Hillphoenix

A DOVER COMPANY

ADVANSOR CO2 BOOSTER PRE-STARTUP GUIDE and STARTUP GUIDE

ADVANSOR CO2 BOOSTER STARTUP GUIDE
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Hill PHOENIX Pressure-Temperature Chart for CO2

Temp °F	CO2 (R-744) Pressure psi(g)	CO2 (R-744) Pressure bar(g)	Temp °C
-39	134.2	9.3	-39.4
-38	137.2	9.5	-38.9
-37	140.3	9.7	-38.3
-36	143.5	9.9	-37.8
-35	146.7	10.1	-37.2
-34	149.9	10.3	-36.7
-33	153.2	10.6	-36.1
-32	156.5	10.8	-35.6
-31	159.9	11.0	-35.0
-30	163.3	11.3	-34.4
-29	166.8	11.5	-33.9
-28	170.3	11.7	-33.3
-27	173.9	12.0	-32.8
-26	177.5	12.2	-32.2
-25	181.2	12.5	-31.7
-24	185.0	12.8	-31.1
-23	188.7	13.0	-30.6
-22	192.6	13.3	-30.0
-21	196.5	13.5	-29.4
-20	200.4	13.8	-28.9
-19	204.4	14.1	-28.3
-18	208.5	14.4	-27.8
-17	212.6	14.7	-27.2
-16	216.7	14.9	-26.7
-15	221.0	15.2	-26.1
-14	225.2	15.5	-25.6
-13	229.6	15.8	-25.0
-12	234.0	16.1	-24.4
-11	238.4	16.4	-23.9
-10	242.9	16.7	-23.3
-9	247.5	17.1	-22.8
-8	252.1	17.4	-22.2
-7	256.8	17.7	-21.7
-6	261.5	18.0	-21.1
-5	266.3	18.4	-20.6
-4	271.2	18.7	-20.0
-3	276.1	19.0	-19.4
-2	281.1	19.4	-18.9
-1	286.1	19.7	-18.3
0	291.2	20.1	-17.8
1	296.4	20.4	-17.2
2	301.7	20.8	-16.7
3	307.0	21.2	-16.1

Low Temp Suction, Typical

Temp °F	CO2 (R-744) Pressure psi(g)	CO2 (R-744) Pressure bar(g)	Temp °C
4	312.3	21.5	-15.6
5	317.8	21.9	-15.0
6	323.2	22.3	-14.4
7	328.8	22.7	-13.9
8	334.4	23.1	-13.3
9	340.1	23.5	-12.8
10	345.9	23.8	-12.2
11	351.7	24.3	-11.7
12	357.6	24.7	-11.1
13	363.6	25.1	-10.6
14	369.7	25.5	-10.0
15	375.8	25.9	-9.4
16	382.0	26.3	-8.9
17	388.2	26.8	-8.3
18	394.5	27.2	-7.8
19	400.9	27.6	-7.2
20	407.4	28.1	-6.7
21	414.0	28.5	-6.1
22	420.6	29.0	-5.6
23	427.3	29.5	-5.0
24	434.0	29.9	-4.4
25	440.9	30.4	-3.9
26	447.8	30.9	-3.3
27	454.8	31.4	-2.8
28	461.9	31.8	-2.2
29	469.0	32.3	-1.7
30	476.3	32.8	-1.1
31	483.6	33.3	-0.6
32	491.0	33.9	0.0
33	498.5	34.4	0.6
34	506.0	34.9	1.1
35	513.6	35.4	1.7
36	521.4	35.9	2.2
37	529.2	36.5	2.8
38	537.1	37.0	3.3
39	545.0	37.6	3.9
40	553.1	38.1	4.4
41	561.2	38.7	5.0
42	569.5	39.3	5.6
43	577.8	39.8	6.1
44	586.2	40.4	6.7
45	594.7	41.0	7.2
46	603.2	41.6	7.8

