# $CO_2$ Transcritical Systems


## *Installation & Operation Manual*

**IMPORTANT**

**Keep in store for future reference!**

**P/N 2H17721001_B**
**August 2018**

# BEFORE YOU BEGIN

**Read these instructions completely and carefully.**

## PERSONAL PROTECTION EQUIPMENT (PPE)

Personal Protection Equipment (PPE) is required whenever servicing this equipment. Always wear safety glasses, gloves, protective boots or shoes, long pants, and a long-sleeve shirt when handling glass.

Hussmann reserves the right to change or revise specifications and product design in connection with any feature of our products. Such changes do not entitle the buyer to corresponding changes, improvements, additions or replacements for equipment previously sold or shipped.

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## REVISION HISTORY

**ORIGINAL ISSUE —** August 2015

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## ANSI Z535.5 DEFINITIONS

- **DANGER** – Indicate[s] a hazardous situation which, if not avoided, will result in death or serious injury.

- **WARNING** – Indicate[s] a hazardous situation which, if not avoided, could result in death or serious injury.

- **CAUTION** – Indicate[s] a hazardous situation which, if not avoided, could result in minor or moderate injury.

- **NOTICE** – *Not related to personal injury* – Indicates[s] situations, which if not avoided, could result in damage to equipment.


This warning does not mean that Hussmann products will cause cancer or reproductive harm, or is in violation of any product-safety standards or requirements. As clarified by the California State government, Proposition 65 can be considered more of a 'right to know' law than a pure product safety law. When used as designed, Hussmann believes that our products are not harmful. We provide the Proposition 65 warning to stay in compliance with California State law. It is your responsibility to provide accurate Proposition 65 warning labels to your customers when necessary. For more information on Proposition 65, please visit the California State government website.

# INSTALLATION

## SYSTEM OVERVIEW

This manual covers Trans-critical $CO_2$ systems manufactured by LMP Systems for Hussmann Corp. These systems can be used in large or small format supermarkets using commercial refrigeration equipment with $CO_2$ refrigerant. This manual should be used by installers and maintenance personnel when installing or servicing these Hussmann PURITY Trans-critical $CO_2$ systems.

All PURITY Trans-critical $CO_2$ systems are UL Listed and conform to ANSI/ UL 1995 * CSA C22.2 No.236-11

LISTED

Equipment must be installed in accordance with all local codes, state codes, fire codes and the National Electrical Code.

**WARNING**

**Trans-critical CO2 refrigeration systems operate under high pressure. Excessive pressure can result in the rupture of components resulting in physical injury. DO NOT tamper with or remove pressure relief devices. DO NOT install additional isolation valves which could trap carbon dioxide in tubing or other components without providing proper pressure relief device.**

**WARNING**

**Trans-critical CO2 systems use carbon dioxide as a refrigerant. Carbon dioxide is non-flammable, odorless, colorless gas that can displace oxygen in the atmosphere resulting in asphyxiation. If any of the below initial symptoms are experienced evacuate the area and seek open space.**
**Never disable leak detection devices, ventilation systems or pressure relief devices during system charging or servicing.**

| Carbon Dioxide Concentration Inhaled | EFFECTS |
|---|---|
| 1% | Breathing rate increases slightly. |
| 2% | Breathing rate increases to 50% above normal level. Prolonged exposure can cause headache, tiredness. |
| **3%** | **Breathing increases to twice normal rate and becomes labored.** Weak narcotic effect. Impaired hearing, headache, increased blood pressure and pulse rate. |
| 4–5% | Breathing increases to approximately four times normal rate, symptoms of intoxication become evident, and slight choking may be felt. |
| **5–10%** | Characteristic sharp odor noticeable. **Very labored breathing, visual impairment,** headache, and ringing in the ears. **Judgment may be impaired, followed within minutes by loss of consciousness.** |
| **10–100%** | Unconsciousness occurs more rapidly above 10% level. **Prolonged exposure to high concentrations may eventually result in death from asphyxiation.** |

# SYSTEM COMPONENTS

## COMPRESSORS

The compressors used in these systems are Bitzer reciprocating, Copeland reciprocating and/or Copeland Scrolls and are sized to provide optimal system function at all times during the standard operation of the unit.

## SYSTEM LUBRICANTS

The Hussmann PURITY trans-critical compressors use a Polyol Ester (POE) lubricant. Specific viscosities are required by the compressor manufacturers. See the chart below for acceptable lubricants.

| Compressor | Accepted Lubricant |
|---|---|
| Copeland Reciprocating | EMKARATE RL68HB |
| Copeland Scroll | EMKARATE RL68HB |
| Bitzer Reciprocating | EMKARATE RL68HB |

NOTE: Adding any lubricant additives in the field during install or during service will void the Hussmann and compressor warranty.

## FACTORY PIPING:

The systems will come with:

a. Suction, and Liquid Headers and optional Gas Defrost Headers with individual circuits specific for refrigeration lineups as provided by the customer. They can also be designed to accommodate a loop system where a single liquid and suction lines are "looped" in the store, and individual drops are piped to each lineup. At Hussmann's discretion, these two designs may be mixed on the same system depending on the requirements.

b. Oil Management System – The oil management system is designed to provide proper oil distribution and return to the compressors during normal operation. Proper line sizing is very important to ensure proper oil return to the compressors. Variance from the recommended line sizes may void the Hussmann warranty.

c. Liquid Reservoir (Flash Tank) w/ Relief Valves – Sized to hold the entire refrigerant charge this component insure that the liquid lines are supplied with 100% liquid $CO_2$.

d. Relief Valves – These valves are supplied by Hussmann for field installation and must be installed in accordance with the procedures in this manual along with adherence to all local and national codes, fire codes and authorities having jurisdiction.

e. Suction Filters – Suction Filters are used prior to each compressor suction header to insure that all solid contaminants are removed from the refrigerant stream prior to the compressors.

f. Liquid Drier – Liquid dryers are installed in the liquid line and are sized based on the refrigeration load for that system. It is recommended that the cores used be a minimum of 50% molecular sieves. This will ensure proper moisture and acid removal. It is also recommended that the filter cores be replaced every time the system is opened for any period of time for any reason. At the time of shipment two sets of cores are shipped with the unit, one set is to be installed during system install and the other installed after 7 days of run time.

## GAS COOLER

The Gas Cooler is piped directly after the MT Compressors. The Gas Cooler removes sensible heat from the $CO_2$ gas when the system is in trans-critical mode. When the outside temperature allows the system to function in subcritical mode, the gas cooler behaves similar to a standard condenser, where both latent heat and sensible heat are removed. There are several different manufacturers each with specific requirements, the shipped equipment will have specific information enclosed. When situations exist (high ambient temperatures and low relative humidity) – an adiabatic gas cooler may be used. This type of gas cooler utilizes water sprayed in the airstream to drop the condensing temperature to near wet bulb temperature. This allows the system to run more efficiently at higher ambient temperatures.

