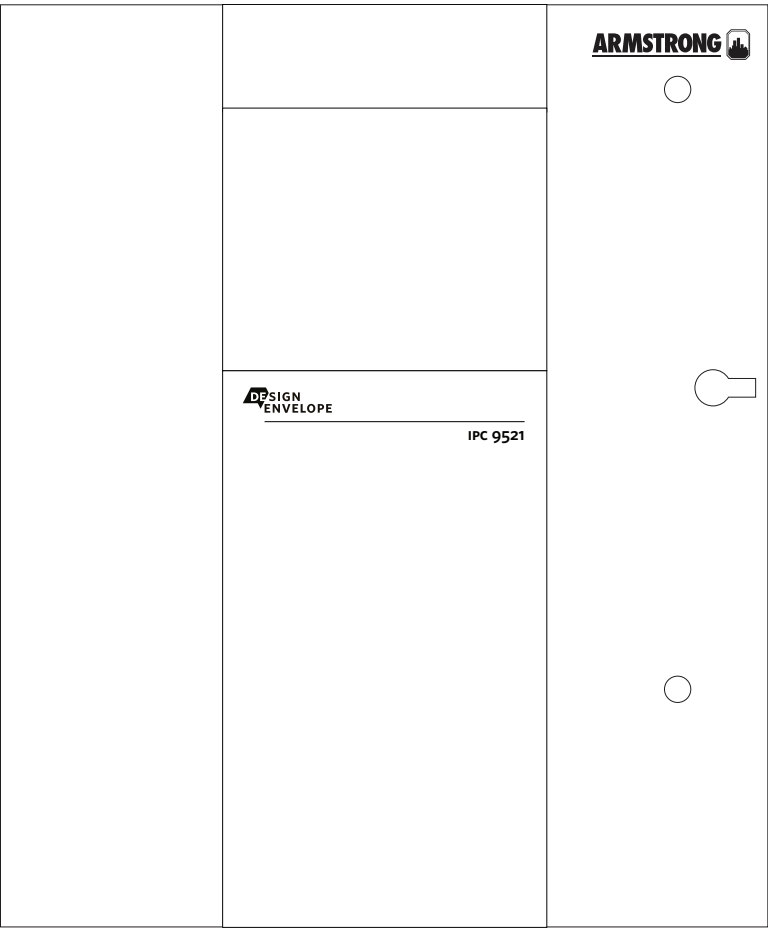

Design Envelope IPC 9521

Sequence of operation

File No: 90.912
Date: DECEMBER 15, 2014
Supersedes: NEW
Date: NEW

LIST OF ABBREVIATIONS:

ADJ: Field Adjustable
BAS: Building Automation System
HMI: Human Machine Interface

IPC 9521 CONTROL SYSTEM

The IPC9521 is comprised of two control panels (IPC9521 & ITC3600) with the following functionality:

- Operation of up to 5 chilled water pumps and up to 5 condenser water pumps, (Single, DualArm or Twin). Configuration can be Headered or Dedicated (only Dedicated configuration is available for DualArm and Twin pumps), and one pump can be selected as stand-by.
- Optional sensorless pump speed control for both set of pumps and Parallel Sensorless™ sequencing if headered.
- Control of up to 5 chillers.
- Control of up to 5 cooling tower fans.
- Monitoring of up to 5 zones.
- I/O interface to chilled water pumps and chillers, condenser pumps, cooling tower fans and sensors is capable of basic standalone operation and graphic interface, in case the main CPU becomes unavailable.
- Software and firmware upgrades don't require shutting down the plant.
- Touch screen HMI with graphical displays of the control system, trends and configuration with three levels of password protection.
- Option to control pumps, chillers and Chilled Water Set point from optimization module (Opti-Visor).
- BAS interface for Modbus RTU, Modbus TCP, BACnet MS/TP, BACnet IP or Lonworks.

