

# **K Process**

## **Control Narrative**





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## Process Overview

The K process represents a typical batch process. Dwg. 0001 presents an overall view of the process. It consists of 29 basic units divided into four areas. The loadin area consists of a wet unload cell, with truck wet and rail wet unload units (Dwg. 1001), and additive cell consisting of a dry additive makeup unit (Dwg. 1003) and a wet additive makeup unit (Dwg. 1004), a dry unload cell consisting of rail dry unload unit (Dwg. 2001), truck dry unload unit (Dwg. 2003), dry storage loadin, and dry storage loadout (Dwg. 2002), a powder unload cell consisting of truck and rail powder unload units (Dwg. 2004), and a gas ingredient unload unit (Dwg. 2007). The raw ingredients are unloaded from trucks and rail cars into storage tanks in the appropriate ingredient storage units. The wet ingredient storage (Dwg. 2001) is shared between the loadin area and production area. The powder storage (Dwg. 2006) is shared between the loading and production area. The gas storage (Dwg. 2008) is shared between the loading and production area. The production area is divided into a reactor and ion exchange cell. The reactor cell has a blending unit (Dwg. 3000) and four reactor units (Dwgs. 3001, 3002, 3003, and 3004), and a QA sample unit (Dwg. 3008). Certain ingredients are blended to produce one of the ingredients for two of the reactor units. Each reactor takes the appropriate ingredients from the blend and ingredient storage units and combines them to make a batch of product. The product is transferred though an ion exchanger to remove some impurities. The ion exchange cell (Dwgs. 4001, 4002, and 4003) has six ion exchangers. Ion exchangers 1 and 2 are for reactors 1 and 2. Ion exchangers 3 and 4 are for reactor 3. Ion exchangers 5 and 6 are for reactor 4. The ion exchangers are regenerated after a certain amount of product passes through the ion exchanger. The QA sample unit samples product from reactors 1 and 2 at the appropriate point in the reactor operation and presents the result to the operator so that he/she can decide how much, if any, additional reaction time is necessary. The loadout area consists of five units: a product storage 1 unit (Dwg 5001), a product storage 2 unit (Dwg. 5003), a product storage unit (Dwg. 5004) and a three loadout units (Dwg. 5002 and 5005). The product from an ion exchanger is initially stored in a QA tank before it is transferred to one of three storage tanks. From the storage tanks, it is transferred to a truck/rail loadout system. The utility area contains two clean-in-place (CIP) units (Dwg 6001 and 6002); and a QA sampling unit (Dwg. 3008). Each CIP unit has a tank and a recirculating loop that maintain the cleaning water temperature. The CIP 1 system (Dwg 6001) cleans out piping in the reactor 1, reactor 2, ion exchange 1, ion exchange 2 units and the product storage 1 unit. In the CIP 1 unit, soda ash and hot water are used to make up the cleaning water. The CIP 1 unit (Dwg 6002) cleans out piping in the reactor 4, ion exchange 5 and ion exchange 6 units. In the CIP 2 unit, liquid caustic and hot water are used to make up the cleaning water.

Note that the units could be divided differently. For example, the rail dry unload unit could be combined with the dry storage loadin unit and the dry storage loadout unit could be combined with reactor 2. The units are divided to provide projects that are approximately the same size. Details about the project teams are described in the project description document.

## Truck Wet Unload Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
P-1145	Truck Unload Pump	Centrifugal pump that transfers liquid ingredient from one of two truck unload stations to truck unload header and to one of the wet ingredient storage tanks.

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
FI1148	Indicator	Truck unload header flow	Measure outflow of truck unload pump	0-1000 gpm	
FQI1148	Indicator	Totalized truck unload transfer flow	Measure amount of ingredient transferred to tank		
PI1111	Indicator	XV1111 purge air pressure	Measure purge air pressure at truck unload station 1	0-100 psi	
PI1121	Indicator	XV1121 purge air pressure	Measure purge air pressure at truck unload station 2	0-100 psi	

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
P-1145	Pump	Truck Unload Pump	Pumps liquid from truck stations into truck unload header	
XV1111	Valve	Truck Station 1 Purge Air Valve	Allows purge air into truck trailer at truck station 1	
XV1112	Valve	Truck Station 1 Unload Valve	Allows flow of wet ingredient from truck station 1 into pump	
XV1121	Valve	Truck Station 2	Allows purge air into	

		Purge Air Valve	truck trailer at truck station 2	
XV1122	Valve	Truck Station 2 Unload Valve	Allows flow of wet ingredient from truck station 2 into pump	
XV1145	Valve	Truck Unload Header Feed Valve	Allows flow of liquid from truck unload stations into truck unload header	
XV1146	Valve	Truck Cleaning Water Feed Valve	Allows flow of hot cleaning water into truck unload header	

### **Devices in Wet Ingredient Storage**

XV2111	Valve	T-2110 Truck Feed Valve	Controls flow from truck unload header into T-2110	
XV2121	Valve	T-2120 Truck Feed Valve	Controls flow from truck unload header into T-2120	
XV2131	Valve	T-2130 Truck Feed Valve	Controls flow from truck unload header into T-2130	
XV2141	Valve	T-2140 Truck Feed Valve	Controls flow from truck unload header into T-2140	
XV2196	Valve	Truck Header Drain Valve	Controls flow from truck unload header to drain	

## ***Unit Operation Interactions***

**Rail Wet Unload Unit** Liquids unloaded from a truck trailer must not go into the same destination tank being used by the rail wet unload unit.

## ***Truck Wet Unload Unit Operational States***

Note: The operator must select a source station and a destination tank.

- Transfer - Transfers the entire contents of the tank trailer at the selected truck unload station to the selected destination tank. Do not allow this operation to start if any Truck Transfer is in operation. Steps:
  - Display prompt for operator and operator selects source and destination
  - If destination tank is more than 80% full, abort operation (jump to last step)
  - If Rail Transfer to selected destination tank is in operation, abort operation
  - Close all valves (one step)
  - Initialize FQI1148
  - Open appropriate air purge valve (XV1111 or XV1121)
  - Open appropriate unload valve (XV1112 or XV1122)
  - Open XV1145
  - Open appropriate XV21x1
  - Start P-1145
  - Wait until destination tank is full (level > 95%), or low flow in truck unload header (flow < 10 gpm)
  - Shut down the system
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Flush - Flushes the truck unload header with hot water. Can only be requested if already shutdown
  - Open truck header water return valve XV2196
  - Open XV1146
  - Open XV1145
  - Start P-1145
  - Flush for 10 minutes
  - Shut down the system
- Shutdown - Turns off the pump and all valves:
  - Stop P-1145
  - Close XV1111
  - Close XV1112
  - Close XV1121
  - Close XV1122
  - Close XV1145
  - Close XV1146
  - Close XV2111
  - Close XV2121
  - Close XV2131
  - Close XV2141
  - Close XV2196
- E-Shutdown - Immediately turns off the pump and all storage header valves:
  - Stop P-1145

Close XV1111, XV1112, XV1121, XV1122, XV1145, XV1146, XV2111, XV2121,  
XV2131, XV2141, XV2196

### *Truck Wet Unload Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

PI1111 < 10 psi and XV1111 open 5 seconds → Alarm

PI1121 < 10 psi and XV1121 open 5 seconds → Alarm

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Rail Wet Unload Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
P-1195	Rail Unload Pump	Centrifugal pump that transfers liquid ingredient from one of two rail unload stations to rail unload header and to one of the wet ingredient storage tanks.

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
FI1198	Indicator	Rail unload header flow	Measure outflow of rail unload pump	0-1000 gpm	
FQI1198	Indicator	Totalized rail car unload transfer flow	Measure amount of ingredient transferred to tank		
PI1151	Indicator	XV1151 purge air pressure	Measure purge air pressure at rail unload station 1	0-100 psi	
PI1161	Indicator	XV1161 purge air pressure	Measure purge air pressure at rail unload station 2	0-100 psi	

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
P-1195	Pump	Rail Unload Pump	Pumps liquid from rail stations into rail unload header	
XV1151	Valve	Rail Station 1 Purge Air Valve	Allows purge air into railcar at rail station 1	
XV1152	Valve	Rail Station 1 Unload Valve	Allows flow of wet ingredient from rail station 1 into pump	
XV1161	Valve	Rail Station 2	Allows purge air into	

		Purge Air Valve	railcar at rail station 2	
XV1162	Valve	Rail Station 2 Unload Valve	Allows flow of wet ingredient from rail station 2 into pump	
XV1195	Valve	Rail Unload Header Feed Valve	Allows flow of liquid from rail unload stations into rail unload header	
XV1196	Valve	Rail Cleaning Water Feed Valve	Allows flow of hot cleaning water into rail unload header	

### **Devices in Wet Ingredient Storage**

XV2112	Valve	T-2110 Rail Feed Valve	Controls flow from rail unload header into T-2110	
XV2122	Valve	T-2120 Rail Feed Valve	Controls flow from rail unload header into T-2120	
XV2132	Valve	T-2130 Rail Feed Valve	Controls flow from rail unload header into T-2130	
XV2142	Valve	T-2140 Rail Feed Valve	Controls flow from rail unload header into T-2140	
XV2198	Valve	Rail Header Drain Valve	Controls flow from rail unload header to drain	

### ***Unit Operation Interactions***

**Truck Wet Unload Unit** Liquids unloaded from a rail car must not go into the same destination tank being used by the truck wet unload unit.

### ***Rail Wet Unload Unit Operational States***

Note: The operator must select a source station and a destination tank.



- Transfer - Transfers the entire contents of the tankcar at the selected rail unload station to the selected destination tank. Do not allow this operation to start if any Rail Transfer is already in operation. Steps:
  - Display prompt for operator and operator selects source and destination
  - If destination tank is more than 80% full, abort operation (jump to last step)
  - If Truck Transfer to selected destination tank is in operation, abort operation
  - Close all valves (one step)
  - Initialize FQI1198
  - Open appropriate air purge valve (XV1151 or XV1161)
  - Open appropriate unload valve (XV1152 or XV1162)
  - Open XV1195
  - Open XV21x2
  - Start P-1195
  - Wait until destination tank is full (level > 95%), or low flow in rail unload header (flow < 10 gpm)
  - Shut down the system
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Flush - Flushes the rail unload header with hot water. Can only be requested if already shutdown.
  - Open rail header water return valve XV2198
  - Open XV1196
  - Open XV1195
  - Start P-1195
  - Flush for 10 minutes
  - Shutdown
- Shutdown - Turns off the pump and all valves:
  - Stop P-1195
  - Close XV1151
  - Close XV1152
  - Close XV1161
  - Close XV1162
  - Close XV1195
  - Close XV1196
  - Close XV2112
  - Close XV2122
  - Close XV2132
  - Close XV2142
  - Close XV2198
- E-Shutdown - Immediately turns off the pump and all storage header valves:
  - Stop P-1195
  - Close XV1151, XV1152, XV1161, XV1162, XV1195, XV1196, XV2112, XV2122, XV2132, XV2142, XV2198

### *Rail Wet Ingredient Unload Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

PI1151 < 10 psi and XV1151 open 5 seconds → Alarm

PI1161 < 10 psi and XV1161 open 5 seconds → Alarm

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Dry Additive Makeup Unit

### *Major Equipment*

<u><b>TAG</b></u>	<u><b>DESCRIPTION</b></u>	<u><b>PURPOSE</b></u>
A-1300	Mix Tank agitator	Mix the additive into water
P-1310	Mix Tank Unload Pump	Centrifugal pump that transfers liquid additive to dry additive header and to one of the additive ingredient storage tanks.
T-1300	Additive Mix Tank	500 gallon tank. Dry additive is mixed in tank and is transferred from this tank.
C-1301	Additive Conveyor	Conveys additive from the material addition hopper to the slide gate.
G-1300	Additive Tank Slide Gate	Additive enters the mix tank through this gate.

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<u><b>TAG</b></u>	<u><b>TYPE</b></u>	<u><b>DESCRIPTION</b></u>	<u><b>PURPOSE</b></u>	<u><b>OTHER INFO</b></u>	<u><b>SEQUENCE BASED INTERLOCKS</b></u>
AI1300	Indicator	pH of Mix Tank	Monitor pH to determine proper make-up	0-14	
FIC1320	Loop	Hot water supply flow control	Controls feed rate of hot water to Mix tank	0-50 gpm, Fail closed, direct acting	
FQI1320	Indicator	Totalized hot water flow	Measures amount of hot water placed into mix tank		
LI1300	Indicator	Level of Mix Tank	Monitor level	0-100 (units %)	

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<u><b>TAG</b></u>	<u><b>TYPE</b></u>	<u><b>DESCRIPTION</b></u>	<u><b>PURPOSE</b></u>	<u><b>SEQUENCE BASED INTERLOCKS</b></u>
A-1300	Motor	Mix tank agitator	Mixes water and	

			additive in mix tank	
C-1301	Conveyor	Ingredient Conveyor	Moves ingredient from hopper to mix tank slide gate.	
M-1300	Motor	Mix Tank Slide Gate Motor	Opens/closes mix tank slide gate	
P-1310	Pump	Mix Tank Unload Pump	Pumps liquid from mix tank into dry additive header	
SS1301	Speed Switch	C-1301 Speed Switch	Indicates that conveyor is stopped	
XV1311	Valve	Mix Tank Outlet Valve	Allows flow of additive from mix tank into pump	
XV1312	Valve	Dry Mix Unload Valve	Allows flow of liquid from pump into dry mix header	
XV1313	Valve	Hot water supply Valve	Allows flow of hot cleaning water into dry mix header	
XV1314	Valve	Drain Valve	Allows flow of liquid from pump to drain	
XV1321	Valve	Cold water supply Valve	Allows flow of cold water into mix tank	
ZSC1300	Limit Switch	ZS1300 slide gate switch	Indicates slide gate is closed	
ZSO1300	Limit Switch	ZS1300 slide gate switch	Indicates slide gate is open	

#### **Devices in Wet Ingredient Storage**

XV2152	Valve	T-2150 Dry Add Feed Valve	Controls flow from dry additive header into T-2150	
XV2162	Valve	T-2160 Dry Add Feed Valve	Controls flow from dry additive header into T-2160	
XV2194	Valve	Dry Add Header Drain Valve	Controls flow from dry additive header to drain	

### ***Unit Operation Interactions***

**Wet Additive Makeup Unit** Liquids unloaded from dry additive makeup must not go into the same destination tank being used by the wet additive makeup unit.

### ***Dry Additive Makeup Unit Operational States***

Note: The operator must select a destination tank.

- **Make-up** - Makes up a new batch of additive from the hot water supply and bagged material from hopper, initiated by operator.
  - If Mix Tank level  $\geq 2\%$ , abort.
  - Display prompt for operator and operator selects destination
  - If Wet Additive to selected destination tank is in operation, abort operation
  - Close all valves (one step)
  - Initialize FQI1300
  - Request amount of hot water from operator
  - Wait for confirmation from operator
  - Put Hot Water Flow Controller FIC1320 in auto, setpoint = 40 gpm
  - Wait for amount of hot water
  - Start Agitator A-1300
  - Open Mix Tank Slide Gate G-1300
  - Start Mix Conveyor C-1300
  - Wait for operator confirmation that additive sample is okay
  - Stop Mix Conveyor C-1300
  - Close Mix Tank Slide Gate G-1300
  - Open appropriate XV21x1
  - Open Dry Mix Unload Valve XV1312
  - Open Mix Tank Outlet Valve XV1311
  - Start pump P-1310
  - Wait for Mix Tank level to be less than 1% for 30 seconds
  - Shut down the system
- **Hold** - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- **Flush** - Flushes the dry additive header with hot water. Can only be requested if already shutdown.
  - Open dry additive header water return valve XV2194
  - Open XV1312
  - Open XV1313
  - Start P-1310
  - Flush for 10 minutes
  - Shutdown
- **Shutdown** - Turns off the pump and all valves:

If Mix Conveyor C-1300 running,  
    Wait 20 seconds for conveyor to clear  
Close Mix Tank Slide Gate G-1300  
Stop P-1310  
Stop A-1300  
Set FIC1320 to manual, 0% output  
Close XV1311  
Close XV1312  
Close XV1313  
Close XV1314  
Close XV1321  
Close XV2152  
Close XV2162  
Close XV2194

- E-Shutdown - Immediately turns off the pump and all storage header valves:  
    Stop P-1310, A-1300  
    Set FIC1320 to manual, 0% output  
    Close XV1311, XV1312, XV1313, XV1314, XV1321, XV2152, XV2162, XV2194

### *Dry Additive Makeup Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

C-1301 failure for 1 second → Shutdown  
SS1301 indicates conveyor off 20 seconds after startup → Shutdown  
Destination tank level > 90% → Shutdown  
AS1302 indicates conveyor belt out of alignment for 3 seconds → E-Shutdown  
Any pump failure → Hold  
Any valve failure → Hold  
Standard Aux, HOA, overload alarms on pumps  
Standard Fail to Open, Fail to Close alarms on valves

## Wet Additive Makeup Unit

### *Major Equipment*

<u>TAG</u>	<u>DESCRIPTION</u>	<u>PURPOSE</u>
A-1400	Mix Tank agitator	Mix the additive into water
P-1410	Mix Tank Unload Pump	Centrifugal pump that transfers liquid additive to wet additive header and to one of the additive ingredient storage tanks.
P-1440	Wet Add Inlet Pump	Centrifugal pump that transfers liquid additive from stations to mix tank.
T-1400	Additive Mix Tank	500 gallon tank. Mixed additive is transferred from this tank.

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<u>TAG</u>	<u>TYPE</u>	<u>DESCRIPTION</u>	<u>PURPOSE</u>	<u>OTHER INFO</u>	<u>SEQUENCE BASED INTERLOCKS</u>
AI1400	Indicator	pH of Mix Tank	Monitor pH to determine proper make-up	0-14	
FI1440	Indicator	Additive flow	Measures flow rate of additive pumped into mix tank	0-50 gpm	
FIC1422	Loop	Hot water supply flow control	Controls feed rate of hot water to Mix tank	0-50 gpm, Fail closed, direct acting	
FQI1440	Indicator	Totalized additive flow	Measures amount of additive placed into mix tank		
FQI1422	Indicator	Totalized hot water flow	Measures amount of hot water placed into mix tank		
LI1400	Indicator	Level of Mix Tank	Monitor level	0-100 (units %)	

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
A-1400	Motor	Mix tank agitator	Mixes water and additive in mix tank	
P-1410	Pump	Mix Tank Unload Pump	Pumps liquid from mix tank into wet additive header	
P-1410	Pump	Wet Add Inlet Pump	Pumps liquid from one of the additive stations into mix tank	
XV1411	Valve	Mix Tank Outlet Valve	Allows flow of additive from mix tank into pump	
XV1412	Valve	Wet Mix Unload Valve	Allows flow of liquid from pump into wet mix header	
XV1413	Valve	Hot water clean supply valve	Allows flow of hot cleaning water into wet mix header	
XV1414	Valve	Drain Valve	Allows flow of liquid from pump to drain	
XV1420	Valve	Cold water supply Valve	Allows flow of cold water into mix tank	
XV1421	Valve	Hot water mixer supply valve	Allows flow of hot water into mixing tank	
XV1441	Valve	Additive station #1 outlet valve	Allows flow of additive at station #1 to pump	
XV1442	Valve	Additive station #2 outlet valve	Allows flow of additive at station #2 to pump	
XV1443	Valve	Additive station #3 outlet valve	Allows flow of additive at station #3 to pump	

#### **Devices in Wet Ingredient Storage**

XV2151	Valve	T-2150 Wet Add Feed Valve	Controls flow from wet additive header into T-2150	
XV2161	Valve	T-2160 Wet Add Feed Valve	Controls flow from wet additive header into T-2160	
XV2171	Valve	T-2170 Wet Add Feed Valve	Controls flow from wet additive header into T-2170	



XV2192	Valve	Wet Add Header Drain Valve	Controls flow from wet additive header to drain	
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### ***Unit Operation Interactions***

**Dry Additive Makeup Unit** Liquids unloaded from wet additive makeup must not go into the same destination tank being used by the dry additive makeup unit.

### ***Wet Additive Makeup Unit Operational States***

Note: The operator must select a source station and a destination tank.

- Make-up - Makes up a new batch of additive from the hot water supply and one of the material addition stations, initiated by operator.
  - If LI1400, Mix Tank level  $\geq 2\%$ , abort.
  - Display prompt for operator and operator selects source and destination
  - If Dry Additive to selected destination tank is in operation, abort operation
  - Request amount of hot water and amount of additive from operator
  - Wait for confirmation from operator
  - Close all valves (one step)
  - Initialize FQI1422 and FQI1440
  - Put Hot Water Flow Controller FIC1422 in auto, setpoint = 40 gpm
  - Wait for amount of hot water, FQI1422
  - Start Agitator A-1400
  - Open appropriate XV144x valve
  - Start wet additive inlet pump P-1440
  - Wait for amount of additive, FQI1440
  - Stop wet additive inlet pump P-1440
  - Close appropriate XV144x valve
  - Open appropriate XV21x1
  - Open Wet Mix Unload Valve XV1412
  - Open Mix Tank Outlet Valve XV1411
  - Start pump P-1410
  - Wait for Mix Tank level to be less than 1% for 30 seconds
  - Shut down the system
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.

- Flush - Flushes the dry additive header with hot water. Can only be requested if already shutdown.
  - Open wet additive header water return valve XV2192
  - Open XV1412
  - Open XV1413
  - Start P-1410
  - Flush for 10 minutes
  - Shutdown
- Shutdown - Turns off the pump and all valves:
  - Stop P-1410
  - Stop P-1440
  - Stop A-1400
  - Set FIC1422 to manual, 0% output
  - Close XV1411
  - Close XV1412
  - Close XV1413
  - Close XV1414
  - Close XV1420
  - Close XV1421
  - Close XV2151
  - Close XV2161
  - Close XV2192
- E-Shutdown - Immediately turns off the pump and all storage header valves:
  - Stop P-1410, P-1440, A-1400
  - Set FIC1422 to manual, 0% output
  - Close XV1411, XV1412, XV1413, XV1414, XV1420, XV1421, XV2151, XV2161, XV2192

### *Wet Additive Makeup Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

Destination tank level > 90% → Shutdown

FI1440 < 1 gpm while transferring additive to tank for 2 seconds → Shutdown

SS1301 indicates conveyor off 20 seconds after startup → Shutdown

AS1302 indicates conveyor belt out of alignment for 3 seconds → E-Shutdown

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Wet Ingredient Storage Unit

### Major Equipment

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
T-2110	Ingred W Tank	10,000 gallon storage tank to hold ingredient W. When needed, its contents are transferred to the blend unit.
T-2120	Ingred X Tank	10,000 gallon storage tank to hold ingredient W. When needed, its contents are transferred to the blend unit.
T-2130	Ingred Y Tank	10,000 gallon storage tank to hold ingredient Y. When needed, its contents are transferred to the blend unit.
T-2140	Ingred Z Tank	10,000 gallon storage tank to hold ingredient Z. When needed, its contents are transferred to the blend unit.
T-2150	Ingred S Tank	10,000 gallon storage tank. When needed, its contents are transferred to reactor 1.
T-2160	Ingred T Tank	10,000 gallon storage tank. When needed, its contents are transferred to reactor 2 or reactor 3.
T-2170	Ingred U Tank	10,000 gallon storage tank. When needed, its contents are transferred to reactor 4.

### Analog Instrument and Control Point Listing

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
LI2110	Indicator	Level of Ingred. W	Monitor level	0-100 (units %)	
LI2120	Indicator	Level of Ingred. X	Monitor level	0-100 (units %)	
LI2130	Indicator	Level of Ingred. Y	Monitor level	0-100 (units %)	
LI2140	Indicator	Level of Ingred. Z	Monitor level	0-100 (units %)	
LI2150	Indicator	Level of Ingred. B in Storage Tank #1	Monitor level	0-100 (units %)	
LI2160	Indicator	Level of Ingred. B in Storage Tank #2	Monitor level	0-100 (units %)	

### Discrete Instrument and Control Point Listing

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
XV2111	Valve	T-2110 Truck Feed Valve	Controls flow from truck unload header	

			into T-2110	
XV2112	Valve	T-2110 Rail Feed Valve	Controls flow from rail unload header into T-2110	
XV2115	Valve	T-2110 Discharge Valve	Controls flow from T-2110 to blend unit	
XV2121	Valve	T-2120 Truck Feed Valve	Controls flow from truck unload header into T-2120	
XV2122	Valve	T-2120 Rail Feed Valve	Controls flow from rail unload header into T-2120	
XV2125	Valve	T-2120 Discharge Valve	Controls flow from T-2120 to blend unit	
XV2131	Valve	T-2130 Truck Feed Valve	Controls flow from truck unload header into T-2130	
XV2132	Valve	T-2130 Rail Feed Valve	Controls flow from rail unload header into T-2130	
XV2135	Valve	T-2130 Discharge Valve	Controls flow from T-2130 to blend unit	
XV2141	Valve	T-2140 Truck Feed Valve	Controls flow from truck unload header into T-2140	
XV2142	Valve	T-2140 Rail Feed Valve	Controls flow from rail unload header into T-2140	
XV2145	Valve	T-2140 Discharge Valve	Controls flow from T-2140 to blend unit	
XV2151	Valve	T-2150 Wet Add Feed Valve	Controls flow from wet additive header into T-2150	
XV2152	Valve	T-2150 Dry Add Feed Valve	Controls flow from dry additive header into T-2150	
XV2155	Valve	T-2150 Discharge Valve	Controls flow from T-2150 to reactor 1	
XV2161	Valve	T-2160 Wet Add Feed Valve	Controls flow from wet additive header into T-2160	
XV2162	Valve	T-2160 Dry Add Feed Valve	Controls flow from dry additive header into T-2160	
XV2165	Valve	T-2160 Discharge	Controls flow from T-	

		Valve	2160 to reactor 2	
XV2166	Valve	T-2160 Discharge Valve	Controls flow from T-2160 to reactor 3	
XV2171	Valve	T-2170 Wet Add Feed Valve	Controls flow from wet additive header into T-2170	
XV2175	Valve	T-2170 Discharge Valve	Controls flow from T-2170 to reactor 4	
XV2192	Valve	Wet Add Header Drain Valve	Controls flow from wet additive header to drain	
XV2194	Valve	Dry Add Header Drain Valve	Controls flow from dry additive header to drain	
XV2196	Valve	Truck Header Drain Valve	Controls flow from truck unload header to drain	
XV2198	Valve	Rail Header Drain Valve	Controls flow from rail unload header to drain	

### ***Unit Operation Interactions***

**Wet Unload Units** Liquid ingredients are received from the truck wet unload unit and rail wet unload unit and transferred to the appropriate tank. The truck wet unload and rail wet unload units completely control the inlet side of the wet storage unit operation.

**Additive Units** Dry ingredients are received from the dry additive unit and liquid ingredients are received from the wet additive unit and transferred to the appropriate tank. The dry additive and wet additive units completely control the inlet side of the wet storage unit operation.

**Blend Unit** Liquid ingredients are transferred to the blend unit. The blend unit controls the outlet side of the appropriate tanks of the wet storage unit.

