4. Weak Chemical Zone

4.1. Purpose

The purpose of the Weak Chemical Zone is to begin the process of regenerating the resin in the cylinders of an ISEP carousel. As resin beads undergo regeneration, they swell, and while they become exhausted through service in the Product Zone, they shrink. Temperature fluctuations as the cylinders cycle through the various zones also subject the resin beads to thermal stress. Abrupt changes in the physical and chemical environment can cause the resin beads to fracture, shortening their useful life. For this reason, the Weak Chemical Zone introduces regenerant to the resin beads gently in a mild, diluted concentration, at gradually increasing temperature, in order to minimize physical stress.

4.2. Functional Description

The Weak Chemical Zone comprises three index positions situated between the Beer Off Zone and the Strong Chemical Zone, demarcated by ports #18, #19, and #20 of the top disc of the compound rotary valve. The Weak Chemical Zone receives cylinders from the Beer Off Zone and releases them to the Strong Chemical Zone.

When a cylinder enters the Weak Chemical Zone, it is full of water at ambient temperature, and the resin it contains is in a completely exhausted state but has been rinsed free of CMB. As a cylinder moves through the Weak Chemical Zone, its resin beads are bathed in a heated, diluted regenerant-chemical solution, which consists of a mixture of the effluent from the Heated Rinse Zone and the effluent from the Strong Chemical Zone. The high temperature of the diluted regenerant in the Weak Chemical Zone decreases its viscosity, thereby facilitating circulation through the tiny passages in the resin beads.

In all three carousels, RO water is supplied to the Heated Rinse Zone scalding hot (130°F to 140°F), and when discharged from the Heated Rinse Zone to be mixed with the effluent from the Strong Chemical Zone, it is still quite hot.

In the anion and decolorizer carousels, the regenerant chemical (caustic) is supplied to the Strong Chemical Zone scalding hot (130°F to 140°F), and when discharged from the Strong Chemical Zone, it is still very hot. When combined with the hot effluent from the Heated Rinse Zone to enter the Weak Chemical Zone, the resulting mixture is quite hot.

In the cation carousel, the regenerant chemical (hydrochloric acid) is supplied to the Strong Chemical Zone at ambient temperature, and when discharged from the Strong Chemical Zone, it is still near ambient temperature. When combined with the hot effluent from the Heated Rinse Zone to enter the Weak Chemical Zone, the resulting mixture is very warm, but not as hot as that in the anion and decolorizer carousels.

By the time a cylinder leaves the Weak Chemical Zone, the resin it contains has become acclimated to a higher temperature and to the regenerant chemical, and it is ready to enter the Strong Chemical Zone for more intense regeneration.