Medium Temp Suction, Typical

Hill PHOENIX Pressure-Temperature Chart for CO2

Temp °F	CO2 (R-744) Pressure		Temp °C
	psi(g)	bar(g)	
47	611.9	42.2	8.3
48	620.7	42.8	8.9
49	629.5	43.4	9.4
50	638.5	44.0	10.0
51	647.5	44.6	10.6
52	656.7	45.3	11.1
53	665.9	45.9	11.7
54	675.2	46.6	12.2
55	684.6	47.2	12.8
56	694.2	47.9	13.3
57	703.8	48.5	13.9
58	713.5	49.2	14.4
59	723.3	49.9	15.0
60	733.3	50.6	15.6
61	743.3	51.2	16.1
62	753.4	51.9	16.7
63	763.6	52.7	17.2
64	774.0	53.4	17.8
65	784.4	54.1	18.3
66	795.0	54.8	18.9
67	805.7	55.5	19.4
68	816.4	56.3	20.0
69	827.3	57.0	20.6
70	838.3	57.8	21.1
71	849.4	58.6	21.7
72	860.7	59.3	22.2
73	872.0	60.1	22.8
74	883.5	60.9	23.3
75	895.1	61.7	23.9
76	906.9	62.5	24.4
77	918.7	63.3	25.0
78	930.7	64.2	25.6
79	942.8	65.0	26.1
80	955.1	65.9	26.7
81	967.5	66.7	27.2
82	980.0	67.6	27.8
83	992.7	68.4	28.3
84	1005.6	69.3	28.9
85	1018.6	70.2	29.4
86	1031.8	71.1	30.0
87	1045.1	72.1	30.6
87.8	1055.5	72.8	31

*All data from NIST Refprop 8.0 [Barometric Press=14.50377psi]

Transcritical Gas Cooler
Pressure and Temperature correlations

Below are approximate gas cooler pressures at *dropleg temperatures* that a system might be subject to

Dropleg Temp °F	*Gas Cooler* CO2		Dropleg Temp °C
	psi(g)	bar(g)	
81	1037	71.5	27.2
82	1055	72.8	27.8
83	1073	74.0	28.3
84	1091	75.2	28.9
85	1109	76.5	29.4
86	1127	77.7	30.0
87	1145	79.0	30.6
88	1163	80.2	31.1
89	1180	81.4	31.7
90	1198	82.6	32.2
91	1216	83.9	32.8
92	1234	85.1	33.3
93	1252	86.3	33.9
94	1270	87.6	34.4
95	1288	88.8	35.0
96	1306	90.1	35.6
97	1323	91.2	36.1
98	1341	92.5	36.7
99	1359	93.7	37.2
100	1377	95.0	37.8
101	1395	96.2	38.3
102	1413	97.4	38.9
103	1431	98.7	39.4
104	1449	99.9	40.0
104+	1450	100.0	40.0+

Advansor CO2 Booster Pre-Startup Guide

06/2018

PRIOR TO STARTUP

Mechanical and Electrical Systems

1. *Properly installed as per code and regulatory requirements*

Piping Installed

2. *Assembly of Carbon/Stainless Steel, or Wieland K65 and Muller Streamline XHP High Pressure Copper Iron Pipes to Gas Cooler*
   A. Steel connections are joined by means of TIG-welding
      i. Care must be taken to avoid slag inside the pipe during welding (see installation manual)
   B. Copper connections must be brazed using standard brazing methods
      i. 15% silver solder joining copper to copper
      ii. 45% silver solder joining copper to steel
   C. Assembly must be carried out by a certified welder in accordance with local code
   Note: Contractors will be responsible for providing copper-to-steel transition fittings in the event steel piping is used for installation of the high side piping
3. *Assembly of Pipes to Evaporators*
   A. MT suction piping needs to be installed using copper pipe rated to 650 psig [45 barg]
   B. LT suction piping needs to be installed using copper pipe rated to 435 psig [30 barg] for electric defrost systems and at least 650 psig [45 barg] for hot gas defrost systems
   C. All liquid lines must be rated to at least 650 psig [45 barg]
   D. Piping selected and mounted based on approved piping practices
4. *Pressure Testing with Nitrogen and Vented*
   A. The rack is pressure tested at the factory to 10% above the rated relief pressure for each section of the system prior to installing relief valves
   B. Field pressure test should be performed per local building codes or customer specifications (if supplied)
   Note: In the case of test pressures being above pressure relief valve ratings, pressure relief valves need to be removed and its mounting location sealed - replace relief valve after completion of pressure test
   C. Regardless of pressure testing method, the following <u>minimum</u> testing pressures shall be held for a minimum of 24 hours allowing for pressure variations due to ambient air temperature changes
   Note: Relief valves do not need to be removed for pressure tests below valve ratings
      i. LT Suction: 30 barg (435 psig) relief – test pressure=350 psig
      ii. MT Suction/Liquid: 45 barg (650 psig) relief – test pressure=525 psig
      iii. MT Suction/Liquid: 60 barg (870 psig) relief – test pressure=700 psig
      iv. MT Discharge: 120 barg (1740 psig) relief – test pressure=1400 psig
      v. MT Discharge: 130 barg (1885 psig) relief – test pressure-1500 psig

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All Valves Checked for Evacuation Positioning

BEFORE EVACUATION PROCESS:

5. *Open All Service Valves On Compressors, Oil System Valves and All System Isolation Valves (Rack)*
    - *A.* For electric valves on the rack, make sure to turn ON control circuit power, but keep compressor power OFF and crankcase heaters OFF
6. *Open Valves for Store/Circuit Piping Systems*
7. *Open High Pressure Regulating Valve*
    - A. Remove head from high pressure valve
    - B. Use provided magnet to turn clockwise to open valve 100%
8. *To Protect Transducers During Evacuation, Close Respective Isolation Valves*

System Triple Evacuation

USE THE FOLLOWING PROCESS WITH AN ELECTRONIC MICRON METER, OR IF CUSTOMER HAS VACUUM EVACUATION SPECIFICATION, FOLLOW IT.