**Reactor 1, Reactor 2, and Reactor 3 Units** Liquid ingredients are transferred to the appropriate reactor unit. The reactor units control the outlet side of the appropriate tanks of the wet storage unit.

## Rail Dry Unload Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
B-1591	Dust Collector Blower	Centrifugal fan that draws dust from conveyors to dust collector.
BE-1510	Bucket Elevator Conveyor	Conveys dry ingredient to overhead conveyor
C-1503	Left Rail Dump Conveyor	Conveys dry ingredient from left hopper to common conveyor, C-1505
C-1504	Right Rail Dump Conveyor	Conveys dry ingredient from right hopper to common conveyor, C-1505
C-1505	Rail Dump Conveyor	Conveys dry ingredient to bucket elevator
C-1520	Overhead Conveyor 1	Conveys dry ingredient from bucket elevator to conveyor 2.
C-1530	Overhead Conveyor 2	Conveys dry ingredient from conveyor 1 to dry ingredient storage.
G-1501	Left Rail Dump Slide Gate	Dry ingredient enters system from left rail dump hopper.
G-1502	Right Rail Dump Slide Gate	Dry ingredient enters system from right rail dump hopper.
T-1590	Dust Collector	Holds dust drawn from conveyors.

### *Discrete Instrument and Control Point Listing*

#### **Discrete Control Points**

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
AS1506	Alignment Switch	C-1505 Belt Alignment Switch	Indicates that conveyor belt out of alignment (off=misalign)	
AS1521	Alignment Switch	C-1520 Belt Alignment Switch	Indicates that conveyor belt out of alignment (off=misalign)	
AS1531	Alignment Switch	C-1530 Belt Alignment Switch	Indicates that conveyor belt out of alignment (off=misalign)	
B-1591	Motor	Dust Collector Vacuum Blower	Sucks dust from conveying system	
BE-1510	Bucket Elevator	Rail Dump Bucket Elevator	Moves dry ingredient from common rail dump conveyor to overhead conveyor	
ES1523	E-Stop	C-1520 Belt E-Stop	Pull to e-stop	

	Switch	Pull Cord	conveyor	
ES1533	E-Stop Switch	C-1530 Belt E-Stop Pull Cord	Pull to e-stop conveyor	
C-1503	Conveyor	Left Rail Dump Conveyor	Moves dry ingredient from left rail dump hopper to common rail dump conveyor	
C-1504	Conveyor	Right Rail Dump Conveyor	Moves dry ingredient from right rail dump hopper to common rail dump conveyor	
C-1505	Conveyor	Common Rail Dump Conveyor	Moves dry ingredient from rail dump to bucket elevator	
C-1520	Conveyor	Overhead Conveyor 1	Moves dry ingredient from bucket elevator to conveyor 2	
C-1530	Conveyor	Overhead Conveyor 2	Moves dry ingredient from conveyor 1 to dry ingredient storage	
L-1592	Motor	Dust Collector Air Lock	Discharges dust from dust collector	
M-1501	Motor	Left Slide Gate Motor	Allows dry ingredient from railcar to enter left rail dump conveyor	
M-1502	Motor	Right Slide Gate Motor	Allows dry ingredient from railcar to enter right rail dump conveyor	
PS1508	Plug Switch	C-1505 Belt Plug Switch	Indicates that grain plugging end of conveyor (off=plug)	
PS1525	Plug Switch	C-1520 Belt Plug Switch	Indicates that grain plugging end of conveyor (off=plug)	
PS1535	Plug Switch	C-1530 Belt Plug Switch	Indicates that grain plugging end of conveyor (off=plug)	
SS1503	Speed Switch	C-1503 Speed Switch	Indicates that left conveyor stopped	
SS1504	Speed Switch	C-1504 Speed Switch	Indicates that right conveyor stopped	
SS1505	Speed Switch	C-1505 Speed Switch	Indicates that conveyor stopped	

SS1510	Speed Switch	C-1510 Speed Switch	Indicates that conveyor stopped	
SS1520	Speed Switch	C-1520 Speed Switch	Indicates that conveyor stopped	
SS1530	Speed Switch	C-1530 Speed Switch	Indicates that conveyor stopped	
ZSC1501	Limit Switch	G-1501 slide gate switch	Indicates left slide gate closed	
ZSO1501	Limit Switch	G-1501 slide gate switch	Indicates left slide gate open	
ZSC1502	Limit Switch	G-1502 slide gate switch	Indicates right slide gate closed	
ZSO1502	Limit Switch	G-1502 slide gate switch	Indicates right slide gate open	

### ***Unit Operation Interactions***

**Dry Ingredient Storage Unit** Dry ingredients unloaded from railcars are sent to the dry ingredient storage unit.

### ***Rail Dry Unload Unit Operational States***

- **Transfer** – Starts transfer of the left or right railcar contents to desired destination tank. Steps:  
 Display prompt for operator and operator selects source and destination  
 If transfer to selected destination tank already in operation (presumably from truck dry unload unit), abort operation (jump to last step)  
 If destination tank is more than 80% full, abort operation (jump to last step)  
 Request Dry Storage to Start Path to proper destination tank  
 Wait for path started  
 Start B-1591  
 Start L-1592  
 Start C-1530  
 Start C-1520  
 Start BE-1510  
 Start C-1505  
 Start left or right rail dump conveyor  
 Open left or right rail slide gate  
 Wait until destination bin is full (level > 95%)  
 Shut down the system
- **Hold** - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.



- Shutdown – Orderly shutdown of conveyor system. If failure in upstream device, skip wait. For example, if failure in either C-1505, skip the succeeding 20 second delay). Steps skip wait:
  - Close both slide gates
  - Wait 10 seconds
  - Stop C-1503 and stop C-1504
  - Wait 20 seconds
  - Stop C-1505
  - Wait 20 seconds
  - Stop BE-1510
  - Stop L-1592
  - Wait 30 seconds
  - Stop C-1520
  - Wait 20 seconds
  - Stop C-1530
  - Stop B-1591
  - Request Dry Storage to Shutdown
  - Wait for Dry Storage to finish shutting down
- E-Shutdown - Immediately turns off all equipment:
  - Close both slide gates
  - Stop C-1503, C-1504, C-1505, BE-1510, C-1520, C1530
  - Stop L-1592, B-1591

### *Rail Dry Ingredient Unload Unit Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

- L-1592 failure for 1 second → Hold
- B-1591 failure for 1 second → Hold
- C-1503 failure for 1 second → Shutdown
- C-1504 failure for 1 second → Shutdown
- C-1505 failure for 1 second → Shutdown
- BE-1510 failure for 1 second → Shutdown
- C-1520 failure for 1 second → Shutdown
- G-1501 failure for 1 second → Shutdown
- G-1502 failure for 1 second → Shutdown
- SS1503 indicates conveyor off 20 seconds after startup → Shutdown
- SS1504 indicates conveyor off 20 seconds after startup → Shutdown
- SS1505 indicates conveyor off 20 seconds after startup → Shutdown
- SS1510 indicates bucket elevator off 20 seconds after startup → Shutdown
- SS1520 indicates conveyor off 20 seconds after startup → Shutdown
- SS1530 indicates conveyor off 20 seconds after startup → Shutdown
- AS1506 indicates conveyor belt out of alignment for 3 seconds → E-Shutdown
- AS1521 indicates conveyor belt out of alignment for 3 seconds → E-Shutdown

AS1531 indicates conveyor belt out of alignment for 3 seconds → E-Shutdown  
PS1508 indicates conveyor plugged for 2 seconds → E-Shutdown  
PS1525 indicates conveyor plugged for 2 seconds → E-Shutdown  
PS1535 indicates conveyor plugged for 2 seconds → E-Shutdown  
ES1523 indicates E-stop pull cord pulled for 1 second → E-Shutdown  
ES1533 indicates E-stop pull cord pulled for 1 second → E-Shutdown  
In transfer and Dry Storage not in requested path for 3 seconds → E-Shutdown  
In transfer and lose heartbeat to Dry Storage for 10 seconds → E-Shutdown  
Standard Aux, HOA, overload alarms on motors  
Standard Fail to Open, Fail to Close alarms on slide gate

## Truck Dry Unload Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
B-1691	Dust Collector Blower	Centrifugal fan that draws dust from conveyors to dust collector.
BE-1610	Bucket Elevator Conveyor	Conveys dry ingredient to overhead conveyor
C-1604	Live Bottom Hopper Conveyor	Conveys dry ingredient from hopper to conveyor, C-1605
C-1607	Truck Dump Conveyor	Conveys dry ingredient to bucket elevator
C-1620	Overhead Conveyor 1	Conveys dry ingredient from bucket elevator to conveyor 2.
C-1630	Overhead Conveyor 2	Conveys dry ingredient from conveyor 1 to dry ingredient storage.
P-1601	Platform raiser hydraulic pump	Dry ingredient enters system from left rail dump hopper.
T-1690	Dust Collector	Holds dust drawn from conveyors.

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<u><b>TAG</b></u>	<u><b>TYPE</b></u>	<u><b>DESCRIPTION</b></u>	<u><b>PURPOSE</b></u>	<u><b>SEQUENCE BASED INTERLOCKS</b></u>
AS1605	Alignment Switch	C-1604 Belt Alignment Switch	Indicates that conveyor belt out of alignment (off=misalign)	
AS1608	Alignment Switch	C-1607 Belt Alignment Switch	Indicates that conveyor belt out of alignment (off=misalign)	
AS1621	Alignment Switch	C-1620 Belt Alignment Switch	Indicates that conveyor belt out of alignment (off=misalign)	
AS1631	Alignment Switch	C-1630 Belt Alignment Switch	Indicates that conveyor belt out of alignment (off=misalign)	
B-1691	Motor	Dust Collector Vacuum Blower	Sucks dust from conveying system	
BE-1610	Bucket Elevator	Rail Dump Bucket Elevator	Moves dry ingredient from common rail dump conveyor to overhead conveyor	
C-1607	Conveyor	Truck Dump	Moves dry ingredient	

		Conveyor	from live bottom hopper to bucket elevator	
C-1620	Conveyor	Overhead Conveyor 1	Moves dry ingredient from bucket elevator to conveyor 2	
C-1630	Conveyor	Overhead Conveyor 2	Moves dry ingredient from conveyor 1 to dry ingredient storage	
ES1623	E-Stop Switch	C-1620 Belt E-Stop Pull Cord	Pull to e-stop conveyor	
ES1633	E-Stop Switch	C-1630 Belt E-Stop Pull Cord	Pull to e-stop conveyor	
L-1602	Lift Control Up	Trailer Table Lift Cylinder Control	Causes hydraulic lift cylinder to raise trailer	
L-1603	Lift Control Down	Trailer Table Lift Cylinder Control	Causes hydraulic lift cylinder to lower trailer	
L-1692	Motor	Dust Collector Air Lock	Discharges dust from dust collector	
P-1601	Motor	Platform raiser hydraulic pump	Provides hydraulic pressure for cylinder to tilt trailer	
PS1606	Plug Switch	C-1604 Belt Plug Switch	Indicates that grain plugging end of conveyor (off=plug)	
PS1609	Plug Switch	C-1607 Belt Plug Switch	Indicates that grain plugging end of conveyor (off=plug)	
PS1625	Plug Switch	C-1620 Belt Plug Switch	Indicates that grain plugging end of conveyor (off=plug)	
PS1635	Plug Switch	C-1630 Belt Plug Switch	Indicates that grain plugging end of conveyor (off=plug)	
SS1604	Speed Switch	C-1604 Speed Switch	Indicates that live bottom conveyor stopped	
SS1607	Speed Switch	C-1607 Speed Switch	Indicates that conveyor stopped	
SS1610	Speed Switch	BE-1610 Speed Switch	Indicates that elevator stopped	
SS1620	Speed Switch	C-1620 Speed Switch	Indicates that conveyor stopped	

SS1630	Speed Switch	C-1630 Speed Switch	Indicates that conveyor stopped	
ZSD1601	Limit Switch	Dump lift cylinder switch	Indicates lift down	
ZSU1601	Limit Switch	Dump lift cylinder switch	Indicates lift up	

### ***Unit Operation Interactions***

**Dry Ingredient Storage Unit** Dry ingredients unloaded from trucks are sent to the dry ingredient storage unit.

### ***Truck Dry Unload Unit Operational States***

- Transfer – Starts transfer of the live bottom hopper contents to desired destination tank.  
Steps:
  - Display prompt for operator and operator selects destination
  - If transfer to selected destination tank already in operation (presumably from rail dry unload unit), abort operation (jump to last step)
  - If destination tank is more than 80% full, abort operation (jump to last step)
  - Request Dry Storage to Start Path to proper destination tank
  - Wait for path started
  - Start B-1691
  - Start L-1692
  - Start C-1630
  - Start C-1620
  - Start BE-1610
  - Start C-1607
  - Start C-1604
  - Start P-1601
  - Wait until destination bin is full (level > 95%)
  - Shut down the system
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown – Orderly shutdown of conveyor system. If failure in upstream device, skip wait. For example, if failure in C-1604, skip the succeeding 10 second delay). Steps:
  - Stop P-1601
  - Wait 10 seconds
  - Stop C-1604
  - Wait 10 seconds
  - Stop C-1607

- Wait 20 seconds
- Stop BE-1610
- Stop L-1692
- Wait 30 seconds
- Stop C-1620
- Wait 20 seconds
- Stop C-1630
- Stop B-1691
- Request Dry Storage to Shutdown
- Wait for Dry Storage to finish shutting down
- E-Shutdown - Immediately turns off all equipment:
  - Stop P-1601
  - Stop C-1604, C-1607, BE-1610, C-1620, C1630
  - Stop L-1692, B-1691

### ***Truck Dry Unload Manual Control***

- Start/stop pump:
  - Panel pushbuttons
- Raise lift:
  - Activate L-1602 to raise lift
- Lower lift:
  - Activate L-1603 to lower lift

### ***Truck Dry Ingredient Unload Unit Abnormal Conditions***

The following conditions are abnormal and will cause the indicated action.

L-1692 failure for 1 second → Hold  
 B-1691 failure for 1 second → Hold  
 C-1604 failure for 1 second → Shutdown  
 C-1607 failure for 1 second → Shutdown  
 BE-1610 failure for 1 second → Shutdown  
 C-1620 failure for 1 second → Shutdown

SS1604 indicates conveyor off 20 seconds after startup → Shutdown  
SS1607 indicates conveyor off 20 seconds after startup → Shutdown  
SS1610 indicates bucket elevator off 20 seconds after startup → Shutdown  
SS1620 indicates conveyor off 20 seconds after startup → Shutdown  
SS1630 indicates conveyor off 20 seconds after startup → Shutdown  
AS1605 indicates conveyor belt out of alignment for 3 seconds → E-Shutdown  
AS1608 indicates conveyor belt out of alignment for 3 seconds → E-Shutdown  
AS1621 indicates conveyor belt out of alignment for 3 seconds → E-Shutdown  
AS1631 indicates conveyor belt out of alignment for 3 seconds → E-Shutdown  
PS1606 indicates conveyor plugged for 2 seconds → E-Shutdown  
PS1609 indicates conveyor plugged for 2 seconds → E-Shutdown  
PS1625 indicates conveyor plugged for 2 seconds → E-Shutdown  
PS1635 indicates conveyor plugged for 2 seconds → E-Shutdown  
ES1623 indicates E-stop pull cord pulled for 1 second → E-Shutdown  
ES1633 indicates E-stop pull cord pulled for 1 second → E-Shutdown  
In transfer and Dry Storage not in requested path for 3 seconds → E-Shutdown  
In transfer and lose heartbeat to Dry Storage for 10 seconds → E-Shutdown  
Standard Aux, HOA, overload alarms on motors  
Standard Fail to Open, Fail to Close alarms on slide gate

## Dry Storage Loadin Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
C-2211	First Storage Conveyor	Conveys dry ingredient from unload to Gate 1
C-2231	Second Storage Conveyor	Conveys dry ingredient from Gate 1 to Gate 2
C-2251	Third Storage Conveyor	Conveys dry ingredient from Gate 3 to T-2250
G-2215	Diverter Gate 1	Conveys dry ingredient from first conveyor to T-2210 or second conveyor.
G-2235	Diverter Gate 2	Conveys dry ingredient from second conveyor to T-2230 or third conveyor.
T-2210	Dry Ingredient Storage Tank 1	Stores dry ingredient for use in reactor 2
T-2230	Dry Ingredient Storage Tank 2	Stores dry ingredient for use in reactor 2
T-2250	Dry Ingredient Storage Tank 3	Stores dry ingredient for use in reactor 2

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
LI2210	Indicator	Level of T-2210	Monitor level	0-100 (units %)	
LI2230	Indicator	Level of T-2230	Monitor level	0-100 (units %)	
LI2250	Indicator	Level of T-2250	Monitor level	0-100 (units %)	

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
AS2212	Alignment Switch	C-2211 Belt Alignment Switch	Indicates that conveyor belt out of alignment (off=misalign)	
AS2232	Alignment Switch	C-2231 Belt Alignment Switch	Indicates that conveyor belt out of alignment (off=misalign)	
AS2252	Alignment	C-2251 Belt	Indicates that	



	Switch	Alignment Switch	conveyor belt out of alignment (off=misalign)	
C-2211	Conveyor	First Storage Conveyor	Moves dry ingredient from unload unit to gate 1	
C-2231	Conveyor	Second Storage Conveyor	Moves dry ingredient from gate 1 to gate 2	
C-2251	Conveyor	Third Storage Conveyor	Moves dry ingredient from gate 2 to T-2250	
G-2215	Gate Control	Gate 1 Solenoid Control	Changes gate 1 to divert to T-2210 or C-2231	
G-2235	Gate Control	Gate 2 Solenoid Control	Changes gate 1 to divert to T-2230 or C-2251	
PS2215	Plug Switch	C-2211 Belt Plug Switch	Indicates that grain plugging end of conveyor (off=plug)	
PS2235	Plug Switch	C-2231 Belt Plug Switch	Indicates that grain plugging end of conveyor (off=plug)	
SS2211	Speed Switch	C-2211 Speed Switch	Indicates that conveyor stopped	
SS2231	Speed Switch	C-2231 Speed Switch	Indicates that conveyor stopped	
SS2251	Speed Switch	C-2251 Speed Switch	Indicates that conveyor stopped	
ZSL2215	Limit Switch	G-2215 flop gate switch	Indicates flop gate in position to divert dry ingredient to T-2210	
ZSR2215	Limit Switch	G-2215 flop gate switch	Indicates flop gate in position to divert dry ingredient to C-2231	
ZSL2235	Limit Switch	G-2235 flop gate switch	Indicates flop gate in position to divert dry ingredient to T-2230	
ZSR2235	Limit Switch	G-2235 flop gate switch	Indicates flop gate in position to divert dry ingredient to C-2251	

### ***Unit Operation Interactions***

**Rail Dry Unload Unit** Dry ingredients unloaded from railcars are conveyed to the dry ingredient storage unit. Rail Dry Unload controls the path startup and shutdown of Dry Storage Loadin.

**Truck Dry Unload Unit** Dry ingredients unloaded from trucks are conveyed to the dry ingredient storage unit. Truck Dry Unload controls the path startup and shutdown of Dry Storage Loadin.

### ***Dry Storage Loadin Unit Operational States***

- Start Path to T-2210 – Starts equipment to transfer material from dry unload unit to T-2210. Do not allow this operation to start if any other load in path is in operation or if T-2210 is more than 95% full. Steps:
  - Put Gate 1 in position to transfer material to T-2210
  - Start C-2211
- Start Path to T-2230 – Starts equipment to transfer material from dry unload unit to T-2230. Do not allow this operation to start if any other load in path is in operation or if T-2230 is more than 95% full. Steps:
  - Put Gate 2 in position to transfer material to T-2230
  - Start C-2231
  - Put Gate 1 in position to transfer material to C-2231
  - Start C-2211
- Start Path to T-2250 – Starts equipment to transfer material from dry unload unit to T-2250. Do not allow this operation to start if any other load in path is in operation or if T-2250 is more than 95% full. Steps:
  - Start C-2251
  - Put Gate 2 in position to transfer material to C-2251
  - Start C-2231
  - Put Gate 1 in position to transfer material to C-2231
  - Start C-2211
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown – Orderly shutdown of conveyor system:
  - If C-2211 running,
    - Wait 30 seconds
    - Stop C-2211
  - If C-2231 running,
    - Wait 20 seconds
    - Stop C-2231
  - If C-2251 running,
    - Wait 20 seconds
    - Stop C-2251

- E-Shutdown - Immediately turns off all conveyors:  
Stop C-2211, C-2231, C-2251

### *Dry Storage Loadin Unit Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

C-2211 failure for 1 second → E-Shutdown

C-2231 failure for 1 second → E-Shutdown

C-2251 failure for 1 second → E-Shutdown

SS2211 indicates conveyor off 20 seconds after startup → E-Shutdown

SS2231 indicates conveyor off 20 seconds after startup → E-Shutdown

SS2251 indicates conveyor off 20 seconds after startup → E-Shutdown

AS2212 indicates conveyor belt out of alignment for 5 seconds → E-Shutdown

AS2232 indicates conveyor belt out of alignment for 5 seconds → E-Shutdown

AS2252 indicates conveyor belt out of alignment for 5 seconds → E-Shutdown

PS2215 indicates conveyor plugged for 2 seconds → E-Shutdown

PS2235 indicates conveyor plugged for 2 seconds → E-Shutdown

Standard Aux, HOA, overload alarms on motors

Standard Fail to Open, Fail to Close alarms on flop gates

Path active and shutdown complete of (either) dry storage unload → Shutdown

Path active and lose heartbeat to dry storage unload that commanded path → Shutdown

## Dry Storage Loadout Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
C-2290	Outlet Conveyor	Conveys dry ingredient from storage tanks to reactor 2.
T-2210	Dry Ingredient Storage Tank 1	Stores dry ingredient for use in reactor 2
T-2230	Dry Ingredient Storage Tank 2	Stores dry ingredient for use in reactor 2
T-2250	Dry Ingredient Storage Tank 3	Stores dry ingredient for use in reactor 2

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
AS2291	Alignment Switch	C-2290 Belt Alignment Switch	Indicates that conveyor belt out of alignment (off=misalign)	
AS2292	Alignment Switch	C-2290 Belt Alignment Switch	Indicates that conveyor belt out of alignment (off=misalign)	
C-2290	Conveyor	Outlet Conveyor	Moves dry ingredient from bins to reactor 2	
L-2219	Motor	T-2210 Air Lock	Discharges dry ingredient from T-2210	
L-2239	Motor	T-2230 Air Lock	Discharges dry ingredient from T-2230	
L-2259	Motor	T-2250 Air Lock	Discharges dry ingredient from T-2250	
SS2290	Speed Switch	C-2290 Speed Switch	Indicates that conveyor stopped	

### *Unit Operation Interactions*

**Reactor 2** Dry ingredients are conveyed to reactor 2 unit.

### ***Dry Storage Loadout Unit Operational States***

- Start Path from T-2210 – Starts equipment to transfer material from T-2210 to reactor 2. Do not allow this operation to start if any other load out path is in operation or if T-2210 is less than 2% full. Steps:  
     Stop all airlocks (L-2219, L-2239, L-2259) – one step  
     Start C-2290  
     Start L-2219
- Start Path from T-2230 – Starts equipment to transfer material from T-2230 to reactor 2. Same as Start Path from T-2210, except use T-2230 and L-2239 in place of T-2210 and L-2219, respectively.
- Start Path from T-2250 – Starts equipment to transfer material from T-2250 to reactor 2. Same as Start Path from T-2210, except use T-2250 and L-2259 in place of T-2210 and L-2219, respectively.
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown – Orderly shutdown of conveyor system. If failure in conveyor, skip wait:  
     Stop L-2219  
     Stop L-2239  
     Stop L-2259  
     Wait 60 seconds  
     Stop C-2290
- E-Shutdown - Immediately turns off all devices:  
     Stop L-2219, L-2239, L-2259, C-2290

### ***Dry Storage Unit Abnormal Conditions***

The following conditions are abnormal and will cause the indicated action.

L-2219 failure for 1 second → Loadout Shutdown

L-2239 failure for 1 second → Loadout Shutdown

L-2259 failure for 1 second → Loadout Shutdown

C-2290 failure for 1 second → Loadout E-Shutdown

SS2290 indicates conveyor off 20 seconds after startup → Loadout E-Shutdown

AS2291 indicates conveyor belt out of alignment for 5 seconds → Loadout E-Shutdown

AS2292 indicates conveyor belt out of alignment for 5 seconds → Loadout E-Shutdown

Standard Aux, HOA, overload alarms on motors

Shutdown of reactor using dry storage → Loadout Shutdown

Lose heartbeat with reactor using dry storage for 10 seconds → Loadout E-Shutdown

## Truck Powder Unload Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
T-2440	Receiver/Air Filter	Holds powder drawn from truck before being conveyed to storage. Contains filter element that must be cleaned at intervals.
B-2445	Truck Powder Unload Blower	Positive displacement blower to create vacuum and generate positive pressure conveying air flow. Transfers powder from one of two truck unload stations to truck unload header and to one of the powder ingredient storage tanks.

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
FI2448	Indicator	Truck unload header flow	Measure outflow of truck unload receiver	0-300 lbs/min	
FQI2448	Indicator	Totalized truck unload transfer flow	Measure amount of ingredient transferred to tank		
PI2442	Indicator	Truck unload receiver tank pressure	Measure vacuum pressure of receiver tank	0-15 psi vacuum	
PI2443	Indicator	XV2443 filter purge air pressure	Measure filter purge air pressure at truck unload receiver	0-100 psi	
PI2445	Indicator	B-2445 suction	Measure blower suction pressure	0-15 psi vacuum	
PI2446	Indicator	XV2447 air pressure	Measure air pressure at receiver outlet	0-100 psi	

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
B-2445	Blower	Truck Powder Unload Blower	Transfers powder from truck stations into	

			truck unload header	
L-2441	Motor	Receiver Air Lock	Discharges powder from receiver	
XV2412	Valve	Truck Station 1 Unload Valve	Allows flow of powder from truck station 1 into receiver	
XV2422	Valve	Truck Station 2 Unload Valve	Allows flow of powder from truck station 2 into receiver	
XV2443	Valve	Receiver Purge Inlet Valve	Allows flow of purge air into receiver for filter cleaning	
XV2444	Valve	Receiver Vent Valve	Allows air out of receiver during filter cleaning cycle	
XV2447	Valve	Truck Station Outlet Valve	Allows powder to flow from receiver to truck unload header	Must be open whenever blower is running.

### ***Unit Operation Interactions***

**Rail Powder Unload Unit** Powder unloaded from a truck trailer must not go into the same destination tank being used by the rail powder unload unit.

### ***Truck Powder Unload Unit Operational States***

Note: The operator must select a source station and a destination tank.

