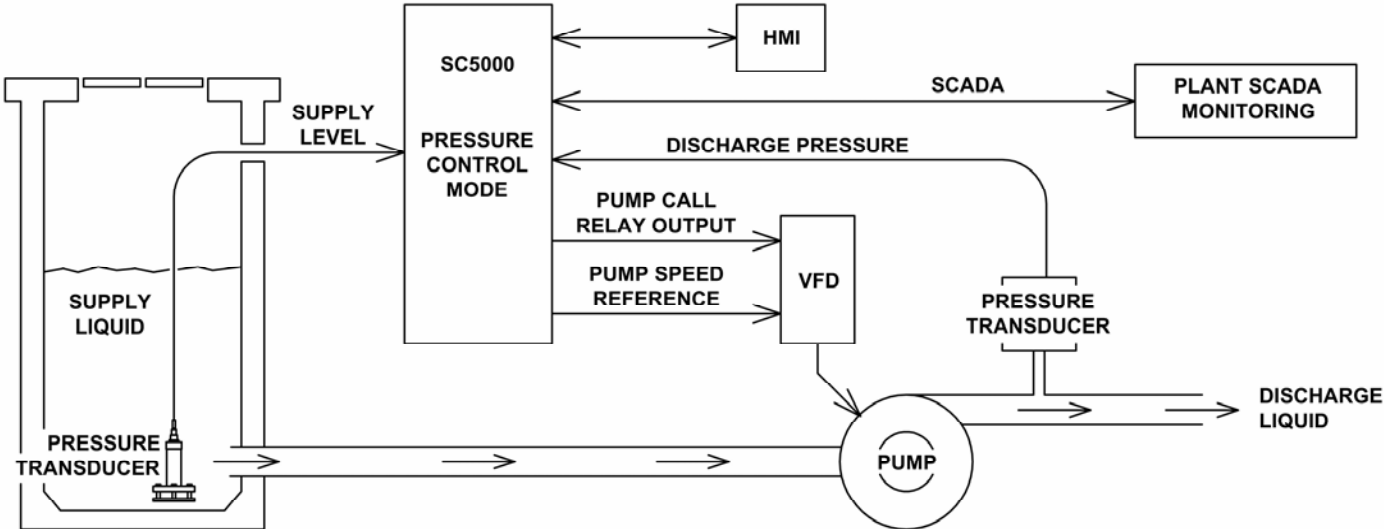


# SC5000

## INSTRUCTION MANUAL

### SECTION 3

### PRESSURE CONTROL



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# SECTION 3

## PRESSURE CONTROL

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# PRESSURE CONTROL

## DESCRIPTION OF FEATURES

### General Description

With the Master Control Mode (Parameter P.091) set for "Pressure Control" the SC5000 will function as a Pressure Controller, and all logic pertaining to "Level Control", "Flow Control" and "Booster Control" will be disabled.

In the Pressure Control Mode, a PID Controller (Proportional, Integral, Derivative) is provided to regulate the pump speed in order to maintain the Discharge Pressure at the Discharge Pressure Setpoint.

The Pressure Control logic also determines the number of pumps required to run in order to maintain the Discharge Pressure at the Discharge Pressure Setpoint.

The Pressure Control logic also alternates the pumps and provides a First Pump Start Delay, Lag Pump Delay, Number of Pumps Required at Startup, Low Level Alarm, High Level Alarm, Low Discharge Pressure Alarm, High Discharge Pressure Alarm, and Pump Cutoff upon Low Level. It also has parameters in the menu that allow the operator to set the Number of Pumps Present, the Maximum Number of Pumps Allowed to Run At the Same Time, and the Maximum Number of Pumps Allowed to Run While On a Generator.

The Pressure Control Mode requires that each pump have its own VFD.

The Pressure Control Mode also requires that the Controller be ordered with an optional Analog Output for each pump for the VFD speed reference (see Ordering Information).

### HMI Features

The **SC500-CTS-HMI** is a **Color Touch Screen HMI** programmed with screens that show the Supply Level, Discharge Pressure, Pump Speed Reference, Pump Run Status, Pump Available for Service indication, High Supply Level and Low Supply Level alarms, High Discharge Pressure and Low Discharge Pressure alarms, Discharge Pressure Setpoint Override Active indication, Supply Level Too Low For Pump Operation alarm, Low-Low Level Pump Cutoff Active alarm, Elapsed Run Time meters for each pump, and any Fault Codes that may be present. All the control and alarm settings are made readily available to the operator for viewing or changing. An operator may also perform Level Simulation, reset the Elapsed Run Time meters, and reset any Fault Codes.

### Discharge Pressure Setpoint

The Discharge Pressure Setpoint (Parameter P.445) must be set by the operator for the desired Discharge Pressure that the liquid should be pumped at as it leaves the pumping station.

At startup, the Pressure Control logic will bring on the Number of Pumps Required at Startup (Parameter P.470). If number of pumps called at startup are unable to bring the Discharge Pressure up to the Discharge Pressure Setpoint, then another pump will be started. If the setpoint is still not reached, then the control logic will call another pump to run and then another until the Discharge Pressure Setpoint is met. Additionally, the logic will turn off any unneeded pumps.

The PID Controller will follow what is set on the Discharge Pressure Setpoint as it regulates the Discharge Pressure, except when the supply liquid level is low. In this case the Controller may be setup to not strictly following the setpoint, but rather decrease the Discharge Pressure when the supply liquid level is low, and follow the Discharge Pressure Setpoint when the supply liquid level returns to the normal range.

### First Pump Start Delay

After power is applied to the Controller and after all the initial conditions are satisfied and the First Pump Start Delay (Parameter P.468) has expired, the Number of Pumps Required at Startup (Parameter P.470) will be started, and the Lag Pump Delay (Parameter P.469) will set the minimum time period between each pump call. The following are the initial conditions which must first be met for the First Pump Start Delay to begin timing out:

There must be an adequate supply of liquid in the well or tank that the pumps are drawing from. The liquid level must be at or above what is set on the Pump Operation Enable Supply Level (Parameter P.459).

The "All Pump Disable" Discrete Input (Discrete Input Function 17) must be open.

The "Pump Cutoff Low-Low Level" Discrete Input (Discrete Input Function 59) must be open and the delay set on the pump Re-enable Delay (Parameter P.153) must have expired.

At least one pump must be available for service (Not having its Pump Disable Discrete Input closed (Discrete Input Functions 11 - 16)).

After all of the above conditions are met and the First Pump Start Delay times out, then the first pump will be started.

## PRESSURE CONTROL

### Lag Pump Delay

The Lag Pump Delay (Parameter P.469) sets the minimum time period between the calling of pumps to run at startup. It is also used to delay the turning on of the replacement pump when an operating pump is suddenly disabled, or when a time based alternation of the pumps is performed.

### Number of Pumps Required at Startup

The Number of Pumps Required at Startup (Parameter P.470) sets the minimum number of pumps that are initially turned on in order to meet the Discharge Pressure Setpoint. When the First Pump Start Delay (Parameter P.468) expires, the first of the required pumps will be turned on and each additional required pump will wait for the Lag Pump Delay (Parameter P.469) to expire.

### Pump Turn On and Off

#### Operating Principal

After the Number of Pumps Required at Startup (Parameter P.470) are started, the Pressure Control logic will then control the number of additional pumps that are required to run in order to maintain the Discharge Pressure at the Discharge Pressure Setpoint. The control logic determines when an additional pump is needed and when to turn off an unneeded pump based on the following operating principal:

The number of pumps required to run is regulated so that the PID Controller does not drive the pump speed reference significantly higher than or lower than a predetermined pump speed range.

See the [Discharge Pressure Versus Pump Speed graph on page 3-12](#).

#### Turning On Pumps

If at some point conditions in the system require that the pump speed be increased in order to maintain the Discharge Pressure Setpoint, then the pump speed reference will be increased as needed. If the pump speed reference were to be increased to the point that it were equal to or greater than what is set on the Pump Speed Upper Threshold (Parameter P.454), then one additional pump would be turned on, after the delay set on the Delay To Turn On One Pump (Parameter P.455) expires. This may be repeated again and again until all the available pumps are called to run, or until the pump speed becomes lower than the Pump Speed Upper Threshold (Parameter P.454).