9. *Evacuation Procedure*

    Note: Change oil in vacuum pump after every pull (use)

    A. 1st vacuum hold at 1500 microns for minimum of an hour

    B. Break to positive pressure (1 or 2 psi) with nitrogen

    Note: Change oil in vacuum pump after every pull (use)

    C. 2nd vacuum hold at 500 microns for minimum of an hour

    D. Break to positive pressure (1 or 2 psi) with CO2 VAPOR

    E. Add oil to oil reservoir
        - i. Use only manufacturer specified compressor oil (i.e., Bitzer BSE-85K, Reniso C85E, or approved alternate)
        - ii. Fill all oil reservoir(s) via the oil reservoir charging port(s) to the sight glass(es) with oil.

          ATTENTION: Additional oil will be needed on site to complete startup - contractor supplied

    Note: Change oil in vacuum pump after every pull (use)

    Note: Install filter drier core(s) and suction filter shell(s) as applicable

    F. 3rd vacuum to below 500 microns and must maintain for 24 hrs with no more than 100 micron increase with vacuum pump OFF and isolated

    G. REPEAT step 9.F (3rd vacuum step) until 24 hr test is completed successfully
        - i. System vacuum testing must be verified with an electronic vacuum meter which should be placed at the furthest possible location from vacuum pump
        - ii. Ensure that *ALL* portions of the system are under vacuum

    Note: For low pressure oil systems (filterless oil separator), add 7.5 liters of oil after oil level has initially filled half of the oil reservoir sight glass

10. *Gas Cooler Instrumentation Verification*
    - A. All inputs and outputs on condenser/gas cooler installed and confirmed
    - B. Outdoor air temperature sensor located in the airstream of the gas cooler
        - i. Air cooled gas cooler: sensor needs to be installed in fully shaded airstream, even at low sun angles (morning and evening when sun is close to horizon).
        - ii. Adiabatic gas cooler: sensor installed in between pad and coils, far enough away from pad and coils to avoid water and metal contact with sensor

C. Verify parameter list for condenser/gas cooler controller (parameters enterable *at gas cooler*)
    i. Common BAC parameters:
        1. Precool start parameter will depend on geographic climate of store (BAC defined in Carell Controller)
        2. Diff SP, or deadband, defines at what temp precool mode stops (found in Technician Screen (passcode "1703") should be set to 3 degrees below start setpoint)
D. Verify controller condenser/gas cooler parameters (parameters enterable *at controller*)
    i. Common Gas Cooler Setpoints {Emerson CPC E2 equivalent parameters}
        1. Approach Setpoint (Dropleg Temp – Air Over Coil Temp) – 10°R {AM2 eq:10ddf}
        2. Minimum Condenser Dropleg Setpoint – 46°F {AM3 eq:46df}
        3. Maximum Condenser Dropleg Setpoint – 80°F {AM4 eq:80df}
        4. Additional Emerson Condenser Application Setpoints:
            a. {C1 General: Condenser Min Capacity Setpoint = 0.00}
            b. {C2 Setpoints: TR (Throttling Range) Temperature = 25.00}
    ii. Units with BAC adiabatic coolers, 0-10V output needs to correlate with 100%-0% fan operation (or 10-0V with 0-100% fan operation). This fail-safe ensures fans ramp to 100% if signal is lost for any reason (wire short or board output failure). This logic is not industry wide, therefore, air gas coolers probably don't need to have this parameter switched.
E. Leaving gas pressure transducer located on the rack for high-pressure control
F. Leaving gas temperature probes (one for high pressure valve and one for fan control) mounted properly (horizontally at 5 and 7 o'clock and as close to coil outlet as possible) and well insulated (cork insulation tape) as close to an outlet header as possible on the gas cooler
    ATTENTION: These sensors must be installed correctly as shown in manual's diagram
    i. If multiple parallel coils, DO NOT mount probes on common pipe. Select one gas cooler coil and mount probe on its outlet

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Advansor CO2 Booster Startup Guide

06/2018

STARTUP

Electrical

1. *All circuit breakers and switches are OFF*
2. *UPS protected circuits plugged into proper UPS outlet labeled "Surge and Battery Backup"*
3. *Phase monitor restart to be set for 10 second delay*