- Transfer - Transfers the entire contents of the tank trailer at the selected truck unload station to the selected destination tank. Do not allow this operation to start if any Truck Transfer is in operation. Steps:
  - Display prompt for operator and operator selects source and destination
  - If destination tank is more than 80% full, abort operation (jump to last step)
  - If Rail Transfer to selected destination tank is in operation, abort operation
  - Close all valves (one step)
  - Initialize FQI2448
  - Open appropriate unload valve (XV2412 or XV2422)
  - Open XV2447



Open appropriate XV26x1

Start L-2441

Start B-2445

Wait until destination tank is full (level > 95%), or low flow in truck unload header (flow < 5 lbs/min)

Shut down the system

- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Filter Clean – Cleans receiver filter with pressurized air. Can only be requested if already shutdown
  - Open XV2444
  - Open XV2443 for 0.5 sec
  - Pause 1 sec
  - Open XV2443 for 0.5 sec
  - Pause 1 sec
  - Open XV2443 for 0.5 sec
  - Pause 1 sec
  - Shut down the system
- Shutdown - Turns off the blower, air lock, and all valves:
  - Stop B-2445
  - Stop L-2441
  - Close XV2412
  - Close XV2422
  - Close XV2443
  - Close XV2444
  - Close XV2447
  - Close XV2611
  - Close XV2621
  - Close XV2631
  - Close XV2641
- E-Shutdown - Immediately turns off the blower, air lock, and all storage header valves:
  - Stop B-2445, Stop L-2441
  - Close XV2412, XV2422, XV2443, XV2444, XV2447, XV2611, XV2621, XV2631, XV2641

### *Truck Powder Unload Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

PI2445 < 3 psi vacuum and B-2445 running for 20 seconds → Shutdown

PI2442 < 3 psi vacuum and B-2445 running for 30 seconds → Shutdown

PI2446 > 80 psi for 5 seconds → Alarm  
PI2446 > 90 psi for 10 seconds → Shutdown

Any pump failure → Hold  
Any valve failure → Hold  
Standard Aux, HOA, overload alarms on pumps  
Standard Fail to Open, Fail to Close alarms on valves

## Rail Powder Unload Unit

### Major Equipment

TAG	DESCRIPTION	PURPOSE
T-2490	Receiver/Air Filter	Holds powder drawn from truck before being conveyed to storage. Contains filter element that must be cleaned at intervals.
B-2495	Railcar Powder Unload Blower	Positive displacement blower to create vacuum and generate positive pressure conveying air flow. Transfers powder from one of two truck unload stations to truck unload header and to one of the powder ingredient storage tanks.

### Analog Instrument and Control Point Listing

#### Analog Control Points

<u>TAG</u>	<u>TYPE</u>	<u>DESCRIPTION</u>	<u>PURPOSE</u>	<u>OTHER INFO</u>	<u>SEQUENCE BASED INTERLOCKS</u>
FI2498	Indicator	Railcar unload header flow	Measure outflow of railcar unload receiver	0-300 lbs/min	
FQI2498	Indicator	Totalized railcar unload transfer flow	Measure amount of ingredient transferred to tank		
PI2492	Indicator	Railcar unload receiver tank pressure	Measure vacuum pressure of receiver tank	0-15 psi vacuum	
PI2493	Indicator	XV2493 filter purge air pressure	Measure filter purge air pressure at railcar unload receiver	0-100 psi	
PI2495	Indicator	B-2495 suction	Measure blower suction pressure	0-15 psi vacuum	
PI2496	Indicator	XV2497 air pressure	Measure air pressure at receiver outlet	0-100 psi	

### Discrete Instrument and Control Point Listing

#### Discrete Control Points

<u>TAG</u>	<u>TYPE</u>	<u>DESCRIPTION</u>	<u>PURPOSE</u>	<u>SEQUENCE BASED INTERLOCKS</u>
B-2495	Blower	Railcar Powder	Transfers powder from	

		Unload Blower	railcar stations into rail unload header	
L-2491	Motor	Receiver Air Lock	Discharges powder from receiver	
XV2452	Valve	Railcar Station 1 Unload Valve	Allows flow of powder from railcar station 1 into receiver	
XV2462	Valve	Railcar Station 2 Unload Valve	Allows flow of powder from railcar station 2 into receiver	
XV2493	Valve	Receiver Purge Inlet Valve	Allows flow of purge air into receiver for filter cleaning	
XV2494	Valve	Receiver Vent Valve	Allows air out of receiver during filter cleaning cycle	
XV2497	Valve	Railcar Station Outlet Valve	Allows powder to flow from receiver to rail unload header	Must be open whenever blower is running.

### ***Unit Operation Interactions***

**Truck Powder Unload Unit** Powder unloaded from a railcar must not go into the same destination tank being used by the truck powder unload unit.

### ***Rail Powder Unload Unit Operational States***

Note: The operator must select a source station and a destination tank.

- **Transfer** - Transfers the entire contents of the tank trailer at the selected railcar unload station to the selected destination tank. Do not allow this operation to start if any Rail Transfer is in operation. Steps:
  - Display prompt for operator and operator selects source and destination
  - If destination tank is more than 80% full, abort operation (jump to last step)
  - If Truck Transfer to selected destination tank is in operation, abort operation
  - Close all valves (one step)
  - Initialize FQI2498
  - Open appropriate unload valve (XV2452 or XV2462)

Open XV2497  
 Open appropriate XV26x2  
 Start L-2491  
 Start B-2495  
 Wait until destination tank is full (level > 95%), or low flow in rail unload header (flow < 5 lbs/min)  
 Shut down the system

- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Filter Clean – Cleans receiver filter with pressurized air. Can only be requested if already shutdown
  - Open XV2494
  - Open XV2493 for 0.5 sec
  - Pause 1 sec
  - Open XV2493 for 0.5 sec
  - Pause 1 sec
  - Open XV2493 for 0.5 sec
  - Pause 1 sec
  - Shut down the system
- Shutdown - Turns off the blower, air lock, and all valves:
  - Stop B-2495
  - Stop L-2491
  - Close XV2452
  - Close XV2462
  - Close XV2493
  - Close XV2494
  - Close XV2497
  - Close XV2612
  - Close XV2622
  - Close XV2632
  - Close XV2642
- E-Shutdown - Immediately turns off the blower, air lock, and all storage header valves:
  - Stop B-2495, Stop L-2491
  - Close XV2452, XV2462, XV2493, XV2494, XV2497, XV2612, XV2622, XV2632, XV2642

### *Rail Powder Unload Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

PI2495 < 3 psi vacuum and B-2495 running for 20 seconds → Shutdown

PI2492 < 3 psi vacuum and B-2495 running for 30 seconds → Shutdown

PI2496 > 80 psi for 5 seconds → Alarm

PI2496 > 90 psi for 10 seconds → Shutdown

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Powder Ingredient Storage Unit

### Major Equipment

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
B-2690	Powder Convey Blower	Blower to generate positive pressure conveying air flow. Transfers powder from one of 4 storage tanks to reactor 3.
T-2610	Ingred N Tank	5,000 pound storage tank to hold ingredient N. When needed, its contents are transferred to reactor 3.
T-2620	Ingred P Tank	5,000 pound storage tank to hold ingredient P. When needed, its contents are transferred to reactor 3.
T-2630	Ingred Q Tank	5,000 pound storage tank to hold ingredient Q. When needed, its contents are transferred to reactor 3.
T-2640	Ingred R Tank	5,000 pound storage tank to hold ingredient R. When needed, its contents are transferred to reactor 3.

### Analog Instrument and Control Point Listing

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
LI2610	Indicator	Level of Ingred. N	Monitor level	0-100 (units %)	
LI2620	Indicator	Level of Ingred. P	Monitor level	0-100 (units %)	
LI2630	Indicator	Level of Ingred. Q	Monitor level	0-100 (units %)	
LI2640	Indicator	Level of Ingred. R	Monitor level	0-100 (units %)	

### Discrete Instrument and Control Point Listing

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
B-2690	Blower	Powder Unload Blower	Transfers powder from storage tank to reactor 3	
L-2614	Motor	T-2610 Outlet Air Lock	Discharges powder from T-2610	
L-2624	Motor	T-2620 Outlet Air Lock	Discharges powder from T-2620	
L-2634	Motor	T-2630 Outlet Air	Discharges powder	

		Lock	from T-2630	
L-2644	Motor	T-2640 Outlet Air Lock	Discharges powder from T-2640	
XV2611	Valve	T-2610 Truck Feed Valve	Controls flow from truck unload header into T-2610	
XV2612	Valve	T-2610 Rail Feed Valve	Controls flow from rail unload header into T-2610	
XV2615	Valve	T-2610 Discharge Valve	Controls flow from T-2610 to reactor 3 unit	
XV2616	Valve	T-2610 Pressurized Air Inlet	Controls flow into T-2610 to push powder out	
XV2621	Valve	T-2620 Truck Feed Valve	Controls flow from truck unload header into T-2620	
XV2622	Valve	T-2620 Rail Feed Valve	Controls flow from rail unload header into T-2620	
XV2625	Valve	T-2620 Discharge Valve	Controls flow from T-2620 reactor 3 unit	
XV2626	Valve	T-2620 Pressurized Air Inlet	Controls flow into T-2620 to push powder out	
XV2631	Valve	T-2630 Truck Feed Valve	Controls flow from truck unload header into T-2630	
XV2632	Valve	T-2630 Rail Feed Valve	Controls flow from rail unload header into T-2630	
XV2635	Valve	T-2630 Discharge Valve	Controls flow from T-2630 to reactor 3 unit	
XV2636	Valve	T-2630 Pressurized Air Inlet	Controls flow into T-2630 to push powder out	
XV2641	Valve	T-2640 Truck Feed Valve	Controls flow from truck unload header into T-2640	
XV2642	Valve	T-2640 Rail Feed Valve	Controls flow from rail unload header into T-2640	
XV2645	Valve	T-2640 Discharge Valve	Controls flow from T-2640 to reactor 3 unit	
XV2646	Valve	T-2640 Pressurized	Controls flow into T-	



		Air Inlet	2640 to push powder out	
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### ***Unit Operation Interactions***

**Powder Unload Units** Powder ingredients are received from the truck powder unload unit and rail powder unload unit and transferred to the appropriate tank. The truck powder unload and rail powder unload units completely control the inlet side of the powder storage unit operation.

**Reactor 3 Unit** Powder ingredients are transferred to this unit. The reactor 3 unit controls the blower and the outlet side of the appropriate tanks of the powder storage unit.

## Gas Storage Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
T-2810	Gas A Storage Tank	4,000 scf storage tank to hold gas ingredient A. When needed, its contents are transferred to reactor 4.
T-2820	Gas B Storage Tank	4,000 scf storage tank to hold gas ingredient B. When needed, its contents are transferred to reactor 4.
T-2830	Gas C Storage Tank	4,000 scf storage tank to hold gas ingredient C. When needed, its contents are transferred to reactor 4.
T-2840	Gas D Storage Tank	4,000 scf storage tank to hold gas ingredient D. When needed, its contents are transferred to reactor 4.

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
PI2810	Indicator	Pressure of Gas A	Monitor pressure	0-500 psi	
PI2820	Indicator	Pressure of Gas B	Monitor pressure	0-500 psi	
PI2830	Indicator	Pressure of Gas C	Monitor pressure	0-500 psi	
PI2840	Indicator	Pressure of Gas D	Monitor pressure	0-500 psi	

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
XV2811	Valve	T-2810 Feed Valve	Controls flow from gas ingredient unload into T-2810	
XV2815	Valve	T-2810 Discharge Valve	Controls flow from T-2810 to reactor 4 unit	
XV2821	Valve	T-2820 Feed Valve	Controls flow from gas ingredient unload into T-2820	
XV2825	Valve	T-2820 Discharge Valve	Controls flow from T-2820 reactor 4 unit	

XV2831	Valve	T-2830 Feed Valve	Controls flow from gas ingredient unload into T-2830	
XV2835	Valve	T-2830 Discharge Valve	Controls flow from T-2830 to reactor 4 unit	
XV2841	Valve	T-2840 Feed Valve	Controls flow from gas ingredient unload into T-2840	
XV2645	Valve	T-2840 Discharge Valve	Controls flow from T-2840 to reactor 4 unit	

### ***Unit Operation Interactions***

**Gas Unload Unit** Gaseous ingredients are received from the gas unload unit and transferred to the appropriate tank. The gas unload unit completely controls the inlet side of the gas storage unit operation.

**Reactor 4 Unit** Gaseous ingredients are transferred to this unit. The reactor 4 unit controls the outlet side of the appropriate tanks of the gas storage unit.

## Blend Unit

### Major Equipment

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
P-3001	Raw W Outlet Pump	Centrifugal pump that transfers liquid product out of raw W storage tank to be blended and transported to one of two surge vessels.
P-3002	Raw X Outlet Pump	Centrifugal pump that transfers liquid product out of raw X storage tank to be blended and transported to one of two surge vessels.
P-3003	Raw Y Outlet Pump	Centrifugal pump that transfers liquid product out of raw Y storage tank to be blended and transported to one of two surge vessels.
P-3004	Raw Z Outlet Pump	Centrifugal pump that transfers liquid product out of raw Z storage tank to be blended and transported to one of two surge vessels.

### Analog Instrument and Control Point Listing

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
FIC3001	Loop	Raw W transfer flow control	Controls feed rate of raw W to surge vessel	0-200 gpm, pump VS drive, cascade from surge level loop	
FQI3001	Indicator	Totalized raw W transfer flow	Measures amount of raw W transferred to surge		
FIC3002	Loop	Raw X transfer flow control	Controls feed rate of raw X to surge vessel	0-200 gpm, pump VS drive, SP ratio of raw W flow rate level loop	
FQI3002	Indicator	Totalized raw X transfer flow	Measures amount of raw X transferred to surge		
FIC3003	Loop	Raw Y transfer flow control	Controls feed rate of raw Y to surge vessel	0-200 gpm, pump VS drive, SP ratio of raw W flow rate level loop	
FQI3003	Indicator	Totalized raw Y	Measures amount of		

		transfer flow	raw Y transferred to surge		
FIC3004	Loop	Raw Z transfer flow control	Controls feed rate of raw Z to surge vessel	0-200 gpm, pump VS drive, SP ratio of raw W flow rate level loop	
FQI3004	Indicator	Totalized raw Z transfer flow	Measures amount of raw Z transferred to surge		

### *Discrete Instrument and Control Point Listing*

#### **Discrete Control Points**

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
XV3001	Valve	Raw W Feed Valve	Blocks flow of raw W into blend	
XV3002	Valve	Raw X Feed Valve	Blocks flow of raw X into blend	
XV3003	Valve	Raw Y Feed Valve	Blocks flow of raw Y into blend	
XV3004	Valve	Raw Z Feed Valve	Blocks flow of raw Z into blend	
XV3011	Valve	Blend to T-3001 outlet valve	Blocks flow of blend to reactor T-3001	
XV3013	Valve	Blend to T-3002 outlet valve	Blocks flow of blend to reactor T-3002	

#### **Devices in Wet Ingredient Storage**

XV2115	Valve	T-2110 Discharge Valve	Controls flow from T-2110 to blend unit	
XV2125	Valve	T-2120 Discharge Valve	Controls flow from T-2120 to blend unit	
XV2135	Valve	T-2130 Discharge Valve	Controls flow from T-2130 to blend unit	
XV2145	Valve	T-2140 Discharge Valve	Controls flow from T-2140 to blend unit	

## ***Unit Operation Interactions***

**Wet Ingredient Storage Unit** Liquid ingredients are received from the wet ingredient storage unit. This unit has direct control over the outlet valves of selected tanks in the wet ingredient storage unit.

**Reactor 1 Unit** Upon demand from the reactor 1 unit, liquid ingredient A is blended and transferred to the reactor unit.

**Reactor 2 Unit** Upon demand from the reactor 2 unit, liquid ingredient A is blended and transferred to the reactor unit.

## ***Blend Unit Operational States***

- Blend for Reactor 1 – Combines raw materials W, X, Y, and Z to produce ingredient A for reactor 1. Do not allow this operation if Blend for Reactor 1 or Blend for Reactor 2 is in operation. Steps:
  - Check all storage tank levels  $\geq 20\%$  and Reactor 1 in Make Batch
  - Close all valves (one step)
  - Operator verifies blend ratios okay
  - Reset all accumulators (FQI3001, FQI3002, FQI3003, FQI3004)
  - Open XV3011
  - Open XV3001
  - Open XV2115
  - If FY3002 (X ratio)  $> 0.0$ 
    - Open XV3002
    - Open XV2125
  - If FY3003 (Y ratio)  $> 0.0$ 
    - Open XV3003
    - Open XV2135
  - If FY3004 (Z ratio)  $> 0.0$ 
    - Open XV3004
    - Open XV2145
  - Start P-3001
  - Set Raw W Flow Controller FIC3001 to auto, setpoint = 200 gpm
  - If FY3002 (X ratio)  $> 0.0$ 
    - Start P-3002
    - Set FIC3002 to auto, setpoint from ratio of FT3001
  - If FY3003 (Y ratio)  $> 0.0$ 
    - Start P-3003
    - Set FIC3003 to auto, setpoint from ratio of FT3001
  - If FY3004 (Z ratio)  $> 0.0$ 
    - Start P-3004
    - Set FIC3004 to auto, setpoint from ratio of FT3001

Signal to Reactor 1 that all flows started

- Blend for Reactor 2 – Combines raw materials W, X, Y, and Z to produce ingredient A for reactor 2. Do not allow this operation if Blend for Reactor 1 or Blend for Reactor 2 is in operation. Steps:
  - Check all storage tank levels  $\geq 20\%$  and Reactor 2 in Make Batch
  - Close all valves (one step)
  - Operator verifies blend ratios okay
  - Reset all accumulators (FQI3001, FQI3002, FQI3003, FQI3004)
  - Open XV3013
  - Open XV3001
  - Open XV2115
  - If FY3002 (X ratio)  $> 0.0$ 
    - Open XV3002
    - Open XV2125
  - If FY3003 (Y ratio)  $> 0.0$ 
    - Open XV3003
    - Open XV2135
  - If FY3004 (Z ratio)  $> 0.0$ 
    - Open XV3004
    - Open XV2145
  - Start P-3001
  - Set Raw W Flow Controller FIC3001 to auto, setpoint = 200 gpm
  - If FY3002 (X ratio)  $> 0.0$ 
    - Start P-3002
    - Set FIC3002 to auto, setpoint from ratio of FI3001
  - If FY3003 (Y ratio)  $> 0.0$ 
    - Start P-3003
    - Set FIC3003 to auto, setpoint from ratio of FI3001
  - If FY3004 (Z ratio)  $> 0.0$ 
    - Start P-3004
    - Set FIC3004 to auto, setpoint from ratio of FI3001
  - Signal to Reactor T-3002 that all flows started
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off all pumps and all valves:
  - Stop P-3001
  - Set FIC3001 to manual, 0% output
  - Close XV3001
  - Close XV2115
  - Stop P-3002
  - Set FIC3002 to manual, 0% output
  - Close XV3002

- Close XV2125
- Stop P-3003
- Set FIC3003 to manual, 0% output
- Close XV3003
- Close XV2135
- Stop P-3004
- Set FIC3004 to manual, 0% output
- Close XV3004
- Close XV2145
- Close XV3011
- Close XV3013
- E-Shutdown - Immediately turns off all pumps and all valves:
  - Stop P-3001, P-3002, P-3003, P-3004
  - Set FIC3001 to manual, 0% output
  - Set FIC3002 to manual, 0% output
  - Set FIC3003 to manual, 0% output
  - Set FIC3004 to manual, 0% output
  - Close XV2115, XV2125, XV2135, XV2145
  - Close XV3001, XV3002, XV3003, XV3004, XV3011, XV3013

### *Blend Unit Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

- LI2110 < 5% for 20 seconds while blending to T-3001 or T-3002 → Shutdown
- LI2120 < 5% for 20 seconds and X ratio > 0.0 → Shutdown
- LI2130 < 5% for 20 seconds and Y ratio > 0.0 → Shutdown
- LI2140 < 5% for 20 seconds and Z ratio > 0.0 → Shutdown
- In Blend to Reactor 1 and Reactor 1 not in Make Batch → E-Shutdown
- In Blend to Reactor 1 and lose heartbeat with Reactor 1 for 10 seconds → E-Shutdown
- In Blend to Reactor 2 and Reactor 2 not in Make Batch → E-Shutdown
- In Blend to Reactor 2 and lose heartbeat with Reactor 21 for 10 seconds → E-Shutdown
- Any pump failure → Hold
- Any valve failure → Hold
- Standard Aux, HOA, overload alarms on pumps
- Standard Fail to Open, Fail to Close alarms on valves

Lose heartbeat with reactor using blend for 10 seconds → E-Shutdown



## Reactor 1 Unit

### Major Equipment

TAG	DESCRIPTION	PURPOSE
A-3100	Reactor Tank agitator	Mix the ingredients in the reactor tank to keep uniform
P-3100	Reactor Outlet Pump	Centrifugal pump that transfers liquid product out of reactor to the ion exchange unit.
P-3102	Ingredient S Pump	Centrifugal pump that transfers liquid ingredient S into the reactor tank.
T-3100	Reactor Tank	5,000 gallon tank to produce one batch of product. Ingredients are added and the reaction progresses to make product. When the analyzer indicates the batch is finished, it is transferred to the ion exchange unit.

### Analog Instrument and Control Point Listing

#### Analog Control Points

<u>TAG</u>	<u>TYPE</u>	<u>DESCRIPTION</u>	<u>PURPOSE</u>	<u>OTHER INFO</u>	<u>SEQUENCE BASED INTERLOCKS</u>
AI3100	Indicator	pH of Product in Reactor Tank	Monitor pH	0-14	
FI3101	Indicator	Ingredient A flow rate	Monitor flow	0-1000 gpm	
FI3110	Indicator	Rinse water flow rate	Monitor flow	0-1000 gpm	
FIC3102	Loop	Ingredient S transfer flow control	Controls feed rate of ingredient S to reactor vessel	0-600 gpm, Fail closed, direct acting	
FQI3101	Indicator	Totalized ingredient A transfer flow	Measures amount of ingredient A transferred to reactor		
FQI3102	Indicator	Totalized ingredient S transfer flow	Measures amount of ingredient S transferred to reactor		
FQI3110	Indicator	Totalized rinse water transfer flow	Measures amount of rinse water transferred to reactor		
LI3100	Indicator	Level of Reactor Tank	Monitor level	0-100 (units %)	
TI3100	Indicator	Temperature of Reactor Tank	Monitor temperature	70-140 deg F	

## *Discrete Instrument and Control Point Listing*

### **Discrete Control Points**

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
A-3100	Motor	Reactor tank agitator	Mixes ingredients in reactor tank	The agitator should not run when level falls below 2%
P-3100	Motor	Reactor Outlet Pump	Pumps liquid product from reactor tank to ion exchange	This pump should not run if: LI3100<2%
P-3102	Motor	Ingred. S Pump	Pumps ingredient S to reactor vessel	This pump should not run if PV:FIC3002<1.0 gpm and VO:FIC3002=100%
P-3110	Motor	Rinse Water Return Pump	Pumps rinse water out of reactor vessel	
XV2155	Valve	Raw S Storage Discharge Valve	Controls flow of ingred. S out of tank	
XV3100	Valve	Reactor Discharge Valve	Controls flow of product out of reactor tank	
XV3101	Valve	Ingred. A Feed Valve	Blocks flow of ingred. A into reactor	
XV3102	Valve	Ingred. S Feed Valve	Blocks flow of ingred. S into reactor	
XV3110	Valve	Rinse Water Feed Valve	Blocks flow of rinse water into reactor	
XV3111	Valve	Rinse Water Discharge Valve	Controls flow of rinse water out of reactor	
XV3121	Valve	CIP to Reactor Valve	Controls flow of CIP water into piping to ion exchange	
XV3122	Valve	Product to Ion Exchange Xfer Valve	Controls flow of product to ion exchange	
XV3123	Valve	CIP Return Valve	Directs CIP water back to CIP System	

### **Devices in Wet Ingredient Storage**

XV2155	Valve	T-2150 Discharge Valve – Ingred. S	Controls flow from T-2150 to reactor 1	
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## ***Unit Operation Interactions***

**Wet Ingredient Storage Unit** Ingredient S is received from the wet ingredient storage unit. This unit has direct control over one of the valves in the wet ingredient storage unit.

**Blend** A liquid ingredient is received from the blend unit. This unit commands the blend unit to transfer an ingredient mix.

**QA Sample** The QA sample unit is controlled by the reactor. When sampling is requested by the reactor unit, valve paths are set to direct reactor contents to the analyzer system and then returned to the reactor.

**CIP System** The reactor unit requests CIP water. When CIP is granted, CIP water is directed to the reactor discharge pump, and the outlet piping valves are properly set to transfer the remaining product in the piping to the ion exchanger and then return the cleaning water to the CIP tank. When the flush is finished, then the CIP system is requested to return to its normal online/recycle operation.

**Ion Exchange Cell** Liquid product is transferred to the ion exchange cell from the reactor. If neither ion exchange unit #1 or #2 is ready, no new batches will be made.

**Water Unit** Used to get rinse water to rinse reactor between batches.

## ***Reactor 1 Operational States***

Note: the following steps assume fixed amounts of ingredients. Could be modified to use a recipe.

- **Make Batch** – Combines ingredient A and ingredient B to produce product. Do not allow this operation if Make Batch or Rinse or Flush is in operation. Steps:
  - Check Reactor Level LI3100 < 1% and TI3100 < 80 deg. F and either Ion Exchange online
  - Close all valves (one step)
  - Add 1000 gal. of water:
    - Reset FQI3110
    - Open XV3110
    - Wait for FQI3110 >= 1000 gal.
    - Close XV3110
  - Start A-3100
  - Add 1000 gal. of Ingredient A:
    - Reset FQI3101
    - Open XV3101
    - Request Blend Unit to Blend for Reactor 1 and wait for all blend flows started
    - Wait for FQI3101 >= 1000 gal.
    - Request Blend Unit to Shutdown and wait for Blend Unit Shutdown finished
    - Close XV3101
  - Agitate for 10 minutes

Add 3000 gal. of Ingredient S:

Reset FQI3102

Open XV2155

Open XV3102

Start P-3102

Set Ingrid. S Flow Controller FIC3102 to auto, setpoint = 500 gpm

Wait for FQI3102  $\geq$  3000 gal.

Stop P-3102

Set FIC3102 to manual, 0% output

Close XV3102

Agitate for 10 minutes

Request QA Sample from QA Sampling System

Wait for QA sample finished (display QA result to operator)

Prompt operator for additional agitation minutes

Agitate for additional minutes.

Request Lock Reactor 1 from QA Sample system

Wait for lock

Agitate for 2 minutes

Request Unlock Reactor1 from QA Sample system

Wait for unlock

If neither Ion Exchange online,

Request Ion Exchange #1 to startup and wait for Ion Exchange #1 starting

Wait for Ion Exchange #1 online

Open XV3122

Open XV3100

Start P-3100

Wait for reactor level LI3100  $<$  1%

Stop A-3100

Stop P-3100

Close XV3100

Close XV3122

Initiate Rinse

- Rinse – Rinse reactor vessel in preparation for next batch. Only allowed if reactor is at end of Make Batch or Shutdown. Steps:

Check Reactor Level LI3100  $<$  1%

Close all valves (one step)

Open XV3110

Wait for LI3100  $\geq$  10%.

Start A-3100

Wait for LI3100  $\geq$  95%.

