106 (92% Ethanol Receiver) transmits a signal to level indicating controller (LIC-4102-003) which regulates flow through level control valve (LV-4102-003) to maintain a constant level within the 92% Ethanol Receiver. This is reflux flow to the top of rectifier column. The liquid condensate discharge rate is measured by FE-4101-019.
CIP/ BC REBOILER LEVEL **LOOP 4102-005** Alternate for CIP only	**LOOP ELEMENTS:** LT-4102-014 LIC-4102-014 LV-4102-005	*****Alternate control for CIP only (see LOOP 4102-014).*** A level transmitter (LT-4102-014) located on ET-4104 (BC Reboiler) transmits a signal to level indicating controller (LIC-4102-014) which regulates flow through level control valve (LV-4102-005) to maintain a constant level of CIP within the ET-4104 (BC Reboiler) fluid reservoir. *(See CIE CIP Sequencing Description)*
RC CONDENSER BC REBOILER LEVEL **LOOP 4102-008**	**LOOP ELEMENTS:** LT-4102-008 LIC-4102-008 LV-4102-008	A level transmitter (LT-4102-008) located on ET-4103 (RC Cond/BC Reboiler) transmits a signal to level indicating controller (LIC-4102-008) which regulates flow through level control valve (LV-4102-008) to maintain a constant level within the ET-4103 (RC Condenser/BC Reboiler) fluid reservoir. Feed to ET-4103 is controlled by level control in ET-4104. *(See CIE CIP Sequencing Description)*
RC CONDENSER BC REBOILER LEVEL **LOOP 4102-008** Alternate for CIP only	**LOOP ELEMENTS:** LT-4102-008 LIC-4102-008 LV-4102-014	*****Alternate control for CIP only (LOOP 4102-008).*** Modulation of LV-4102-014 is switched to act in communication with LT/LIC-4102-008 during CIP.
BC REBOILER LEVEL **LOOP 4102-014**	**LOOP ELEMENTS:** LT-4102-014 LIC-4102-014 LV-4102-014	A level transmitter (LT-4102-014) located on ET-4104 (BC Reboiler) transmits a signal to level indicating controller (LIC-4102-014) which regulates flow through level control valve (LV-4102-014) to maintain a constant level within the ET-4104 (BC Reboiler) fluid reservoir.

CIP/ BC REBOILER LEVEL **LOOP 4102-014** Alternate for CIP only	***CIP ONLY*** **LOOP ELEMENTS:** LT-4102-014 LIC-4102-014 LV-4102-005	*(See CIE C IP Sequencing Description)* *****Alternate control for CIP only (LOOP 4102-014).*** A level transmitter (LT-4102-014) located on ET-4104 (BC Reboiler) transmits a signal to level indicating controller (LIC-4102-014) which regulates flow through level control valve (LV-4102-005) to maintain a constant level of CIP within the ET-4104 (BC Reboiler) fluid reservoir. During CIP operation LT-4102-014 and LIC-4102-014 act in communication with CIP supply valve LV-4102-005.
99.5 wt% ETHANOL RECEIVER VENT FLOW **LOOP 4102-022**	**LOOP ELEMENTS:** FE-4102-022 FT-4102-022 FIC-4102-022 FV-4102-022	Flow element (FE-4102-022) and transmitter (FT-4102-022) located on TP-4107 (99.5 wt% Ethanol Receiver) measures the actual inert CO_2 vent flow (to ET-4201; PD-4201) and transmits a signal to a flow indicating controller (FIC-4102-022) which regulates the position of flow control valve (FV-4102-022 located on PD-4201) so that FE-4102-022 may equilibrate to and indicate a desired operator set flowrate. Flow set point is determined by regulating the acidity in samples of 200 proof ethanol.
