



Sequence of Operations

CN-IC1-04

Title:

i-Controller (6-70 Ton) MPU Sequence Of Operations REV.201

i-Controller (6-70 Ton) MPU

Sequence of Operation Revision 201



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Unit Configurations

Tonnage	Compressors <i>(If Equipped)</i>	Condenser Fans <i>(Air-Cooled)</i>	Water-Cooled Condenser Coils	Evaporator Coils <i>(Refrigerant/Water)</i>	Outside Air Dampers (OAD)	Return Air Dampers (RAD)	Bypass Air Dampers (BAD)
6, 7, 8, 10	1	1	1	Single	1	1	1
9, 11, 13, 15	2	2	1	Single	1	1	1
14, 16, 18, 20	2	2	1	Single	1	1	1
25, 30	2	3	1	Single	1	1	1
26, 31, 40	4	4	1	Single	2 (Parallel)	2 (Parallel)	2 (Parallel)
50 - 70	4	6	2	Split	2 (Parallel)	2 (Parallel)	2 (Parallel)

Table 1. Unit Configuration Table

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Multi-Path Sequence of Operation

****Highlighted Values** in this document are configurable parameters, adjustable and set as needed on a site-by-site basis. The configuration values of these properties are stored in the i-Controller Parameters file.

The Multi-Path unit (MPU) sequence follows two modes of operation. The two modes of operation are based on Occupied (OCC) and Unoccupied (UNOCC) Time Schedules.

- Time Schedule: A list of times when planned events are to take place (e.g. opening and closing hours).
- Occupied (OCC): The hours when the store is open.
- Unoccupied (UNOCC): The hours when the store is closed.

The i-Controller is pre-configured with a default time schedule. The parameters file, unless specified by the customer, arrives with the default Time Schedule: Occupied at [9:00] am and Unoccupied at [9:00] pm. The time schedule is configurable allowing modifications as needed.

Network Communication

The i-Controller supports BACnet and Modbus protocols to communicate with the Building Management System (BMS). Modbus is the default communication protocol. If a BMS connection is not available, the FLO MPU is fully functional in stand-alone mode.

If a BMS connection is desired, the i-Controller will accept OCC/UNOCC, cooling/heating setpoints and Occupancy signal from the BMS master controller.

Smoke Detection and Unit Shutdown

A closed smoke detector input is required for MPU operation. When the input is closed, the unit will operate normally. When the input opens, the MPU will shut down. The opening of this input indicates an Emergency Shutdown condition has occurred. During an Emergency Shutdown an advisory entry will be generated and displayed in the alarm log.

In the event of a unit shutdown, all mechanical equipment (compressors, fans, heating module) will be disabled, and all dampers will be closed.

The following events will cause a unit shutdown:

- Smoke Detection
- Phase Loss Detection
- Drain Pan Overflow Detection
- Absence of a Digital Airflow Proof
- Simultaneous Space and Return Temperature Sensor Failure
- Network Disable Signal Initiated by the Building Management System

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Supply Fan Strategy

Variable Frequency Drive(s) (VFD)

The MPU is equipped with a Variable Frequency Drive (VFD) to control total air flow via the draw-through supply fan. The VFD runs continuously and will modulate between [50]-100% depending on the mode of operation. During Dehumidification or “Dehum + Cool” mode, the VFD will ramp down to allow for the return air damper position to reduce to its minimum position. This reduction provides more of a “Dual-Path” damper operation.

The VFD speed defaults are set as follows:

Mode	VFD %	
	Occupied (OCC)	Unoccupied (UNOCC)
Dehumidification ¹	[80%]	[50%]
Dehum + Cool ²	[90%]	[50%]
Heat	[100%]	[100%]
Cooling/Fan Only	[100%]	[50%]

Table 2. VFD% Operation per Mode

¹If the dew point in the space increases above the Unoccupied Dew Point Set Point + [2.0°F], the supply fan will gradually ramp up to the Occupied Dehumidification or Dehum + Cool VFD percent until the dew point is below set point.

²“Dehum + Cool” mode refers to Dehumidification mode with space temperature greater than the Cooling set point.

Airflow Switches and Fan Proof

The MPU is equipped with two airflow switches:

- **Digital Airflow Switch:** Provides a dry contact closure connected to the i-Controller and indicates airflow within the unit’s airstream. A fan ‘proof’ occurs when the input is closed. This switch is normally open (NO).
- **Mechanical Airflow Switch:** Provides a contact closure and completes the MPU safety circuit. This mechanical ‘proof’ and redundant safety requires verification at start-up.

NOTE: If a Fan Fail advisory is generated via the digital ‘proof’ input, a unit shut down will occur. The advisory must be manually cleared on the i-Controller Visograph display before the MPU will resume normal operation.

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Airflow Dampers

The Multi-Path design has three airstreams controlled by independent dampers. Each damper or set of dampers (in larger units) has a designated position for each mode of operation.

Outdoor Air Damper(s) (OAD)

- During OCCUPIED mode, the OAD damper(s) will open to the specified operating position. The set position is the maximum allowable outdoor airflow (including DCV if applicable) and is determined during unit start-up and air balance.
- During UNOCCUPIED mode, the OAD damper(s) will close completely or to a minimum position if specified.
- The OAD will close completely in the event of a unit shutdown (see *Smoke Detection and Unit Shutdown*), a controller power reboot, or return temperature control.
- When transitioning from closed or minimum position to open, the OAD damper(s) will gradually open over a [10]-minute period. This is referred to as 'Slow Open'.
- During Demand Control Ventilation (DCV), the OAD damper(s) will open an additional percentage.

Economizer Mode – Free Cooling

The Economizer Mode (Free Cooling Strategy) will use advantageous ambient conditions to provide cooling to the space when there is a demand. During Economizer Mode, all mechanical cooling (compressors, water-chilled coils, etc.) is locked out (no mechanical cooling will be used). This mode provides “free cooling” to the space to treat the sensible load while reducing energy consumption.

