ARMSTRONG

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SEQUENCE OF OPERATION
IPS Controller 9510 with Chiller Sequencing

General Information

The IPS Controller 9510 is designed to control the variable primary pumps and chillers in a hydronic distribution system and can be configured for a variety of process variables (inputs), and output signals. The details of the IPS Controller hardware configuration are detailed on the "IPS Controller 9500" project Submittal sheet. Output signals are to the variable frequency drives (VFD), VFD by-pass (if applicable), chillers, and optionally to the building management system (BMS). The following summarizes the range of input variable possible for each of the IPS Controller 9510 variants:

Possible (maximum) Input/Output (I/O) Variables* with chiller sequencing:

- ☐ IPS CONTROLLER 9511 (with up to 6 pumps and 5 chillers and 6 zones)
- ☐ IPS CONTROLLER 9512 (with up to 6 pumps and 5 chillers and 12 zones)
- ☐ IPS CONTROLLER 9513 (with up to 6 pumps and 5 chillers and 18 zones)

1. 18 analog inputs (AI) for zone differential pressure (DP) transmitter signals 4-20 mA
2. 1 AI for DP transmitter for primary pump run-out protection (if selected)
3. 6 digital inputs (DI) for up to 6 primary pump DP switches
4. 5 DI's for primary pump remote start/stop signals from up to 5 chillers
5. 6 DI's for VFD fault signals on up to 6 primary pumps
6. 1 digital output (DO) for alarm horn (buzzer)
7. 1 DI for alarm silencer
8. 6 analog outputs (AO) for VFD speed signals on up to 6 primary pumps
9. 6 DO's for up to 6 primary pump run signals
10. 5 DO's for alarms:
    a. pump/motor/VFD alarm,
    b. (b) DP transmitter alarm,
    c. (c) general system alarm,
    d. (d) primary pump fatal alarm,
    e. e) chiller alarm
11. 6 DO's for up to 6 VFD automatic bypass run signals on primary pumps
12. 6 AI's for primary motor temperatures selectable between NTC or PT1000
13. 6 DI's for VFD run feedback signals on primary pumps
14. 6 DI's for VFD Bypass run feedback signals on primary pumps
15. 5 AO's for primary and distribution flow measurement, kW, supply and return temperature sensors
16. 1 AO for bypass 2-way modulating valve
17. 1 serial port for communication with the BMS
18. 1 serial port for communication with the VFD's
19. 5 AI's for up to 5 chiller kW reading
20. 5 AI's for up to 5 chiller current (Amp) reading
21. 5 AO's for up to 5 chiller demand limit set-point
22. 5 DO's for up to 5 chiller start/stop run signal
23. 5 DO's for up to 5 chiller isolation valve ON/OFF
24. 5 DI's for up to 5 chiller isolation valve feedback signals

Optional Controller I/O*:

1. BMS communications serial port
2. VFD automatic bypass: In the event of a system failure due to VFD fault, the PLC shall automatically start the pump across the line. An alarm shall be displayed on the operator's interface indicating VFD failure. In case there is an overload trip on that pump across the line, automatically alternate to start the stand-by pump on VFD mode
3. 18 zones DP transmitters max (IPS CONTROLLER 9513)

*The details of the IPS Controller hardware configuration are detailed on the "IPS Controller 9500" project Submittal sheet.

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Processor Generic Logical Features:

1. Standard IPS Controller 9510 is supplied with 10.4" Human Machine Interface (HMI) or touch-screen
2. A schematic of the system is displayed on the HMI showing all variable speed primary pumps variables on the screen
3. Zone DP, system flow, kW input (consumption) and supply & return temperatures shall be displayed if applicable and when connected to the IPS Controller 9510
4. Monitor single zone differential pressure transmitter (up to 18 transmitters as an option remotely installed by contractor)
5. Compare each value to its set point. The zone that has deviated the most from its set-point shall be set as the controlling zone (see detailed specifications for multi-zone control)
6. PID control algorithm for pump speed control in PLC
7. Independent PID control loop for each remote signal
8. Monitor chiller(s)/boiler(s) minimum and maximum flows and control automatic modulating bypass valve
9. Stage primary pumps upon increase of system demands based on either maximum pump speed, pump BEP or wire-to-water efficiency program
10. Sequence chiller(s)/boiler(s) and their associated 2-way automatic isolation valves as required by system demand
11. Automatically disable any zone differential pressure signals that are not within limits and alert the operator of a possible transmitter failure
12. Motor speed would be switched to manual at speed set by the operator if all transmitters failed
13. Manual VFD bypass
14. Manual and automatic alternation of primary pumps based on hours of operation (1 week alternation)
15. Alarms shall include transmitters failure, pump/motor/drive failure, primary pump fatal alarms, and general system failure
16. Run-out protection on variable speed primary pumps based on DP or flow sensor (if selected)
17. 3 levels of password protection on operator interface

Active Zone Selection (Multi-zone) Logic:

The multi-zone controller will select a “control signal” from one of up to eighteen (18) signals (signal is the differential pressure, e.g. 40 KPa). Each signal is compared to its set point to calculate the “error from set point” (e.g. The set point might be 30 KPa, giving 40 – 30 = +10 KPa error from set point).