99.5 wt% ETHANOL RECEIVER LEVEL **LOOP 4102-023**	**LOOP ELEMENTS:** LT-4102-023 LIC-4102-023 LV-4102-023	A level transmitter (LT-4102-023) located on TP-4107 (99.5 wt% Ethanol Receiver) transmits a signal to level indicating controller (LIC-4102-023) which regulates flow through level control valve (LV-4102-023) to maintain a constant level within TP-4107. *(Note: consider cascade to flow contro LOOP # FE-4102-025)*
CIP/RC CONDENSER BC REBOILER FLOW **LOOP 4102-027** Alternate for CIP only	**LOOP ELEMENTS:** LV-4102-008 FE-4102-027 FT-4102-027 FIC-4102-027	*****Alternate control for CIP only (see LOOP 4102-008).*** Flow element (FE-4102-027) and transmitter (FT-4102-027) located on PC-4103 (RC Cond/BC Reboiler Recirculation Pump) discharge measures the actual liquid flow and transmits a signal to a flow indicating controller (FIC-4102-027) which regulates the position of flow control valve (LV-4102-008) so that FE-4102-027 may equilibrate to and indicate a desired operator set flowrate. *(See GATEWAY CIP Sequencing Description)*
BEER COLUMN LEVEL **LOOP 4103-001**	**LOOP ELEMENTS:** LT-4103-001 LIC-4103-001 LV-4103-001 LS-4103-004	A level transmitter (LT-4103-001) located on TW-4101 (Beer Column) transmits a signal to level indicating controller (LIC-4103-001) which regulates flow through level control valve (LV-4103-001) to maintain a constant level within the bottom of the Beer Column. INTERLOCK – High level in Beer Column shuts down steam to Rectifier Reboiler.
BEER COLUMN PRESSURE **LOOP 4103-010**	**LOOP ELEMENTS:** PT-4103-010 PIC-4103-010 PIC-4201-001 PV-4201-001	PT-4103-010, located at the top of the TW-4101 (Beer Column) measures the pressure at the top of the Beer Column and PIC-4103-010 controls PV-4205 suction pressure via a pressure control valve (PV-4201-001) located on PV-4201 to return a portion of the vapor from the separator to the suction of the vacuum pump. INTERLOCK – High high pressure shuts down steam to Rectifier Reboiler

CO2 FLASH TANK LEVEL **LOOP 4103011**	**LOOP ELEMENTS:** LT-4103-011 LIC-4103-011 LV-4103-011	A level transmitter (LT-4103-011) located on TP-4105 (CO2 Flash Tank) transmits a signal to level indicating controller (LIC-4103-011) which regulates flow through level control valve (LV-4103-011) located on PC-4105 (Beer Column Feed Pump) discharge which maintains a constant level within the CO2 Flash Tank and creates a steady flow of beer feed to the top of TW-4101.
CO2 FLASH TANK TEMPERATURE **LOOP 4103-016**	**LOOP ELEMENTS:** TE-4103-016A TT-4103-016A TDIC-4103-016 TE-4103-016B TT-4103-016B TDV-4103-016	CO2 and ethanol/water vapors are released from TP-4105 (CO2 Flash Tank) and ET-4105 (CO2 Flash Condenser) by temperature differential valve (TDV-4103-016) which is regulated by the Flash Tank temperature difference in/out (TE/TT-4103-016A & TE/TT-4103-016B).
BEER COLUMN FEED FLOW **LOOP 4103-017**	**LOOP ELEMENTS:** FE-4103-017 FT-4103-017 FIC-4103-017 FV-4103-017	Flow element (FE-4103-017) and transmitter (FT-4103-017) located on discharge of EP-4113A/B (Beer Preheater) measures the beer feed flow and transmits a signal to a flow indicating controller (FIC-4103-017) which regulates the position of flow control valve (FV-4103-017) so that FE-4103-017 may equilibrate to and indicate a desired operator set flowrate to TP-4105 (CO2 Flash Tank).
MASH FLASH COOLER #1 LEVEL **LOOP 4103-020**	**LOOP ELEMENTS:** LT-4103-020 LIC-4103-020 LV-4103-020	A level transmitter (LT-4103-020) located on TP-4112 (Mash Flash Cooler #1) transmits a signal to a level indicating controller (LIC-4103-020) which regulates flow through level control valve (LV-4103-020) to maintain a constant level of mash within the TP-4112 (Mash Flash Cooler #1).