OPERATION

All equipment must be set in **Auto** mode for the plant to work as described below. However, any individual equipment can be set to **Hand** or **Off** mode. Any equipment in **Hand** or **Off** mode is not operated by the automatic sequencing of the plant. Any pump placed in **Hand** mode starts immediately as long as the IPC is **On**. Any chiller placed in **Hand** mode immediately initiates its startup sequence as long as the IPC is **On**. Any valve placed in **Hand** mode allows the operator to select its position: open or close. If any equipment or sensor malfunctions, an alarm is time stamped and logged in the HMi and made available to be read by the BAS.

1 GENERAL SEQUENCE

1.1 When the IPC9521 control system is set to **Remote Start**, two conditions are required to turn On the control system: a command from the BAS (digital input from IPC3500 or serial communication signal) and the IPC switch set to Enable.

1.2 When the IPC9521 control system is set to **Local Start**, the IPC will turn On as soon as the IPC switch is set to Enable.

1.3 On both conditions (Remote and Local Start), the IPC will turn Off when the IPC switch is set to Off.

1.4 Emergency shutdown: if a refrigerant leak is detected or if the Emergency Stop push button is pressed, all operating chillers, pumps and fans are immediately stopped. An alarm is issued (**Refrigerant Leak alarm** or **Emergency Stop pressed**), and the IPC is locked out of operation until manually reset.

1.5 The operator is able to force the plant to be always enabled from the HMI.

1.6 The BAS is also able to enable/disable the plant overriding the IPC9521 logic.

1.7 Once the IPC is On, the lead chiller isolation valve is opened and the lead chilled water pump is started.

1.8 But the lead chiller is not started if the difference between supply set point and return temperature indicates there is little or no load.

1.9 Even if no chillers are running, as long as the IPC is enabled one distribution pump is kept running to circulate water. The pump speed is determined to maintain the differential pressure or temperature of up to 5 zones at or above set point, or by Sensorless™ control.

1.10 The bypass valve regulates its position to maintain the flow above one chiller minimum flow.

1.11 The Chilled Water Set point can be determined by 3 options:

1.11.1. Fixed (44°F adj.), manually entered on the HMI

1.11.2. Calculated based on the outdoor air temperature

1.11.3. Written by an external optimization module or the BAS

1.12 If the Supply Temperature climbs 1.5°F (adj.) over the Chilled Water Supply Temperature Set point, the IPC starts a chiller.

1.13 The plant load (in % and Tons or kWR) is shown in the HMI. The IPC uses this value to optimally Stage On and Off chillers.

1.14 To use ASHRAE 90.1 pressure reset, the position of the most open cooling valve must be provided by the BAS. Pressure/ temperature set points are then adjusted to maintain this position at 95% open (adj.)

2 CHILLED WATER PUMPS

2.1 The IPC can operate up to 5 chilled water pumps. Pump type can be single, DualArm or Twin. Their configuration can be headered or dedicated and, when it's headered, 1 pump can be selected as stand-by. Note: DualArm and Twin pumps can only operate in dedicated configuration.

2.2 The pumps are rotated periodically to balance their run hours.

2.3 Pumps in alarm are skipped by the sequencing logic and locked out of operation until manually reset.

2.4 Dual Arms are staged based on flow demand.

2.5 Pump speed can be selected to be determined by Zone demand sensors (differential pressure or return water temperature), Sensorless Control or an External command. In case of sensor fault, the speed is determined by safety constrains.

2.6 In an emergency shutdown, all operating pumps are stopped immediately.

3 CHILLER OPERATION

3.1 The IPC can control up to 5 chillers.

3.2 Once the plant is enabled and there is enough cooling demand, the Lead chiller is enabled.

3.3 The Lead chiller is rotated periodically.

3.4 Chillers in alarm are skipped by the sequencing logic and locked out of operation until manually reset.

3.5 The IPC stages **On** the chillers based on load, high supply temperature, high flow, high current and high kW.

3.6 The IPC stages **Off** the chillers based on load, low return temperature, low flow, low current and low kW.

3.7 Alternatively, if the user selects control from the optimization module, the number of chillers to operate is determined by the module, overriding the IPC logic.

3.8 Before a chiller is staged **On**, to prevent freezing the running chillers, their capacity is reduced via their demand limit input or by reducing the primary flow.