When the unit has a demand for Cooling Only, Economizer (ECON) Mode will compare the Ambient Temperature to the Cooling Setpoint. If the unit does not have an Outdoor Humidity Sensor, ECON mode will be initiated when the Outdoor Temperature is less than 55°F. If there the unit is equipped with an Outdoor Humidity sensor, when the Ambient Temperature is 10°F below the Cooling Setpoint and the Outdoor Dewpoint less than or equal to the Space Dewpoint Setpoint, ECON Mode will be enabled.

Once ECON mode has been initiated, the Outdoor Air Damper(s) will open to 100%. During ECON Mode, the space dewpoint and space temperature will be monitored in 30-minute intervals. If space dew point increases more than 1°F or space temperature does not decrease within 30-min, ECON mode will be disabled if ambient conditions allow and mechanical cooling will resume. ECON mode will remain active if compressors are locked out due to ambient conditions.

Once disabled, ECON mode will not be initiated again until a new cooling demand and all other ECON conditions are met.

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ECON Mode Initiation Parameters

Cooling Economizer mode is initiated when:

Unit has an Outdoor Humidity sensor:

- There is a Cooling only demand in the space
- Ambient Temperature(°F) < Space Cooling Temperature Setpoint(°F) - 10°F
- Ambient Dewpoint(°F) <= Space Dewpoint Setpoint(°F)

Unit does not have an Outdoor Humidity sensor:

- There is a Cooling only demand in the space
- Ambient Temperature(°F) < 55°F

ECON Mode Operational Parameters

During ECON Mode the unit will:

- Increase the OAD operational % to 100%
- ECON mode will be disabled if the demand is satisfied OR if within 30-minutes:
 - Space Temperature increases by 3°F or shows no change
 - Space Dewpoint increases by 2°F
 - ECON mode will not be allowed to run again after being disabled until the demand in the space has been cleared and there is a new Cooling Demand

Demand Control Ventilation (DCV) (if equipped)

If the CO2 level exceeds [800ppm], the OAD(s) will be opened past their current operating percentage/position. At a level of [1500ppm] or greater and a CO2 alarm will be generated. The additional OAD opening for high CO2 is set to a default value of [10%]. The additional percentage will be added incrementally to the current OAD position on a linear scale as the CO2 level increases from [800ppm] to [1000ppm] (e.g. at 900ppm, [5%] will be added to the OAD; at [1000ppm], [10%] will be added).

Return Air Damper(s) (RAD)

- The RAD(s) minimum opening is set to maintain the specified airflow for dehumidification. If space temperature increases above the cooling set point during dehumidification, the RAD(s) may open to the Dehum + Cool% [60%] for the fan to operate at the “Dehum + Cool” VFD setting.
- During slow open, the RAD positions for “Dehumidification” and “Dehum + Cool” will equal the RAD Min% + (OAD% Position Setting – Current OAD%) to maintain airflow across the cooling coil.

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Bypass Air Damper(s) (BAD)

- The BAD position will remain at open to its maximum position throughout dehumidification to allow for cooling coil bypass.
- The BAD will remain open to its minimum position for all other modes of operation.

Table 3 illustrates the expected damper positions for each mode of operation. Minimum and Maximum positions for each damper will be determined on a site-by-site basis.

Mode	Damper Position Table					
	Occupied (OCC)			Unoccupied (UNOCC)		
	OAD %	RAD %	BAD %	OAD %	RAD %	BAD %
Dehumidification	[20%]	[20%]	100%	[0%]	100%	[30%]
Dehum + Cool	[20%]	[40%]	100%	[0%]	100%	[30%]
Fan Only/Heat/Cool	[20%]	[60%]	[30%]	[0%]	100%	[30%]
DCV*	Current + [10%]	Current%	Current%	[10%]	Current%	Current%
Economizer*	100%	Current%	Current%	100%	Current%	Current%

Table 3. Damper Positions per Mode (*if Equipped)

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Dehumidification

Dehumidification takes PRIORITY OVER Comfort Cooling. Dehumidification is enabled based on the space dew point setpoint.

- (OCCUPIED) Space Dew Point > Occ Set Point [-0.5°F] = DEHUM ENABLE
- (OCCUPIED) Space Dew Point < Occ Set Point [-1.25°F] = DEHUM DISABLE
- (UNOCCUPIED) Space Dew Point > UnOcc Set Point = DEHUM ENABLE
- (UNOCCUPIED) Space Dew Point < UnOcc Set Point [-0.75°F] = DEHUM DISABLE

Compressor Operation:

- OCCUPIED MODE

Suction Group 1 (6 – 30-ton Units)

- Space Dew Point > Occ Set Point [-0.5°F] = DEHUM ENABLE (GROUP 1 Enable)
- Space Dew Point < Occ Set Point [-1.25°F] = DEHUM DISABLE (GROUP 1 Disable)

Suction Group 2 (31 – 70-ton Units)

- Space Dew Point > Occ Set Point [-0.50°F] = DEHUM ENABLE (GROUP 1 Enable)
- Space Dew Point < Occ Set Point [-1.75°F] = DEHUM DISABLE (GROUP 1 Disable)
- Space Dew Point > Occ Set Point [-0.25°F] = GROUP 2 ENABLE
- Space Dew Point < Occ Set Point [-1.25°F] = GROUP 2 DISABLE

- UNOCCUPIED MODE

6 – 30-ton Units

- Space Dew Point > [UnOcc Set Point] = DEHUM ENABLE (COMP 1 Enable)
- Space Dew Point < UnOcc Set Point [-0.75°F] = DEHUM DISABLE (COMP 1 Disable)

31 – 70-ton Units

- Space Dew Point > [UnOcc Set Point] = DEHUM ENABLE (GROUP 1&2 Enable)
- Space Dew Point < UnOcc Set Point [-0.75°F] = DEHUM DISABLE (GROUP 1&2 Disable)

Unoccupied Mode: the suction pressure set point is set to the minimum of the scale throughout dehumidification.