Compressor Oil Charging

4. *Pressurize Entire System to 150psig (~10barg)*
   A. Break last successful vacuum and pressurize to 150psig [10barg] with CO2 VAPOR
   B. Compressor oil fill instructions **(ATTENTION: Additional oil will be needed on site to complete startup – contractor supplied)**
      i. Shut oil line feed from oil separator to oil reservoir and shut oil vent line between oil reservoir and CO2 flash tank
      ii. Using the access port at the bottom of the reservoir, add additional oil as required to sight glass level
      iii. Using the access port at the top of the reservoir, pressurize the oil reservoir to 300 psig [20 barg] with CO2 VAPOR
         1. Maintain 300 psig within the reservoir during oil fill process
      iv. Starting with MT #1 compressor, trace the oil fill line from the compressor to the oil solenoid block - make note of the compressor and solenoid order
      v. With the MT #1 compressor breaker OFF, activate the compressor control circuit in the controller (bypass ON - override Compressor Run Signal in the controller) and turn ON compressor control switch to force the oil solenoid to energize
      vi. Check to ensure the oil fill solenoid on the block is energized - red indicator solenoid light should be lit when energized
         1. The oil fill solenoid will only stay energized for the duration of the cycle for Medium Temp oil fill cycle
            a. MT Oil Timer Setting: Every 60 seconds, ON for 30 seconds.

         Note: MT Oil Systems that are in the filterless (muffler) system: Every 60 seconds, on for 50 seconds.
         2. Filling the compressor with oil may require more than one cycle of the oil feed solenoid. Monitor oil level in the reservoir and add more oil if required.
      vii. Watch the oil level sensor on that compressor and continue filling the compressor with oil until the red indicator ring on the compressor oil level switch illuminates, indicating the compressor has proper oil level to operate
      viii. Check to ensure the oil fill solenoid for the MT #1 compressor is now de-energized
      ix. Repeat steps 4B.v through 4B.viii for each MT and LT compressor.
         1. The oil fill solenoid will only stay energized for the duration of the cycle for Low Temp oil fill cycle
            a. LT Oil Timer Setting: Every 60 seconds, ON for 5 seconds.

2. Filling the compressor with oil may require more than one cycle of the oil feed solenoid. Monitor oil level in the reservoir and add more oil if required.

x. If oil level controls are electronic types (OM4/OM5), verify oil level via sight glass on the oil control mounted on the compressor

xi. Once all the compressors are properly filled with oil and all oil fill solenoid's functionality have been confirmed, recharge oil reservoir to sight glass and open the oil line feed from the oil separator to the oil reservoir and open the oil vent line between the oil reservoir and CO2 flash tank

xii. Verify oil reservoir alarm by disconnecting electronic head from well sensor for each compressor

xiii. Verify MT and LT compressor oil alarms by closing compressor oil supply valve and seeing alarm and shut down logic execute in controller

Note: For oil systems that are in the filterless (muffler) system, if the oil level in the compressor sight glass is not halfway full:

1. Isolate the compressor lacking oil
2. Add oil directly through suction port of the compressor until oil sight glass is half full

Note: Muffler systems also have a timer external to the control logic that must be set to open the solenoid valve to feed the oil reservoir for 5 seconds every 60 seconds.

C. Energize crankcase heaters

Wiring Verification

5. *EMS/Controller*

A. Contact Hillphoenix Field Service if base operating program issues arise

6. *All Sensors, Transducers, Valves, Vfds, Hpv, Fgbv Checked and Proofed*

A. Verify and check all the parameters in the High Pressure Control Valve Controller and Actuator are correct

i. If a component that requires parameter input is not working properly and it is believed that parameter verification is required, contact Hillphoenix Field Service

B. Calibrate High Pressure Valve:

i. Disconnect the red lead wire on the valve actuator

ii. Take the actuator off of the valve, then use the supplied HPV magnet to manually run valve to fully close, and then fully open

iii. Put the actuator back on the valve and reconnect the red lead wire

iv. Wait until the valve closes to zero (this should be done at low pressure, while the system is pressurized to 150psig [10barg] CO2 vapor)

v. Take the actuator off of the valve again and ensure the valve is fully closed with the supplied HPV magnet

vi. Restore the actuator and wiring when calibration process is complete

C. Calibrate Flash Gas Bypass Valve

i. Disconnect power on the valve controller

ii. Reconnect power on the valve controller

Note: Removing and reapplying power on the valve controller should force the valve to a fully closed state, including the overdrive steps

iii. If leak-by occurs, contact Hillphoenix Field Service for further troubleshooting steps

