i-Controller (31-70 Ton) MPU

Sequence of Operation Revision 200

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****All highlighted values are adjustable and will be set on a site-by-site basis in the i-Controller Parameters file.**

Multi-Path Sequence of Operation

The Multi-Path unit follows two modes of operation based on the *Time Schedules*: OCCUPIED (Occ) defines the store open hours. UNOCCUPIED (UnOcc) defines the hours in which the store is closed. Any Time Schedule modification from the default time schedule is set upon store commissioning. 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.

Network Communication

The Flō i-controller has been configured to communicate with BMS controllers via Modbus or BACNET. The Flō unit will run stand-alone if a BMS is not connected. If a BMS connection is desired, the i-controller will accept Occupied/Unoccupied cooling and heating setpoints, as well as the Occupancy signal from the BMS controller.

Smoke Detection and Unit Shutdown

There is at least one input for a smoke detector in the Multi-Path unit. When this input is closed, the unit will operate normally. If the input opens, the Multi-Path unit will shut down, as an Emergency Shutdown condition has been encountered and an advisory will be generated.

In the event of a unit shutdown, all mechanical equipment (compressors, fans, heating module) will be disabled, and all dampers will close. The following events can 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 or a network disable signal initiated by the building management system.

Fan Strategy

Variable Frequency Drive (VFD)

The Flō Unit is equipped with a Variable Frequency Drive (VFD) to control total air flow. The VFD runs continuously at speeds ranging from 50-100% depending on the mode of operation. During Dehumidification or "Dehum + Cool" mode, the VFD will ramp down to 80 or 90% to allow for the return air damper position to reduce to its minimum. This reduction allows for more of a "Dual-Path" damper configuration. The VFD speed defaults are set as follows:

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

Table 1. VFD % Operation per Mode

[1]If the dew point in the space increases above the Unoccupied Dew Point Set Point + 2.0 ˚F, the supply fan will slowly 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

There are two airflow switches installed in every Multi-Path Unit:

- The Digital Airflow Switch is connected to the controller and indicates a fan 'proof' when closed (normally open switch).
- The Mechanical Airflow Switch also provides a fan 'proof' and is verified and set at start-up.

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 Visograph before the Multi-Path unit will attempt to run again.

Airflow Dampers

The Multi-Path design has three airflow dampers. Each damper has a designated position for each mode of operation.

Outdoor Air Damper (OAD)

- During OCCUPIED mode, the OAD will open to the specified operating position. The set position (20%) is the maximum allowable outdoor airflow (including DCV if applicable) and is determined during unit commissioning and air balance.
- During UNOCCUPIED mode, the OAD will close completely or to a minimum position (0%) if specified.
- The OAD will close completely in the event of a unit shutdown (see *Smoke Detection and Unit Shutdown* section for specific conditions), a controller power reboot, or return temperature control.
- When transitioning from closed (or 0%) to open, the OAD will slowly open over a 10-minute period.
- During a Demand Control Ventilation (DCV) call, the OAD will open an additional 10% during Occupied or 10% during Unoccupied.

Return Air Damper (RAD)

- 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.
- The RAD minimum opening is set to maintain the specified airflow for dehumidification. If space temperature increases above the cooling set point during dehumidification, the RAD may open to the Dehum + Cool% (60%) for the fan to operate at the "Dehum + Cool" VFD setting.

Bypass Air Damper (BAD)

- The BAD position will vary to allow for cooling coil bypass with maximum setting for dehumidification.
- The default minimum BAD position is set to 30%.

Table 2 illustrates the expected damper positions for each mode of operation. Min and Max positions for each damper will be determined on a site by site basis.

	Damper Position Matrix					
	Occupied			**Unoccupied**		
Mode	**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%

*If Equipped.

Table 2. Damper Positions per Mode

Demand Control Ventilation (DCV) (*if equipped)*

If the CO2 level exceeds 800ppm, the OAD will be opened past its current operating position. At a level of 1500ppm or greater, the CO2 alarm will activate. The additional OAD opening for a CO2 call is set to a default value of 10%, and can be adjusted during unit commissioning. The additional value will be added incrementally to the current OAD position on a linear scale as the CO2 level increases from 800ppm to 1000ppm (i.e. at 900ppm, 5% will be added to the OAD; at 1000ppm, 10% will be added).

Compressors

This Multi-Path Small Box unit contains one suction group containing 1-2 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). Compressors will be disabled if the Outdoor air temperature dips below 42 ˚F, and will remain locked out until the outdoor air temperature increases above 50 ˚F.

Dehumidification

Dehumidification takes priority over Comfort Cooling and is enabled based on the space dew point setpoint. The following describes the mode and compressor operation throughout dehumidification.

- OCCUPIED MODE

Suction Group 1:

  - Space Dew Point > Occ Set Point – 0.75 ˚F = DEHUM ENABLE (GROUP 1 Enable)
  - Space Dew Point < Occ Set Point – 1.75 ˚F = DEHUM DISABLE (GROUP 1 Disable)

Suction Group 2:

  - 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

  - 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)

During Unoccupied Mode, the suction pressure set point is set to the minimum of the scale throughout dehumidification. During 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 of the scale upon initiation of dehum mode, and will float towards the minimum of the scale as the space dew point increases above set point.

Comfort Cooling

Comfort cooling is enabled based on the space temperature setpoint. Note that dehumidification will take 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 (155psi) of the scale upon initiation of cool mode, and will float towards the minimum of the scale (120psi) as the space temperature increases above set point.