Close XV3110

Agitate for 10 minutes

Open XV3111

Start P-3110

Wait for LI3100  $\leq$  1%

Stop A-3100  
Shutdown the system

- Flush - Flushes the piping to the ion exchange header with CIP water. Can only be requested if already shutdown
  - If neither Ion Exchange is Online,
    - Request Ion Exchange #1 to startup and wait for Ion Exchange #1 starting
    - Wait for Ion Exchange #1 online
  - If CIP System is in shutdown or e-shutdown,
    - Request CIP System to go online/recycle and wait for CIP system online
    - Request CIP System for Reactor 1 Path and wait for CIP system Reactor 1 path set
    - Open ion exchange feed valve XV3122
    - Open CIP to reactor feed valve XV3121
    - Start P-3100
    - Wait 3 minutes for product to be flushed into ion exchange. Then open XV3123 and close XV3122
    - Flush for 10 minutes
    - Request CIP system to go online/recycle and wait for XV6003 to be closed
    - Shutdown
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off all pumps and all valves:
  - Stop A-3100
  - Stop P-3102
  - Stop P-3100
  - Stop P-3110
  - Close XV2155
  - Close XV3101
  - Close XV3102
  - Close XV3110
  - Close XV3100
  - Close XV3111
  - Close XV3121
  - Close XV3122
  - Close XV3123
- E-Shutdown - Immediately turns off all pumps and all valves:
  - Stop A-3100
  - Stop P-3100, P-3102, P-3110
  - Close XV2155, XV3101, XV3102, XV3110, XV3100, XV3111, XV3121, XV3122, XV3123

## *Reactor 1 Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

LI3100 > 96% for 20 seconds → Alarm

LI3100 > 98% for 20 seconds → Shut down process

LI3100 < 1% for 20 seconds while transferring product to ion exchange in progress → Shutdown

AI3100 < 6 or > 8 for 20 seconds while making batch → Alarm

AI3100 < 5.5 or > 8.5 for 20 seconds while making batch → Shutdown

TI3100 >= 110 deg F for 20 seconds while making batch → Alarm

TI3100 >= 125 deg F for 20 seconds while making batch → Shutdown

CIP\_1 System not in Reactor 1 Path when Reactor in steps where CIP\_1 system used → E-Shutdown

Lose heartbeat with CIP\_1 System for 10 seconds when Reactor in steps where CIP\_1 system used → Hold

Adding Ingredient S and T2150 level < 2% → Shutdown

QA System not in Lock R1 in steps waiting for valid QA sample reading after QA System confirmed in Lock R1 state → Shutdown

Lose heartbeat with QA System for 10 seconds when in steps using the QA system → Hold

Ion Exchange #1 or Ion Exchange #2 not online when transferring product from reactor → Hold

Lose heartbeat with Ion Exchange #1 for 10 seconds and lose heartbeat with Ion Exchange #2 for 10 seconds → Hold

Blend shutdown when adding ingredient A → Hold

Lose heartbeat with Blend for 10 seconds when adding ingredient A → Hold

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Reactor 2 Unit

### Major Equipment

TAG	DESCRIPTION	PURPOSE
A-3200	Reactor Tank agitator	Mix the ingredients in the reactor tank to keep uniform
P-3200	Reactor Outlet Pump	Centrifugal pump that transfers liquid product out of reactor to the ion exchange unit.
C-3250	Ingredient C Conveyor	Transfers dry ingredient C into the reactor tank.
T-3200	Reactor Tank	5,000 gallon tank to produce one batch of product. Ingredients are added and the reaction progresses to make product. When the analyzer indicates the batch is finished, it is transferred to the ion exchange unit.

### Analog Instrument and Control Point Listing

#### Analog Control Points

<u>TAG</u>	<u>TYPE</u>	<u>DESCRIPTION</u>	<u>PURPOSE</u>	<u>OTHER INFO</u>	<u>SEQUENCE BASED INTERLOCKS</u>
AI3200	Indicator	pH of Product in Reactor Tank	Monitor pH	0-14	
FI3201	Indicator	Ingredient A flow rate	Monitor flow	0-1000 gpm	
FI3210	Indicator	Rinse water flow rate	Monitor flow	0-1000 gpm	
FI3250	Indicator	Ingredient A flow rate	Monitor flow	0-500 lbs/min.	
FIC3210	Loop	Rinse water flow control	Controls flow rate of rinse water into reactor vessel	0-1000 gpm, Fail closing, direct acting	
FQI3201	Indicator	Totalized ingredient A transfer flow	Measures amount of ingredient A transferred to reactor		
FQI3210	Indicator	Totalized rinse water transfer flow	Measures amount of rinse water transferred to reactor		
FQI3250	Indicator	Totalized dry ingredient transfer flow	Measures amount of dry ingredient transferred to reactor		
LI3200	Indicator	Level of Reactor Tank	Monitor level	0-100 (units %)	
TI3200	Indicator	Temperature of Reactor Tank	Monitor temperature	70-140 deg F	

### *Discrete Instrument and Control Point Listing*

#### **Discrete Control Points**

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
A-3200	Motor	Reactor tank agitator	Mixes ingredients in reactor tank	The agitator should not run when level falls below 2%
AS3251	Alignment Switch	C-3250 Belt Alignment Switch	Indicates that conveyor belt out of alignment (off=misalign)	
C-3250	Conveyor	Ingred. C Feed Conveyor	Feeds ingred. C into reactor	
P-3200	Motor	Reactor Outlet Pump	Pumps liquid product from reactor tank to ion exchange	This pump should not run if: LI3200<0.5% and not in flush
P-3210	Motor	Rinse Water Return Pump	Pumps rinse water out of reactor vessel	
SS3250	Speed Switch	C-3250 Speed Switch	Indicates that conveyor stopped	
XV3200	Valve	Reactor Discharge Valve	Controls flow of product out of reactor tank	
XV3201	Valve	Ingred. A Feed Valve	Blocks flow of ingred. A into reactor	
XV3210	Valve	Rinse Water Feed Valve	Blocks flow of rinse water into reactor	
XV3211	Valve	Rinse Water Discharge Valve	Controls flow of rinse water out of reactor	
XV3221	Valve	CIP to Reactor Valve	Controls flow of CIP water into piping to ion exchange	
XV3222	Valve	Product to Ion Exchange Xfer Valve	Controls flow of product to ion exchange	
XV3223	Valve	CIP Return Valve	Directs CIP water back to CIP System	

#### **Devices in Wet Ingredient Storage**

XV2165	Valve	T-2160 Discharge Valve – Ingred. T	Controls flow from T-2160 to reactor 2	
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## ***Unit Operation Interactions***

**Blend** A liquid ingredient is received from the blend unit. This unit commands the blend unit to transfer an ingredient mix.

**Dry Ingredient Storage Unit** Dry ingredients are received from the dry ingredient storage unit. This unit has control over the dry ingredient storage unit.

**QA Sample** The QA sample unit is controlled by the reactor. When sampling is requested by the reactor unit, valve paths are set to direct reactor contents to the analyzer system and then returned to the reactor.

**CIP System** The reactor unit requests CIP water. When CIP is granted, CIP water is directed to the reactor discharge pump, and the outlet piping valves are properly set to transfer the remaining product in the piping to the ion exchanger and then return the cleaning water to the CIP tank. When the flush is finished, then the CIP system is requested to return to its normal online/recycle operation.

**Ion Exchange Cell** Liquid product is transferred to the ion exchange cell from the reactor. If neither ion exchange unit is ready, no new batches will be made.

**Rinse Water Unit** Used to get rinse water to rinse reactor between batches.

## ***Reactor 2 Operational States***

- **Make Batch** – Combines ingredient A and ingredient B to produce product. Do not allow this operation if Make Batch or Rinse or Flush is in operation. Steps:
  - Check Reactor Level LI3200 < 1% and TI3200 < 80 deg. F and either Ion Exchange online
  - Display prompt for operator and operator selects dry ingredient source
  - Close all valves (one step)
  - Add 1000 gal. of water:
    - Reset FQI3210
    - Open XV3210
    - Set Water Flow Controller FIC3210 to auto, setpoint = 100 gpm
    - Wait for FQI3210 >= 1000 gal.
    - Set FIC3210 to manual, 0% output
    - Close XV3210
  - Start A-3200
  - Add 1000 gal. of Ingredient A:
    - Reset FQI3201
    - Open XV3201
    - Request Blend Unit to Blend for T-3201
    - Wait for all blend flows started

- Wait for FQI3201  $\geq$  1000 gal.
- Request Blend Unit to Shutdown
- Wait for Blend Unit Shutdown finished
- Close XV3201
- Agitate for 5 minutes
- Add Ingredient C:
  - Reset FQI3250
  - Start C-3250
  - Start path from selected dry storage tank
  - Wait for path set
  - Wait for FQI3250  $\geq$  500 lbs.
  - Start Dry Storage Loadout Shutdown
  - Wait for Dry Storage Loadout Shutdown complete
  - Wait 20 seconds
  - Stop C-3250
- Agitate for 10 minutes
- Request QA Sample from QA Sampling System
- Wait for QA sample finished
- Display QA result to operator
- Prompt operator for additional agitation minutes
- Agitate for additional minutes.
- Request Lock Reactor 2 from QA Sample system
- Wait for lock
- Agitate for 2 minutes
- Request Unlock Reactor 2 from QA Sample system
- Wait for unlock
- If neither Ion Exchange online,
  - Request Ion Exchange #2 to startup and wait for Ion Exchange #2 starting
  - Wait for Ion Exchange #2 online
- Open XV3222
- Open XV3200
- Start P-3200
- Wait for reactor level LI3200  $<$  1%
- Stop A-3200
- Stop P-3200
- Close XV3200
- Close XV3222
- Initiate Rinse
- Rinse – Rinse reactor vessel in preparation for next batch. Only allowed if reactor is at end of Make Batch or Shutdown. Steps:
  - Check Reactor Level LI3200  $<$  1%
  - Close all valves (one step)
  - Open XV3210
  - Set Water Flow Controller FIC3210 to manual, 100% output
  - Wait for LI3200  $\geq$  10%.

Start A-3200  
Wait for LI3200  $\geq$  95%.  
Set FIC3210 to manual, 0% output  
Close XV3210  
Agitate for 10 minutes  
Open XV3211  
Start P-3210  
Wait for LI3200  $\leq$  1%  
Stop A-3200  
Shutdown the system

- Flush - Flushes the piping to the ion exchange header with CIP water. Can only be requested if already shutdown
  - If neither Ion Exchange online,
    - Request Ion Exchange #2 to startup and wait for Ion Exchange #2 starting
    - Wait for Ion Exchange #2 online
  - If CIP System is in shutdown or e-shutdown,
    - Request CIP System to go online/recycle
    - Wait for CIP system online
  - Request CIP System for Reactor 2 Path
  - Wait for CIP system Reactor 2 path set
  - Open ion exchange feed valve XV3222
  - Open CIP to reactor feed valve XV3221
  - Start P-3200
  - Wait 3 minutes for product to be flushed into ion exchange. Then open XV3223 and close XV3222
  - Flush for 10 minutes
  - Request CIP system to go online/recycle and wait for XV6006 to be closed
  - Shutdown
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off all pumps and all valves:
  - Stop A-3200
  - Stop P-3200
  - Stop P-3210
  - Stop C-3250
  - Close XV3201
  - Set FIC3210 to manual, 0% output
  - Close XV3210
  - Close XV3200
  - Close XV3211
  - Close XV3221
  - Close XV3222

Close XV3223

- E-Shutdown - Immediately turns off all pumps and all valves:  
 Stop A-3200  
 Stop P-3200, P-3210, C-3250  
 Set FIC3210 to manual, 0% output  
 Close XV3201, XV3210, XV3200, XV3211, XV3221, XV3222, XV3223

## *Reactor 2 Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

LI3200 > 96% for 20 seconds → Alarm

LI3200 > 98% for 20 seconds → Shut down process

LI3200 < 1% for 20 seconds while transferring product to ion exchange in progress → Shutdown

AI3200 < 6 or > 8 for 20 seconds while making batch → Alarm

AI3200 < 5.5 or > 8.5 for 20 seconds while making batch → Shutdown

TI3200 >= 110 deg F for 20 seconds while making batch → Alarm

TI3200 >= 125 deg F for 20 seconds while making batch → Shutdown

SS3250 indicates conveyor off 20 seconds after startup → E-Shutdown

AS3251 indicates conveyor belt out of alignment for 5 seconds → E-Shutdown

CIP\_1 System not in Reactor 2 Path when Reactor in steps where CIP\_1 system used → E-Shutdown

Lose heartbeat with CIP\_1 System for 10 seconds when Reactor in steps where CIP\_1 system used → Hold

QA System not in Lock R2 in steps waiting for valid QA sample reading after QA System confirmed in Lock R2 state → Shutdown

Lose heartbeat with QA System for 10 seconds when in steps using the QA system → Hold

Ion Exchange #1 and Ion Exchange #2 not online when transferring product from reactor → Hold

Lose heartbeat with Ion Exchange #1 for 10 seconds and lose heartbeat with Ion Exchange #2 for 10 seconds → Hold

Blend shutdown when adding ingredient A → Hold

Lose heartbeat with Blend for 10 seconds when adding ingredient A → Hold

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Reactor 3 Unit

### Major Equipment

TAG	DESCRIPTION	PURPOSE
A-3300	Reactor Tank agitator	Mix the ingredients in the reactor tank to keep uniform
P-3300	Reactor Outlet Pump	Centrifugal pump that transfers liquid product out of reactor to the ion exchange unit.
P-3302	Ingredient T Pump	Transfers wet ingredient T into the reactor tank.
T-3300	Reactor Tank	3,000 gallon tank to produce one batch of product. Ingredients are added and the reaction progresses to make product. When the analyzer indicates the batch is finished, it is transferred to the ion exchange unit.

### Analog Instrument and Control Point Listing

#### Analog Control Points

<u>TAG</u>	<u>TYPE</u>	<u>DESCRIPTION</u>	<u>PURPOSE</u>	<u>OTHER INFO</u>	<u>SEQUENCE BASED INTERLOCKS</u>
AI3300	Indicator	pH of Product in Reactor Tank	Monitor pH	0-14	
FI3301	Indicator	Powder ingredient flow rate	Monitor flow	0-200 lbs/min	
FI3302	Indicator	Ingred. T flow rate	Monitor flow	0-300 gpm	
FI3330	Indicator	Rinse water flow rate	Monitor flow	0-500 gpm	
FIC3302	Loop	Ingred. T flow rate controller	Control flow of ingred. T into reactor	0-300 gpm	
FIC3310	Loop	Water flow rate controller	Control flow of water into reactor	0-500 gpm	
FQI3301	Indicator	Totalized powder ingredient transfer flow	Measures amount of powder ingredient transferred to reactor		
FQI3302	Indicator	Totalized ingred. T transfer flow	Measures amount of ingredient T transferred to reactor		
FQI3310	Indicator	Totalized rinse water transfer flow	Measures amount of rinse water transferred to reactor		
LI3300	Indicator	Level of Reactor Tank	Monitor level	0-100 (units %)	
TI3300	Indicator	Temperature of Reactor Tank	Monitor temperature	70-140 deg F	

## *Discrete Instrument and Control Point Listing*

### **Discrete Control Points**

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
A-3300	Motor	Reactor tank agitator	Mixes ingredients in reactor tank	The agitator should not run when level falls below 2%
P-3300	Motor	Reactor Outlet Pump	Pumps liquid product from reactor tank to ion exchange	This pump should not run if: LI3300<2%
P-3302	Motor	Ingredient T Pump	Pumps ingredient T into reactor vessel	
P-3310	Motor	Rinse Water Return Pump	Pumps rinse water out of reactor vessel	
XV3300	Valve	Reactor Discharge Valve	Controls flow of product out of reactor tank	
XV3301	Valve	Powder Ingred. Feed Valve	Blocks flow of powder ingred. into reactor	
XV3302	Valve	Ingred. T Feed Valve	Blocks flow of ingred. T into reactor	
XV3310	Valve	Rinse Water Feed Valve	Blocks flow of rinse water into reactor	
XV3311	Valve	Rinse Water Discharge Valve	Controls flow of rinse water out of reactor	
XV3321	Valve	Rinse to Piping Valve	Controls flow of rinse water into piping to ion exchange	
XV3322	Valve	Product to Ion Exchange Xfer Valve	Controls flow of product to ion exchange	
XV3323	Valve	Rinse Water Return Valve at Ion Exchg	Directs Rinse water back to drain	

### **Devices in Wet Ingredient Storage**

XV2166	Valve	T-2160 Discharge Valve – Ingred. T	Controls flow from T-2160 to reactor 3	
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### **Devices in Powder Ingredient Storage**

B-2690	Blower	Powder Unload Blower	Transfers powder from storage tank to reactor 3	
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L-2614	Motor	T-2610 Outlet Air Lock	Discharges powder from T-2610	
L-2624	Motor	T-2620 Outlet Air Lock	Discharges powder from T-2620	
L-2634	Motor	T-2630 Outlet Air Lock	Discharges powder from T-2630	
L-2644	Motor	T-2640 Outlet Air Lock	Discharges powder from T-2640	
XV2615	Valve	T-2610 Discharge Valve	Controls flow from T-2610 to reactor 3	
XV2625	Valve	T-2620 Discharge Valve	Controls flow from T-2620 to reactor 3	
XV2635	Valve	T-2630 Discharge Valve	Controls flow from T-2630 to reactor 3	
XV2645	Valve	T-2640 Discharge Valve	Controls flow from T-2640 to reactor 3	
XV2616	Valve	T-2610 Pressure Air Inlet Valve	Air to help blow powder from T-2610 to reactor 3	
XV2626	Valve	T-2620 Pressure Air Inlet Valve	Air to help blow powder from T-2620 to reactor 3	
XV2636	Valve	T-2630 Pressure Air Inlet Valve	Air to help blow powder from T-2630 to reactor 3	
XV2646	Valve	T-2640 Pressure Air Inlet Valve	Air to help blow powder from T-2640 to reactor 3	

### ***Unit Operation Interactions***

**Powder Storage Unit** Powder ingredients are received from the powder storage unit. This unit has direct control over the outlet side of the storage tanks in the powder storage unit.

**Wet Ingredient Storage Unit** Ingredient T is received from the wet ingredient storage unit. This unit has direct control over one of the valves in the wet ingredient storage unit.

**Ion Exchange Cell** Liquid product is transferred to the ion exchange cell from the reactor. If neither ion exchange 3 or 4 unit is ready, no new batches will be made.

**Rinse Water Unit** Used to get rinse water to rinse reactor between batches.

### ***Reactor 3 Operational States***

- Make Batch – Combines powder and ingredient T to produce product. Do not allow this operation if Make Batch or Rinse or Flush is in operation. Steps:
  - Check Reactor Level LI3300 < 1% and TI3300 < 80 deg. F and either Ion Exchange 3 or 4 online
  - Display prompt for operator and operator selects powder source
  - Close all valves (one step)
  - Add 2000 gal. of water:
    - Reset FQI3310
    - Open XV3310
    - Set Water Flow Controller FIC3310 to auto, setpoint = 250 gpm
    - Wait for FQI3310 >= 2000 gal.
    - Set FIC3310 to manual, 0% output
    - Close XV3310
  - Start A-3300
  - Add 450 lbs. of powder:
    - Reset FQI3301
    - Open XV3301
    - Open appropriate powder tank outlet valve (XV26x5)
    - Start appropriate powder tank airlock valve motor (L-26x4)
    - Open appropriate powder tank pressurized air inlet valve (XV26x6)
    - Start B-2690
    - Wait for FQI3301 >= 450 lbs.
    - Close all XV26x6 (one step)
    - Stop all L-26x4 (one step)
    - Wait for FI3301 < 5 lbs/min
    - Stop B-2690
    - Close XV3301
  - Agitate for 5 minutes
  - Add Ingredient T:
    - Reset FQI3302
    - Open XV3302
    - Open XV2166
    - Set Ingrid T Flow Controller FIC3302 to auto, setpoint = 200 gpm
    - Start P-3302
    - Wait for FQI3302 >= 500 gal.
    - Stop P-3302
    - Set FIC3302 to manual, 0% output
  - Agitate for 10 minutes
  - [Operator takes sample from reactor]
  - Prompt operator for additional agitation minutes
  - Agitate for additional minutes.



- If neither Ion Exchange 3 or 4 is Online,  
    Request Ion Exchange #3 to startup and wait for Ion Exchange #3 starting  
    Wait for Ion Exchange #3 online  
Open XV3322  
Open XV3300  
Start P-3300  
Wait for reactor level LI3300 < 1%  
Stop A-3300  
Stop P-3300  
Close XV3300  
Close XV3322  
Initiate Rinse
- Rinse – Rinse reactor vessel in preparation for next batch. Only allowed if reactor is at end of Make Batch or Shutdown. Steps:  
    Check Reactor Level LI3300 < 1%  
    Close all valves (one step)  
    Open XV3310  
    Set Water Flow Controller FIC3310 to manual, 100% output  
    Wait for LI3300 >= 10%.  
    Start A-3300  
    Wait for LI3300 >= 95%.  
    Set FIC3310 to manual, 0% output  
    Close XV3310  
    Agitate for 10 minutes  
    Open XV3311  
    Start P-3310  
    Wait for LI3300 <= 1%  
    Stop A-3300  
    Shutdown the system
  - Flush - Flushes the piping to the ion exchange header with rinse water. Can only be requested if already shutdown  
    If neither Ion Exchange 3 or 4 is Online,  
        Request Ion Exchange #3 to startup and wait for Ion Exchange #3 starting  
        Wait for Ion Exchange #3 online  
    Open ion exchange feed valve XV3322  
    Open Rinse water to piping feed valve XV3321  
    Start P-3300  
    Wait 3 minutes for product to be flushed into ion exchange. Then open XV3323 and close XV3322  
    Flush for 10 minutes  
    Shutdown
  - Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.

- Shutdown - Turns off all pumps and all valves:
  - Stop B-2690
  - Stop all L26x4 (one step)
  - Close all XV26x6 (one step)
  - Close all XV26x5 (one step)
  - Close XV3301
  - Stop A-3300
  - Close XV2166
  - Stop P-3302
  - Stop P-3300
  - Stop P-3310
  - Set FIC3302 to manual, 0% output
  - Close XV3302
  - Set FIC3310 to manual, 0% output
  - Close XV3310
  - Close XV3300
  - Close XV3311
  - Close XV3321
  - Close XV3322
  - Close XV3323
- E-Shutdown - Immediately turns off all pumps and all valves:
  - Stop B-2690, L26x4
  - Close all XV26x6, XV26x5
  - Stop A-3300
  - Stop P-3300, P-3302, P-3310
  - Set FIC3302 to manual, 0% output
  - Set FIC3310 to manual, 0% output
  - Close XV2166, XV3301, XV3302, XV3310, XV3300, XV3311, XV3321, XV3322, XV3323

### *Reactor 3 Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

LI3300 > 96% for 20 seconds → Alarm

LI3300 > 98% for 20 seconds → Shut down process

LI3300 < 1% for 20 seconds while transferring product to ion exchange in progress → Shutdown

AI3300 < 6 or > 8 for 20 seconds while making batch → Alarm

AI3300 < 5.5 or > 8.5 for 20 seconds while making batch → Shutdown

TI3300 >= 110 deg F for 20 seconds while making batch → Alarm

TI3300 >= 125 deg F for 20 seconds while making batch → Shutdown

Ion Exchange #3 or Ion Exchange #4 is not online when transferring product to ion exchange → E-Shutdown

Lose heartbeat with Ion Exchange #3 for 10 seconds and lose heartbeat with Ion Exchange #4 for 10 seconds → Hold

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Reactor 4 Unit

### Major Equipment

TAG	DESCRIPTION	PURPOSE
A-3400	Reactor Tank agitator	Mix the ingredients in the reactor tank to keep uniform
P-3400	Reactor Outlet Pump	Centrifugal pump that transfers liquid product out of reactor to the ion exchange unit.
C-3402	Ingredient U Pump	Transfers wet ingredient U into the reactor tank.
T-3400	Reactor Tank	2,000 gallon tank to produce one batch of product. Ingredients are added and the reaction progresses to make product. When the batch is finished, it is transferred to the ion exchange unit.

### Analog Instrument and Control Point Listing

#### Analog Control Points

<u>TAG</u>	<u>TYPE</u>	<u>DESCRIPTION</u>	<u>PURPOSE</u>	<u>OTHER INFO</u>	<u>SEQUENCE BASED INTERLOCKS</u>
AI3400	Indicator	pH of Product in Reactor Tank	Monitor pH	0-14	
FI3401	Indicator	Powder ingredient flow rate	Monitor flow	0-200 lbs/min	
FI3402	Indicator	Ingred. T flow rate	Monitor flow	0-300 gpm	
FI3411	Indicator	Rinse water flow rate	Monitor flow	0-500 gpm	
FI3412	Indicator	CIP fluid flow rate	Monitor flow	0-500 gpm	
FQI3401	Indicator	Totalized powder ingredient transfer flow	Measures amount of powder ingredient transferred to reactor		
FQI3402	Indicator	Totalized ingred. T transfer flow	Measures amount of ingredient T transferred to reactor		
FQI3411	Indicator	Totalized rinse water transfer flow	Measures amount of rinse water transferred to reactor		
FQI3412	Indicator	Totalized CIP fluid transfer flow	Measures amount of CIP fluid transferred to reactor		
LI3400	Indicator	Level of Reactor Tank	Monitor level	0-100 (units %)	
TI3400	Indicator	Temperature of Reactor Tank	Monitor temperature	70-140 deg F	

#### Devices in Gas Storage

XV2815	Valve	T-2810 Discharge Valve	Controls flow from T-2810 to reactor 4	
XV2825	Valve	T-2820 Discharge Valve	Controls flow from T-2820 to reactor 4	
XV2835	Valve	T-2830 Discharge Valve	Controls flow from T-2830 to reactor 4	
XV2845	Valve	T-2840 Discharge Valve	Controls flow from T-2840 to reactor 4	

### *Discrete Instrument and Control Point Listing*

#### **Discrete Control Points**

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
A-3400	Motor	Reactor tank agitator	Mixes ingredients in reactor tank	The agitator should not run when level falls below 2%
P-3400	Motor	Reactor Outlet Pump	Pumps liquid product from reactor tank to ion exchange	This pump should not run if: LI3400<1%
P-3402	Motor	Ingredient U Pump	Pumps ingredient U into reactor vessel	
XV3400	Valve	Reactor Discharge Valve	Controls flow of product out of reactor tank	
XV3401	Valve	Gas Ingredient Feed Valve	Blocks flow of gas ingred. into reactor	
XV3402	Valve	Ingred. U Feed Valve	Blocks flow of ingred. U into reactor	
XV3411	Valve	Water Feed Valve	Blocks flow of water into reactor	
XV3412	Valve	CIP Fluid Feed Valve	Blocks flow of CIP fluid into reactor	
XV3422	Valve	Product to Ion Exchange Xfer Valve	Controls flow of product to ion exchange	
XV3423	Valve	CIP Return Valve at Ion Exchg	Directs CIP fluid back to CIP 2 system	

#### **Devices in Wet Ingredient Storage**

XV2175	Valve	T-2170 Discharge Valve – Ingred. U	Controls flow from T-2170 to reactor 4	
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### ***Unit Operation Interactions***

**Gas Storage Unit** Gaseous ingredients are received from the gas storage unit. This unit has direct control over the outlet side of the storage tanks in the gas storage unit.