D. Verify Hot Gas Dump functions properly – situation where return superheat to compressors is too low
   i. Manually override solenoid ON via controller (verify correct relay energizes)
   ii. *Either* of the following two parameters will activate MT Hot Gas Dump:
      1. MT Suction Superheat
         Note:°R refers to a differential temperature calculation value, like superheat, not a probe measurable temperature from a thermometer, which is reported in °F.
         a. Cut-in Setpoint 14°R
         b. MT Cut-out Setpoint 18°R
      2. MT Suction Minimum Suction Pressure
         a. Cut-in Setpoint 330pisg (7°F)
         b. Cut-out Setpoint 350pisg (11°F)
   iii. LT Hot Gas Dump only available on Hot Gas Defrost Systems:
      1. LT Suction Superheat
         Note:°R refers to a differential temperature calculation value, like superheat, not a probe measurable temperature from a thermometer, which is reported in °F.
         a. Cut-in Setpoint 14°R
         b. Cut-out Setpoint 18°R
      2. LT Suction Minimum Suction Pressure
         a. Cut-in Setpoint 170psig (-28°F)
         b. Cut-out Setpoint 180psig (-25°F)

E. Verify Liquid Injection functions properly – situation where return superheat to compressors is too high
   i. Manually override solenoid ON via controller (verify correct relay energizes)
   ii. *Both* of the following two parameters are needed to activate Liquid Injection:
      1. MT Suction Superheat
         Note:°R refers to a differential temperature calculation value, like superheat, not a probe measurable temperature from a thermometer, which is reported in °F.
         a. Cut-in Setpoint 55°R
         b. Cut-out Setpoint 45°R
      2. MT Discharge Temperature
         a. High Temperature Cut-in 250°F
         b. High Temperature Cut-out 240°F

F. Verify compressor VFD alarms
   i. Contact Hillphoenix Field Service if VFD drive issues arise

G. LT Discharge High Pressure Switches (Mechanical) should be set to 600psi with lowest differential pressure setting

H. LT Suction Low Pressure Switch (Mechanical - if equipped) should be set to 100psi

I. Verify LT/MT mechanical startup time delays are set to
   i. MT (10 sec)
   ii. LT (10 sec)

J. Verify Low Suction alarms setpoints in controller are set to
   i. MT (300psi)
   ii. LT (140psi)

K. Verify High Discharge setpoints in controller are set to

i. MT (1490 psi)
ii. LT (550 psi)

7. *Evaporator Instrumentation Verification*
   A. Verify all circuit controls are complete, operational and coordinated correctly (ie – controls operate correct circuit)
   B. Verify all temperature probes are located and installed as per coil manufacturer's specifications
   C. Verify all circuit pressure transducers are correctly installed to prevent oil from accumulating in transducers (never install transducer pointed down)
   D. Verify that all circuit probes and transducers are communicating properly with both case controller and rack controller.
   E. Verify EEV pressure transducer readings to ensure that measured pressure values match to corresponding saturated evaporation temperatures
      i. Room Temperature Example: 75°F = 895psig
      ii. Operating Temperature Example: -20.0°F = 200 psig
   F. Verify temperature probes to ensure that measured temperature values match actual temperatures of the evaporators
      i. Ensure that probes and controller are wired and landed correctly by means of cold spray or warming by hand with verification of temperature input fluctuation reported by the controller.
   G. See Emerson XM unit Startup Manual for more detailed information
      i. See appendix

System Charging

8. *Prepare System for Liquid Charging*
   A. Manually override EEV valves closed via the rack controller
   Note: Prior to removing the EEV override, verify that the suction transducer in the case/coil is at suction pressure. If the transducer reads closer to liquid pressure the liquid and suction lines are most likely crossed.
   B. Open suction line ball valves on header
   C. Close liquid line ball valves at header
   D. Hot Gas Defrost Systems
      i. Close hot gas defrost ball valves on header
      ii. Override the hot defrost gas control valve in the open position until rack is operational
   E. Ensure all manual isolation valves are open
      i. Hot Gas Dump (injection) isolation valve open
      ii. Oil feed solenoid isolation valves open
      iii. Pressure transducer isolation valve open
      iv. Liquid injector isolation valve open
      v. Flash Gas Bypass Valve isolation valve open
   F. Close the Manual ¼" Flash Gas Bypass Ball Valve (around the FGBV)
   G. Verify Compressor crankcase heaters are ON
   H. Turn ON power to Gas Cooler, check rotation direction of fans on gas cooler/condenser
      i. With ON/OFF controlled fans: check startup sequence of the fans (recommend that header end fans are first ON last OFF)

ii. For modulating fans, manually ramp fans to 0%, 25%, 50%, 100% to ensure proper control of all fans (make sure all fans run at appropriate levels)
iii. Validate gas cooler alarm signal and functionality

I. Rack controller and related gas cooler controls should be in automatic mode and ready to operate
J. Turn ON power (breakers in control panel) to compressors so they are ready to operate
K. Ensure that CO2 gas detector and emergency ventilation system are functional
L. For safety precautions, remove compressor suction and discharge service valve caps (replace caps after startup is complete)