MASH FLASH COOLER #2 LEVEL **LOOP 4103-021**	**LOOP ELEMENTS:** LT-4103-021 LIC-4103-021 LV-4103-021	A level transmitter (LT-4103-021) located on TP-4113 (Mash Flash Cooler #2) discharge transmits a signal to a level indicating controller (LIC-4103-021) which regulates flow through level control valve (LV-4103-021) to maintain a constant level of mash within the TP-4113 (Mash Flash Cooler #2).
WHOLE STILLAGE FLASH TANK TEMPERATURE **LOOP 4201-002**	**LOOP ELEMENTS:** TE-4201-002 TT-4201-002 TIC-4201-002 TV-4201-002	Temperature element and transmitter (TE/TT-4201-002) measure and transmit temperature of TP-4207 (Whole Stillage Flash Tank) whole stillage beer bottoms reboiler discharge to a temperature indicating controller (TIC-4102-002) which regulates control valve (TV-4102-002) position to achieve an operator set defined temperature.
VACUUM PUMP CONDENSATE LEVEL **LOOP 4201-003**	**LOOP ELEMENTS:** LT-4201-003 LIC-4201-003 LV-4201-003	A level transmitter (LT-4201-003) transmits a signal to level indicating controller (LIC-4201-003) which regulates excess seal fluid to TP-4205 through level control valve (LV-4201-003) to maintain a constant liquid level within the vacuum system.
EVAPORATOR 1ST EFFECT LEVEL	**LOOP ELEMENTS:** LT-4201-005 LIC-4201-005 LV-4201-005	A level transmitter (LT-4201-005) located on ET-4201 (Evaporator 1, 1st Effect) liquid discharge transmits a signal to level indicating controller (LIC-4201-005) which regulates thin stillage ET-4201 feed flow through level

LOOP 4201-005		control valve (LV-4201-005) to maintain a constant liquid level within the bottom of ET-4201. Controller setpoint to be adjusted for CIP sequence.
1ST EFFECT CONDENSATE COLLECTION TANK LEVEL **LOOP 4201-007**	**LOOP ELEMENTS:** LT-4201-007 LIC-4201-007 LV-4201-007	A level transmitter (LT-4201-007) located on TP-4205 (1st Effect Condensate Collection Tank) transmits a signal to level indicating controller (LIC-4201-007) which regulates 50.77% ethanol liquid discharge flow through level control valve (LV-4201-007) to maintain a constant liquid level within the bottom of TP-4205.
WHOLE STILLAGE FLASH TANK LEVEL **LOOP 4201-008**	**LOOP ELEMENTS:** LT-4201-008 LIC-4201-008 LV-4201-008	A level transmitter (LT-4201-008) located on TP-4207 (Whole Stillage Flash Tank) transmits a signal to level indicating controller (LIC-4201-008) which regulates whole stillage discharge flow through level control valve (LV-4201-008) to maintain a constant liquid level within TP-4207.
EVAPORATOR 2ND EFFECT LEVEL **LOOP 4202-004**	**LOOP ELEMENTS:** LT-4202-004 LIC-4202-004 LV-4202-004	A level transmitter (LT-4202-004) located on ET-4201 (Evaporator 2, 2ND Effect) liquid discharge transmits a signal to level indicating controller (LIC-4202-004) which regulates mid stillage ET-4202 feed flow through level control valve (LV-4202-004) to maintain a constant liquid level within the bottom of ET-4202. Controller setpoint to be adjusted for CIP sequence.
2ND EFFECT CONDENSATE COLLECTION TANK LEVEL **LOOP 4202-006**	**LOOP ELEMENTS:** LT-4202-006 LIC-4202-006 LV-4202-006	A level transmitter (LT-4202-006) located on TP-4206 (2ND Effect Condensate Collection Tank) transmits a signal to level indicating controller (LIC-4202-006) which regulates process condensate discharge flow through level control valve (LV-4202-006) to maintain a constant liquid level within the bottom of TP-4206.
