SyncroFlo

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Operational Overview and Controls Guide

Standard Two or Three Pump Type VFD Booster Controls

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BETTER CONTROL THROUGH SYSTEMS ENGINEERING

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I. PUMP SEQUENCING

The controller continuously monitors the pressure of the suction and system headers with a pressure transmitter for each. An optional paddle wheel flow sensor may be included to measure flow rate. In automatic operation, the controller will signal the appropriate pump(s) to start or stop based upon the sequencing described herein. It should be noted that all pumps follow the same speed control signal produced by the controller. Upon starting, the pumps will slowly ramp up to the appropriate speed to avoid overshoot. Once this startup sequence is complete, the pumps will always run at whatever speed is required to maintain the set point pressure. All pumps are protected by minimum run timers to prevent unnecessary cycling. Whenever a lag pump stops, a momentary drop in system pressure may occur, resulting in the remaining pump(s) to speed up temporarily to compensate. The pumps will stop in the reverse order from which they started.

A minimum run timer auto-adjust feature is available through the human machine interface. If enabled, the MRT will be automatically adjusted over a range from 30 seconds to 5 minutes. The function keeps the MRT as short as possible (30 seconds), unless any particular motor sees more than 3 starts in a 20 minute period. If a motor does see excessive starts, the MRT will automatically be increased by 1 minute. Conversely, if there are not excessive starts of any motor during the period, the MRT will automatically be decreased. If the function is disabled, the system will operate with a fixed MRT as set by the operator.

Please note that many of the set points described below are adjustable through the human machine interface (HMI). This is described in greater detail in both the Appendix 1 - Set Points section of this manual and the HMI manual.

A. Restart Sequencing

Anytime the system is reset from a complete alarm shutdown or after power is restored, pump sequencing is modified to help prevent water hammer. The lead pump will start on low system pressure as normal. However, there is a 10-second interval before each lag pump may start.

B. Lead Pump Sequencing

Through the HMI, the operator may choose to enable lead pump shut down or have the lead pump run continuously. If enabled, the lead pump will stop if no other pump is running, the lead pump minimum run time has expired, system demand/flow rate is very low (less than 10 gpm), and system pressure is within two pounds of the set point. As an alternate, if high suction pressure occurs (as measured by either a pressure transmitter or switch), the lead pump will stop.

If lead pump shut down is enabled and a HydroCumulator is supplied with the system, the operator may choose to charge the HydroCumulator and system an additional 10 psig before allowing the lead pump to stop. This will occur after the above-mentioned low demand conditions are met and will stop if system demand increases. This feature can be used to help conserve energy by allowing the HydroCumulator to meet system demand while the lead pump remains off longer.

In addition, the operator may set a lead pump shutdown/run schedule through the HMI (24 hour per weekday or weekend). The high suction pressure shutdown feature is independent of this schedule and will allow the system to shut down anytime high suction occurs.

The lead pump will start when system pressure drops several pounds below the desired system pressure (system pressure set point - pressure sequencing deadband).

C. Lag Pump Sequencing

If the capacity of the lead pump is exceeded, the lag pump will start after an adjustable time delay. A lag pump can start on low system pressure, high power usage, or high flow (if an optional paddle wheel flow sensor is included). If the capacity of the lead pump and lag pump is exceeded, the second lag pump (on three pump systems) will start. For pressure sequencing, the lag pump(s) will also start if *both* of the following conditions occur:

1) System pressure drops several pounds below the desired system pressure (similar to the lead pump)

and

2) The VFD speed is equal to or greater than the lag pump start speed.

Please note that the speed consideration for starting the lag pump can be effectively disabled by setting a low speed requirement (equal to minimum speed). Thus, the VFD speed would always be satisfactory and the lag pump(s) would simply sequence on low pressure. A relatively high value for this set point is recommended however, to ensure any running pump is near capacity before starting another pump.

The lag pump(s) will run for at least the duration of the minimum run time and then stop as demand recedes.

D. Sequence Alternation

The pumps will switch starting positions each time the lead pump either runs for 24 hours or has a non-alarm shutdown. They will also alternate starting positions if the lead pump has over 50 more hours of run time than the next pump in the sequence (if enabled through the HMI). If the lead pump is running at the time of alternation, it will continue to run for 10 seconds more with the new lead pump to help prevent water hammer.

II. SPEED CONTROL

A. Automatic PID Speed Control

In this mode, the booster system will automatically maintain desired system pressure. The controller uses the system pressure measurement from the system pressure transmitter and a proportional, integral, and derivative (PID) algorithm to maintain system pressure. As the pressure in the pipe decreases, the pump speed will increase until the pressure is returned to its set point value. If the pressure begins to rise above the set point, the pump speed will decrease

until the set point is reached.