## CONTROL PANEL

The Control Power is fully factory wired with
a. Pre-wired Distribution Power Block
b. Individual Integral (combined circuit breaker and contactor) or Component Circuit Breakers and Contactors
c. Color Coded wiring
d. All electrical components (ie relays, switches) as required.

## CONTROL VOLTAGE

208 volts/1 phase/ 60 hertz — Refer to wiring diagram for connection type.

## REFRIGERANT

Carbon Dioxide ($CO_2$) is the only refrigerant required with the Hussmann Purity trans-critical $CO_2$ system. The following properties apply:

**Table 1. Physical Properties of Carbon Dioxide**

| | |
|---|---|
| Molecular Weight | 44.01 |
| Boiling Point (at 1 atm) (°F) | -109.1 |
| Triple Point (at 75.2 psia) | 69.8 |
| Critical Temperatue (°F) | 87.9 |
| Specific Gravity Gas (at 1 atm) | 1.53 |
| OSHA (TLV (ppm)-TWA (%)) | 5000 - 0.5 |

**Table 2. Thermodynamic Properties of Carbon Dioxide**

| Property | @-20°F | @+20°F |
|---|---|---|
| Saturation Pressure (psig) | 200.2 | 407.2 |
| Liquid Density, lb./cu. Ft. | 66.9 | 60.3 |
| Vapor Density, lb./cu. Ft. | 2.40 | 4.94 |
| Heat of Vaporization, BTU/lb. | 129.6 | 107.5 |

**Table 3. Grades of Carbon Dioxide**

| Grade | $CO_2$ Purity |
|---|---|
| Industrial Grade | 99.5% |
| Bone Dry Grade | 99.8% |
| Anaerobic Grade | 99.9% |
| Coleman (Instrument) Grade | 99.99% |
| Research Grade | 99.999% |
| Ultra-Pure Grade | 99.9999% |

Though many grades of $CO_2$ are available, Hussmann recommends using $CO_2$ with a purity equal to or greater than Bone Dry Carbon Dioxide. The use of this grade ensures proper operation of the equipment and is of a purity high enough to prevent accumulation of non-condensable gases in the system. Mixing of higher purity grades of $CO_2$ is acceptable. Lower grades of $CO_2$, though less expensive, are not recommended for use in Hussmann PURITY systems. These contain higher levels of contaminants and water, and may decrease system performance. Higher levels of moisture may react with the $CO_2$ and form carboxylic acid which may degrade component integrity. It is recommended, depending on your location and availability of $CO_2$, that enough refrigerant be kept on site to fill the unit charge.

## SHIP LOOSE PARTS

All required ship loose parts will accompany the system delivery including, but not limited to:

a. Liquid Drier Cores
b. Suction Filter Cores
c. Vibration Isolation Pads
d. Temperature and Pressure Transducers and Probes (as required)
e. All required accessories as defined by the customer

## SHIPPING DAMAGE

All equipment should be thoroughly examined for shipping damage before and while unloading. This equipment has been carefully inspected at our factory and the carrier has assumed responsibility for safe arrival. If damaged, either apparent or concealed, claim must be made with the carrier.

**Apparent Loss or Damage**
If there is an obvious loss or damage, it must be noted on the freight bill or express receipt and signed by the carrier's agent, otherwise, carrier may refuse claim. The carrier will supply the necessary claim forms.

**Concealed Loss or Damage**
When loss or damage is not apparent until after equipment is uncrated, a claim for concealed damage is made. Upon discovering damage, make request in writing to carrier for inspection within 15 days and retain all packing. The carrier will supply inspection report and required claim forms.

## EQUIPMENT ROOM REQUIREMENTS

The equipment room floor must solidly support the compressor unit as a live load. Ground level installation seldom presents problems, but a mezzanine installation must be carefully engineered.

Follow ANSI/ASHRAE 15 for ventilation requirements. Ventilation should normally be between 65 and 100 cfm per compressor unit horsepower (check local codes). The air inlet should be sized for a maximum of 500 fpm velocity. The ventilation fans should cycle by thermostatic control.

All equipment room ventilation equipment must be field supplied. Check local codes for variances.

Proper ventilation provides airflow across the compressors. Duct work may be necessary.

Provide Carbon Dioxide Leak Detection system for the Equipment Room as required by codes.

Provide a floor drain for disposal of condensate that may form on the compressor unit or header defrost assembly.

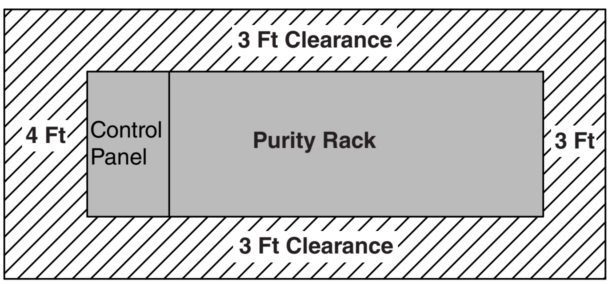
Equipment must be located in the equipment room to provide enough working space for service personnel, and to meet electrical codes.

Consult National Electric Code, National Fire Protection Agency Handbook particularly “Installation of Switch Boards” and “Working Space Requirements”. Refer to local codes for each installation.

## MINIMUM ALLOWABLE DISTANCES IN EQUIPMENT ROOM

It is recommended that a minimum access of 3 feet be maintained on all sides of the rack for serviceability. The exception is the side of the control panel where a 4-ft minimum is required.

Observe the minimum and maximum distances as described below for setting the system in relation to other equipment.




## LOCATION AND LEVELING

- Each $CO_2$ System must be located in the machine room so that it is accessible from all sides. A minimum of 36 inches clearance is recommended to provide easy access to equipment.

- Vibration isolation pads are supplied with each rack. The entire weight of the rack must rest on these pads (see Table 1-1). The pads should be located as shown in Figure. Cross-level the compressor unit so all compressors are level with each other.