EVAPORATOR 2ND EFFECT DENSITY/FLOW **LOOP 4202-007** **Cascade controlled**	**LOOP ELEMENTS:** DE-4202-007 DI-4202-007 FE-4202-007 FIC-4202-007 FV-4202-007	Density of ET-4202 (Evaporator 2, 2ND Effect) liquid/syrup recirculation is measured by mass flow meter (DE/DI-4202-007) and operator set point is defined via DIC-4202-007. Density of syrup from recirculation loop is mainained at a operator defined density by regulating flow control valve (FV-4202-007). Operator sets flow indicating controller (FE/FT/FIC-4202-007) to an original set point and cascading control density/flow loop fluctuates from original set-point to hold density constant within recirculation loop. PV>SP – increase flow to lower density PV<SP – decrease flow to raise density
EVAPORATOR CONDENSATE RECEIVER LEVEL **LOOP 4203-004**	**LOOP ELEMENTS:** LT-4203-004 LIC-4203-004 LV-4203-004	A level transmitter (LT-4203-004) located on TP-4204 (Evaporator Condensate Receiver) transmits a signal to level indicating controller (LIC-203-004) which regulates process condensate discharge flow through level control valve (LV-4203-004) to maintain a constant liquid level within the bottom of TP-4204.

VACUUM PUMP CONDENSATE LEVEL **LOOP 4203-006**	**LOOP ELEMENTS:** LT-4203-006 LIC-4203-006 LV-4203-006	A level transmitter (LT-4203-006) located on PV-4201 (Vacuum Pump) transmits a signal to level indicating controller (LIC-4203-006) which regulates seal fluid discharge flow through level control valve (LV-4203-006) to maintain a constant liquid level within the vacuum system.
VACUUM PUMP PRESSURE **LOOP 4203-010**	**LOOP ELEMENTS:** PT-4203-010 PIC-4203-010 PV-4203-010	PT-4203-010 measures ET-4204 (Condenser Main Surface) discharge pressure while PIC-4203-010 controls PV-4201 pressure control valve (PV-4203-010) to maintain an operator set point value by returning a portion of non-condensables leaving separator to pump suction.
MOLECULAR SIEVE PRESSURE CONTROL **LOOP 4301-005**	**LOOP ELEMENTS:** PT-4301-005 PIC-4301-005 PV-4301-005	Pressure measured entering adsorption unit (PT-4301-005 & PIC-4301-005) controls pressure control valve (PV-4301-005) on the sieve outlet.
MOLECULAR SIEVE OPERATIONS FLOW **LOOP 4301-017**	**LOOP ELEMENTS:** FE-4301-017 FT-4301-017 FIC-4301-017 FV-4301-017A FV-4301-017B	FV-4301-017 are used for regeneration/purge sweep flow control while an operator establishes a defined set-point flow rate via FIC-4301-017 & FE/FT-4301-017. Set point varies with MSU sequencing.
DEPRESS. CONDENSATE RECEIVER LEVEL **LOOP 4302-004**	**LOOP ELEMENTS:** LT-4302-004 LIC-4302-004 LV-4302-004	A level transmitter (LT-4302-004) located on TP-4304 (Depressurization Condensate Receiver) transmits a signal to level indicating controller (LIC-4302-004) which regulates 90% ethanol liquid discharge flow through level control valve (LV-4302-004 to Regen Tank TP-4303) to maintain a constant liquid level within the bottom of TP-4304. Need to set up so changes will be slow. (averaging function)
REGENERATIO N TANK LEVEL **LOOP 4302-005**	**LOOP ELEMENTS:** LT-4302-005 LIC-4302-005 LV-4302-005	A level transmitter (LT-4302-005) located on TP-4303 (Regeneration Tank) transmits a signal to level indicating controller (LIC-4302-005) which regulates 40% ethanol liquid discharge flow through level control valve (LV-4302-005) to maintain a constant liquid level within the bottom of TP-4303. Consider averaging function.
VACUUM PUMP CONDENSATE LEVEL **LOOP 4302-009**	**LOOP ELEMENTS:** LT-4302-009 LIC-4302-009 LV-4302-009	A level transmitter (LT-4302-009) transmits a signal to level indicating controller (LIC-4302-009) which regulates excess seal fluid flow through level control valve (LV-4302-009) to maintain a constant liquid level within the vacuum system seal loop separator.