Both the system pressure set point (SP) and process variable (PV - measured system pressure) are used to determine the speed of the pump(s). The controller uses a proportional, integral, and derivative (PID) algorithm to respond to changes in system pressure. All of the PID tuning constants are adjustable through the HMI. Proper settings ensure accurate and timely system response without overshoot or hunting. Any changes made in the field should be done so carefully and notes should be taken.

The larger the difference between PV and SP, the quicker the correction in speed. This effect is provided by the proportional part of the PID speed control algorithm. The integral part of the PID algorithm allows the controller to correct the speed based on the time accumulated difference between the PV and SP. The integral term is effective for closing in on the set point when the process is already very close to the set point and the proportional gain has little effect. For example, if the set point is 12 PSI and the PV is hovering at 11.5 PSI, the longer the PV remains at 11.5, the faster the speed of the pump will be increased. The derivative part of the PID algorithm allows the controller to anticipate a sudden surge in the system by correcting the speed based on the rate at which the process variable is changing. If the PV suddenly increases in a very short time, the derivative term will make a large correction in the speed to compensate. If the derivative gain is set too high, the system will oscillate (hunt), so it is generally best to keep the gain constant low for the derivative term.

There are minimum and maximum speed limits that can be set so that the pump is never operated above or below certain speeds. These values are set through the HMI.

B. Manual Speed Control

If the system pressure transmitter fails or the operator chooses, the controller will output a constant speed value to the drive, which can be adjusted by the operator using the HMI.

III. OPERATOR CONTROLS

The primary controls interface is the HMI, which allows access to the pump operation touch keys, status of the system, alarms, set points, and all transmitter measurements. The HMI is described in detail in the HMI manual.

On the main screen of the HMI, the operator has open access to pump selector switches and an alarm silence/reset push button (the alarm silence/reset push button is also on the alarm status screen). These devices are described below:

A. Pump Selector Switch

The pump selector switch is on the HMI. Each pump button must be pushed for half a second to take affect. A "HELP" button in the upper right corner also gives instructions.

"HAND" - Use for manual operation only - to start up, restart and reset, or test each pump. No

pump should run in this position without supervision.

"OFF" - Pump will not run at all. Use during start up, restart and reset, or when a pump is down for service.

"AUTO" - Automatic position for each pump, which allows the controller to have full control over the pumps operation.

B. Alarm Silence/Reset Push Button

Push once to silence the alarm horn, wait five seconds and push a second time to reset the system from alarm mode back to normal automatic operation. The system will not reset unless the original cause of the alarm(s) has been corrected or removed.

This button can also be used to defeat the minimum run time of the pumps and allow the lag pumps to turn off if they are not required to be running. This is a useful feature when testing or monitoring the system.

C. Alarm Horn

The horn sounds when an alarm condition occurs. It has a medium volume that is not adjustable. Its piercing sound can be easily heard in mechanical rooms.

IV. ALARMS

Several of the alarms described below feature adjustable set points. These can be adjusted using the HMI. This is described in greater detail in both the Appendix 1 - Set Points section of this manual and the HMI manual. Please note that each of the alarms described below, except as noted, will activate the alarm horn, post a scrolling alarm message on each screen of the HMI, and post an alarm status on the HMI.

A. Low Suction Pressure \ Level Alarm

If the low suction device (pressure switch, pressure transmitter, or level switch) signals a loss of supply water pressure for 5 seconds (default), all pumps will be locked off. This alarm and the system will be disabled in the event of a suction pressure transmitter failure.

The operator may select either manual reset or limited automatic reset of this alarm through the HMI. The procedure for manual resetting is described below. The limited automatic reset feature allows the controller to reset this alarm automatically up to three times in an hour after the low suction condition signal has cleared for one minute. If the alarm occurs four times in an hour, the automatic reset feature will be canceled and the alarm will require manual resetting.

B. Low System Pressure Alarm

If system pressure drops to or below the low system pressure set point for 30 seconds (default), this alarm will activate. System performance will not be affected by this alarm. It is used to alert the operator that a problem occurred. This alarm will be disabled in the event of a system pressure transmitter failure. The alarm requires manual resetting as described below.

C. High System Pressure Alarm

If system pressure rises above the high system pressure set point for 5 seconds (default), this alarm will activate. This alarm will be disabled in the event of a system pressure transmitter failure.

