Natural Refrigerant Training Summit

Building a Sustainable Workforce

Co2 Installation and Service

Dale Sizemore

Kysor Warren/Epta

NORTH AMERICAN Sustainable Refrigeration Council

NORTH AMERICAN Sustainable Refrigeration Council

Natural Refrigerant Training Summit

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Who We Are

A 501c3 nonprofit working to create a sustainable future for supermarket refrigeration by removing barriers to natural refrigerant adoption.

160+
member companies

55K+
food retail locations

Goals

- Build a sustainable technician workforce
- Increase funding for natural refrigerant equipment
- Improve technology options, education, and awareness

What are Natural Refrigerants?

CO_2	C_3H_8	NH_3
R744 Carbon Dioxide	**R290** Propane	**R717** Ammonia

NORTH AMERICAN
Sustainable Refrigeration Council

Council

CO2 REFRIGERATION TRANSCRITICAL BOOSTER SYSTEM
Installation and Service

Dale Sizemore
Director, Technical Services

KYSOR WARREN
eptarefrigeration

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CASE SET UP

CO2 TRANSCRITICAL SYSTEM

DISPLAY CASES

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Electronic Expansion Valve (EEV)
- Pulse – open-close
- Steeper – modulating*

Pressure Transducer (PT) Required

Superheat Control Required (TS)

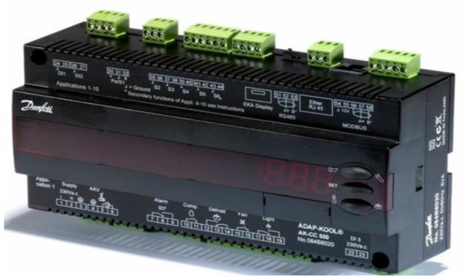
Valve Stations
- Supply and Return

Case Controller

Defrost
- Electric (LT commonly)
- Off Time (MT commonly)

Liquid Supply Temp
- MT & LT 36F (30F-38F)

Design Pressure 655 Psi (45 Bar)



Ball valve with check bypass
- Supply
- Return

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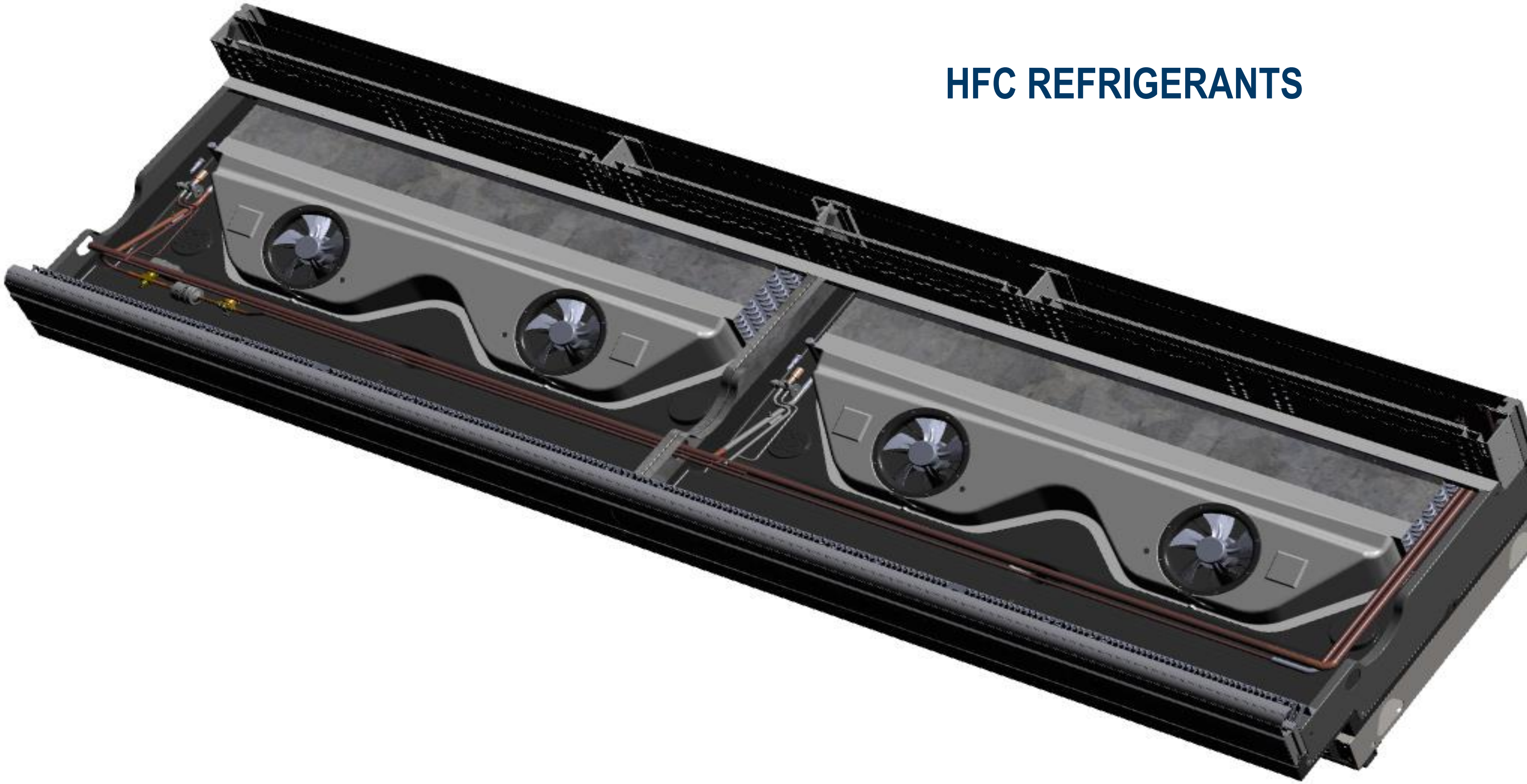
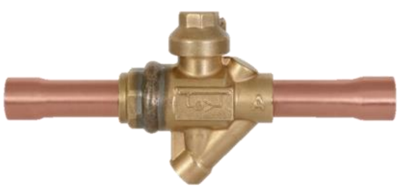


HFC REFRIGERANTS

SAFETY

- Avoid trapping CO_2 in circuit or loop during isolation
- Allows CO_2 to vent back to main CO_2 tank in rack
- Valve stations at supply and return lines

CO2 REFRIGERANT



Ball valve with check bypass

- Supply
- Return

CASE & UNIT COOLER COILS

SUBSYSTEM AND COMPONENTS

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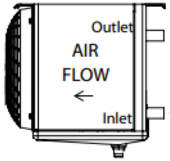
- Because CO2 systems operate at higher pressures than other refrigerant systems
- Tubing and pipe used in the evaporator is the main determinant of its pressure bearing capability
- Case and unit coils are optimized specifically for CO2 applications

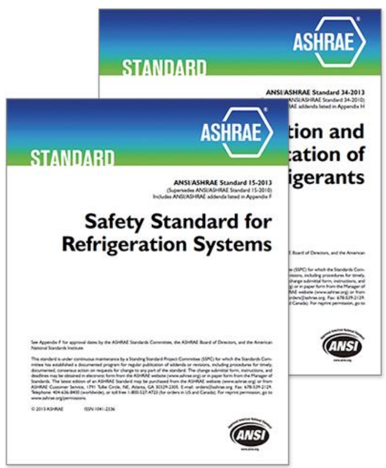


SYSTEM INSTALLATION

DOCUMENTATION

The following are general guidelines for installing the CO_2 Transcritical Booster Refrigeration system:

- “Safety Standard for Refrigeration Systems” (ANSI/ASHRAE Standard 15)
- “Refrigeration Piping Standard” (ASME B31.5)



GENERAL INSTRUCTIONS

- ☑ A minimum of 1" insulation recommended for all Medium and Low temperatures lines
- ☑ Straps and support tubing are used to prevent excessive line vibration and noise (where required)

PIPING LINE SIZE

- ☑ Piping lines are installed according to the drawings, customer specs.

PICTURES

PIPE PRESSURE RATINGS / INSTALLATION

PIPING

CO_2 as a refrigerant has a higher density and pressure compared to other conventional refrigerants. Thus the pipe sizes are smaller compared to other refrigerant systems.