Often machine rooms have uneven floors. To insure both proper leveling and vibration isolation in these instances, perform the following:

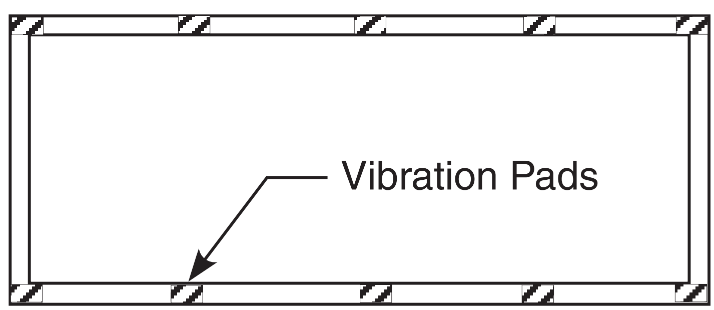
1. Lift the Trans-critical Custom System in accordance with procedures detailed.

2. Place 15 gauge 3” x 3” galvanized steel shims to compensate for uneven floors. (Shims must be field supplied).

3. Place vibration isolation pads on top of shims.

**Vibration Pad Quantities**
**3 in. x 3 in. x 2 in.**

| # of compressors per pack | Reciprocating or Scroll |
|---|---|
| 2 Compressors | 4 Each |
| 3 Compressors | 4 Each |
| 4 Compressors | 6 Each |
| 5 Compressors | 6 Each |
| 6 Compressors | 6 Each |
| 7 Compressors | 8 Each |
| 8 Compressors | 8 Each |
| 9 Compressors | 8 Each |
| 10 Compressors | 10 Each |



# NOTES FROM INSTALLING CONTRACTOR:

# COMPONENT PIPING & LINE SIZING

## RACK PIPING OVERVIEW

This section provides information for installing the refrigeration lines for a rack. The components are piped as completely as practical at the factory. Field piping requires only interconnection of the major components and the coolers, freezers and display cases. Piping must also be supported to minimize vibration. Pulsation of the refrigerant and compressor vibration can cause piping to vibrate. This vibration can cause line breakage and damage to components.

Use only clean, dehydrated, sealed refrigeration grade copper tubing. Use dry nitrogen at low pressure in the tubing during brazing to prevent the formation of copper oxide. All joints should be made with a 15 percent silver alloy brazing material. Use a 45 percent silver braze material for dissimilar metals.

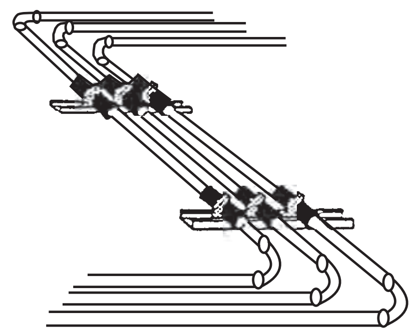
**⚠ WARNING**

**Always use a pressure regulator when operating nitrogen tanks.**

## REFRIGERATION LINE RUNS

Liquid lines and suction lines must be free to expand and contract independently of each other. Do not clamp or join them together. Supports must allow tubing to expand and contract freely. Do not exceed 100 feet without a change of direction or/and offset. Plan proper pitching, expansion allowance, and waterseal at the base of all suction risers. Use long radius elbows to reduce line resistance and breakage. Do not use 45 degree elbows. Install service valves at several locations for ease of maintenance and reduction of service costs. These valves must be UL recognized or listed for the minimum design working pressure of the system.

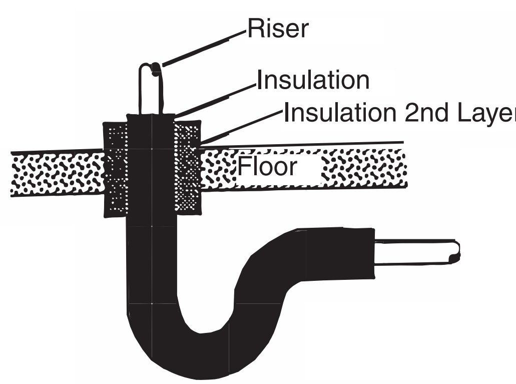
Ceiling Run with Supports



Floor Piping Run

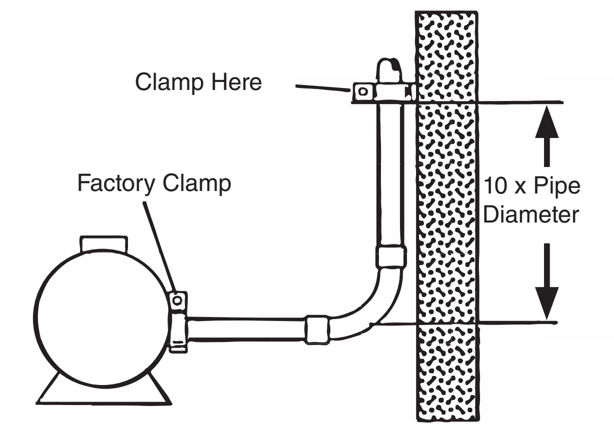
**Through Walls or Floors**

Refrigeration lines that are run through walls or floors must have a waterseal installed, and the lines must be properly insulated. Avoid running lines through the refrigeration cases. When this is done the lines must be adequately insulated using a closed-cell elastomeric foam insulation.

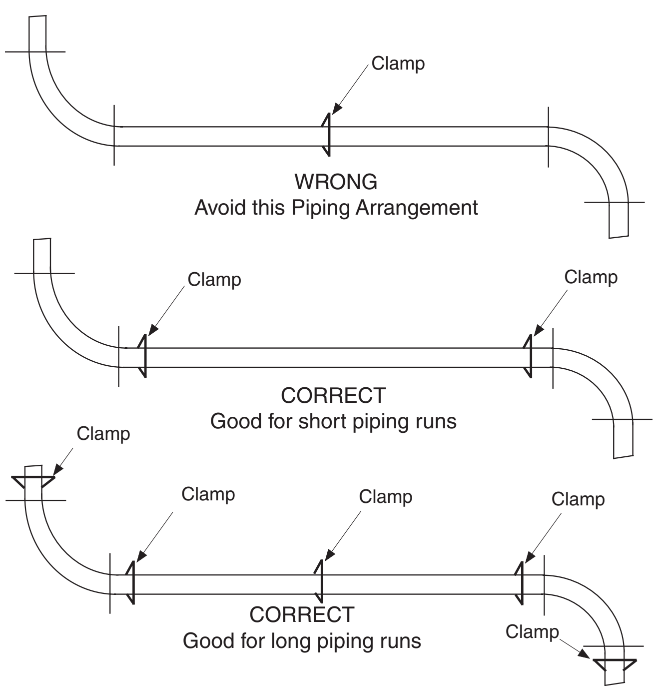



Insulating a Riser

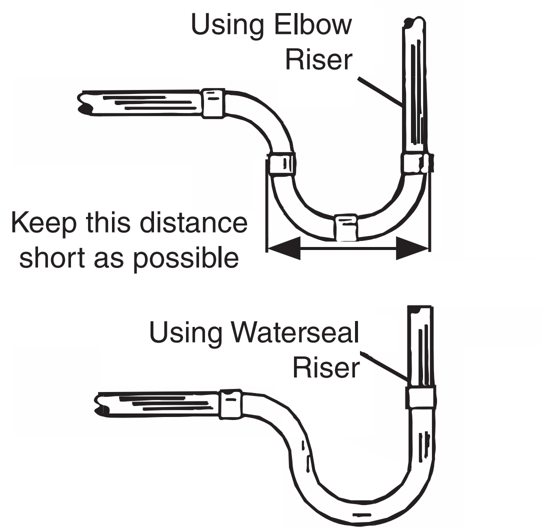
**From Machinery to Solid Object**
When mounting lines from machinery to a solid object allow line freedom for vibration to prevent metal fatigue.