The operator may select either manual reset or limited automatic reset of this alarm through the HMI. The procedure for manual resetting is described below. The limited automatic reset feature allows the controller to reset this alarm automatically three times in an hour after system pressure returns to normal for 10 seconds. If the alarm occurs four times in an hour, the automatic reset feature will be canceled and the alarm will require manual resetting.

D. Pressure Transmitter Out of Range Alarms

The correct output range of the pressure transmitter(s) is 1 - 6 kHz. The pressure transmitter failed low alarm will activate if the controller receives an abnormally low signal for 2 seconds. The pressure transmitter failed high alarm will activate if the controller receives an abnormally high signal for 8 seconds. The system will run at the manual speed set point if the system pressure transmitter fails. If a suction pressure transmitter is included and fails, the system will be disabled. These alarms will automatically reset when the transmitter operates in its correct range.

E. Individual Drive Fault Alarms

If a fault occurs in the drive when it is being called to run, the VFD failure alarm will be activated. This alarm will stop the pump with the failed drive and start the next available pump if it is not currently running.

The operator may select either manual reset or limited automatic reset of these alarms through the HMI. The procedure for manual resetting is described below. The limited automatic reset feature allows the controller to reset this alarm automatically three times in an hour after the fault signal clears for 15 seconds. If the alarm occurs four times in an hour, the automatic reset feature will be canceled and the alarm will require manual resetting.

F. Irregular Power Alarm (optional)

If a power monitor is included with this system, it will protect the system from an abnormal main power condition. If irregular power is sensed, the system will shut down all motors until normal power has been restored for 10 seconds.

G. Power Failure Alarm

Each time the PLC is powered up, this alarm will occur. The previously described restart delay helps prevent water hammer as pumps are brought back online.

H. Manually Resetting Alarms

The reset push button can be found on the main screen of the HMI and also the alarm status screen. Before resetting an alarm, the alarm horn must first be silenced by pressing the alarm silence / reset push button. Five seconds after silencing the alarm horn, the system can be reset (provided the original reason for the alarm has been corrected).

I. Event History

This feature displays the last 200 events that have occurred on the system with record 0 being the most recent. An event is when any alarm occurs or the operator attempts to reset an alarm with the alarm reset push button. For each event record, the following information is provided:

1) Alarm Name
2) Date
3) Time
4) System Flow Rate (gpm) – if a flow sensor is provided, otherwise Suction Pressure (psig)
5) System Pressure (psig)
6) System Pressure Set Point (psig)
7) Pumps Running Status (0,1,2,3-if three pump system)

Please refer to the Human machine interface Manual for further details.

V. PROTECTION DEVICES

A. Operator Safety

The enclosure features door-interlocking motor disconnecting devices (motor starter protectors, fused disconnect switches, or circuit breakers). These prevent the opening of the panel while the motors are running. To open the control panel, turn off each of the motor disconnecting devices. Auxiliary contacts will de-energize the 120V control power if motor starter protectors or fused disconnect switches are provided. If circuit breakers are provided, a limit switch will de-energize the 120V control power. In either case, <u>high voltage may still exist in the panel.</u>

B. Motor Protection

Anytime a motor protection device trips, the cause of the problem should be determined before returning the motor to service. Each motor will be protected against overload and short circuit current by one of the following devices:

Motor Starter Protectors

If a MSP should trip due to over-current, the MSP handle will turn to an intermediate position between "ON" and "OFF". To reset the MSP, turn the handle to the "OFF" position and then back to "ON", similar to a tripped circuit breaker.

Fused Disconnect Switches

Dual-element fuses are provided for over-current protection.

Circuit Breakers

If a circuit breaker should trip due to over-current, the handle will turn to the "TRIP" position. To reset the circuit breaker, turn the handle to the "OFF" position and then back to "ON".

C. Control Circuit Protection

The control power transformer is sized according to the consumption of power of the controls. Fuses that are sized according to N.E.C. requirements for transformers protect the primary and secondary circuits.

D. Pump Over-Temperature Protection

Each pump is fitted with a temperature purge valve. If the water in a pump becomes too hot (at low flow), the valve will open. The hot water is then dumped to drain, allowing cool water to enter the pump from the suction side. Once the pump is cool again, the temperature purge valve will close.

VI. PROGRAMMABLE CONTROLLER

The controller features both non-adjustable and adjustable timers. The adjustable timers can be changed using the HMI. Please refer to the Human machine interface Manual for instructions on how to do this. A listing of the set points for all timers is provided in Appendix 1 - Set Points.

A. Status LEDs

The status of the PC can be determined by observing the LEDs on the face of the PC. To do this, the control panel door must be opened and the control circuits must be energized. The function of each LED is described below.
POWER - This LED should be illuminated continuously if control power is on.