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Occupied Mode: the suction pressure setpoint is reset based on the space dew point behavior and distance from space dew point setpoint.

The suction pressure setpoint will be set to the maximum [118psig] of the scale upon initiation of dehumidification mode and will float towards the minimum of the scale [107psig] as the space dew point increases above set point.

Comfort Cooling

Comfort cooling is enabled based on the space temperature setpoint.

NOTE: Dehumidification takes PRIORITY OVER comfort cooling.

- (OCCUPIED) Space Temp > Occ Cool Set Point [+ 0.25°F] = COOL ENABLE
- (OCCUPIED) Space Temp < Occ Cool Set Point [- 0.75°F] = COOL DISABLE
- (UNOCCUPIED) Space Temp > UnOcc Cool Set Point [+ 0.25°F] = COOL ENABLE
- (UNOCCUPIED) Space Temp < UnOcc Cool Set Point [- 0.75°F] = COOL DISABLE

During Occupied and Unoccupied Mode, the suction pressure setpoint is reset based on the space temperature behavior and distance from cooling setpoint. The suction pressure setpoint will be set to the maximum [155psig] of the scale upon initiation of cool mode and will float towards the minimum of the scale [120psig] as the space temperature increases above set point.

Compressors

The Small Box MPU has one suction group with 1 or 2 compressors. Compressor one is a Copeland Digital Scroll with Modulating Capacity (1-5VDC). Compressor two (*if Equipped*) is a Copeland Scroll Compressor, ON/OFF (24VAC).

Tonnage	Digital Scroll Compressor(s) (1 – 5VDC)	Scroll Compressor(s) ON/OFF (24VDC)
6, 7, 8, 10	1	0
9, 11, 13, 15	1	1
14, 16, 18, 20	1	1
25, 30	1	1
26, 31, 40	2	2
50 - 70	2	2

Table 4. Compressor Type by Tonnage

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Compressor Safeties

Ambient Compressor Lockout: Dehumidification, Cooling and Compressors will be disabled if the Outdoor air temperature is below 42°F, and will remain locked out until the outdoor air temperature rises above 50°F.

NOTE: Compressors will not be locked out on Heat Pump units.

Chilled Water Coil *(if equipped)*

Chilled water cooling will provide cooling and dehumidification to the space when there is a demand present based on space temperature and dewpoint. ON/OFF valves will be used to control the flow of cold water through the chilled water coil.

Chilled Water Cooling and Dehumidification

Dehumidification and Cooling mode will be enabled/disabled, and cooling coil(s) will be staged ON according to the standard MPU sequence of operation.

For chilled-water coil operation, the pump will be enabled using the chilled-water pump digital ON/OFF output.

The valves will be opened to 100% regardless of valve type (fixed or modulating). The coil flow proof must be closed by the flow of water through the coil(s). The coil entering and leaving temperature sensors will be used to monitor coil operation. When the dehumidification or cooling demand in the space has been satisfied the chilled water enable and pump will be disabled.

Chilled Water Safeties

- **Coil Freeze Protection:** To protect the coil from freezing due to exposure of low-temperature ambient air, the following safety strategies are implemented:
 - If the Outdoor Air Temperature is below 35°F (OAT < 35°F)
 - Cooling mode will be turned ON until OAT > 40°F
 - If Space temp decreases below (Heating Setpoint + 0.5) and cooling is enabled due to safety
 - Close the Outdoor Air Damper (OAD) to 0% and disable Cool Mode
 - Re-enable Cool Mode and open OAD when Space Temperature increases above (Heating Setpoint + 2.5)
 - If during Unoccupied mode, the Return Air Temperature (RAT) will be used instead of OAT

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Chilled Water Coil Alarms

- **Water Temperature Alarm:** High coil entering water temperature when entering water temperature rises above 70F.
- **Flow Proof Alarm:** If cooling mode is activated and the Proof of Flow Switch does not close, an alarm will be generated, and all other unit operations will continue.

Heating

Heating is enabled solely upon space temperature setpoint. The heating setpoint is configurable to accommodate the desired space temperature control. When heating is enabled, heating stages are sequenced ON/OFF to maintain the space temperature to the heating set point.

NOTE: Heat Stage 1 will remain active throughout heat mode.

- (OCCUPIED) Space Temp < Occ Heat Set Point [- 1.0°F] = HEAT ENABLE
- (OCCUPIED) Space Temp > Occ Heat Set Point [+ 1.0°F] = HEAT DISABLE
- (UNOCCUPIED) Space Temp < UnOcc Heat Set Point [- 1.0°F] = HEAT ENABLE
- (UNOCCUPIED) Space Temp > UnOcc Heat Set Point [+ 1.0°F] = HEAT DISABLE

Heating Safeties

High Supply Temperature: If supply temperature is > [130°F], no additional stages of heating will be enabled.

Water Source Heat Pump (WSHP)

WSHP Discharge Pressure and Heating Setpoint

The heating discharge pressure setpoint is reset based on the space temperature's distance from the heating setpoint. When heating mode is initiated, the discharge pressure setpoint will be set to a (350psig minimum) of the scale and will float toward (450psig maximum) as the space temperature decreases below setpoint.

WSHP Reversing Valves

The reversing valve will default to Cooling Mode (ON) until a Heating Mode is activated (OFF). When Heating Mode is deactivated, the valve will return to Cooling Mode.

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WSHP Changeover Operation

When the WSHP mode changes from Heating to Cooling:

- Compressors are locked out (after minimum runtime has expired)
- Reversing valves changeover
- Upon proof of water-flow through the condenser, compressors will be unlocked to allow heating/cooling mode

NOTE: Heating mode will not be activated within 2-minutes of the termination of dehumidification mode.

WSHP Heat Reclaim *(If equipped)*

A WSHP heat reclaim coil is enabled:

- Heat is NOT active
- Heat Setpoint [$+2^{\circ}\text{F}$] < Space Temp < Reclaim Set Point = RECLAIM ENABLE
- Space Temp > Reclaim Set Point + [1°F] = RECLAIM DISABLE

NOTE: If heat mode activates while reclaim is active, heat reclaim will be disabled after the minimum reclaim runtime has expired.