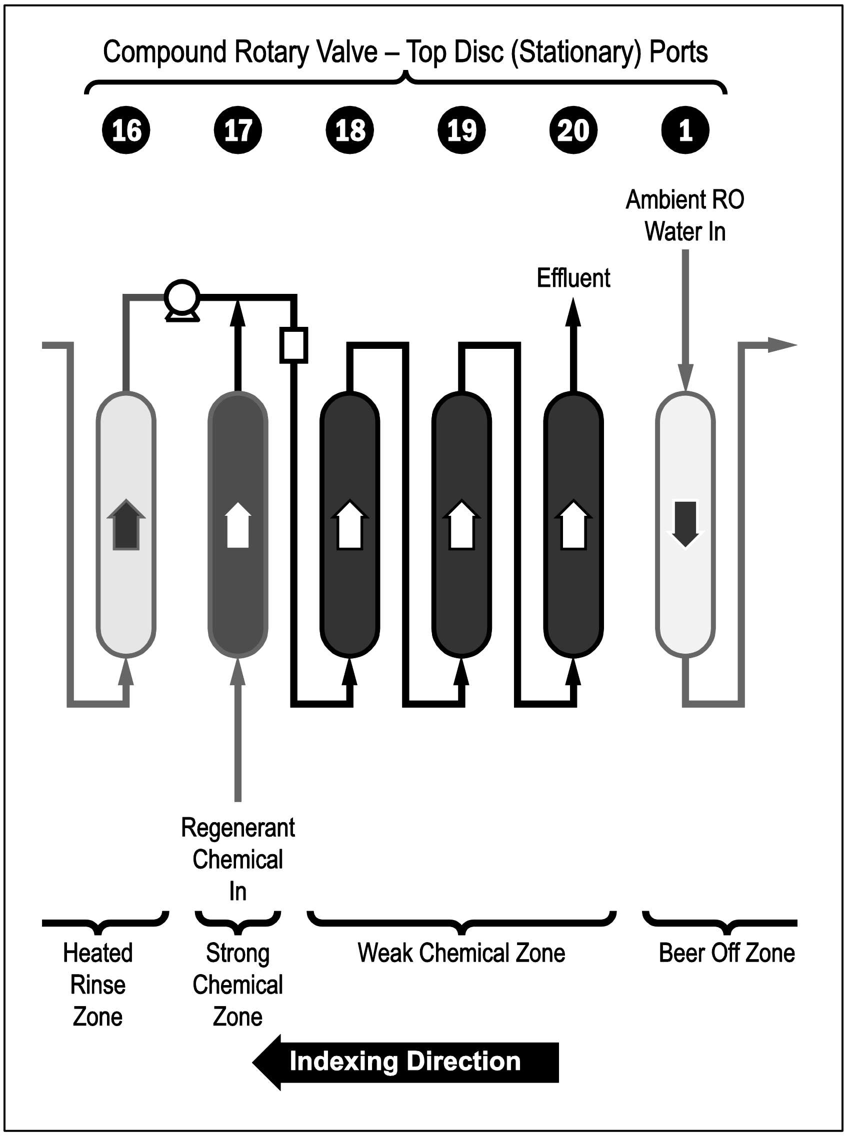

Figure 2-96 Weak Chemical Zone – Functional Diagram

4.3. Control Devices, Ports & Piping

Diluted regenerant chemical is supplied to the Weak Chemical Zone through a static mixer, which combines the effluent from the Strong Chemical Zone (Port #17) with the effluent from the Heated Rinse Zone (Port #16). This mixture is fed into the cylinder located in Index Position 3 of the Weak Chemical Zone through Port #18-L of the top disc of the compound rotary valve (see Table 2.22).

In the anion and cation carousels, the piping for the Weak Chemical circuits is identical (see Figure 2-97). Because the Weak Chemical circuit on the decolorizer carousel requires a higher flow rate than those of the anion and cation carousels, the supply piping to the Weak Chemical Zone of the decolorizer carousel incorporates a pressure sensor and a booster pump (P301). The booster pump is situated between the merge point of the Heated Rinse and Strong Chemical effluents and the static mixer (see Figure 2-98).

Table 2.22 Weak Chemical Zone – Compound Rotary Valve Ports

Weak Chemical Zone Index Position	Compound Rotary Valve Top Disc Ports	
	Inlet	**Outlet**
3	18-R	18-L
2	19-R	19-L
1	20-R	20-L