#### Turning Off Pumps

If at some point in time the conditions in the system were to change such that a lower pump speed were required to maintain the Discharge Pressure Setpoint, then the pump speed reference would be decreased as needed. If the pump speed reference were to be decreased to the point where it was equal to or less than what is set on the Pump Speed Lower Threshold (Parameter P.456), then one of the pumps would be turned off, after the delay set on the Delay To Turn Off One Pump (Parameter P.457) expires. This may be repeated again and again until all but one pump is left running, or until the pump speed becomes higher than the Pump Speed Lower Threshold (Parameter P.456).

### Pump Operation Enable / Disable

The pump operation in the Pressure Control Mode requires that there be an adequate supply of liquid in the well or tank. The following two parameters provide the operator with control over how low the supply liquid level is allowed to drop before turning off all the pumps and at what level pumping should be allowed to resume:

#### Pump Operation Enable Supply Level

To allow any pumps to start, the liquid level must first rise up to or be above what is set on the Pump Operation Enable Supply Level (Parameter P.459). See page 3-13.

#### Pump Operation Disable Supply Level

If the liquid level falls below what is set on the Pump Operation Disable Supply Level (Parameter P.460) then all the pumps will be turned off. See page 3-13.

#### Alarm Status

When pump operation is disabled, based on Parameters P.459 and P.460, the "Supply Level Too Low for Pump Operation" alarm status bit will be set and may be read from Modbus Coil 258 (Register 40017 Bit 1).

## PRESSURE CONTROL

### Controlling Setpoint

At start up, to ensure the smooth stable control of the Discharge Pressure, the PID Controller is sent a gradually increasing Setpoint (the Controlling Setpoint (Parameter Pd.31)) that slowly increases to equal the Discharge Pressure Setpoint (Parameter P.445). The rate of the increase is set by the operator on the Discharge Pressure Ramp Rate (Parameter P.465). [See the graph on page 3-15.](#)

After start up, as long as the Supply Level remains in the normal range (above what is set on Parameter P.462), the Controlling Setpoint will be kept equal to the Discharge Pressure Setpoint and the PID Controller will regulate the pump speed to keep the Discharge Pressure at or near what is set on the Discharge Pressure Setpoint.

During start up or at any time, if the Supply Level becomes low (below what is set on Parameter P.462), then the value of the Controlling Setpoint will be ramped down along the linear slope established by Parameters P.461, P.462, P.463 and P.445. [See the graph on page 3-14.](#)

If while the pumps are operating and the Discharge Pressure Setpoint is changed by an operator, then the Controlling Setpoint will be ramped up or down to the new value of the Discharge Pressure Setpoint using the Discharge Pressure Ramp Rate (Parameter P.465).

While the Controlling Setpoint is being ramped up or down to the Discharge Pressure Setpoint, the “PID Controller Setpoint Override Active” status bit will be set and may be read from Modbus Coil 257 (Register 40017 Bit 0).

### Pump Alternation

#### Automatic Alternation

In the Pressure Control Mode the pump Alternation Sequence Mode (Parameter P.122) is fixed to always be in the Standard Alternation, and the pumps will be Alternated “First On First Off”. [See page 3-8.](#)

[See the alternation sequence diagram on page 3-18.](#)

#### Manual Pump Call Sequence

When manual control over the pump call sequence is desired, the operator can use the Forced Lead Pump Position feature (Parameter P.129) to set the Lead Pump Position. This sets the order the pumps are called in. The Lead Pump Position may also be set using a Lead Pump Selector switch that is connected to Discrete Inputs assigned to Functions 31 - 36. [See page 3-8.](#)

[See connection diagrams on page A-13.](#)

#### Time Based Alternation

Time Based Alternation is also available in the Pressure Control Mode. The Time Based Alternation logic may be triggered by an Internal Time Clock or from an External Time Clock. The Internal Time Clock alternation period is menu selectable (Parameter P.131). The External Time Clock may be triggered to alternate from either a External Time Clock connected to a Discrete Input on the Controller (set for Function 21), or it may be part of a SCADA system’s logic, where the SCADA system would set Modbus Coil 95 (Register 40006 Bit 14) to force the alternation of the pumps. [See page 3-8.](#)

### Pump Cutoff Low-Low Level

The Pump Operation Enable / Disable feature (setup on Parameters P.459 and P.460) monitors the Analog Supply Level Input to determine if there is an adequate supply of liquid in the well or tank. By using a Low-Low Level Float Switch connected to a Discrete Input a redundant pump cut off may also be implemented. This Pump Cutoff Low-Low Level feature also includes a Re-enable Delay to prevent the short cycling of the pumps.

The Low-Low Level Float Switch must be connected to a Discrete Input assigned to Function 59.

The Re-enable Delay (Parameter P.153) starts timing out when the Discrete Input opens. When the Re-enable Delay expires the Pump Cutoff Low-Low Level feature will no longer prevent pump operation.

The “Pump Cutoff Active Low-Low Level” status is available from Modbus Coil 131 (Register 40009 Bit 2).

While the Pump Cutoff Low-Low Level input is closed, the Low Level Alarm will also be activated. The contacts of a relay assigned to the Low Level Alarm (Function 7) will also close.

## **PRESSURE CONTROL**

### **Supply Level Input Select**

The Pressure Control Mode requires an analog 4-20mA Level Input be provided to monitor the liquid level in the wet well. The default Level Input is connected to Analog Level Meter ALM1. If a second or backup Level Input is desired then it must be connected to Analog Level Meter ALM2. The Level Input Select (Parameter P.133) allows for the selection between two Analog Level Meters ALM1 or ALM2 as the Level Input source (each Level Meter must be connected to its own Pressure Transducer). The second analog 4-20mA Level Input may be either manually or automatically switched into service as the controlling Level Input. See Section M.

### **Discharge Pressure Input Select**

The Pressure Control Mode requires that an analog Discharge Pressure Input be provided to the Controller to monitor the Discharge Pressure. The Discharge Pressure Input Select (Parameter P.441) is provided to allow for the selection one of two Analog Pressure Meters APM1, or APM2. See Section N.

# PRESSURE CONTROL

## Discrete Inputs

30 Discrete Inputs (D1 - D30) that may be setup to perform the following Functions:

- Pump Disable Inputs
- All Pump Disable - Phase Monitor Input
- On Generator - Limits number of pumps allowed to run
- Toggle Between ALM1 & ALM2 for Level Input selection
- External Alternation - External Time Clock Input
- Sequence Inputs - Lead Pump Selector Switch Inputs
- Call Pump Last Inputs
- Pump Cutoff Low-Low Level Input
- High and Low Level Alarm Inputs
- Collection of Discrete Input Data for SCADA

## Relay Outputs

12 Relay Outputs (ROX1 - ROX12) that may be setup to perform the following Functions:

- Up to Six Pump Call to Run Outputs
- High or Low Supply Level Alarm Outputs
- High or Low Discharge Pressure Alarm Outputs
- SCADA Remote Control Outputs

## Analog Inputs

2 Standard Analog Inputs (AIX1 - AIX2) and up to 8 more Optional Analog Inputs (A1 - A8).

The Analog Inputs may be setup to perform one of the following Functions:

- Analog Level Meter ALM1 or ALM2
- Analog Flow Meter AFM1, AFM2 or AFM3
- Analog Pressure Meter APM1 or APM2
- Analog Current Meter ACMA, ACMB or APMC
- Collection of Analog Input Data for SCADA

## Analog Outputs

1 Standard Analog Output (AOX1) and up to 6 more Optional Analog Outputs (AO1 - AO6).

The Analog Outputs may be setup to perform one of the following Functions:

- Analog Signal for Pumps 1 - 6 Speed Reference
- Analog Signal for Pumps Speed Reference any Pump (Always Active)
- Analog Signal that is a Copy of Wet Well Level

## Pulse Counter Inputs

Option for up to 3 Pulse Counter Inputs (DPC1 - DPC3) that may be used to perform the following:

- Pulse Counter Input for Pulse Flow Meter PFM1, PFM2 or PFM3

## PRESSURE CONTROL

User / Operator Info.		SCADA		Description of Parameters and SCADA Notes
Parameter	Default Value	Current Value	Register Address	
<b>Master Control Mode</b>				
P.091	1		40091	Master Control Mode 1 = Level Control 2 = Flow Control 3 = Pressure Control 4 = Booster Control <span style="color: red;"><b>Must Be Set On "3" for Pressure Control</b></span>
<b>Pump Setup</b>				
P.092	6		40092	Number of Pumps Present 1 = 1 Pump    2 = 2 Pumps    3 = 3 Pumps 4 = 4 Pumps    5 = 5 Pumps    6 = 6 Pumps
P.093	6		40093	Maximum Number of Pumps Allowed to Run at the Same Time 1 = 1 Pump    2 = 2 Pumps    3 = 3 Pumps 4 = 4 Pumps    5 = 5 Pumps    6 = 6 Pumps
P.094	6		40094	Maximum Number of Pumps Allowed to Run While On Generator 1 = 1 Pump    2 = 2 Pumps    3 = 3 Pumps 4 = 4 Pumps    5 = 5 Pumps    6 = 6 Pumps Note: Must Connect Transfer Switch Contact to Discrete Input assigned to Function 18.