**Wet Ingredient Storage Unit** Ingredient U is received from the wet ingredient storage unit. This unit has direct control over one of the valves in the wet ingredient storage unit.

**Ion Exchange Cell** Liquid product is transferred to the ion exchange cell from the reactor. If neither ion exchange 5 or 6 unit is ready, no new batches will be made.

**Clean In Place 2 Unit** Used to get rinse water to rinse reactor between batches.

### ***Reactor 4 Operational States***

- **Make Batch** – Combines water and ingredient U and "bubbles" gas ingredient through the mixture to produce product. Do not allow this operation if Make Batch or Flush is in operation. Steps:
  - Check Reactor Level LI3400 < 1% and TI3400 < 80 deg. F and either Ion Exchange 5 or 6 online
  - Display prompt for operator and operator selects gas tank source
  - Close all valves (one step)
  - Add 1000 gal. of water:
    - Reset FQI3411
    - Open XV3411
    - Wait for FQI3411 >= 1000
    - Close XV3411
  - Start A-3400
  - Add 400 gal. of Ingredient U:
    - Reset FQI3402
    - Open XV3402
    - Open XV2175
    - Start P-3402
    - Wait for FQI3402 >= 400
    - Stop P-3402
  - Bubble 500 scfm gas through mixture:
    - Reset FQI3401
    - Open XV3401
    - Open XV3440
    - Open appropriate gas tank outlet valve, XV28x5

- Wait for FQI3401  $\geq 500$
- Close XV28x5
- Close XV3401
- Close XV3440
- Agitate for 10 minutes
- If neither Ion Exchange 5 or 6 is Online,
  - Request Ion Exchange #5 to startup and wait for Ion Exchange #5 starting
  - Wait for Ion Exchange #5 online
- Open XV3422
- Open XV3400
- Start P-3400
- Wait for reactor level LI3400  $< 1\%$
- Stop A-3400
- Stop P-3400
- Close XV3400
- Close XV3422
- Initiate Flush
- Flush - Flushes reactor vessel and piping to ion exchange in preparation for next batch. Only allowed if reactor is at end of Make Batch or Shutdown.
  - Check Reactor Level LI3400  $< 1\%$
  - Close all valves (one step)
  - If CIP\_2 System is in shutdown or e-shutdown,
    - Request CIP\_2 System to go online/recycle and wait for CIP\_2 system online
  - Request CIP\_2 System for Reactor 4 Path and wait for CIP\_2 system Reactor 4 path set
  - Open XV3412
  - Wait for LI3400  $\geq 10\%$ .
  - Start A-3400
  - Wait for LI3400  $\geq 95\%$ .
  - Close XV3412
  - Agitate for 10 minutes
  - Open XV3423
  - Open XV3400
  - Start P-3400
  - Wait for LI3400  $\leq 1\%$
  - Stop A-3400
  - Request CIP\_2 system to go online/recycle and wait for XV6203 to be closed
  - Shutdown
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off all pumps and all valves:
  - Close XV2175
  - Stop P-3402
  - Close XV3402

- Close all XV28x5 (all in one step)
- Close XV3401
- Close XV3411
- Close XV3412
- Stop A-3400
- Stop P-3400
- Close XV3400
- Close XV3422
- Close XV3423
- Close XV3440
- E-Shutdown - Immediately turns off all pumps and all valves:
  - Close XV2175 and all XV28x5
  - Stop A-3400
  - Stop P-3400, P-3402
  - Close XV3401, XV3402, XV3411, XV3412, XV3400, XV3422, XV3423, XV3440

### *Reactor 4 Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

- LI3400 > 96% for 20 seconds → Alarm
- LI3400 > 98% for 20 seconds → Shut down process
- LI3400 < 1% for 20 seconds while transferring product to ion exchange in progress → Shutdown
- TI3400 >= 110 deg F for 20 seconds while making batch → Alarm
- TI3400 >= 125 deg F for 20 seconds while making batch → Shutdown
- AI3400 <= 5.0 or AI3400 >=9.0 for 20 seconds while making batch → Shutdown
- Ion Exchange #5 and Ion Exchange #6 is not online when transferring product to ion exchange → E-Shutdown
- CIP\_2 System not in Reactor 4 Path when Reactor in steps where CIP\_2 system used → E-Shutdown
- Lose heartbeat with CIP\_2 System for 10 seconds when Reactor in steps where CIP\_2 system used → Hold
- Ion Exchange #5 and Ion Exchange #6 not online when flushing product into ion exchange → E-Shutdown
- Lose heartbeat with Ion Exchange #5 for 10 seconds and lose heartbeat with Ion Exchange #6 → Hold
- Any pump failure → Hold
- Any valve failure → Hold
- Standard Aux, HOA, overload alarms on pumps
- Standard Fail to Open, Fail to Close alarms on valves



Note: "While making batch" means "after 1000 gal. water added and reactor level > 5% while product transferred out of reactor"

## QA Sample Unit

### *Major Equipment*

<u>TAG</u>	<u>DESCRIPTION</u>	<u>PURPOSE</u>
A-3800	Product Analyzer	Analyzer that assesses product quality.
P-3810	R1 Sample Pump	Bellows metering pump that transfers liquid product out of reactor 1 through analyzer and back to reactor 1.
P-3820	R2 Sample Pump	Bellows metering pump that transfers liquid product out of reactor 2 through analyzer and back to reactor 2.

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<u>TAG</u>	<u>TYPE</u>	<u>DESCRIPTION</u>	<u>PURPOSE</u>	<u>OTHER INFO</u>	<u>SEQUENCE BASED INTERLOCKS</u>
AI3800	Indicator	Analyzer measurement	Monitor major quality indicator in reactor product	0-100	
FI3810	Indicator	Reactor 1 sample inlet flow	Measures flow of sample	0-4 gpm	
FI3820	Indicator	Reactor 2 sample inlet flow	Measures flow of sample	0-4 gpm	

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<u>TAG</u>	<u>TYPE</u>	<u>DESCRIPTION</u>	<u>PURPOSE</u>	<u>SEQUENCE BASED INTERLOCKS</u>
P-3810	Pump	R1 Sample Pump	Pumps sample from R1	
P-3820	Pump	R2 Sample Pump	Pumps sample from R2	
XV3811	Valve	Reactor 1 QA Sample Inlet Valve	Allows R1 contents to be transferred for quality sampling	
XV3812	Valve	Reactor 1 Path Hot Water Inlet Valve	Allows hot water to flush out reactor 1 path	
XV3813	Valve	Reactor 1 Analyzer Inlet Valve	Allows R1 contents to enter analyzer	

XV3814	Valve	Reactor 1 Analyzer Outlet Valve	Allows R1 contents to exit analyzer	
XV3815	Valve	Reactor 1 Sample Return Drain Valve	Drains path back to R1	
XV3816	Valve	Reactor 1 Sample Return Valve	Returns sample to R1	
XV3821	Valve	Reactor 2 QA Sample Inlet Valve	Allows R2 contents to be transferred for quality sampling	
XV3822	Valve	Reactor 2 Path Hot Water Inlet Valve	Allows hot water to flush out reactor 2 path	
XV3823	Valve	Reactor 2 Analyzer Inlet Valve	Allows R2 contents to enter analyzer	
XV3824	Valve	Reactor 2 Analyzer Outlet Valve	Allows R2 contents to exit analyzer	
XV3825	Valve	Reactor 2 Sample Return Drain Valve	Drains path back to R2	
XV3826	Valve	Reactor 2 Sample Return Valve	Returns sample to R2	
XV3881	Valve	Analyzer Outlet Drain Valve	Drains analyzer outlet	

### ***Unit Operation Interactions***

**Reactor Units** When requested by a reactor unit, the valve paths are set to direct reactor contents to the analyzer system and then returned to the reactor.

### ***QA Sample Unit Operational States***

- Sample R1 - Samples reactor 1 product. Extracts a sample from reactor 1 and initially sends it to the drain until analyzer reading has stabilized. Then the product is continuously sampled and returned to reactor 1. Do not allow this operation to start if sampling for reactor 2 and indication to reactor 2 has not been sent or if sampling system is locked to reactor 2. After indication is sent to reactor 1, the QA sampling system can be requested by reactor 2. Steps:  
 If Sample R2 in progress, close all valves (one step), stop P-3820  
 Open Reactor 1 QA sampling inlet, XV3811  
 Open R1 analyzer inlet, XV3813  
 Open analyzer drain, XV3881  
 Start R1 sample pump, P-3810

Wait 30 seconds (for sample to travel to analyzer)  
Monitor AI3800, waiting for AI 3800 to stay within +/- 1.0 for 30 seconds  
Set/latch "QA Sample finished" to reactor 1  
Set/latch "Sample R1 in progress" (so Sample R2 can interrupt)  
Open R1 analyzer outlet, XV3814  
Open R1 sample return drain, XV3815  
Close analyzer drain, XV3881  
Wait 30 seconds (for sample to travel to sample return drain)  
Open R1 sample return, XV3816  
Close R1 sample return drain, XV3815  
Reset/unlatch "Sample R1 in progress"  
Reset/unlatch "QA Sample finished" to reactor 1

- Sample R2 - Samples reactor 2 product. Extracts a sample from reactor 2 and initially sends it to the drain until analyzer reading has stabilized. Then the product is continuously sampled and returned to reactor 2. Do not allow this operation to start if sampling for reactor 1 and indication to reactor 1 has not been sent or if sampling system is locked to reactor 1. After indication is sent to reactor 2, the QA sampling system can be requested by reactor 1. Steps:
  - If sampling reactor 1, close all valves (one step), stop P-3810
  - Open Reactor 2 QA sampling inlet, XV3821
  - Open R2 analyzer inlet, XV3823
  - Open analyzer drain, XV3881
  - Start R2 sample pump, P-3820
  - Wait 30 seconds (for sample to travel to analyzer)
  - Monitor AI3800, waiting for AI 3800 to stay within +/- 1.0 for 30 seconds
  - Set/latch "QA Sample finished" to reactor 2
  - Set/latch "Sample R2 in progress" (so Sample R1 can interrupt)
  - Open R2 analyzer outlet, XV3824
  - Open R2 sample return drain, XV3825
  - Close analyzer drain, XV3881
  - Wait 30 seconds (for sample to travel to sample return drain)
  - Open R2 sample return, XV3826
  - Close R2 sample return drain, XV3825
  - Reset/unlatch "Sample R2 in progress"
  - Reset/unlatch "QA Sample finished" to reactor 2
- Lock R1 - Locks sampling system to reactor 1. Extracts a sample from reactor 1 and initially sends it to the drain until analyzer reading has stabilized. Then the product is continuously sampled and returned to reactor 1. Do not allow this operation to start if sampling system is locked to reactor 2. Steps:
  - Set/latch "R1 locked"
  - Other steps same as "Sample Reactor 1"
- Lock R2 - Locks sampling system to reactor 2. Extracts a sample from reactor 2 and initially sends it to the drain until analyzer reading has stabilized. Then the product is continuously

sampled and returned to reactor 2. Do not allow this operation to start if sampling system is locked to reactor 1. Steps:

Set/latch "R2 locked"

Same as "Sample Reactor 2"

- Unlock R1 - Cancel lock of sampling system to reactor 1. Only allowed if sampling system is locked to reactor 1. Steps:
  - Reset/unlatch "R1 locked"
  - Initiate shutdown
- Unlock R2 - Cancel lock of sampling system to reactor 2. Only allowed if sampling system is locked to reactor 2. Steps:
  - Reset/unlatch "R2 locked"
  - Initiate shutdown
- Flush R1 Path - Flush R1 sampling system with hot water. Only allowed if sampling system is already shutdown or E-shutdown:
  - Open XV3815
  - Open XV3814
  - Open XV3813
  - Open XV3812
  - Start P-3810
  - Flush for 5 minutes
  - Initiate shutdown
- Flush R2 Path - Flush R2 sampling system with hot water. Only allowed if sampling system is already shutdown or E-shutdown:
  - Open XV3825
  - Open XV3824
  - Open XV3823
  - Open XV3822
  - Start P-3820
  - Flush for 5 minutes
  - Initiate shutdown
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off the pumps and closes all valves:
  - Stop P-3810
  - Stop P-3820
  - Close XV3811
  - Close XV3821
  - Close XV3812
  - Close XV3822
  - Close XV3813

Close XV3823  
Close XV3881  
Close XV3814  
Close XV3824  
Close XV3815  
Close XV3825  
Close XV3816  
Close XV3826

- E-Shutdown - Immediately turns off the pumps and closes all valves:  
Stop P-3810, P-3820  
Close XV3811, XV3821, XV3812, XV3822, XV3813, XV3823,  
XV3881, XV3814, XV3824, XV3815, XV3825, XV3816, XV3826

### *QA Sampling Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

If P-3810 is running and FI3810 < 0.1 gpm for 30 seconds → Alarm and Hold

If P-3810 is running and FI3810 < 0.1 gpm for 1 minute → Shutdown

If P-3820 is running and FI3820 < 0.1 gpm for 30 seconds → Alarm and Hold

If P-3820 is running and FI3820 < 0.1 gpm for 1 minute → Shutdown

Any pump failure for 30 seconds → Hold

Any valve failure for 30 seconds → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

Shutdown of unit using QA\_Sample → Shutdown

Losing heartbeat with any unit using QA\_Sample for 10 seconds → Shutdown

## Ion Exchange #1 Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
T-4100	Ion Exchange #1 Tank	500 gallon tank to process the reactor product to remove some of the product impurities.
P-4102	Regen Pump	Centrifugal pump that transfers regenerating liquid into the ion exchange tank.

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
AI4100	Indicator	Conductivity of Ion Exchange Tank	Monitor conductivity	0-100 mmho/cm	
FI4101	Indicator	Product flow rate	Measures flow rate of product through ion exchange	0-200 gpm	
FQI4101	Indicator	Totalized product in transfer flow	Measures amount of product from reactor being transferred through ion exchange		
FIC4102	Loop	Regen material transfer flow control	Controls flow rate of regen material to ion exchange vessel	0-100 gpm, Fail closed, direct acting	
FQI4102	Indicator	Totalized regen material transfer flow	Measures amount of regen material being transferred to ion exchange		
FIC4103	Loop	Rinse water flow control	Controls feed rate of rinse water to ion exchanger	0-100 gpm, Fail closed, direct acting	
FQI4103	Indicator	Totalized rinse water transfer flow	Measures amount of rinse water transferred to ion exchange		

## *Discrete Instrument and Control Point Listing*

### **Discrete Control Points**

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
P-4102	Motor	Regen Material Pump	Pumps regen material to ion exchanger	This pump should not run if PV:FIC4102<1.0 gpm and VO:FIC4102=100%
XV4101	Valve	Ion Exchange #1 Product Inlet Valve	Controls flow of product into ion exchange tank	
XV4102	Valve	Ion Exchange #1 Regen Material Inlet Valve	Controls flow of regen into ion exchange tank	
XV4103	Valve	Rinse Water Feed Valve	Controls flow of rinse water into ion exchange	
XV4105	Valve	Ion Exchange #1 Product Discharge Valve	Controls flow of product out of ion exchange tank	
XV4106	Valve	Ion Exchange #1 Regen Material Discharge Valve	Controls flow of regen out of ion exchange tank	
XV4107	Valve	Rinse Water Discharge Valve	Controls flow of rinse water out of ion exchange	
XV4121	Valve	CIP to Ion Exchange Valve	Controls flow of CIP water into piping to QA Tank 1	
XV4122	Valve	Product to QA Tank Xfer Valve	Controls flow of product to QA tank 1	
XV4123	Valve	CIP Return Valve	Directs CIP water back to CIP System	

## ***Unit Operation Interactions***

**Reactor 1 and Reactor 2 Unit** Liquid product is received from either reactor unit. This unit has no direct control over the reactor units.

**CIP System** The ion exchange unit requests CIP water. When CIP is granted, CIP water is directed to the ion exchange discharge pump, and the outlet piping valves are properly set to transfer the remaining



product in the piping to the QA tank and then return the cleaning water to the CIP tank. When the flush is finished, then the CIP system is requested to return to its normal online/recycle operation.

**Product Storage 1 Unit** Liquid product is transferred to the QA tank 1 from the ion exchange unit. If the QA tank 1 is too full, the ion exchange unit is shutdown.

**Regeneration Material Unit** Used to get regeneration material to ion exchange for regeneration.

**Rinse Water Unit** Used to get rinse water to ion exchange after regeneration.

### ***Ion Exchange #1 Unit Operational States***

- Startup – Starts up the online operation of ion exchange tank #1. Requested by operator or reactor unit. Steps:
  - Check Ion Exchange #1 Conductivity AI4100 < 50 mmho/cm
  - Close XV4102, XV4103, XV4106, XV4107, XV4121, XV4123
  - Reset FQI4101
  - Open XV4101
  - Open XV4105
  - Open XV4122
  - Initiate Online
- Online – Online operation of ion exchange tank #1. Steps:
  - When FQI4101 >= 100,000 gal., initiate Regenerating
- Regenerate – Regenerate ion exchange bed. Initiated by operator or if 100,000 gal. of product has passed through the ion exchange. Only allowed if both reactor 1 and reactor 2 are not in Make Batch. Steps:
  - Close XV4101, XV4103, XV4105, XV4107
  - Regenerate bed with 1500 gal. of regeneration material
  - Open XV4102
  - Open XV4106
  - Set Regen Material Flow Controller FIC4102 to manual, 20% output
  - Reset FQI4102
  - Start P-4102
  - Set Regen Material Flow Controller FIC4102 to auto, setpoint = 70 gpm
  - Wait for FQI4102 >= 1500 gal.
  - Stop P-4102
  - Set FIC4102 to manual, 0% output
  - Close XV4102
  - Close XV4106
  - Rinse bed with 2000 gal. of water
  - Reset FQI4103
  - Open XV4103
  - Open XV4107

Set Rinse Water Flow Controller FIC4103 to manual, 10% output  
 Set Rinse Water Flow Controller FIC4103 to auto, setpoint = 40 gpm  
 Wait for FQI4103  $\geq$  1000 gal.  
 Set Rinse Water Flow Controller FIC4103 to auto, setpoint = 70 gpm  
 Wait for FQI4103  $\geq$  2000 gal.  
 Set FIC4103 to manual, 0% output  
 Close XV4103  
 Close XV4107  
 Shutdown the system

- Flush - Flushes the piping to the QA tank 1. Can be requested if already shutdown:  
 If CIP\_1 System is in shutdown or e-shutdown, request CIP\_1 System to go online/recycle  
 Wait for CIP\_1 system online  
 Request CIP\_1 System to set Ion Exchange Path  
 Wait for CIP\_1 system path set  
 Open QA tank feed valve XV4122  
 Open CIP\_1 to ion exchange feed valve XV4121  
 Wait 2 minutes for product to be flushed into QA tank 1.  
 Open XV4123 and close XV4122 (one step)  
 Flush for 10 minutes  
 Request CIP\_1 system to go online/recycle and wait for XV6004 to be closed  
 Shutdown
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off all pumps and all valves:  
 Stop P-4102  
 Close XV4101  
 Set FIC4102 to manual, 0% output  
 Close XV4102  
 Set FIC4103 to manual, 0% output  
 Close XV4103  
 Close XV4105  
 Close XV4106  
 Close XV4107  
 Close XV4121  
 Close XV4122  
 Close XV4123
- E-Shutdown - Immediately turns off all pumps and all valves:  
 Stop P-4102  
 Set FIC4102 to manual, 0% output  
 Set FIC4103 to manual, 0% output

Close XV4101, XV4102, XV4103, XV4105, XV4106, XV4107, XV4121, XV4122,  
XV4123

### *Ion Exchange #1 Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

AI4100 > 50 mmho/cm for 20 seconds → Alarm

AI4100 > 60 mmho/cm for 20 seconds → Shutdown process

Product Storage Tank 1 full → E-Shutdown

CIP\_1 System not in Ion Exchange Outlet Path when Ion Exchange in steps where CIP\_1 system used → E-Shutdown

Lose heartbeat with CIP\_1 System for 10 seconds when Ion Exchange in steps where CIP\_1 system used → E-Shutdown

Lose heartbeat with Stor\_Tnk\_1 System for 10 seconds → E-Shutdown

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Ion Exchange #2 Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
T-4200	Ion Exchange #2 Tank	500 gallon tank to process the reactor product to remove some of the product impurities.
P-4202	Regen Pump	Centrifugal pump that transfers regenerating liquid into the ion exchange tank.

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
AI4200	Indicator	Conductivity of Ion Exchange Tank	Monitor conductivity	0-100 mmho/cm	
FI4201	Indicator	Product flow rate	Measures flow rate of product through ion exchange	0-200 gpm	
FQI4201	Indicator	Totalized product in transfer flow	Measures amount of product from reactor being transferred through ion exchange		
FIC4202	Loop	Regen material transfer flow control	Controls flow rate of regen material to ion exchange vessel	0-200 gpm, Fail closed, direct acting	
FQI4202	Indicator	Totalized regen material transfer flow	Measures amount of regen material being transferred to ion exchange		
FIC4203	Loop	Rinse water flow control	Controls feed rate of rinse water to ion exchanger	0-200 gpm, Fail closed, direct acting	
FQI4203	Indicator	Totalized rinse water transfer flow	Measures amount of rinse water transferred to ion exchange		

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
P-4202	Motor	Regen Material Pump	Pumps regen material to ion exchanger	This pump should not run if PV:FIC4202<1.0 gpm and VO:FIC4202=100%
XV4201	Valve	Ion Exchange #1 Product Inlet Valve	Controls flow of product into ion exchange tank	
XV4202	Valve	Ion Exchange #1 Regen Material Inlet Valve	Controls flow of regen into ion exchange tank	
XV4203	Valve	Rinse Water Feed Valve	Controls flow of rinse water into ion exchange	
XV4205	Valve	Ion Exchange #1 Product Discharge Valve	Controls flow of product out of ion exchange tank	
XV4206	Valve	Ion Exchange #1 Regen Material Discharge Valve	Controls flow of regen out of ion exchange tank	
XV4207	Valve	Rinse Water Discharge Valve	Controls flow of rinse water out of ion exchange	
XV4221	Valve	CIP_1 to Ion Exchange Valve	Controls flow of CIP_1 water into piping to QA Tank 1	
XV4222	Valve	Product to QA Tank Xfer Valve	Controls flow of product to QA tank 1	
XV4223	Valve	CIP_1 Return Valve	Directs CIP water back to CIP_1 System	

### ***Unit Operation Interactions***

**Reactor 1 and Reactor 2 Unit** Liquid product is received from either reactor unit. This unit has no direct control over the reactor units.

**CIP\_1 System** The ion exchange unit requests CIP\_1 water. When CIP\_1 is granted, CIP\_1 water is directed to the ion exchange discharge pump, and the outlet piping valves are properly set to transfer the remaining product in the piping to the QA tank and then return the cleaning water to the CIP\_1 tank. When the flush is finished, then the CIP\_1 system is requested to return to its normal online/recycle operation.

**Product Storage 1 Unit** Liquid product is transferred to the QA tank 1 from the ion exchange unit. If the QA tank 1 is too full, the ion exchange unit is shutdown.

**Regeneration Material Unit** Used to get regeneration material to ion exchange for regeneration.

**Rinse Water Unit** Used to get rinse water to ion exchange after regeneration.

### ***Ion Exchange #2 Unit Operational States***

- Startup – Starts up the online operation of ion exchange tank #2. Requested by operator or reactor unit. Steps:
  - Check Ion Exchange #2 Conductivity AI4200 < 50 mmho/cm
  - Close XV4202, XV4203, XV4206, XV4207, XV4221, XV4223
  - Reset FQI4201
  - Open XV4201
  - Open XV4205
  - Open XV4222
  - Initiate Online
- Online – Online operation of ion exchange tank #2. Steps:
  - When FQI4201 >= 100,000 gal., initiate Regenerating
- Regenerate – Regenerate ion exchange bed. Initiated by operator or if 100,000 gal. of product has passed through the ion exchange. Only allowed if both reactor 1 and reactor 2 are not in Make Batch. Steps:
  - Close XV4201, XV4203, XV4205, XV4207
  - Regenerate bed with 500 gal. of regeneration material
    - Open XV4202
    - Open XV4206
    - Set Regen Material Flow Controller FIC4202 to manual, 20% output
    - Reset FQI4202
    - Start P-4202
    - Set Regen Material Flow Controller FIC4202 to auto, setpoint = 150 gpm
    - Wait for FQI4202 >= 500 gal.
    - Stop P-4202
    - Set FIC4202 to manual, 0% output
    - Close XV4202
    - Close XV4206
  - Rinse bed with 1000 gal. of water
    - Reset FQI4203
    - Open XV4203
    - Open XV4207
    - Set Rinse Water Flow Controller FIC4203 to manual, 10% output
    - Set Rinse Water Flow Controller FIC4203 to auto, setpoint = 80 gpm
    - Wait for FQI4203 >= 500 gal.

Set Rinse Water Flow Controller FIC4203 to auto, setpoint = 140 gpm  
Wait for FQI4203  $\geq$  1000 gal.  
Set FIC4203 to manual, 0% output  
Close XV4203  
Close XV4207  
Shutdown the system

- Flush - Flushes the piping to the QA tank 1. Can be requested if already shutdown:  
If CIP\_1 System is in shutdown or e-shutdown, request CIP\_1 System to go online/recycle  
Wait for CIP\_1 system online  
Request CIP\_1 System to set Ion Exchange Path  
Wait for CIP\_1 system path set  
Open QA tank feed valve XV4222  
Open CIP\_1 to ion exchange feed valve XV4221  
Wait 2 minutes for product to be flushed into QA tank 1.  
Open XV4223 and close XV4222 (one step)  
Flush for 10 minutes  
Request CIP\_1 system to go online/recycle and wait for XV6004 to be closed  
Shutdown
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off all pumps and all valves:  
Stop P-4202  
Close XV4201  
Set FIC4202 to manual, 0% output  
Close XV4202  
Set FIC4203 to manual, 0% output  
Close XV4203  
Close XV4205  
Close XV4206  
Close XV4207  
Close XV4221  
Close XV4222  
Close XV4223
- E-Shutdown - Immediately turns off all pumps and all valves:  
Stop P-4202  
Set FIC4202 to manual, 0% output  
Set FIC4203 to manual, 0% output  
Close XV4201, XV4202, XV4203, XV4205, XV4206, XV4207, XV4221, XV4222, XV4223

### *Ion Exchange #2 Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

AI4200 > 50 mmho/cm for 20 seconds → Alarm

AI4200 > 60 mmho/cm for 20 seconds → Shutdown process

Product Storage Tank 1 full → E-Shutdown

CIP\_1 System not in Ion Exchange Outlet Path when Ion Exchange in steps where CIP\_1 system used → E-Shutdown

Lose heartbeat with CIP\_1 System for 10 seconds when Ion Exchange in steps where CIP\_1 system used → E-Shutdown

Lose heartbeat with Stor\_Tnk\_1 System for 10 seconds → E-Shutdown

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves



## Ion Exchange #3 Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
T-4300	Ion Exchange #3 Tank	500 gallon tank to process the reactor product to remove some of the product impurities.
P-4302	Regen Pump	Centrifugal pump that transfers regenerating liquid into the ion exchange tank.