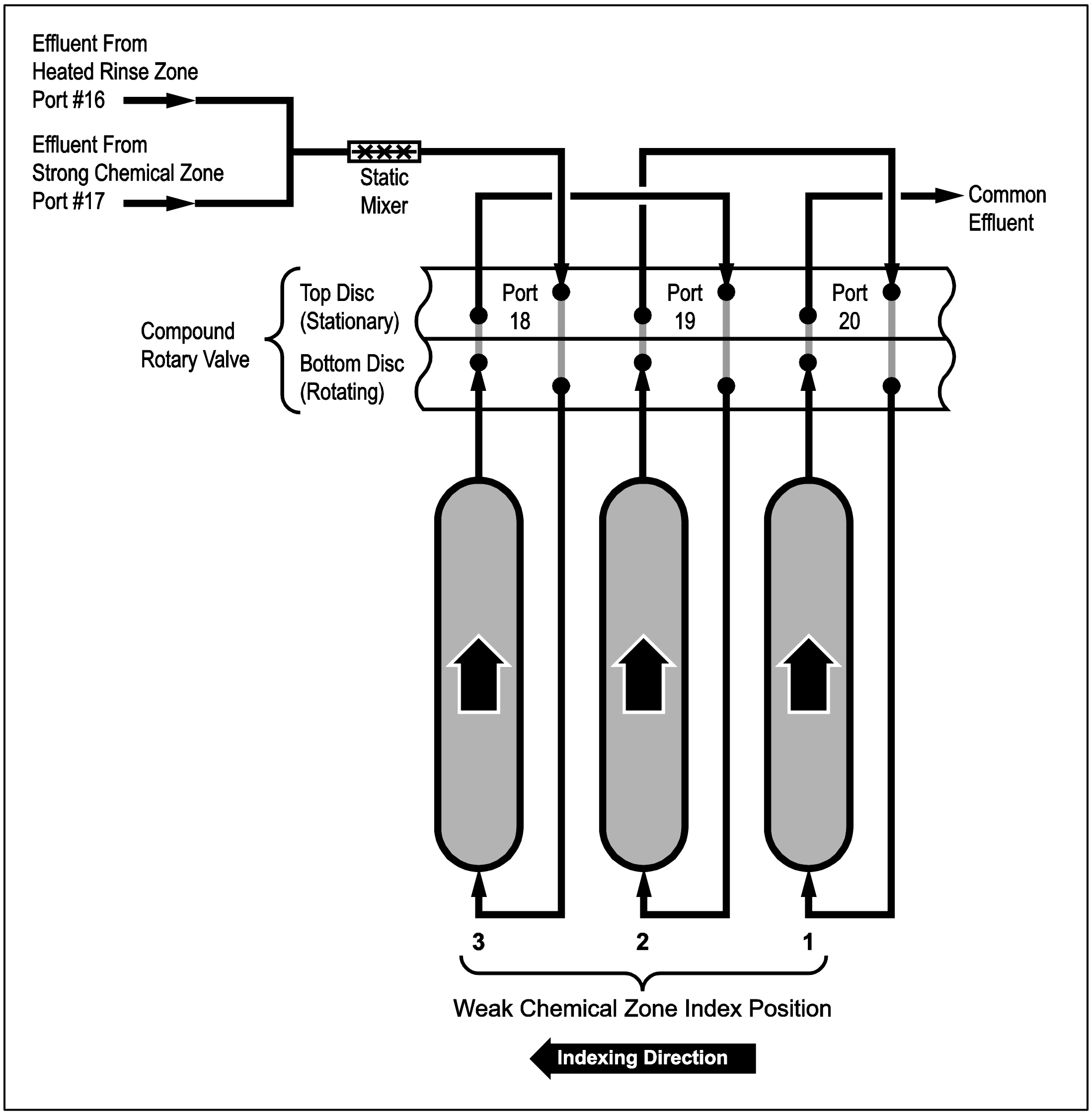

Figure 2-97 Weak Chemical Circuit – Anion & Cation Carousels

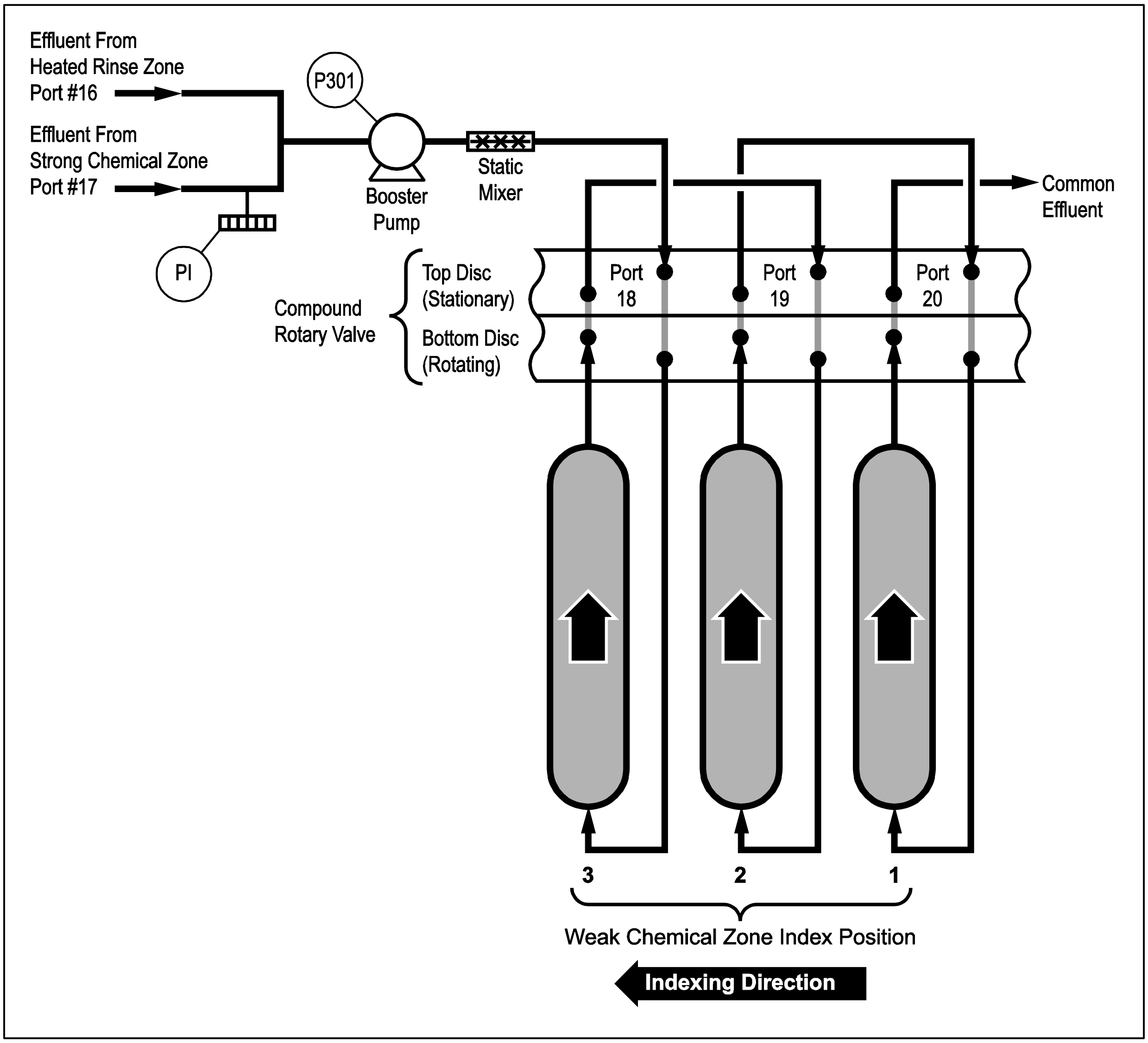

Figure 2-98 Weak Chemical Circuit – Decolorizer Carousel

The Weak Chemical circuits are located in the upper left-front quadrant of the carousels, when viewed from the front (see Figure 2-99). In the anion and cation carousels, the Weak Chemical circuits operate passively. The supply pressure under which they receive diluted regenerant from the Heated Rinse and Strong Chemical circuits is sufficient to force the regenerant through the cylinders in all three index positions and discharge it to the common effluent. The Weak Chemical circuits in the anion and cation carousels therefore have no sensors or powered components (see Figure 2-100).