Section	Max Pressure psi (bar)	Max Temp °F (°C)	Material
MT Discharge to HPV Inlet	1740 (120)	+320°F (+160°C)	CuFe2P (C19400 Alloy) 120 Bar rated tubes supplied as Wieland K65™ or Mueller XHP™
HPV Outlet to EEV (Cases & Unit Coolers)	655 (45)	+35°F (+1.7°C)	Mueller Streamline Copper rated to 700 psi (48 Bar) @250°F up to OD1-1/8" - L type Soft OD1-3/8" - L type Hard OD1-5/8" to 2-5/8" - K type Hard
Flash Tank	655 (45)	+35°F (+1.7°C)	
Medium Temp. Suction Line	655 (45)	+25°F (-3.9°C)	
Flash Gas Return Line	655 (45)	+35°F (+1.7°C)	
Liquid Supply	655 (45)	+35°F (+1.7°C)	
Low Temperature Suction Line *	435 (30)	-22°F (-30°C)	

Mueller Streamline ACR Piping can be used for all store piping; otherwise, the installer must have the following provisions:

- ☑ Pipe and fitting material identification in inventory
- ☑ Pipe and fitting material identification of installed piping
- ☑ Callout of pipe and fitting material in store drawings
- ☑ Copper Tube can be rated for 435 psig (30 bar)
    - ☑ **up to OD1-3/8" - L type Soft**
    - ☑ **up to OD2-1/8" - K type Soft**

WORKING AND DESIGN PRESSURES FOR A CO2 TRANSCRITICAL BOOSTER REFRIGERATION SYSTEM

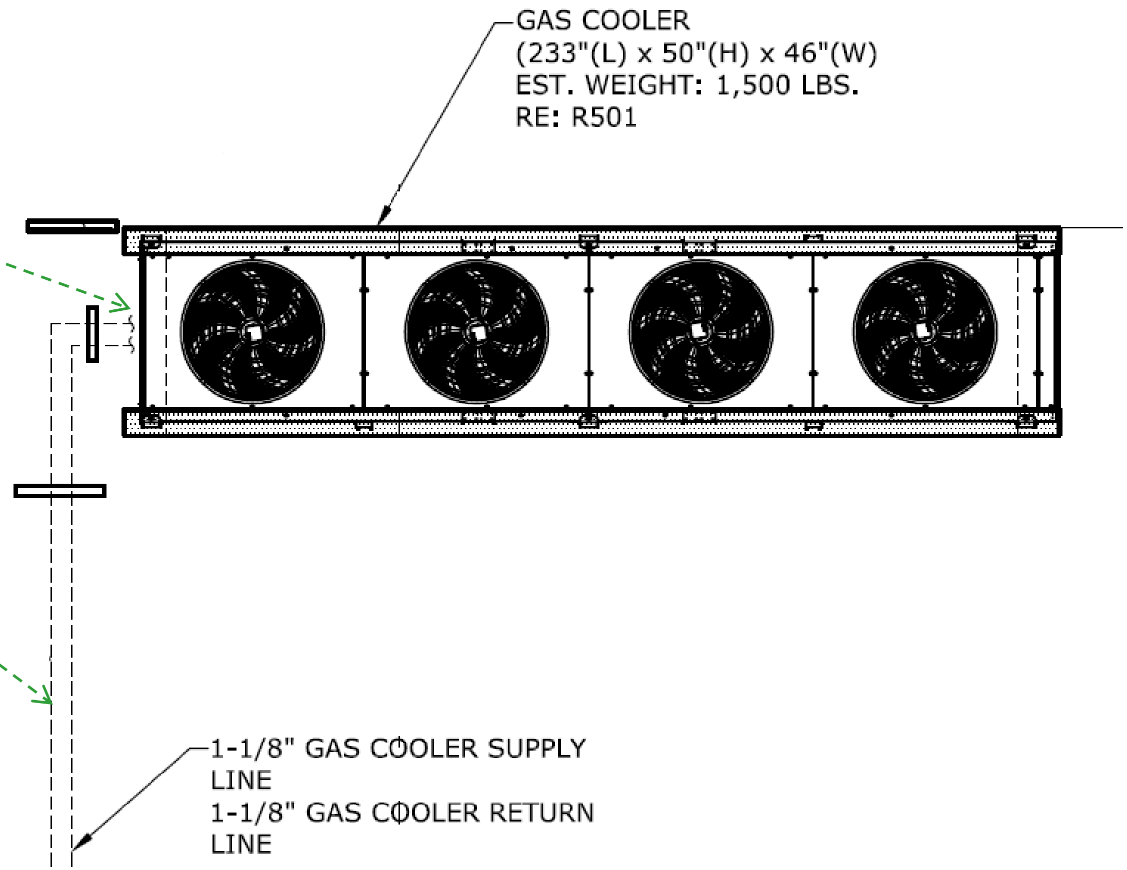
The range of working pressures and design pressures for the system are shown in the Table 1-2.

	Description	Working Pressure	Components	Design Pressure
	Low side	188 to 218 psig (13 to 15 bar)	LT Cases, LT Suction Piping	435 psig (30 bar, 28 bar for scroll compressors)
	IM Press Stage – MT Suction	377 to 435 psig (26 to 30 bar)	MT Cases, LT Compressors, MT Suction Piping, LT Discharge Piping	652 psig (45 bar, 43 bar for scroll compressors)
	IM Press Stage – Liquid Line	493 to 551 psig (34 to 38 bar)	Flash Tank, FGBV, FG EEV, Case EEVs, Liquid Supply Piping	652 psig (45 bar)
	High side	652 to 1495 psig (45 to 103 bar)	Gas Cooler, HPEV, MT Compressors, MT Discharge Piping	1740 psig (120 bar)

Table 1-2. Working and Design Pressures for a CO2 Transcritical Booster Refrigeration System

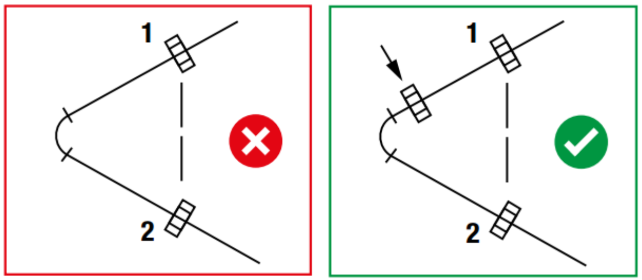
Pressure Relief Valve, Angle Valve and Ball Valve installation

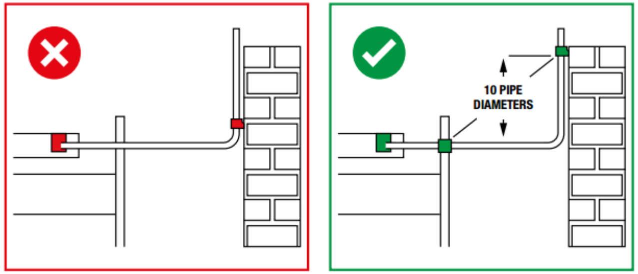
Gas cooler supply & return lines. Refrigeration contractor to source Mueller Industries XHP or Weiland K65 120BAR Copper-Iron piping for installation on “high-side” of system



PIPING INSTALLATION TIPS
PIPING

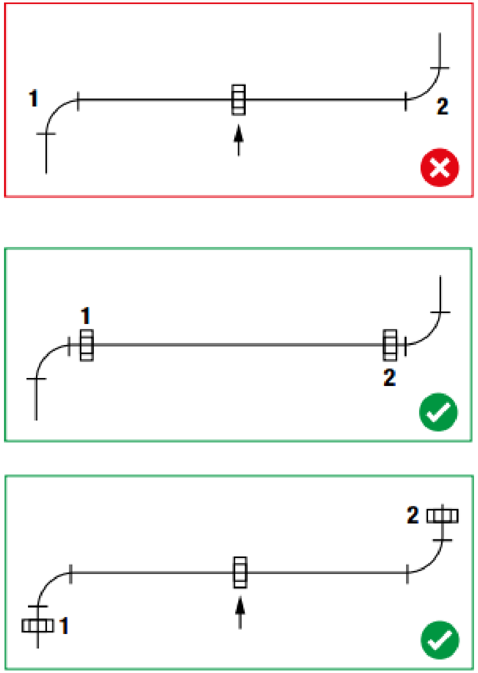
Piping dimensions and capacities meet or exceed maximum operating pressure and temperatures





There is adequate clearance between pipe and adjacent walls and hangers to allow for service and inspection

Pipe sleeves are used through walls, floors, and ceilings, electrical



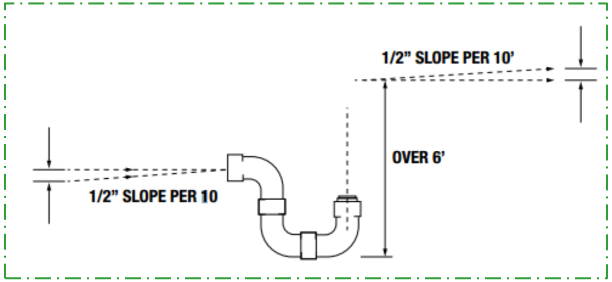
CO2 Case and Unit Cooler piping is similar to the other existing conventional refrigeration systems.

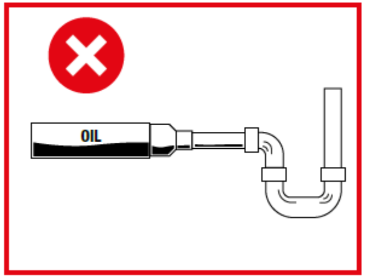
LIQUID LINES

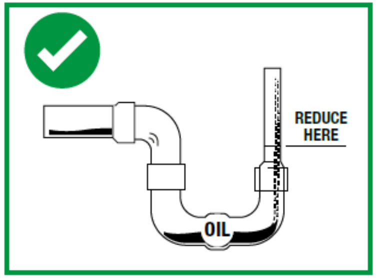
Liquid lines are sized for a minimum pressure drop to prevent flashing that would create additional pressure drop and poor expansion valve operation

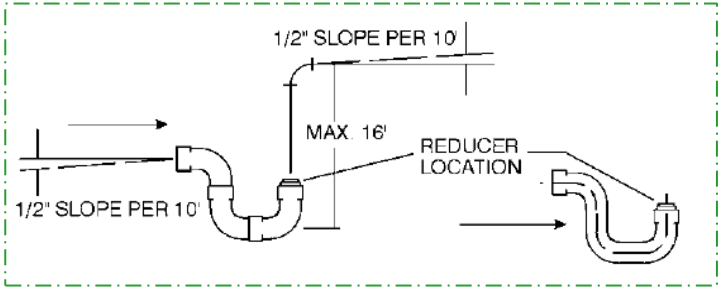
SUCTION LINES

- ☑ Any suction line that travels vertically and the direction of refrigerant flow inside it is against gravity, is called a suction riser
- ☑ Refrigerant flowing through suction risers are unable to carry the lubrication oil through the pipes to the compressor due to the low flow velocity. Oil traps are designed into the suction risers.