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
AI4300	Indicator	Conductivity of Ion Exchange Tank	Monitor conductivity	0-100 mmho/cm	
FI4301	Indicator	Product flow rate	Measures flow rate of product through ion exchange	0-200 gpm	
FQI4301	Indicator	Totalized product in transfer flow	Measures amount of product from reactor being transferred through ion exchange		
FIC4302	Loop	Regen material transfer flow control	Controls flow rate of regen material to ion exchange vessel	0-100 gpm, Fail closed, direct acting	
FQI4302	Indicator	Totalized regen material transfer flow	Measures amount of regen material being transferred to ion exchange		
FIC4303	Loop	Rinse water flow control	Controls feed rate of rinse water to ion exchanger	0-100 gpm, Fail closed, direct acting	
FQI4303	Indicator	Totalized rinse water transfer flow	Measures amount of rinse water transferred to ion exchange		

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
P-4302	Motor	Regen Material Pump	Pumps regen material to ion exchanger	This pump should not run if PV:FIC4302<1.0 gpm and VO:FIC4302=100%
XV4301	Valve	Ion Exchange #3 Product Inlet Valve	Controls flow of product into ion exchange tank	
XV4302	Valve	Ion Exchange #3 Regen Material Inlet Valve	Controls flow of regen into ion exchange tank	
XV4303	Valve	Rinse Water Feed Valve	Controls flow of rinse water into ion exchange	
XV4305	Valve	Ion Exchange #3 Product Discharge Valve	Controls flow of product out of ion exchange tank	
XV4306	Valve	Ion Exchange #3 Regen Material Discharge Valve	Controls flow of regen out of ion exchange tank	
XV4307	Valve	Rinse Water Discharge Valve	Controls flow of rinse water out of ion exchange	
XV4321	Valve	Rinse to Ion Exchange Out Piping Valve	Controls flow of rinse water into piping to QA Tank 2	
XV4322	Valve	Product to QA Tank Xfer Valve	Controls flow of product to QA tank 2	
XV4323	Valve	Rinse Return Valve	Directs rinse water in piping to drain	

### ***Unit Operation Interactions***

**Reactor 3 Unit** Liquid product is received from reactor unit. This unit has no direct control over the reactor units.

**Product Storage 2 Unit** Liquid product is transferred to the QA tank 2 from the ion exchange unit. If the QA tank 2 is too full, the ion exchange unit is shutdown.

**Regeneration Material Unit** Used to get regeneration material to ion exchange for regeneration.

**Rinse Water Unit** Used to get rinse water to ion exchange after regeneration.

### ***Ion Exchange #3 Unit Operational States***

- Startup – Starts up the online operation of ion exchange tank #3. Requested by operator or reactor unit. Steps:
  - Check Ion Exchange #3 Conductivity AI4300 < 50 mmho/cm
  - Close XV4302, XV4303, XV4306, XV4307, XV4321, XV4323
  - Reset FQI4301
  - Open XV4301
  - Open XV4305
  - Open XV4322
  - Initiate Online
- Online – Online operation of ion exchange tank #3. Steps:
  - When FQI4301 >= 100,000 gal., initiate Regenerating
- Regenerate – Regenerate ion exchange bed. Initiated by operator or if 100,000 gal. of product has passed through the ion exchange. Only allowed if Reactor 3 is not in Make Batch. Steps:
  - Close XV4301, XV4303, XV4305, XV4307
  - Regenerate bed with 1500 gal. of regeneration material
    - Open XV4302
    - Open XV4306
    - Set Regen Material Flow Controller FIC4302 to manual, 20% output
    - Reset FQI4302
    - Start P-4302
    - Set Regen Material Flow Controller FIC4302 to auto, setpoint = 70 gpm
    - Wait for FQI4302 >= 1500 gal.
    - Stop P-4302
    - Set FIC4302 to manual, 0% output
    - Close XV4302
    - Close XV4306
  - Rinse bed with 2000 gal. of water
    - Reset FQI4303
    - Open XV4303
    - Open XV4307
    - Set Rinse Water Flow Controller FIC4303 to manual, 10% output
    - Set Rinse Water Flow Controller FIC4303 to auto, setpoint = 40 gpm
    - Wait for FQI4303 >= 1000 gal.
    - Set Rinse Water Flow Controller FIC4303 to auto, setpoint = 70 gpm
    - Wait for FQI4303 >= 2000 gal.
    - Set FIC4303 to manual, 0% output
    - Close XV4303
    - Close XV4307
  - Shutdown the system

- Flush - Flushes the piping to the QA tank 2. Can be requested if already shutdown:
  - Open QA tank feed valve XV4322
  - Open rinse to ion exchange out piping feed valve XV4321
  - Wait 2 minutes for product to be flushed into QA tank.
  - Open XV4323 and close XV4322 (one step)
  - Flush for 10 minutes
  - Shutdown
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off all pumps and all valves:
  - Stop P-4302
  - Close XV4301
  - Set FIC4302 to manual, 0% output
  - Close XV4302
  - Set FIC4303 to manual, 0% output
  - Close XV4303
  - Close XV4305
  - Close XV4306
  - Close XV4307
  - Close XV4321
  - Close XV4322
  - Close XV4323
- E-Shutdown - Immediately turns off all pumps and all valves:
  - Stop P-4302
  - Set FIC4302 to manual, 0% output
  - Set FIC4303 to manual, 0% output
  - Close XV4301, XV4302, XV4303, XV4305, XV4306, XV4307, XV4321, XV4322, XV4323

### *Ion Exchange #3 Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

AI4300 > 50 mmho/cm for 20 seconds → Alarm

AI4300 > 60 mmho/cm for 20 seconds → Shutdown process

Product Storage Tank 2 full → E-Shutdown

Lose heartbeat with Stor\_Tnk\_2 System for 10 seconds → E-Shutdown

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Ion Exchange #4 Unit

### Major Equipment

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
T-4400	Ion Exchange #4 Tank	500 gallon tank to process the reactor product to remove some of the product impurities.
P-4402	Regen Pump	Centrifugal pump that transfers regenerating liquid into the ion exchange tank.

### Analog Instrument and Control Point Listing

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
AI4400	Indicator	Conductivity of Ion Exchange Tank	Monitor conductivity	0-100 mmho/cm	
FI4401	Indicator	Product flow rate	Measures flow rate of product through ion exchange	0-200 gpm	
FQI4401	Indicator	Totalized product in transfer flow	Measures amount of product from reactor being transferred through ion exchange		
FIC4402	Loop	Regen material transfer flow control	Controls flow rate of regen material to ion exchange vessel	0-100 gpm, Fail closed, direct acting	
FQI4402	Indicator	Totalized regen material transfer flow	Measures amount of regen material being transferred to ion exchange		
FIC4403	Loop	Rinse water flow control	Controls feed rate of rinse water to ion exchanger	0-100 gpm, Fail closed, direct acting	
FQI4403	Indicator	Totalized rinse water transfer flow	Measures amount of rinse water transferred to ion exchange		

### Discrete Instrument and Control Point Listing

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
P-4402	Motor	Regen Material Pump	Pumps regen material to ion exchanger	This pump should not run if PV:FIC4402<1.0 gpm and VO:FIC4402=100%
XV4401	Valve	Ion Exchange #4 Product Inlet Valve	Controls flow of product into ion exchange tank	
XV4402	Valve	Ion Exchange #4 Regen Material Inlet Valve	Controls flow of regen into ion exchange tank	
XV4403	Valve	Rinse Water Feed Valve	Controls flow of rinse water into ion exchange	
XV4405	Valve	Ion Exchange #4 Product Discharge Valve	Controls flow of product out of ion exchange tank	
XV4406	Valve	Ion Exchange #4 Regen Material Discharge Valve	Controls flow of regen out of ion exchange tank	
XV4407	Valve	Rinse Water Discharge Valve	Controls flow of rinse water out of ion exchange	
XV4421	Valve	Rinse to Ion Exchange Out Piping Valve	Controls flow of rinse water into piping to QA Tank 2	
XV4422	Valve	Product to QA Tank Xfer Valve	Controls flow of product to QA tank 2	
XV4423	Valve	Rinse Return Valve	Directs rinse water in piping to drain	

### ***Unit Operation Interactions***

**Reactor 3 Unit** Liquid product is received from reactor unit. This unit has no direct control over the reactor units.

**Product Storage 2 Unit** Liquid product is transferred to the QA tank 2 from the ion exchange unit. If the QA tank 2 is too full, the ion exchange unit is shutdown.

**Regeneration Material Unit** Used to get regeneration material to ion exchange for regeneration.

**Rinse Water Unit** Used to get rinse water to ion exchange after regeneration and to flush piping.

### ***Ion Exchange #4 Unit Operational States***

- Startup – Starts up the online operation of ion exchange tank #4. Requested by operator or reactor unit. Steps:
  - Check Ion Exchange #4 Conductivity AI4400 < 50 mmho/cm
  - Close XV4402, XV4403, XV4406, XV4407, XV4421, XV4423
  - Reset FQI4401
  - Open XV4401
  - Open XV4405
  - Open XV4422
  - Initiate Online
- Online – Online operation of ion exchange tank #4. Steps:
  - When FQI4401 >= 100,000 gal., initiate Regenerating
- Regenerate – Regenerate ion exchange bed. Initiated by operator or if 100,000 gal. of product has passed through the ion exchange. Only allowed if Reactor 3 is not in Make Batch. Steps:
  - Close XV4401, XV4403, XV4405, XV4407
  - Regenerate bed with 1500 gal. of regeneration material
    - Open XV4402
    - Open XV4406
    - Set Regen Material Flow Controller FIC4402 to manual, 20% output
    - Reset FQI4402
    - Start P-4402
    - Set Regen Material Flow Controller FIC4402 to auto, setpoint = 70 gpm
    - Wait for FQI4402 >= 1500 gal.
    - Stop P-4402
    - Set FIC4402 to manual, 0% output
    - Close XV4402
    - Close XV4406
  - Rinse bed with 2000 gal. of water
    - Reset FQI4403
    - Open XV4403
    - Open XV4407
    - Set Rinse Water Flow Controller FIC4403 to manual, 10% output
    - Set Rinse Water Flow Controller FIC4403 to auto, setpoint = 40 gpm
    - Wait for FQI4403 >= 1000 gal.
    - Set Rinse Water Flow Controller FIC4403 to auto, setpoint = 70 gpm
    - Wait for FQI4403 >= 2000 gal.
    - Set FIC4403 to manual, 0% output
    - Close XV4403
    - Close XV4407
  - Shutdown the system

- Flush - Flushes the piping to the QA tank 2. Can be requested if already shutdown:
  - Open QA tank feed valve XV4422
  - Open rinse to ion exchange out piping feed valve XV4421
  - Wait 2 minutes for product to be flushed into QA tank
  - Open XV4423 and close XV4422 (one step)
  - Flush for 10 minutes
  - Shutdown
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off all pumps and all valves:
  - Stop P-4402
  - Close XV4401
  - Set FIC4402 to manual, 0% output
  - Close XV4402
  - Set FIC4403 to manual, 0% output
  - Close XV4403
  - Close XV4405
  - Close XV4406
  - Close XV4407
  - Close XV4421
  - Close XV4422
  - Close XV4423
- E-Shutdown - Immediately turns off all pumps and all valves:
  - Stop P-4402
  - Set FIC4402 to manual, 0% output
  - Set FIC4403 to manual, 0% output
  - Close XV4401, XV4402, XV4403, XV4405, XV4406, XV4407, XV4421, XV4422, XV4423

### *Ion Exchange #4 Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

AI4400 > 50 mmho/cm for 20 seconds → Alarm

AI4400 > 60 mmho/cm for 20 seconds → Shutdown process

Product Storage Tank 2 full → E-Shutdown

Lose heartbeat with Stor\_Tnk\_2 System for 10 seconds → E-Shutdown

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves



## Ion Exchange #5 Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
T-4500	Ion Exchange #5 Tank	400 gallon tank to process the reactor product to remove some of the product impurities.
P-4502	Regen Pump	Centrifugal pump that transfers regenerating liquid into the ion exchange tank.

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
AI4500	Indicator	Conductivity of Ion Exchange Tank	Monitor conductivity	0-100 mmho/cm	
FI4501	Indicator	Product flow rate	Measures flow rate of product through ion exchange	0-200 gpm	
FQI4501	Indicator	Totalized product in transfer flow	Measures amount of product from reactor being transferred through ion exchange		
FIC4502	Loop	Regen material transfer flow control	Controls flow rate of regen material to ion exchange vessel	0-100 gpm, Fail closed, direct acting	
FQI4502	Indicator	Totalized regen material transfer flow	Measures amount of regen material being transferred to ion exchange		
FIC4503	Loop	Rinse water flow control	Controls feed rate of rinse water to ion exchanger	0-100 gpm, Fail closed, direct acting	
FQI4503	Indicator	Totalized rinse water transfer flow	Measures amount of rinse water transferred to ion exchange		

## *Discrete Instrument and Control Point Listing*

### **Discrete Control Points**

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
P-4502	Motor	Regen Material Pump	Pumps regen material to ion exchanger	This pump should not run if PV:FIC4502<1.0 gpm and VO:FIC4502=100%
XV4501	Valve	Ion Exchange #5 Product Inlet Valve	Controls flow of product into ion exchange tank	
XV4502	Valve	Ion Exchange #5 Regen Material Inlet Valve	Controls flow of regen into ion exchange tank	
XV4503	Valve	Rinse Water Feed Valve	Controls flow of rinse water into ion exchange	
XV4505	Valve	Ion Exchange #5 Product Discharge Valve	Controls flow of product out of ion exchange tank	
XV4506	Valve	Ion Exchange #5 Regen Material Discharge Valve	Controls flow of regen out of ion exchange tank	
XV4507	Valve	Rinse Water Discharge Valve	Controls flow of rinse water out of ion exchange	
XV4521	Valve	CIP_2 to Ion Exchange Out Piping Valve	Controls flow of CIP_2 fluid into piping to QA Tank 3	
XV4522	Valve	Product to QA Tank Xfer Valve	Controls flow of product to QA tank 3	
XV4523	Valve	CIP_2 Return Valve	Directs CIP_2 fluid in piping to drain	

## ***Unit Operation Interactions***

**Reactor 4 Unit** Liquid product is received from reactor unit. This unit has no direct control over the reactor units.

**CIP\_2 System** The ion exchange unit requests CIP\_2 water. When CIP\_2 is granted, CIP\_2 water is directed to the ion exchange discharge pump, and the outlet piping valves are properly set to transfer the remaining product in the piping to the QA tank and then return the cleaning water to the CIP\_2 tank.

When the flush is finished, then the CIP\_2 system is requested to return to its normal online/recycle operation.

**Product Storage 3 Unit** Liquid product is transferred to the QA tank 3 from the ion exchange unit. If the QA tank 3 is too full, the ion exchange unit is shutdown.

**Regeneration Material Unit** Used to get regeneration material to ion exchange for regeneration.

**Rinse Water Unit** Used to get rinse water to ion exchange after regeneration.

### ***Ion Exchange #5 Unit Operational States***

- Startup – Starts up the online operation of ion exchange tank #5. Requested by operator or reactor unit. Steps:
  - Check Ion Exchange #5 Conductivity AI4500 < 50 mmho/cm
  - Close XV4502, XV4503, XV4506, XV4507, XV4521, XV4523
  - Reset FQI4501
  - Open XV4501
  - Open XV4505
  - Open XV4522
  - Initiate Online
- Online – Online operation of ion exchange tank #5. Steps:
  - When FQI4501 >= 50,000 gal., initiate Regenerating
- Regenerate – Regenerate ion exchange bed. Initiated by operator or if 50,000 gal. of product has passed through the ion exchange. Only allowed if Reactor 4 is not in Make Batch. Steps:
  - Close XV4501, XV4503, XV4505, XV4507
  - Regenerate bed with 1000 gal. of regeneration material
    - Open XV4502
    - Open XV4506
    - Set Regen Material Flow Controller FIC4502 to manual, 20% output
    - Reset FQI4502
    - Start P-4502
    - Set Regen Material Flow Controller FIC4502 to auto, setpoint = 70 gpm
    - Wait for FQI4502 >= 1000 gal.
    - Stop P-4502
    - Set FIC4502 to manual, 0% output
    - Close XV4502
    - Close XV4506
  - Rinse bed with 2000 gal. of water
    - Reset FQI4503
    - Open XV4503
    - Open XV4507
    - Set Rinse Water Flow Controller FIC4503 to manual, 10% output

Set Rinse Water Flow Controller FIC4503 to auto, setpoint = 40 gpm  
Wait for FQI4503  $\geq$  1000 gal.  
Set Rinse Water Flow Controller FIC4503 to auto, setpoint = 70 gpm  
Wait for FQI4503  $\geq$  2000 gal.  
Set FIC4503 to manual, 0% output  
Close XV4503  
Close XV4507  
Shutdown the system

- Flush - Flushes the piping to the QA tank 3. Can be requested if already shutdown:  
Open QA tank feed valve XV4522  
If CIP\_2 System is in shutdown or e-shutdown,  
Request CIP\_2 System to go online/recycle and wait for CIP\_2 system online  
Request CIP\_2 to set path to ion exchange and wait for path set  
Open CIP\_2 fluid to ion exchange out piping feed valve XV4521  
Wait 2 minutes for product to be flushed into QA tank.  
Open XV4523 and close XV4522 (one step)  
Flush for 10 minutes  
Request CIP\_2 system to go online/recycle and wait for XV6204 closed  
Shutdown
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off all pumps and all valves:  
Stop P-4502  
Close XV4501  
Set FIC4502 to manual, 0% output  
Close XV4502  
Set FIC4503 to manual, 0% output  
Close XV4503  
Close XV4505  
Close XV4506  
Close XV4507  
Close XV4521  
Close XV4522  
Close XV4523
- E-Shutdown - Immediately turns off all pumps and all valves:  
Stop P-4502  
Set FIC4502 to manual, 0% output  
Set FIC4503 to manual, 0% output  
Close XV4501, XV4502, XV4503, XV4505, XV4506, XV4507, XV4521, XV4522,  
XV4523

### *Ion Exchange #5 Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

AI4500 > 50 mmho/cm for 20 seconds → Alarm

AI4500 > 60 mmho/cm for 20 seconds → Shutdown process

CIP\_2 System not in Ion Exchange Path when Ion\_Exc\_5 in steps where CIP\_2 system used → E-Shutdown

Lose heartbeat with CIP\_2 System for 10 seconds when Ion Exchange in steps where CIP\_2 system used → E-Shutdown

Product Storage Tank 3 full → E-Shutdown

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Ion Exchange #6 Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
T-4600	Ion Exchange #6 Tank	400 gallon tank to process the reactor product to remove some of the product impurities.
P-4602	Regen Pump	Centrifugal pump that transfers regenerating liquid into the ion exchange tank.

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
AI4600	Indicator	Conductivity of Ion Exchange Tank	Monitor conductivity	0-100 mmho/cm	
FI4601	Indicator	Product flow rate	Measures flow rate of product through ion exchange	0-200 gpm	
FQI4601	Indicator	Totalized product in transfer flow	Measures amount of product from reactor being transferred through ion exchange		
FIC4602	Loop	Regen material transfer flow control	Controls flow rate of regen material to ion exchange vessel	0-100 gpm, Fail closed, direct acting	
FQI4602	Indicator	Totalized regen material transfer flow	Measures amount of regen material being transferred to ion exchange		
FIC4603	Loop	Rinse water flow control	Controls feed rate of rinse water to ion exchanger	0-100 gpm, Fail closed, direct acting	
FQI4603	Indicator	Totalized rinse water transfer flow	Measures amount of rinse water transferred to ion exchange		

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
P-4602	Motor	Regen Material Pump	Pumps regen material to ion exchanger	This pump should not run if PV:FIC4602<1.0 gpm and VO:FIC4602=100%
XV4601	Valve	Ion Exchange #6 Product Inlet Valve	Controls flow of product into ion exchange tank	
XV4602	Valve	Ion Exchange #6 Regen Material Inlet Valve	Controls flow of regen into ion exchange tank	
XV4603	Valve	Rinse Water Feed Valve	Controls flow of rinse water into ion exchange	
XV4605	Valve	Ion Exchange #6 Product Discharge Valve	Controls flow of product out of ion exchange tank	
XV4606	Valve	Ion Exchange #6 Regen Material Discharge Valve	Controls flow of regen out of ion exchange tank	
XV4607	Valve	Rinse Water Discharge Valve	Controls flow of rinse water out of ion exchange	
XV4621	Valve	CIP_2 to Ion Exchange Out Piping Valve	Controls flow of CIP_2 fluid into piping to QA Tank 3	
XV4622	Valve	Product to QA Tank Xfer Valve	Controls flow of product to QA tank 3	
XV4623	Valve	CIP_2 Return Valve	Directs CIP_2 fluid in piping to drain	

### ***Unit Operation Interactions***

**Reactor 4 Unit** Liquid product is received from reactor unit. This unit has no direct control over the reactor units.

**CIP\_2 System** The ion exchange unit requests CIP\_2 water. When CIP\_2 is granted, CIP\_2 water is directed to the ion exchange discharge pump, and the outlet piping valves are properly set to transfer the remaining product in the piping to the QA tank and then return the cleaning water to the CIP\_2 tank. When the flush is finished, then the CIP\_2 system is requested to return to its normal online/recycle operation.

**Product Storage 3 Unit** Liquid product is transferred to the QA tank 3 from the ion exchange unit. If the QA tank 3 is too full, the ion exchange unit is shutdown.

**Regeneration Material Unit** Used to get regeneration material to ion exchange for regeneration.

**Rinse Water Unit** Used to get rinse water to ion exchange after regeneration and to flush piping.

### ***Ion Exchange #6 Unit Operational States***

- Startup – Starts up the online operation of ion exchange tank #6. Requested by operator or reactor unit. Steps:
  - Check Ion Exchange #6 Conductivity AI4600 < 50 mmho/cm
  - Close XV4602, XV4603, XV4606, XV4607, XV4621, XV4623
  - Reset FQI4601
  - Open XV4601
  - Open XV4605
  - Open XV4622
  - Initiate Online
- Online – Online operation of ion exchange tank #6. Steps:
  - When FQI4601 >= 50,000 gal., initiate Regenerating
- Regenerate – Regenerate ion exchange bed. Initiated by operator or if 50,000 gal. of product has passed through the ion exchange. Only allowed if Reactor 4 is not in Make Batch. Steps:
  - Close XV4601, XV4603, XV4605, XV4607
  - Regenerate bed with 1000 gal. of regeneration material
    - Open XV4602
    - Open XV4606
    - Set Regen Material Flow Controller FIC4602 to manual, 20% output
    - Reset FQI4602
    - Start P-4602
    - Set Regen Material Flow Controller FIC4602 to auto, setpoint = 70 gpm
    - Wait for FQI4602 >= 1500 gal.
    - Stop P-4602
    - Set FIC4602 to manual, 0% output
    - Close XV4602
    - Close XV4606
  - Rinse bed with 2000 gal. of water
    - Reset FQI4603
    - Open XV4603
    - Open XV4607
    - Set Rinse Water Flow Controller FIC4603 to manual, 10% output
    - Set Rinse Water Flow Controller FIC4603 to auto, setpoint = 40 gpm
    - Wait for FQI4603 >= 1000 gal.
    - Set Rinse Water Flow Controller FIC4603 to auto, setpoint = 70 gpm



Wait for FQI4603  $\geq$  2000 gal.  
Set FIC4603 to manual, 0% output  
Close XV4603  
Close XV4607  
Shutdown the system

- Flush - Flushes the piping to the QA tank 3. Can be requested if already shutdown:  
Open QA tank feed valve XV4622  
If CIP\_2 System is in shutdown or e-shutdown,  
Request CIP\_2 System to go online/recycle and wait for CIP\_2 system online  
Request CIP\_2 to set path to ion exchange and wait for path set  
Open CIP\_2 fluid to ion exchange out piping feed valve XV4621  
Wait 2 minutes for product to be flushed into QA tank  
Open XV4623 and close XV4622 (one step)  
Flush for 10 minutes  
Request CIP\_2 system to go online/recycle and wait for XV6204 closed  
Shutdown
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off all pumps and all valves:  
Stop P-4602  
Close XV4601  
Set FIC4602 to manual, 0% output  
Close XV4602  
Set FIC4603 to manual, 0% output  
Close XV4603  
Close XV4605  
Close XV4606  
Close XV4607  
Close XV4621  
Close XV4622  
Close XV4623
- E-Shutdown - Immediately turns off all pumps and all valves:  
Stop P-4602  
Set FIC4602 to manual, 0% output  
Set FIC4603 to manual, 0% output  
Close XV4601, XV4602, XV4603, XV4605, XV4606, XV4607, XV4621, XV4622,  
XV4623

### *Ion Exchange #6 Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

AI4600 > 50 mmho/cm for 20 seconds → Alarm

AI4600 > 60 mmho/cm for 20 seconds → Shutdown process

CIP\_2 System not in Ion Exchange Path when Ion\_Exc\_6 in steps where CIP\_2 system used → E-Shutdown

Lose heartbeat with CIP\_2 System for 10 seconds when Ion Exchange in steps where CIP\_2 system used → E-Shutdown

Product Storage Tank 3 full → E-Shutdown

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Product Storage 1 Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
A-5100	QA Tank agitator	Mix the liquid product in the QA tank to keep uniform
F-5102	Product filter	Removes impurities from product.
P-5101	QA Pump	Centrifugal pump that transfers liquid product from QA tank into any storage tank.
T-5100	QA Tank	10,000 gallon storage tank to collect product. When enough product is in the tank and product meets QA specifications, it is transferred to one of the storage tanks.
T-5110	Storage Tank #1	10,000 gallon storage tank. Product may be stored here until transferred to the truck/rail loadout.
T-5120	Storage Tank #2	10,000 gallon storage tank. Product may be stored here until transferred to the truck/rail loadout.
T-5130	Storage Tank #3	10,000 gallon storage tank. Product may be stored here until transferred to the truck/rail loadout.

### *Analog Instrument and Control Point Listing*

#### **Analog Control Points**

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
DPI5102	Indicator	Pressure drop across F-5102 filters	Monitors pressure drop to indicate when filters need to be changed	0-150"	
LI5100	Indicator	Level of QA Tank 1	Monitor level	0-100 (units %)	
LI5110	Indicator	Level of Storage Tank #1	Monitor level	0-100 (units %)	
LI5120	Indicator	Level of Storage Tank #2	Monitor level	0-100 (units %)	
LI5130	Indicator	Level of Storage Tank #3	Monitor level	0-100 (units %)	

### *Discrete Instrument and Control Point Listing*

#### **Discrete Control Points**

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
A-5100	Motor	QA tank 1 agitator	Mixes liquid product in QA tank	Automatic on/off control with deadband. Off when level falls below 10%, On when level rises above 15%
P-5101	Motor	QA 1 Pump	Pumps liquid product from QA tank into any storage tank	This pump should not run if: LI5100<2% or DPI5102>140"
XV5100	Valve	QA Tank 1 Discharge Valve	Controls flow out of QA Tank	
XV5111	Valve	Storage Tank #1 Feed Valve	Controls flow into Storage Tank #1	
XV5121	Valve	Storage Tank #2 Feed Valve	Controls flow into Storage Tank #2	
XV5131	Valve	Storage Tank #3 Feed Valve	Controls flow into Storage Tank #3	
XV5180	Valve	Loadout Header CIP_1 Return Valve	Returns liquid flushed through header to CIP_1	

### ***Unit Operation Interactions***

**Ion Exchange Unit** Liquid product is received from the ion exchange #1 and #2 units into the QA tank 1. This unit has no control over the ion exchange units, except to shut them down when the QA level gets too high.