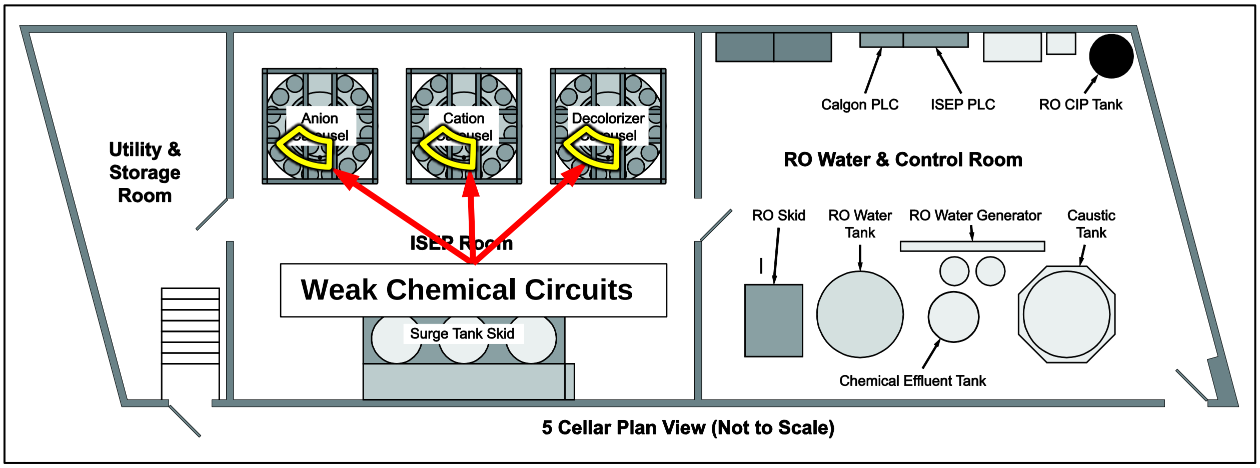

Figure 2-99 Weak Chemical Circuit Location

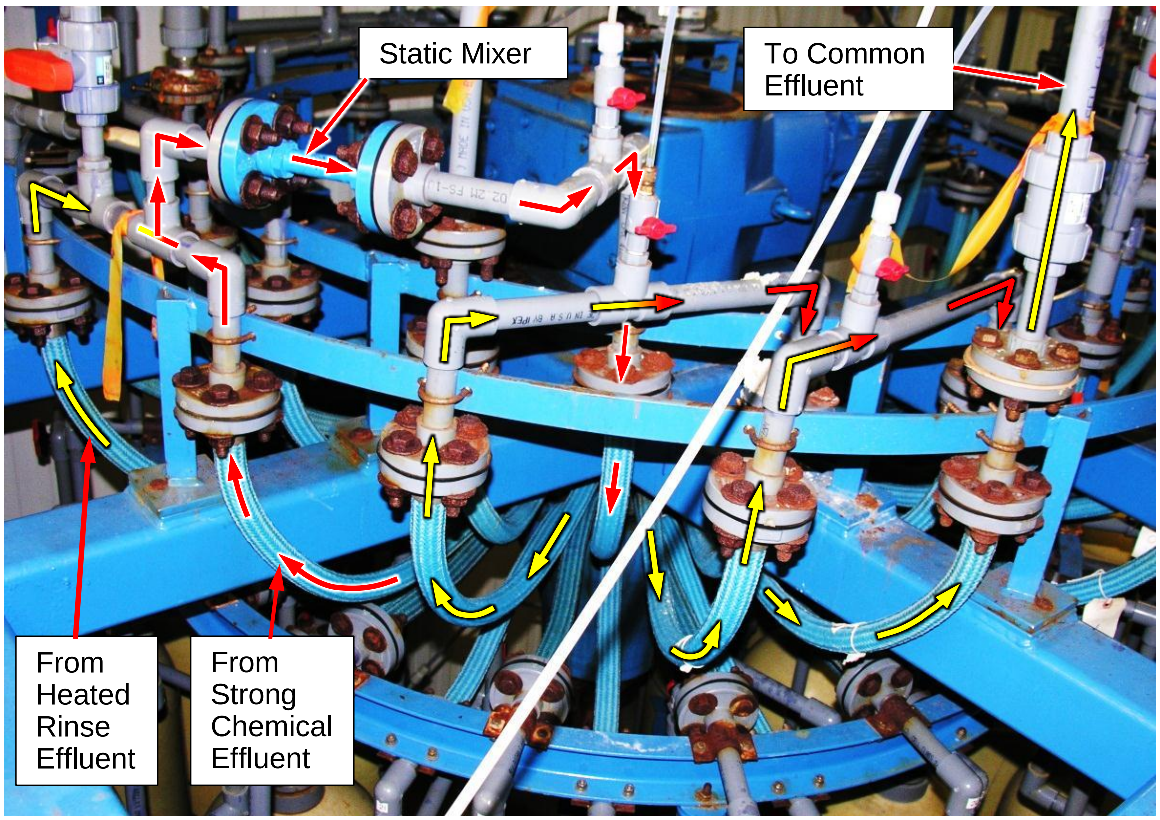

Figure 2-100 Weak Chemical Circuit Piping – Anion & Cation Carousels (Cation Carousel Shown)

In the decolorizer carousel, the Weak Chemical circuit requires additional pressure to ensure that the diluted regenerant passes through the Weak Chemical Zone successfully. This additional pressure is provided immediately upstream of the static mixer by a booster pump (device tag number P301), which is mounted to the top frame of the decolorizer carousel (see Figure 2-101, Figure 2-102, and Figure 2-103). The booster pump is connected to a piping loop with hand valves that allow the booster pump to be bypassed.