User / Operator Info.		SCADA		Description of Data
Parameter	Register Address			
<b>Elapsed Time Meter Data</b>				
Etd.1	41891	Pump 1 - Elapsed Time Meter (hours and 1/10 hours)		Range: 0.0 - 6553.5 hours
Etd.2	41892	Pump 2 - Elapsed Time Meter (hours and 1/10 hours)		Range: 0.0 - 6553.5 hours
Etd.3	41893	Pump 3 - Elapsed Time Meter (hours and 1/10 hours)		Range: 0.0 - 6553.5 hours
Etd.4	41894	Pump 4 - Elapsed Time Meter (hours and 1/10 hours)		Range: 0.0 - 6553.5 hours
Etd.5	41895	Pump 5 - Elapsed Time Meter (hours and 1/10 hours)		Range: 0.0 - 6553.5 hours
Etd.6	41896	Pump 6 - Elapsed Time Meter (hours and 1/10 hours)		Range: 0.0 - 6553.5 hours



## PRESSURE CONTROL

User / Operator Info.			SCADA	Description of Parameters and SCADA Notes
Parameter	Default Value	Current Value	Register Address	
<b>Pump Alternation Setup</b>				
P.122	1	1	40122	<p>Alternation Sequence Mode</p> <p>1 = Standard Alternation of Pumps 1 - 6 <span style="float: right;">See page 3-16.</span></p> <p>Note: With the Master Control Mode set on Pressure Control the Alternation Sequence Mode will be fixed on Standard Alternation.</p>
P.129	0		40129	<p>Forced Lead Pump Position</p> <p>0 = Normal Alternation    X = Pump X as Lead</p>
P.131	0		40131	<p>Time Based Alternation <span style="float: right;">Range: 0 - 65535 minutes</span></p> <p>0 = Disabled    60 = 1 hour    480 = 8 hours    1440 = 24 hours</p> <p>Note: Pump Alternation may be triggered using the Internal Time Clock setup using Parameter P.131, or it can also be triggered by an External Time Clock, which may be either a hardware device connected to a Discrete Input setup to perform Function 21, or it may be triggered by having the SCADA system set Bit 14 in Register 40006.</p>
<b>Pump Alternation Status</b>				
Ad.01	-	-	41888	<p>Current Lead Pump    Shows the number of the current Lead Pump.</p>

## PRESSURE CONTROL

User / Operator Info.		SCADA		Description of Parameters and SCADA Notes
Parameter	Default Value	Current Value	Register Address	
<b>Supply Level Input Setup</b>				
P.133	1		40133	<p>Level Input Select</p> <p>1 = Analog Level Meter - ALM1 - Single or Dual Transducers            2 = Analog Level Meter - ALM2 - Single or Dual Transducers            3 = Analog Level Meter - ALM1 - Dual Transducers            4 = Analog Level Meter - ALM2 - Dual Transducers</p> <p>Notes:            Selection 1 - Dual Transducers are Manually switched from ALM1 to ALM2. See Section M.            Selection 2 - Dual Transducers are Manually switched from ALM2 to ALM1. See Section M.            Selection 3 - Dual Transducers are Automatically switched from ALM1 to ALM2. See Section M.            Selection 4 - Dual Transducers are Automatically switched from ALM2 to ALM1. See Section M.</p>
<b>Supply Level Input Data</b>				
Ld.01	-	-	42143	<p>Supply Level Input Data - For Numerical Display of Level</p> <p>Note: This is the value of the Supply Level Input selected on Parameter P.133 scaled into feet and 1/10 of feet for numerical display.</p>
Ld.02	-	-	42144	<p>Supply Level Input Data - For Bar Graph Display of Level</p> <p>Note: This is the value of the Supply Level Input selected on Parameter P.133 scaled for display on a bar graph. It is scaled to a range of 0 - 4095. The Bar Graph Display scaling setup on the HMI device must be set for 0 - 4095.</p>
Ld.03	-	-	42145	<p>Level Input Source Status</p> <p>1 = Analog Level Meter - ALM1            2 = Analog Level Meter - ALM2            3 = Level - Simulated</p>

## PRESSURE CONTROL

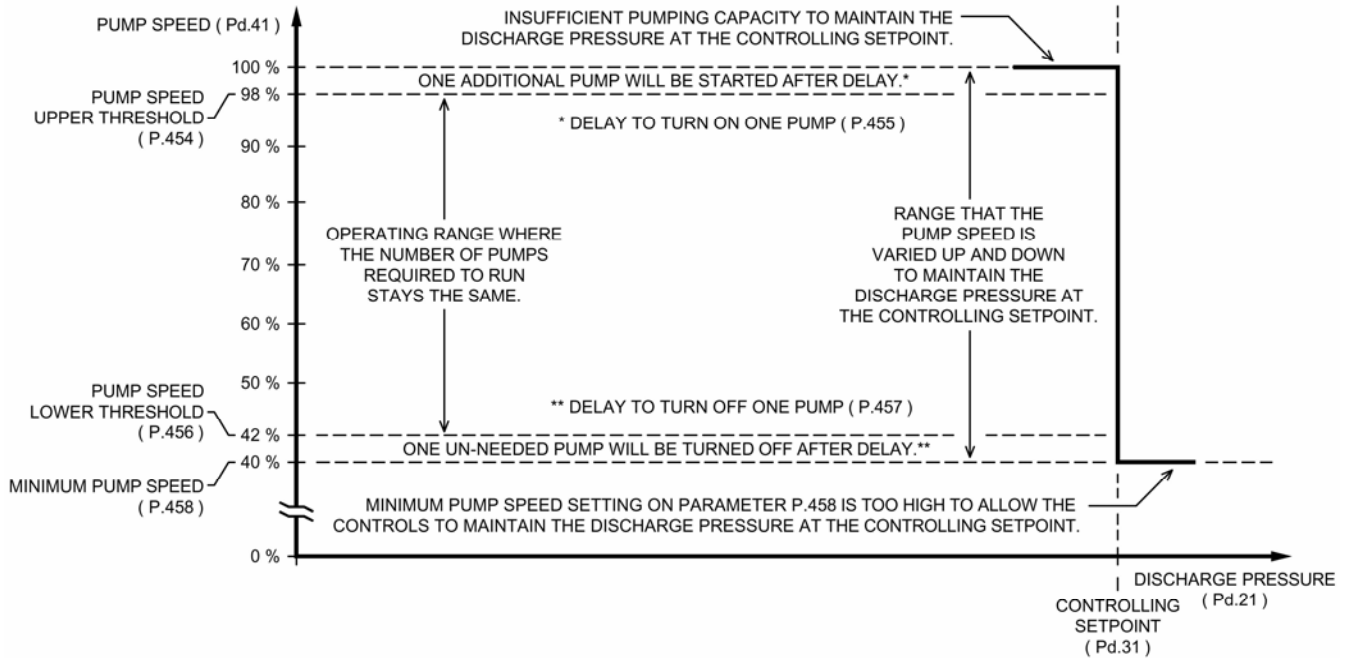
User / Operator Info.		SCADA		Description of Parameters and SCADA Notes
Parameter	Default Value	Current Value	Register Address	
<b>Discharge Pressure Input Setup</b>				
P.441	1		40441	<p>Discharge Pressure Input Select</p> <p>1 = Analog Pressure Meter APM1      2 = Analog Pressure Meter APM2</p> <p>Note: This parameter establishes which Analog Pressure Meter's data will be used as the Process Variable (PV) that goes into the PID Controller used for Discharge Pressure Control. The Discharge Pressure data selected here is available to be read from Parameters Pd.21 and Pd.22. See pages N-1 and N-2.</p>
P.442	100.0 psi		40442	<p>Discharge Pressure Input Bar Graph Span</p> <p>Note: This parameter sets the span of the Discharge Pressure Bar Graph for Parameter Pd.22.</p>
<b>Discharge Pressure Input Data</b>				
Pd.21	-	-	42231	<p>Discharge Pressure Input Data - For Numerical Display of Pressure</p> <p>Note: This is the value of the pressure data selected on Parameter P.441 scaled into psi for numerical display.</p>
Pd.22	-	-	42232	<p>Discharge Pressure Input Data - For Bar Graph Display of Pressure</p> <p>Note: This is the value of the pressure data selected on Parameter P.441 scaled for display on a bar graph. It is scaled to a range of 0 - 4095 by using the "Discharge Pressure Input Bar Graph Span" (Parameter P.442). The Bar Graph Display scaling setup on the HMI device must be set for 0 - 4095.</p>