PIPING DETAILS
TRAP AND CLAMP

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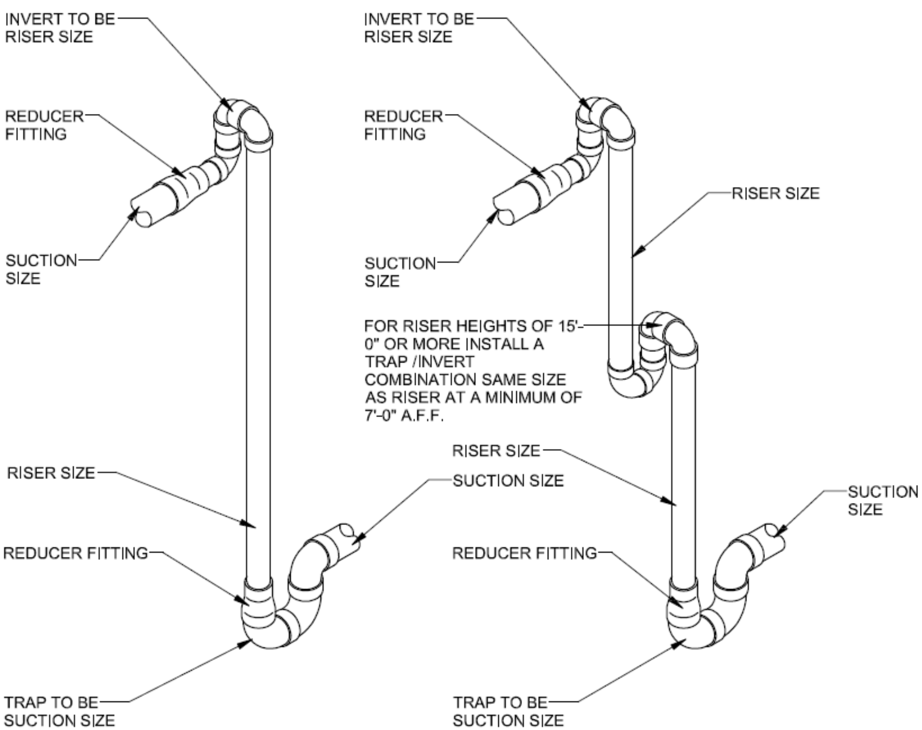
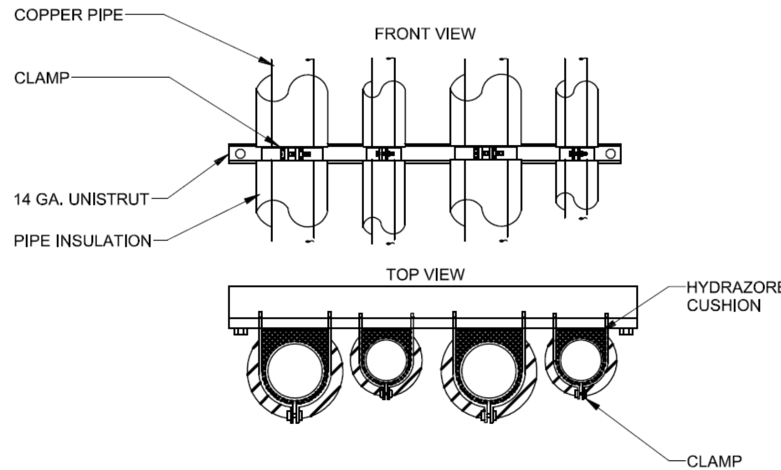
TYPICAL TRAP AND INVERT



NOTE:

1. FITTED TRAPS SHALL BE SUCTION SIZE. ONE PIECE FIELD SHAPED TRAPS SHALL BE RISER SIZE.

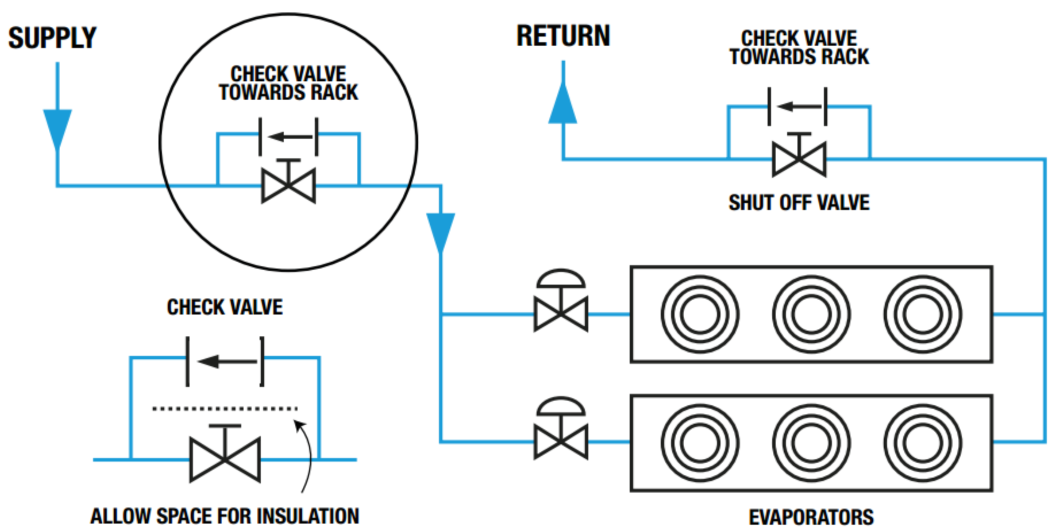
TYPICAL VERTICAL WALL CLAMP DETAIL



NOTE:

1. REFRIGERATION TO SUPPLY AND INSTALL ONLY HYDRAZORB CUSHION CLAMPS.
2. CLAMPS SHALL CORRESPOND EXACTLY WITH PIPING SIZE.
3. REFRIGERATION CONTRACTOR TO ENSURE NO DIRECT CONTACT BETWEEN COPPER PIPE AND METAL CLAMP.

ISOLATION VALVES
PIPING



- ☑ Full port ball valves with return check valves and rated for minimum design pressure of 652 psig
- ☑ Direction of check valve should point towards the rack
- ☑ The bypass check valves are required for instances when the isolation valves are closed while the pressure of the refrigerant can build up in the system

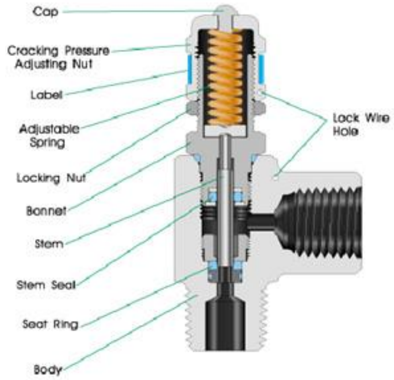
RELIEF VALVE / EXPANSION JOINTS
PIPING

RELIEF VALVE

- Pressure relief valves should exhaust to exterior locations to comply with ASHRAE 15.
- Valves must be at a location and orientation such that they can discharge pressurized refrigerant safely without releasing refrigerant in a direction towards personnel.

EXPANSION JOINTS

- Expansion joints should be designed into the system to provide **strain relief**
- Expansion joints are designed by adding a **"Z-bend"** or change in direction at areas of concerns
- **Long straight runs** of pipe should include extra changes in direction to accommodate expansion.



PIPING JOINTS

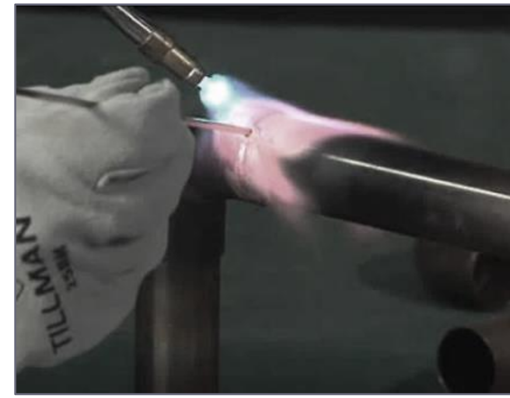
PIPING

Copper joints are brazed with minimum 15% silver brazing alloy (filler) and for dissimilar metals use minimum 45% silver brazing alloy (filler)

While brazing, must flow nitrogen gas through the pipe or tubing to prevent oxidation as each joint is brazed.