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ALARMS AND INTERLOCKS LIST

Project Name:		Project Number:	
Project Manager:	K DACKSON	Location:	[illegible]
Revision Number:	0	Date:	5/29/2007

TAG	EQUIPMENT DESCRIPTION	(P&ID)	Range Type	XALL	XAL	NORM	XAH	XAHH	INTERLOCKED?	GENERAL REMARKS
FT-4002-001	PROCESS WATER TO TK CONDENSER FLOW TRANSMITTER	PD-4002	LB/HR		TBD	35,000 LB/HR				ALARM IF IS FLOW IS TOO LOW
CT-4002-006	CONDUCTIVITY TRANSMITTER	PD-4002	current			~110 - 150 µS	1,500 µS/cm			ALARM IF ELECTRICAL CONDUCTIVITY IS TOO HIGH - INDICIDAVE OF HIGH CHLORIDE CONTENT
CT-4002-018	CONDUCTIVITY TRANSMITTER	PD-4002	current			~110 - 150 µS	1,500 µS/cm			note to consult with local water treatment specialist on actual set point to control scale formation
FIC-4002-015	BLOW DOWN WATER TO WASTE WATER TIE IN# 4002-TP01	PD-4002	LB/HR		TBD	6500 LB/HR				ALARM IF IS FLOW IS TOO LOW
FIC-4002-025	BLOW DOWN WATER TO WASTE WATER TIE IN# 4002-TP01	PD-4002	LB/HR		TBD	1500 LB/HR				ALARM IF IS FLOW IS TOO LOW
FIC-4101-001	STEAM SUPPLY TO ET-4102	PD-4101	LB/HR		min flow LB/HR	49515 LB/HR			I-1	ALARM IF IS FLOW IS TOO LOW; CLOSES FV-4101-001 STEAM FLOW
LIC-4101-002	STEAM CONDENSATE RECIEVER LEVEL TRANSMITTER	PD-4101	% LEVEL		25%	50%	75%			LAL PROTECT PUMP -LAL/LAH WITH RESPECT TO (w.r.t. BOTTOM WELD LINE OF TANK)
LIC-4101-006	RECTIFIER COLUMN BOTTOMS LEVEL TRANSMITTER	PD-4101	% LEVEL		25%	50%	75%			LAL PROTECT PUMP, LAH PROTECT OVERFILL
LS-4101-008	RECTIFIER COLUMN BOTTOMS LEVEL SWITCH	PD-4101	% LEVEL						I-1	CLOSES FV-4101-001 STEAM FLOW TO PREVENT TARY DAMAGE WITHIN TW-4102
PT-4101-009	RECTIFIER COLUMN BOTTOMS PRESSURE TRANSMITTER	PD-4101	psia			56.45 psia	75 psia		I-2	CLOSES FV-4101-001 STEAM FLOW TO PREVENT PSV OPEN OR EQUIPMENT DAMAGE
TIC-4101-014	RECTIFIER COLUMN TEMPERATURE TRANSMITTER AT TRAY 21	PD-4101	degrees F		238 F	248 F	258 F			TAH INDICATES HIGH STEAM OR LOW PROOF
PIC-4101-020	RECTIFIER COLUMN PRESSURE	PD-4101	psia			56.45 psia	65 psia			PAH ALARM IF PRESSURE IS TOO HIGH
LIC-4101-024	FUSEL OIL DECANTER INTERFACE TRANSMITTER	PD-4101	% LEVEL		25%	50%	75%			LAL PROTECT PUMP (PC-4108); LAH PROTECT OVERFILL WITHIN FUSEL OIL DECANTER - w.r.t. bottom weld line of tank
LIC-4101-026	FUSEL OIL DECANTER LEVEL TRANSMITTER	PD-4101	% LEVEL		25%	50%	75%			LAH ALARM WHEN LEVEL IS LOW REDUCES PUMP (PD-4109) DISCHARGE; LAH PROTECTS TANK OVERFILL AND REDUCES PD-4109 FUSEL OIL DISCHARGE