Don't over support piping that is in contact with the compressor racks. The machinery must not be tightly stressed from piping that does not allow for some vibration. If piping is too tight metal fatigue will occur.

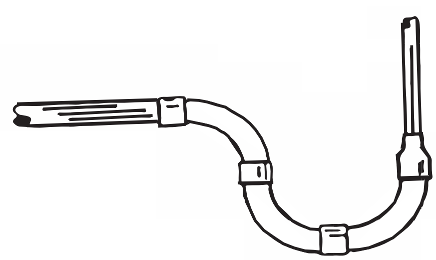



**Waterseal Construction**
Waterseals must be installed at the bottom of all suction risers to return oil to the compressors to avoid trapping oil.




Waterseal Construction

**Reduced Riser**
When a reduced riser is necessary, place the reduction coupling downstream of the waterseal.



Reduces Riser

**Protecting Valves and Clamps**
When brazing near factory installed clamps or valves be sure to protect them with a wet rag to avoid overheating. Insulate all reduced risers.

All clamps must be properly anchored. Rubber gromets must be installed to prevent chafing of the lines.

# FIELD WIRING

## FIELD WIRING

**Remote Alarms –** All wiring on remote alarms must adhere to the National Electrical Code (NEC) as written by the National Fire Protection Agency (NFPA).

**Temperature Probes and Transducers –** Based on the location and number of probes and transducers, some may be ship loose. If ship loose, follow the manufacturers' recommendations as to application and mounting.

**Unit Cooler Wiring –** All wiring on Unit Coolers must adhere to the National Electrical Code (NEC) as written by the National Fire Protection Agency (NFPA).

**Door Switch Wiring –** All wiring on Unit Cooler Door Switch Wiring must adhere to the National Electrical Code (NEC) as written by the National Fire Protection Agency (NFPA).

**Defrost Controls –** When electric defrost is specified, typically the contactors and breakers for the defrost circuits will be in a remote defrost panel.

**Electrical Schematics –** General wiring schematics for the rack will be provided showing typical wiring techniques.

...ATTENTION INSTALLER

**It is the installing contractor's responsibility to consult local agencies for local code requirements.**

## OPTIONAL ACCESSORIES

Pressure Regulating Relief Valves
Pressure regulating relief valves are shipped loose with each system and must be installed in the field. The piping for the regulating valves is stubbed at the rack and must be piped to the outside atmosphere. DO NOT pipe to the Equipment room or other occupied space.

NOTE:
The relief valve must be placed at the end of the line run.
Sizing – The relief valves are set to match the maximum design pressure of the system and are not to be altered in any way. Other systems relief tubing shall not be piped together
Piping – All field supplied piping for the pressure relief system must be sized in accordance with ANSI/ASHRAE 15 (latest revision) and local or regional codes.

## PIPING

Requirements – All piping used is sized to insure proper oil return and pressure ratings. All low side piping shall be copper Type K minimum. Type L or water tubing shall not be used. All high side piping should be 300 series stainless steel. All piping shall be cleaned and de-burred prior to joining.

Joining – All copper tubing is to be joined using 15% silver minimum braze material. Proper penetration of the braze material in the joint is required to prevent leaks. All stainless steel shall be welded by an AWS certified welder. Butt joints are not allowed. To adhere to ANSI/ASHRAE 147-2013, flare joints shall not be used when the temperature of that joint can see temperatures below 40°F.

Nitrogen – Nitrogen shall be used during all copper tubing brazing to prevent oxidation on the inside of the copper tubing. A minimum of 1 scfm is recommended.

Line Sizing – As with standard DX refrigeration systems, line sizing is very important. Because of the nature of $CO_2$, refrigeration lines are smaller. Liquid and suction line sizing for all circuits and loops will be stated on the refrigeration schedule. The provided line sizes are designed to provide minimum pressure drop while providing enough velocity to carry the lubricant throughout the system. If line sizes are provided, they should be followed to insure proper lubricant return. Deviation from the stated sizes should be approved by Hussmann Application Engineering. Type K copper shall be used on all lines, except the MT discharge lines to the gas cooler and from the gas cooler to the throttle valve.

If lines are calculated in the field, pressure drop across the equivalent length of the line run is important. Pressure drop should be kept at a minimum and the following tables can be used.

Line Installation – Systems suction refrigerant lines should slope back to the rack. Typical slope is ¼” per 10 ft in length or greater.

Traps and “P” Traps – Vertical risers should be equipped with a trap for every 10 to 12 feet of vertical rise. This will insure proper lubricant return from the evaporators back to the parallel rack. At the top of the riser an inverted “P” trap is recommended to ensure that lubricant will not drain back down the riser.

Risers - depending on the design, the riser size may be slightly smaller in size than the horizontal line run. Velocity of the refrigerant in the riser is paramount to maintain lubricant return to the compressors. Velocity in the riser should be between 1,000 and 3,000 fpm.

**Liquid Line Capacities – 2 psi/100ft**

| CAPACITY +20 F | | | | CAPACITY -20 F | | |
|---|---|---|---|---|---|---|
| Pipe Size | Capacity BTU | Flow (lb./min.) | Velocity (ft/min.) | Capacity BTU | Flow (lb./min.) | Velocity (ft/min.) |
| ½” | 84,000 | 13 | 133 | ½” | 13.6 | 125 |
| 5/8 | 136,000 | 21 | 147 | 5/8 | 17 | 139 |
| 1” | 348,000 | 58 | 192 | 1” | 45.4 | 157 |
| 1-1/8” | 595,000 | 90 | 210 | 1-1/8” | 95 | 200 |
| 1-3/8” | 1,008,000 | 156 | 240 | 1-3/8” | 115 | 230 |

# CHARGING

## CHARGING

Charging $CO_2$ into the system is slightly different than a standard HFC DX system.