Cap the system with a reusable plug after each brazing operation to retain the nitrogen and prevent entrance of air and moisture

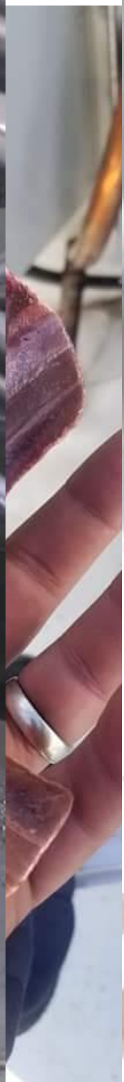
Limit the soldering paste or flux to the minimum required in order to prevent contamination on dissimilar metal



Special instructions for copper K65

- 15% silver
- Good brazing technique
- Natural cooling without water
- Wet rags OK for heat sink ONLY

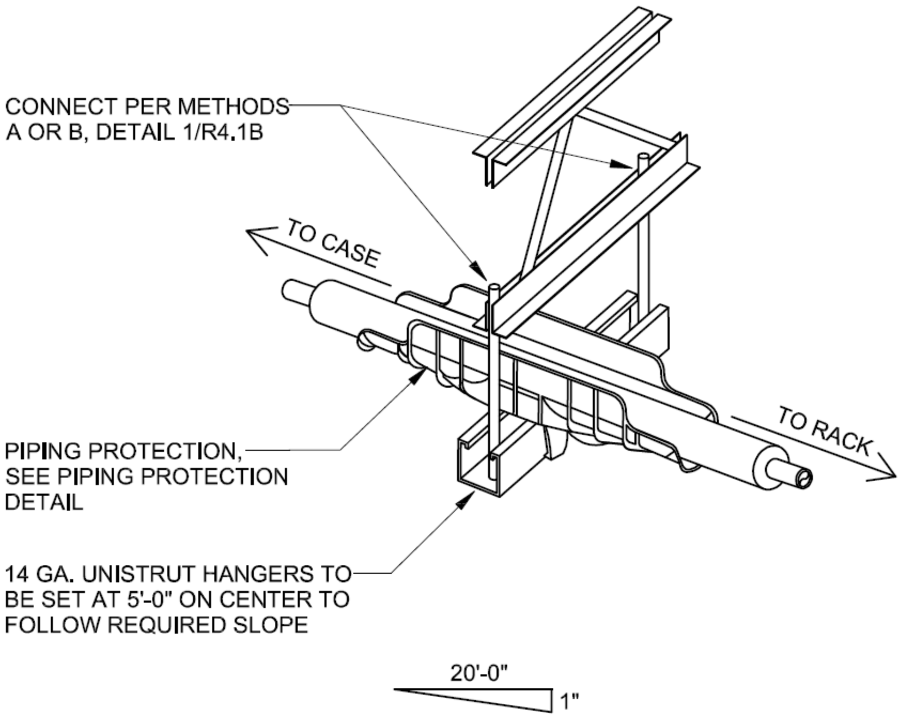
NEVER TRAP LIQUID CO_2



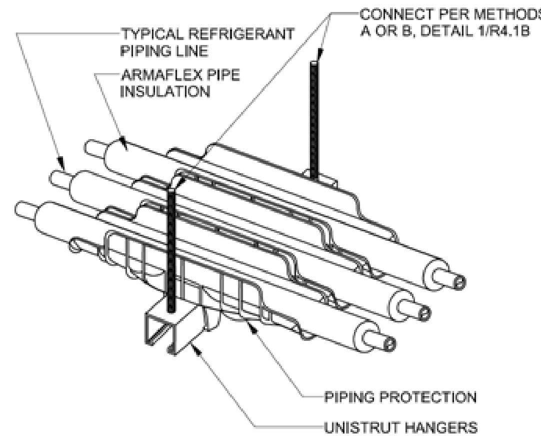
LIQUID LEAK

- Co2 Liquid leaks very easy to find
- Normally are very loud and visible
- Dry Ice, frost and popping sounds

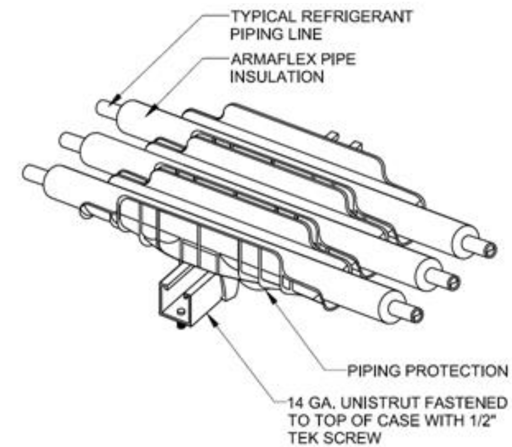
STANDARD OVERHEAD PIPE SLOPE DETAIL



PIPING PROTECTION DETAIL



NOTE:
PVC saddles 12" length and 6" diameter or pre-manufactured saddles



PIPING DETAILS
PROTECTION, ISOLATION VALVE

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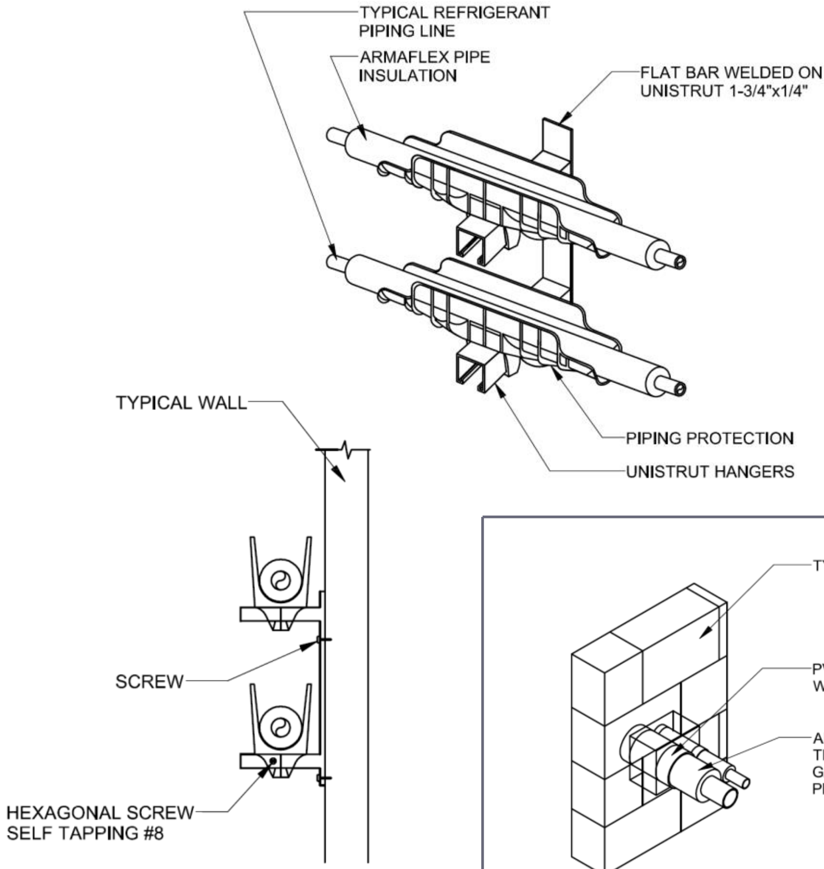
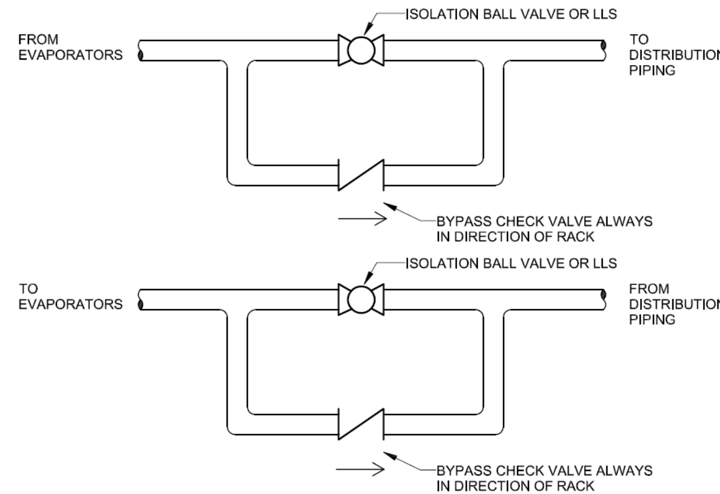
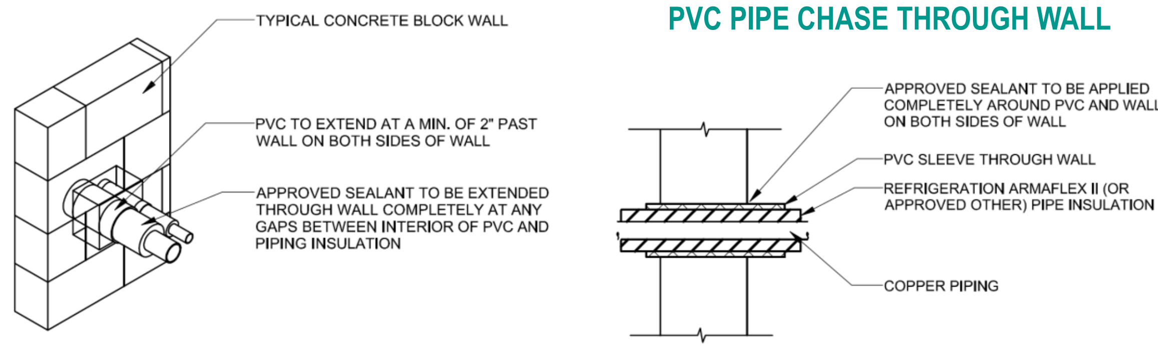
WALL MOUNTED PIPE PROTECTOR



CO2 PIPING ISOLATION VALVE WITH BYPASS CHECK VALVE



PVC PIPE CHASE THROUGH WALL



- Arrows indicating direction of flow
- In addition, some piping should provide labels to show:
  - Fluid type (i.e., Carbon Dioxide)
  - Origin of Flow
  - Typical Operating Pressure

Kysor Warren recommends pressure testing and triple-evacuation to ensure proper elimination of moisture and non-condensable gases.