## PRESSURE CONTROL

User / Operator Info.		SCADA		Description of Parameters and SCADA Notes
Parameter	Default Value	Current Value	Register Address	
<b>Discharge Pressure Setpoint</b>				
<b>P.445</b>	30.0 psi		40445	Discharge Pressure Setpoint (SP) <span style="float: right;">Range: 3.0 - 300.0 psi</span> Note: This is the parameter that sets the desired Discharge Pressure of the liquid being pumped.
<b>Pd.31</b>	-	-	42233	<b>Controlling Setpoint</b> Note: To ensure a smooth stable control of the Discharge Pressure during startup, the value of the Controlling Setpoint (Parameter Pd.31) sent to the PID Controller is ramped up to the value set on the Discharge Pressure Setpoint (Parameter P.445), using the ramp rate set on the Discharge Pressure Ramp Rate (Parameter P.465). If the Supply Level becomes low at startup or at any time (below what is set on Parameter P.462), then the value of the Controlling Setpoint will be ramped down along the linear slope established by Parameters P.461, P.462, P.463 and P.445, as shown on page 3-14. The rate at which it is ramped down (or up) the slope is set on the Discharge Pressure Ramp Rate (Parameter P.465), as shown on page 3-15.
At startup or at any time the Setpoint Override logic keeps the Controlling Setpoint from being equal to the Discharge Pressure Setpoint, the "PID Controller Setpoint Override Active" status bit will be set. Its status may be read from Modbus Coil 257 (Register 40017 Bit 0).				
<b>PID Controller Tuning</b>				
<b>P.447</b>	1.00		40447	<b>Controller Gain (Kc)</b> <span style="float: right;">Range: 0.01 - 30.00</span> Note: This parameter is used to tune the proportional component of the PID Controller's Pump Speed Reference output.
<b>P.448</b>	0.04 minutes / repeat		40448	<b>Integral Time (Ti)</b> <span style="float: right;">Range: 0.01 - 60.00 minutes / repeat</span> Note: This parameter is used to tune the integral component of the PID Controller's Pump Speed Reference output. Changes to this parameter may result in significant changes to the Pump Speed Reference. Therefore, it is recommended that only small changes are made to this parameter while the system is in operation.
<b>P.449</b>	0.00 minutes		40449	<b>Derivative Time (Td)</b> <span style="float: right;">Range: 0.00 - 2.00 minutes</span> Note: This parameter is used to tune the derivative component of the PID Controller's Pump Speed Reference output.
<b>Pump Speed Reference Data</b>				
<b>Pd.41</b>	-		41877	<b>Pump Speed Reference Data</b> <span style="float: right;">Range: 0.0 - 100.0 percent</span> Notes: 1. The Pump Speed Reference is determined by the PID Controller and is sent to the VFDs, as a 4-20mA signal, to control the pump speed 2. All operating pumps receive the same Speed Reference. 3. Parameter Pd.41 is the Pump Speed Reference as a percent of full speed.

# PRESSURE CONTROL

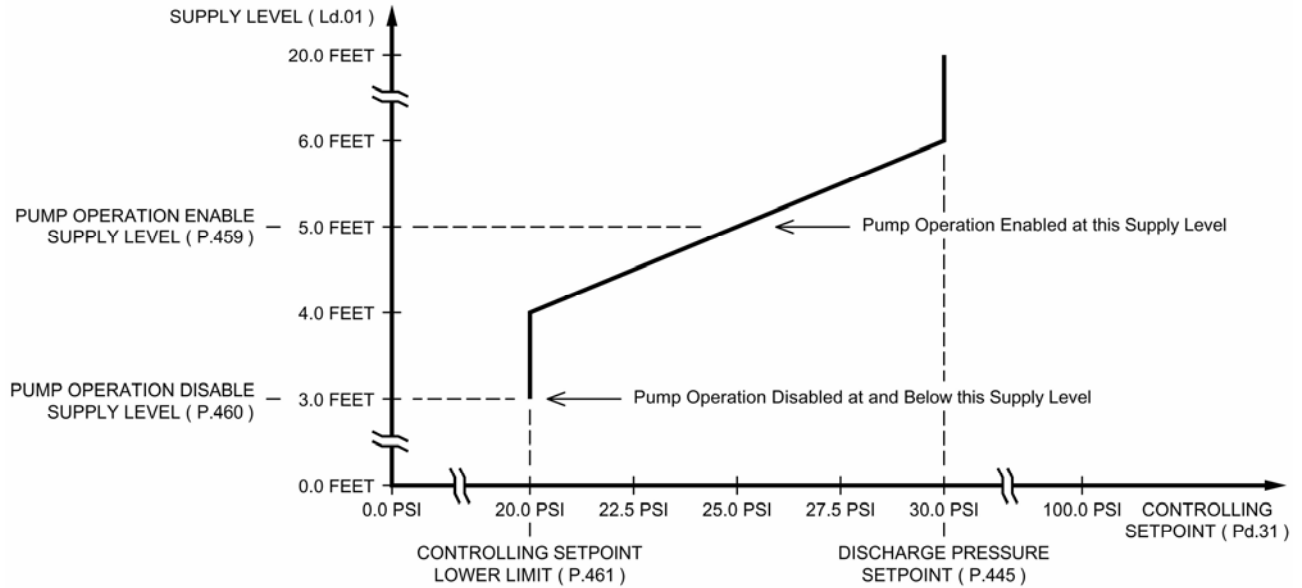
## Turning On / Off Pumps



User / Operator Info.		SCADA		Description of Parameters and SCADA Notes
Parameter	Default Value	Current Value	Register Address	
<b>Turning On of Pumps</b>				
<b>P.454</b>	98.0 %		40454	<b>Pump Speed Upper Threshold</b> Range: 30.0% - 100.0% of Full Speed Note: When the Pump Speed Reference has increased to where it is greater than or equal to what is set on this parameter, the <b>Delay To Turn On One Pump</b> (Parameter P.455) is started. When the delay expires an additional pump will be turned on.
<b>P.455</b>	10 sec.		40455	<b>Delay To Turn On One Pump</b> Range: 1 - 600 seconds Note: This delay starts when the Pump Speed Reference has increased to where it is greater than or equal to the <b>Pump Speed Upper Threshold</b> (Parameter P.454). When the delay expires an additional pump will be turned on.
<b>Turning Off of Pumps</b>				
<b>P.456</b>	42.0 %		40456	<b>Pump Speed Lower Threshold</b> Range: 10.0% - 90.0% of Full Speed Note: When the Pump Speed Reference has decreased to where it is less than or equal to what is set on this parameter, the <b>Delay To Turn Off One Pump</b> (Parameter P.457) is started. When the delay expires one pump will be turned off.
<b>P.457</b>	10 sec.		40457	<b>Delay To Turn Off One Pump</b> Range: 1 - 600 seconds Note: This delay starts when the Pump Speed Reference has decreased to where it is less than or equal to the <b>Pump Speed Lower Threshold</b> (Parameter P.456). When the delay expires one pump will be turned off.
<b>Minimum Pump Speed</b>				
<b>P.458</b>	40%		40458	<b>Minimum Pump Speed</b> Range: 0% - 95% of full speed Note: For each application there is usually a minimum speed, below which pump operation is undesirable. This parameter sets the minimum pump speed allowed. With the <b>Minimum Pump Speed</b> set on Parameter P.458, care must be taken that there is not also a minimum speed set on the VFDs.

# PRESSURE CONTROL

## Pump Operation Enable / Disable



### Supply Level Required to Enable Pump Operation

For cases where it is desirable to continue pumping, even when the Supply Level is low, the Controller has a Discharge Pressure Setpoint Override feature. The logic of the feature allows the operator to setup the Controller to continue pumping at a lower Discharge Pressure during a low Supply Level condition.