WSHP Auxiliary Heat *(If equipped)*

WSHP with auxiliary heat: Auxiliary heating is enabled once compressor capacity has reached 100 percent for over 15 minutes. Once enabled, auxiliary heating stages are sequenced ON/OFF to maintain the space temperature to the heating set point. Auxiliary heating will be disabled once compressor capacity has reduced below 90 percent.

WSHP Safeties

Proof of Flow: The condenser(s) are equipped with a water flow proof switch to confirm water is flowing through the condenser and a proof of water-flow is required for compressors to operate.

Low Suction Mechanical Cut-Out: Low suction pressure mechanical cut-out occurs at 75psig.

High Discharge Pressure Mechanical Cut-Out: High discharge pressure mechanical cut-out occurs at 550psig.

Fast recovery: Opens the condenser valves to 100% during heating:

- Discharge pressure > 450psig
- Suction pressure > 106psig
- Gradual Compressor Shutdown (Digital Compressors Only) during heating:
 - If discharge pressure > 520psig, compressors will modulate down, or locked out if they are at their minimum percentage. When the discharge pressure decreases below 450psig, the compressors will be unlocked.

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- If the suction pressure < 90psig, the compressors will modulate down, or locked out if they are at their minimum percentage. When the suction pressure increases above 110psig, the compressors will be unlocked.

WSHP Alarms

- **Condenser Coil Flow Proof Alarm:** Alarm is activated if no flow is detected through the condenser coils within 30-seconds of opening the condenser valve above Min Flow %. This will lock out the compressor(s) linked to this condenser coil.
- **High Discharge Gradual Shutdown Alarm:** Alarm is activated when compressors are forcibly reduced due to high suction pressure in cooling or dehumidification mode.
- **Low Suction Gradual Shutdown Alarm:** Alarm is activated when compressors are forcibly reduced to low suction pressure in heating mode.
- **High Entering Water Temp Alarm:** Alarm is activated if, during cooling or dehumidification, the entering water temperature rises above 100°F. This will lock out the associated compressor(s).
- **Low Entering Water Temp Alarm:** Alarm is activated if, during heating, the entering water temperature sinks below 48°F. This will lock out the associated compressor(s).
- **Coil Freeze Protection Alarm:** Alarm indicates the OAD has reduced due to Supply Air Temp dropping below 42°F.

Pre-Heat (if equipped)

Pre-heat warms the Outside Air before it passes through the unit. Pre-heat is only active when the OAD is open.

- Ambient Temp < Preheat Set Point - 2°F = PREHEAT ENABLE
- Ambient Temp > Preheat Set Point + 2°F = PREHEAT DISABLE

Reheat Coil (if equipped)

The reheat coil(s) utilize compressor discharge heat to reheat the supply airstream throughout dehumidification. The coil(s) will only be enabled during dehumidification when the space temperature meets the following conditions:

Reheat Stage 1:

- Space Temp < [Reheat Set Point] = REHEAT ENABLE
- Space Temp > Reheat Set Point [+ 1.0°F] = REHEAT DISABLE

Reheat Stage 2:

- Space Temp < [Reheat Set Point] [- 0.8°F] = REHEAT 2 ENABLE
- Space Temp > Reheat Set Point [+ 0.2°F] = REHEAT 2 DISABLE

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Once enabled, the Reheat coil has a minimum run time of 8-minutes. As a default, the Reheat set point is set to the midpoint between the Occupied Heating and Cooling set point and can be adjusted if necessary.

Heat Reclaim Coil *(if equipped)*

Heat reclaim is a process where heat from the refrigeration rack is transferred to a coil located the MPU. Heat reclaim is used to raise the temperature of the supply air and will be enabled when the space temperature meets the following conditions:

- Space Temp < [Reclaim Set Point] = RECLAIM ENABLE
- Space Temp > Reclaim Set Point [+ 1.0°F] = RECLAIM DISABLE

Once enabled, the Heat Reclaim Coil has a minimum run time of 15-minutes. As a default, the Heat Reclaim set point is set to the midpoint between the Occupied Heating and Cooling set point and can be adjusted if necessary.

Hydronic Heating Coil *(if equipped)*

A hydronic heating coil is used to provide auxiliary heat to the space when there is a heating demand. ON/OFF valves will be used to control the flow of hot water through the coil.

The heating water coil pump will be enabled using the hot water pump digital ON/OFF output. The valves will be opened to 100% regardless of valve type (fixed or modulating). The coil flow proof must be closed by the flow of water through the coil. The entering and leaving temperature sensors will be used to monitor operation. When the heating demand in the space has been satisfied the water pump ON/OFF output will be disabled and the valve will close to 0%.

Hydronic Reheat Coil *(if equipped)*

In the event the hot water coil is to be used for reheating during dehumidification, the hydronic heating coil will be enabled during the following conditions:

- Space Temp < Reheat Set Point = HYDRONIC HEATING ENABLE
- Space Temp > Reheat Set Point [+ 1°F] = HYDRONIC HEATING DISABLE

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Hydronic Coil Safeties

- **Hydronic Heating Lockout Safety:** If the entering temperature of the Hydronic Hot Water Coil drops below 90°F, the Hydronic Heating mode will be locked out until the Entering Water Temperature rises above 90°F.
- **Dehumidification Safety:** If during Dehumidification mode, the suction pressure drops below 110psig, the reheat coil, if present, will turn ON.
- **Coil Freeze Protection:** To prevent the coil from freezing from exposure to low air temperatures:
 - During operation if Outdoor Air Temperature drops below 35°F (OAT < 35°F)
 - Heating mode will be turned ON until OAT > 40°F
 - If Space temp increases above (Cooling Setpoint – 0.5) and we are still heating due to safety
 - Close Outdoor Air Damper (OAD) to 0% and disable Heat Mode
 - Re-enable Heat Mode and open OAD when Space Temperature drops below (Cooling Setpoint – 2.5)
 - If this occurs during Unoccupied mode, Return Air Temperature (RAT) will be used instead of OAT

NOTE: Coil Freeze Protection will not be used in a Water Source Heat Pump with Hydronic Heating Unit.