PROCEDURE
Preparing the system for charging in a $CO_2$ system is as important as a standard HFC system. Refrigerant leaks are to be kept at a minimum, so preparation is important. Positive pressure testing is required (usually 250 psig held for a minimum of 3 hours), along with a triple evacuation to a minimum of 500 microns of vacuum. Once the system is determined to be leak free, the system can be charged with $CO_2$.

DO NOT INITIALLY CHARGE WITH LIQUID.

There are several reasons for this

1). As the liquid refrigerant enters the vacuum, it will immediately turn solid, to Dry Ice, this will clog the tubing.

2.) The shock of such low temperatures can cause the metal components of the system to crack.

Only charge the system with $CO_2$ gas until the pressure reaches 200 psig. When this pressure is reached inside the system, charging with liquid $CO_2$ can be started. Do not trap liquid refrigerant between two isolation valves.

Trapped liquid $CO_2$ expands very quickly when heated and can reach very high pressures very quickly. These pressures may cause components to burst.

## LEAK DETECTION

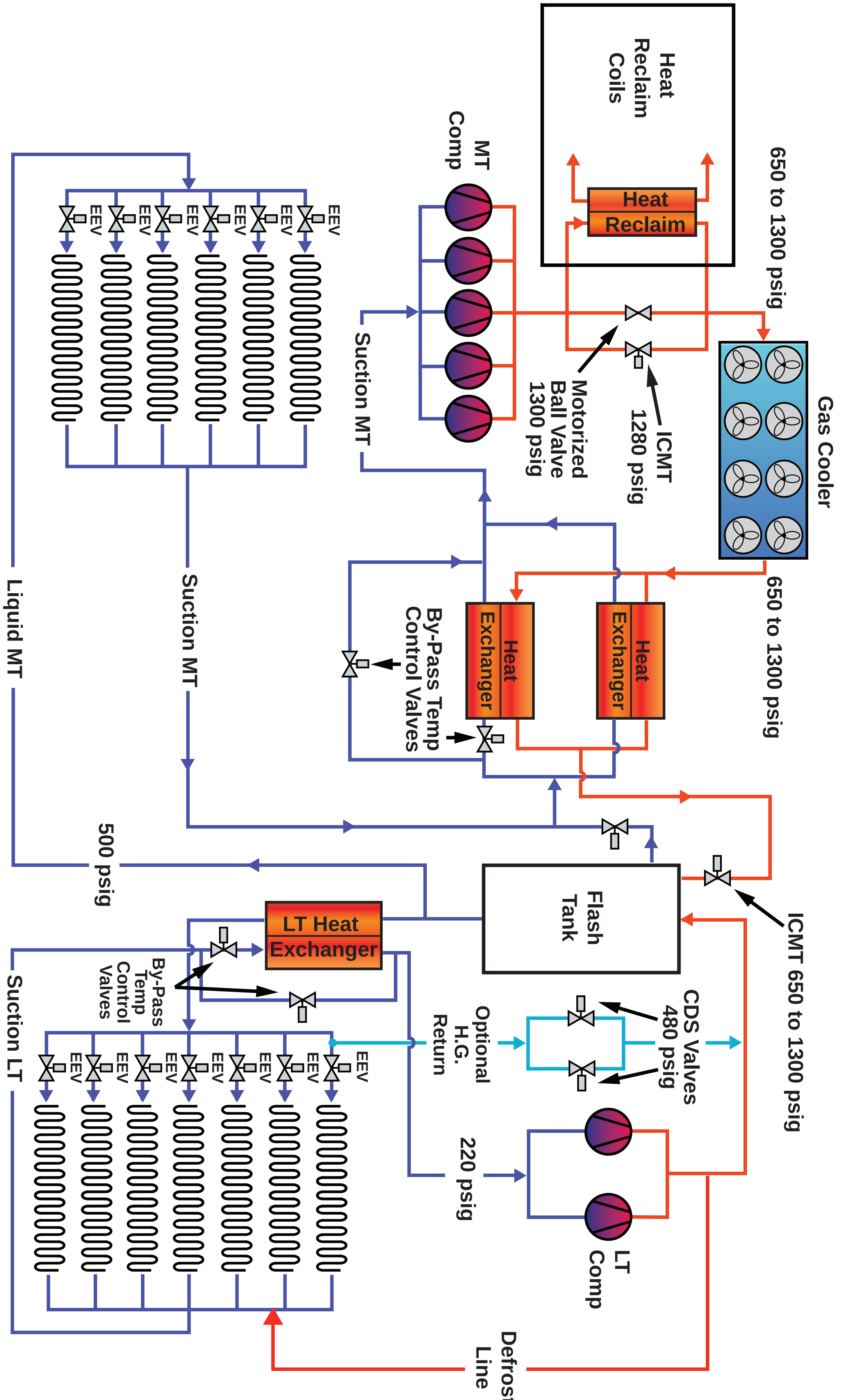
Detecting $CO_2$ leaks in any $CO_2$ refrigerant system is difficult. This is because $CO_2$ is present in ambient air. $CO_2$ can be found in concentrations between 300 and 1500 ppm in the ambient air. It is also a by-product of many processes including human and animal respiration.

Standard sniffer detectors are available however, calibrating them can be difficult due to varying $CO_2$ concentrations throughout the store. Though not as effective, other procedures can be followed when looking for $CO_2$ leaks. They include looking for lubricant leaks or the forming of dry ice on liquid line joints. In walk-in coolers and freezers, occupied spaces or equipment rooms, $CO_2$ alarms should be set at 3,000 ppm. Additional requirements may be found in ANSI/ASHRAE 15 and ANSI/ASHRAE 34 standards.

**⚠ WARNING**

**Do not trap liquid refrigerant between two isolation valves.**

SYSTEM DIAGRAM



# "PURITY" CO2 TRANS-CRITICAL RACK PRINCIPLE

The "PURITY" Trans-critical $CO_2$ 2-stage rack system is a system type where the low evaporating temperature (LT) part of the system absorbs the refrigeration load from the low temperature heat exchangers at a suction pressure of about 200 psig. The LT compressors discharge gas flows through an oil separator, and then to the flash tank where it is mixed with $CO_2$ that has been dropped in pressure and temperature via the throttling valve.

The $CO_2$ gas is drawn from the top of the flash tank, mixed with the suction return gas of the medium temperature heat exchangers, (which absorb the medium temperature load) then routed to the MT compressors. The required pressure in the flash tank is maintained by upstream pressure regulating valve, normally set 100 psi higher than the suction pressure of the MT compressors.