A pressure sensor located between the Strong Chemical discharge and the tee-joint merge with the Heated Rinse discharge sends a signal to the PLC, which is referenced in determining booster-pump speed.

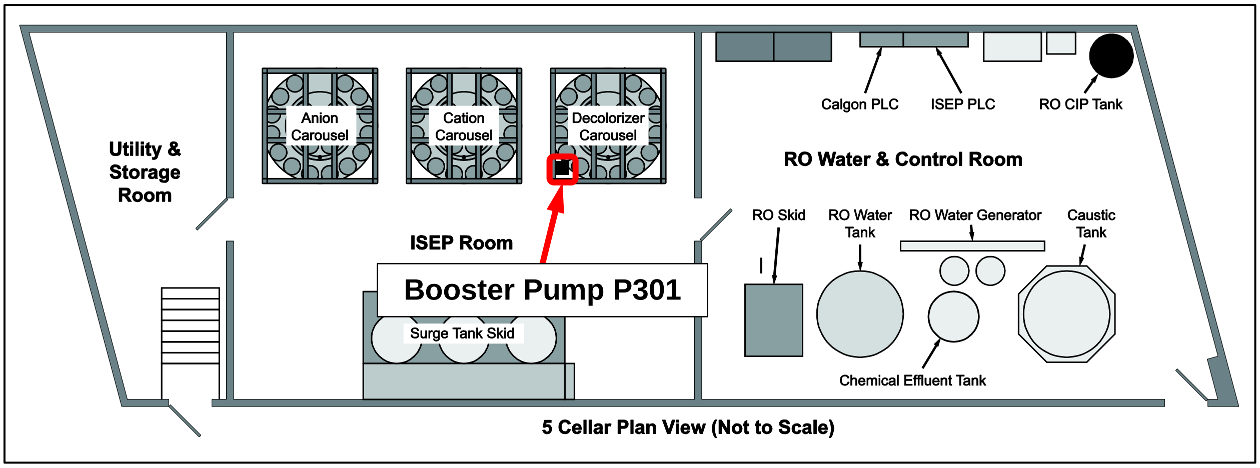

Figure 2-101 Decolorizer Carousel – Weak Chemical Circuit Booster Pump (P301) Location

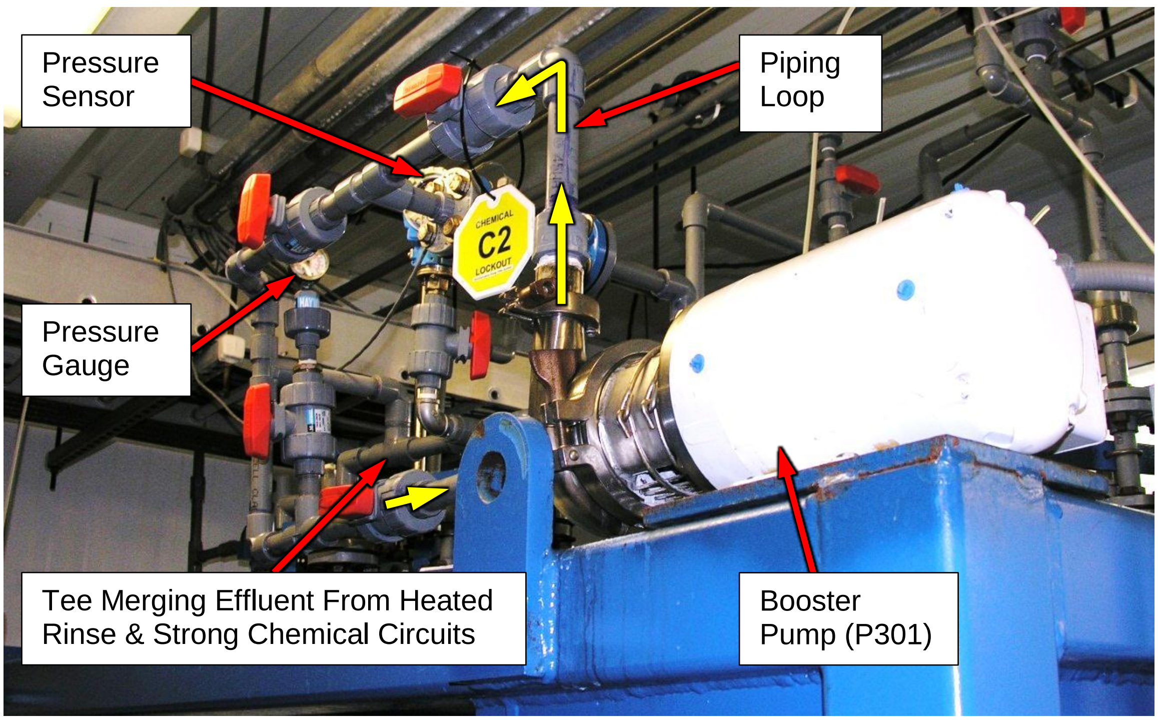

Figure 2-102 Decolorizer Carousel – Booster Pump (P301) Viewed From Left Front Corner