**CIP 1 System** The product storage unit requests CIP\_1 water. When CIP\_1 is granted, CIP\_1 water is directed to the QA discharge pump, and the storage header valves are properly set to transfer the remaining product in the header to one of the tanks and then return the cleaning water to the CIP\_1 tank. When the flush is finished, then the CIP\_1 system is requested to return to its normal online/recycle operation.

**Storage Loadout 1 Unit** When requested by the operator, the product from one of the tanks, is directed to one of the stations in the truck/rail loadout 1.

### ***Product Storage 1 Operational States***

- **Transfer** - Transfers the entire contents of the QA tank 1 to desired destination tank. Do not allow this operation to start if Transfer is in operation. Steps:

Ask for operator verification that destination selected  
Check QA Tank Level > 5%  
If destination tank is more than 80% full, abort operation (jump to last step)  
Close all valves  
Open appropriate tank inlet valve (XV5111, XV5121, or XV5131)  
Open XV5100  
Start P-5101  
Wait until destination tank is full (level > 95%), or QA Tank is empty (level < 3%)  
Shut down the system

- Flush - Flushes the storage tank header with CIP 1 water. Can only be requested if already shutdown
  - If QA tank level < 5% (enough to recharge product header), abort (go to last step)
  - If CIP\_1 System is in shutdown or e-shutdown,
    - Request CIP\_1 System to go online/recycle and wait for CIP\_1 system online
    - Request CIP\_1 System to set Feed Storage Path and wait for CIP\_1 path set
  - If Storage Tank #3 has a level < 90%, open feed valve to tank #3 XV5131. Otherwise, open CIP\_1 return valve XV5180
  - Start P-5101
  - If XV5131 opened, wait 45 seconds for product to be flushed into tank #3. Then open XV5180 and close XV5131
  - Flush for 10 minutes
  - Request CIP\_1 system to go online/recycle and wait for XV6002 to be closed
  - Open XV5100
  - Charge product storage header with product (90 seconds)
  - Shutdown
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off the pump and all storage header valves:
  - Stop P-5101
  - Close XV5100
  - Close XV5111
  - Close XV5121
  - Close XV5131
  - Close XV5180
- E-Shutdown - Immediately turns off the pump and all storage header valves:
  - Stop P-5101
  - Close XV5100, XV5111, XV5121, XV5131, XV5180

### *Product Storage 1 Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

LI5100 > 90 (units in %) for 20 seconds → Alarm

LI5100 > 95% for 20 seconds → Shut down process (not implemented)

LI5100 < 2% for 20 seconds while transfer in progress → Shutdown

DPI5102 > 130" for 1 second → Alarm

DPI5102 > 140" for 1 second → Shutdown

LI5110 > 95% for 60 seconds while in transfer to T-5110 → Shutdown

LI5120 > 95% for 60 seconds while in transfer to T-5120 → Shutdown

LI5130 > 95% for 60 seconds while in transfer to T-5130 → Shutdown

CIP\_1 System not in Feed Storage Path when unit in steps where CIP\_1 system used → E-Shutdown

Lose heartbeat with CIP\_1 System for 10 seconds when unit in steps where CIP\_1 system used →  
E-Shutdown

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Storage 1 Loadout Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
P-5181	Loadout Pump	Centrifugal pump that transfers liquid product from any storage tank to the truck/rail loadout 1

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
FIC5181	Loop	Loadout transfer flow control	Controls feed rate of transfer to truck/rail loadout 1	0-200 gpm, Fail closed, direct acting	
FQI5181	Indicator	Totalized loadout product flow	Measures amount of product transferred to loadout 1		
LI5110	Indicator	Level of Storage Tank #1	Monitor level	0-100 (units %)	
LI5120	Indicator	Level of Storage Tank #2	Monitor level	0-100 (units %)	
LI5130	Indicator	Level of Storage Tank #3	Monitor level	0-100 (units %)	

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
P-5181	Motor	Loadout Pump	Pumps liquid product from any storage tank to the truck/rail loadout 1	This pump should not run if PV:FIC5200<0.5 gpm and VO:FIC5200=100%
XV5112	Valve	Storage Tank #1 Discharge Valve	Controls flow out of Storage Tank #1	
XV5122	Valve	Storage Tank #2 Discharge Valve	Controls flow out of Storage Tank #2	

XV5132	Valve	Storage Tank #3 Discharge Valve	Controls flow out of Storage Tank #3	
XV5191	Valve	Truck Load Station #1 Valve	Controls flow into truck at station #1	
XV5192	Valve	Truck Load Station #2 Valve	Controls flow into truck at station #2	
XV5196	Valve	Rail Load Station #1 Valve	Controls flow into railcar at station #1	
XV5197	Valve	Rail Load Station #2 Valve	Controls flow into railcar at station #2	

### ***Unit Operation Interactions***

**Storage Unit 1** This unit loads out product from the product storage 1 unit. This unit has no control over the product storage 1 unit.

### ***Storage 1 Loadout Unit Operational States***

- Transfer - Transfers the entire contents of source tank to the desired station:
  - Ask for operator verification that source and destination selected
  - If source tank is less than 3% full, abort operation
  - Close all valves
  - (Start up loadout system)
  - Reset loadout flow totalizer, FQI5181
  - Request amount of product from operator
  - Open appropriate load station valve (XV5191, XV5192, XV5196, or XV5197)
  - Open appropriate tank outlet valve (XV5112, XV5122, or XV5132)
  - Start P-5181
  - Initialize the loadout flow controller to operator-adjusted setpoint
  - Wait until source tank is empty (level <3%) or FQI5181 totalized flow >= desired
  - Shut down the system
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off the pump and all discharge header valves:
  - Stop P-5181
  - Set FIC5181 to manual, -10% output
  - Close XV5112
  - Close XV5122
  - Close XV5132
  - Close XV5191



Close XV5192

Close XV5196

Close XV5197

- E-Shutdown - Immediately turns off the pump and all discharge header valves:  
Stop P-5181  
Set FIC5181 to manual, -10% output  
Close XV5112, XV5122, XV5132, XV5191, XV5192, XV5196, XV5197

### *Storage 1 Loadout Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

LI5110 < 3% for 20 seconds and T5110 Transfer in progress → Shut down

LI5120 < 3% for 20 seconds and T5120 Transfer in progress → Shut down

LI5130 < 3% for 20 seconds and T5130 Transfer in progress → Shut down

FI5181 deviates from setpoint by more than 2 gpm for 10 seconds while transfer in progress →  
Alarm

FI5181 deviates from setpoint by more than 2 gpm for 3 minutes while transfer in progress →  
Shutdown

FI5181 deviates from setpoint by more than 2 gpm for 2 seconds and FY5181 = 100% while transfer  
in progress → Shutdown (blocked valve in loadout)

FI5181 < 0.5 gpm and FY5181 = 100% for 2 seconds → Shutdown (pump protection)

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Product Storage 2 Unit

### Major Equipment

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
A-5200	QA Tank 2 agitator	Mix the liquid product in the QA tank to keep uniform
F-5202	Product filter	Removes impurities from product.
P-5201	QA Pump 2	Centrifugal pump that transfers liquid product from QA tank into any storage tank.
T-5200	QA Tank 2	10,000 gallon storage tank to collect product. When enough product is in the tank and product meets QA specifications, it is transferred to one of the storage tanks.
T-5210	Storage Tank #21	10,000 gallon storage tank. Product may be stored here until transferred to the truck/rail loadout.
T-5220	Storage Tank #22	10,000 gallon storage tank. Product may be stored here until transferred to the truck/rail loadout.
T-5230	Storage Tank #23	10,000 gallon storage tank. Product may be stored here until transferred to the truck/rail loadout.

### Analog Instrument and Control Point Listing

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
DPI5202	Indicator	Pressure drop across F-5202 filters	Monitors pressure drop to indicate when filters need to be changed	0-150"	
LI5200	Indicator	Level of QA Tank 2	Monitor level	0-100 (units %)	
LI5210	Indicator	Level of Storage Tank #11	Monitor level	0-100 (units %)	
LI5220	Indicator	Level of Storage Tank #12	Monitor level	0-100 (units %)	
LI5230	Indicator	Level of Storage Tank #13	Monitor level	0-100 (units %)	

### Discrete Instrument and Control Point Listing

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED</u></b>
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				<b><u>INTERLOCKS</u></b>
A-5200	Motor	QA tank 2 agitator	Mixes liquid product in QA tank	Automatic on/off control with deadband. Off when level falls below 10%, On when level rises above 15%
P-5201	Motor	QA Pump 2	Pumps liquid product from QA tank into any storage tank	This pump should not run if: LI5500<2% or DPI5600>140"
XV5200	Valve	QA Tank 2 Discharge Valve	Controls flow out of QA Tank	
XV5203	Valve	Loadout Header Rinse Inlet Valve	Admits liquid flushed through header	
XV5211	Valve	Storage Tank #21 Feed Valve	Controls flow into Storage Tank #21	
XV5221	Valve	Storage Tank #22 Feed Valve	Controls flow into Storage Tank #22	
XV5231	Valve	Storage Tank #23 Feed Valve	Controls flow into Storage Tank #23	
XV5280	Valve	Loadout Header Rinse Return Valve	Returns liquid flushed through header to drain	

### ***Unit Operation Interactions***

**Ion Exchange #3 and #4 Units** Liquid product is received from the ion exchange #3 and #4 units into the QA tank 2. This unit has no control over the ion exchange units, except to shut them down when the QA level 2 gets too high.

**Rinse Water Unit** Used to get rinse water to flush piping.

**Storage Loadout 2 Unit** When requested by the operator, the product from one of the tanks, is directed to one of the stations in the truck/rail loadout 2.

### ***Product Storage 2 Operational States***

- **Transfer** - Transfers the entire contents of the QA tank 2 to desired destination tank. Do not allow this operation to start if Transfer is in operation. Steps:
  - Ask for operator verification that destination selected
  - Check QA Tank Level > 5%
  - If destination tank is more than 80% full, abort operation (jump to last step)

Close all valves  
 Open appropriate tank inlet valve (XV52x1)  
 Open XV5200  
 Start P-5201  
 Wait until destination tank is full (level > 95%), or QA Tank 2 is empty (level < 3%)  
 Shut down the system

- Flush - Flushes the storage tank header with rinse water. Can only be requested if already shutdown
  - If QA tank level < 5% (enough to recharge product header), abort (go to last step)
  - Open XV5203
  - If Storage Tank #23 has a level < 90%, open feed valve to tank #23 XV5231. Otherwise, open rinse return valve XV5280
  - Start P-5201
  - If XV5231 opened, wait 45 seconds for product to be flushed into tank #23. Then open XV5280 and close XV5231
  - Flush for 10 minutes
  - Close XV5203
  - Open XV5200
  - Charge product storage header with product (90 seconds)
  - Shutdown
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off the pump and all storage header valves:
  - Stop P-5201
  - Close XV5200
  - Close XV5203
  - Close XV5211
  - Close XV5221
  - Close XV5231
  - Close XV5280
- E-Shutdown - Immediately turns off the pump and all storage header valves:
  - Stop P-5201
  - Close XV5200, XV5203, XV5211, XV5221, XV5231, XV5280

### *Product Storage 2 Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

LI5200 > 90 (units in %) for 20 seconds → Alarm  
 LI5200 > 95% for 20 seconds → Shut down process (not implemented)  
 LI5200 < 2% for 20 seconds while transfer in progress → Shutdown

DPI5202 > 130" for 1 second → Alarm

DPI5202 > 140" for 1 second → Shutdown

LI5210 > 95% for 60 seconds while in transfer to T-5210 → Shutdown

LI5220 > 95% for 60 seconds while in transfer to T-5220 → Shutdown

LI5230 > 95% for 60 seconds while in transfer to T-5230 → Shutdown

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Storage 2 Loadout Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
P-5281	Loadout Pump	Centrifugal pump that transfers liquid product from any storage tank to the truck/rail loadout 2

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
FIC5281	Loop	Loadout transfer flow control	Controls feed rate of transfer to truck/rail loadout 2	0-200 gpm, Fail closed, direct acting	
FQI5281	Indicator	Totalized loadout product flow	Measures amount of product transferred to loadout 2		
LI5210	Indicator	Level of Storage Tank #21	Monitor level	0-100 (units %)	
LI5220	Indicator	Level of Storage Tank #22	Monitor level	0-100 (units %)	
LI5230	Indicator	Level of Storage Tank #23	Monitor level	0-100 (units %)	

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
P-5281	Motor	Loadout Pump	Pumps liquid product from any storage tank to the truck/rail loadout	This pump should not run if PV:FIC5281<0.5 gpm and VO:FIC5281=100%
XV5212	Valve	Storage Tank #21 Discharge Valve	Controls flow out of Storage Tank #21	
XV5222	Valve	Storage Tank #22 Discharge Valve	Controls flow out of Storage Tank #22	

XV5232	Valve	Storage Tank #23 Discharge Valve	Controls flow out of Storage Tank #23	
XV5291	Valve	Truck Load Station #1 Valve	Controls flow into truck at station #1	
XV5292	Valve	Truck Load Station #2 Valve	Controls flow into truck at station #2	
XV5296	Valve	Rail Load Station #1 Valve	Controls flow into railcar at station #1	
XV5297	Valve	Rail Load Station #2 Valve	Controls flow into railcar at station #2	

### ***Unit Operation Interactions***

**Storage Unit** This unit loads out product from the product storage unit. This unit has no control over the product storage unit.

### ***Storage 2 Loadout Unit Operational States***

- Transfer - Transfers the entire contents of source tank to the desired station:
  - Ask for operator verification that source and destination selected
  - If source tank is less than 3% full, abort operation
  - Close all valves
  - (Start up loadout system)
  - Reset loadout flow totalizer, FQI5281
  - Request amount of product from operator
  - Open appropriate load station valve (XV5291, XV5292, XV5296, or XV5297)
  - Open appropriate tank outlet valve (XV52x2)
  - Start P-5281
  - Initialize the loadout flow controller to operator-adjusted setpoint
  - Wait until source tank is empty (level <3%) or FQI5281 totalized flow >= desired
  - Shut down the system
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off the pump and all discharge header valves:
  - Stop P-5281
  - Set FIC5281 to manual, -10% output
  - Close XV5212
  - Close XV5222
  - Close XV5232
  - Close XV5291

Close XV5292

Close XV5296

Close XV5297

- E-Shutdown - Immediately turns off the pump and all discharge header valves:  
Stop P-5281  
Set FIC5281 to manual, -10% output  
Close XV5212, XV5222, XV5232, XV5291, XV5292, XV5296, XV5297

### *Storage 2 Loadout Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

LI5210 < 3% for 20 seconds and T5210 Transfer in progress → Shut down

LI5220 < 3% for 20 seconds and T5220 Transfer in progress → Shut down

LI5230 < 3% for 20 seconds and T5230 Transfer in progress → Shut down

FI5281 deviates from setpoint by more than 2 gpm for 10 seconds while transfer in progress →  
Alarm

FI5281 deviates from setpoint by more than 2 gpm for 3 minutes while transfer in progress →  
Shutdown

FI5281 deviates from setpoint by more than 2 gpm for 2 seconds and FY5281 = 100% while transfer  
in progress → Shutdown (blocked valve in loadout)

FI5281 < 0.5 gpm and FY5281 = 100% for 2 seconds → Shutdown (pump protection)

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves



## Product Storage 3 Unit

### Major Equipment

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
A-5300	QA Tank 3 agitator	Mix the liquid product in the QA tank to keep uniform
F-5302	Product filter	Removes impurities from product.
P-5301	QA Pump 3	Centrifugal pump that transfers liquid product from QA tank into any storage tank.
T-5300	QA Tank 3	10,000 gallon storage tank to collect product. When enough product is in the tank and product meets QA specifications, it is transferred to one of the storage tanks.
T-5310	Storage Tank #31	10,000 gallon storage tank. Product may be stored here until transferred to the truck/rail loadout.
T-5320	Storage Tank #32	10,000 gallon storage tank. Product may be stored here until transferred to the truck/rail loadout.
T-5330	Storage Tank #33	10,000 gallon storage tank. Product may be stored here until transferred to the truck/rail loadout.

### Analog Instrument and Control Point Listing

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
DPI5302	Indicator	Pressure drop across F-5302 filters	Monitors pressure drop to indicate when filters need to be changed	0-150"	
LI5300	Indicator	Level of QA Tank 3	Monitor level	0-100 (units %)	
LI5310	Indicator	Level of Storage Tank #31	Monitor level	0-100 (units %)	
LI5320	Indicator	Level of Storage Tank #32	Monitor level	0-100 (units %)	
LI5330	Indicator	Level of Storage Tank #33	Monitor level	0-100 (units %)	

### Discrete Instrument and Control Point Listing

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED</u></b>
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				<b><u>INTERLOCKS</u></b>
A-5300	Motor	QA tank 3 agitator	Mixes liquid product in QA tank	Automatic on/off control with deadband. Off when level falls below 10%, On when level rises above 15%
P-5301	Motor	QA Pump 3	Pumps liquid product from QA tank into any storage tank	This pump should not run if: LI5500<2% or DPI5600>140"
XV5300	Valve	QA Tank 3 Discharge Valve	Controls flow out of QA Tank	
XV5303	Valve	Loadout Header Rinse Inlet Valve	Admits liquid flushed through header	
XV5311	Valve	Storage Tank #31 Feed Valve	Controls flow into Storage Tank #31	
XV5321	Valve	Storage Tank #32 Feed Valve	Controls flow into Storage Tank #32	
XV5331	Valve	Storage Tank #33 Feed Valve	Controls flow into Storage Tank #33	
XV5380	Valve	Loadout Header Rinse Return Valve	Returns liquid flushed through header to drain	

### ***Unit Operation Interactions***

**Ion Exchange #5 and #6 Units** Liquid product is received from the ion exchange #5 and #6 units into the QA tank 3. This unit has no control over the ion exchange units, except to shut them down when the QA level 3 gets too high.

**CIP 2 Unit** The product storage unit requests CIP 2 water. When CIP\_2 is granted, CIP\_2 water is directed to the QA discharge pump, and the storage header valves are properly set to transfer the remaining product in the header to one of the tanks and then return the cleaning water to the CIP\_2 tank. When the flush is finished, then the CIP\_2 system is requested to return to its normal online/recycle operation.

**Storage Loadout 3 Unit** When requested by the operator, the product from one of the tanks, is directed to one of the stations in the truck/rail loadout 3.

### ***Product Storage 3 Operational States***

- Transfer - Transfers the entire contents of the QA tank 3 to desired destination tank. Do not allow this operation to start if Transfer is in operation. Steps:
  - Ask for operator verification that destination selected
  - Check QA Tank Level > 5%
  - If destination tank is more than 80% full, abort operation (jump to last step)
  - Close all valves
  - Open appropriate tank inlet valve (XV53x1)
  - Open XV5300
  - Start P-5301
  - Wait until destination tank is full (level > 95%), or QA Tank 3 is empty (level < 3%)
  - Shut down the system
- Flush - Flushes the storage tank header with rinse water. Can only be requested if already shutdown
  - If QA tank level < 5% (enough to recharge product header), abort (go to last step)
  - Open XV5303
  - If CIP\_2 System is in shutdown or e-shutdown,
    - Request CIP\_2 System to go online/recycle and wait for CIP\_2 system online
    - Request CIP\_2 System to set Feed Storage Path and wait for CIP\_2 path set
  - If Storage Tank #13 has a level < 90%, open feed valve to tank #13 XV5231. Otherwise, open rinse return valve XV5380
  - Start P-5301
  - If XV5331 opened, wait 45 seconds for product to be flushed into tank #33. Then open XV5380 and close XV5331
  - Flush for 10 minutes
  - Request CIP\_2 system to go online/recycle and wait for XV6202 to be closed
  - Close XV5303
  - Open XV5300
  - Charge product storage header with product (90 seconds)
  - Shutdown
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off the pump and all storage header valves:
  - Stop P-5301
  - Close XV5300
  - Close XV5303
  - Close XV5311
  - Close XV5321
  - Close XV5331
  - Close XV5380
- E-Shutdown - Immediately turns off the pump and all storage header valves:
  - Stop P-5301
  - Close XV5300, XV5303, XV5311, XV5321, XV5331, XV5380

### *Product Storage 3 Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

LI5300 > 90 (units in %) for 20 seconds → Alarm

LI5300 > 95% for 20 seconds → Shut down process (not implemented)

LI5300 < 2% for 20 seconds while transfer in progress → Shutdown

DPI5302 > 130" for 1 second → Alarm

DPI5302 > 140" for 1 second → Shutdown

LI5310 > 95% for 60 seconds while in transfer to T-5310 → Shutdown

LI5320 > 95% for 60 seconds while in transfer to T-5320 → Shutdown

LI5330 > 95% for 60 seconds while in transfer to T-5330 → Shutdown

CIP\_2 System not in Feed Storage Path when unit in steps where CIP\_2 system used → E-Shutdown

Lose heartbeat with CIP\_2 System for 10 seconds when unit in steps where CIP\_2 system used →  
E-Shutdown

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Storage 3 Loadout Unit

### *Major Equipment*

<b>TAG</b>	<b>DESCRIPTION</b>	<b>PURPOSE</b>
P-5381	Loadout Pump	Centrifugal pump that transfers liquid product from any storage tank to the truck/rail loadout 3

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>OTHER INFO</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
FIC5381	Loop	Loadout transfer flow control	Controls feed rate of transfer to truck/rail loadout 3	0-200 gpm, Fail closed, direct acting	
FQI5381	Indicator	Totalized loadout product flow	Measures amount of product transferred to loadout 3		
LI5310	Indicator	Level of Storage Tank #31	Monitor level	0-100 (units %)	
LI5320	Indicator	Level of Storage Tank #32	Monitor level	0-100 (units %)	
LI5330	Indicator	Level of Storage Tank #33	Monitor level	0-100 (units %)	

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
P-5381	Motor	Loadout Pump	Pumps liquid product from any storage tank to the truck/rail loadout	This pump should not run if PV:FIC5381<0.5 gpm and VO:FIC5381=100%
XV5312	Valve	Storage Tank #31 Discharge Valve	Controls flow out of Storage Tank #31	
XV5322	Valve	Storage Tank #32 Discharge Valve	Controls flow out of Storage Tank #32	

XV5332	Valve	Storage Tank #33 Discharge Valve	Controls flow out of Storage Tank #33	
XV5391	Valve	Truck Load Station #1 Valve	Controls flow into truck at station #1	
XV5392	Valve	Truck Load Station #2 Valve	Controls flow into truck at station #2	
XV5396	Valve	Rail Load Station #1 Valve	Controls flow into railcar at station #1	
XV5397	Valve	Rail Load Station #2 Valve	Controls flow into railcar at station #2	

### ***Unit Operation Interactions***

**Storage Unit 3** This unit loads out product from the product storage 3 unit. This unit has no control over the product storage unit.

### ***Storage 3 Loadout Unit Operational States***

- Transfer - Transfers the entire contents of source tank to the desired station:
  - Ask for operator verification that source and destination selected
  - If source tank is less than 3% full, abort operation
  - Close all valves
  - (Start up loadout system)
  - Reset loadout flow totalizer, FQI5381
  - Request amount of product from operator
  - Open appropriate load station valve (XV5391, XV5392, XV5396, or XV5397)
  - Open appropriate tank outlet valve (XV53x2)
  - Start P-5381
  - Initialize the loadout flow controller to operator-adjusted setpoint
  - Wait until source tank is empty (level <3%) or FQI5381 totalized flow >= desired
  - Shut down the system
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off the pump and all discharge header valves:
  - Stop P-5381
  - Set FIC5381 to manual, -10% output
  - Close XV5312
  - Close XV5322
  - Close XV5332
  - Close XV5391

Close XV5392

Close XV5396

Close XV5397

- E-Shutdown - Immediately turns off the pump and all discharge header valves:  
Stop P-5381  
Set FIC5381 to manual, -10% output  
Close XV5312, XV5322, XV5332, XV5391, XV5392, XV5396, XV5397

### *Storage 3 Loadout Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

LI5310 < 3% for 20 seconds and T5310 Transfer in progress → Shut down

LI5320 < 3% for 20 seconds and T5320 Transfer in progress → Shut down

LI5330 < 3% for 20 seconds and T5330 Transfer in progress → Shut down

FI5381 deviates from setpoint by more than 2 gpm for 10 seconds while transfer in progress →  
Alarm

FI5381 deviates from setpoint by more than 2 gpm for 3 minutes while transfer in progress →  
Shutdown

FI5381 deviates from setpoint by more than 2 gpm for 2 seconds and FY5381 = 100% while transfer  
in progress → Shutdown (blocked valve in loadout)

FI5381 < 0.5 gpm and FY5381 = 100% for 2 seconds → Shutdown (pump protection)

Any pump failure → Hold

Any valve failure → Hold

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

## Clean-In-Place (CIP) 1 Unit

### *Major Equipment*

<u>TAG</u>	<u>DESCRIPTION</u>	<u>PURPOSE</u>
A-6000	CIP 1 Tank agitator	Mix the cleaning water in the CIP tank to keep uniform
H-6000	CIP 1 Heat Exchanger	Plate and frame heat exchanger to heat up the CIP water with 50# steam.
P-6000	CIP 1 Pump	Centrifugal pump that recirculates cleaning water through the heat exchanger, or transfers it to the reactor, ion exchange, or product storage unit.
T-6000	CIP 1 Tank	4,000 gallon storage tank to store cleaning water and to mix in soda ash.