The refrigerant from the flash tank is fully saturated and routed through the plate heat exchanger where it is slightly warmed thus ensuring ideal super heat for the MT compressors. The suction flow rate through the heat exchangers is controlled by the bypass valves, which are piped in parallel with the heat exchangers. The desired suction pressure for the medium temperature is about 380 psig., and the flash tank's pressure is 480 psig. The tank will feed the medium and low-temperature liquid manifolds.

The medium compressors discharge gas, the pressure of which can vary from 900 to 1,350 psig, flows through the oil separator(s) and then flows into the gas cooler. Flow through the gas cooler is controlled by the throttling valve based on the $CO_2$ outlet temperature, and is monitored by a temperature probe mounted on the gas outlet of the gas cooler. The set point of 60° Fahrenheit provides reliable operation of the system.

A second temperature probe is installed at the outlet of the gas cooler to control the fans. After passing through the throttling valve, the gas/liquid mixture flows into the flash tank where the liquid is separated from the vapor and is accumulated in the lower part of the tank. The vapor from the top part of the tank is then fed through the flash tank regulating valve, which maintains the flash tank pressure to 480 psig, which then flows to the suction side of the MT compressors.

The critical point of carbon dioxide (the pressure at which $CO_2$ will not condense into a liquid form) is 1,070 psig, pressures above 1,070 dictate that we run in trans-critical mode, (the gas cooler will only de-superheat the gas and the throttling valve drops the pressure of the carbon dioxide to a saturated state). Pressures below 1,070 allow the gas cooler to perform as a standard DX condenser, where the carbon dioxide will change from a vapor to a liquid allowing for a higher COP.

The -22°F and -30°F groups: The exchange is between the LT suction and the liquid line downstream of the flash tank.

It is important to know that the low temperature compressors cannot function if the medium temperature compressors are not running. This is key to the function of the booster compressor system. If there is maintenance to be performed on the medium rack and the rack is out of operation, it is imperative to also stop the low-temperature compressors.

**CO2 temperature-pressure chart**

| Temp F° | Temp C° | Pressure (psig) | Pressure (bar) | Temp F° | Temp C | Pressure (psig) | Pressure (bar) |
|---|---|---|---|---|---|---|---|
| -40 | -40 | 131 | 9.04 | 22 | -5.6 | 420 | 29.00 |
| -38 | -38.9 | 137 | 9.46 | 24 | -4.4 | 434 | 29.93 |
| -36 | -37.8 | 143 | 9.89 | 26 | -3.3 | 448 | 30.87 |
| -34 | -36.7 | 150 | 10.34 | 28 | -2.2 | 462 | 31.85 |
| -32 | -35.6 | 156 | 10.79 | 30 | -1.1 | 476 | 32.84 |
| -30 | -34.4 | 163 | 11.26 | 32 | 0 | 491 | 33.85 |
| -28 | -33.3 | 170 | 11.74 | 34 | 1.1 | 506 | 34.89 |
| -26 | -32.2 | 177 | 12.24 | 36 | 2.2 | 521 | 35.95 |
| -24 | -31.1 | 185 | 12.75 | 38 | 3.3 | 537 | 37.58 |
| -22 | -30 | 192 | 13.28 | 42 | 4.4 | 569 | 39.26 |
| -20 | -28.9 | 200 | 13.82 | 44 | 5.6 | 586 | 40.41 |
| -18 | -27.8 | 208 | 14.27 | 46 | 6.7 | 603 | 41.59 |
| -16 | -26.7 | 217 | 14.94 | 48 | 7.8 | 621 | 42.79 |
| -14 | -25.6 | 225 | 15.53 | 50 | 8.9 | 638 | 44.02 |
| -12 | -24.4 | 234 | 16.13 | 52 | 10.0 | 657 | 45.28 |
| -10 | -23.3 | 243 | 16.75 | 55 | 12.8 | 684 | 47.20 |
| -8 | -22.2 | 252 | 17.38 | 60 | 15.6 | 733 | 50.56 |
| -6 | -21.1 | 261 | 18.03 | 62 | 16.7 | 753 | 51.95 |
| -4 | -20 | 271 | 18.7 | 64 | 17.8 | 774 | 53.36 |
| -2 | -18.9 | 281 | 19.35 | 66 | 18.9 | 795 | 54.81 |
| 0 | -17.8 | 291 | 20.08 | 68 | 20 | 816 | 56.29 |
| 2 | -16.7 | 302 | 20.8 | 70 | 21.1 | 838 | 57.8 |
| 4 | -15.6 | 312 | 21.53 | 72 | 22.2 | 861 | 59.34 |
| 6 | -14.4 | 323 | 22.29 | 74 | 23.3 | 883 | 60.92 |
| 8 | -13.3 | 334 | 23.06 | 76 | 24.4 | 907 | 62.52 |
| 10 | -12.2 | 346 | 23.85 | 78 | 25.6 | 931 | 64.17 |
| 12 | -11.1 | 357 | 24.66 | 80 | 26.7 | 955 | 65.85 |
| 14 | -10.0 | 370 | 25.49 | 82 | 27.8 | 980 | 67.57 |
| 16 | -8.9 | 382 | 26.33 | 84 | 28.9 | 1005 | 69.33 |
| 18 | -7.8 | 394 | 27.2 | 86 | 30 | 1032 | 71.14 |
| 20 | -6.7 | 407 | 28.09 | 87 | 30.6 | 1045 | 72.06 |

## HEAT RECLAIM

The return pressure from the heat reclaim is regulated by ICMT valves, and the set point pressure ranges from 850 to 1,100 psig, depending on the outside temperature, this set point is the same for all heat reclaim heat exchangers. This provides appropriate flow for all heat exchangers in order to obtain the required heat capacity.

## DEFROST

Gas defrosts are performed by low temperature compressors. A minimum of two compressors are used for defrosts. For a -22°F group, the suction pressure is maintained to a minimum of 200 psig with a charge transfer from medium-temperature to low, which opens on demand and only during the defrost cycle. During normal operation, the transfer is closed. The gas defrost type used is a reverse cycle hot gas system, and when initiated, the electronic expansion valve (EEV) of the circuit starts closing and when it is completely closed, the hot gas solenoid is energized. Koolgas defrost is not an option with transcritical $CO_2$ systems.

The main discharge valve is an electronic valve, which during the defrost cycle operates from 100% to about 26% opening to keep a pressure of approximately 565 psig. The valve will return to 100% when defrosting is complete.

Defrost return is sent back to the flash tank, and the pressure is controlled by two CDS valves in parallel. Return pressure is adjusted from 500 to 526 psig depending on location. These valves are in pressure control mode at all times.