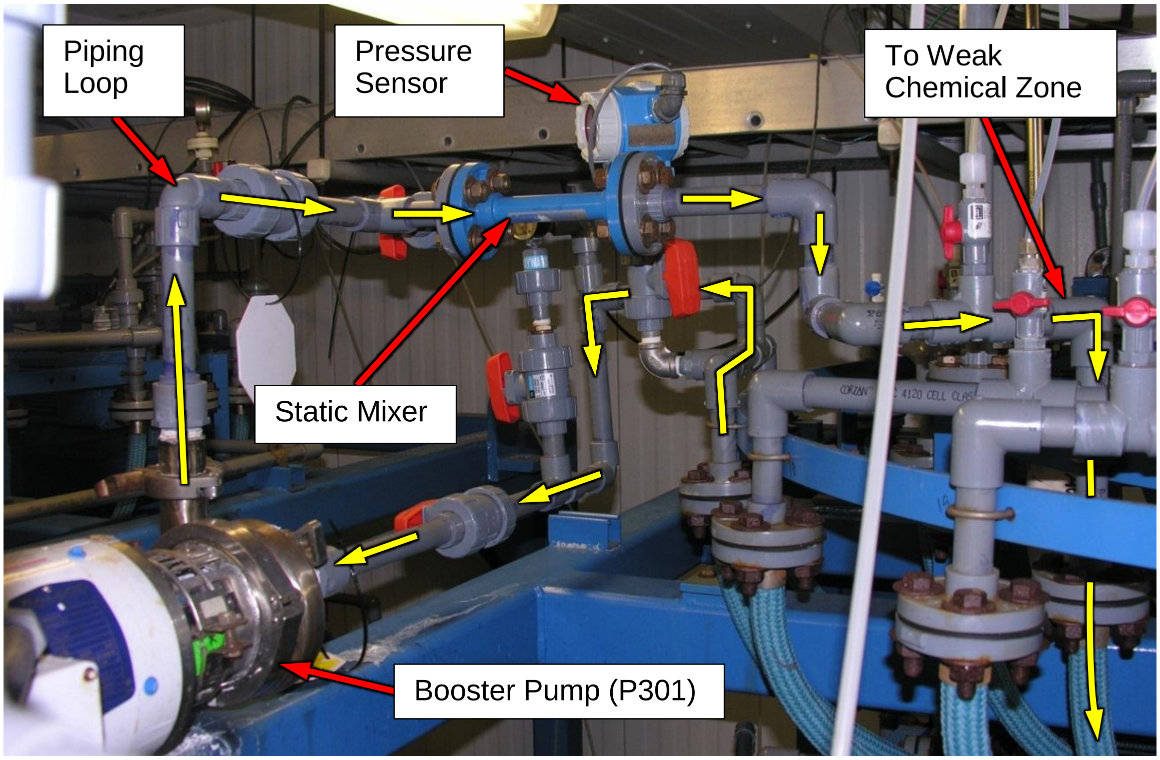

Figure 2-103 Decolorizer Carousel – Booster Pump (P301) Viewed From Front

4.4. PLC Controls

There are no flow-control mechanisms or flow setpoints specifically for the Weak Chemical circuit. The flow rate and chemical composition of the liquid stream through the Weak Chemical circuit are the result the combined effluent from the Heated Rinse circuit (which also contains residual entrained strong regenerant) mixed with the effluent from the Strong Chemical circuit (which also contains residual entrained weak regenerant).

4.4.1. PID Force P100 to P700 Screen

In the anion and cation carousels, the Weak Chemical circuits have no powered components or sensors, and there are therefore no control parameters in the ISEP PLC for the Weak Chemical circuits as such. Since the Weak Chemical circuit of the decolorizer carousel incorporates a pressure sensor and a booster pump (device tag number P301), the **PID Force P100 to P700** screen in the ISEP PLC includes parameters for these devices (see Table 2.23 and Figure 2-104): The ISEP PLC is programmed to maintain a pressure setpoint on the inlet side of the booster pump (currently set at 10.0 PSI). Since the booster pump is not capable of providing enough suction to achieve this setpoint, the pump is kept running constantly.

For the Weak Chemical circuit of the decolorizer carousel, the PID Force P100 to P700 screen contains four control parameters (see Table 2.23 and Figure 2-104)

Table 2.23 PID Force P100 to P77 Screen – Weak Chemical Circuit Parameters

Parameter	Description	Settings
Manual Setpoint	User-specified percentage of booster-pump	Numerical value from 0

(%)	speed capacity when booster pump P301 is operating in Manual mode	to 100; normally set at 100.
Decolor Caustic Booster Pump P301	Sets operating mode of booster pump P301	Off, Manual,or Auto
Auto Setpoint	User-specified inlet pressure for booster pump P301 to maintain when operating in Auto mode	Normally set at 10.0 PSI
Actual (PSI)	Displays output value of pressure sensor	N. A.