3.9 After a chiller is staged **Off**, it is kept out of the sequencing and its status is changed to **Not ready**, for the minimum time between chiller restarts (5 min adj.). After this time elapses, the chiller status changes to **ready** and it is incorporated into the sequencing.

3.10 After a chiller is staged **On** or **Off**, no more chillers are staged until the time interval after chiller staging (10 min adj.) expires.

3.11 Chillers are kept running for at least their minimum run time (10 min adj.), unless safeties require to stop them.

3.12 At any given time, the IPC maintains flow between the minimum and maximum required by the number of chillers running.

4 CHILLED WATER BYPASS AND EVAPORATOR ISOLATION VALVES

4.1 The chilled water bypass valve is controlled to maintain the minimum flow required by the running chillers.

4.2 If the flow meter fails, the bypass valve will open, until the alarm is reset.

4.3 The isolation valves open and close feedback can be enabled or disabled. If the open or close feedbacks are not detected when expected, an alarm will be issued.

5 CONDENSER WATER PUMPS

5.1 The IPC9521 can operate up to 5 condenser pumps. Pump type can be single, DualArm or Twin. Configuration can be headered or dedicated and, in the case of headered, 1 pump can be selected as stand-by. Note: DualArm and Twin pumps can only operate in dedicated configuration.

5.2 The total condenser flow is determined by either a flow sensor, the condenser pumps Sensorless flow readings, or a heat balance.

5.3 The condenser pumps speed is controlled to maintain the total condenser flow at the design value of the running chillers, unless the condenser pumps are dedicated and sensorless capable, in which case each pumps is controlled to maintain its flow at the design flow of its associated chiller.

5.4 If control from an optimization module is enabled, the IPC condenser pump control is overridden.

5.5 Condenser pump speed is limited by the minimum and maximum limits entered at the HMI.

6 COOLING TOWERS

6.1. The IPC9521 can operate up to 5 cooling towers with 1 fan drive each.

6.2 When the lead chiller is enabled and the condenser water temperature exceeds the minimum the chiller can take, the lead tower fan is enabled.

6.3 The number of tower fans running is selected to match the number of running chillers.

6.4 The IPC9521 stops all fans if the condenser water temperature drops below the minimum the chillers can take.

6.5 If all the fans fail, an emergency plant shutdown is initiated.

6.6 Make up and the blowdown water volumes are measured.

7 HMI. INFORMATION TO BE DISPLAYED IS DIVIDED IN FOUR CATEGORIES:

7.1. Operator screens

- **7.1.1** Source of control: Local or Remote
- **7.1.2** IPC9521 Status: On/Off
- **7.1.3** System overview graphic. This display adjusts to the selected configuration (i.e. number of pumps, number of chillers, piping configuration, number of zones, number of towers)
- **7.1.4** Plant enabled/disabled indicator
- **7.1.5** Chilled water temperature set point
- **7.1.6** Chilled water supply and return temperatures
- **7.1.7** Condenser water leaving and entering temperatures
- **7.1.8** Primary and condenser (if enabled) flow
- **7.1.9** Plant efficiency
- **7.1.10** Pump information: Running/Off/Alarm, Duty 1, Duty 2, Stand-by, etc.
- **7.1.11** Pump control: HOA switch, **Set as Duty 1** button
- **7.1.12** Fan control: HOA switch
- **7.1.13** Pump VFD information: Speed, Amps, Power, Volts AC, head & flow
- **7.1.14** Fan VFD information: Speed, Amps, Power, Volts AC
- **7.1.15** Chiller Information: Ready/Enabled/Started/Running/Shutdown/Alarm/Not Ready, Lead, Lag1, etc.
- **7.1.16** Chiller control: HOA switch, **Set as Lead** button
- **7.1.17** Chiller Isolation valves status: Open/Close/Alarm, Hand/Auto (for a header system only)
- **7.1.18** Cooling tower Isolation valve status: Open/Close/Alarm, Hand/Auto
- **7.1.19** Bypass valve status: Hand/Auto, percent opening
- **7.1.20** All enabled zones present value, set point and error. Indication of which one is the active zone
- **7.1.21** Pump, Fan and chiller hours of operation, as well as button to reset them