STEP 1
Pre-check

STEP 2
Isolate components not suitable for pressure levels

STEP 3
Disconnect or bypass all defrost heaters

STEP 4
Open valves

STEP 5
Check for leaks

STEP 6
Pre-evacuation

STEP 7
Tripe Evacuation
1st evacuation
2nd evacuation
3rd evacuation

1. PRE-CHECK

- ☑ Visually inspect refrigerant lines and joints for proper piping assembly and installation.
- ☑ Proper bracing is used throughout.
- ☑ Inspect for any metal to metal contact points.
- ☑ Manually verify that all mechanical joints are tight.
- ☑ Ensure all electrical connections are tight.
- ☑ Check phase monitor for correct polarity.

☐ 2. ISOLATE COMPONENTS NOT SUITABLE FOR THE PRESSURE LEVELS

☐ 3. DISCONNECT PR BYPASS ALL DEFROST HEATERS

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☑ 1. PRE-CHECK

2. ISOLATE COMPONENTS NOT SUITABLE FOR THE PRESSURE LEVELS

- ☑ All components not designed to withstand the induced pressures are isolated from these pressures.

☐ 3. DISCONNECT PR BYPASS ALL DEFROST HEATERS

☑ 1. PRE-CHECK

☑ 2. ISOLATE COMPONENTS NOT SUITABLE FOR THE PRESSURE LEVELS

3. DISCONNECT PR BYPASS ALL DEFROST HEATERS

4. OPEN VALVES

- ☑ Ball valves to circuits, branches, satellites, condenser, heat reclaim, receiver, etc.
- ☑ Both sides of condenser and heat reclaim piping
- ☑ De-energize the solenoid valves (which are normally open).

☐ 5. CHECK FOR LEAKS

☐ 6. PRE-EVACUATION

☑ 4. OPEN VALVES

5. CHECK FOR LEAKS

- ☑ Verify pressurization at multiple system access points.
- ☑ System pressure is brought to a minimum of 300 psig.

☐ 3. DISCONNECT PR BYPASS ALL DEFROST HEATERS

☑ 4. OPEN VALVES

5. CHECK FOR LEAKS

IF LEAK IS IDENTIFIED:

- ☑ Leak is isolated from rest of system
- ☑ Leak is repaired
- ☑ Area of repair is retested
- ☑ Area is re-pressurized to a minimum 300 psig
- ☑ All valves are re-opened
- ☑ After all leaks are repaired and retested, system stands unaltered for 24 hours with no greater than a +- 1 PSIG change
- ☑ When system is ready to be evacuated, the nitrogen charge is released.

☐ 6. PRE-EVACUATION

☑ 4. OPEN VALVES

☑ 5. CHECK FOR LEAKS

6. PRE-EVACUATION

- ☑ System is depressurized
- ☑ Evacuation pump and sensors working properly
- ☑ Evacuation pump is connected to as many as possible access points on the rack.
- ☑ Copper lines or special vacuum hoses are required
- ☑ Vacuum pump is rated at 8cfm as a minimum and can reach all parts of the system.
- ☑ Vacuum pump oil as recommended by manufacturer and is new and clean.
- ☑ Electrical connections are secure and uninterrupted
- ☑ There are no leaks at the vacuum pump connections.

☑ 4. OPEN VALVES

☑ 5. CHECK FOR LEAKS

6. PRE-EVACUATION

LINES AND VALVES

- ☑ Copper lines or suitable hoses are used.
- ☑ Packless valves are used
- ☑ All schrader valve caps are tightened and checked.
- ☑ All access valves are capped tightened
- ☑ Make sure pressure transducers are valved-off while under vacuum

NOTE:
Never use more than one vacuum pump at the same time

MICRON VACUUM GAUGE

- ☑ Gauge is properly calibrated
- ☑ Verify with gauge that pump can pull a vacuum of at least 300 microns
- ☑ Vacuum is measured at a minimum of two points which are at extreme points within the system

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7. TRIPLE EVACUATION PROCEDURE (1ST EVACUATION)

- ☑ Ball valves to circuits, branches, satellites, condenser, heat reclaim, receiver, etc.
- ☑ Both sides of condenser and heat reclaim piping
- ☑ De-energize the solenoid valves (which are normally open).

☐ 8. CHARGING

☐ 9. FINAL CHECK

7. TRIPLE EVACUATION PROCEDURE (2ND EVACUATION)

- ☑ Pull a second vacuum to a minimum of 500 microns
- ☑ Close vacuum header valves
- ☑ If the 500 micron vacuum holds for a minimum of 30 minutes, then break the vacuum with the refrigerant to be used in the system to a pressure of 2 psig
- ☑ Install system suction and liquid drier cores

☐ **8. CHARGING**

☐ **9. FINAL CHECK**

7. TRIPLE EVACUATION PROCEDURE (3RD EVACUATION)

- ☑ Pull a third vacuum to a minimum of 300 microns
- ☑ Close vacuum header valves and allow system to stand for a minimum of 24 hours
- ☑ System is ready to be charged with refrigerant If the 300 micron vacuum holds for 24 hours with a maximum drift of 100 microns over the 24 hour period
- ☑ Break the vacuum with the refrigerant to be used in the system and charge the system with refrigerant
- ☑ Add oil to the compressors, oil separator and oil reservoirs, if equipped before starting compressors.

☐ 8. CHARGING

☐ 9. FINAL CHECK

STEPS
STARTUP CHECK LIST

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	INSPECTION, COMMISSIONING & STARTUP CHECKLIST	
	CO2 TRANSCRITICAL SYSTEMS	PROJECT #

AKNOWLEDGEMENT

The following items must be checked and completed by installing contractor prior to the arrival of the Kysor Warren Technical Sales Support personnel.
One form per rack shall be filled out; in case of multiple racks at the same job site, one form per rack must be completed.
This check list involves mechanical, electrical, site piping and communication wiring requirements to ensure proper system commissioning and start up.
Should additional time or site visits be required to account for out-of-scope services or downtime not attributed to Kysor Warren Epta US, the customer will be subject to additional charges.

Please complete, sign and e-mail this form to your local Kysor Warren Technical Sales Support representative as confirmation of completion.

Mechanical and Store Piping Requirements	Complete
The rack has been set, is leveled and secured to the structure or floor	☐
Store piping is complete and insulated, both liquid and suction lines	☐
System has been properly leak checked	☐
Verify proper copper pipe and fittings material type has been used according to pressure rating. K65 for connecting the compressor rack to and from gas cooler.	☐
Verify store piping has been properly supported	☐
Verify suction lines have proper slope returning to the compressor rack	☐
Verify all relief valves are the proper ratings and the relief trees (when applicable) are opened to the valve with the hose attached.	☐
Verify all pressure transducer readings and locations are per the PID and I/O list.	☐
Verify the water supply and drain piping has been connected to gas cooler (applicable for Adiabatic gas coolers only)	☐
Store piping has been pressure tested with a minimum of 300 psi or per customer specification (log data such as pressure reading, length of test and date)	☐
System evacuation (triple evacuation) was complete and successful to 300 microns or per customer specification (log data such as micron reading, length of test and date)	☐
Verify all filters have been installed(Suction filters, liquid driers, oil separator filter, etc.)	☐
Verify proper oil has been added to the compressors, oil separator and oil reservoir between 2nd and 3rd sight glass	☐
System has been charged with CO2 vapor Instrument, Coleman or Refrigeration grade to approximately 150 psi	☐
Verify the gas cooler fans and speed signal are working properly	☐
Verify the crank case heaters are working properly	☐

Store Wiring Requirements	Complete
Verify the correct main power supply for the compressor rack and gas cooler per the refrigeration schedule is connected and properly terminated.	☐
Verify the correct control power supply per the refrigeration schedule is connected and properly terminated.	☐
Verify the correct power supply for all display cases as required per the refrigeration schedule is connected and properly terminated	☐
Verify the correct power supply for remote electrical panels for walk in boxes as per the refrigeration schedule is connected and properly terminated. All wiring is landed properly, and all connections are tested for each panel.	☐
All electrical connections have been checked and tightened as required.	☐
Verify all temperature sensor locations and readings are accurate for all display cases and walk–in boxes.	☐
Verify all pressure transducer locations and readings are accurate for all display cases and walk–in boxes.	☐
Verify proper communication between system equipment (rack controller, case controllers, gas cooler)	☐
Verify the compressor Rack controller has been programmed properly	☐
Verify all rack I/O boards are online and communicating	☐
Verify all evaporator walk-in and case controllers are online, setup, and programmed properly	☐
Verify the compressors VFDs are programmed correctly	☐
Exercise all relay outputs and verify proper operation of each component	☐
All evaporator and cases are powered ON and issue free	☐