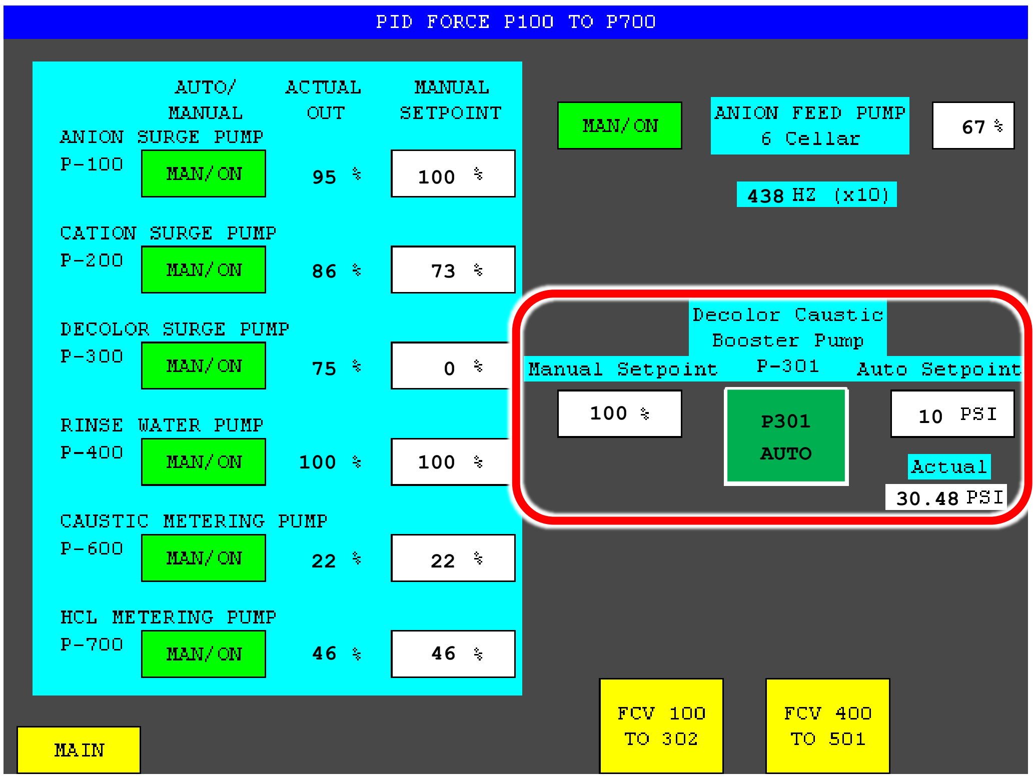

Figure 2-104 PID Force P100 to P700 Screen

4.4.2. RO Water & Steam Screen

For the Weak Chemical circuit of the decolorizer carousel, the RO Water and Steam screen displays two parameters, which duplicate parameters accessed in the PID Force P100 to P700 screen. (see 0 and Figure 2-132).

Table 2.24 RO Water & Steam Screen – Weak Chemical Circuit Parameters

Parameter	Description	Settings
Manual Setpoint (%)	User-specified percentage of booster-pump speed capacity when booster pump P301 is operating in Manual mode	Numerical value from 0 to 100; normally set at 100.
Actual (PSI)	Displays output value of pressure sensor	N. A.

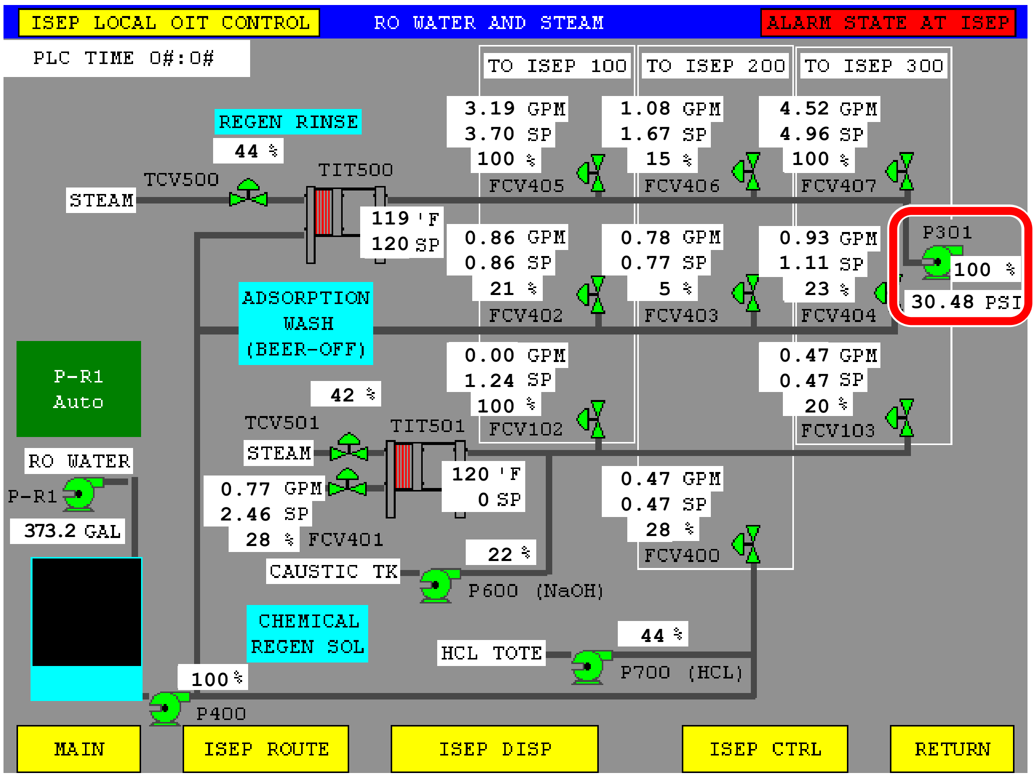

Figure 2-105 RO Water and Steam Screen

4.4.3. Alarm Setpoints

There are no alarms to be set specifically for the flows through the Weak Chemical circuits. There is no instrumentation on the circuits to enable alarms. The component flows (Heated Rinse and Strong Chemical) are alarm-enabled, and low flows in those circuits may be caused by constriction downstream in the Weak Chemical circuit. In the Weak Chemical circuit of the decolorizer carousel, if the booster pump (P301) fails to start or run, an alarm will be triggered.