7.2 Alarm Screens

- **7.2.1** Alarms with time stamp
- **7.2.2** Alarm help
- **7.2.3** Alarm history
- **7.2.4** Diagnostic screen indicating firmware and station version
- **7.2.5** Alarm silencer button or digital input (from IPC3500) acknowledges alarms and silences horn

7.3 Setup Screens. There should be three levels of access:

- **7.3.1** Level 0. No password, allows view only access
- **7.3.2** Level 1. Operator use, allows changing the HOA mode of pumps and chillers and HA mode of valves. Allows changing Local and Remote, turning On and Off the IPS and resetting alarms.
- **7.3.3** Level 1. Allows operator use and modification of all parameters. Allows Restoring previously saved values (no saving)
- **7.3.4** Level 2. Allows operator use and modification of all parameters. Allows saving and restoring all parameters

7.4. Trends

- **7.4.1** Temperature sensors
- **7.4.2** Zone Sensors
- **7.4.3** Load
- **7.4.4** CHW and CW Pump speed
- **7.4.5** Fan speed
- **7.4.6** Chiller & pump kW consumption
- **7.4.7** Plant efficiency

8 BAS

8.1 The IPC9521 will allow communication by any of the following protocols: Modbus RTU, BACnet MS/TP, BACnet IP, BACnet Ethernet and Lonworks.

8.2 The following points will be available through all protocols:

- **8.2.1** Remote Start/Stop
- **8.2.2** IPC9521 On/Off Status
- **8.2.3** Enable/Disable plant
- **8.2.4** Chilled water supply and return temperatures
- **8.2.5** Condenser water leaving and entering temperatures
- **8.2.6** Chilled water and condenser flow

8.2.7 CHW & CW Pump information: Running/Off/Alarm, HOA switch, Duty 1, Duty 2, Stand-by, etc.

8.2.8 Fan information: Running/Off/Alarm, HOA switch

8.2.9 CHW & CW Pump VFD information: Speed, Amps, Power, Volts AC, Head, Flow.

8.2.10 Fan VFD information: Speed, Amps, Power, Volts AC

8.2.11 Chiller Information: Ready/Enabled/Running/Shut-down/Alarm/Not Ready, HOA switch, Lead, Lag1, etc.

8.2.12 Chiller Isolation valve status: Open/Close/Alarm, Hand/Auto

8.2.13 Cooling tower isolation valve status: Open/Close/Alarm, Hand/Auto

8.2.14 Bypass valve status: Hand/Auto, percent opening

8.2.15 All zones present value, set point and error. If a zone is not enabled the error should show 999.9

8.2.16 Active Zone present value, set point and error

8.2.17 Pump, fan and chiller hours of operation

8.2.18 Position of the cooling valve with the maximum opening

8.3. The IPC has the following Digital Outputs for BAS alarms (through IPC3500):

8.3.1 Sensor Alarm (any sensor alarm)

8.3.2 General Alarm (any alarm in the IPC)

TORONTO

23 BERTRAND AVENUE
TORONTO, ONTARIO
CANADA
M1L 2P3
+1 416 755 2291

BUFFALO

93 EAST AVENUE
NORTH TONAWANDA, NEW YORK
U.S.A.
14120-6594
+1 716 693 8813

BIRMINGHAM

HEYWOOD WHARF, MUCKLOW HILL
HALESOWEN, WEST MIDLANDS
UNITED KINGDOM
B62 8DJ
+44 (0) 8444 145 145

MANCHESTER

WOLVERTON STREET
MANCHESTER
UNITED KINGDOM
M11 2ET
+44 (0) 8444 145 145

BANGALORE

#59, FIRST FLOOR, 3RD MAIN
MARGOSA ROAD, MALLESWARAM
BANGALORE, INDIA
560 003
+91 (0) 80 4906 3555

SHANGHAI

NO. 1619 HU HANG ROAD, XI DU TOWNSHIP
FENG XIAN DISTRICT, SHANGHAI
P.R.C.
201401
+86 21 3756 6696

MAKING ENERGY MAKE SENSE™

ARMSTRONG FLUID TECHNOLOGY
ESTABLISHED 1934

ARMSTRONGFLUIDTECHNOLOGY.COM