



Walmart CO2 Pump Skid Control Sequence of Operation Rev 3.1_10OCT2024

**All setpoints and time delays listed in this document shall be exposed for manipulation at the Carel
CpCO display**

CO2 Pump Skid

The CO2 Pump Skid is a stand-alone assembly piped to a -26°F SST DX refrigeration rack liquid and suction line, similar to a conventional refrigerated fixture. The Skid consists of two pumps (operated in Run/Standby fashion), a CO2 Liquid-Vapor Separator (LVS), four thermosiphon heat exchangers (HX) or evaporators and associated piping/valves and controls. The Skid is designed to supply -10°F liquid CO2 to the fixtures. The DX portion of the Skid consists of two suction and liquid connections from the existing refrigeration rack that each branch into 2 identical parallel circuits at the Skid for flow through the Heat Exchangers (HX). Skid DX circuits receive liquid refrigerant from the refrigeration rack to an Electronic Expansion Valve (EEV) for each HX. The thermosiphon HX draws CO2 vapor from the top of the LVS and gravity returns -20°F liquid CO2 back into the LVS. The suction vapor from the primary refrigerant side of the HX flows back to the suction side of the DX refrigeration rack.

Piping to the fixtures for the liquid CO2 is separate from the DX circuit. Liquid CO2 piping connects to the skid pump outlet (supply), then continues to the fixtures, and finally completes the loop back to the inlet (return) of the LVS. In normal operation the pumps continuously circulate -20°F liquid CO2 through this loop. The loop supply and return piping will branch to each designated fixture to provide cooling to the fixture. Each fixture has temperature control via solenoid valve from a remoted mounted case controller (by others) to maintain appropriate fixture temperature.

The Skid shall incorporate a Carel CpCO controller to operate all CO2 skid functions, with the exception of HX control which will be handled by standalone superheat controllers mounted inside control enclosure.

CO2 Liquid Pump Control

CO2 Liquid pumps shall be enabled in lead/lag fashion in normal operation to continuously circulate liquid 24x7, provided there is sufficient liquid present in the LVS so as not to run the pumps dry and cause damage. A transducer mounted at the LVS shall determine when the fluid pressure is sufficient to safely operate the pumps. Pumps shall rotate lead/lag position every Wednesday at 9am. Should lead pump fail, lag pump will enable to allow for liquid CO2 flow to the fixtures.

Logic to enable the Skid pumps if all the following are true:

- Skid local On/Off switch is closed to the ON position.
- Liquid-Vapor Separator pressure is greater than 160 psig for 10 minutes, disabled below 150 psig, no time delay
- Liquid-Vapor Separator Transducer is less than 300 psig, no time delay, disabled above 325 psig, no time delay.
- Low Liquid-Vapor Separator switch is closed, indicating liquid present in the LVS.

Once enabled the pump variable speed reference will be set to a fixed speed with no modulation required.

VFD Run Light or output will close when the respective pump is enabled.

VFD Fail Light output will close when the respective Pump VFD Fail input closes.

Should the CpCO controller fail, one VFD must be put in hand and set to the speed determined appropriate during the flow setting procedure. The EEV enable contacts must be jumpered to for the required number of EEVs to operate. It is best to start with EEV1a, and then add one at a time once the jumpered circuit(s) are loaded according to the EEV position.

Heat Exchanger

The heat exchangers are broken into a total of four refrigerant circuits, each utilizing an EEV controlled by an Emerson Superheat controller. Early design iterations also included a normally closed liquid line solenoid with a manual lift stem enabled in unison with the EEV controller. In normal operation, CpCO will stage the EEVs to maintain -10°F to -20°F supply fluid according to the Supply Temp Setpoint. The EEV controller will maintain superheat at 6°F on each respective HX circuit, based on suction temp and pressure values as read by the Emerson controller, with a provision for full off pumpdown should CO2 liquid supply temperature drop below -25°F.

With circuit enabled and EEV controlling SH, should SH drop below 1°F and remain so for 30 seconds, EEVs are disabled, returning to operation at 5° SH.

EEV staging is allowed when:

- Skid On/Off switch is ON.
- Supply Liquid CO2 Temp is above -18°F, disabled below -22°F (for a supply temp setpoint of -20°F)
- Suction pressure proof from Refrigeration Rack that at least one compressor is running, disable if SST exceeds 0°F, re-enable when SST falls below -5°F.