4.5. Tuning Strategy

In the Weak Chemical circuits, tuning options are minimal. These circuits merely receive the combined effluent passively from the Heated Rinse and Strong Chemical circuits, in each of which tuning is critical. The recommended tuning strategy is to tune the two component circuits and allow the resulting Weak Chemical flow and concentration to float.

On the decolorizer carousel, the back-pressure setpoint for booster pump (P301) should be set at the minimum level that provides adequate flow through the upstream heated rinse and strong chemical circuits, while minimizing wear and tear on the pump and drive.

Table 2.25 Weak Chemical Circuit – Flow Rate & Concentration Setpoints.

		Carousel		
		Anion	**Cation**	**Decolorizer**
Regenerant Chemical		Caustic	Hydrochloric Acid (HCl)	Caustic
Calculated Chemical Concentration (%)		0.60	1.60	0.20
Weak Chemical Feed Rate	**Bed Volumes (BV)**	18.70	6.50	17.51
	Gallons per Minute (GPM)	4.94	1.54	5.40
	GPM Accounting for HCl Flow	N. A.	1.63	N. A.

Note:

- The Weak Chemical feed rate equals the sum of the Strong Chemical and Heated Rinse components.
- For the cation carousel, the actual flow rate is slightly higher than the combined flow rates of the Heated Rinse and Strong Chemical circuits. The cation Strong Chemical metered flow rate reflects only the flow rate of the RO water used to dilute the regenerant, due to its highly corrosive nature (4.8% hydrochloric acid).
- The Weak Chemical feed rates listed are valid for a Product feed rate of 9.25 GPM at current optimum treatment ratios.

4.6. Troubleshooting

Calcium Scale Buildup – In the Weak Chemical circuits, the principal issue is that scaling can build up, impeding flow upstream in the Heated Rinse and Strong Chemical circuits. In the cation carousel, flow resistance is not an issue, partially because the regenerant chemical is hydrochloric acid and partially because the component-circuit flow rates are very low. In the anion and decolorizer carousels, flow resistance is a persistent problem, because the regenerant chemical is caustic, and the component-circuit flow rates are much higher. In the anion carousel, the flow rate through the Heated Rinse circuit is especially high because rinsing caustic out of the resin is very difficult.

In the anion and decolorizer carousels, calcium scale builds up gradually inside the piping of the Weak Chemical, Strong Chemical, and Heated Rinse circuits, eventually obstructing flow. The greater the buildup, the more severe is the obstruction. Calcium scale builds up within the ports of the top disc of the compound rotary valve that support the Weak Chemical, Strong Chemical, and Heated Rinse circuits and in the associated piping, and is most prominent at points of high shear, especially in the static mixers.

Calcium scale buildup is counteracted by contact with acids, and CMB is acidic. Since the bottom disc of the compound rotary valve, the associated piping, and all the cylinders continually cycle through the Product Zone – and are therefore continually exposed to the acidic CMB – any calcium buildup that may occur in these components is continually removed.

In the decolorizer carousel, the buildup of calcium scaling is not severe enough to pose a problem. In the anion carousel, however, the buildup of calcium scaling is a recurring problem. If the flow rate in the Strong Chemical circuit is 50 percent of the set point or less, the Weak Chemical circuit is severely obstructed, and the rinsing-and-regeneration train must be descaled.

CAUTION:

Failure to perform a descaling procedure on the anion carousel when the Weak Chemical circuit is severely obstructed may result in a burst cylinder or cylinders.

Descaling is accomplished by circulating a phosphoric acid solution at ambient temperature through the upper (stationary) piping of the rinsing-and-regeneration train (Heated Rinse, Strong Chemical, and Weak Chemical circuits). During the descaling procedure, the manual valves in the piping connected to the cylinders must be set in the bypass position, in order to prevent damaging the resin inside the cylinders.

Resin Swelling – In the anion carousel, swelling of the resin (Rohm and Haas Amberlite FPA42Cl) in reaction to the regenerant chemical can also impede flow through the rinsing-and-regeneration train. If a cylinder is filled with too much resin, when the resin swells in the Strong Chemical Zone, it will displace the freeboard inside the cylinder. The swollen resin will become packed solid and obstruct the flow of liquid through the cylinder. Fill levels should be carefully verified with the resin in its most swollen state, either in the Strong Chemical Zone (port #17 of the top disc of the compound rotary valve), or in the Heated Rnse Zone, in order to ensure that there is adequate freeboard inside the cylinders.

CAUTION:

Overfilling the cylinders of the anion carousel with resin may result in burst cylinders.