DI-4101-028	FUSEL OIL DENSITY TRANSMITTER	PD-4101	lb/ft3			49.92 lb/ft3	TBD			DAH ALARM IF DENSITY IS ABOVE DESIRED DENSITY - DAH INDICITAVE OF WATER/INTERFACE CARRY OVER IN FUSEL OIL
LIC-4101-032	RC BOTTOMS LEVEL TRANSMITTER	PD-4101	% LEVEL		25%	50%	75%			LAL PROTECTS PUMP (PC-4110); LAH PROTECTS OVERFILL WITHIN RC BOTTOMS FLASH TANK (TP-4110)
LIC-4102-003	92% ETHANOL RECEIVER LEVEL TRANSMITTER	PD-4102	% LEVEL		25%	50%	75%			LAL PROTECTS PUMP (PC-4102) AND RC COLUMN INTERNALS; LAH PROTECTS OVERFILL WITHIN TANK
LIC-4102-008	RC CONDENSER/BC REBOILER (ET-4103) LEVEL TRANSMITTER	PD-4102	% LEVEL		25%	50%	75%			LAL PROTECT PUMP, LAH PROTECT OVERFILL
LIC-4102-014	BC REBOILER/200 PROOF ETHANOL CONDENSER (ET-4104) LEVEL TRANSMITTER	PD-4102	% LEVEL		25%	50%	75%			LAL PROTECT PUMP, LAH PROTECT OVERFILL
LIC-4102-023	200 PROOF ETHANOL RECEIVER (TP-4107) LEVEL TRANSMITTER	PD-4102	% LEVEL		25%	50%	75%			LAL PROTECT PUMP, LAH PROTECT OVERFILL
TT-4102-028	BC REBOILER/200 PROOF ETHANOL CONDENSER (ET-4104) TEMPERATURE TRANSMITTER	PD-4102	degrees F			230 F	260			TAH INDICATES INADEQUATE DESUPERHEAT ETHANOL FLOW
LIC-4103-001	BEER COLUMN BOTTOMS LEVEL TRANSMITTER	PD-4103	% LEVEL		25%	50%	75%			LAL PROTECT PUMP, LAH PROTECT OVERFILL
LS-4103-004	BEER COLUMN BOTTOMS LEVEL SWITCH	PD-4103	% LEVEL						I-3	CLOSES FV-4101-001 STEAM FLOW TO PREVENT TRY DAMAGE WITHIN TW-4102
PIC-4103-010	BEER COLUMN PRESSURE TRANSMITTER	PD-4103	psia		8 psia	10.168 psia	15 psia			PAH ALARM IF PRESSURE IS TOO HIGH; PAL IS PRESSURE IS TOO LOW
LIC-4103-011	CO2 FLASH TANK LEVEL TRANSMITTER	PD-4103	% LEVEL		10%	TBD	75%			LAL PROTECT PUMP, LAH PROTECTS OVERFILL
LIC-4103-020	MASH FLASH COOLER #1 LEVEL TRANSMITTER	PD-4103	% LEVEL		10%	TBD	75%			LAL PROTECT PUMP, LAH PROTECTS OVERFILL
LIC-4103-021	MASH FLASH COOLER #2 LEVEL TRANSMITTER	PD-4103	% LEVEL		10%	TBD	75%			LAL PROTECT PUMP, LAH PROTECTS OVERFILL
TIC-4201-002	WHOLE STILLAGE FLASH TANK TEMPERATURE TRANSMITTER	PD-4201	degrees F			185 F	195 F			ALARM IF TEMPERATURE IS TOO HOT
LIC-4201-005	EVAPORATOR 1 - IST EFFECT LEVEL TRANSMITTER	PD-4201	% LEVEL		25%	50%	75%			LAL PROTECTS WHOLE STILLAGE FLASH PUMP (PC-4207); LAH PROTECTS OVERFILL
LIC-4201-007	1ST EFFECT CONDENSATE COLLECTION TANK LEVEL TRANSMITTER	PD-4201	% LEVEL		25%	50%	75%			LAL PROTECTS EVAP. RECIRC. PUMP 1ST STAGE; LAH PROTECTS OVERFILL