9. Begin Liquid Charging

A. Verify that the flash gas tank pressure relief valve is set to the lowest of the two relief valves for normal operation (the higher of the two should only be selected during pump down operation)
   i. Follow the diagram attached to the relief valves for proper positioning of the handle to match the correct open port
B. Add liquid CO2 to the system via the flash tank liquid access port
   i. Verify CO2 liquid level alarm clears after 1-2 CO2 bottles
C. Monitor Low Temp and Med Temp suction pressure of the system. Pressure should not bypass any circuits resulting in suction pressure rise. FGBV should be closed until approx. 490 psig [34 barg] is reached
   i. If either Low Temp or Med Temp suction pressure rises, determine source and correct before continuing to fill system
D. As pressure rises above flash tank pressure control setting (490-550 psig [34 – 38 barg]) the Flash Gas Bypass Valve (FGBV) will start to open and provide pressure to the Medium Temp suction. A compressor should start at this time to keep the pressure from rising
   i. Check compressor operation; if a VFD is supplied, check that the compressor operates as it should
   ii. Check and confirm that FGBV opens and operates correctly
      1. If FGBV valve does not modulate, keep vessel pressure low using the manual bypass ball valve until issue with FGBV is corrected
E. Check BOTH the low sight glass and electronic level sensor (same level physically on tank). If liquid is seen in the low sight glass but sensor has not lit RED, the level sensor needs to be evaluated
   i. A RED indicator light on a level sensor means liquid is present, no lights on sensor means no liquid detected at that level
F. Charge and maintain liquid CO2 level in receiver to first (bottom) sight glass level (ball will float in sight glass) until system is fully operational
G. Verify CO2 leak detector devices alarm properly

Suction Groups Startup

10. MT Suction Group

A. Turn on one MT circuit at a time (no more than 25% of all MT circuits) by allowing the EEVs to operate normally (take out the override from the earlier step, open ball valves to each case if applicable)

Note: Prior to removing the EEV override, verify that the suction transducer in the case/coil is at suction pressure. If the transducer reads closer to liquid pressure the liquid and suction lines are most likely crossed.

i. Caution must be observed to not bring circuits on too fast resulting in the suction pressure rising too high and discharging CO2

B. As MT suction pressure begins to rise from circuits exchanging heat, the controller will make the MT compressors cycle ON and OFF several times, gradually pulling the suction temperature down; compressors will continue cycling until enough load is available to keep them running

C. Do not overload suction group by activating too many circuits on at one time to try to keep compressor cycling down; cycling is natural for startup, back off turning on cases to allow suction temperature to recover if needed

D. Verify that circuit valves, fans, and superheats are properly working as circuits are brought online

E. Continue to monitor refrigerant level and add liquid CO2 as necessary to maintain a minimum level in vessel (CO2 should always be visible in the bottom sight glass)

F. Check oil system; level satisfied at compressor (level switches), and monitor sight glasses in compressors. Monitor and maintain Oil Reservoir level at sight glass during startup of all MT and LT circuits.

G. Check and confirm that the receiver pressure and condenser/gas cooler pressure regulate correctly

i. During duration of startup, use pressure gauges or review trending graphs of tank pressure, gas cooler fan power (pid%), and HPV/FGBV % opening

ii. Receiver pressure should not fluctuate much more than ±20psi around setpoint

iii. Check Pressure-Temperature chart in (page 1) to verify that condensing pressure is appropriate based on ambient temperature and programmed approach setpoint

1. "Approach": the difference in temperature from the coil entering air temp (precooled air on adiabatic units) to the condenser/gas cooler outlet CO2 temp (dropleg)

H. Closely observe the compressor suction superheat temperature – make sure that no liquid returns from evaporator

i. Suction temperature needs to have at least 14°R of superheat; reported probe temperature higher than saturated suction temperature from reported suction pressure transducer

Note:°R refers to a differential temperature calculation value, like superheat, not a probe measurable temperature from a thermometer, which is reported in °F.

ii. Suction temperature can be no less than 5F (318psig [22barg])

Note: If either superheat or suction temperature is too low, the MT Hot Gas Dump valve needs to energize - verify that the HG Dump valve works properly

I. Repeat steps 10.A through 10.H for the next 25% of the MT circuits

J. Once 50% of the MT circuits are active, continue to LT suction group

11. LT Suction Group

A. Once 50% of the MT suction group has reached temperature and stabilized, begin the same procedure with the LT suction group

B. Turn ON one circuit at a time (no more than a group of 25% of all LT circuits) by allowing the EEVs to operate normally (take out override from earlier step and open ball valves to each case if applicable)

Note: Prior to removing the EEV override, verify that the suction transducer in the case/coil is at suction pressure. If the transducer reads closer to liquid pressure the liquid and suction lines are most likely crossed.