Hydronic Coil Alarms

- **Water Temperature Alarm:** If Entering Water Temperature drops below 90°F, generate low entering water temperature alarm.
- **Flow Proof Alarm:** If heating mode is activated and the Proof of Flow Switch does not close, an alarm will be generated. Unit operation will continue.

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Condenser Control (*Head Pressure Control*)

Air Cooled Condenser

The Flō unit will modulate condenser fans to maintain proper discharge pressure throughout cooling and dehumidification. The following summarizes the condenser fan control sequence for each unit setup.

- **One Condenser Fan Setup:**
 - COMP 1 ENABLE = FAN 1 ENABLE
- **Two Condenser Fan Setup:**
 - COMP 1 ENABLE = FAN 1 ENABLE
 - COMP 2 ENABLE = FAN 2 ENABLE
- **Three Condenser Fan Setup:**
 - COMP 1 ENABLE = FAN 1 ENABLE
 - MAX DISCHARGE PRESSURE FOR COMPS 1 & 2 > 370psig = FAN 2 ENABLE
 - MAX DISCHARGE PRESSURE FOR COMPS 1 & 2 < 300psig = FAN 2 DISABLE
 - COMP 2 ENABLE = FAN 3 ENABLE
- **Four Condenser Fan Setup:**
 - COMP 1 ENABLE = FAN 1 ENABLE
 - COMP 2 ENABLE = FAN 2 ENABLE
 - COMP 3 ENABLE = FAN 3 ENABLE
 - COMP 4 ENABLE = FAN 4 ENABLE
- **Six Condenser Fan Setup:**
 - COMP 1 ENABLE = FAN 1 ENABLE
 - MAX DISCHARGE PRESSURE FOR COMPS 1 & 2 > 370psig = FAN 2 ENABLE
 - MAX DISCHARGE PRESSURE FOR COMPS 1 & 2 < 300psig = FAN 2 DISABLE
 - COMP 2 ENABLE = FAN 3 ENABLE
 - COMP 3 ENABLE = FAN 4 ENABLE
 - MAX DISCHARGE PRESSURE FOR COMPS 3 & 4 > 370psig = FAN 5 ENABLE
 - MAX DISCHARGE PRESSURE FOR COMPS 3 & 4 < 300psig = FAN 5 DISABLE
 - COMP 4 ENABLE = FAN 6 ENABLE

Water-Cooled Condenser (*if equipped*)

One water condenser is present per suction group. The condenser flow valves modulate to maintain the proper coil pressure throughout cooling and dehumidification. The minimum condenser flow rate will be set in the field during air balance. [default to 60% min flow %].

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No Demand: Condenser valve will remain closed if there is not a compressor demand.

Dehumidification/ Cooling:

- Condenser valve will open to [min flow %] as soon as a cooling/dehumidification demand is activated
- Condenser flow valve will modulate from [min flow %] to [85% open] to maintain the **discharge pressure setpoint**
- The discharge pressure setpoint will be set 15°F above the Entering water temperature (e.g. if the Entering Water Temperature is 90°F, the discharge pressure setpoint will be set to $90+15 = 105^\circ\text{F} = 337\text{psig}$)

The discharge pressure setpoint limits are (236psig minimum) and (450psig maximum). If the discharge pressure is below setpoint, modulate the valve closed. If the discharge pressure is above setpoint, modulate the valve open.

Heating (Heat Pump ONLY):

- Condenser valve will open to [min flow %] as soon as a heating demand is activated
- Condenser flow valve will modulate from [min flow %] to [85% open] to maintain the **heating suction pressure setpoint**
 - The heating suction pressure setpoint will be set 15°F below the entering water temperature (e.g. if the Entering Water Temperature is 68°F, the heating suction pressure setpoint will be set to $63-15 = 48^\circ\text{F} = 137\text{psig}$)

The heating suction pressure setpoint has a lower (108psig) and upper (170psig) limit. If the heating suction pressure is below setpoint, modulate the valve open, if heating suction pressure is above setpoint, modulate the valve closed.

NOTE: When the unit is equipped with a Water Reclaim Coil piped through the heat exchanger, the condenser flow valves will be opened to 100% during heat reclaim operation.

Water-Cooled Condenser Safeties

Compressor discharge temperature monitoring with condenser fast recovery: Fast recovery opens the condenser valves to 100%. It is triggered at [450psig] discharge pressure during cooling.

Flow Proof: Each condenser contains a flow proof switch to confirm water is flowing through the coil(s). Proof of flow is required before compressors will run.

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Water-Cooled Condenser Alarms

- **Condenser Coil Flow Proof Alarm:** Alarm is activated if no flow is detected through the condenser coils within 30-seconds of opening the condenser valve above Min Flow %. This will lock out the compressor(s) linked to this condenser coil.
- **High Entering Water Temp Alarm:** Alarm is activated if, during cooling or dehumidification, the entering water temperature rises above 100°F. This will lock out the associated compressor(s).
- **Low Entering Water Temp Alarm:** Alarm is activated if, during heating, the entering water temperature sinks below 48°F. This will lock out the associated compressor(s).

Remote Condenser (*Split-System*)

The MPU split-system is a unit where the condenser is mounted separately (remotely) from the Air Handling Unit (AHU). In the split-system design, the remote condenser will operate mechanically, according to the condenser manufacturer's specification and configuration. All condenser control will be disabled in the FLO unit controller. The AHU section of the split-system will house the unit controller, compressors and operate according to this sequence of operation.

Condenser Safeties

In the event of a discharge pressure transducer failure on circuit 1 or 2, fan 2 will activate when either compressor 1 or 2 enables. In the event of a discharge transducer failure on circuits 3 or 4, fan 5 will activate when either compressor 3 or 4 enables.