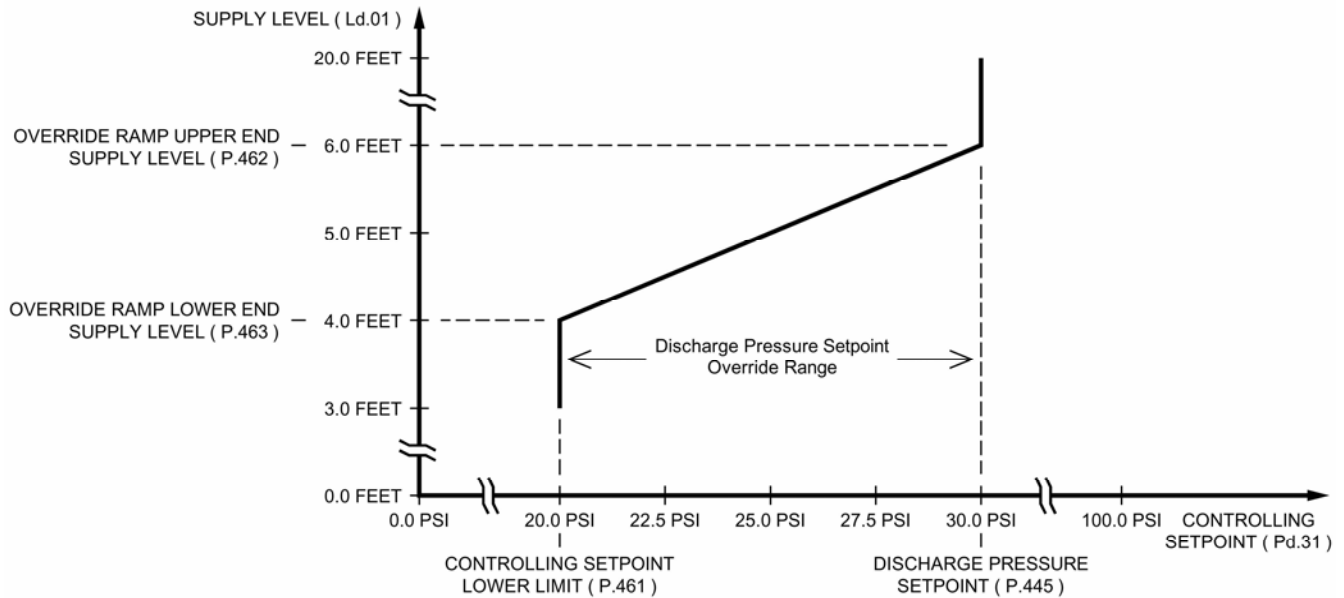
The purpose of the graph above is to point out the relationship between the Pump Operation Enable and Disable Parameters (P.459 and P.460) and the Discharge Pressure Setpoint Override Ramp, which will be discussed on the next page.

The Pump Operation Enable Supply Level (Parameter P.459) may be located higher or lower than what is shown above, but it must always be set higher than the Pump Operation Disable Supply Level (Parameter P.460).

User / Operator Info.			SCADA	Description of Parameters and SCADA Notes
Parameter	Default Value	Current Value	Register Address	
<b>Pump Operation Enable / Disable</b>				
<b>P.459</b>	5.0 feet		40459	Pump Operation Enable Supply Level      Range: 0.1 - 231.0 feet Note: This is the supply liquid level at which the operation of all available pumps will be enabled to run as needed to meet the <b>Discharge Pressure Setpoint</b> .
<b>P.460</b>	3.0 feet		40460	Pump Operation Disable Supply Level      Range: 0.1 - 231.0 feet Note: This is the supply liquid level at which all pump operation will be disabled and all pumps will be turned off in order to prevent the level from continuing to lower.
When pump operation is disabled, based on Parameters P.459 and P.460, the "Supply Level Too Low for Pump Operation" status bit will be set, and may be read from Modbus Coil 258 (Register 40017 Bit 1).				

## PRESSURE CONTROL

### Discharge Pressure Setpoint Override - Upon Low Supply Level



### Discharge Pressure Setpoint Override - Upon a Low Supply Level

Upon a low Supply Level condition, where the Supply Level is lower than what is set on Parameter P.462, the Setpoint Override logic will ramp down the Controlling Setpoint as shown in the graph above. This is done to prevent the Supply Level from becoming so low that all pumping would need to be stopped.

Upon a low Supply Level condition the Controlling Setpoint Override logic makes the Controlling Setpoint (Pd.31) lower (or much lower) than the Discharge Pressure Setpoint (P.445). Then the PID Controller responds by ramping down the Pump Speed Reference (Pd.41). The reduced pump speed may prevent the Supply Level from going any lower or at least slow down the decline in Supply Level.

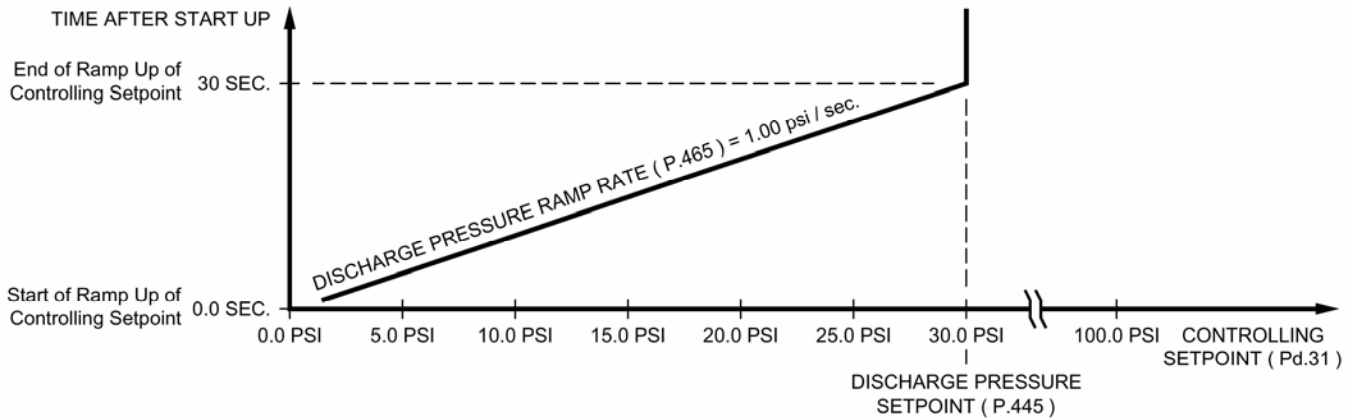
If the low Supply Level condition requires that the Pump Speed Reference (Pd.41) be decreased to the point where it is less than or equal to Parameter P.456, for the time set on Parameter P.457, then the control logic will turn off one or more of the pumps. See Parameters P.456 and P.457 on page 3-12.

User / Operator Info.			SCADA	Description of Parameters and SCADA Notes
Parameter	Default Value	Current Value	Register Address	
<b>Controlling Setpoint Lower Limit</b>				
<b>P.461</b>	20.0 psi		40461	Controlling Setpoint Lower Limit Range: 3.0 - 300.0 psi Note: Parameter P.461 sets the lowest value that the Setpoint Override logic is allowed to make the Controlling Setpoint.
<b>Override Ramp Upper End Supply Level</b>				
<b>P.462</b>	6.0 feet		40462	Override Ramp Upper End Supply Level Range: 0.1 - 231.0 feet Note: Parameter P.462 sets the Supply Level that corresponds to where the Setpoint Override logic makes the Controlling Setpoint equal to the Discharge Pressure Setpoint (Parameter P.445).
<b>Override Ramp Lower End Supply Level</b>				
<b>P.463</b>	4.0 feet		40463	Override Ramp Lower End Supply Level Range: 0.1 - 231.0 feet Note: Parameter P.463 sets the Supply Level that corresponds to where the Setpoint Override logic makes the Controlling Setpoint equal to the Controlling Setpoint Lower Limit (Parameter P.461).
At startup or at any time the Setpoint Override logic keeps the Controlling Setpoint from being equal to the Discharge Pressure Setpoint, the "PID Controller Setpoint Override Active" status bit will be set. Its status may be read from Modbus Coil 257 (Register 40017 Bit 0).				