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	CO2 TRANSCRITICAL SYSTEMS	PROJECT #

Mechanical and Store Piping Requirements (continuation)	Complete
Verify the HPV (high pressure valve) opens and closes properly and ensure the controller is programmed for that specific valve model	☐
Verify the FGBV (flash gas bypass valve) opens and closes properly and ensure the controller is programmed for that specific valve model	☐
Verify there is enough of the proper grade CO2 vapor and liquid at the store for start up (it is recommended to have an extra full charge available)	☐
It is recommended to have a charging station for roof top mounted racks.	☐
It is recommended to provide a scale large enough to weigh the CO2 tanks while charging the system.	☐

Mechanical – Check Completion	
Company	
Name	
Signature	
Date	
Witness	
Signature	
Date	

Wiring / Electrical – Check Completion	
Company	
Name	
Signature	
Date	
Witness	
Signature	
Date	

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Mechanical and Store Piping Requirements	Complete
The rack has been set, is leveled and secured to the structure or floor	☐
Store piping is complete and insulated, both liquid and suction lines	☐
System has been properly leak checked	☐
Verify proper copper pipe and fittings material type has been used according to pressure rating. K65 for connecting the compressor rack to and from gas cooler.	☐
Verify store piping has been properly supported	☐
Verify suction lines have proper slope returning to the compressor rack	☐
Verify all relief valves are the proper ratings and the relief trees (when applicable) are opened to the valve with the hose attached.	☐
Verify all pressure transducer readings and locations are per the PID and I/O list.	☐
Verify the water supply and drain piping has been connected to gas cooler (applicable for Adiabatic gas coolers only)	☐
Store piping has been pressure tested with a minimum of 300 psi or per customer specification (log data such as pressure reading, length of test and date)	☐
System evacuation (triple evacuation) was complete and successful to 300 microns or per customer specification (log data such as micron reading, length of test and date)	☐
Verify all filters have been installed(Suction filters, liquid driers, oil separator filter, etc.)	☐
Verify proper oil has been added to the compressors, oil separator and oil reservoir between 2nd and 3rd sight glass	☐
System has been charged with CO_2 vapor Instrument, Coleman or Refrigeration grade to approximately 150 psi	☐
Verify the gas cooler fans and speed signal are working properly	☐
Verify the crank case heaters are working properly	☐

Store Wiring Requirements	Complete
Verify the correct main power supply for the compressor rack and gas cooler per the refrigeration schedule is connected and properly terminated.	☐
Verify the correct control power supply per the refrigeration schedule is connected and properly terminated.	☐
Verify the correct power supply for all display cases as required per the refrigeration schedule is connected and properly terminated	☐
Verify the correct power supply for remote electrical panels for walk in boxes as per the refrigeration schedule is connected and properly terminated. All wiring is landed properly, and all connections are tested for each panel.	☐
All electrical connections have been checked and tightened as required.	☐
Verify all temperature sensor locations and readings are accurate for all display cases and walk-in boxes.	☐
Verify all pressure transducer locations and readings are accurate for all display cases and walk-in boxes.	☐
Verify proper communication between system equipment (rack controller, case controllers, gas cooler)	☐
Verify the compressor Rack controller has been programmed properly	☐
Verify all rack I/O boards are online and communicating	☐
Verify all evaporator walk-in and case controllers are online, setup, and programmed properly	☐
Verify the compressors VFDs are programmed correctly	☐
Exercise all relay outputs and verify proper operation of each component	☐
All evaporator and cases are powered ON and issue free	☐

SYSTEM OPERATION

Kysor Warren recommends pressure testing and triple-evacuation to ensure proper elimination of moisture and non-condensable gases.

STEP 1
Commissioning

STEP 2
System Power

STEP 3
CO_2 Initial Charging

- Oil Charge
- CO_2 Vapor Change

STEP 4
Starting Compressors

- Start ACU (optional)
- Controls/Instrumentation Check
- Liquid CO_2 Charge to Flash Tank
- Start MT compressors
- Pull Down MT Cases & Walk-ins
- Start LT compressors
- Pull down LT Cases & Walk-ins

STEP 5
Evaporator Temp. Control

STEP 6
Defrost Setup

STEP 7
Walk-In Door Switches

1. SYSTEM POWER (Prior to charging the system or starting compressors)

- ☑ Power has been turned on to each subsystem
- ☑ Control Panel is energized
- ☑ Panel switches are set with compressor OFF
- ☑ Check operation of cooling fans
    - ☑ Gas Cooler Fans Operating
    - ☑ Case Fans Operating
- ☑ Control System is installed and programmed according the System SOO set points
- ☑ Controls, gauges, and thermometers are displaying temperatures and pressures (Check values expected without refrigeration system operating)

☐ 2. INITIAL CHARGING

☐ 3. STARTING COMPRESSORS

☑ 1. SYSTEM POWER

2. INITIAL CHARGING

2.1 – REQUIRED EQUIPMENT AND MATERIALS

- ☑ CO_2 Vapor Cylinders
- ☑ CO_2 Liquid Cylinders (w/dip tube)
- ☑ Charging Hoses
  - ☑ 3/8" hose for faster charging
  - ☑ rated for 1740 psig working pressure

Instrument or Coleman Grade CO_2 vapor to break vacuum and pressurize the system to 150 psig

Instrument or Coleman Grade CO_2 for remainder of charge – reference refrigeration legend for estimated charge

☐ 3. STARTING COMPRESSORS

☑ 1. SYSTEM POWER

2. INITIAL CHARGING

2.1 – REQUIRED EQUIPMENT AND MATERIALS

- ☑ CGA-320 Adapter Fitting
- ☑ Filter/Dryer
- ☑ Refrigerant Scale
- ☑ POE Oil
- ☑ Manual Oil Pump

CO2 cylinders (liquid and vapor) have CGA-320 fittings. An adaptor is required to connect the CO2 cylinder to a flare connection on charging hoses for liquid charging

Use on the charging port for both liquid and vapor charging. Provide one core for about every 600lb. CO2

- Emerson Copeland CO2 Compressors use POE Oil – **EMKARATE RL68HB**
- BITZER CO2 compressors use POE oil – **BSE85K**

☐ 3. STARTING COMPRESSORS

☑ 1. SYSTEM POWER

2. INITIAL CHARGING

2.2 – OIL CHARGE

Oil charge to the **Oil Reservoir**

- ☑ Confirm that oil is compatible with compressors
- ☑ Close valves to isolate oil reservoir
- ☑ Fill reservoir with oil 50%
- ☑ Open valve between oil reservoir and compressors

This step need to be done between 2nd and 3rd evacuation

☐ 3. STARTING COMPRESSORS

☑ 1. SYSTEM POWER

2. INITIAL CHARGING

2.2 – OIL CHARGE

Oil charge to **Compressor**

☑ Check that compressor oil is at the proper level

☑ Confirm that the compressor crankcase heaters are energized for 24h before start up

Oil level requirement may vary with compressor manufacturer
Crankcase heater must be operating to warm the oil prior to starting the compressor.

☐ 3. STARTING COMPRESSORS

☑ 1. SYSTEM POWER

2. INITIAL CHARGING

2.3 – CO_2 VAPOR CHARGE

- ☑ Break the vacuum with Vapor CO_2 to 150 psig
- ☑ Leave all valves open - complete system and piping distribution network with vapor charge
- ☑ Close compressor suction and discharge valves
- ☑ Continue charging vapor CO_2 to 150 psig
- ☑ Check that any rack gauges and control pressures read 150 psig

PRESSURE RATINGS

Less 150psig
- some valves might be closed, or faulty pressure transducer

Greater 150psig
- faulty pressure transducer reading

CO_2: Tsat = -34F @ 150 psig

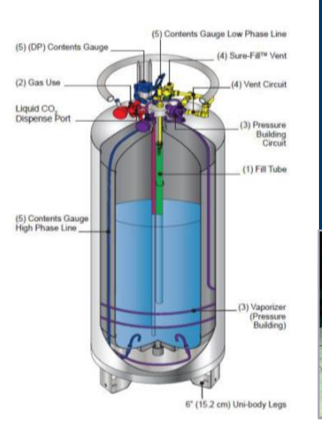
☐ 3. STARTING COMPRESSORS

☑ 1. SYSTEM POWER

2. INITIAL CHARGING

2.3 – CO2 VAPOR CHARGE

- ☑ As vapor is drawn from the CO2 cylinders, pressure and temperature inside the cylinder will decrease
- ☑ Frosting on the bottom exterior → some CO2 liquid evaporated inside
- ☑ Pressure reduction → slower flow rate of vapor into the system
- ☑ Cylinder flow slowed to a low level, the cold cylinder should be disconnected and allowed to warm
- ☑ After the cylinder warms, additional CO2 can be removed. In the meantime, another warm tank can be connected to the system to continue the charging process