MPU Safeties

Compressor Equipped Unit Safeties

- Low suction pressure mechanical cut-out at 60psig
- High discharge pressure mechanical cut-out at 600psig
- Compressor anti-short cycling timer of 2-minutes when suction group is enabled
- Compressor discharge temperature monitoring with condenser fast recovery. The fast recovery is both electromechanical and an application within the controller.

Safeties Included with All Units

- Phase and brown-out protection: Upon detection of a phase issue, the monitor opens the secondary 24VAC circuit, disables the control circuit and causes a unit shutdown. If the condition clears, the phase monitor will auto-reset.

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MPU Alarms and Notices

The following alarms when detected, will be displayed in the i-Controller alarm log. All alarm timers are reset when alarms are manually cleared.

- **Clogged Filter Notice:** Alarm activated when the filters in the unit need to be replaced. Activated via a closure of the normal open clogged filter switch.
- **Fan Fail Alarm:** Alarm activated when the fan proof has not been made for more than 10-minutes. This alarm will cause a unit shutdown and must be manually reset in the Visograph.
- **Smoke Alarm:** Alarm activated when a smoke detection occurs. This alarm will cause the unit to shut down. Alarm is activated via an opening of the normal closed smoke detector input and is automatically reset upon closure of the input.
- **Drain Pan Overflow Alarm:** Alarm activated when the drain pan float switch detects an elevated level of condensate. This alarm will cause the unit to shut down after a 30-second delay. Alarm is activated via an opening of the normal closed drain pan float switch input and is automatically reset upon closure of the input.
- **Phase Loss Alarm:** Alarm activated when the digital phase monitor detects a fluctuation in the main unit power outside of the acceptable limits. This alarm will cause the unit to shut down after a 30-second delay. Alarm is activated via an opening of the normal closed phase loss input and is automatically reset upon closure of the input.
- **CO2 Notice*:** A high CO2 level notice is activated when the CO2 level in the space increases above the specified ppm limit (1500 ppm by default). The notice is automatically reset when CO2 level falls into the acceptable range.
- **Heat Alarm:** Alarm is activated if the supply temperature has not increased at least 5°F with at least 2-heat stages activated for [15]-minutes. Alarm is automatically reset upon heat mode disable.
- **Heat Reclaim Notice*:** Alarm is activated if the supply temperature has not increased at least 5°F after heat reclaim has been enabled for [15]-minutes. Alarm is automatically reset upon heat reclaim disable.
- **Sensor Failure Alarm:** Alarm is activated when one or more of the temperatures, transducer, humidity or CO2* sensors fail.
- **Refrigerant Leak Alarm*:** Alarm is activated if there is a leak in the store's refrigeration system. A digital signal is received from the refrigeration rack controller that signifies a leak has been detected. Once the signal is received, the OAD of the Flō unit will open to 100% to flush the store. The OAD will automatically return to normal operation once the refrigerant leak alarm has been resolved. Alarm is activated via a normal open network signal and is automatically reset upon an open signal. **If Equipped.*

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NOTE: Suction and Discharge Alarms are only present when the MPU is equipped with compressors.

- **Low Suction Pressure Alarm:** Alarm is activated when the suction pressure decreases below the lower pressure limit (80psig). Alarm is automatically reset when suction pressure increases above 100psig.
- **High Suction Pressure Alarm:** Alarm is activated when suction pressure stays above the current operation mode's acceptable limit for more than 10-minutes. All High Suction Alarms will automatically reset upon dehumidification and cool mode disable, or if the suction pressure falls below the acceptable limit.
- **High Discharge Pressure Alarm:** Alarm is activated when discharge pressure increases above 500psig while the compressor is enabled. Alarm is automatically reset when the discharge pressure falls below 450psig and there has been a compressor proof for at least 5-minutes.
- **Compressor Proof Alarm:** Alarm indicates the specific compressor is not running when enabled by the controller. Alarm will automatically reset when a successful proof is made.
- **Compressor High Discharge Trip Alarm:** Alarm indicates a compressor trip due to high discharge pressure. Alarm will automatically reset when a compressor proof is made.

Additional Functionality

Additional features available in the i-Controller that are not included in the core sequence of operation.

Return Temp Control

In the event the space temperature probe is not yet installed or is malfunctioning outside of the probe operating range, the return air temperature reading will be used as the space temperature control value. If the unit is under return temperature control, the supply fan will continue to operate per the current mode, the OAD will close completely, and the RAD and BAD will revert to Unoccupied mode settings.

If a DCV demand exists during Return Temp Control operation, the OAD will open incrementally according to the current CO2 levels. If the **RETURN** and **SPACE** temperature sensors fail, the unit will enter a **SHUTDOWN** mode.

Heat without Supply Temp

If the supply temperature sensor has not been installed or is malfunctioning, safety heat mode will be enabled if a heating demand is initiated. Once enabled, safety heat mode will activate 50% of the heat stages until the space (or return temp during a temporary start-up) temperature is satisfied.

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Set Point Limits and Adjustments

The OCC/UNOCC heating, cooling, and dehumidification set points are subject to the limits and requirements listed below.

- Heating set point limit: 50°F - 80°F
- Cooling set point limit: 60°F - 85°F
- Dehumidification set point limit: 48°F - 60°F

A minimum difference of 4°F between the heating and cooling set points is required to prevent the short cycling of operation modes. If the difference is less than 4°F, the set points will automatically adjust per the following rules:

- Outdoor Air Temp > 60°F: Heating Set Point = Cooling Set Point - 4°F
- Outdoor Air Temp < 50°F: Cooling Set Point = Heating Set Point + 4°F

Reheat/Reclaim setpoints must be less than 2°F below the OCC cooling set point, and 1°F above the OCC heating set point. The Reheat/Reclaim disable point (cutout) must also occur no greater than 1°F below the OCC cooling set point. If the inputted set point or cutout is not within these limits, the values will be automatically adjusted as follows:

- Reheat/Reclaim SP \geq Occ Cool SP - 1°F: Reheat/Reclaim SP = Occ Cool SP - 2°F
- Reheat/Reclaim SP < Occ Heat SP + 1°F: Reheat/Reclaim SP = Occ Heat SP + 1°F
- Reheat/Reclaim SP + Cutout > Occ Cool SP - 1°F: Cutout = Occ Cool SP - 1°F - Reheat/Reclaim SP

Sensor Offsets and Limits

A minor offset may be used to calibrate a sensor and improve its accuracy. However, if a sensor requires an offset outside the allowable range, the sensor must be replaced.