C. Verify correct circuit operation, including fan starting.
D. Check and confirm that each compressor starts one at a time
E. Make sure that LT compressors are supplied with oil, and there is enough oil in the oil reservoir (RED oil indicator lights ON means level SATISFIED).
    i. In systems where there are digital scrolls configured on the Low Temp portion of the rack, maintain proper oil level in compressors and verify OMB system is functioning properly
F. Allow temperature in first circuit to pull down and stabilize
G. Do not overload suction group by activating too many cases on at one time to try to keep compressor cycling down; cycling is natural for startup, back off turning on cases to allow suction temperature to recover if needed
H. Verify that case valves, fans, and superheats are properly working as cases are brought online
I. Continue to monitor refrigerant level and add liquid CO_2 as necessary to maintain a minimum level in vessel (CO_2 should always be visible in the bottom sight glass)
J. Closely observe the compressor suction temperature – make sure that no liquid returns from evaporator,
    i. Suction temperature needs to have at least 36°R of superheat; reported probe temperature higher than saturated suction temperature from reported suction pressure transducer
    Note:°R refers to a differential temperature calculation value, like superheat, not a probe measurable temperature from a thermometer, which is reported in °F.
K. Repeat steps 11.B through 11.J for the next 25% of the LT circuits
L. Return to the MT Suction Group and repeat step 10.H until all MT circuits are active
M. Repeat LT Suction Group step 11.K until all LT circuits are active

System Operation Verification and Optimization

12. *Rack and Case Verification (recommend min of 12 hrs after completed startup)*

A. Watch compressor cycle counts and ensure that excessive short cycling is not occurring - recommend no more than 6 cycles per hour (cycle count recommendation for fully loaded system after startup is completed)
B. Run cases/circuits through defrosts
    i. Verify defrost programming, set points, times, etc. match customer's/manufacturer's recommendations and that insulation/wiring is not in contact with defrost heaters
    ii. Hot Gas defrost – Set Defrost valve to maintain 550psig with a 33 bar flash tank (approx. 75 psi diff) and check the following to ensure proper operation and adjust as necessary.
        1. Electronic pressure switch settings (Wika) – Hot Gas Differential Valve bypass solenoid control set at 39 bar.
        2. Override Hot Gas Defrost valve OFF (unplug if necessary)
            a. Put each circuit into defrost one at a time and test that all valves work properly.
                i. Place circuit in defrost

ii. Wait until circuit hot gas valve opens
iii. Slowly open hot gas ball valve to make sure the suction stop is working properly and has shut, preventing discharge gas from entering the suction header
iv. Leave all valves open for that circuit

3. Once all circuits have been tested, remove Hot Gas Defrost valve override (plug in if necessary)
    a. Test each hot gas circuit for full operation.
4. Make sure the LT head pressure does not trip while performing a defrost test on the circuit located closest to the rack as well as the smallest hot gas defrost circuit
5. Make sure the defrost termination probe is mounted in the correct location and that it approaches the case specified defrost temperature during defrost to ensure there is enough heat to effectively defrost the circuit located farthest from the rack as well as the largest hot gas defrost circuits
6. If the hot gas defrost system is not defrosting as expected, contact a Hillphoenix Field Service Engineer before making adjustments

C. After system is stable and has operated for at least 12 hours, perform a power-loss/auto-restart test
    i. Follow the Simulated Electrical Power Loss Test procedure at end of this guide. The procedure should be executed top to bottom and is intended to first test various scenarios of power loss to the parts of the system, then to simulate an entire store power loss. Testing scenarios independently and verifying the achievement of expected results helps trouble shoot issues that could arise based on power failures. The last steps of the table simulate a complete power loss to all parts of the system.
D. Two days to one week after the system is fully operational, change filters (oil filter, Suction Filter-Drier/Liquid Filter as applicable) and clean "Y" strainer on gas cooler return line and main liquid supply line (also as applicable)
    i. Ensure that as much startup debris is out of system as possible
    ii. Include the cleaning of filters and strainers on the scheduled preventative maintenance of the system
E. Two weeks after the system is fully operational, if pressure drops are measureable and higher than expected, change filters. If pressure drops are not measureable, change filters (oil filter, Suction Filter-Drier/Liquid Filter as applicable)
F. Three weeks after the system is fully operational, if pressure drops are measureable and higher than expected, change filters. If pressure drops are not measureable, change filters (oil filter, Suction Filter-Drier/Liquid Filter as applicable)

Auxiliary Unit Operational Test

13. *Auxiliary Unit*
    A. Verify that power comes from generator switch panel
    B. Lower the high pressure switch on main rack for the liquid solenoid valve for auxiliary unit
    C. Verify charge and operation