If LVS saturation temp exceeds the LVS SST setpoint plus the differential to start, one circuit will be enabled and an interstage delay timer begins to count. Once the first circuit is enabled, additional circuits will be enabled if all currently active circuits have EEV position above the Stage Up Threshold for 30 seconds. One circuit will be staged off if all currently active circuits have valve positions below the Stage Down Threshold for 30 seconds.

Any circuit whose superheat falls below 1°F for 30 seconds will be disabled until the superheat rises above 5°F. All circuits will be disabled for one minute, at 8am on Wednesday morning, to allow the EEV driver to recalibrate to the current EEV position.

Circuits are staged in order 1a, 1b, 2a, and 2b. If a circuit is unavailable due to low superheat, communication or sensor fault, the next available circuit in the sequence will be staged on.

Monitor Inputs

The following inputs are monitor only, need to view from Carel display and be able to graph from the Boss, but don't figure into the logic

- Liquid-Vapor Separator High and Mid Level Switch
- Return Temperature Sensor
- Suction Temperature and Pressure, per circuit

Alarms

Critical (will impact equipment function)

- Unit Turned Off
 - Secondary skid has been turned off for 5 minutes via controller keypad or skid on/off switch.
- Hi Vessel Press
 - Vessel pressure exceeds 325psig.
 - Auto reset when pressure falls below 300psig.
- Low Vessel Press
 - Vessel Pressure below Pump Low Pressure Cutout (150psig).
 - Pumps disabled, will re-enable when vessel pressure exceeds 160psig.
- Low Vessel Level
 - Vessel level below low level eye
 - Pumps disabled to protect from cavitation
- Flow Fail
 - Both pumps unable to achieve flow for 5 minutes
 - Requires manual reset to restore operation
- Rack Disabled
 - Rack indicated inactive by SST exceeding 0°F.
 - Auto reset when SST falls below -5°

Warning (equipment will continue to function using redundancies)

- Sensor Fault Vessel Pres
 - Invalid reading from Vessel Pressure Sensor. Secondary skid will continue to call for cooling ignoring vessel pressure.
- Pump 1 or 2 VFD Fault
 - Pump VFD Fault. Unit will switch to other pump.
- Sens Fault EEV Pres 1, 2, 3 or 4
 - Invalid reading from EEV controller pressure sensor. Circuit will be removed from staging to use alternate circuit.
- Sens Fault EEV Suc Temp 1, 2, 3 or 4
 - Invalid reading from EEV controller temperature sensor. Circuit will be removed from staging to use alternate circuit.
- Sens Fault Pump Dis Pres
 - Invalid reading from pump discharge pressure sensor. Flow will be assumed and continue to operate without discharge pressure reading.
- Comm Loss EXV1-2 or 3-4
 - Loss of comm with EXV controller. Secondary skid will operate using remaining controller. If comms are lost with both controllers, secondary skid will cease to operate.
- Step Mtr EXV1-2 or 3-4

- EXV stepper motor error. Circuit will be removed from staging to use alternate circuit. User will need to look at EXV controller to see which valve motor on that controller has failed.
- Low Superheat 1, 2, 3 or 4
 - Superheat below 1°F. Circuit will be removed from staging to use alternate circuit. Automatic reset when superheat exceeds 5°F.
- Pump 1 Flow or Pump 2 Flow
 - Pump has failed to achieve flow. Secondary skid has switched to other pump. Alarm will clear when affected pump has started and achieved flow, or when power is cycled.

Informative (equipment will continue to function unaffected)

- Sens Fault Ret Temp
 - Invalid reading from Return Temperature sensor. Sensor is monitoring only, no impact to secondary skid operation.
- Sens Fault Supply Temp
 - Invalid reading from Supply Temperature sensor. Sensor is monitoring only, no impact to secondary skid operation.
- High Out Fluid Temp
 - Outlet Fluid Temperature above 0°F. Sensor is monitoring only, no impact to secondary skid operation.
- Low Level Warn
 - Liquid Level below 30%. CO2 charge should be added until liquid level is approximately 50%.
- High Vessel Level
 - Vessel level is above 85%. CO2 charge should be reduced until liquid level is approximately 50%.