# PRESSURE CONTROL

## Discharge Pressure Setpoint Override - During Start Up - with Normal Supply Level

Where: Supply Level (Ld.01)  $\geq$  Override Ramp Upper End Supply Level (P.462)



### Start Up

To ensure the smooth stable control of the Discharge Pressure during start up, the Controlling Setpoint (Parameter Pd.31) that is sent to the PID Controller is slowly ramped up at the rate set on the Discharge Pressure Ramp Rate (Parameter P.465) until it matches the Discharge Pressure Setpoint (Parameter P.445).

During startup, as long as the Supply Level stays above what is set on the Override Ramp Upper End Supply Level (Parameter P.462), the control logic will ramp up the Controlling Setpoint (Pd.31) as shown in the graph above.

However, if the Supply Level drops below what is set on the Override Ramp Upper End Supply Level (Parameter P.462), the control logic will regulate the Controlling Setpoint (Pd.31) as shown in the graph on page 3-14.

User / Operator Info.			SCADA	Description of Parameters and SCADA Notes
Parameter	Default Value	Current Value	Register Address	
<b>Discharge Pressure Ramp Rate</b>				
<b>P.465</b>	1.00 psi / sec		40465	Discharge Pressure Ramp Rate                      Range: 0.01 - 10.00 psi / sec Note: To ensure a smooth stable control of the Discharge Pressure during start up, or when the Discharge Pressure Setpoint is changed, the Controlling Setpoint (Parameter Pd.31), sent to the PID Controller, is ramped up or down as needed at the rate set on the Discharge Pressure Ramp Rate (Parameter P.465), until it matches the Discharge Pressure Setpoint (Parameter P.445).
At startup or at any time the Setpoint Override logic keeps the Controlling Setpoint from being equal to the Discharge Pressure Setpoint, the "PID Controller Setpoint Override Active" status bit will be set. Its status may be read from Modbus Coil 257 (Register 40017 Bit 0).				



## PRESSURE CONTROL

User / Operator Info.			SCADA	Description of Parameters and SCADA Notes
Parameter	Default Value	Current Value	Register Address	
<b>First Pump Start Delay</b>				
P.468	10 sec.		40468	<p>First Pump Start Delay <span style="float: right;">Range: 1 - 180 seconds</span></p> <p>Notes: The First Pump Start Delay period starts when all the following conditions are met:</p> <ol style="list-style-type: none"> <li>1. Power is applied to Controller.</li> <li>2. The Supply Level is at or above the Pump Operation Enable Supply Level (Parameter P.459).</li> <li>3. The "All Pump Disable" discrete input (Discrete Input Function 17) is open.</li> <li>4. The "Pump Cutoff Low-Low Level" discrete input (Discrete Input Function 59) is open and the delay set on the pump Re-enable Delay (Parameter P.153) has expired.</li> <li>5. At least one Pump is available for service and has its "Pump Disable" discrete input (Discrete Input Functions 11 - 16) open.</li> </ol>
<b>Lag Pump Delay</b>				
P.469	5 sec.		40469	<p>Lag Pump Delay <span style="float: right;">Range: 1 - 100 seconds</span></p> <p>Note: This is the minimum time period between the calling of pumps to run at startup. It is also used to delay the turning on of the replacement pump when an operating pump is suddenly disabled, or when a time based alternation of the pumps is performed.</p>
<b>Number of Pumps Required at Startup</b>				
P.470	1		40470	<p>Number of Pumps Required at Startup <span style="float: right;">Range: 1 - 6</span></p> <p>Note: This is the minimum number of pumps that are initially turned on in order to meet the Discharge Pressure Setpoint. When the First Pump Start Delay (Parameter P.468) expires, the first required pump will be turned on and each additional required pump will wait for the Lag Pump Delay (Parameter P.469) to expire.</p>
<b>Re-enable Delay - Pump Cutoff Low-Low Level</b>				
P.153	10 sec.		40153	<p>Re-enable Delay - Pump Cutoff Low-Low Level <span style="float: right;">Range: 1 - 600 seconds</span></p> <p>Notes:</p> <ol style="list-style-type: none"> <li>1. While the Low-Low Level Float Switch is closed no pump operation will be allowed.</li> <li>2. A Low-Low Level Float Switch must be connected to a Discrete Input assigned to Function 59.</li> <li>3. The Delay starts timing out when the Discrete Input opens. When the Re-enable Delay expires the Pump Cutoff Low-Low Level feature will no longer prevent pump operation.</li> <li>4. While the Pump Cutoff Low-Low Level input is closed the Low Level Alarm will be active. The contacts of a relay assigned to the Low Level Alarm (Function 7) will also be close. Also, Fault Code 1041 will be generated.</li> </ol>
<p>The "Pump Cutoff Active Low-Low Level" status is available from Modbus Coil 131 (Register 40009 Bit 2).</p> <p>The "Low Level Alarm" status is available from Modbus Coil 47 (Register 40003 Bit 14).</p>				

## PRESSURE CONTROL

User / Operator Info.		SCADA		Description of Parameters and SCADA Notes
Parameter	Default Value	Current Value	Register Address	
<b>Pump Speed Acceleration / Deceleration Rate</b>				
<b>P.166</b>	30 sec.		40166	<p>Pump Speed Acceleration Rate      Range: 1 - 100 seconds / 100% speed</p> <p>Notes:</p> <ol style="list-style-type: none"> <li>When a pump is turned on, this is the rate at which the pump's Speed Reference will be increased until it matches the Pump Speed Reference produced by the PID Controller (Parameter Pd.41). This is also the rate at which a pump's Speed Reference will follow increases of the Pump Speed Reference produced by the PID Controller.</li> <li>The setting on Parameter P.166 is the time required for a pump's Speed Reference to go from 0% - 100%.</li> <li>The Controller performs the Acceleration of the pump speed of the individual pumps. Therefore, the Accel Parameter on the VFDs should be set to a value less than or equal to what is set on Parameter P.166.</li> </ol>
<b>P.167</b>	30 sec.		40167	<p>Pump Speed Deceleration Rate      Range: 1 - 100 seconds / 100% speed</p> <p>Notes:</p> <ol style="list-style-type: none"> <li>When a pump is turned off, this is the rate at which the pump's Speed Reference will be decreased to 0% speed. This is also the rate at which a pump's Speed Reference will follow decreases of the Pump Speed Reference produced by the PID Controller.</li> <li>The setting on Parameter P.167 is the time required for a pump's Speed Reference to go from 100% - 0%.</li> <li>When a pump is turned off, the pump's Control Relay contact will be kept closed during the Deceleration of the pump to 0% speed, then the contact will be opened.</li> <li>The Controller performs the Deceleration of the pump speed of the individual pumps. Therefore, the Decel Parameter on the VFDs should be set to a value less than or equal to what is set on Parameter P.167.</li> </ol>
<b>Supply Level Alarms</b>				
<b>P.101</b>	2.0 feet		40101	<p>Low Level Alarm      Range: 0.0 - 231.0 feet</p> <p>Notes:</p> <ol style="list-style-type: none"> <li>This sets the level at which the Low Level Alarm will be activated.</li> <li>The Low Level Alarm operation is delayed for 90 seconds after power is applied.</li> <li>The Low Level Alarm does not act as a redundant pump off.</li> <li>A Float Switch connected to a Discrete Input assigned to either Function 59 or 61 will also activate the Low Level Alarm.</li> <li>Upon a Low Level Alarm, the contacts of a relay assigned to Function 7 will close.</li> </ol>
The "Low Level Alarm" status is available from Modbus Coil 47 (Register 40003 Bit 14).				
<b>P.102</b>	10.0 feet		40102	<p>High Level Alarm      Range: 0.1 - 231.0 feet</p> <p>Notes:</p> <ol style="list-style-type: none"> <li>This sets the level at which the High Level Alarm will be activated.</li> <li>The High Level Alarm operation is delayed for 10 seconds after power is applied.</li> <li>A Float Switch connected to a Discrete Input assigned to Function 62 will also activate the High Level Alarm.</li> <li>Upon a High Level Alarm, the contacts of a relay assigned to Function 8 will close.</li> </ol>
The "High Level Alarm" status is available from Modbus Coil 48 (Register 40003 Bit 15).				
<b>Discharge Pressure Alarms</b>				
<b>P.393</b>	20.0 psi		40393	<p>Low Discharge Pressure Alarm      Range: 0.0 - 300.0 psi</p> <p>Note: Upon a Low Discharge Pressure Alarm, the contacts of a relay assigned to Function 13 will close.</p>
The "Low Discharge Pressure Alarm" status is available from Modbus Coil 267 (Register 40017 Bit 10).				
<b>P.394</b>	70.0 psi		40394	<p>High Discharge Pressure Alarm      Range: 0.1 - 300.0 psi</p> <p>Note: Upon a High Discharge Pressure Alarm, the contacts of a relay assigned to Function 14 will close.</p>
The "High Discharge Pressure Alarm" status is available from Modbus Coil 268 (Register 40017 Bit 11).				