Simulated Electrical Power Loss Test

Action	Expected Results
Simulate Case power loss (but Rack and Controller still powered)	
*Turn off all breakers to Low Temperature circuits. * Keep breakers off till future step	Associated case power loss liquid line solenoids de-energize and evaporators pump out. Fans will shut OFF. Compressors will shut down on low suction pressure.
*Turn off all breakers to Medium Temp circuits. * Keep breakers off till future step	Associated case power loss liquid line solenoids de-energize and evaporators pump out. Fans will shut OFF. Compressors will shut down on low suction pressure. (Compressor will cycle to hold flash tank pressure)
Simulate Case power loss and Rack power loss (but Controller still powered)	
*Disconnect wire from Terminal 1 (not power terminals 25/26) on Danfoss 326A controller (or similar point on other controllers). *Reconnect wire	ICMTS (high pressure valve) and CCM (flash tank bypass valve) close to 0%.
*Auxiliary unit (if present) bypassed to ON to test operation.	Auxiliary unit starts. Need to validate sufficient refrigeration charge and set point for mechanical pressure control.
Simulate Rack power loss (but Cases and Controller still powered) – Case Controller *Electronic* Safety	
*Locate and activate single input point in main controller that forces ALL case EEVs closed (forcing OPEN N.C. or CLOSE N.O. inputs via software or hardware). *After bypassing control inputs, the breakers for all MT circuits and LT circuits are to be turned back ON.	Because of no signal from controller: All EEV's close to 0% All Fans in cases and evaps to stay OFF.
Simulate Rack power loss (but Cases and Controller still powered) – Case Controller *Mechanical* Safety	
*Remove PMR (Phase Monitor Relay) to simulate a phase loss to the 600V	Because Phase Monitor Relay failure at rack: All EEV's close to 0% Compressors will shut OFF or be unavailable.
Simulate Rack power, Case power and Controller power restored	
*Return the case override from previous step to normal operating position. *Replace Relay. *Return Rack to Normal operation for at least 30 minutes. (turn ON all breakers)	Everything will restart.
Simulate Rack power, Case power and Controller power loss and recovery	
*Complete shutdown of electrical to Mechanical room and cases for 30 minutes (monitor suction pressures). Turn OFF circuit breakers Turn OFF rack control breakers Turn OFF Rack main power	Refrigeration system shutdown.
*Turn power back on.	Everything restarts automatically.

Quick Summary Booster Validation List

- ☐ 1. HPV valve settings validated in Danfoss ICMTS actuator
- ☐ 2. HPV/CCM controller settings validated 326a/iPro/781
- ☐ 3. Co2 Liquid level alarm
    - Verify prior to start up and during charging to clear alarm- Light ON after 1 or to Liquid bottles added
- ☐ 4. Oil reservoir alarm Verify prior to start up – Remove HB sensor electronic from well sensor
- ☐ 5. Oil separator solenoid operation prior to start up by cycling RO in EMS & once light comes ON the HB sensor after system running. (Close Outlet ball valve from Separator to reservoir until HB sensor light comes on in which to then verify the Solenoid operates)
- ☐ 6. Compressor Oil Failure operation to shut off and alarm (Prior to start up or after)
    - All MT Compressors
    - All LT Compressors
    - Validate Oil Solenoids for each compressor operate when calling for oil (Trace oil lines to solenoids)
    - Prior to S/U - Remove HB sensor electronic from well sensor/close compressor ball valve - monitor operation for Oil Fail
    - After- DO above or close oil valve off to monitor operation for Oil Fail
- ☐ 7. Validate Hot Gas Valve opens when called for LOW SH or if enabled low load
- ☐ 8. Validate Liquid injection operates when calling High Superheat or High Discharge Temp
- ☐ 9. Validate VFD alarm for any compressor VFD on system
- ☐ 10. Validate Gas Cooler alarming currently Luvata only until BAC alarming enabled or option is purchased
- ☐ 11. Validate high-pressure mechanical controls & compressor Safety circuits for each compressor in LT & MT suction groups. When each alarm opens/trips compressor must shut off.
    - Mechanical High Discharge for LT (600psi) and MT (1490psi)
    - Verify case shutdown enabled during this check
- ☐ 12. LT & MT Time delays set in main electrical panel
    - LT 10 Sec
    - MT 10 sec
- ☐ 13. Case shutdown validated to shut off case groupings as per load sequences – See NEW appendix for thorough validation
- ☐ 14. Phase loss check to alarm
    - Validate the 326a iPro is off (POR relay) Shutdown with CCM and HPV O%
    - Case shutdown enabled at this time
- ☐ 15. Low Suction for MT (Currently 300psi) & LT groups (Currently 140Psi)
- ☐ 16. Co2 leak detector alarms

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