When the circuit is completely defrosted and the drip time cycle is finished, the circuit suction CDS valve goes into pressure drainage mode. This drainage is performed in 5 steps. The circuit suction CDS valve will re-open at different percentages every 2 minutes in order to drain the excess pressure in the system, before opening to 100%. Under normal circumstances, these percentages are: 1% (2 min.), 2% (2 min.), 4% (2min.), 8% (2 min.), 25% (2 min.).

WARNING:
The circuit suction CDS valve is in communication with all the case controllers involved in its circuit. When there is a problem with either an expansion valve, a pressure sensor or a evaporator temperature sensor, this problem will be sent to the CDS valve so it closes down to 0% as long as the problem is not resolved This action is used to prevent liquid slugging into the compressor.

Electric Defrost is also available and operates similarly to a standard parallel rack.

## OIL MANAGEMENT

The oil management of a R744 system is of extreme importance. The $CO_2$ compressors have a substantial oil carryover, even at a normal suction temperatures. The Purity System includes Temprite oil separators with filter that should be replaced as needed or at least once a year. The oil recovered by the separator is returned directly to the oil reservoirs that feed all the compressors in the rack.

**Low temperature oil separator:** The output of the separator is equipped with a solenoid valve that cycles for 60 seconds every 5 minutes, and then only if it is not in defrost mode. If the system is in defrost mode and the discharge pressure is greater than 520 psig, the solenoid valve on the separator will not operate until the pressure drops below 520 psig. The solenoid is fed to a first cycle of 60 seconds. This oil is then sent to the common flash tank.

If the system is in defrost mode and the discharge pressure is greater than 520 psig, the solenoid valve on the separator will not operate until the pressure drops below 520 psig. The solenoid is fed to a first cycle of 60 seconds. This oil is then sent to the common flash tank.

**Medium temperature oil separator:** The output of the separators is at a very high pressure (900-1350 psig.). It is then passed through a filter before being depressurized by a mechanical valve that manages a pressure at its outlet. Its adjustment is between 550 and 600 psig and then to be sent to the common reservoir.

**Common oil reserves:** These oil reserves that receive the oil from the low and medium temperature separators are equipped with a system for purging excess pressure that consists of a check valve, in which the vapors from the reserve are sent to the liquid container drain line, immediately before the CDS-17 valve that maintains 480 psig in the tank by sending the excess of pressure to the medium temperature suction. Finally, this concept will keep a minimum of 480 psig in the oil reserve in order to be able to power the oil level devices of the compressors.
The depressurization valve at the medium separator outlet being adjusted between 550 to 600 psig, provides a constant flow to the 480 psig pressure oil reserves. Technically, there should never be any accumulation of oil in the separators. If any oil is found, it indicates that the valve is blocked. It is usually easy to unblock it by increasing its adjustment temporarily and then returning it to its original position.

Once the system is in operation and the oil levels are at acceptable levels, do not add additional oil before checking the base of the separator and ensure that oil has not logged in the gas cooler or evaporator coils. There is a sensor in the bottom of the oil reserves, and the level should never fall below the sensor's location.

It is considered a service emergency when a low oil level alarm is received.

Some of the compressors used do not have a built-in oil pump. The oil pressure control is maintained by the electronic oil control. It is this control that cuts off the compressor if it has failed to reach an acceptable pressure level within 120 seconds. It will restart automatically when its level is reached.

## COMPRESSORS

The options include Copeland scrolls on LT and Copeland and Bitzer recips on MT.
Use the vendor software for determining BTU/HR output KW input, and RLA. Play special attention to the voltage, especially when utilizing VFD's (Never run below 25 Hz).
Digital technology is also available, utilize when possible.

## OIL REGULATORS

TRAXOIL (OMB) Electronic Oil Floats are always utilized, no matter the compressor used.

## CRANKCASE HEATERS

Crankcase heaters are recommended when the compressors will be exposed to temperatures below 40° F.

# REFRIGERATION

## CO2 TRANS-CRITICAL RACK PRINCIPLE

Application- 2-stage “Booster” type CO2 trans-critical rack with flash gas bypass valve

The low evaporating temperature part of the system (low stage) absorbs the refrigeration load from the low temperature equipment with a suction pressure of about 200 PSIG and condensing temperature of 300F (subcritical conditions). The compressor discharge passes through an oil separator, and then is fed to the liquid receiver (flash tank) or deflected by a set of valves to the defrost manifold, as the low temperature compressors are used to perform the hot gas defrost for the medium and the low temperature parts of the system. The principle is explained in the defrost section.

The discharge is fed to the receiver (flash tank) where it is mixed with the flow from the throttling thus lowering its temperature. The vapors from the flash tank are fed to the suction manifold of the medium temperature compressors, which also absorb the medium temperature load. The required pressure in the receiver is maintained by a CDS-17 pressure regulating valve.

This charge coming from the reservoir to the suction of the medium-temperature is continuous, and varies depending on the load on the low-temperature and the opening of the Danfoss throttle valve. The opening of this valve varies depends on the efficiency of the gas cooler and the ambient temperature. Warning: The vapors from the flash tank tends to carryover some amount of liquid when passing through the CDS-17 valve, and for this reason the suction flow is passed through a plate heat exchanger in order to maintain acceptable superheat at the compressors suction inlet for each suction group (20°F, -20°F, & -30°F). The suction flow rate through the heat exchangers is controlled by the temperature of the suction compressor manifold (bypass valves). The desired suction pressure for the medium temperature is about 380 psig. and the flash tank’s pressure is 480 psig. The tank will feed the medium and low-temperature liquid manifolds.

The medium compressors discharge pressure, which can vary from 900 to 1,350 psig, is then passed through two oil separators and then is fed to the gas cooler , or deflected by a set of valves to the heat reclaim heat exchangers. The return pressure is regulated by CX7 Emerson valves , and the set point pressure ranges from 850 to 1,100 psig, depending on the outside temperature, this set point is the same for all heat reclaim heat exchangers. This provides appropriate flow for all heat exchangers in order to obtain the required heat capacity. The gas then will be fed to the inlet of the gas cooler.

The gas cooler is controlled by the R744 outlet temperature, and a Micro-Thermo 10K probe is installed on the gas outlet of the gas cooler. From field experience, when possible , the set point of 18 degrees Celsius provides reliable operation of the system. A second 1K probe is installed on the same place and controls the fans (M-T 10K).

The 1K probe is plugged into the Danfoss controller # 2 model EKC326A located in the small rack panel located above the recovery valves . This probe will be used to determine the pressure to be maintained in the gas cooler (trans-critical or sub-critical).

The module responds according to the temperature of the gas in order to obtain an optimum cop, which means have a maximum of liquid produced by the passage of the depressurized gas with the Danfoss throttle valve. The higher the temperature of the gas leaving the gas cooler, the higher the Danfoss throttle valve will adjust the pressure in the gas cooler. (See CO2 chart).