The allowable offset range for each sensor type is:

- Temperature Sensors: +/- 3°F
- Pressure Transducers: +/- 5psig
- Humidity Sensor: +/- 3%
- Dew Point Sensor: +/- 2°F
- CO2 Sensor: +/- 50ppm

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Run-Time Delays (*Equipment Timers*)

Mechanical equipment within the unit may require safety time delays to protect against erratic behavior and preserve the life of the equipment. Time delays can be implemented as a minimum run time delay, meaning the minimum amount of time the equipment is required to run before it can be disabled. The delays can also be implemented as an ON delay, meaning the minimum amount of time required before the equipment is activated. Below is a list of equipment time delays.

- Digital and ON/OFF Compressor ON Delay: 2-minutes
- Reclaim Minimum Run: 15-minutes
- Reheat Minimum Run: 8-minutes
- Heat Stage 2, 3, 4 On Delay: 5-minutes

Pre-Emptive Dehumidification

If the FLō unit is equipped with an Outdoor RH sensor, the option for pre-emptive dehumidification ramp-up is available. The ramp-up will occur during Occupied hours if the unit is not in dehumidification or heat mode, the OAD position is > 0%, and the outdoor dew point is [8.6°F] higher than the OCC Dew Point SP. If the ramp-up is initiated, suction group 1 will be enabled with a suction pressure set point of 120psig.

Load Shed

Electrical companies often offer rebates for reducing energy consumption during peak usage times. Load shed is an available option that reduces operation of the FLō unit when activated. A digital input or network signal can be sent to the controller to enable Load Shed mode. Once activated, the following will occur:

- Heat Stages 2, 3, & 4 are locked out for units with either gas or electric heat
- Compressor 2 is locked out
- The supply fan is reduced to Min%, and the dampers will revert to Unoccupied mode settings

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Energy Recovery Ventilation (ERV) *(if equipped)*

Energy Recovery Ventilation (ERV) is sometimes required for units with 100% outdoor air requirements. The ERV wheel exchanges energy between the incoming outdoor air and the exhausted return air. The exhausted air pre-conditions the outdoor air. The additional equipment required for this process includes: ERV Wheel, Power Exhaust, ERV Bypass*, and Store Exhaust*. The i-Controller ERV strategy also includes a Free Dehum Mode.

For the ERV strategy, the following sequence will take place.

The economizer will activate when there is a cooling or dehumidification demand in the space and OA Dew Point < 3.5°F below the OCC Dew Point Set Point, this mode is activated.

- ERV Wheel is activated during Occupied hours and anytime the OAD is open.
- Power Exhaust is activated during Occupied hours.

- If Free Dehum Mode is active:
 - ERV Wheel and Power Exhaust are disabled.
 - Store Exhaust* will be activated to help sweep the supply air across the store.
 - ERV Bypass* will open to provide pressure relief within the ERV chamber.
 - MPU compressors are locked out.
 - OAD will open to 80% minimum.

- If the Outdoor Air temperature dips below 10°F, the ERV defrost cycle will be initiated to ensure moisture does not freeze on the wheel surface. The defrost cycle proceeds as follows:
 - The ERV Wheel is activated for 5s to move to a new position.
 - The ERV Wheel is held in this position for 30-seconds with the Power Exhaust ON to remove moisture from the wheel.
 - After 30s, the ERV Wheel is activated again for 5s to move to a new position.
 - The above activation/pause steps are repeated 12 consecutive times to ensure moisture is removed from the entire wheel.
 - This defrost cycle will occur once every hour if the outdoor temperature remains below 10°F.

Return Air Power Exhaust *(if equipped)*

Return air power exhaust is an available option for MPU's. The power exhaust will operate according to the following sequence:

- The OAD is open and the end limit switch on the damper assembly is ON, the power exhaust is activated. If the exhaust fan is equipped with a VFD for variable power exhaust, the VFD will be set at minimum speed [20%].
- When the OAD closes and the end limit damper switch turns OFF, the power exhaust will be disabled.

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- During a Smoke Alarm event, the variable power exhaust will be enabled, and the fan speed will be set to maximum speed [100%].

Exhaust Fan Interlocks *(if equipped)*

Exhaust fan interlocks are available in the i-Controller. The interlocks signify that an exhaust source is active and activate the OAD to open and additional [X%]. This default percentage is set to [10%] and can be adjusted using the Visograph display. A maximum of 3 interlock signals can be sent as digital inputs or network signals to the i-Controller.

Thermostat Control 2-Stage *(if equipped)*

The MPU may be configured to operate using a 2-stage zone thermostat wired to the i-Controller. This configuration will allow for the control of:

- 2-stages of cooling (Y1, Y2)
- 2-stages of heat (W1, W2)
- Fan (G)
- Occupancy (OCC)

Dehumidification control will be based off the field installed zone temperature and humidity sensor that is wired to the i-Controller and controlled according to the standard MPU sequence of operation. Reheat, if equipped, will be enabled upon Dehumidification demand.

Occupancy can be determined by either an internal schedule configured on the Visograph display or by a physical input (OCC) on the i-Controller. This input can be from an external time clock, or an occupancy output from the thermostat.

Comfort Cooling

Comfort cooling is enabled based on zone thermostat and its space temperature setpoint.