LIC-4201-008	WHOLE STILLAGE FLASH TANK LEVEL TRANSMITTER	PD-4201	% LEVEL		25%	50%	75%			LAL PROTECTS 1ST EFFECT CONDENSATE PUMP; LAH PROTECTS OVERFILL
LIC-4202-006	2ND EFFECT CONDENSATE COLLECTION TANK LEVELTRANSMITTER	PD-4202	% LEVEL		25%	50%	75%			LAL PROTECTS EVAP. RECIRC. PUMP 1ST STAGE; LAH PROTECTS OVERFILL
DIC-4202-007	EVAPORATOR 2 - 2ND EFFECT DENSITY	PD-4202	lb/ft3		TBD	73.63 lb/ft3	TBD			DAH ALARM IF DENSITY IS ABOVE DESIRED DENSITY - SYRUP DURING CIP OR CONTROL FINISHER WATER MAKE-UP
LIC-4203-004	EVAP. COND. RECEIVER LEVEL TRANSMITTER	PD-4203	% LEVEL		25%	50%	75%			LAL PROTECTS TK CONDENSATE PUMP; LAH PROTECTS OVERFILL
LIC-4203-006	VACUUM PUMP (PV-4201) LEVEL TRANSMITTER	PD-4203	% LEVEL		25%	50%	75%			LAL IF LEVEL IS LOW; LAH PROTECTS OVERFILL
PIC-4203-010	VACUUM PUMP/CONDENSER PRESSURE TRANSMITTER	PD-4203	psia			1.94 psia	3 psia			PAL PROTECTS VACUUM PUMP; PAH ALARM IS VACUUM FOR CONDENSER NOT ADEQUATE
PIC-4301-005	190 PROOF TO MOL SIEVE PRESSURE TRANSMITTER	PD-4301	psia		45 psia	55 psia	69 psia			CONTROL PV-4301-005:PAH ALARM IF PRESSURE IS TOO HIGH - CONSIDER INTERLOCK (CLOSE FEED FLOW VALVE TO MSU)
XV-4301-001, XV-4301-003	MOL SIEVES BLOCK VALVES (fail closed)	PD-4301			OPEN		CLOSED			ALARM IF DESIRED POSITION FAILS TO OCCUR WITHIN 5 SECONDS
XV-4301-015, XV-4301-016	MOL SIEVES BLOCK VALVES (fail in position)	PD-4301			OPEN		CLOSED			ALARM IF DESIRED POSITION FAILS TO OCCUR WITHIN 5 SECONDS
PIC-4301-027	DEPRES/REGEN PRESSURE TRANSMITTER	PD-4301	psia		45 psia	55 psia	69 psia			PAH ALARM IF PRESSURE IS TOO HIGH
LIC-4302-004	DEPRESSURIZATION COND. RECEIVER LEVEL TRANSMITTER	PD-4302	% LEVEL		25%	50%	75%			LAL IF LEVEL IS LOW; LAH PROTECTS OVERFILL
LIC-4302-005	REGENERATION COND. RECEIVER LEVEL TRANSMITTER	PD-4302	% LEVEL		25%	50%	75%			LAL IF LEVEL IS LOW; LAH PROTECTS OVERFILL
XV-4302-012, XV-4302-013	DEPRESSURIZATION & REGENERATION CONDESER BLOCK VALVES (fail in position)	PD-4302			OPEN		CLOSED			ALARM IF DESIRED POSITION FAILS TO OCCUR WITHIN 5 SECONDS

	INTERLOCKS AND EMERGENCY STOPS
E-STOP	CLOSES STEAM VALVES FV-4101-001 & TV-4101-021
I-1	**CLOSES STEAM VALVE** FV-4101-001 CLOSES WHEN LAHH-4101-008 > 75%
I-2	**CLOSES STEAM VALVE** FV-4101-001 CLOSES WHEN PT-4101-009 > ## psia
I-3	**CLOSES STEAM VALVE** FV-4101-001 CLOSES WHEN LAHH-4103-004 > 75%

INTERLOCK POINTS INDICATED ON P&ID'S
ALARM POINTS INDICATED ON P&ID'S

NOTE
LEVEL % REFERS TO LEVEL INSIDE VESSEL - NOT TOAL MEASURABLE LEVEL