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<u>TAG</u>	<u>TYPE</u>	<u>DESCRIPTION</u>	<u>PURPOSE</u>	<u>OTHER INFO</u>	<u>SEQUENCE BASED INTERLOCKS</u>
AI6000	Indicator	pH of CIP 1 Tank	Monitor pH to determine proper make-up and when new make-up needs to be formulated	0-14	
FIC6050	Loop	Hot water supply flow control	Controls feed rate of hot water to CIP 1 tank	0-100 gpm, Fail closed, direct acting	
FQI6050	Indicator	Totalized hot water flow	Measures amount of hot water placed into CIP 1 tank		
LI6000	Indicator	Level of CIP 1 Tank	Monitor level	0-100 (units %)	
TIC6000	Loop	CIP 1 Tank Recirculating water temperature control	Controls feed rate of steam supply to heat exchanger	70-200 deg F, Fail open, reverse acting	

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points



<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
A-6000	Motor	CIP 1 tank agitator	Mixes water and ash in CIP 1 tank to maintain uniform temperature	Automatic on/off control with deadband. Off when level falls below 10%, On when level rises above 15%
P-6000	Motor	CIP 1 Pump	Pumps water from CIP 1 tank	This pump should not run <b>if:</b> LI6000<2%
XV6001	Valve	CIP 1 Tank Recycle Valve	Controls flow out of CIP 1 Tank and through heat exchanger	
XV6002	Valve	CIP 1 to Storage Valve	Controls flow of CIP 1 water into Storage Unit	
XV6003	Valve	CIP 1 to Reactor 1 Equipment Valve	Controls flow of CIP 1 water to Reactor 1 Unit	
XV6004	Valve	CIP 1 to Ion Exchange 1 & 2 Valve	Controls flow of CIP 1 water to Ion Exchange 1 & 2	
XV6005	Valve	CIP 1 to Waste Tank	Controls flow of CIP 1 water into Waste tank	
XV6006	Valve	CIP 1 to Reactor 2 Equipment Valve	Controls flow of CIP 1 water to Reactor 2 Unit	

### ***Unit Operation Interactions***

**Reactor 1 and 2 Units** When requested by the reactor 1 or 2 units, the valve paths are set to direct CIP water to the reactor process equipment and then returned to the CIP tank. When the reactor piping flush is finished, then the CIP system returns to its normal online/recycle operation.

**Ion Exchange Unit** When requested by the ion exchange unit, the valve paths are set to direct CIP water to the ion exchange #1 or #2 equipment and then returned to the CIP tank. When the ion exchange piping flush is finished, then the CIP system returns to its normal online/recycle operation.

**Product Storage 1 Unit** When requested by the product storage 1 unit, the valve paths are set to direct CIP water to the product storage 1 unit QA discharge pump and then to be returned to the CIP tank. When the product storage flush is finished, then the CIP system returns to its normal online/recycle operation.

**Waste Tank Unit** When requested by the operator, the valve paths are set to direct CIP water to the waste tank, thereby emptying the CIP tank. When the tank is empty, the CIP system starts make-up.

**Soda Ash Unit** Loads soda ash when requested by this unit.

**50# Steam Supply** Used by heat exchanger to maintain CIP water temperature.

**Hot Water Supply** Used to get water supply to recharge CIP system cleaning water.

### ***CIP 1 Unit Operational States***

- Online/Recycle - Starts up the system and starts recycling the cleaning water through the heat exchanger to maintain its temperature:
  - If CIP 1 Tank level < 20%, wait.
  - Open CIP 1 Recycle Valve, XV6001
  - Close CIP 1 to Storage Valve, XV6002
  - Close CIP 1 to Reactor 1 Valve, XV6003
  - Close CIP 1 to Ion Exchange Valve, XV6004
  - Close CIP 1 to Waste Valve, XV6005
  - Close CIP 1 to Reactor 2 Valve, XV6006
  - Put Recirculating temperature control, TIC6000, in auto, setpoint=150 F
  - Start CIP 1 Pump, P-6000
- Reactor 1 Path - Sets the path to direct CIP 1 water to the Reactor unit, initiated by Reactor 1 Flush sequence, or operator. If commanded by operator, only allowed when in online/recycle. Not allowed when pH alarm ON.
  - If CIP 1 Tank level < 20%, wait.
  - Put TIC6000 in manual, output = 0%
  - Open CIP 1 to Reactor 1 Valve, XV6003
  - Close CIP 1 Recycle Valve, XV6001
  - Close CIP 1 to Storage Valve, XV6002
  - Close CIP 1 to Ion Exchange Valve, XV6004
  - Close CIP 1 to Waste Valve, XV6005
  - Close CIP 1 to Reactor 2 Valve, XV6006
  - Start CIP 1 Pump, P-6000
- Reactor 2 Path - Sets the path to direct CIP 1 water to the Reactor 2 unit, initiated by Reactor 2 Flush sequence, or operator. If commanded by operator, only allowed when in online/recycle. Not allowed when pH alarm ON.
  - If CIP 1 Tank level < 20%, wait.
  - Put TIC6000 in manual, output = 0%
  - Open CIP 1 to Reactor 2 Valve, XV6006
  - Close CIP 1 Recycle Valve, XV6001
  - Close CIP 1 to Storage Valve, XV6002
  - Open CIP 1 to Reactor 1 Valve, XV6003
  - Close CIP 1 to Ion Exchange Valve, XV6004
  - Close CIP 1 to Waste Valve, XV6005
  - Start CIP 1 Pump, P-6000
- Ion Exchange Path - Sets the path to direct CIP water to the Ion Exchange #1 and #2 area, initiated by either Ion Exchange Flush sequence, or operator. If commanded by operator, only allowed when in online/recycle. Not allowed when pH alarm ON.
  - If CIP 1 Tank level < 20%, wait.

- Put TIC6000 in manual, output = 0%
- Open CIP 1 to Ion Exchange Valve, XV6004
- Close CIP 1 Recycle Valve, XV6001
- Close CIP 1 to Storage Valve, XV6002
- Close CIP 1 to Reactor 1 Valve, XV6003
- Close CIP 1 to Waste Valve, XV6005
- Close CIP 1 to Reactor 2 Valve, XV6006
- Start CIP 1 Pump, P-6000
- Product Storage 1 Path - Sets the path to direct CIP water to the Product Storage 1 unit, initiated by Product Storage Flush sequence, or operator. If commanded by operator, only allowed when in online/recycle. Not allowed when pH alarm ON.
  - If CIP 1 Tank level < 20%, wait.
  - Put TIC6000 in manual, output = 0%
  - Open CIP 1 to Storage Valve, XV6002
  - Close CIP 1 Recycle Valve, XV6001
  - Close CIP 1 to Reactor 1 Valve, XV6003
  - Close CIP 1 to Ion Exchange Valve, XV6004
  - Close CIP 1 to Waste Valve, XV6005
  - Close CIP 1 to Reactor 2 Valve, XV6006
  - Start CIP 1 Pump, P-6000
- To Waste Tank - Sets the path to direct CIP 1 water to the Waste Tank area, initiated by operator:
  - If Waste Tank level > 70%, abort (not implemented).
  - Put TIC6000 in manual, output = 0%
  - Open CIP 1 to Waste Valve, XV6005
  - Close CIP 1 Recycle Valve, XV6001
  - Close CIP 1 to Storage Valve, XV6002
  - Close CIP 1 to Reactor 1 Valve, XV6003
  - Close CIP 1 to Ion Exchange Valve, XV6004
  - Close CIP 1 to Reactor 2 Valve, XV6006
  - Start CIP 1 Pump, P-6000
  - Wait until CIP 1 Tank level < 2% for 10 minutes
  - Initiate CIP Make-up
- CIP Make-up - Makes up a new batch of cleaning water from the hot water supply and soda ash from hopper, initiated by operator. Initiation only allowed if CIP tank is online/recycle, to waste tank, hold, shutdown, or e-shutdown:
  - If CIP 1 Tank level >= 80%, abort.
  - Open CIP 1 Recycle Valve, XV6001
  - Close CIP 1 to Storage Valve, XV6002
  - Close CIP 1 to Reactor 1 Valve, XV6003
  - Close CIP 1 to Ion Exchange Valve, XV6004
  - Close CIP 1 to Waste Valve, XV6005
  - Close CIP 1 to Reactor 2 Valve, XV6006
  - Initialize FQI6000
  - Put Hot Water Flow Controller FIC6050 in auto, setpoint = 100 gpm
  - Wait for CIP 1 Tank level >= 20%

Start CIP 1 Pump, P-6000  
 Put Heat Exchanger Temperature Controller TIC6000 in auto, setpoint = 150 F  
 Wait for CIP 1 Tank level  $\geq 90\%$   
 Put FIC6050 in manual, output = 0%  
 Initiate Soda Ash B-6000 Start Transfer and wait for it to start  
 Wait for CIP 1 Tank pH AI6000  $\geq 9$   
 Initiate Soda Ash B-6000 Shutdown and wait for it to shut down  
 Wait 15 minutes for soda ash to disperse in cleaning water  
 Initiate Online/Recycle

- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off the pump and closes all valves:
  - Stop P-6000
  - Set TIC6000 to manual, 0% output
  - Set FIC6050 to manual, 0% output
  - Close XV6002
  - Close XV6003
  - Close XV6004
  - Close XV6005
  - Close XV6006
  - Close XV6001
- E-Shutdown - Immediately turns off the pump and closes all valves:
  - Stop P-6000
  - Set TIC6000 to manual, 0% output
  - Set FIC6050 to manual, 0% output
  - Close XV6001, XV6002, XV6003, XV6004, XV6005, XV6006

### *CIP 1 Unit Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

- AI6000 < 7.25 for 2 minutes and in Online/Recycle or Product Storage 1 Path or Reactor 1 Path or Reactor 2 Path or Ion Exchange Path → pH Alarm (need to empty CIP tank and do CIP make-up)
- LI6000 > 90% for 20 seconds → Alarm
- LI6000 < 10% for 10 seconds and in Online/Recycle or Product Storage 1 Path or Reactor 1 Path or Reactor 2 Path or Ion Exchange Path → Alarm
- LI6000 < 2% for 10 seconds and in Online/Recycle or Product Storage 1 Path or Reactor 1 Path or Reactor 2 Path or Ion Exchange Path → Shutdown
- FI6050 deviates from setpoint by more than 2 gpm for 10 seconds while filling CIP tank with hot water → Alarm
- FI6050 deviates from setpoint by more than 2 gpm for 3 minutes while filling CIP tank with hot water → Shutdown

TIC6000 PV deviates from setpoint by more than 10 F for 1 minute while online/recycling or makeup → Alarm

TIC6000 PV deviates from setpoint by more than 10 F for 10 minutes while online/recycling or makeup → Shutdown

TIC6000 PV deviates from setpoint by more than 10 F for 1 minute while online/recycling or makeup and TY6000 = 100% → Shutdown (loss of steam)

Any pump failure → Hold

Any valve failure → Hold

Soda Ash shuts down while in CIP Makeup → Hold

QA Tank 1 not in Flush while in Product Storage Path 1 → Online/Recycle

Standard Aux, HOA, overload alarms on pumps

Standard Fail to Open, Fail to Close alarms on valves

Shutdown of unit using CIP\_1 → Shutdown

Lose heartbeat to Soda Ash for 10 seconds when transferring ash → Hold

Lose heartbeat with unit using CIP\_1 when unit using CIP\_1 for 10 seconds → Shutdown

Shutdown of CIP\_1 should trigger shutdown of any unit using CIP\_1 (during \_Path state)

## Soda Ash Unit

### *Major Equipment*

<b><u>TAG</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>
B-6100	Soda Ash Storage Hopper	300 pound storage hopper. Soda ash that is added to the cleaning water is transferred from this tank.
C-6100	Soda Ash Screw Conveyor	Conveys soda ash from the storage hopper to the slide gate.
G-6000	CIP Tank Slide Gate	Soda ash enters the CIP tank through this gate.
L-6100	Soda Ash Airlock	Soda ash air lock discharge valve from storage hopper.

### *Analog Instrument and Control Point Listing*

#### **Analog Control Points**

### *Discrete Instrument and Control Point Listing*

#### **Discrete Control Points**

<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
C-6100	Conveyor	Soda Ash Screw Conveyor	Moves soda ash from hopper to CIP tank slide gate.	
L-6100	Motor	Soda Ash air lock	Discharges soda ash from hopper	
LSL6100	Level Switch	Soda Ash level	Indicates low level	
M-6000	Motor	CIP Tank Slide Gate Motor	Opens/closes CIP tank slide gate	
SS6100	Speed Switch	C-6100 Speed Switch	Indicates that conveyor is stopped	
ZSC6000	Limit Switch	ZS6000 slide gate switch	Indicates slide gate is closed	
ZSO6000	Limit Switch	ZS6000 slide gate switch	Indicates slide gate is open	

## *Unit Operation Interactions*

**CIP Tank Unit** Requests start transfer and shutdown of this unit.

### ***Soda Ash Unit States***

- Start Transfer - Starts up the transfer of soda ash to the CIP tank:
  - Open CIP Tank Slide Gate G-6000
  - Start Soda Ash Screw Conveyor C-6100
  - Start Soda Ash Airlock L-6100
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off the pump and closes all valves:
  - Stop Soda Ash Airlock L-6100
  - Wait 30 seconds for C-6100 to clear
  - Stop Soda Ash Screw Conveyor C-6100
  - Close CIP Tank Slide Gate G-6000
- E-Shutdown - Immediately turns off all motors and closes the slide gate:
  - Stop L-6100, C-6100
  - Close G-6000

### ***Soda Ash Abnormal Conditions***

The following conditions are abnormal and will cause the indicated action.

L-6100 failure for 1 second → Shutdown  
 C-6100 failure for 1 second → E-Shutdown  
 G-6000 failure for 1 second → E-Shutdown  
 SS6100 indicates conveyor off → Alarm  
 LSL6100 indicates low bin level for 2 seconds → Alarm  
 LSL6100 indicates low bin level for 20 seconds and transfer started → Shutdown  
 CIP\_1 shutdown for 1 second and in transfer state → Shutdown  
 Lose heartbeat to CIP\_1 for 10 seconds and in transfer state → E-Shutdown  
 Standard Aux, HOA, overload alarms on motors  
 Standard Fail to Open, Fail to Close alarms on slide gate

## Clean-In-Place (CIP) 2 Unit

### *Major Equipment*

<u>TAG</u>	<u>DESCRIPTION</u>	<u>PURPOSE</u>
A-6200	CIP 2 Tank agitator	Mix the cleaning water in the CIP tank to keep uniform
H-6200	CIP 2 Heat Exchanger	Plate and frame heat exchanger to heat up the CIP water with 50# steam.
P-6200	CIP 2 Pump	Centrifugal pump that recirculates cleaning water through the heat exchanger, or transfers it to the reactor, ion exchange, or product storage unit.
T-6200	CIP 2 Tank	4,000 gallon storage tank to store cleaning water and to mix in caustic.
T-6300	CIP 2 Caustic Storage Tank	500 gallon storage tank to store caustic.

### *Analog Instrument and Control Point Listing*

#### Analog Control Points

<u>TAG</u>	<u>TYPE</u>	<u>DESCRIPTION</u>	<u>PURPOSE</u>	<u>OTHER INFO</u>	<u>SEQUENCE BASED INTERLOCKS</u>
AI6200	Indicator	pH of CIP 2 Tank	Monitor pH to determine proper make-up and when new make-up needs to be formulated	0-14	
FIC6250	Loop	Hot water supply flow control	Controls feed rate of hot water to CIP 2 tank	0-100 gpm, Fail closed, direct acting	
FQI6250	Indicator	Totalized hot water flow	Measures amount of hot water placed into CIP 2 tank		
LI6200	Indicator	Level of CIP 2 Tank	Monitor level	0-100 (units %)	
TIC6200	Loop	CIP 2 Tank Recirculating water temperature control	Controls feed rate of steam supply to heat exchanger	70-200 deg F, Fail open, reverse acting	

### *Discrete Instrument and Control Point Listing*

#### Discrete Control Points



<b><u>TAG</u></b>	<b><u>TYPE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>PURPOSE</u></b>	<b><u>SEQUENCE BASED INTERLOCKS</u></b>
A-6200	Motor	CIP 2 tank agitator	Mixes water and ash in CIP 2 tank to maintain uniform temperature	Automatic on/off control with deadband. Off when level falls below 10%, On when level rises above 15%
P-6200	Motor	CIP 2 Pump	Pumps water from CIP 2 tank	This pump should not run <b>if:</b> LI6200<2%
P-6302	Motor	Caustic Storage Pump	Pumps water from caustic storage	This pump should not run <b>if:</b> LI6300<2%
XV6201	Valve	CIP 2 Tank Recycle Valve	Controls flow out of CIP 2 Tank and through heat exchanger	
XV6202	Valve	CIP 2 to Storage 3 Valve	Controls flow of CIP 2 water to Storage 3 Unit	
XV6203	Valve	CIP 2 to Reactor 4 Equipment Valve	Controls flow of CIP 2 water to Reactor 1 Unit	
XV6204	Valve	CIP 2 to Ion Exchange 5 & 6 Valve	Controls flow of CIP 2 water to Ion Exchange 1 & 2	
XV6205	Valve	CIP 2 to Waste Tank	Controls flow of CIP 2 water into Waste tank	
XV6301	Valve	Caustic Storage Outlet Valve	Controls flow out of caustic storage tank	

### ***Unit Operation Interactions***

**Reactor 4 Unit** When requested by the reactor 4 unit, the valve paths are set to direct CIP water to the reactor process equipment and then returned to the CIP tank. When the reactor piping flush is finished, then the CIP system returns to its normal online/recycle operation.

**Ion Exchange Unit** When requested by the ion exchange unit, the valve paths are set to direct CIP water to the ion exchange #5 or #6 equipment and then returned to the CIP tank. When the ion exchange piping flush is finished, then the CIP system returns to its normal online/recycle operation.

**Waste Tank Unit** When requested by the operator, the valve paths are set to direct CIP water to the waste tank, thereby emptying the CIP tank. When the tank is empty, the CIP system starts make-up.

**50# Steam Supply** Used by heat exchanger to maintain CIP water temperature.

**Hot Water Supply** Used to get water supply to recharge CIP system cleaning water.

### ***CIP 2 Unit Operational States***

- Online/Recycle - Starts up the system and starts recycling the cleaning water through the heat exchanger to maintain its temperature:
  - If CIP 2 Tank level < 20%, wait.
  - Open CIP 2 Recycle Valve, XV6201
  - Close CIP 2 to Storage 3 Valve, XV6202
  - Close CIP 2 to Reactor 1 Valve, XV6203
  - Close CIP 2 to Ion Exchange Valve, XV6204
  - Close CIP 2 to Waste Valve, XV6205
  - Put Recirculating temperature control, TIC6200, in auto, setpoint=150 F
  - Start CIP 2 Pump, P-6200
- Reactor 4 Path - Sets the path to direct CIP 2 water to the Reactor 4 unit, initiated by Reactor 4 Flush sequence, or operator. If commanded by operator, only allowed when in online/recycle. Not allowed when pH alarm ON.
  - If CIP 2 Tank level < 20%, wait.
  - Put TIC6200 in manual, output = 0%
  - Open CIP 2 to Reactor 4 Valve, XV6203
  - Close CIP 2 Recycle Valve, XV6201
  - Close CIP 2 to Storage 3 Valve, XV6202
  - Close CIP 2 to Ion Exchange Valve, XV6204
  - Close CIP 2 to Waste Valve, XV6205
  - Start CIP 2 Pump, P-6200
- Ion Exchange Path - Sets the path to direct CIP water to the Ion Exchange #5 and #6 area, initiated by either Ion Exchange Flush sequence, or operator. If commanded by operator, only allowed when in online/recycle. Not allowed when pH alarm ON.
  - If CIP 2 Tank level < 20%, wait.
  - Put TIC6200 in manual, output = 0%
  - Open CIP 2 to Ion Exchange Valve, XV6204
  - Close CIP 2 Recycle Valve, XV6201
  - Close CIP 2 to Storage 3 Valve, XV6202
  - Close CIP 2 to Reactor 4 Valve, XV6203
  - Close CIP 2 to Waste Valve, XV6205
  - Start CIP 2 Pump, P-6200
- Storage 3 Path - Sets the path to direct CIP water to the Storage Tank #3 unit, initiated by Storage Tank #3 Flush sequence, or operator. If commanded by operator, only allowed when in online/recycle. Not allowed when pH alarm ON.
  - If CIP 2 Tank level < 20%, wait.
  - Put TIC6200 in manual, output = 0%
  - Open CIP 2 to Storage 3 Valve, XV6202
  - Close CIP 2 Recycle Valve, XV6201
  - Close CIP 2 to Reactor 4 Valve, XV6203
  - Close CIP 2 to Ion Exchange Valve, XV6204
  - Close CIP 2 to Waste Valve, XV6205

- Start CIP 2 Pump, P-6200
- To Waste Tank - Sets the path to direct CIP 2 water to the Waste Tank, initiated by operator:
  - If Waste Tank level > 70%, abort (not implemented).
  - Put TIC6200 in manual, output = 0%
  - Open CIP 2 to Waste Valve, XV6205
  - Close CIP 2 Recycle Valve, XV6201
  - Close CIP 2 to Storage 3 Valve, XV6202
  - Close CIP 2 to Reactor 4 Valve, XV6203
  - Close CIP 2 to Ion Exchange Valve, XV6204
  - Start CIP 2 Pump, P-6200
  - Wait until CIP 2 Tank level < 2% for 10 minutes
  - Initiate CIP Make-up
- CIP Make-up - Makes up a new batch of cleaning water from the hot water supply and caustic tank, initiated by operator. Initiation only allowed if CIP tank is online/recycle, to waste tank, hold, shutdown, or e-shutdown:
  - If CIP 2 Tank level >= 80%, abort.
  - Open CIP 2 Recycle Valve, XV6201
  - Close CIP 2 to Storage 3 Valve, XV6202
  - Close CIP 2 to Reactor 4 Valve, XV6203
  - Close CIP 2 to Ion Exchange Valve, XV6204
  - Close CIP 2 to Waste Valve, XV6205
  - Initialize FQI6200
  - Put Hot Water Flow Controller FIC6250 in auto, setpoint = 100 gpm
  - Wait for CIP 2 Tank level >= 20%
  - Start CIP 2 Pump, P-6200
  - Put Heat Exchanger Temperature Controller TIC6200 in auto, setpoint = 150 F
  - Wait for CIP 2 Tank level >= 90%
  - Put FIC6250 in manual, output = 0%
  - Open XV6301
  - Start P-6302
  - Wait for CIP 2 Tank pH AI6200 >= 9
  - Stop P-6302
  - Close XV6301
  - Wait 5 minutes for caustic to disperse in cleaning water
  - Initiate Online/Recycle
- Hold - Allow the operator access to manipulate discrete points in the system, from local field interfaces, while the process system is running.
- Shutdown - Turns off the pump and closes all valves:
  - Stop P-6200
  - Stop P-6302
  - Set TIC6200 to manual, 0% output
  - Set FIC6250 to manual, 0% output
  - Close XV6301
  - Close XV6203
  - Close XV6202

- Close XV6204
- Close XV6205
- Close XV6201
- E-Shutdown - Immediately turns off the pump and closes all valves:
  - Stop P-6200, P6302
  - Set TIC6200 to manual, 0% output
  - Set FIC6250 to manual, 0% output
  - Close XV6301, XV6201, XV6202, XV6203, XV6204, XV6205

### *CIP 2 Unit Abnormal Conditions*

The following conditions are abnormal and will cause the indicated action.

- AI6200 < 7.25 for 2 minutes and in Online/Recycle or Reactor 4 Path or Ion Exchange Path → pH Alarm (need to empty CIP tank and do CIP make-up)
- LI6200 > 90% for 20 seconds → Alarm
- LI6200 < 10% for 10 seconds and in Online/Recycle or Reactor 4 Path or Ion Exchange Path → Alarm
- LI6200 < 2% for 10 seconds and in Online/Recycle or or Reactor 4 Path or Ion Exchange Path → Shutdown
- FI6250 deviates from setpoint by more than 2 gpm for 10 seconds while filling CIP tank with hot water → Alarm
- FI6250 deviates from setpoint by more than 2 gpm for 3 minutes while filling CIP tank with hot water → Shutdown
- TIC6200 PV deviates from setpoint by more than 10 F for 1 minute while online/recycling or makeup → Alarm
- TIC6200 PV deviates from setpoint by more than 10 F for 10 minutes while online/recycling or makeup → Shutdown
- TIC6200 PV deviates from setpoint by more than 10 F for 1 minute while online/recycling or makeup and TY6200 = 100% → Shutdown (loss of steam)
- Any pump failure → Hold
- Any valve failure → Hold
- Standard Aux, HOA, overload alarms on pumps
- Standard Fail to Open, Fail to Close alarms on valves

Shutdown of unit using CIP\_2 → Shutdown

Lose heartbeat with unit using CIP\_2 when unit using CIP\_2 for 10 seconds → Shutdown

Shutdown of CIP\_2 should trigger shutdown of any unit using CIP\_2 (during \_Path state)

## Revision History

Rev 0	29 Mar 2005	First release
Rev 1	25 Mar 2007	Fix typos.
Rev 2	3 Sep 2007	Added Ion Exchange #2
Rev 3	15 Jan 2008	Fix typos.
Rev 4	2 Sep 2013	Added Dry Add Makeup unit.
Rev 4.1	7 Sep 2013	Fix typo - add FIC3210 to Reactor 2.
Rev 5.0	3 Sep 2014	Added Wet Additive Unit, Powder Unload Cell, React 3, Ion Exchange 3 & 4, Product Storage 2
Rev 5.1	11 Sep 2014	Fix typos
Rev 5.2	15 Sep 2014	Fix typos in dry additive and wet additive units
Rev 5.3	22 Sep 2014	Conveyor alignment switch and plug switch states described.
Rev 5.4	29 Sep 2014	Add XV2166 to Wet Ingredient Storage
Rev 5.5	4 Nov 2014	Fixed Dry Storage Loadin unit operation interactions
Rev 6.0	28 Aug 2016	Added Reactor 4, CIP 2, Ion Exchange 5 & 6, Product Storage 3, and Product Loadout 3. Renumbered equipment tags in Product Storage 1 & 2 and Product Loadout 1 & 2.
Rev 6.1	12 Sep 2016	Fix typos
Rev 6.2	23 Sep 2016	To CIP 2 unit, added missing caustic tank to major equipment and added caustic outlet valve and pump to discrete control points.
Rev 6.3	7 Oct 2016	To Ion_Exc_5 and Ion_Exc_6, added steps in Flush. React_4 typos in analog control points fixed.
Rev 6.4	27 Jan 2017	React_4 needs to use CIP_2 in Flush
Rev 6.5	29 Sep 2017	Clarify unit interactions with Reactors 1 and 2
Rev 6.6	17 Oct 2017	React_2 add prompt for dry ingredient source. Fix React_1 interaction to start Ion_Exc_1 and React_2 interaction to start Ion_Exc_2
Rev 6.7	4 Sep 2018	Correct typos in Blend, React_1, and React_2
Rev 6.8	13 Nov 2018	Minor revs to most units.
Rev 6.9	19 Sep 2019	Correct descriptions in Product Storage 3 and Product Loadout 3
Rev 6.10	17 Oct 2019	Minor revs to many units
Rev 6.11	23 Oct 2020	Minor revs to many units. Added storage unit valves to discrete control points in R/TWet unload, R/TPowder unload, Dry/Wed Additive, Blend, React_3, React_4
Rev 6.12	11 Mar 2021	Revs to React_1 and React_2 abnormal conditions
Rev 7.0	25 Aug 2021	Add abnormal conditions when communication heartbeats are lost
Rev 7.1	22 Dec 2021	Corrections to abnormal conditions involving heartbeats. Corrections to TDry_Unl abnormal conditions.
Rev 7.2	16 Nov 2022	Added XV26x6 valves to Reactor 3 devices. Fix typos in Dry Storage LoadIn and LoadOut.
Rev 7.3	22 Oct 2023	Correction to Flush for Ion_Exc_5 and Ion_Exc_6.