NOTE: Dehumidification takes PRIORITY OVER comfort cooling.

During Occupied and Unoccupied Mode, the suction pressure setpoint is reset based on the inputs from the zone thermostat. The suction pressure setpoint will be set to the maximum [140psig] of the scale upon initiation of cool mode call from the thermostat (Y1) and a thermostat (Y2) demand will set the suction pressure to the minimum of [120psig] as the space temperature increases. In Dehum+Cool mode, the (Y1) demand will disable Reheat if equipped.

Heating

Heating is enabled based on zone thermostat and its space temperature setpoint. During Occupied and Unoccupied Mode, the demand from (W1 & W2) will enable / disable heating. W1, will enable 50% of the units heating capacity. W2, will enable 100% of the units heating capacity. Standard MPU heating safeties will apply and if supply temperature is > [130°F], no additional heating capacity will be enabled.

Fan

Fan is controlled with the zone thermostat (G) demand. During Occupied or Unoccupied times when there is a (G) demand, the unit will operate according to the standard MPU sequence of operations. Upon losing the (G) demand, the fan will continue to run for one minute and then the unit will go to standby mode and the fan will be shutoff.

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VAV Operation *(if equipped)*

**Applies ONLY to stores equipped with MPU VAV configuration.

The VAV setup utilizes the supply air from the Flō Multi-Path unit to treat the office and breakroom areas. The Flō unit will continue to operate based on the sales floor conditions, and the VAV damper, fan, and booster heater are used to maintain conditions for the VAV zones. The VAV heating and cooling set points are sent to the Flō controller from the Siemens controller via Modbus. The control temperature is set to either the office temperature, breakroom temperature, or an average of the office and breakroom temperatures if both spaces are being treated with the same VAV.

VAV Equipment

- Temperature probes in either the office, breakroom, or both areas
- 0-10V Fan in the VAV Box with a Fan Enable Input
- 2-10V Damper
- Booster Heater

VAV Fan Control

The VAV Fan is enabled whenever the VAV Damper is opened more than 60% and will continue to run until the damper closes to below 50%. The VAV Fan speed is initially set to 35% when the damper opening is greater than 55% and will remain at 35% until the damper closes below 50%. At damper positions above 55%, The fan will ramp to 100% as the damper position approaches 100%. If the VAV Booster heater is activated, the VAV Fan speed will default to 100%.

VAV Damper Control

If the VAV zones are demanding heating or cooling, the VAV Damper will modulate on a control loop to maintain the control temperature close to the current set point. If all temperature probes fail for the controlled zone, the VAV Damper position will remain at 15%.

The VAV Damper minimum is 15% unless the following exceptions exist:

- During Cool mode, if the Supply temperature is greater than the control temperature or the control temperature is less than VAV Cool SP – 0.2°F, then the damper minimum is set to 5%
- During Heat mode, if the Supply temperature is less than the control temperature or the control temperature is greater than VAV Heat SP + 0.2°F, then the damper minimum is set to 5%.

If the VAV Booster heater is activated, the VAV Damper position will default to 100%.

VAV Cooling

The Cool Set Point is received via the BMS. The cool set point must be between 60°F - 85°F.

Cooling is enabled based on the following conditions:

- Control temperature > [Cool Set Point] + 0.5°F = COOL ENABLE
- Control temperature < [Cool Set Point] – 0.5°F = COOL DISABLE

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Once Cooling mode is enabled, the VAV damper will modulate to maintain the current set point.

VAV Quick Cool Down

The VAV Quick Cool Down mode will be activated when all the following is true:

- Reheat or Heat Reclaim is active
- VAV Control Temp > [Cool Set Point] + 2°F

When the Quick Cool Down mode is activated, the reheat or heat reclaim coil will be disabled for 15-minutes every hour until the control temperature falls below the Cool Set Point + 2°F.

VAV Heating

The Heat Set Point is received via the BMS. The heat set point must be between 50 °F - 80°F.

Heating is enabled based on the following conditions:

- Control temperature < [Heat Set Point] - 0.5°F = HEAT ENABLE
- Control temperature > [Heat Set Point] + 0.5°F = HEAT DISABLE

Once Heating mode is enabled, the VAV damper will modulate to maintain the current set point.

VAV Booster Heat

The VAV Booster Heat mode is enabled based on the following conditions:

- Supply Temperature > 80°F:
 - Control temperature < [Heat Set Point] - 3.3°F = BOOSTER HEAT ENABLE
 - Control temperature > [Heat Set Point] - 2.7°F = BOOSTER HEAT DISABLE
- Supply Temperature < 75°F:
 - Control temperature < [Heat Set Point] - 0.3°F = BOOSTER HEAT ENABLE
 - Control temperature > [Heat Set Point] + 0.3°F = BOOSTER HEAT DISABLE

If the control temperature is below the above enable and there is no sensor failure, then the booster heater will be enabled.

Initially, the booster will only activate for 2-minutes. If after 2-minutes the control temperature is still below the booster enable set point, then the booster will continue to run until the control temperature is above the booster heat disable point. If the control temperature is greater than or equal to the booster set point after the initial 2-minutes, the booster heater will turn OFF until the control temperature falls below Booster SP - 0.5°F.



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VAV Temp Sensor Selection

For units requiring VAV functionality, either 1 or 2 temperature sensors can be used to control the VAV zone. If two sensors are selected, the VAV will be controlled based on the average of the two temperature readings. If only one temperature sensor is selected, only the reading from that probe will be used for control, and all sensor failure alarms for the second probe will be disabled.

For a one probe setup, the location of the sensor must be set in the Visograph. Refer to *TM-1004 i-Controller Visograph* manual for the step-by-step procedure.

This document is intended to provide a basic overview of the Flö unit operation and features. It does not include detailed explanations of all operational sequences or control parameters. The information included in this document is proprietary, confidential and is the property of Flö Energy Solutions. Flö Energy Solutions accepts no responsibility or liability for any damage to property, equipment or personal injury as a result of using this documentation or Flö products.