A typical full 100 lb. cylinder contains approximately 50 lbs. of useable CO2 that can be charged into the system. On the first attempt, 20-25 lbs. of CO2 vapor can typically be obtained from the cylinder before reaching a low-temperature/pressure of the tank

☐ 3. STARTING COMPRESSORS

☑ 1. SYSTEM POWER

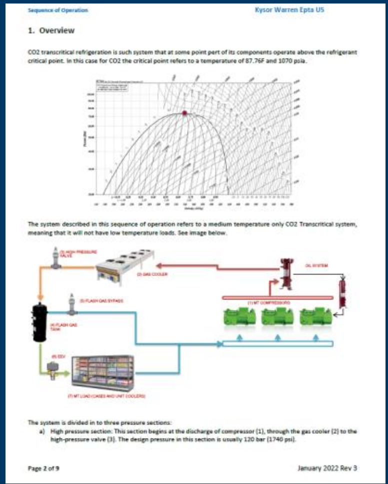
☑ 2. INITIAL CHARGING

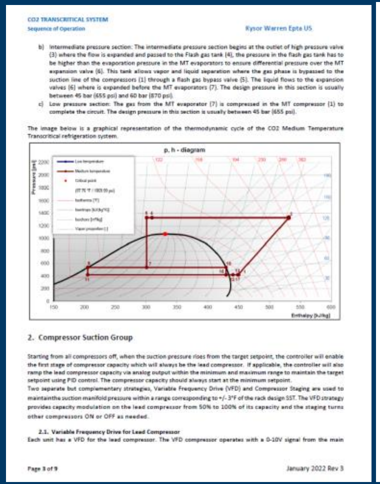
3. STARTING COMPRESSORS

SOO (Sequence of Operation) is provided for individual systems, providing information for programming of controls and various alarms

3.2 CONTROLS / INSTRUMENTATION CHECK

- ☑ Mechanical Pressure Switches
- ☑ Pressure & Temperature Sensors
- ☑ Digital Input Verification
- ☑ Relay Output Verification
- ☑ Analog Output Verification
- ☑ VFD Set-up Verification
- ☑ Electrical Connections





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☑ 1. SYSTEM POWER

☑ 2. INITIAL CHARGING

3. STARTING COMPRESSORS

3.1 – START ACU (OPTIONAL)

- ☑ Check ACU Pressure Control setpoint
- ☑ Power up ACU by temporarily lowering the ACU Pressure Control setpoint until it closes
- ☑ Confirm that ACU compressor and fans are running
- ☑ Return ACU Pressure Control to its proper setpoint. The switch should open and the ACU compressor will cycle off on its low pressure control

1. With ACU

ACU is activated by ACU Pressure Control on the flash tank. When the flash tank pressure rises to the ACU set point, this control energizes the liquid line solenoid to the ACU heat exchanger

2. Without ACU

LT / MT loads should be gradually bought online; system operation and controls are validated prior to adding further charge under guidance of contractor/ technician

☑ 1. SYSTEM POWER

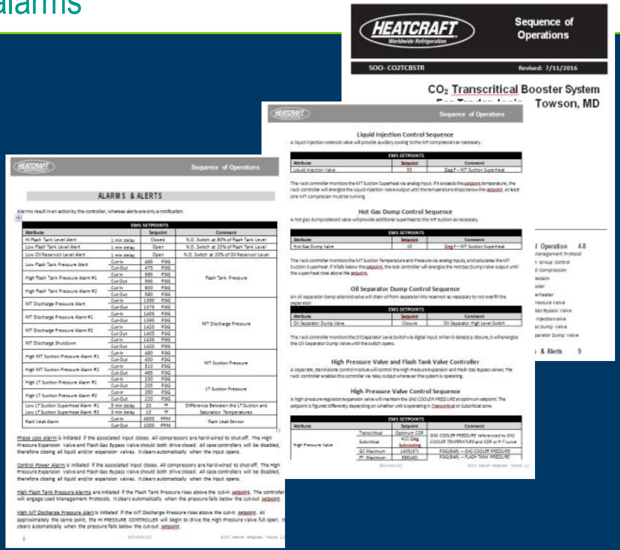
☑ 2. INITIAL CHARGING

3. STARTING COMPRESSORS

3.2 CONTROLS / INSTRUMENTATION CHECK

- ☑ Mechanical Pressure Switches
- ☑ Pressure & Temperature Sensors
- ☑ Digital Input Verification
- ☑ Relay Output Verification
- ☑ Analog Output Verification
- ☑ VFD Set-up Verification
- ☑ Electrical Connections

SOO (Sequence of Operation) is provided for individual systems, providing information for programming of controls and various alarms



☑ 1. SYSTEM POWER

☑ 2. INITIAL CHARGING

3. STARTING COMPRESSORS

3.3 LIQUID CO2 CHARGE TO FLASK TANK

- ☑ Close the main CO2 liquid line valve
- ☑ Check that EEVs at cases and walk-ins are also in the closed position
- ☑ Purge air from refrigerant tank supply hoses before attaching to the flash tank
- ☑ Fill liquid CO2 directly to the flash tank

When ACU is NOT present

- Close the isolation valves on all lines connected to flash tank
- Position PRV change over valve to pump-down position

When ACU is present

- Manually turn on ACU
- Check that compressor is running, fan is turning, and unit is cooling

☑ 1. SYSTEM POWER

☑ 2. INITIAL CHARGING

3. STARTING COMPRESSORS

3.3 LIQUID CO2 CHARGE TO FLASK TANK

- ☑ Adjust the flow by the valve on the tank
- ☑ Check design specification for initial charge level
- ☑ Do not exceed the second sight glass (~50%) during charging
- ☑ Frost should form on the base of the tank when the tank is close to empty
- ☑ Check to purge air from hoses when adding new refrigerant tank(s)
- ☑ Change the core of the filter drier on the charging port for every 500 lbs. of refrigerant added.

☑ 1. SYSTEM POWER

☑ 2. INITIAL CHARGING

3. STARTING COMPRESSORS

3.4 START MT COMPRESSORS

- ☑ MT compressors should be powered on in “stand-by”
- ☑ Change panel switch for compressors to ON
- ☑ Turn on case controllers for the first section of MT loads to be started (Never start at full load)
- ☑ Slowly open main CO_2 liquid line valve(s) to MT loads
- ☑ MT compressors begin running and pulling down case pressures and temperatures.
- ☑ Add CO_2 Liquid Charge to maintain the flash tank level just above first site glass (no more than 25%) after cases are running at operating temperatures

When ACU is NOT present:

- Open isolation valve between HPEV and Flash Tank
- Open isolation valve between FGBV and Flash Tank

☑ 1. SYSTEM POWER

☑ 2. INITIAL CHARGING

3. STARTING COMPRESSORS

3.5 PULL DOWN MT CASES & WALK-INS

☑ Confirm that MT Cases and Walk-Ins are meeting the required temperatures

☑ 1. SYSTEM POWER

☑ 2. INITIAL CHARGING

3. STARTING COMPRESSORS

3.6 START LT COMPRESSORS

- ☑ Open main CO2 liquid line valve(s) to the LT loads
- ☑ LT Compressors should be powered on in “stand-by”
- ☑ Change panel switch for compressors to ON
- ☑ Turn on case controllers for the first section of LT loads to be started (Never start at full load)
- ☑ Slowly open main CO2 liquid line valve(s) to the LT loads
- ☑ LT compressors begin running and pulling down case pressures and temperatures
- ☑ Add CO2 Liquid Charge to maintain flash tank level after cases are running at operating temperatures

CO2 Charge Capacity - The CO2 Flash tank has sufficient volume for various operating conditions. The final charge should be checked when the system is stable, and when the cases and walk-ins are pulled down to their set-point temperatures

☑ 1. SYSTEM POWER

☑ 2. INITIAL CHARGING

3. STARTING COMPRESSORS

3.7 PULL DOWN LT CASES & WALK-INS

- ☑ Continue bringing all cases and walk-ins online and adjusting charge as needed
- ☑ Confirm that LT Cases and Walk-Ins are meeting the required temperatures

4. EVAPORATOR TEMPERATURE CONTROL

- ☑ Verify temperature sensor locations indicated by the controller
- ☑ Validate temperature readings on the controller with a known temperature source. This is done using “ice bath” method, or using a calibrated thermometer
- ☑ Some adjustment may be required on controller settings.

☐ 5. DEFROST OPERATION

☐ 6. WALK-IN DOOR SWITCHES

☑ 4. EVAPORATOR TEMPERATURE CONTROL

5. DEFROST OPERATION

- ☑ Defrost should be programmed to operate with 10% to 20% of system load/capacity at a time
- ☑ Defrosting CO_2 evaporators is similar to conventional systems
- ☑ Defrosting the evaporators is accomplished in (3) sequential stages, referred to as operating modes:

STEP 1
Pump down mode
10-12min

›

STEP 2
Heating mode
45-60min

›

STEP 3
Drip mode
10min

☐ 6. WALK-IN DOOR SWITCHES

☑ 4. EVAPORATOR TEMPERATURE CONTROL

☑ 5. DEFROST OPERATION

6. WALK-IN DOOR SWITCHES

Door switches should be installed to walk-ins, set to cut-off fans during door openings and refrigeration after delay.