RUN - This LED should be illuminated during normal operation. If this LED is off, make sure the switch under the small door to the left of the HMI connection is in the RUN position.

PROG-E / CPU-E - If this LED is flashing, then a program error is indicated. If it stays on continuously, a processor error is indicated. If turning power off and on cannot clear either of these errors, consult the factory.

IN / OUT - These individually numbered red LEDs turn on when their corresponding INput or OUTput point is on.

B. Program Changes

SyncroFlo will do all programming for the PC. Every phase of the program will have been tested with the entire machine at the factory. Final adjustments are made at start-up by factory trained personnel. If a program change is required, it will be made by SyncroFlo and transmitted to the field via a program loader or chip. SyncroFlo keeps a copy of the program at the factory so that any changes can be made and transmitted immediately.

C. Maintenance

The PC requires no routine maintenance. The program is stored on an EEPROM chip so that it will not be lost due to loss of power no matter how long the power is off.

A periodic check of the PC status lights will be sufficient to check for correct operation. The power and run status LEDs should always be on when control power is available. Testing all control functions to see if the PC performs as described can check the inputs and outputs. Remember that when an input or output contact is on, its status LED will be on.

D. Repairs

It is unlikely that a problem will develop with the PC itself. If a problem seems to be evident, call the factory for assistance. If it is determined that a problem does exist, a new unit can usually be shipped in 24 hours. Please note that if, for example, lightning struck the control panel and destroyed the PC, the pumps can still be run in the hand position while repairs are underway.

VII. REMOTE INDICATION

Indication of the low system pressure alarm, high system pressure alarm, low suction pressure / level alarm, and if a pump is disabled is provided. Normally open contacts close when these conditions occur. The contact ratings and acceptable voltages are shown on the schematics.

Appendix 1 - Set Points

A. Non-Adjustable Set Points

Reset Delay after Alarm Silence	5 sec.
Pressure Transmitter Failed Low Delay	2 sec.
Pressure Transmitter Failed High Delay	8 sec.
VFD Fault Delay	0 sec.

B. Adjustable Set Points

i. Time Delay Set Points

	Default	Range
Low System Press. Alarm Delay	30 sec.	10 - 60 sec.
Low Suction Press. / Lev. Alarm Delay	5 sec.	0 - 30 sec.
Tank Charge Timer (if shutdown enabled)	30 sec.	0 - 999 sec.
Pump Pressure Start Time Delay	5 sec.	2 - 30 sec.
Lag Pump Power Start Time Delay	2 sec.	2 – 30 sec.
Lag Pump Flow Start Time Delay (if provided)	2 sec.	2 - 30 sec.
Pump Minimum Run Time (Manual or Auto-Adjust Set)	300 sec.	30 - 300 sec.

ii. Pressure Set Points

	Default	Range
System Pressure	(See Sys. Data Sheet)	0 - 999 psig
Pressure Sequencing Deadband	5 psid	0 - 999 psid
Low System Pressure Deadband	10 psid	0 - 999 psid
High System Pressure Deadband	30 psid	0 - 999 psid
Low Suction Press. Alarm (if available)	5 psig	0 - 999 psig
High Suction Press. Stop (if available)	System Pressure + 1	0 - 999 psig

iii. Power Set Points

	Default	Range
Lag 1 On Power	See Factory Default Sticker (inside control panel door)	0 – 999 Hp
Lag 1 Off Power	See Sticker	0 – 999 Hp
Lag 2 On Power (if available)	See Sticker	0 – 999 Hp
Lag 2 Off Power (if available)	See Sticker	0 – 999 Hp

iv. Flow Rate Set Points (optional)

	Default	Range
Lag 1 On Flow Rate	One Pump Capacity	0 - 9999 gpm
Lag 1 Off Flow Rate	85% of Pump Cap.	0 - 9999 gpm
Lag 2 On Flow Rate (if available)	200% of Pump Cap.	0 - 9999 gpm
Lag 2 Off Flow Rate (if available)	185% of Pump Cap.	0 - 9999 gpm

v. Speed Control

	Default	Range
VFD Minimum Speed	30 Hz	15 – 60 Hz
VFD Maximum Speed	60 Hz	15 – 60 Hz
VFD Manual Speed	50 Hz	Min. - Max. Speed
Lag Pump Start Speed	50 Hz	Min. - Max. Speed

vi. PID Set Points

	Default	Range
Proportional Gain	500 %	1 - 32767 %
Integral Time Constant	30 decisec.	0 - 32767 sec./10
Derivative Gain	100 %	1 - 100 %
Derivative Time Constant	5 centisec.	0 - 32767 sec./100