No zone shall have a –ve error. The eighteen “errors from set-point” would be compared to select which error would be used to determine the input to the speed control algorithm. The following logic would be used to select the zone signal error:

i. The controller will look constantly at all 18 error signals. If all errors are –ve then the zone with the highest negative error will be the controlling signal
ii. If all 18 errors are +ve then the controlling signal shall be the zone with the smallest positive error
iii. At the end of every 60 seconds the controller will switch to the active zone that has deviated the most from its set-point

Generic Process Sequence of Operation:

1. When IPS Controller is set to “Remote”, BMS sends signal to controller to start / enable lead chiller, lead condenser water, and associated primary lead pump.
2. When the IPS Controller is set to “Local” the lead chiller and associated primary lead pump will automatically be started.
3. Check that the chiller has been off for the length of time required by manufacturer before starting. If not, wait until off-time limit has expired (the chiller should have a 10 minute delay (adjustable) to restart after it was off).
4. Enable lead chiller and lead condenser water tower (signal to pump starter and tower fan VFD, tower fan speed determined independent of pump package controller).
5. In “Remote” or “Local” mode, the H-O-A switch must be in “A” position for the lead pump to start as per the sequence of operation.
6. The controller shall signal the lead chiller 2-way isolation valve to open first. Wait until time required for opening (adjustable), and/or until the controller can verify that the valve is open.
7. Check for flow through lead pump (DP switches).
8. The primary pump will adjust its speed to keep the flow above the startup flow required by the chiller.

9. If primary pump fails to start, an alternate pump shall automatically start and an alarm shall be sent to the BMS.
10. Once flow through pump has been proven and isolation valve proven fully open, turn ON lead chiller as follows:
11. Set demand limit on chiller to 30% (adjustable to chiller's manufacturer recommendation) and start chiller.
12. Wait two minutes (adjustable to chiller's manufacturer recommendation), and check to see that chiller is running through power usage.
13. After two minutes of operation (adjustable to chiller's manufacturer recommendation), switch gradually to normal chiller operation by raising the demand limit to 100% at a flow rate change of 10% per minute.
14. The Chiller is now running at normal operation.
15. Flow rate change shall be limited to 30% during chiller normal operation.
16. In normal operation when H-O-A switch is on "H" position then the pump will maintain a speed that the operator enters in the HMI. When the H-O-A switch is on "A" position then the controller will modulate the primary lead pump speed as required by system demands.
17. The system demand is based on the error between zone actual DP value and zone DP set-point.
18. The zone that deviates the most from its set-point will be the "active" zone.
19. The active zone is used to control the speed of the primary pump(s).
20. The controller will maintain the active zone differential pressure set-point.
21. If the active zone is not satisfied then the controller will increase the primary lead pump speed.
22. If CHWS flow through the chiller(s) exceeds 95% of the maximum rated flow of the operating chiller(s) for more than 5 minutes (field adjustable), or the temperature actual value exceeds set-point by 1.5°F for more than 15 minutes and lead pump speed is at 95% (adjustable), slowly open the lag chiller isolation valve and then start lag chiller with associated lag pump.
23. Once flow through lag pump has been proven and isolation valve proven fully open, turn ON lag chiller in the same sequence as 11-13 above.
24. After a chiller has been brought on-line, a timer starts to prevent from cycling ON and OFF.
25. The lag chiller shall run for a minimum of 15 minutes (adjustable) before it is shut OFF.
26. Controller shall de-stage lag chiller based on flow or RLA of chiller compressor.
27. Controller sends lag chiller disable signal, and after 60 second delay (adjustable); disable lag condenser water (tower fan VFD and pump).
28. Shut OFF lag chiller (recommended sequence below) and wait for 3 minutes (adjustable).
29. The following stop sequence is recommended:
30. Start by reducing the demand limit for the chiller to 30% (or to the manufacturer's minimum recommended chiller operating demand).
31. Wait for two minutes and then shut off the chiller.
32. Wait an additional three minutes and then close lag chiller 2-way isolation valve.
33. The controller shall reduce primary lead pump speed as control valves modulate towards the closing position to maintain light load demands.
34. Once the operating chiller minimum recommended flow has been approached (30% of chiller design flow, adjustable), the controller shall start to modulate the 2-way bypass valve open to maintain the minimum required flow through the operating chiller.
35. The flow shall be monitored by flow sensor in the chiller supply header. The set-point on the flow sensor shall be the required minimum flow rate through operating chiller(s).
36. VFD automatic bypass as an option: In the event of a VFD failure, the controller shall automatically start the pump across the line. An alarm shall be displayed on the HMI indicating VFD failure.
37. VFD automatic bypass feedback to IPS Controller confirming VFD bypass operation.
38. IPS Controller shall be capable of staging and de-staging secondary pumps when running on bypass.
39. In case there is an overload trip on that pump across the line, automatically alternate to start the lag pump on VFD mode.
40. Manual and automatic alternation of primary pumps based on hours of operation (1 week alternation adjustable).
41. Automatically disable any zone differential pressure signals that are not within limits and alert the operator of a possible transmitter failure.
42. Upon failure of all zone DP sensors the controller shall run the pump at a selected speed of 95% (adjustable) and shall send an alarm signal to the BMS.
43. When the DP sensor failure alarm has been reset the controller shall revert to VFD operation and scanning the zone DP signals to maintain their set-points.
44. Controller shall protect the pumps from running out on their curves and overloading the motors.
45. Upon a pump failure alarm the pump shall be stopped and locked out of service until the alarm is manually reset.

46. A pump failure alarm shall automatically replace the failed pump with the next pump in sequence (lag pump).
47. Alarms shall include transmitters failure, pump/motor/drive failure, and general system failure.
48. Wire-to-water efficiency shall be displayed on the HMI.
49. Pumps shall be staged and de-staged based on wire-to-water efficiency program and speed references shall be adjustable on site.

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