Door switches are wired to the system controller where door openings are recorded. Extended door openings set an alarm at the controller.

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	INSPECTION, COMMISSIONING & STARTUP CHECKLIST	
	CO2 TRANSCRITICAL SYSTEMS	PROJECT #

Startup report should be completed by the end of startup week, submit a copy to your local Kysor Warren Technical Sales Support representative.

CO2 Start-Up Report

					YES / NO		PASS / FAIL	OL	:00
DATE		SALES ORDER #							
STORE #		RACK MODEL #							
CITY		RACK SERIAL #							
STATE		CONTRACTOR							
TECH		INDOOR TEMPERATURE		INDOOR HUMIDITY					

RACK VOLTAGE							EMS VOLTAGE
L1-L2	L1-L3	L2-L3		L1	L2	L3	

COMPRESSOR TESTING/SETTING

	AMP DRAW			HP CONTROL -PASS/FAIL			CCH	OIL LEVEL	OIL FAIL-PASS/FAIL		TIME DELAY	NOTES
	L1	L2	L3	SET	MECHANICAL	CONTROLLER	AMPS	1/4,1/2,3/4,FULL	MECHANICAL	CONTROLLER	SET	
LTC- #1				586								
LTC- #2				586								
LTC- #3				586								
LTC- #4				586								
MTC- #1				1570								
MTC- #2				1570								
MTC- #3				1570								
MTC- #4				1570								
MTC- #5				1570								

LT COMPRESSOR VFD

	YES/NO	NOTES
ALL PARAMETERS ARE SET PER SPEC (YES/NO)		
VFD-DOES SPEED RAMP UP AND DOWN PROPERLY (YES/NO)		

MT COMPRESSOR VFD

	YES/NO	NOTES
ALL PARAMETERS ARE SET PER SPEC (YES/NO)		
VFD-DOES SPEED RAMP UP AND DOWN PROPERLY (YES/NO)		

RACK CONTROLS

	DESIGN SP	ACTUAL SP	PASS/FAIL		NOTES
	FROM KOR	ON SITE	MECHANICAL	CONTROLLER	
LT LOW PRESSURE CONTROL	130/190				
MT LOW PRESSURE CONTROL	260/320				
LT SUCTION SETPOINT	196				
MT SUCTION SETPOINT	420				
FLASH TANK PRV SERVICE	1305/870				
FLASH TANK PRV OPERATION	650				
HIGH SIDE PRV	1740				
MT LOW SIDE PRV	650				
LT LOW SIDE PRV	435				
PHASE LOSS MONITOR					
HEAT REC (MODULATING VALVES)					
OIL SEPARATOR DUMP VALVE					
HIGH PRESSURE VALVE					
FLASH GAS VALVE					
FLASH TANK LEVEL LOW					

FTE ENABLE

	YES/NO	NOTES
VALVES B8, B9, B10, B11, B12 OPEN		
VALVES B2, B5, B13 CLOSED		
FTE JUMPER IS REMOVED		
FTE TANK 10% - 30%		
MT CASES DROP TO 3° SUPERHEAT		

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TRANSDUCERS

	PASS/FAIL	NOTES
MT SUCTION		
LT SUCTION		
GAS COOLER OUTLET		
FLASH TANK		
FTE TANK		
MT DISCHARGE		

SENSORS

	PASS/FAIL	NOTES
OAT		
MACHINE ROOM TEMP		
GAS CLR OUTLET TEMP		
GAS CLR AIR COIL TEMP(PRECOOL)		
MT SUCTION TEMP		
LT SUCTION TEMP		
MT DISCHARGE TEMP		
MT FTE RETURN TEMP		
LIQ SUPPLY TEMP		
MT RETURN TEMP		
LT RETURN TEMP		
HEAT RECLAIM TANK OUT TEMP		

GAS COOLER AND VFD

			NOTES
GAS COOLER MAKE			
GAS COOLER MODEL			
GAS COOLER SERIAL			
NUMBER OF FANS			
AMPS PER FAN			
VOLTS			
FILL VALVE WORKING YES/NO			
DRAIN VALVE WORKING YES/NO			
ALL FANS ROTATE IN THE PROPER DIRECTION			
FAN SPEED (0V. = 100% / 9.5V. = 0%) (YES/NO)			
	DESIGN	ACTUAL	
CABINET HEATER	32°		
ADIABATIC MODE CUT IN/CUT OUT	81°/77°		
FAN DISABLE MODE CUT IN			
FAST RECOVERY MODE CUT IN			

MISC CONTROLS

	YES/NO	PASS/FAIL	NOTES
LEAK DETECTION SYSTEM			
BATTERY BACKUP			
LL BYPASS VALVE CLOSED			

MAINTENANCE & TROUBLESHOOTING

PUMPING-DOWN THE SYSTEM FOR SERVICE

1. Close liquid CO2 supply ball valve from flash tank

2. System starts to self-pump-down Wait until there is no pressure rise in LT and MT suction. Pressure rise in LT and MT suction is the indication of liquid present in the system. When MT and LT compressors stays off for 10 minutes continuously move to step 3.

(MT pump-down pressure set point is 350 psig and LT pump-down pressure set point is 160 psig)

3. Turn OFF compressors using their switches on control panel.

4. Isolate flash tank. Close valves to FGBV, Oil reservoir, and from HPEV

5. Use change over valve on the flash tank to switch from the 650 psig PRV to the 1305 psig PRV Check the pressure setting stamped on the PRVs to be sure the 1305 psig PRV is in use during pump down.

6. Turn OFF the breakers for all the LT and MT compressors.

7. System pump-down is complete.

RESTARTING THE SYSTEM AFTER PUMPING-DOWN AND SERVICE

1. Make sure gas cooler fans are operating or ready to operate.
2. Make sure all the compressors switches are OFF
3. Turn on all the breakers ON
4. Check to make sure controller is calling for open FGBV and close HPEV
5. Turn ON the switch for the lead MT compressor
6. Gradually open angle valve from HPEV. Since controller is calling for close HPEV there should be no increase in flash tank pressure

High pressure in FGT above the max pressure set point (580 psig) will make the controller open the FGBV and close the HPEV

Use only the lead MT compressor to operate in steps 4 to 12 by turning the switches OFF for remaining of compressors.

LT compressors switches have to be OFF during the steps 4 to 14

RESTARTING THE SYSTEM AFTER PUMPING-DOWN AND SERVICE

7. Gradually open the ball valve to FGBV. Initially barely cracked open till lead MT compressor starts running. This will cause the suction pressure of MT compressors to rise and controller should start the lead MT compressor. Let the pressure in flash tank decreases. **Do not let the MT suction pressure higher than (500)**

8. When operating the lead MT compressors to reduce the FGT pressure, pay attention to gas cooler pressure and do not let it rise **above 1400 psig.** In case of having plate HTX as Gas coolers where the internal volume is very small, the high side pressure is very sensitive.

9. Flash tank pressure should stabilize around 520 psig

10. Use change over valve on flash tank to switch to 650 psig pressure relief valve.

Caution: Opening the ball valve fast can result in releasing refrigerant charge from MT suction PRV (A9)

RESTARTING THE SYSTEM AFTER PUMPING-DOWN AND SERVICE

11. Open the valve that connects flash tank to oil reservoir

12. Turn ON switches for the rest of MT compressors and make sure they are ready to operate

13. Gradually open Liquid CO2 supply angle valve. The system should start running and pulling down MT cases

14. After MT cases are stable turn ON LT compressor switches. Controller should start LT compressor and start pulling LT cases down

15. Double check to make sure the valves from HPEV, oil reservoir, FGBV to flash tank and liquid CO2 supply are fully open and 650 psig PRV on flash tank is in service.

Caution: Opening the ball valve fast can result in releasing refrigerant charge from MT suction PRV (A9)

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STARTUP

- ☑ Change all filters and driers (end 1st week of startup)
- ☑ Change the filter driers (2nd time after 90 days)
- ☑ Remove the suction line filter core
- ☑ Replace oil coalescing media

☐ WEEKLY

☐ MONTHLY

☐ ANNUALLY

☑ STARTUP

WEEKLY

- ☑ Visually inspect equipment.
- ☑ Check refrigerant charge.
- ☑ Check compressor oil level and color.
- ☑ Check compressor crankcase heater operation.
- ☑ Check main power and control voltage.
- ☑ Check appearance of area around the unit.
- ☑ Check system pressures.
- ☑ Check moisture indicator in liquid sight glass.

☐ MONTHLY

☐ ANNUALLY

☑ STARTUP

☑ WEEKLY

MONTHLY

- ☑ Check the system for leaks.
- ☑ Check suction filters and liquid line filter driers for pressure drop.
- ☑ Check all flanged connection bolts, fittings and line clamps for tightness.
- ☑ Inspect condenser fan blades and motor mounts for cracks, loose set screws or mounting bolts.
- ☑ Tighten all electrical connections.
- ☑ Check operation and condition of contactors.
- ☑ Check operation of auxiliary equipment.

☐ ANNUALLY

☑ STARTUP

☑ WEEKLY

☑ MONTHLY

ANNUALLY

- ☑ Obtain oil sample for analysis; change oil if required.
- ☑ Change liquid line filter drier and suction filter cores.
- ☑ Test all operating and safety controls and record in service log book

THANK YOU!!

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