# PUMP ALTERNATION SEQUENCE

## STANDARD ALTERNATION Parameter P.122 = 1

With the Master Control Mode set on Pressure Control the Alternation Sequence Mode will be fixed on Standard Alternation (Parameter P.122 = 1).

The pumps will be Alternated “First On First Off”.

Discrete Inputs assigned the Function of “Pump Disable” (Functions 11 - 16) inputs may be used to disable pumps so that they will not be called to run.

Discrete Inputs assigned the Function of “Call Pump Last” (Functions 41 - 46) may be used to assign pumps to standby status, where they will only be called to run if no other pumps are available.

Discrete Inputs assigned the Function of “Sequence Input” (Functions 31 - 36) may be used to set the lead pump.

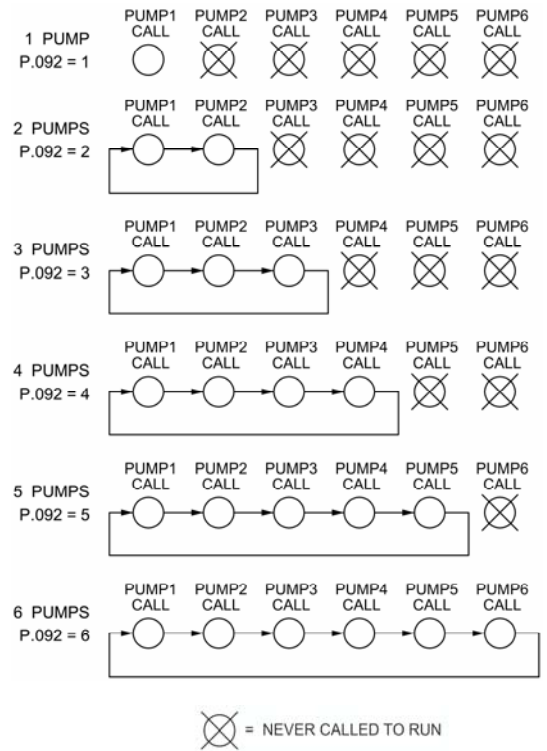
The “Forced Lead Pump Position” (Parameter P.129) may be used to set the lead pump.

“Time Based Alternation” (Parameter P.131) may be setup to force an alternation using an Internal Time Clock.

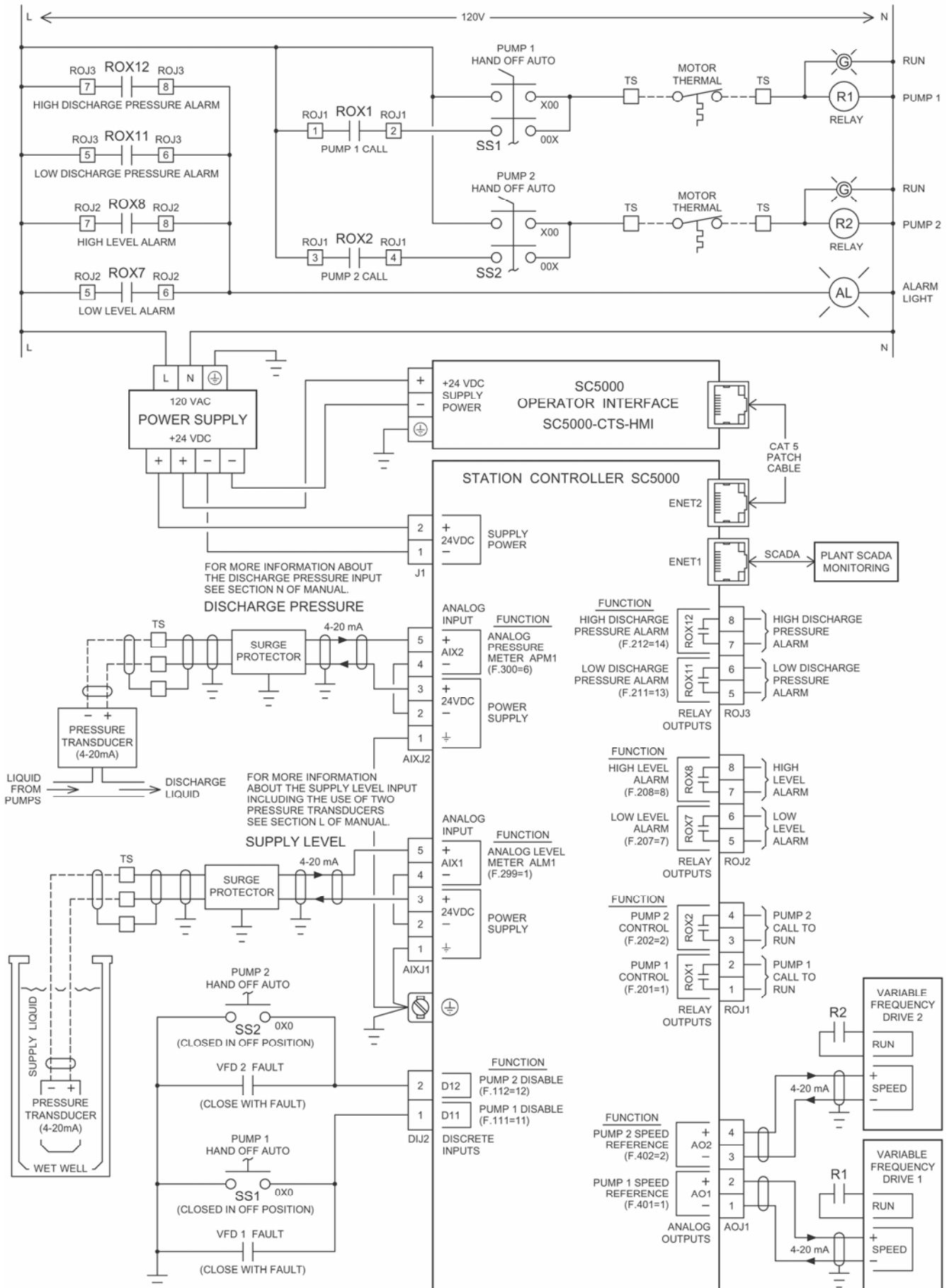
A Discrete Input assigned the Function of “External Alternation” (Function 21) may be connected to an External Time Clock and used to force an alternation.

A SCADA system may initiate an alternation by momentarily setting Modbus Coil 95 (Register 40006, Bit 14).

## Movement of Lead Pump Upon Alternation



# PRESSURE CONTROL EXAMPLE



# PRESSURE CONTROL - Touchscreen HMI SCREENS

## Main Screen

STATION CONTROLLER SC5000

<p><b>Fault Code</b></p> <p>FLC 1234</p> <p>LFC 1234</p> <p>Reset</p>	<p>Control Mode Select</p> <p>Pump Setup</p> <p>Security Setup</p> <p>SCADA Setup</p> <p>Backup / Restore</p>	<p><b>Parameter Security</b></p> <p>PARAMETERS UNLOCKED</p> <p>Security Code Entry</p>
<p><b>I / O</b></p> <p>Discrete Inputs</p> <p>Relay Outputs</p> <p>Analog Inputs</p> <p>Analog Outputs</p>	<p><b>Meters</b></p> <p>Level</p> <p>Pressure</p> <p>Flow</p> <p>Current</p>	<p>Station Status &amp; Setup</p>

## Control Mode Select

CONTROL MODE SELECT

Previous Screen

**Master Control Mode**

1	<p>1 = Level Control</p> <p>2 = Flow Control</p> <p>3 = Pressure Control</p> <p>4 = Booster Control</p>
---	---

Parameter: P.091

# PRESSURE CONTROL - Touchscreen HMI

## Pump Setup

**PUMP SETUP**

[Previous Screen](#)

Number of Pumps Present   
Parameter: P.092

Maximum Number of Pumps Allowed To Run At The Same Time   
Parameter: P.093

Maximum Number of Pumps Allowed To Run While On Generator   
(See Discrete Input Function 18) Parameter: P.094