Heating

Heating is enabled solely upon space temperature. The heating setpoints can be changed to accommodate the desired space temperature control. Once heating is enabled, the heating stages are controlled to maintain space temperature at the heating set point. Heat Stage 1 will remain active throughout heat mode. Additional heat stages can only be enabled if the supply temperature is below the high limit (130 ˚F). Typically, there are four stages of heating for all Multi-Path Units. Typical heating safeties are applicable to all Multi-Path Units: high limit switches, roll back switches, pressure differential switches, etc.

- (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

Reheat Coil *(if equipped, Enables 3-Way Valve in Flō unit)*

The reheat coil is used to reheat the supply airstream throughout dehumidification. It is enabled only during dehumidification when the space temperature meets the following conditions:

Reheat Stage 1:

- Space Temp < Reheat Set Point = REHEAT 1 ENABLE
- Space Temp > Reheat Set Point + 1.0 ˚F = REHEAT 1 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

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 Control *(if equipped)*

The heat reclaim coil is enabled anytime 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.

Head Pressure Control – Condenser Fan Control

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.

- 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 > 370psi = FAN 2 ENABLE
  - MAX DISCHARGE PRESSURE FOR COMPS 1 & 2 < 300psi = FAN 2 DISABLE
  - COMP 2 ENABLE = FAN 3 ENABLE
  - COMP 3 ENABLE = FAN 4 ENABLE
  - MAX DISCHARGE PRESSURE FOR COMPS 3 & 4 > 370psi = FAN 5 ENABLE
  - MAX DISCHARGE PRESSURE FOR COMPS 3 & 4 < 300psi = FAN 5 DISABLE
  - COMP 4 ENABLE = FAN 6 ENABLE

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. If a discharge transducer were to occur on circuits 3 or 4, fan 5 will activate when either compressor 3 or 4 enables.

Safeties

Refrigeration Safeties

Safeties are applicable to all Flō Units:

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

Phase Loss Control Safeties

All Multi-Path Units are equipped with a phase and brown-out protector. Upon detection of a phase issue, the protector opens the secondary 24VAC circuit disabling the control circuit of the Multi-Path Unit and causing a unit shutdown. The phase monitor will auto-reset.

Alarms

The following alarms will be detected and reported by the Flō unit controller. When alarms are manually cleared, all alarm timers will be reset.

- **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.

- **Low Suction Pressure Alarm:** Alarm is activated when the suction pressure decreases below the lower pressure limit (80psi). Alarm is automatically reset when suction pressure increases above 100 psi.

- **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 500psi while the compressor is enabled. Alarm is automatically reset when the discharge pressure falls below 450psi 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 indicates a compressor trip due to high discharge pressure. Alarm will automatically reset when a compressor proof is made.

- **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 is activated when one or more of the temperature, 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.*

Additional Functionalities

This section explains additional functionalities available in the i-Controller that are not included in the core sequence of operation.

Temporary Start-Up/Faulty Space or Supply Temp Sensor

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.

Safety Heat without Supply Temp

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

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 2.0 ˚F below the OCC cooling set point, and 1.0 ˚F above the OCC heating set point. The Reheat/Reclaim disable point (cutout) must also occur no greater than 1.0 ˚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 >= 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 Offset Rules

Sensor calibration is critical to the performance of the Flō unit. During unit commissioning, an offset may be set on each sensor reading to ensure calibration. However, if the sensor requires an offset outside of allowable range, replacement of the sensor is recommended. The allowable offset range for each sensor type is listed below.

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

Test and Setup Modes (Unit Commissioning)

Automated test modes are available in the i-Controller to assist in unit operation verification/commissioning. The following test modes are accessible through the Visograph located in the control cabinet. Please refer to *TM-1001 i-Controller Visograph Manual* for specific instruction.

Once activated, each mode has a maximum duration of 30 minutes with the exception of Air Balance Mode that has a maximum duration of 2 hours. The Slow Open function of the OAD is ignored when test modes are activated. Below is a description of each test mode. All test modes are still subject to the alarms and safeties listed above.

- **Occupancy Test Mode:** This mode can be used to test unit response during Occupied and Unoccupied hours.

- **Dehumidification Test Mode:** This mode can be used to test unit response to a space dehumidification call. When activated the space temperature and humidity will be overridden to 72˚F and 70%, resulting in a dew point reading of 70˚F. To ensure the compressors initiate, the suction pressure will be overridden to 150psi if ambient conditions are above compressor lockout conditions.

- **Cooling Test Mode:** This mode can be used to test unit response to a space cooling call. When activated the space temperature and humidity will be overridden to 81.5˚F and 15%. To ensure the compressors initiate, the suction pressure will be overridden to 170psi if ambient conditions are above compressor lockout conditions.

- **Heating Test Mode:** This mode can be used to test unit response to a space heating call. When activated the space temperature and humidity will be overridden to 58.5˚F and 15%.

- **Gas Pressure Check Mode:** This mode can be used to aid in the gas pressure setting process during unit commissioning. When activated, all available heat stages will be overridden on.

- **Air Balance Mode:** This mode can be used to aid in the air balancing process during unit commissioning. When activated, the OAD will initially be set to 0% for supply fan balancing with the RAD and BAD set to Unoccupied fan only positions. For outdoor air balancing, the OAD will open to the default 20% with the RAD and BAD set to Occupied Fan Only mode positions. The OAD position can then be modulated open or closed to achieve the desired outdoor air flow. Please refer to the *TG- 0703 i-Controller Air Balancing Guide* for the step-by-step procedure.

Equipment Timers

Mechanical equipment within the Flō unit may require safety time delays to protect against erratic behavior and preserve the life of the equipment. The 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 once called for by the controller. 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