After passing through the Danfoss throttle valve, the gas/liquid mixture falls into the liquid receiver (flash tank )where the liquid is separated from the vapors and is accumulated in the lower part of the receiver. The vapors from the top part of the receiver is then fed through  the CDS-17 valve , which maintains the reservoir pressure to 480 psig. The critical point is 1,070 psig, so we determine the trans-critical part above this pressure, and the subcritical below this same pressure.

In sub-critical mode, we can condense the gas into the gas cooler, which is impossible in trans-critical mode In this case, the gas cooler will only de-superheat the gas and the condensation of the gas will be carried out during the depressurization by the Danfoss throttle valve.

The simplified piping diagram should be placed here showing the LT and MT systems, standard pressures and temperatures should also be shown either on the diagram or on a chart referencing points on the diagram.
A temperature-pressure chart for CO2 should be placed here showing
Temperature (F)   Temperature (C)    Pressure (psig)    Pressure (bar)

Suction gas overheat plate VS respective superheat at compressor entry :
The + 20°F group: The exchange is between the suction and the gas cooler return.
The -22°F and -30°F groups: The exchange is between the suction and the liquid line.
It is important to know that the 1st stage of compressors (low- temperature) cannot work if the 2nd stage of compressors (medium-temperature) is not functional. So if there is maintenance to be done on the medium rack and the rack is out of operation, it is imperative to also stop the low-temperature rack.

Gas defrosts are performed by low temperature compressors. A minimum of two compressors are used for defrosts. For a -22°F group, the suction pressure is maintained to a minimum of 200 psig with a charge transfer from medium-temperature to low, which opens on demand and only during the defrost cycle. During normal operation, the transfer is closed.

The gas defrost is a reverse cycle hot gas and when initiated the electronic suction valve of the circuit starts closing and when is completely closed, the hot gas solenoid is energized.  Kool gas defrost is not an option with transcritical CO2 systems.

The main discharge is deviated a SDR4 electronic valve which, during defrost cycle, goes from 100% to +/- 26% opening to keep a pressure of +/- 565psig. If the pressure rises above that number, it will open in order to maintain 565 psig. When defrosting is completed, the valve will return to 100%, and this until the next defrost. A Danfoss mechanical valve installed in parallel with the SDR4 in order to counter sudden excess pressure. This valve is adjusted to +/ - 575psig.
Defrost return is sent back to the reservoir, and the pressure is controlled by two valves in parallel, a SER6 valve and a CDS4 valve. Return pressure is adjusted from 500 to 526 psig, depending on the sites. These valves are in pressure control mode at all times.
When the circuit is completely defrosted and the drip time cycle is finished, the circuit suction CDS valve goes into pressure drainage mode. This drainage is performed in 5 steps. The circuit suction CDS valve will re-open at different percentages every 2 minutes in order to drain the excess pressure in the system, before opening to 100%. Under normal circumstances, these percentages are: 1% (2

min.), 2% (2 min.), 4% (2min.), 8% (2 min.), 25% (2 min.).
Warning: The circuit suction CDS valve is in communication with all the case controllers involved in its circuit. When there is a problem with either an expansion valve, a pressure sensor or a evaporator temperature sensor , this problem will be sent to the CDS valve so it closes down to 0% as long as the problem is not resolved This action is used to prevent liquid slugging into compressor. Has to be found which system has a problem and fix it.
Electric Defrost is also available and operates similarly to a standard parallel rack.

## OIL MANAGEMENT

The oil management of a R744 system is of extreme importance.
The R744 compressors have a substantial oil carryover, even at a normal suction temperature. So, if there is a gas/liquid mixture at the suction, we should expect to have problems recovering the oil.
Our system includes Temprite oil separators with filter that should be replaced as needed, or at least once a year. The oil recovered by the separator is returned directly to the oil reservoirs that feed all the compressors in the rack.
Low temperature oil separator: The output of the separator is equipped with a solenoid valve that cycles for 60 seconds every 5 minutes, and then only if it is not in defrost mode. It is determined that it is defrosting when the low temperature discharge pressure is greater than 520psig. Once the pressure drops below 520psig., The solenoid is fed to a first cycle of 60 seconds. This oil is then sent to the common reservoirs.

Medium temperature oil separator: The output of the separators is at a very high pressure (900-1350 psig.). It is then passed through a filter before being depressurized by a Swagelok mechanical valve that manages a pressure at its outlet. Its adjustment is between 550 and 600 psig, and then to be sent to the common reservoirs.

Common oil reserves: These oil reserves that receive the oil from the low and medium temperature separators are equipped with a system for purging excess pressure that consists of a check valve, in which the vapors from the reserve are sent to the liquid container drain line, immediately before the CDS-17 valve that maintains 480psig in the tank by sending the excess of pressure to the medium temperature suction. Finally, this concept will keep a minimum of 480 lbs in the oil reserve in order to be able to power the trax-oil devices of the compressors.
The Swagelok depressurization valve at the medium separator outlet being adjusted between 550 to 600 lbs, provides a constant flow to the 480 lbs pressure oil reserves.
Technically, there should never be any accumulation of oil in the separators. If any oil found, it indicates that the Swagelok valve is blocked. It is usually easy to unblock it by increasing its adjustment temporarily, and then return it to its original position.
The oil should be retained up to 99% by the separators, so before putting oil in the reserves, it is important to check if the oil is not trapped in the bases of the separators, in which there should never have any oil accumulation. There is a sensor in the bottom of the oil reserves , and the level should never fall below the sensor's location.
If there is an alarm for low oil level, it is considered an emergency because, at the speed the compressors run their oil, it is possible that we might lose compressors because of lack of oil.

The compressors do not have any built-in oil pump, so there is no oil pressure control . It is the trax-oil that cuts off the compressor if it has failed to reach an acceptable level within 120 seconds. It will restart automatically when its level is reached.

## COMPRESSORS

The options include both Bitzer and Copeland compressors for low temp, and Copeland and Bitzer recips for medium temp.

Use the vendor software for determining BTU/HR output KW input and RLA.
Play special attention to the voltage, especially when utilizing VFDs (Never run below 25 Hz.

Digital technology is also available — utilize when possible.

## OIL REGULATORS
## TRAXOIL (OMB)

Oil Floats are always utilized, no matter the compressor used.

## CRANKCASE HEATERS

Crankcase heaters are recommended when the compressors will be exposed to temperatures below 40°F.

**To obtain warranty information or other support, contact your Hussmann representative. Please include the model and serial number of the product.**

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