## Pressure Control Main Screen

**SC5000 PRESSURE CONTROL**

[Main Screen](#)

<p>Fault Code</p> <p>FLC <input type="text" value="1234"/> <input type="text" value="1234"/></p> <p>LFC <input type="text" value="1234"/> <input type="text" value="1234"/></p> <p><input type="button" value="Reset"/></p>	<input type="text"/>	<p>Parameter Security</p> <p style="background-color: #90EE90;">PARAMETERS UNLOCKED</p> <p><input type="button" value="Security Code Entry"/></p>
<input type="button" value="Discharge Pressure"/>	<input type="button" value="Control Setup"/>	<input type="text"/>
<input type="button" value="Alternation Setup"/>	<input type="button" value="Alarms Setup"/>	<input type="text"/>
<input type="button" value="Controller Info."/>	<input type="text"/>	<input type="button" value="Station Status"/>

# PRESSURE CONTROL - Touchscreen HMI SCREENS

## Station Status

The Station Status screen displays the following information:

- Supply Level:** ALM1, High Alarm, Low Alarm, 123.4 feet, Push To Start Level Simulation.
- Discharge Pressure:** High Alarm, Low Alarm, 123.4 psi, Pump Speed Reference 123.4 %.
- Pumps 1-6:** All are 'Not Available For Service'. Each pump has buttons for OFF, DISABLE, FORCE, ELAPSED RUN TIME (HOURS), and RESET. Current FORCE values are 1234.5.
- Controlling Setpoint:** 123.4 psi.
- Pressure Setpoint:** 123.4 psi.
- Active Faults:** All Pump Disable Active, Supply Level Too Low for Pump Operation, Low-Low Level Pump Cutoff Active, Pressure Setpoint Override Active.
- Fault Codes:** FLC 1234, LFC 1234, with a RESET button.
- Navigation:** Previous Screen button.

## Discharge Pressure Setup

The Discharge Pressure Setup screen includes the following configuration options:

- DISCHARGE PRESSURE SETUP:** Title and Previous Screen button.
- Discharge Pressure:** 123.4 psi (Parameter: Pd.21).
- Discharge Pressure Setpoint:** 123.4 psi (Parameter: P.445).
- Configuration Buttons:** Discharge Pressure Input Setup and PID Controller Tuning.

# PRESSURE CONTROL - Touchscreen HMI SCREENS

## Discharge Pressure Input Setup

### DISCHARGE PRESSURE INPUT SETUP

Previous Screen

#### Discharge Pressure Input Select

1

Parameter: P.441

1 = Pressure Meter APM1  
2 = Pressure Meter APM2

The selected Analog Pressure Meter APM1 or APM2 must be setup before using. To Setup go to the Main Screen and select "Pressure".

#### Discharge Pressure

Parameter: Pd.22

123.4

 psi

#### Discharge Pressure Input Bar Graph Span

123.4

 psi

123.4

 psi  
Parameter: Pd.21

## PID Controller Tuning

### PID CONTROLLER TUNING

Previous Screen

Pump 1 Pump 2 Pump 3 Pump 4 Pump 5 Pump 6

#### Supply Level

123.4

 feet  
Parameter: Ld.01

#### Discharge Pressure

123.4

 psi  
Parameter: Pd.21

#### Discharge Pressure Setpoint

123.4

 psi  
Parameter: P.445

#### Discharge Pressure Controlling Setpoint

123.4

 psi  
Parameter: Pd.31

#### Pump Speed Reference

123.4

 %  
Parameter: Pd.41

#### Controller Gain (Kc)

12.34

  
Parameter: P.447

#### Integral Time (Ti) (minutes / repeat)

12.34

  
Parameter: P.448

#### Derivative Time (Td) (minutes)

12.34

  
Parameter: P.449

#### Speed Reference Component Values

Proportional	+	12,345,123
Integral	-	12,345,123
Derivative	+	12,345,123
Derivative	-	12,345,123

Pressure Setpoint  
Override Active

Supply Level Too Low  
for Pump Operation



# PRESSURE CONTROL - Touchscreen HMI SCREENS

## Control Setup

**CONTROL SETUP**

[Previous Screen](#)

**Setup To Turn On Pumps**

Pump Speed Upper Threshold	<input type="text" value="123.4"/> %	<input type="text" value="123"/>	Delay To Turn On One Pump (seconds)
	<small>Parameter: P.454</small>	<small>Parameter: P.455</small>	

**Setup To Turn Off Pumps**

Pump Speed Lower Threshold	<input type="text" value="123.4"/> %	<input type="text" value="123"/>	Delay To Turn Off One Pump (seconds)
	<small>Parameter: P.456</small>	<small>Parameter: P.457</small>	

Minimum Pump Speed	<input type="text" value="12"/> %	
	<small>Parameter: P.458</small>	

[Next Screen](#)

## Control Setup

**CONTROL SETUP**

[Previous Screen](#)

**Pump Operation Enable  
Supply Level**

<input type="text" value="123.4"/> feet
<small>Parameter: P.459</small>

**Pump Operation Disable  
Supply Level**

<input type="text" value="123.4"/> feet
<small>Parameter: P.460</small>

[Next Screen](#)

## PRESSURE CONTROL - Touchscreen HMI SCREENS

### Control Setup

# CONTROL SETUP

[Previous Screen](#)

<p>Override Ramp Upper End Supply Level</p> <div style="border: 1px solid blue; padding: 5px; display: inline-block; font-size: 24px; margin-right: 10px;">123.4</div> feet
---

[Next Screen](#)

### Control Setup

# CONTROL SETUP

[Previous Screen](#)

<p>First Pump Start Delay</p> <div style="border: 1px solid blue; padding: 5px; display: inline-block; font-size: 24px; margin-right: 10px;">123</div> seconds
--

[Next Screen](#)

# PRESSURE CONTROL - Touchscreen HMI SCREENS

## Control Setup

### CONTROL SETUP

Previous Screen

**Pump Speed  
Acceleration Rate**

123

seconds / 100% speed  
(The time required to go from 0% to 100% speed.)

Parameter: P.166

**Pump Speed  
Deceleration Rate**

123

seconds / 100% speed  
(The time required to go from 100% to 0% speed.)

Parameter: P.167

Note:  
The Controller performs the Acceleration and Deceleration of the pump speed.  
The Accel and Decel Parameters on the VFDs should be set to values less than or equal to what is set above.

Next Screen

## Control Setup

### CONTROL SETUP

Previous Screen

**Level Input Select**

1

Parameter: P.133

- 1 = Analog Level Meter - ALM1 - Single or Dual Transducers
- 2 = Analog Level Meter - ALM2 - Single or Dual Transducers
- 3 = Analog Level Meter - ALM1 - Dual Transducers
- 4 = Analog Level Meter - ALM2 - Dual Transducers

Notes:  
Selection 1 - Level Input is Manually switched from ALM1 to ALM2 using a Discrete Input.  
Selection 2 - Level Input is Manually switched from ALM2 to ALM1 using a Discrete Input.  
Selection 3 - Level Input is Automatically switched from ALM1 to ALM2 upon a failure of ALM1.  
Selection 4 - Level Input is Automatically switched from ALM2 to ALM1 upon a failure of ALM2.

**Supply Level**

ALM1

123.4

feet

Parameter: Ld.02

Parameter: Ld.01

# PRESSURE CONTROL - Touchscreen HMI SCREENS

## Pump Alternation Setup

[Previous Screen](#)

### PUMP ALTERNATION SETUP

Forced Lead Pump Position  **Force Alternation**  Current Lead Pump

Parameter: P.129                      Parameter: Ad.01

0 = Alternate  
1 = Pump 1 Lead Pump  
2 = Pump 2 Lead Pump  
3 = Pump 3 Lead Pump  
4 = Pump 4 Lead Pump  
5 = Pump 5 Lead Pump  
6 = Pump 6 Lead Pump

#### Time Based Alternation (Internal Time Clock)

0 = Disabled  
60 = 1 hour  
480 = 8 hour  
1440 = 24 hour

minutes

Parameter: P.131

## Alarms Setup

[Previous Screen](#)

### ALARMS SETUP

#### Supply Level Alarms

High Level Alarm

feet

Parameter: P.102

Low Level Alarm

feet

Parameter: P.101

#### Discharge Pressure Alarms

High Discharge Pressure Alarm

psi

Parameter: P.394

Low Discharge Pressure Alarm

psi

Parameter: P.393